Advance and protect the transportation system. To ensure that the existing public investment in the transportation system is maintained to improve mobility and safety through better operations, management and innovation.

Make transportation personal. To build an understanding by the public, stakeholders and employees about how Arizona's quality of life is directly impacted by an efficient and safe transportation system and that our role in delivering that system is tremendously important.

Create a high-performing organization. Build a nimble organization by evaluating, adapting, supporting and allocating funding and resources. Every group, team and individual is dedicated to quality services to stakeholders and each other.

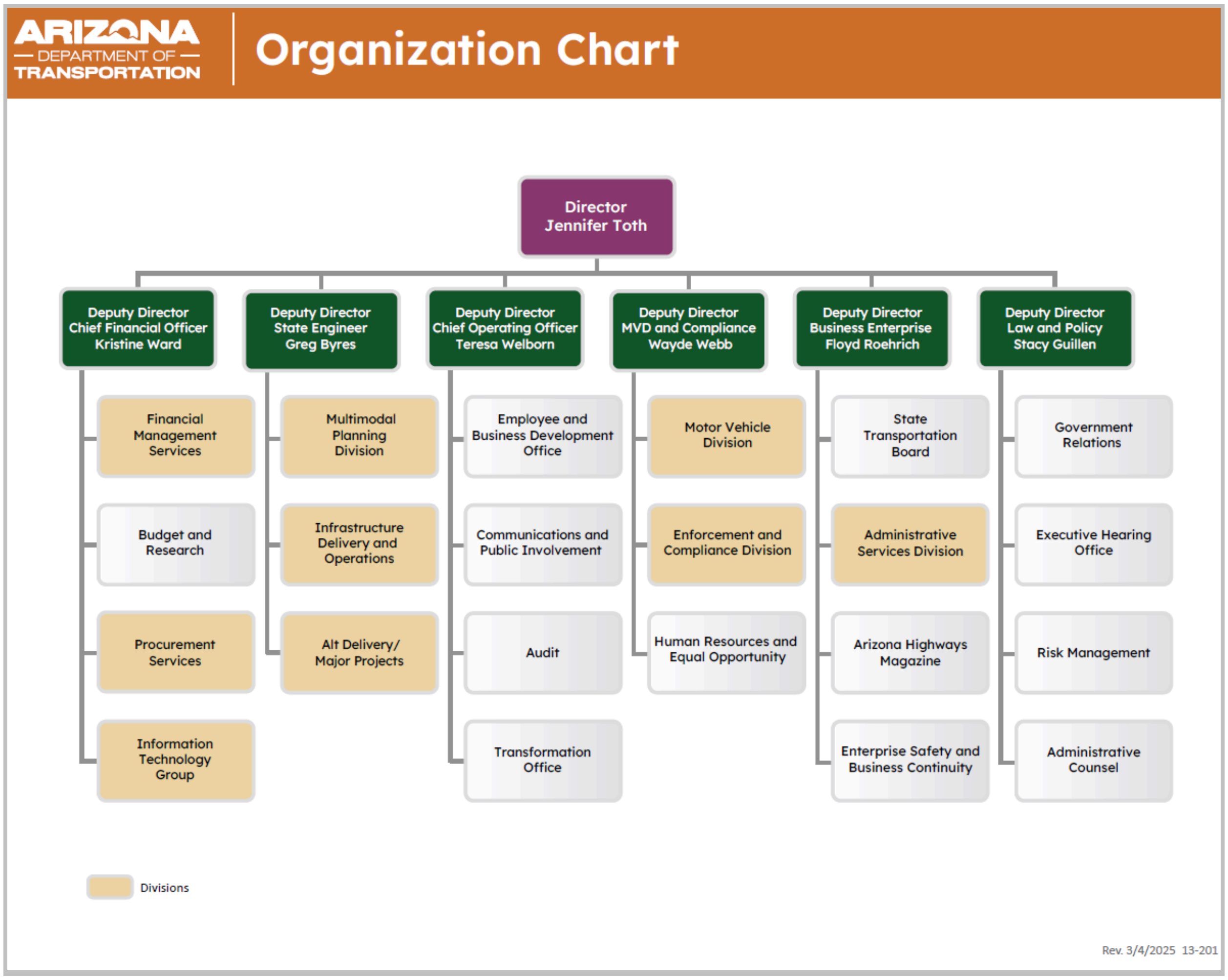


Exhibit 100-2 ADOT Org Chart

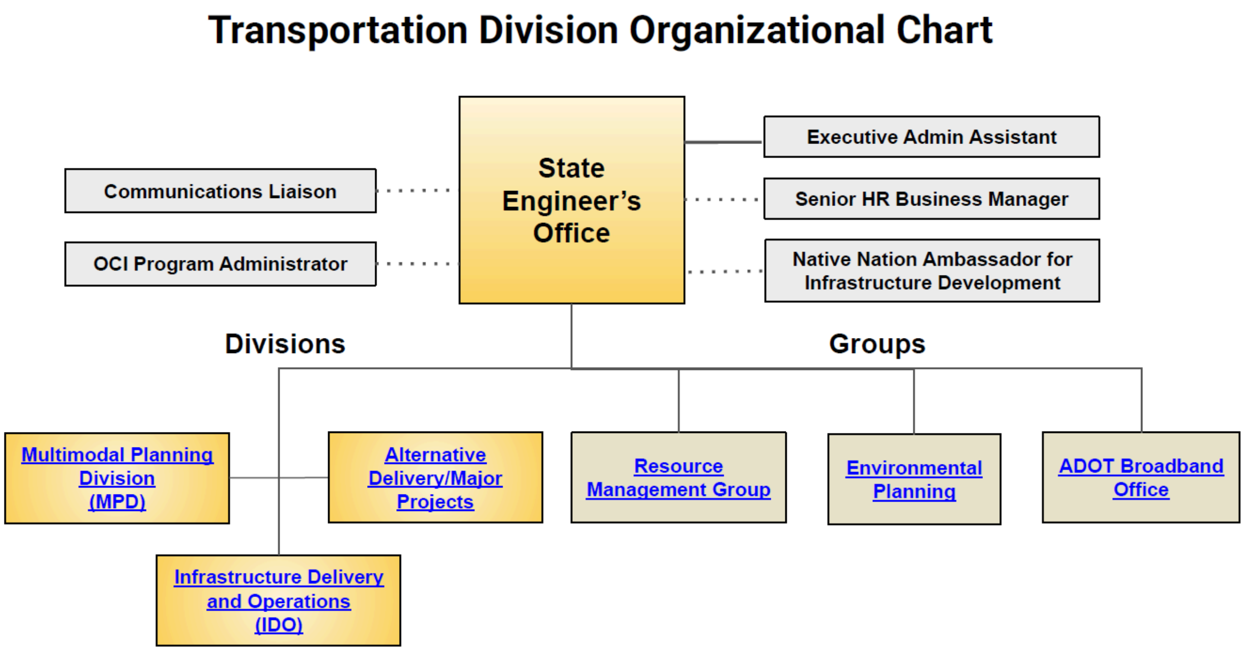


Exhibit 100-3 Deputy Director for Transportation

100 GENERAL

Department Organization

The Arizona Department of Transportation is one of the oldest state agencies dating back to territorial days. At the time of statehood, it was called the Arizona Highway Department and was managed out of a single office in Phoenix. In 1955, the Arizona Highway Department created four District Offices. Each District Office was assigned a region of the state with the duties of constructing and maintaining the roads and bridges within that district. Even today, this district operational structure is still part of the Department's organization.

In 1974, the state legislature merged the Arizona Highway Department with the Arizona Aeronautics Department to form the Arizona Department of Transportation (ADOT). Exhibit 100-2 shows the current organizational structure of ADOT.

The Transportation Director is appointed by the Governor and leads the Department in implementing transportation policy mandated by state law. An independent seven-member Transportation Board is the primary policy-making and governing body for the Department. The Transportation Board determines project priorities, awards construction contracts, presides over the State Highway System, makes local airport grants, and advises the Transportation Director on transportation policy matters. The six members are appointed by the Governor and represent geographical districts in Arizona, with one member serving on an at-large basis.

The Department's Deputy Director for Business Operations leads seven areas (Administrative Services, Information Technology, Human Resources, Financial Management Services, Arizona Highways Magazine, Environmental Services and the Budget, Planning and Research Division). The Deputy Director for Policy provides Transportation Board support and leads the Public Private Partnership component. The Deputy Director for Transportation (State Engineer) leads the Project Delivery and Operations Division (IDO) and the Multimodal Planning Division (MPD) and other Groups (See Exhibit 100-3). PDO is divided into several groups. The groups that have the greatest interaction with construction are Construction, Materials, Bridge, Traffic Engineering, Roadway Engineering, Right-of-way, Environmental Planning, Project Management, and District Operations.

The key activities of each group and their role in construction are summarized on the following pages.

Construction Group

The Construction Group provides support to help districts with managing their construction projects. This includes providing construction administrative services to supplement the workforce with temporary technicians, construction administrative services, material testing assistance, conducting independent review of workmanship, material documentation, providing training for construction technicians, maintaining instructional guides for construction methods and procedures, providing the services of a Registered Landscape Architect, processing monthly pay estimates, quantity documentation, and subcontractor approvals.

Materials Group

The Materials Group consists of Central,Regional and project laboratories. They maintain AASHTO Accreditation for the State and provide materials related technical support. Conducts research into construction materials and methods, develops test methods and specifications, performs testing of soils and aggregates, asphaltic concrete, asphalt binder, concrete, cement, steel and other structural materials. The Regional Labs are responsible for monitoring the acceptance tests performed by project labs and conducting Independent Assurance and Correlation testing in an effort to maintain uniform testing procedures statewide. Steel, geotextiles, and other structural or geotechnical related products and materials are tested by the Structures Lab within the Central Lab. Asphalt binder is tested by the Binder Lab within the Central Lab and occasionally by the Regional Labs.

Bridge Group

If the project includes any major structure, such as a bridge or box culvert, the Bridge Group is there to support ADOT construction personnel by providing technical expertise on structural concrete and structural steel construction. Usually the Designer is consulted first when plans and details require interpretation. However, when major specifications changes are needed or when construction and design standards are to be modified, the Bridge Group should be consulted.

The Bridge Group oversees the inspection of steel sign structure fabrication and sets policy regarding bridge construction standards.

Within Bridge Group is Geotechnical Services which performs subsurface investigations to aid in foundation and pavement design, geogrid reinforced pavements and retaining structures, rock scaling, and soil improvement/stabilization.

Right-Of-Way Group

The Right-of-way Group can be a valuable resource to ADOT's field construction staff. They maintain right-of-way (ROW) plans for all roadways and can provide information about property ownership around your project. Right-of-way can tell you what agreements ADOT has with adjacent landowners for temporary access, rights-of-entry, and construction easements. Information is available on ADOT's property rights and responsibilities. The Right-of-way Group has a Property Management Section that manages all properties owned by ADOT.

Roadway Engineering Group

This group performs the engineering studies and roadway designs necessary to bring a project from inception to construction. Engineering consultants perform this function when the Roadway Group lacks the necessary resources. The Roadway Group develops statewide policies and standards for roadway design and construction details. Roadway is a great source of information when a change made on the project must conform to current highway standards. This could involve a change to shoulder widths, stopping sight distances, or guardrail lengths. Roadway Group publishes the ADOT Construction Standard Drawings (C-Standards).

Within Roadway Engineering Group is part of the Pavement Design Section which performs the following:

- Uses pavement condition data provided by the Pavement Management Section
- Pavement thickness information provided by their coring crew or a materials lab
- Subsurface information provided by the Geotechnical Services Section
- Consideration for the type of pavement desired by the District and State Engineer's Office
- performs analysis to determine necessary roadway preparation and pavement thickness in the form of pavement structural sections and stationing provided in the plans
- Selects specific materials and associated specification requirements for inclusion in the project special provisions

This information is provided to the Project Manager during design in preparation for advertisement. Pavement Design also serves as a consultative resource for the project during construction.

Environmental Planning Group

The Environmental Planning Group is an important source of information on current environmental regulations, including the requirements of the National Pollutant Discharge Elimination System (NPDES) and Storm Water Pollution Prevention Plan (SWPPP) regulations. Environmental Planning can answer any questions concerning environmental regulations and historic preservation.

Partnering

The Partnering Office's mission is to lay the foundation for successful partnerships for teams and groups working on ADOT-related programs and projects. By following partnering practices, teams can achieve win-win relationships based on mutual trust and solid teamwork. Parties to the design and construction process, in agreeing to work under a partnering approach, work to create an atmosphere in which all parties are working in harmony towards common goals. Following this process ensures teams develop protocols that help establish accountability and build trust.

Project Management

The Project Management Group is responsible for getting highway construction projects planned, designed, and advertised for construction once they have been identified and approved by the Transportation Board statewide. They manage the entire project development process, described later in this subsection.

District Operations and the District Offices

As mentioned earlier, the Districts are responsible for highway construction and maintenance within their respective boundaries. Each Construction Field Office within each District manages one or more construction projects for that district.

A Regional Traffic Engineer, a Regional Materials Laboratory, and other technical personnel who provide specialized services not routinely performed by the District's construction and maintenance staff support the Districts. These regional support staff may serve two or more Districts.

Traffic Design Group

Traffic engineering deals with the planning, traffic operations of roads, sight distance, streets and highways and their networks, terminals, abutting lands and relationships with other modes of transportation for the achievement of safe, efficient and convenient movement of people and goods.

During construction the Traffic Design Group can provide assistance in reviewing the traffic needs of a project, clarity of a design or standard detail and re-evaluate an existing condition that appears to be confusing or not functioning as intended.

Quality

The Department defines "Quality" as consistently providing our customers products and services that meet mutually agreed-upon standards. This definition requires discussion of its applicability to highway construction.

The product or service ADOT's field personnel should be most concerned with is the highway project under construction, i.e. the actual building of the project. To construct quality into a highway project let's first talk about the customer.

Our "Customers"

The first step in understanding the Department's definition of quality is to discuss *"Customers"*. Anyone who uses or receives a benefit from the product or service you provide is a customer. In order for us to provide the highest quality work in construction, we have to think about who our customers are now and in the future. The construction of a highway project has many customers with varying needs. They include:

Organization	Who	Primary Needs
Traveling Public	motorists, truckers, mass transit	safety, convenience, easy to drive, maneuver, and navigate

Neighbors	residences, businesses, local jurisdictions	minimal or positive impact on their environment, accessibility
Government	Taxpayers	the best value for every dollar spent
	Representatives	perceived needs of their constituents are being met
	FHWA (when federally funded)	compliance with federal standards and regulations
Utilities and Local Governments	SRP, APS, CenturyLink, SWG, Cities, Counties, etc.	compatibility with their infrastructure and facilities
ADOT	ADOT's Project Manager	project under construction satisfies the project's design scope, completion schedule and overall ADOT budget
	Technical Groups	design and construction standards are met or exceeded
	State Engineer & Director	conformity to current public policy
the District	District Engineer	compliance with ADOT standards and District policy
	Maintenance Engineer and Foreperson	low maintenance costs (few repairs and preventative actions needed)
	Regional Traffic Engineer and Traffic Technicians	traffic control devices (sign, striping, lights, & signals) function effectively and efficiently

With so many customers and so many needs, it's easy to see why getting high quality in a constructed highway project is at the very least challenging. Fortunately, many of the needs complement each other and very few conflict. For example, an easy-to-maintain project is usually a good value to taxpayers. And everyone wants a safe highway that is compatible with the local community.

"Consistency"

The second step in understanding the Department's definition of quality is to discuss "Consistency". As it is applied to highway construction, it means achieving the same results time and again across geographic boundaries. When you provide a product consistently, you are living up to the customers' expectations for receiving the same service as before. Consistency requires effective communication with customers and suppliers as well as knowledge of ADOT's policies and procedures related to construction.

To achieve quality, ADOT must be consistent. Consistency ensures fairness to all our customers throughout the state and to our suppliers (construction contractors, subcontractors, and material suppliers). Carefully following the plans and specifications ensures consistency. Project specific requirements (for example, environmental or geological conditions) are contained in the project Special Provisions, which must be consistently enforced during construction. Choosing to ignore some specifications and enforcing others does not provide quality for all our customers.

Consistency fosters economy. When contractors know they are going to build to the same standards throughout the state, they are less likely to add contingencies to their bid for the unexpected. Furthermore, contractors who bid work in only one part of the state are more likely to compete elsewhere if they can expect the same treatment from all Project Inspectors and the District Offices.

"Mutuality"

The Third step in understanding the Department's definition of quality is to discuss "Mutually". Meaning both the customer and supplier agree upon how the product or service is to conform to the customer's requirements. They must agree on the standards to be used to measure that conformance.

Customer agreement can sometimes be fleeting during construction. As a project is transformed from paper to concrete, customers can now actually see what the final results are going to look like and change their requirements. Good customer service means that Resident Engineers (REs) and Project Supervisors don't follow blindly what is in the Project Plans and Special Provisions. They continually ask themselves, Is what I'm building really going to meet the needs of all my customers? Then they communicate with those customers to reach a mutual agreement.

"Standards"

The fourth step in understanding the Department's definition of quality is to discuss "Standards" or baselines. A baseline is a customer requirement that can be measured, quantified, or compared to something else. First, we have to know each customer's standards and be able to measure those standards to determine whether they are being met.

In highway construction there are two sets of standards. There are formal standards which are the contract documents (the Standard Specifications, the Project Plans, the Special Provisions, Standard Drawings, and other documents referenced in the contract). Then there are informal standards—the written or unwritten policies and procedures used to implement the formal standards. These standards can be found by referring to the Construction Manual and by talking to the customers of the project like the District Engineer (DE) and the Regional Traffic Engineer. Projects must be built to both sets of standards to achieve quality. That is why Resident Engineers, Inspectors, and Project Supervisors who rely too heavily on project plans and specifications sometimes have difficulty in reaching the appropriate level of quality for both the Department and its customers. The degree to which a project strictly conforms to the contract documents should not be the only measure of quality.

ADOT is planning to set up quality indexes for each project. Important standards like workmanship, materials, timeliness, total cost, construction zone delays, and accidents will be tracked, measured, and compared. That way, we can more easily determine how well we are meeting our customers' expectations.

ADOT and Industry partners have joined to form a Standards Committee which serves to facilitate implementation of new standards or revisions/updates to existing standard and stored specifications. This effort ensures a thorough review of proposed changes and a controlled process for implementation of new requirements. As construction practices evolve and the need for updates in requirements becomes apparent, proposals for changes may be submitted to the Standards Committee. Consultation with the Resident Engineer and the appropriate technical group or section is advised prior to making any such submission.

ADOT's Project Development Process

ADOT construction personnel should have a basic understanding of how highway projects are initiated, developed, and placed into service. The actual construction of the project is just part of the entire process. An understanding of this process will give Inspectors, Project Supervisors and Resident Engineers a better appreciation of who their customers are (besides the taxpayers) and how to best serve them.

The project development process or highway development process (as it is sometimes called) begins with a traffic, safety, preservation, or environmental problem that needs to be solved. For example, a passing lane may be needed on a rural highway to relieve congestion and reduce accidents. The problem is usually identified locally by ADOT's Regional Traffic Engineer, a maintenance foreperson, the District Engineer, a city or county Engineer, or an elected official. Some projects are initiated by the Department's Multimodal Planning Division who looks at traffic patterns and highway safety on a statewide basis. Most projects are initiated at the district level.

Since there are usually more projects identified than money to build them, a process of prioritizing each project, determining its overall scope, and estimating its costs is initiated. After public hearings, the results are published in the Five-year Highway Construction Program, identifying which projects will be constructed in the next five years. After a project is approved for the five-year program, it advances to the design and preconstruction phases. Here the project is turned from an abstract idea into engineering drawings and contract specifications. Additional right-of-way is purchased, as needed, and a Construction contractor is selected.

The next step is to build the project. The contractor moves on to the project site and an ADOT Construction Field Office oversees the construction work. Their job is to inspect the work, pay the contractor, and ensure the project serves the public as intended.

The final steps are to open the project to the public and to maintain the project or facility so it performs as needed.

The Project Development process is complicated and dynamic. An entire manual has been devoted to describing and managing this process (see the references at the end of this chapter). Because of its complexity, ADOT assigns a Project Manager to each project whose primary responsibility is to manage and guide the project through this process. The Project Manager achieves this by controlling a project's scope, schedule, and budget. The Project Manager consults with District personnel and personnel from ADOT's technical groups and design sections to determine design elements, construction processes, and materials that will be considered and ultimately included in the project. Scope refers to what the project is intended to do and what major components will be used to achieve the project's objectives. Schedule and budget refer to a project's overall development, design, construction schedule, and costs. Design elements refers to the major or critical features necessary to accomplish the project's objectives. Construction processes refers to the particular means and methods necessary to build the project or accomplish the work. Materials refers to the natural or manufactured materials used to construct the project.

The Project Manager

The Project Manager is an important source of information for the Resident Engineer (RE) concerning the history of the project before construction, the reason for its initiation, and the problems it is trying to solve. The Project Manager can identify the major team members involved in project development, what agreements were made, and who to contact. The Project Manager oversees the entire development and design process and can help clarify issues in design and engineering that may arise in the field (or can at least put you in touch with someone who can).

During construction, the Resident Engineer serves as the technical leader for the project in charge of all construction activities. The Resident Engineer should keep the Project Manager informed of the project's progress and milestones through the weekly meeting minutes and change order notifications. If the Resident Engineer has not followed the project throughout its development, it is the Project Manager's responsibility to brief the Resident Engineer on major project issues and important milestones prior to construction. The Project Manager has the responsibility for coordinating communication between the Resident Engineer (or Project Supervisor), as well as design and development staff regarding plan interpretation and design issues arising from the contractor's operations.

It is important for the Resident Engineer and Project Supervisor to understand the role of ADOT's Project Manager. In a sense the Project Manager is a customer. The Resident Engineer and Project Supervisor construct the project and provide the Project Manager with expertise in construction methods and contract administration policies and procedures. The Department requires the Resident Engineer and the Project Manager to work as a team. The Project Manager represents the design and development aspects of the project, while the Resident Engineer represents the construction aspects. The Project Manager needs to assist the Resident Engineer when:

- Post design services are needed for shop-drawing and specialty-item reviews
- Contract documents need to be clarified and interpreted
- Coordination with other project stakeholders is required
- Background on how the project was designed and developed, and why the contract documents were written the way they were

Similarly the Resident Engineer needs to support the Project Manager in the overall management of the project during construction by:

- Discussing any contract changes to the project that would change the scope of the project
- Providing the Project Manager with construction cost data and change order information
- Involving the Project Manager in any changes to the project milestones or contract completion date
- Providing the Project Manager with design and contract specification changes that can improve the Project development process on future projects

Communication

Communication was previously mentioned as one of the important activities needed in achieving quality in construction. Of all the activities the Resident Engineer and Project Supervisor perform, communication is one of the most important.

Resident Engineers and Project Supervisors are continually in contact with many different people during the construction of a highway project (such as the contractor's Superintendent, the general public, the Project Designer, the District Office, or the Project Inspectors). Referring to the duties of a Resident Engineer in Subsection 105.02 of this manual, you will find that oral and written communication is a fundamental skill a Resident Engineer needs to have. The effectiveness of a Resident Engineer can be directly linked to that person's communication and interpersonal skills.

Good communications can eliminate, or at least help to solve, many construction problems. Why is that?

Most problems in construction can be attributed to misunderstandings, lack of understanding, or ambiguity. The Project Plans and Special Provisions are communication tools that tell the contractor how the Department wants something built. A major responsibility of ADOT's field staff is to help convey that message. This is done through oral and written discussions with the contractor.

Preparation is important before communication. Think the matter through before you speak or send a letter. Make use of all available information including the Project Plans, Standard Specifications, Special Provisions, the Construction Manual, the Materials Manual, and other publications regarding the subject. Consider the opinions of other people, especially those close to the problem or an expert on the subject. Thorough homework will help you to communicate precisely and convincingly.

Establish the aim or purpose of the communication. Do you want approval, comments, concurrence, or action? Are you making a recommendation or just informing? Knowing your purpose will help you stay focused while you communicate.

Decide on what communication medium you will use: telephone, fax, letter, e-mail, or in person. Personal contact is the most effective means of communication because it permits the spoken word to be emphasized, assisted by gestures and expressions. If personal contact is not possible for discussing important issues, make a telephone call followed by a letter or memorandum. This repeated emphasis ensures your message is clearly understood. Few individuals like to be informed of something only by letter. An example is the receipt of a letter from the Regional Materials Laboratory recommending rejection of an out-of-specification material. The report may be correct, but the receiver will feel better if previously informed of the situation.

It is important to keep in mind that a letter or telephone should not communicate everything. There are limits on the amount and quality of information these mediums can convey. Using the wrong communication medium does result in misunderstandings, incomplete information, and rework.

Follow up on the communication. Make sure it was received and see if it was understood. In due time remind the receiver that action is necessary; don't just wait indefinitely for others to act. If the reply is important to your project, you owe it to yourself and the Department to see the matter through to resolution.

Communicating with different groups of people requires you to adjust your communication style. For instance, using highly technical terms is appropriate when talking to an ADOT Engineer but inappropriate when talking to the public. Here are some guidelines to help you communicate better with these different groups.

Communicating with the Public

When you communicate with the public you represent ADOT. Whether you're answering a telephone call, writing a letter to local residences, or speaking at a public meeting, people will identify you as ADOT. These people are our customers. They count on us for good service and responsiveness.

How you deal with the public reflects on the entire Department. Always be courteous and respectful to the public; never argue or raise your voice to them. You are considered a public official who is expected to act professionally and honorably with the public at all times.

Try to avoid getting too technical with the public, they often do not know as much about highway construction or your project as you do. Talk to them as you would talk to a spouse or a neighbor. Whatever you do, don't hide behind policies and procedures. If you can't give them a reasonable explanation on ADOT procedures, then get them in touch directly with the person who can.

Finally, be helpful to them; do not just pass them off to the next person in the ADOT system. Instead, help them through the process. If you can be of assistance to them in some unexpected way, we will keep these people as our customers.

ADOT offers classes on dealing with the public and communication skills that we strongly encourage all field staff to attend.

Communicating with the Media

Introduction

The Arizona Department of Transportation cooperates as fully as possible with the media. There are several reasons for this. As public servants we have an obligation to the public to keep them informed. Members of the news media consider themselves to be public servants as well. They serve the public's "right to know" and have a legitimate right to inquire about projects and programs that are funded by and affect the public. Additionally, we rely on the media to get information to the public about projects and issues important to ADOT, or concerning public safety and convenience, such as road closures and traffic delays.

1. Communicating with the media is very different from speaking at a public meeting or one-on-one communication with someone from the public. First of all, what you say to the media will reach a much larger audience. Secondly, there is no feedback in the communication. The public has no immediate way of asking you to clarify what you say, and you have no way of knowing if they correctly understand the information conveyed. Finally, and most important, there is now an intermediary who controls the communication channel between you and the public. This intermediary can conceal, distort, or misinterpret what you say and convey a message to the public quite different than what you intend. Communicating with the media requires a high level of skill and experience to be effective. The

Department's Communications Office has specially trained staff whose primary duty is to talk to the media.

Procedures

The project office can handle routine requests regarding construction closures and openings. However, it is preferred that these inquiries be directed to the Communications Office. Ask the media representative to direct all future inquiries to the Communications Office.

Other types of requests, regardless of how small or how quickly the media wants a response, should be handled by contacting the Communications Office first. They are a resource to the project team, and they will ensure that a clear, accurate, and consistent message is sent to the public about your project. If the media contacts you regarding your project, immediately contact the Communications Office at 602-712-7355 or after business hours and on weekends the ADOT Traffic Operations Center 602-257-1563. The Communications Office has someone on-call 24 hours a day, 7 days a week to handle media requests.

Contacts with the media initiated by ADOT personnel or consultants require the prior concurrence of the Communications Office.

Media Interviews

The Communications Office can coach you through a media interview when it is in the Department's best interests for you to talk directly to the media. They can help you formulate what you want to say to the media and advise you about how to answer questions. In some cases a conference call can be set up among you, the media representative, and the Communications Office so that they can monitor the questions from the media in an effort to ensure fairness and accuracy.

One important area that you should refrain from discussing with the media is ADOT policy and procedures. The Communications Office should answer questions regarding safety standards, closure notification requirements, administrative procedures, traffic policy, or anything else where the Department decides how something is to be done. Their job is to ensure that we accurately and consistently convey this type of information.

Media Inaccuracies

You can help the Department by reporting to the Communications Office any inaccuracies you hear or read in the media concerning ADOT, its operations, or construction activities. The Communications Office can try to clear up the inaccuracy and get a correction released. Be prompt when reporting these discrepancies since the media is unlikely to change a story or report once it becomes a few days old.

Communicating with the Contractor

Historically, relations between ADOT and the contractor have tended to be adversarial. The inevitable results of such relations have been cost overruns, construction work that is just barely in compliance, delays in project completion, and an increase in contractor claims. In response to these problems, ADOT instituted partnering practices in 1991.

Along with the Covenant of Good Faith and Fair Dealing (see Subsection 104.01 [A]), partnering serves to put the "handshake" back into construction contracts. Refer to Section 104.01(B) of the Standard Specifications (and the corresponding subsection in this manual) for details concerning partnering.

ADOT field staff should keep in mind at all times that they are representatives of the Department and, as such, need to conduct themselves in a courteous and businesslike manner in all relations with the contractor. In dealing with the contractor, Department employees should display a spirit of partnering and cooperation in obtaining first-class work at a minimum cost.

Employees should maintain a fair, impartial attitude without displays of emotion and must not engage in heated arguments with the contractor's personnel. Should a disagreement occur that cannot be resolved to everyone's mutual satisfaction, the disagreement should be escalated to the next level as soon as possible. Any decision rendered should be accepted in a positive businesslike manner.

Employees whose assignment involves direct relations with the contractor must have a clear and thorough knowledge of the plans and specifications that govern the contract. Evidence of this knowledge gains the contractor's respect when questions are asked regarding contract interpretation.

Alleged shortcomings of the contractor's personnel or work methods are to be discussed only within the Department. Derogatory remarks, if made publicly, can be construed as libelous or defamatory and may result in liability for the Department and the individual. The Partnering Office is available to assist in getting teamwork and mutual cooperation back on track whenever requested by the Department. A partnering refresh meeting may be recommended.

Communicating with the District

Most construction related communications with the District Office involve project problems and progress, supplemental agreement requests, and construction policy and procedures. The aim of your more important communications with the district may involve:

- An approval or concurrence
- A clarification
- Information about procedures (guidance)
- Escalating an issue for a decision

Usually these types of communications require you to convey large amounts of information to the District about the project or certain project issues. Often misunderstandings and communication rifts develop between the District and the Field Office when the wrong communication medium is used.

For example, a Resident Engineer invites misunderstanding and frustration when he or she attempts to explain the merits of a $70,000 claim involving both a delay and a differing site condition by cellular phone. Some communication needs to be done face-to-face or in writing in order to be effective.

A face-to-face meeting with the District Engineer is the best way to clear up any misunderstandings about your project. Face-to-face meetings are best used when:

- The topic is controversial and requires discussion, clarification or debate
- The topic is complex with a high probability of being misunderstood
- A dispute or behavior now involves people emotionally
- The amount of information is too extensive to write about

Never minimize the importance of these meetings. However, other forms of communication (fax, E-mail, telephone) are more efficient when:

- The topic is not controversial and a one-on-one discussion is all that is needed
- The topic is simply an exchange of information where there is a low probability of being misunderstood
- Human behavior or peoples' emotions are not an issue
- The amount of information can be easily faxed or e-mailed

There is another important communication rule to remember when dealing with the District: promptly inform the District of significant project issues. This communication is important because the sooner you can get the input of the District Engineer and his or her staff, the more effectively and quickly both the Field Office and the contractor can resolve project issues. The contractor always has the right to escalate an issue to the District Engineer for further consideration, even after prior input from the District Engineer and the District.

Communicating within the Field Office and Empowerment

Within the Construction Field Office, good communication between the Resident Engineer and project personnel is essential. Employees must know what their duties and responsibilities are and, equally important, they must be empowered to handle these responsibilities. The Resident Engineer should brief all employees relative to their duties, responsibilities with other personnel, the schedule of operations, the status of the contract, and any other information that will enable them to do their jobs better.

Employees must be empowered to solve problems as long as they remain within the limits of their authority. Successful empowerment requires accountability and communication about actions taken. Issues that cannot be resolved at the first level must be escalated promptly to the next level of authority to avoid delays to the project. Once a resolution has been reached, the Resident Engineer should explain the resolution to all staff members, giving the reasons for the resolution and emphasizing the teamwork that went into it. This is important so that all employees will understand and help support the outcome.

Communicating with ADOT Technical Support Staff

ADOT technical groups and individual employees must cooperate with each other in order to achieve quality projects (see the previous section on quality). The prompt exchange of information between team members is a key ingredient for success in this area. To avoid having a reputation for being a large bureaucratic organization that is slow to respond, ADOT's field staff should take full advantage of partnering along with ADOT's project management system to help improve the Department's responsiveness.

Communications with other ADOT sections can be strained when a project has a change that requires an amendment or exception to ADOT design policies, design standards, or technical specifications. In this case, the Resident Engineer may be asking an ADOT technical section why a certain specification is written the way it is or whether an engineering detail can be modified. Many times it is necessary to make these inquiries on behalf of the contractors.

Before you talk to ADOT's technical staff about a construction problem, make sure you fully understand the situation in the field, what the contractor is asking for and why. Meet with your Inspectors and discuss the contractor's request. Carefully review the Project Plans, Special Provisions, Standard Specifications, and the Construction Manual before you call.

When you talk to ADOT's technical staff, keep in mind that the project team (which includes the contractor) is counting on you to fully communicate their concern about the issue with their same eloquence and clarity. You are representing the team so don't let your own personal views distort the communication.

At the same time, your response to the contractor and the rest of the team must be equally as clear and expressive as the response you received from the technical section.

In this situation you are acting as a mediator. You must be fair and impartial, yet help define the issues, eliminate obstacles to communication, and explore alternatives.

This impartiality must remain as long as there is a dialogue continuing between the parties. However, once the dialogue has ended and the Department has made a decision, you are expected to fully support and implement the Department's decision.

It is very important that we demonstrate to the contractor that once the project team makes a decision, we are united in supporting and implementing that decision. This is in the contractor's best interest because it removes any lingering doubts about whether more of the contractor's time and money should be spent pressing an issue.

Communicating the Contractor's Technical Proposals

A more formal means of communication with ADOT's technical staff on project issues is the contractor's technical proposal. This is a written proposal by the contractor asking for an exception or a change to the Standard Specifications, Standard Drawings, Special Provisions or Project Plans for work already performed or about to be performed. The Resident Engineer may ask for this proposal whenever the contractor's requested exception or change is significant enough to require an in-depth engineering review.

The purpose of the contractor's proposal is to provide the Department with the information necessary to properly evaluate the effects of the contractor's proposed change. Sometimes contractors have difficulty submitting good technical proposals in a complete and timely manner. Reasons include:

- Lack of engineering expertise of the contractor's staff
- Insufficient time to put a proposal together before other project work becomes delayed
- Lack of consistency among Resident Engineers and the districts on proposal standards
- Lack of clarity as to what the Department really wants in a technical proposal and how it should be presented

The contractors often complain that it takes a long time for the Department to review and approve proposals. ADOT's Technical Managers complain that the reason it takes so long is because contractors provide incomplete information. To improve this process, the following is a suggested minimum that should be included in every contractor's proposal.

The contractor's proposal must be in writing and should include:

- A description of the corrective action, methods; e.g. equipment and materials required, using drawings, sketches, and a narration if necessary
- An explanation as to why it is not feasible to follow the requirements of the contract documents
- A discussion concerning why the Department should make this change, including an engineering analysis, cost analysis or other justification
- A deadline for responding to the proposal

The above is only a recommended format. Depending on the issue, every proposal will require a different approach, level of detail, and review process.

One of the most important things the Resident Engineer can do to improve this process is to find out ahead of time what the contractor is going to need in the proposal (what drawings, calculation, test results, etc.). Write a letter to the contractor listing these requirements. Use the four items listed previously as a starting point. It is important to talk to the people who will be reviewing and approving the proposal and find out what they want. This approach will help avoid the endless cycle of resubmittals that can accompany a contractor's proposal and will lessen the bureaucratic paper shuffling for everyone.

The Resident Engineer should give technical guidance to the contractor in developing a proposal. This doesn't mean doing the engineering for the contractor, but helping with the documentation and sources of information, then providing timely feedback to the contractor as the proposal is being developed. The Resident Engineer should guide and support the contractor through this process, even when the Resident Engineer doubts the proposal's merit. However, the responsibility for submitting a complete and technically accurate proposal is still the contractor's.

Resident Engineers need to work with proposal reviewers to ensure proposals are evaluated and returned to the contractor in a timely manner.

101 DEFINITIONS AND TERMS

This section defines words and abbreviations commonly used throughout the Standard Specifications and the project Special Provisions. Most of the words in this subsection have a very precise meaning, and their use can have a profound effect on how a specification is interpreted.

The Inspector, Project Supervisor, and Resident Engineer should take the time to familiarize themselves with terms defined in this section.

Working Day Definition Guidance

In the interest of achieving consistency statewide, this provides guidance for determining whether a working day would be charged on a Saturday, Sunday or State-recognized holiday.

Work on Saturdays, Sundays, or Holidays needs to be approved in advance. The only work the contractor can do without this approval is protecting the work already accomplished, providing dust control, or work of a similar nature. Several scenarios are provided in the table below to guide whether to charge a working day on a Saturday, Sunday or State-recognized holiday. These conditions assume there is no other work on-going.

Working On A Saturday, Sunday, or State-Recognized Holiday		
Event	WORKING DAY CHARGED	WORKING DAY NOT CHARGED
Maintenance/repairs of temporary traffic control devices		X
Installing new or modifying existing temporary traffic control	X	
Subcontractor performs work without the knowledge of the contractor	X	
Routine maintenance/repairs of SWPPP BMPs		X
SWPPP “Corrective Action” requirements identified in the Inspection & Corrective Action Report Form	X	
Contractor’s survey	X	
Hauling materials/supplies to jobsite (other than the contractor’s yard)	X	
Production of aggregates on-site (within ADOT ROW)	X	
Dust control; pre-wetting		X
Maintenance of contractor’s equipment; job site maintenance/security		X
Setting up contractor’s and/or the Engineer’s field offices		X

Available Resources:

- ADOT Standard Specifications for Road and Bridge Construction 2021
- ADOT Standard Drawings C Standards
- ADOT Traffic Signing and Marking Standard Drawing
- ADOT Traffic Signal and Lighting Standard Drawing
- ADOT Bridge Group - Structure Detail(SD) Drawings
- ADOT Temporary Traffic Control Design Guidelines
- ADOT ITS Standard Drawings
- Manual on Uniform Traffic Control Devices, 2009 Edition with Arizona Supplement
- ADOT Supplemental Agreement Guide

102 BIDDING REQUIREMENTS AND CONDITIONS

102.00 Field Office Responsibilities During Bidding

When the Department advertises a project, the Resident Engineer and the Project Supervisor may receive calls from potential bidders with questions about the Project Plans, Special Provisions, and other contract requirements. The Special Provisions will contain extra requirements for Federal Aid projects. During the advertisement the Field Office should register and download the contract documents and any addendums from the ADOT Contracts and Specifications website for distribution to other project stakeholders, ie RME, RTE or local agencies.

In the advertisement for bids the contractor is directed to submit all questions through BidExpress. If the contractors reach out to the Resident Engineer or Project Supervisor during the advertisement, the RE and PS should direct the contractor to submit the question in accordance with the advertisement instructions.

To obtain the most competitive bids, the Department needs to ensure that each contractor is bidding the same project with the same understanding of how to construct the work. Sharing information about the project site conditions may help ensure the Department receives competitive prices for the work it advertises. Cross sections, geotechnical reports, aerial photographs, and survey information are shared with the bidders through the ADOT Contracts and Specifications website.

Withholding information about site conditions or unusual regulatory requirements may lead to lower initial prices, but the low bidder will be quick to ask for extra work as soon as he or she finds actual site conditions different than anticipated. The Department, in the end, pays for the withheld information in the form of change orders and resolved contract claims.

Cross sections may not be available for pavement preservation projects (AC overlays, etc.), or small projects with very limited earthwork quantities (intersection improvements, etc.). For large earthwork projects, the Resident Engineer may want to have the survey crew stake the roadway centerline and any borrow limits. The staking can help bidders visualize the project work in relationship to its surroundings and the existing site conditions.

102.06 Interpretation of Quantities in the Bidding Schedule

Bid quantities are only approximate. They are not intended to precisely define the amount of work the contractor needs to do. The contractors should perform detailed takeoffs from the plans and specifications to accurately determine the required amount of work and quantity of materials.

The bid quantities are presented in the contract for three reasons:

1. They standardize the bid requirements so that each contractor is bidding for the same amount of work
2. Provide a method of measurement for portions of the work so partial payments can be made
3. Help to equitably adjust the contract amount when work needs to be added or deleted

The contractors should compute their own quantities when estimating work, contractors who rely on bid quantities for pricing their work do so at their own risk.

The problem of relying on bid quantities becomes particularly acute for subcontractors and Material Suppliers who may not have easy access to the project plans and specifications. ADOT's Contracts & Specifications Section (C&S) posts the Project Plans and Special Provisions to their website for anyone to download.

102.07 Examination of Plans, Specifications and Site of Work

The previous two subsections mentioned that ADOT has an obligation to contractors and their suppliers to both disclose all available site information and make contract documents readily available. The contractors have a reciprocal obligation to thoroughly examine all of this information, visit the project site, and ask for clarification of anything they don't understand about the project. The intent of this specification is that both partners have a shared responsibility to produce accurate bids that truly reflect what the Department wants built and the costs associated with that work.

An Electronic Data Temporary Use Agreement Form should be submitted when the contractor is requesting project related CADD files. This form should be signed by either the ADOT Project Manager or Project Engineer, and the requestor. This signed document should then be kept with the project files.

Taking Advantage of Errors

Occasionally the Inspector or Project Supervisor may feel that the contractor is taking advantage of an error in the plans or specifications. This usually happens when the contractor is being paid an excessive amount for some portion of the work. The reason may be due to a large quantity variation or a change in the nature of the work not contemplated by Designers. Sometimes Designers miscalculate quantities or simply misjudge what is required to accomplish the work.

Regardless of the reason, in order to get the contractor to equitably adjust unit prices, the Department must show that the error or omission was readily apparent at the time of bidding. If the error or omission becomes apparent during construction, then the Department has no case under 102.07.

Other resources the Department may pursue in this situation include:

- A reverse differing site condition under 104.02(B)
- A breach of the covenant of good faith and fair dealing described in 104.01(A)
- A violation under 105.06 if the contractor is taking advantage in some other way

Oral Explanations

As mentioned above, ADOT staff needs to be careful about what they say to contractors during the project bidding period. The intent is not to inadvertently change the contract requirements or to give an unfair advantage to one or more bidders.

Although 102.07 contains a waiver about oral explanations or instructions, contractors will still defend the legitimacy of oral explanations, especially if documentation or other evidence substantiating the communication can be produced. During pre bid conferences, the discussions between the Department and potential bidders are recorded and transcribed. These discussions are no longer interpreted to be oral explanations or instructions since a written version does exist.

The bottom line is that representatives of the Department need to be very careful about what they say to bidders. This means researching and discussing questions internally, then answering accurately and consistently.

Keeping silent can be inappropriate especially when tough questions are asked about glaring defects in the plans or specifications. The intention shouldn't be to conceal, but to be honest and open to the bidders.

103 AWARD AND EXECUTION OF CONTRACT

Most of the provisions in this section of the Standard Specifications deal with the procedures both the contractor and ADOT must follow in awarding and executing an ADOT construction contract. The Department's Contracts and Specifications Section (C&S) handles these administrative procedures and provides the Field Office with a copy of the contractor's executed contract.

It is important for the Resident Engineer to check with C&S to ensure the contract has been fully executed before any work begins. An executed contract is a means of ensuring the contractor has met all the bonding and insurance requirements before working within the Department's right-of-way.

When bids close on a project, C&S reviews each bid for completeness and accuracy to determine the lowest responsible bidder. They check for unbalanced bid items, unit price extensions, insurance arrangements, and bonding capacity. C&S makes a recommendation to the State Engineer as to who is the apparent low bidder. The State Engineer, in consultation with the Director, makes a recommendation to the State Transportation Board for awarding of the construction contract. The Board reserves the right to table or reject the recommendation.

When a contract is to be awarded, the State Transportation Board makes the award in an open public meeting. An award letter is then sent to the contractor, and a copy is sent to the assigned Field Office for the contract. It is important for the Field Office to have a copy of this award letter in its files since contract time is based on the date of this award letter (see Subsection 108.02).

The Field Office should avoid any official communications with the contractor until after the award. Early communication with the contractor might create the perception that ADOT staff favors one contractor over another. This problem can become particularly acute when a contract bid is under protest. Award may be delayed while the contractor obtains appropriate licenses for Federal Aid projects in accordance with requirements in the Special Provisions.

Any protests or inquiries a Field Office receives regarding a contractor's bid or the awarding of a contract should be referred to C&S.

103.08 Execution of Contract

Subsections 103.08 and 103.09 of the Special Provisions may require the contractor to "Quick Start" the project. Quick start reduces the time it takes to award the project, but it does not mean the Field Office can have early communication with the contractor prior to award (see above). If the contractor fails to quick start, the project may be awarded to the next responsible bidder, or re-advertised.

103.11 Escrow of Bid Documentation

On large projects and projects of a special nature, the contractor may be required by the Special Provisions to place in storage at a local bank or escrow office all records, quotes, reports, drawings, and calculations used in determining the bid. These bid documents can then be used later as a means of analyzing the effects of project delays, plan omissions, time extensions, and other substantial changes to the contractor's costs. See Subsection 101.02 Bid Documentation, and 103.11(D) Format and Contents, for what type of documentation is required.

The Resident Engineer's use of escrowed bid documents in resolving contract claims can be very limiting since the contractor has control over the Department's access to these documents. If the Resident Engineer would like to compare a contractor's cost analysis of a particular change with bid prices, the Resident Engineer can't use the bid documents without the contractor's permission. The contractor should release documents when requesting additional compensation or an extension of time based on their bid in accordance with Subsection 103.11(C). The contractor may place restrictions on what you can see before permission is granted. The intention here is to not allow the Department to take unfair advantage of the contractor's bid. In competing to be the lowest bidder, the contractor assumes much financial risk. It is not the Department's intention in escrowing bid documents to remove all of the financial rewards that go with assuming the risk. Instead, the intent of the escrowed bid documents is to verify certain costs the contractor may have or is expected to incur.

Bid documents are best used when the contractor is trying to prove that the Department is not paying twice for the same work. They can also be used for determining overhead rates and profit margins. Bid documents should not be used as a means of adjusting prices just because the contractor performed the work at a cost over or under the bid amount.

Bid documents should be returned to the contractor only when all claims and unresolved issues have been settled. This may occur long after the project has been accepted and final documentation is submitted.

104 SCOPE OF WORK

104.01 Intent of Contract

(A) Covenant of Good Faith and Fair Dealing

The intent of this subsection is to recognize that the Department will deal with the contractor in a professional and businesslike manner. Resident Engineers, Project Supervisors, and Inspectors are expected to be honest, fair, and impartial in their dealings with the contractor. It is not the Department's intention to take unfair advantage of the contractor or exploit a predicament of the contractor's to the Department's advantage.

The second paragraph of Subsection 104.01(A) does a good job of defining good faith. It means to proceed diligently, avoid hindering, stay within the law and delegated authority, and cooperate.

What may seem fair to you may not seem fair to another. Webster's defines fairness as "marked by impartiality and honesty: free from self-interest, prejudice or favoritism . . . conforming with the established rules." This last part is most important since the construction contract is the set of established rules by which your fairness should be measured.

Inspectors have often been called unfair by the contractor when they enforce certain contract specifications. It may not be that the Inspector is unfair; it may be that the specification itself is unfair. This is no fault of the Inspector. Sometimes Inspectors are accused of being unfair by enforcing a contract specification too rigidly. In this case the Inspector's fairness is not being measured by the contract specifications, but by the past performance of other Inspectors. In either case, having frequent discussions with the contractor and ADOT management concerning fairness can go a long way to improve the contractor's perception of your impartiality.

(B) Win/Win Solutions and Doing What is Best for the Project

A dilemma that many Resident Engineers and Project Supervisors face is how to remain impartial and be fair to both the Department and the contractor. The best solutions to project issues are the ones that meet the needs of all stakeholders. Win/Win solutions should always be explored first.

Sometimes contractors may not perceive that the solutions you propose are win/win. On the other hand, their solutions may not be perceived by you as win/win either. As an alternative, look at each project issue separately and then do what is best for the project, rather than what is best for either the contractor or the Department. This is a key step in maintaining successful partnerships. This means that sometimes the contractor will have to do more work than expected, and other times the Department will have to pay more than expected.

If you are continually doing what is best for the project, it is difficult to be perceived as biased and unfair when a win/win solution cannot be reached. Experienced Resident Engineers and Project Supervisors have a clear sense of what is best for the overall project in terms of quality, schedule, and costs. By doing their best to balance these needs between the contractor and the Department, they can help achieve good faith and fair dealing with the contractor.

(C) Partnering

An ADOT construction project is a partnership. Fundamentally, the construction contractor provides the necessary:

- Labor
- Materials
- Equipment
- Management expertise

while the owner (ADOT) provides the necessary:

- Construction plans and requirements
- Environmental clearances
- Initial utility clearances
- Money
- Inspection and oversight staff
- Time
- Right-of-way

It is these resources that are combined together to build the project. Each party controls how they apply their resources to the project and uses other organizations (subcontractors, Material Suppliers, Designers, local governments, and others) to help provide these resources.

Obviously the success of a project depends on how well these groups work together in combining their various resources. Working together is the key because these resources cannot be combined separately.

ADOT Standard Specification Section 104.01 (A) contains the Covenant of Good Faith and Fair Dealing. This section imposes the obligation on ADOT and the contractor to perform their contractual duties in an honest, diligent, and cooperative manner. Section 104.01 (B), Partnering, provides a framework for creating the working relationship by requiring a partnering workshop prior to start of work in accordance with the requirements of Subsection 108.02 and prior to the preconstruction conference.

One of the primary functions of ADOT's Partnering Office is to facilitate the partnering meeting between ADOT's construction field office and the contractor. This is done so that important lines of communication can be established as well as roles and responsibilities for the major stakeholders.

The ADOT Partnering Office web site contains partnering process manuals and guides, regarding partnering such as the Partnering Evaluation Program (PEP), Education and outreach Partnerships, Forms, Links, and Contact Information.

The Partnering website includes the following information:

- General Partnering Overview
- Types of Partnerships
- Building a Partnership
- Construction Partnering Workshop
- Issue Resolution
- Partnering Evaluation Program (PEP)
- Role of the Facilitator
- Education
- Partnering Outreach
- Partnering Process Continuous Improvement

Everyone has their own ideas about how to partner and what partnering techniques work the best. Different styles of partnering can and do work. Find one that works for you and adjust it to the needs of your other partners. As long as there is trust, mutual respect, open communication, cooperation and a commitment to continuous improvement, successful partnering can be achieved.

The Resident Engineer as a Partner:

- Champions partnering and sets an example for everyone on what a partner should be

- Ensures everyone is following the “Four C’s” of partnering - Communication, Cooperation, Commitment and Continuous Improvement
- Periodically evaluates the partnering process and makes improvements
- Is proactive in looking for below-the-surface conflicts between partners
- Says the things that need to be said to maintain the harmony of the group
- Listens to the other partners
- Always recognizes the contractor’s good work

The Project Supervisor as a Partner:

- Looks ahead at upcoming construction work for possible conflicts with the Special Provisions, Standard Specifications and Project Plans
- Helps the contractor’s staff interpret plans and specifications
- Is flexible in staffing the project to accommodate the contractor’s needs when possible
- Provides the contractor with timely feedback on noncompliance issues
- Communicates frequently with the contractor’s foreperson and superintendent
- Always recognizes the contractor’s good work

The Inspector as a Partner:

- Uses knowledge of the Project Plans, Special Provisions, Standard Specifications and other contract documents to warn the contractor early about potential problems
- Escalates unresolved issues quickly
- Doesn’t waive contract requirements just to get along
- Anticipates noncompliance issues and brings concerns to the contractor’s attention as soon as possible
- When rejecting work, remains fair and sensitive to the contractor’s predicament, and works with contractor in correcting deficiencies
- Continually reviews contract documents to make sure the contractor’s operations do not accidentally fall into noncompliance
- Appreciates the work the contractor is doing for the Department and the taxpayers, and both praises and encourages good performance

Partnering works best when team members are proactive, anticipating and resolving issues before they affect their partner’s performance. Any known conflicts or issues should be resolved in a meeting room before the work begins; however, issues will inevitably occur on the project and that is when true partnering begins.

104.02 Revisions to the Contract

A contract change is merely something different than what the contract requires. On a highway construction project of any appreciable size, contract changes are inevitable and occur for several reasons. The Department, as the project owner, has the right to make changes that it deems necessary for the satisfactory completion of the project, and the contractor has the right to receive an equitable adjustment in payment or contract time. When the contractor perceives a change to the contract, notification in accordance with Subsection 104.03 must be provided.

The changes to the contract are specified in a supplemental agreement contract. A supplemental agreement must be issued to accomplish extra work, for differing site condition work, for suspended work by the Engineer, or for significant change in the character of the work.

Significant change requires that the character of the work be considerably altered or that the quantities of a major item of work be increased in excess of 125 percent or decreased below 75 percent of the original contract quantity. When the quantity of a major item is not significantly changed a supplemental agreement should not be issued because contract prices should not be changed.

A supplemental agreement can be processed in three different ways. It can be processed as a letter of agreement, a change order, or a force account. Subsection 109.04 provides instructions on supplemental agreement processing.

The Department tracks and monitors the cost of supplemental agreements by categorizing them into types. The types were chosen to enable selecting areas or procedures within the department for possible improvement. The Resident Engineer specifies the type of Supplemental Agreement from the list below when the supplemental agreement is processed. The Resident Engineer should make a conscious effort not to lump types of contract changes within one change order.

General Supplemental Agreement Types:

- Value Engineering
- Work out of Scope (ADOT)
- Work out of Scope (Other Jurisdiction)
- Quantity Omissions
- Plans Revisions/Oversights
- Changed Condition
- Penalties - Bonuses
- Other

Value Engineering

This is a contract change in which both the owner and the contractor agree to alter the contract in some way in order to reduce the total contract amount. Both split the savings 50/50. The contractor usually proposes this change, and the owner accepts or rejects it.

In order to maintain statewide consistency, concurrence from the State Construction Engineer is required for all Value Engineering Proposals. These changes are examined so that future designs will include the value-engineered improvements.

Once the Value Engineering, Supplemental Agreement has been completed, it must be forwarded onto the State Construction Engineer. This is necessary so the Construction Group can accurately compile and create the required FHWA reporting documentation.

Value Engineering is discussed in greater detail within Section 104.13 of this manual.

Work out of Scope

This is for work not required nor included in the original contract, but has later been deemed desirable for satisfactory completion of the contract.

Scope refers to the project limits and the major design elements required to meet the project purpose and needs. The scope of the project was developed in the Scoping Phase and refined in the Design Phase. Changes in scope during the Construction Phase should not normally be necessary.

In general, the addition or deletion of designated elements such as a passing or turning lane would be a change in project scope. This also includes enhancements or special products requested by other ADOT departments, or outside agencies such as BIA, CAP, SRP, local governments, etc. The extending or shortening of a pipe to meet field conditions would not be a scope change. When there is doubt as to whether a contract modification constitutes a scope change, the Construction Project Manager or Resident Engineer should consult with the Design Project Manager and jointly make the determination.

Supplemental Agreements for additions or deletions which change the scope as defined in the contract documents require notification to the Design Project Manager.

The cost of these improvements may compete with funds for new projects and should only be done with a very good reason.

Quantity Omissions

Use this type when an item was shown on the plans, but was not included on the bid tab or when a major item quantity is increased or decreased more than 25 percent of the plan quantity.

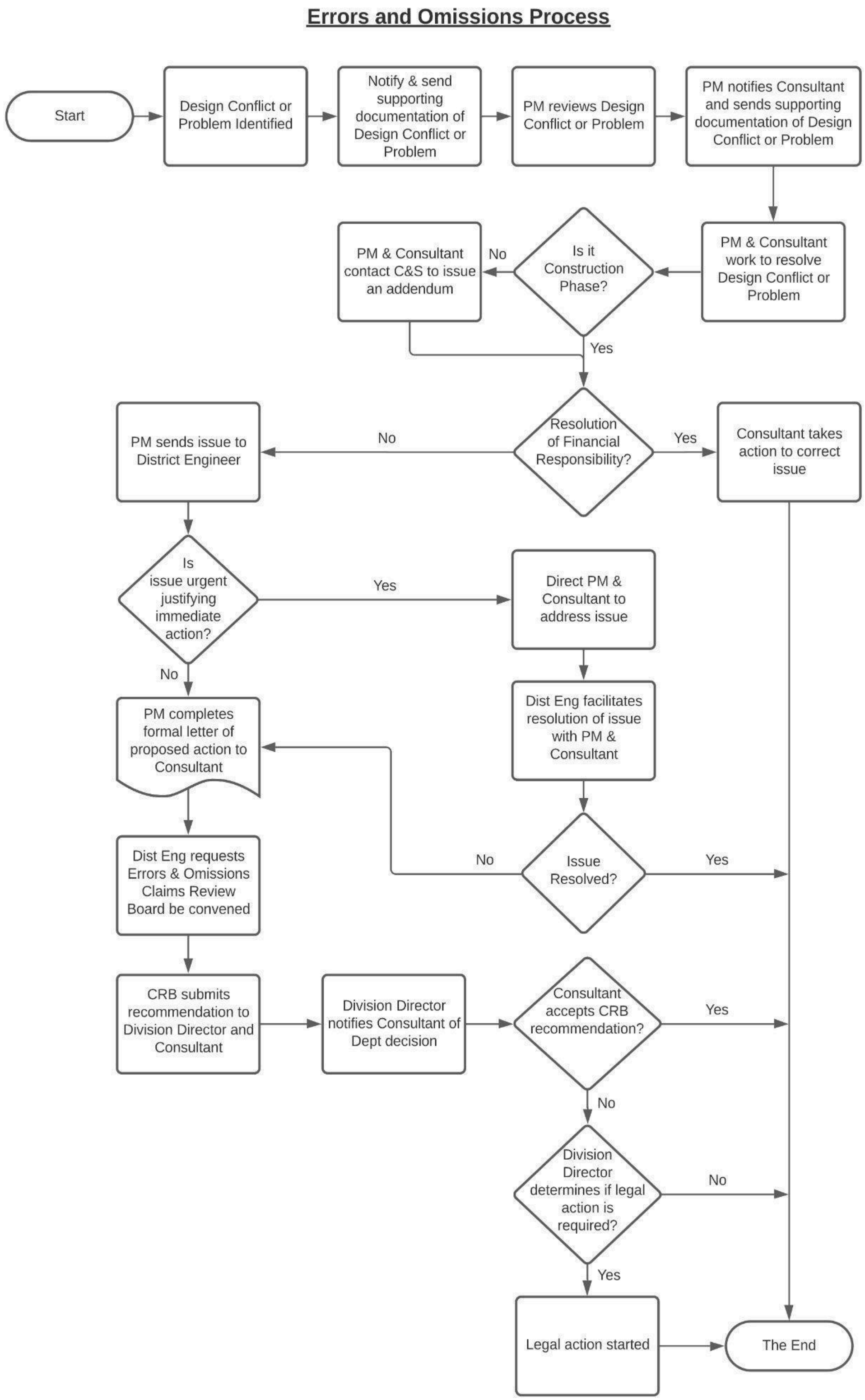
These changes should be examined to determine if improvements could be made to the estimating process.

Plans Revisions and Oversights

Use this type when the plans did not accommodate existing visible field conditions, at the time of construction, and a change to the design is desirable.

Examples: Obvious design oversight or omissions.

These changes are within the original scope and should have been on the original plans. These changes should be examined to determine if improvements could be made to the design process.


Errors and Omissions Process
Start
Design Conflict or Problem Identified
Notify & send supporting documentation of Design Conflict or Problem
PM reviews Design Conflict or Problem
PM notifies Consultant and sends supporting documentation of Design Conflict or Problem
PM & Consultant work to resolve Design Conflict or Problem
Is it Construction Phase?
No
PM & Consultant contact C&S to issue an addendum
Yes
Resolution of Financial Responsibility?
Yes
Consultant takes action to correct issue
No
PM sends issue to District Engineer
Is issue urgent justifying immediate action?
Yes
Direct PM & Consultant to address issue
Dist Eng facilitates resolution of issue with PM & Consultant
Issue Resolved?
Yes
No
No
PM completes formal letter of proposed action to Consultant
Dist Eng requests Errors & Omissions Claims Review Board be convened
CRB submits recommendation to Division Director and Consultant
Division Director notifies Consultant of Dept decision
Consultant accepts CRB recommendation?
Yes
No
Division Director determines if legal action is required?
No
Yes
Legal action started
The End

Changed Condition

Use this type when an unusual and unknown condition occurs on the project after award of the contract.

Examples: Unknown utility conflicts or other subsurface conditions, unknown or unusual material characteristics, unusual acts of nature, vandalism.

This type is a hidden condition that could not be known at contract award. This change cannot be controlled, estimated, or decreased. This category will allow us to explain that a certain percentage of our construction budget must be spent to fix construction conditions that cannot be predicted.

Penalty or Bonus

Use this type when paying for items where construction quality or time was modified and the change was not included in the contract documents.

Examples: ADOT chooses to accept a substandard product at a reduced price or wants to accelerate the contractor's schedule with a bonus, or accepts a different product at a penalty or bonus when the plans materials are unavailable.

Other

Used only when no other reason applies and explain in detail as to why.

Examples: Negotiated settlements should be included in any of the above categories that the change order fits if there is agreement that a contract change has occurred and the price is being negotiated. When a contract change is debated and a settlement is reached as an outcome of escalation, the change order should be included in this category and the negotiated settlement should be explained in detail. Changes in the project’s scope are not to be included in this category.

Partnering workshop expenses split in accordance with the contract are always “Other”.

Selecting the proper Type of Supplemental Agreement

With any system, overlap and redundancy may occur. Exhibit 104.02-1 Choosing Supplemental Agreement Type is a flow diagram that demonstrates the proper logic for choosing the supplemental agreement type. Use the flow diagram to determine the type of change order.

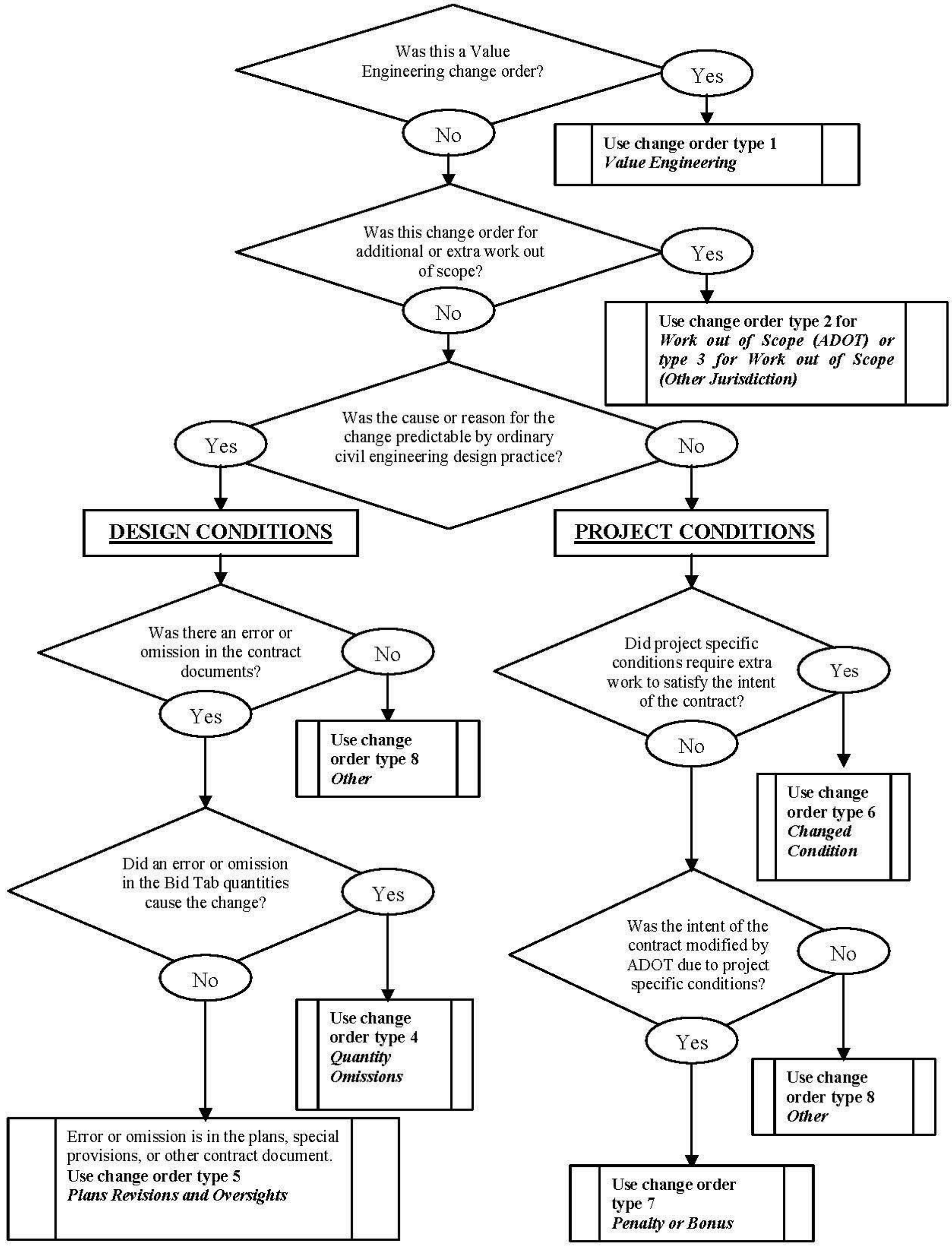


Exhibit 104.02-1 Choosing Supplemental Agreement Type

The following Subsections in the Standard Specifications reference 104.02 directly, or indirectly, and can be used for obtaining more information on the type of contract changes.

- 101.02 Delay
- 104.13 Value Engineering Proposals by the Contractor
- 105.04 Conformity with Plans and Specifications
- 105.06 Coordination of Plans, Specifications, and Special Provisions
- 105.08 Cooperation with Utility Companies
- 105.10 Construction Stakes, Lines, and Grades
- 105.16 Failure to Maintain Roadway or Structure
- 105.18 Opening Sections of Project to Traffic
- 107.05 Archeological Features
- 107.06 Historical Preservation
- 107.07 Sanitary, Health, and Safety Provisions
- 107.15 Contractor’s Responsibility for Utility Property and Services
- 108.08 Determination and Extension of Contract Time
- 108.10 Termination of Contract for Default
- 108.11 Termination of Contract for Convenience of the Department
- 109.02 Scope of Payment
- 109.03 Compensation for Altered Quantities
- 109.04 Adjustment in the Contract Price
- 109.05 Eliminated Items
- 109.10 Lump Sum Payment for Structures

104.03 Notification

This specification formalizes the notice requirements a contractor must give the Department when there is a perceived contract change. It is intended to integrate the partnering process with the claims resolution process so that issues can be resolved in a win-win, cooperative atmosphere.

The contractor has a duty to notify the Department of any changes they perceive in the contract. The contractor shall use the Department’s certification form. This allows the Department to take early preventative measures to mitigate any damages to the contractor that the Department may be held liable. It is very difficult for the Department to mitigate damages if it didn’t even know about a contract change to begin with. Furthermore, it’s unfair to the Department to have to pay for damages it was unaware of and consequently had no control over. The notice requirement puts back some of the fairness into contract changes.

Any potential "changed condition" should be well documented as soon as it becomes apparent. Unforeseen work that has to be performed is often an area of uneasiness and uncertainty for project partners. Whenever possible, the financial responsibility for the work should be resolved before the work begins. If an agreement cannot be reached, the work should still proceed to avoid any adverse impacts to the project. Daily records should be kept in sufficient detail so that the cost of doing the work can be reconstructed accurately.

It is recommended that force account daily reports be used as a means of tracking labor and equipment time as well as material quantities. The work should be treated like a force account in which there is daily agreement on time and materials.

Issue Resolution Process

To expedite the issue resolution process, a formal review process has been created within the Department with definite deadlines for reviews at each level. The contractors often complain that it takes too long to get issues resolved within the Department. This process is designed to streamline the internal review process and get decisions returned to the contractor promptly. The whole process begins when one of the partners has either a technical or relationship issue. Examples of perceived changes (or changed conditions, see Subsection 104.02) include:

- Damages due to weather conditions
- Work performed out of sequence
- Unavailable specialty items
- Lack of free access to the work
- Time restrictions on when work can be performed
- Work stoppages
- Unexpected underground conditions
- Inspections performed to a higher standard than required by the contract
- Interference by adjacent contractors

There is a seven-step procedure the Department follows to resolve a contract issue. The goal is to try to resolve the issue at the field operations level and use litigation or arbitration only as a last resort.

1. Verbal Notice to the Resident Engineer

As soon as the contractor perceives a changed condition, the Resident Engineer should be notified about the issue. The intent is to warn the RE as quickly as possible that current project conditions are not what the contractor anticipated. At this point, there should be a complete understanding concerning the contractor's perceived issue. The Resident Engineer should not be quick to judge the merits of the issue. More importantly, the Resident Engineer should do everything to gain as much understanding as possible about the issue. This means meeting with the contractor, subcontractors, and other concerned partners to discuss the issue at length. In most cases, this discussion will help contractors clarify in their own minds. When some of the more proactive Resident Engineers perceive a situation that may lead to a contract change, they will ask the contractor up front, "Is there an issue here that needs to be resolved?" If the RE perceives that there is an issue with the contractor or project team, the RE must take action to resolve the issue immediately.

2. The Resident Engineer Verbally Responds to the Issue Notice Within Two Working Days

How the RE responds to this will usually set the tone and atmosphere for the rest of the issue resolution process. The RE needs to think carefully before responding (refer to the section on communication in Subsection 100 of this manual). The RE should go back to the office and thoroughly review the Project Plans, Special Provisions, Standard Specifications, Standard Drawings and other contract documents. Everyone, including the contractor, expects the Resident Engineer to do at least that much before responding.

The Resident Engineer should also consult any related documents such as the Materials Testing Manual, the Construction Manual, and any other industry publications that may help resolve the issue. Talk to the Inspectors, the contractor's field staff, the project management team (PM, designer, technical leaders), and one of ADOT's technical experts on the subject to help broaden your perspective. This up-front research is very important and shows that you are taking the contractor's notice seriously.

In responding to the contractor's notice, demonstrate that you have indeed listened to the contractor and describe the issue as he or she described it to you. If you are denying any contract change try to be conciliatory rather than confrontational. Sometimes a one-on-on frank discussion can be helpful in uncovering the real issues. But don't let emotions run to the point where you set yourself up for a win-lose scenario. Instead, leave the contractor an out. Suggest what approaches could be used to improve the merits of this issue and describe the next step the contractor should take.

3. Written Notification by the Contractor

If the contractor and Resident Engineer cannot resolve the issue within two working days a written notice is required by the end of the second working day. The idea behind a prompt written notice is twofold. The first reason is to keep the issue from stagnating and poisoning the atmosphere of trust and cooperation developed through partnering. The second reason is to get an agreement at the project level of what the issues really are. Some issues raised at the project level are the result of misunderstandings or unmet expectations. Often an issue presented in writing clears up any miscommunication and results in a quicker resolution.

On projects which are not partnered, the written notice should meet the requirements of both Subsections 104.03 and 105.21. The rest of the issue resolution process follows the procedures described in Subsections 105.21 and 105.22. When this occurs it will be necessary for ADOT's field personnel to keep force account records on the work under dispute in order to substantiate the contractor's claim.

4. Issue Escalation Through Partnering

If the issue remains unresolved after the RE's review of the contractor's written notice, the issue is immediately escalated to:

- District Engineer's office, then if unresolved, to the
- State Engineer's office.

A "Routing Form for Construction Issue Resolution" and an "Issue Escalation Documentation Binder" are required for all escalations. Good documentation is important. Forms are found on the Partnering website. The State Engineer's office is the final escalation level for all issue resolution through partnering. This whole process shouldn't take more than seven working days. However, what usually happens at some point during the escalation is that additional documentation or analysis is usually needed to clarify the issue. This causes a delay in the proceedings, and before you know it seven days have already passed. If this is the case, as it will be for most issue escalations, the contractor should start to submit some of the items listed in Subsection 104.03(B). This will preserve the contractor's entitlement to damages under 104.03(C).

5. Dispute Resolution Submittal

If the contractor is dissatisfied with the outcome of the escalation hearing at the State Engineer's office, the contractor must then submit the documentation required by 104.03(B) and 105.21 to the Resident Engineer. At this point, the partnering process has ended and a more formal process described in Subsection 105.21 takes over. Usually the RE and District Engineer will informally review the contractor's submittal in a final attempt to resolve the issue. To be in compliance with 104.03 (D), the RE must respond to the contractor's submittal within 10 calendar days. The response should state that the issue is still unresolved and that a formal hearing is scheduled at the State Engineer's office (indicate the date). Basically the Department is exercising its option under 104.03(D) for additional information so a decision can be rendered.

6. State Engineer's Review of the Contractor's Submittal

Instead of an informal review of the issue in the State Engineer's office, a formal presentation of the issue is made by the contractor to the State Engineer. Typically the State Engineer will assemble a panel of unbiased ADOT professionals to hear and decide the issue on behalf of the State Engineer. The RE, with the help of the District Engineer, will represent the Department's side of the issue. The panel functions much like a dispute review board: both parties in the dispute present their side and the board makes a recommendation.

This is the same as Step III in Subsection 105.21. It is unnecessary to cover Steps I and II in 105.21 since the issue has already been addressed and left unresolved at the Resident Engineer's and the District Engineer's level.

Section 105.21 of this manual should be consulted by the Resident Engineer in preparation for the State Engineer's review.

7. Arbitration, Litigation, or Mediation

After the State Engineer's review, the only options left to the contractor of resolving a contract change issue are:

- Binding arbitration if costs are under $200,000
- Litigation in court if costs are over $200,000
- Non-binding mediation (then arbitration or litigation if necessary)

See Subsection 105.21 and 105.22 of this manual for further information.

104.04 Maintenance of Traffic

It is the contractor's obligation to maintain a safe, smooth, and stable road for the traffic and to install and maintain required traffic control devices. It is the Resident Engineer's responsibility to verify that the design of the traffic control plan is appropriate and that the plan is being followed. Traffic must be able to quickly distinguish the correct path when traveling at reasonable speed. Pedestrian traffic safety and access is included in traffic control.

Construction zones require special considerations in traffic control design because many drivers are inexperienced in what to expect. Unpredictable maneuvers can result when objects are too close to the traveled way. Some drivers may veer away, while others may slow down. Loose material can be particularly hazardous and must be kept to a minimum. Positive dust control can assist in improving visibility both day and night. Such factors as road width, shoulder area, relation of curves, height of the driver's eye, and night-time visibility should be considered when placing signs, barriers, barricades, and other traffic control devices.

ADOT will pay (usually a supplemental agreement) for the maintenance of existing roadways under construction up until such time when the contractor's equipment (haul units, earthmovers, etc.) uses the road for construction purposes. The contractor should not be responsible for maintaining an existing road that deteriorates due only to normal wear and tear from ordinary traffic (detours and temporary roadways excluded).

On federal aid projects, the FHWA will not participate in any costs for roadway maintenance done by supplemental agreement. An exception does occur when a roadway is overlaid or sealed to allow higher volumes of traffic when used as a temporary detour or crossover.

The Resident Engineer should review the Special Provisions to see if the traffic control plan, including temporary detours will require approval by the county, or other agencies in order to meet air quality standards. The Special Provisions may also deduct money due the contractor when portions of the roadway remain closed outside the allowable closure period.

(A) Detours

In some cases the Project Plans will provide a designed detour; in other cases it may be necessary for the contractor to produce a design. In the latter event, the contractor prepares a drawing of the detour to a proper scale showing the transition zones, the proposed horizontal and vertical alignment, super elevation, width, base, and surface. The drawing should show proposed signs, striping, barricades, and delineators. The Resident Engineer should submit the design to the Regional Traffic Engineer for review and approval of the traffic aspects of the design.

A complete record (including plans and photographs) must be kept showing all installations and any changes in the detour or traffic control devices. Photographs should be taken in a sequence showing the detour from beginning to end. (Videotaping of the work zone traffic control is an acceptable alternative to photographs.) If possible, all construction personnel should be alerted to the problems involved in the handling of traffic by means of detours. Surprise situations should be avoided because they contribute to accidents. Detours should be drivable at night under varying traffic and weather conditions. The State Highway Patrol (DPS) and local police can often be helpful in locating problem areas.

If it becomes necessary or desirable to use a county road or city street as a detour for an extended period of time, the Resident Engineer should discuss the matter with the appropriate local government official. The Resident Engineer should make certain that there is a complete understanding as to who will pay the cost of maintenance or any reconditioning that may be necessary. The contractor may need a permit for the detour from the local government. After the permit is obtained, the contractor should photograph all existing roadway surfaces along the detour route.

(B) Winter Work Suspension

The Resident Engineer should arrange for the district maintenance staff or the responsible superintendent to review the site prior to release of the contractor for the winter season. This should help in gaining a "meeting of the minds" as to the condition of the roadway at the time when the contractor is released from responsibility and the work that the maintenance crew needs to perform during the winter period. Where feasible, the ADOT crew should leave the project in a condition as close as possible to that when the suspension started.

See Chapter 7 for additional information about traffic control.

104.08 Prevention of Air and Noise Pollution

During the design process, each ADOT project is evaluated by the Environmental Planning Group. This evaluation will yield environmental mitigation requirements that identify federal, state, and local environmental requirements applicable to the project and mitigation measures to minimize project caused environmental impacts. These requirements are incorporated into the project contract.

These environmental clearances, mitigation measures, and commitments are implemented through contract documents containing standard, stored specifications, special provisions, and plan sheet details. Any questions regarding these requirements can be directed to your District Environmental Coordinator.

Pursuant to the Federal Clean Air Act, as implemented and enforced by the county, the Special Provisions may require the contractor to prepare a fugitive dust control plan, and may restrict burning of trash, plant materials, or other waste. The Special Provisions may also require the contractor to discontinue all current work activities if the Governor declares an air pollution emergency. If the project is located in the area covered by the Governor's declaration, then the Resident Engineer must notify the contractor immediately. The contractor must stop work as soon as possible, but no later than four hours after notification. The contractor is entitled to compensation and time extension in accordance with the Special Provisions.

Air Pollution

The U.S. Environmental Protection Agency (EPA), the Arizona Department of Environmental Quality (ADEQ), and the respective county enforce statutes and rules covering air pollution emissions. Each county has different levels of enforcement based on the historical exceedance of emission limits to the point where human health can be impacted. A county that can not reduce emissions of harmful pollutants is considered a non-attainment area. For information about if your county is designated nonattainment, you can visit ADEQ Nonattainment Areas Website.

Environmental Permits

It is the responsibility of the contractor to obtain the following permits when required by pollution control agencies.

Air Quality Equipment Permits

This category of permits covers construction equipment used for crushing and screening operations, asphalt batch or drum dryer plants, heater-scarifiers, hot or cold recycling, and concrete batch plants.

ADEQ administers the permits at the state level and issues equipment-source permits for those counties that do not have an air pollution permit program. Maricopa, Pima, and Pinal Counties have their own permit process.

A specific air quality permit applies to each designated piece of equipment and can be used on multiple sites. It is recommended that contractors obtain a permit for each piece of equipment and keep it active. These permits can take up to four months to obtain.

Site or Project Earth Moving Permits

Maricopa County and Pima County both require a site earth moving permit that covers fugitive dust generated by such operations as grading or excavating. This is covered under their Regulation III–Control of Air Contaminants, Rule 310, Open Fugitive Dust Sources. Some cities and Native Nations require contractors to have site and haul permits. The contractor should be encouraged to call and verify permit requirements at the start of each project.

Projects located in non-attainment areas for dust may include a stored specification modifying Subsection 107.14. The contractor must prepare a dust control plan and obtain a site earth moving permit. Some of the measures which the contractor may use to control or minimize fugitive dust include:

- Increase use of water or chemical dust suppressants
- Cease work temporarily during high winds
- Reduce vehicle speeds and number of trips
- Maintain freeboard of at least three inches or cover hauling equipment
- Cover or stabilize stockpiles

The contractor will be required to cover haul trucks with tarps or other suitable enclosures in some areas.

Where possible, efforts should be made to use chemicals to conserve water.

If additional information is required about air pollution requirements and the location of non-attainment areas, call ADOT's Office of Environmental Planning or reach out to your District Environmental Coordinator.

Noise Control

In areas where construction noise may be a potential issue, the Resident Engineer and the contractor should discuss noise restriction requirements with local officials prior to construction. Generally the standard maximum allowable noise level is 67 decibels.

104.09 Prevention of Landscape Defacement; Protection of Streams, Lakes and Reservoirs

NOTE: This section contains terms that may be new to the reader. A glossary is listed at the end of this section defining these terms.

Highway construction has been identified as a primary source of stormwater pollutants through soil erosion and sediment loss. All Arizona Department of Transportation (ADOT) construction projects must comply with federal, state and local water quality regulations and permit requirements. The National Pollutant Discharge Elimination System (NPDES) is a program administered by the Environmental Protection Agency (EPA), designed to control the discharge of pollutants in stormwater. The program in Arizona is referred to as the Arizona Pollutant Discharge Elimination System (AZPDES). The Arizona Department of Environmental Quality (ADEQ) was given the authority by EPA to administer this program in Arizona. The EPA has retained the right to issue CGP permits on federal and Native lands.

Both the AZPDES and NPDES Programs require the owner (ADOT) to obtain a permit before allowing any construction discharges into protected surface waters or stormwater systems.

Construction General Permits (CGP)

For projects that are not located on Native Nations, an Arizona Construction General Permit (AZCGP, Permit No. AZG2003-001) (AZPDES CGP, Permit No. AZG2020-001) is issued by ADEQ to authorize the discharge of stormwater from a construction project to protected surface water. The current general permit was issued by ADEQ in September of 2021.

For projects that are located on Native Nations, a National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP) is required for stormwater discharges from construction projects to a WOTUS. The current permit was issued by the EPA in February of 2022.

Some projects are located both on and off Tribal Lands and therefore must obtain coverage for and comply with both permits.

The two General Construction Permits are similar in that they both require:

- Preparation of a plan depicting how ADOT and the contractor intend to comply with the requirements of the permit. This plan is called a Stormwater Pollution Prevention Plan (SWPPP)
- Notification to the appropriate agency (ADEQ or EPA) that ADOT and the contractor are electing coverage under one of the permits. This notice is called a Notice of Intent (NOI)
- Periodic monitoring of the controls established in the SWPPP to ensure they are operating as intended.
- Modification of the SWPPP to keep it up-to-date
- Notification to the appropriate agency (ADEQ or EPA) when construction is complete and/or final stabilization is achieved. This notice is called a Notice of Termination (NOT)

Additional information on the elements of the permits and compliance requirements can be found in the Construction Requirements of this subsection.

Other Permits

Municipal Separate Storm Sewer System (MS4) Permit

Runoff from ADOT projects located in municipalities may enter into local storm sewer systems, or into ADOT's own storm sewer systemThese municipalities operate under a Municipal Separate Storm Sewer System (MS4) permit and must ensure that their storm systems comply with regulations to prevent pollution. Prior to developing the SWPPP, the contractor and the ADOT Construction office should familiarize themselves with any local stormwater infrastructure and the applicable erosion control, stormwater quality or grading ordinances. The local jurisdictions may require separate permits or copies of the SWPPP for these activities. This requirement is not always shown in the special provisions. Therefore, the topic should be discussed at the preconstruction conference / partnering workshop. For more information about ADOT Stormwater infrastructure and MS4 permit, contact your District Environmental Coordinator.

Arizona Pollutant Discharge Elimination System (AZPDES) De Minimis General Permit (DMGP)

The DMGP permit (see AZDEQ website for latest permit) is administered by ADEQ and allows for short-term, low volume nuisance discharges that occur on construction projects located anywhere in the state. It can include subterranean dewatering, waterline flushing, and/or drilling activities. Separate coverage for activities outside the Construction General Permit may be required under the Arizona DMGP through a separately filed NOI with ADEQ. The contractor and the Resident Engineer (RE) should determine what is required for any proposed De Minimis discharges prior to the start of construction. Any requirements must be reflected in the SWPPP and the separate NOI must be filed at least from 5 to 30 days in advance of the discharge, depending on the receiving waters. Monitoring may be required.

Multi-Sector General Permit (MSGP)

If the contractor is using a Department-furnished material source that is also used on other projects, the material source is required to have permit coverage under the MSGP. The contractor should contact ADOT Materials Group to determine that the material source is currently permitted. This permit is not required if the material source is dedicated for use on one project and the source is restored when the project is complete. In this case, the material source will be included in the SWPPP prepared under the CGP.

Commercial asphalt and concrete plants (regardless of the size of area disturbed) also fall under different sectors of the MSGP if they produce material for multiple projects. The contractor should ensure that all off-site material sources and industrial facilities have the necessary MSGP coverage.

Administrative Requirements

The RE is responsible for ensuring the following steps have been taken prior to ground-disturbing activities:

- Approve the contractor’s proposed Erosion Control Coordinator (ECC)
- Review, amend and finalize the SWPPP
- Approve, certify and sign the SWPPP (submit SWPPP to ADEQ for approval on projects with impaired or unique waters)
- Prepare and file NOI (ensure the contractor does the same)
- Verify approval of the SWPPP and/or NOIs
- Fully implement the SWPPP

A flowchart (see Exhibit 104.09-1 Administrative Requirements Prior to Project Work Proceeding) has been provided illustrating the required steps to follow prior to beginning any soil disturbing activities.

Contractor’s Erosion Control Coordinator (ECC)

The contractor is required to submit ECC documentation for approval by the RE prior to the start of the project. The RE should consult the 104.09 Stored Specifications for specific qualifications and certification of the ECC. Additional qualifications are required of the ECC on projects located within ¼ mile of impaired or unique waters.

Stormwater Pollution Prevention Plan (SWPPP)

The SWPPP is a management document that details what control measures the contractor and ADOT will implement to ensure that construction operations prevent or control the discharge of pollutants in stormwater runoff. This includes what Best Management Practices (BMPs) will be used, inspected and maintained to prevent erosion and to minimize the discharge of sediment and non–stormwater pollutants. The BMPs can be administrative practices such as periodic inspections, or structural such as a silt fence or track out protection.

SWPPP Development

The contractor's ECC should use the applicable Stored Specifications, project-specific Sediment and Erosion Control Plan sheets, and the ADOT Erosion and Pollution Control Manual to complete the SWPPP for the project. The Sediment and Erosion Control Plan sheets will not be considered a complete SWPPP, since they are prepared assuming standard construction practices. They also do not reflect the contractor's actual methods of construction, access requirements, office location, materials storage locations or project phasing. A SWPPP is a site-specific living document that will be updated throughout the construction process.

The Construction Stormwater Pollution Prevention Plan (SWPPP) template is provided to assist those unfamiliar with the preparation of a SWPPP. The template serves as guidance only for the development of a site-specific SWPPP. Portions of the template may be completed in advance by ADOT Roadside Development and provided to the contractor. The template allows the user to input appropriate information after viewing instructions for each section. The template has been formatted to address all items in the ADEQ Construction SWPPP Checklist.

The contractor or the RE may contact ADOT Water Resources or the District Environmental Coordinator for assistance in the development of the SWPPP.

The ECC is responsible for preparing and finalizing the SWPPP, in a timely manner, with the support and direction of the RE before submittal of the NOI. The RE is responsible for reviewing the SWPPP and verifying its completeness. The RE is also responsible to ensure that the contractor does not perform any earth-disturbing activities prior to fully implementing the approved SWPPP and receiving permit coverage authorization. On larger projects, each 750,000 square feet sub-area must be identified in the SWPPP, along with the sequence of construction and installation plan for erosion control measures for each sub-area. The ADOT Erosion and Pollution Control Manual contains step-by-step guidance for preparing the SWPPP.

In addition, the SWPPP for non-tribal projects must address all requirements of the ADEQ SWPPP Checklist or Appendix A.1 of the ADOT Erosion and Pollution Control Manual and the requirements of the CGP. A copy of the CGP must be included with the SWPPP. A copy of the SWPPP must be kept on the project site.

On non-Tribal Land projects that are located within ¼ mile of impaired or outstanding Arizona waters (OAW), the SWPPP and NOI must be submitted to ADEQ for review and approval. On all other projects, the RE's signature will constitute approval of the SWPPP.

SWPPP Approval for Projects within ¼ Mile of Impaired or Unique Waters (Non-Tribal Lands)

Although SWPPPs must be prepared for all construction projects that will disturb one or more acres, SWPPPs must be submitted to ADEQ for review and approval if the project site is located within ¼ mile of impaired or unique waters. To determine whether any portion of the project lies within the ¼ mile buffer zone for impaired or unique waters, consult the project specifications, special provisions, and the Impaired, Unique and Not Attaining Waters Site Map via the Arizona Department of Environmental Quality webpage. A stormwater monitoring plan, prepared by the contractor, must be included as a component of the SWPPP when required by the Special Provisions. The contractor's stormwater monitoring plan shall comply with the current edition of the ADOT's Stormwater Monitoring Guidance Manual for Construction Activities Ground disturbing activities cannot commence until receipt of an authorization letter from ADEQ accepting the SWPPP and monitoring plan, or until the 32 business day review period has expired.

Stormwater Monitoring Plan Components

Monitoring may consist of visual, photographic, turbidity, and impairment parameter monitoring, depending on the classification of the impaired or unique water body and other factors. ADOT Roadside Development will determine the monitoring points and monitoring parameters within the contract documents and plans. ADEQ will make the final determination on the adequacy of the program. Special training will be necessary for ADOT construction personnel involved in the inspection and verification of the contractor's monitoring plan.

Notice of Intent

After the project SWPPP has been approved, the RE and contractor will each complete separate NOI forms for the project. On projects within ¼ mile of impaired or unique waters, the NOI and the SWPPP are submitted together for ADEQ's approval. Both NOIs must include a certification statement signed and dated by a responsible corporate officer. The RE will act as the corporate officer for ADOT, and this responsibility cannot be delegated. The ADOT Construction Office and the contractor will submit the NOIs to ADEQ or EPA (both if the project is located on Tribal and Non-Tribal lands). Copies of the NOI and SWPPP will be maintained at the construction office and provided to the District office to be stored by the District Environmental Coordinator. The District Environmental Coordinator will be responsible for the transfer of all SWPPP documents from construction to ADOT maintenance at the end of construction.

Ground disturbing activities cannot be performed until the time frames defined by the CGP have been met and after the NOIs have been submitted. If the project has the potential to discharge into a MS4, the applicant must also forward a copy of the completed NOIs to the local municipality with jurisdiction (at the time it is submitted to ADEQ and/or EPA).

On projects with impaired or unique waters, coverage may not be authorized under this permit for 32 business days following receipt of the NOI and SWPPP. ADEQ or EPA may notify the contractor and ADOT within this time frame that there is cause for SWPPP amendment, or denial of coverage. If notification is not received in the 32 business day time frame, the contractor and ADOT may assume coverage under the CGP.

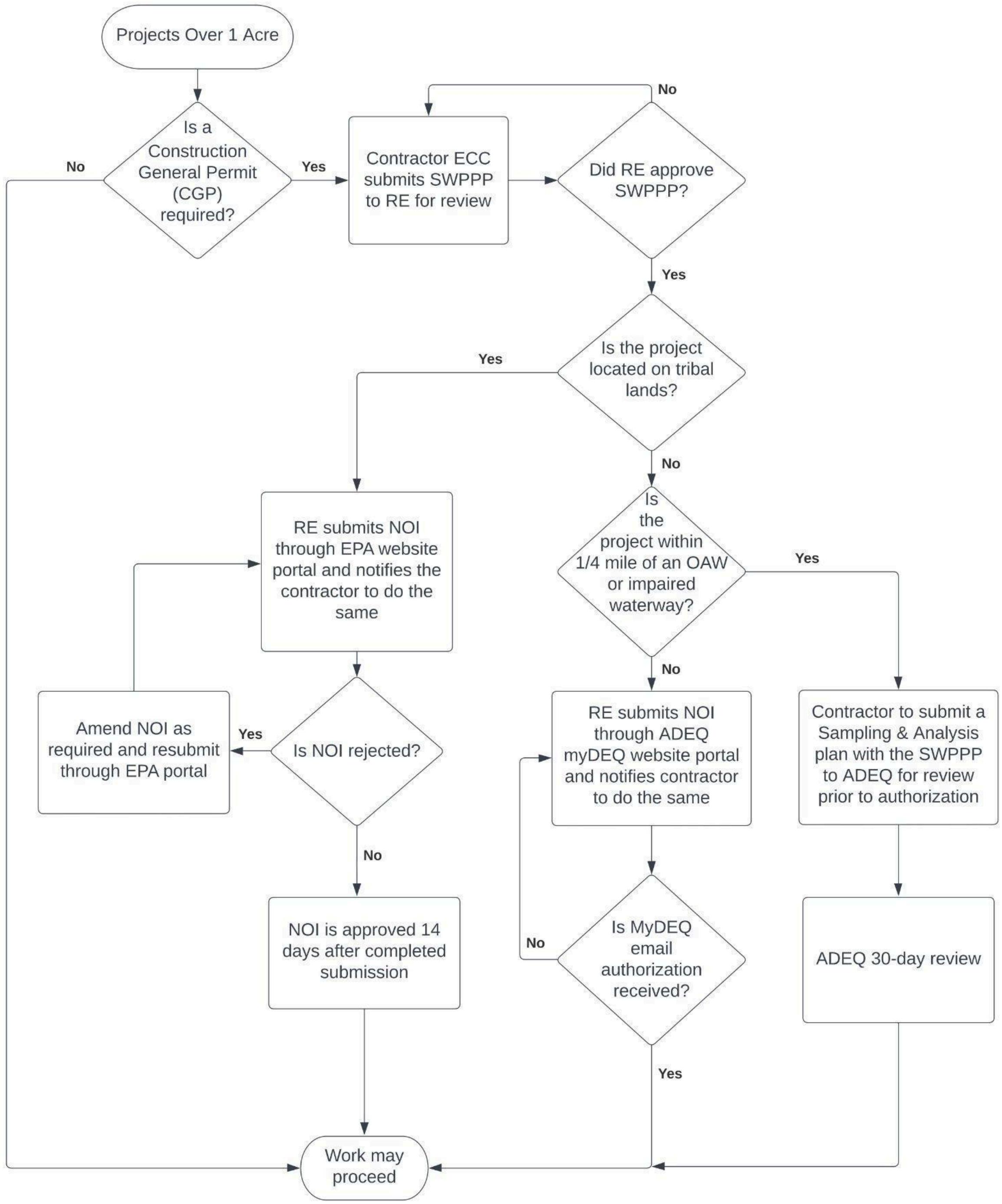


Exhibit 104.09-1 Administrative Requirements Prior To Project Work Proceeding

Construction Requirements

SWPPP Implementation

Upon receipt of the authorization letter or NOI authorization number (or expiration of the review period without notice), the SWPPP may be implemented. The contractor is responsible to ensure that:

- Installation of any Control Measures (CMs) that are required to be placed prior to ground disturbing activities. (Sediment control berms, silt fence, run-on diversions, etc.)
- Surface areas exceeding 750,000 square feet are not exposed to erosion until temporary or permanent erosion control devices have been installed and accepted by the RE. Any exceptions allowing more than one sub-area to be disturbed (such as excavation from one area and hauling to fill in another), must be approved by the RE
- Erosion protection (rock mulch, inlet and outlet riprap, and velocity dissipation) is placed immediately after the drainage structure is complete and functional
- Installation of permanent erosion control measures are given priority over reliance on temporary measures
- Stabilization measures are installed within 14 calendar days in portions of the site where construction activities have temporarily or permanently ceased, unless ground disturbing activities will resume in that area within 14 days (see exceptions in Part IV, D.4.b. of the CGP)

Inspections

The RE and the contractor’s ECC are responsible for jointly inspecting the project regularly to ensure that CMs are being maintained in accordance with the CGP and associated SWPPP. During construction the RE and the ECC shall inspect the project at the frequency specified in the approved SWPPP (normally every 14 calendar days, and within 24 hours after any storm event of 0.50 inches or more).

Compliance Evaluation Report (CER)

ADOT should verify that the ECC is conducting thorough inspections and providing a timely copy of each CER. The CER can be found in Appendix F-3 of the Construction Stormwater Pollution Prevention Plan (SWPPP) template. The CER must be signed by the ECC. It is required that the ECC document these inspections and keep all documents related to the project SWPPP at the contractor’s Field Office. Corrections of any deficiencies noted during inspections should also be documented and kept in the SWPPP.

The RE is advised to work closely with the contractor’s ECC to make field adjustments as necessary: add CMs, maintain or repair CMs, and redesign deficient CMs. The SWPPP is intended to be an evolving plan, which should be revised as a result of changing conditions in the field. It is also the RE’s responsibility to verify the use of certified erosion and pollution control materials in CMs, as specified in Section 810 of the Standard Specifications.

Construction Site Inspection Log

The Construction Site Inspection Log is a comprehensive field log that serves as the basis for completion of the CER. The ECC and ADOT Inspector should use this log during their required joint inspections. The SWPPP template includes a Construction Site Inspection Log, which may be tailored to specific projects. Deficiencies noted during inspections must be corrected within four calendar days or by the next anticipated storm event (whichever is sooner).

Construction Inspection Checklists

ADOT has implemented a process to evaluate conformance on each project. Two construction inspection checklists have been developed for stormwater discharge activities:

- Stormwater Administrative Checklist: Intended to be used by the RE and/or assistant, to ensure that submittals and documentation required by Subsection 104.09 of the Special Provisions are processed timely. One checklist per project is required
- Stormwater Erosion/Sediment Control Checklist: required to allow ADOT inspectors to document BMP conformance in the field on a monthly basis. It may be completed from the data collected during joint inspections utilizing the Construction Site Inspection Log

Additional construction inspection checklists are available for Landscape Construction, Landscaping Establishment and Class II Seeding. The checklists are required to be used by the ADOT personnel to aid in evaluating compliance. Performance evaluation statistics are collected on all projects to track overall conformity and to target areas for improvement.

SWPPP Amendments

SWPPPs must be amended within seven calendar days whenever:

- There is a change in design, construction, operation or maintenance at the construction site not previously addressed
- It is determined by regulatory officials that discharges are causing or contributing to water quality exceedance or that the SWPPP is ineffective in eliminating or significantly minimizing pollutants in stormwater discharges

Stabilization Record

The RE must verify that stabilization efforts are in place. These measures must be installed within 14 calendar days after construction activity has temporarily or permanently ceased for the affected sub-area. The ADOT SWPPP template provides forms for recording the following activity dates:

- When major grading activities occur
- When construction activities temporarily or permanently cease on a portion of the project
- When stabilization measures are initiated and completed (include reasons for delay, when applicable)

The contractor and ADOT must maintain the SWPPP and all associated documents for at least three years from the time that permit coverage is terminated as part of the permit requirement. ADOT is required to maintain all construction documents/records for 10 years after the FHWA acceptance date. All documentation should be made readily available to the public upon request, all such requests should be made through ADOT Risk Management. Visit the ADOT Record Retention Information and Policy Resources website for guidance and standard work.

Non-Compliance

The contractor’s ECC shall be rejected if, in the opinion of the RE, the conditions of the AZPDES General Permit or the approved SWPPP are not being fulfilled. The contractor’s ECC shall be rejected for any of the following:

- Failure to properly implement the SWPPP within three working days after written notification
- Failure to complete corrective measures within two calendar days after written notification. (24 hours if sediment flows directly into a body of water)
- Failure to perform routine maintenance within three working days after written notification

In the event of the ECC’s failure to comply with any of the above requirements, the RE will direct the contractor to stop all affected work and propose a new ECC as soon as possible. However, all erosion and pollution control items specified in the SWPPP shall be maintained at all times. No additional work on construction items affected by the SWPPP will be allowed until the RE has approved a new ECC and all corrective measures have been completed. The contractor will not be allowed compensation or an extension of contract time for any delays to the work.

Termination of Permit Coverage

Should final stabilization be achieved and the contractor has satisfactorily completed work, both ADOT (RE) and the contractor submit their NOTs to ADEQ/EPA. Final stabilization occurs when all of the following applicable events have taken place:

- For any areas that were disturbed during construction, are not covered over by permanent structures, and over which the operator had control during the construction activities, the operator has met the requirements for final vegetative or non-vegetative stabilization in Part 3.4 of CGP
- The operator has removed and properly disposed of all construction materials, waste and waste handling devices, and has removed all equipment and vehicles that were used during construction
- The operator has removed all temporary stormwater controls that were installed and maintained during construction
- The operator has removed all fuel storage, stockpiles, or other pollutant-generating activities associated with construction. If needed for long term use by ADOT maintenance, that will be included in the meeting when transferring the SWPPP to maintenance
- A uniform perennial vegetative cover with a density of 70 percent of the native background cover for the area has been established. A Registered Landscape Architect (RLA) must verify coverage compliance
    - On an individual project basis, there are some alternatives allowed under the 2020 CGP for final stabilization. Both the RE and the contractor should review Section 3.4 of the permit and include appropriate documentation in the SWPPP before using these alternatives as a condition of termination
- Permanent stabilization measures shown in the project plans or SWPPP (such as riprap, granite mulch, gabions or geotextiles) have been employed

There are instances when final stabilization has not occurred, but the contractor has satisfactorily completed work:

Seeding Projects

Seeding may not successfully germinate, grow and become established until after the next rainy season. When drought conditions occur, it may take a year or longer to achieve final stabilization.

The RE and RLA will jointly conduct a thorough inspection of the seeding, including CMs. This will take place approximately two weeks prior to the completion of the 45 calendar day maintenance period on projects with Class II Seeding as part of the SWPPP. If this work is accepted by the RE and RLA, the contractor may file a NOT at the end of the 45 day maintenance period. ADOT assumes responsibility for all stormwater protection and cannot submit its NOT until the seeding is established as described above. (See “Procedure for Assumption of the SWPPP by ADOT” below).

Future Landscape Projects

There are some cases where the final landscaping will occur on a separate project in the future. Two weeks prior to the final walk through, the RE will inspect all temporary CM’s and verify that they comply with the project plans and SWPPP. Upon final acceptance by the RE, the contractor may file a NOT. ADOT assumes responsibility for all stormwater protection and cannot submit its NOT until final stabilization of the future landscape project. (See “Procedure for Assumption of the SWPPP by ADOT” below).

In either case (one or two above), items listed on the Construction Inspection Log, the Construction Performance Evaluation Checklist, and the CER shall be checked for conformance. Any deficiencies, including those noted on the final walk-through, will be corrected to the satisfaction of the RE. All critical or major items on the Construction Inspection Checklist shall be in 100% conformance prior to acceptance of the project. Critical or major items are those “Conforming Attributes” rated 8 or 4, respectively.

Also, prior to final acceptance, a weatherproof sign or other notice must be erected near the main entrance of the construction site. This will be done via Supplemental Agreement. This notice must contain the following information:

- The current NOI, and the NPDES or AZPDES authorization number
- A brief description of the project, and the location of the SWPPP and the contact name and telephone number if the site is inactive or does not have an on-site location to store the plan

If the project is located within a MS4, the contractor must also forward a copy of the completed NOT to the municipality at the time it is submitted to ADEQ/EPA.

Procedure for Assumption of the SWPPP by ADOT

In the case that the contractor submits a NOT, ADOT will operate the CGP. The existing SWPPP will be provided to the District, and will be their responsibility going forward. Following acceptance of the project by ADOT, the Resident Engineer will set up a meeting with the District Environmental Coordinator, the project site's responsible Maintenance Supervisor (and possibly the Maintenance Superintendent) to hand over the SWPPP responsibilities to the DEC and Maintenance. This meeting should take place at the project site so that the RE can walk the DEC and others through the site to identify installed mitigation measures and turn over the SWPPP book to the DEC for future record keeping. At this time, a conversation should take place on any landscape establishment practices or concerns that will need to continue beyond the active project.

The District Environmental Coordinator, or another person who assumes responsibility for the SWPPP, will file the updated NOI, perform the mandatory routine inspections, maintain Control Measures, complete all required reports, and file a NOT when final stabilization is achieved and all temporary CMs have been removed. The SWPPP is an original record of the construction project and should be maintained and kept in accordance with Federal Highway and ADOT Guidelines.

A flowchart (see Exhibit 104.09-2 Administrative Requirements after Construction Completion) has been provided illustrating the required administrative steps to follow after construction has been completed.

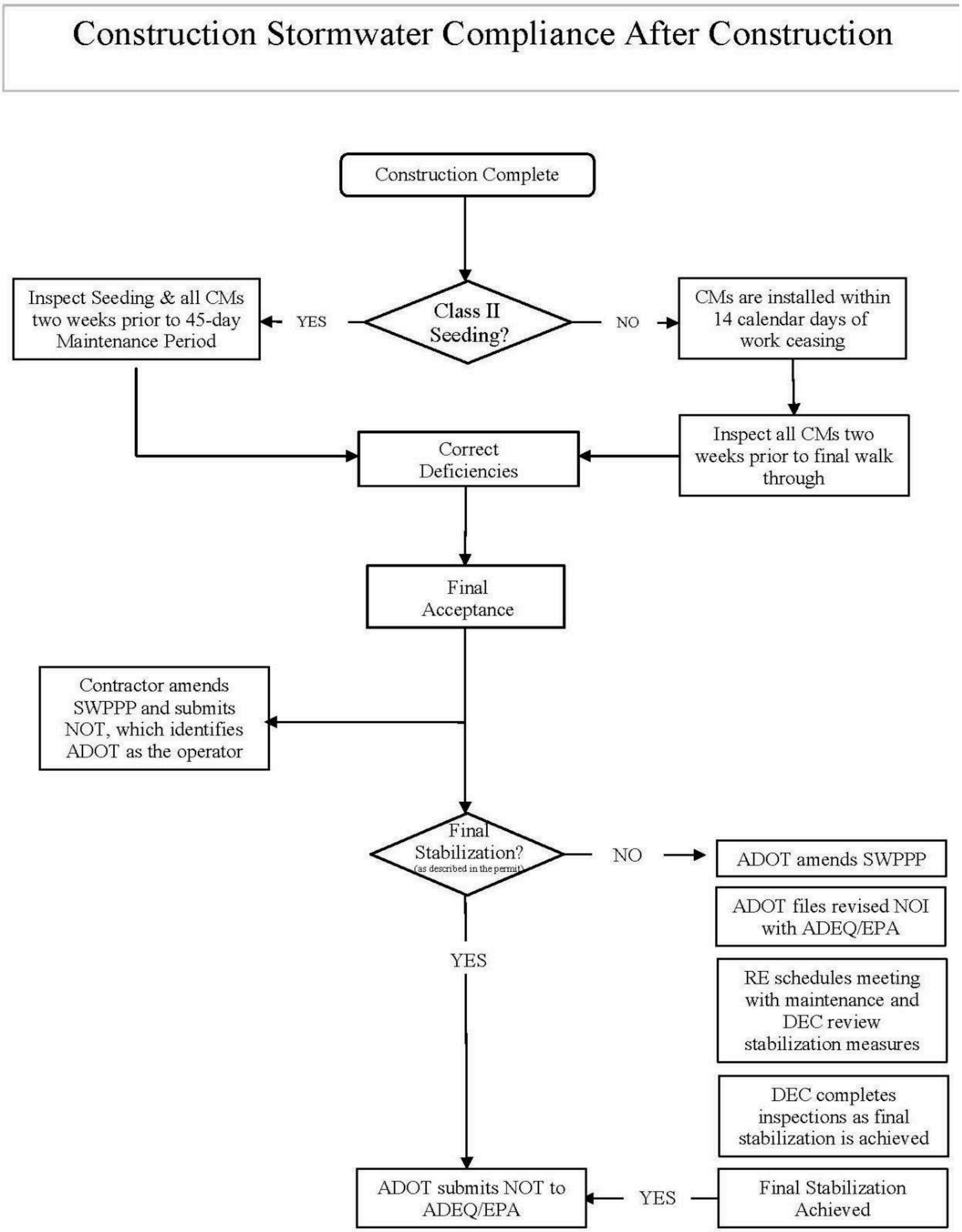


Exhibit 104.09-2 Administrative Requirements after Construction Completion

GLOSSARY OF SOIL EROSION TERMINOLOGY

Arizona Construction General Permit (AZCGP): ADEQ permit provides authorization to discharge under the Arizona Pollutant Discharge Elimination System program, in compliance with the provisions of the Arizona Revised Statutes, Title 49, Chapter 2, Article 3.1; the Arizona Administrative Code, Title 18 Chapter 9, Articles 9 and 10; and the Clean Water Act as amended (33 U.S.C. 1251 et seq.).

Arizona Department of Environmental Quality (ADEQ): state agency with primary responsibility for implementation of environmental statutes, including the AZCGP.

Arizona Pollutant Discharge Elimination System (AZPDES): ADEQ program for administering the requirements of the AZCGP (issuing, modifying, revoking, reissuing, terminating, monitoring, enforcing permits, and imposing and enforcing pretreatment requirements), incorporated by reference under Arizona Administrative Code (AAC) R18-9-A905.

Control Measures (CM): schedule of activities, prohibition of practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to waters of the U.S.

Clean Water Act (CWA): an act passed by the U.S. Congress to control water pollution.

Compliance Evaluation Report (CER): inspection report that documents compliance of BMPs identified in the SWPPP.

Control Measures (CM): Formerly known as BMP's. These are the physical erosion control methods, e.g. wattles, berms, sediment logs, track out pads, silt fence, etc.

De Minimis General Permit (DMGP): issued by ADEQ that allows for discharges associated with potable and reclaimed water systems, subterranean dewatering, well development, aquifer testing, hydrostatic testing of specific pipelines, residential cooling water, charitable car washes, building and street washing, and swimming pool water.

Erosion Control Coordinator (ECC): person knowledgeable in the principles and practice of erosion and sediment controls, who is appointed by the contractor and approved by ADOT.

Environmental Protection Agency (EPA): federal agency with primary responsibility for implementation of federal environmental statutes.

Federal Construction General Permit (FCGP): issued by EPA that provides authorization to discharge under the National Pollutant Discharge Elimination System program, in compliance with 40 Code of Federal Regulations §122.26(a)(1)(v).

Impaired Water: waterway failing to meet water quality standards as defined by ADEQ/EPA. A list of these can be found on the Impaired, Unique and Not Attaining Waters State Map on the Arizona Department of Environmental Quality webpage.

Municipal Separate Storm Sewer Systems (MS4): municipal stormwater system that drains urban areas(including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains).

Multi-Sector General Permit (MSGP): federal permit given to a state under which certain industries may be granted a permit to discharge stormwater.

National Pollutant Discharge Elimination System (NPDES): EPA program for administering the FCGP (issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements), under Sections 307, 318, 402, and 405 of the CWA.

Notice of Intent (NOI): forms completed and signed by construction site operators (contractor and ADOT) notifying ADEQ/EPA that the operators will comply with Arizona's or EPA's applicable stormwater general permits.

Notice of Termination (NOT): form that notifies the permitting authority (ADEQ/EPA) of an operator's intention to terminate coverage under the CGP.

Sediment and Erosion Control Plan Sheets: preliminary project plans prepared by ADOT that provide suggestions for types of structural temporary and permanent BMPs.

Stormwater Management Plan (SWMP): ADOT's statewide comprehensive plan for the implementation of the AZPDES permit requirements for MS4s.

Stormwater Pollution Prevention Plan (SWPPP): identifies construction/contractor activities that could cause pollutants in stormwater and a description of measures or practices to control these pollutants.

Total Maximum Daily Load (TMDL): The calculation of the maximum amount of an offending pollutant the stream can receive from all sources (land and air) and still meet water quality standards.

Unique Water: An unpolluted surface water classified as outstanding state resource water under Arizona Administrative Code R18-11-112. The Arizona Department of Environmental Quality and the EPA provide these waters on a registry.

104.10 Contractor's Responsibility for Work

Projects constructed in washes, creeks, rivers, and other streambeds are susceptible to flood damage. Other projects under construction may affect the drainage of adjacent properties and existing roadways. The preparation of a well thought-out temporary drainage and stormwater management plan can go a long way in both preventing unnecessary rework at the site and avoiding unwarranted conflicts with neighboring businesses and residences.

The intent of Subsection 104.10 is not to require an elaborate drainage plan, but to get the contractor to think about how to handle water flowing through the project. The plan should be integrated with the Storm Water Pollution Prevention Plan (SWPPP) discussed in the previous subsection.

Often there is confusion about the need for both a SWPPP and storm water management plan. The SWPPP discusses how to prevent erosions and spills at the job site. It may show all drainage channels (whether temporary or permanent) within the site and what erosion control measures are to be taken in those channels. On the other hand, the storm water management plan decides in a strategic sense how the site will be drained in order to minimize damage to the work and adjacent properties. It may require the contractor to construct temporary channels and berms, and phase the drainage work through the life of the project.

The storm water management plan looks at site drainage from an overall perspective. The SWPPP gets into the details of how erosion will be controlled when the storm water management plan is implemented. In some cases the storm water management plan may need to precede the SWPPP when existing or permanently constructed drainage facilities cannot be used for temporary drainage.

104.11 Damage by Storm, Flood or Earthquake

This subsection is known as the "acts of nature" provision which is common in most state DOT contracts. Acts of nature are basically natural occurrences of an unusual or extraordinary nature. The intent is to compensate the contractor for damages to the work caused by the forces of nature that ordinary foresight could not have prevented. The acts of nature provision is similar to the differing site condition in that it protects the Department from unwanted contingencies in the contractors' bid that drive up the costs of construction. In this respect, the Department is acting as the contractor's insurer against the unusual and unforeseeable events of nature.

Of course what is unusual and unforeseeable have been open to interpretation over the years. As a result, this subsection attempts to narrowly define the types of occurrences that qualify as acts of nature. Occurrences are limited to tornadoes, strong earthquakes, storms and floods in which a state of emergency is declared and other natural events having all of the characteristics listed below:

- Catastrophic
- Unusual
- Sudden
- Unforeseeable
- Effects of the occurrence are not preventable or minimized by reasonable human foresight

To pass the test, the occurrence must meet all five conditions. If it fails to meet even one of the conditions, then it does not qualify as an act of nature.

For example, a 4-inch rain in August that washes away a partially constructed box culvert would not qualify as an occurrence. In Arizona, 4-inch rains are sudden and can be catastrophic, but are certainly not unusual or unforeseeable. Early winter shutdowns and late spring starts are not considered occurrences either. Although it may be unusual and unforeseeable, a prolonged winter could hardly be classified as sudden and catastrophic.

Subsection 104.11 also identifies the types of damages the contractor can or cannot claim.

Damages that can be claimed include:

- Idle equipment that cannot be placed elsewhere (get an agreement with the contractor for what equipment should be included)
- Repair work needed to restore the project to its condition before the occurrence,
- remobilization costs
- Direct project overhead
- Ripple effects that affect both this project and other projects (some of these costs, like lost profit, are excluded as noted below)
- Lost contract time

Damages that cannot be claimed include:

- Ripple effects from another project where an act of nature has occurred (damages need to be included in that project)
- Idle equipment and remobilization costs on federal aid projects (see the project's Special Provisions)
- Lost profit
- Home office overhead or other types of non-project overhead

To accurately determine the costs due to an act of nature, the Field Office should carefully document on a daily basis all labor, materials, and equipment used to repair damaged work and idle time for the contractor's equipment. It is suggested that the force account daily reports be completed and signed by both the contractor and the Department.

Most acts of nature are done on a force account basis and then converted to a change order once costs are agreed upon.

Ripple effects are more difficult to track and document. The best thing to do is meet with the contractor and discuss the impact an act of nature may have had on other work as well as other projects. Since the Department may be paying for these effects, the contractor has a duty to minimize these additional costs as much as possible. The Resident Engineer has the right to be notified about ripple effects and can change the contractor's sequence and review the contractor's cost reports in order to control these costs.

104.12 Environmental Analysis

The contractor shall provide an EA for any material used on the project in accordance with Section 1001. If it is a new source that hasn't been previously approved the contractor shall prepare the document for review and approval by ADOT EPG. The contractor is to allow 60 calendar days for ADOT's review of the submittal and any subsequent submittals.

The Engineer may issue a time extension if the Department is delayed in their review AND it delays a controlling activity as shown on the contractor's schedule. It is important to make sure this review time is shown on the contractor's CPM.

104.13 Value Engineering Proposals by the Contractor

What is a Value Engineering Proposal (VEP)? Put simply, a VEP is an innovative and original proposal submitted by the contractor that delivers to the owner the intended scope of work under the original contract at a lower cost. This does not mean that work was unnecessarily deleted or a cheaper, lower quality material was used in the construction. The ultimate purpose of the VEP is to deliver the same or better product at lower overall cost to the owner. Further information is available on the Construction Group webpage regarding the VEP process, as well as previously completed VEP's on past projects.

VEP Concept

Prior to the submission of the formal VEP, the contractor shall submit a written concept of what the VEP will entail, ranging from concept of design, all proposed changes, potential cost savings, schedule impacts for both construction of the project or review of the VEP, and any other information which would aid the Department in its evaluation of concept.

When the contractor submits the initial VEP concept, the Resident Engineer, in consultation with the Designer(s), the Project Manager, State Construction Engineer, and the appropriate ADOT technical section, will need to evaluate the merits of the contractor's concept and inform the contractor, in writing, of the chance of the VEP concept succeeding. Any shortcomings will need to be discussed, including what submittals will be required to make a complete evaluation. The letter should clearly describe what the Department will want to see in the proposal. Being specific is key, the Department's response should provide more than quoting the requirements of the Standard Specifications.

It is important for the Resident Engineer to review and respond to the submittal within 10 calendar days. If the contractor is given approval to pursue the VEP, it should also be specified if some information does not need to be submitted due to the simplicity of the VEP. The submittal process should be as streamlined and expeditious as possible while still meeting the intent of the Standard Specifications.

Formal VEP Submittal

When the Department has agreed to allow the contractor to pursue the VEP, the Resident Engineer should be mindful of the time being taken on the development process. Per specification, the contractor is allowed 30 days to complete the formal submittal; therefore, the Resident Engineer should keep track of the design progress and whether the 30-day deadline is going to be met. If the VEP development process is at risk of eclipsing the deadline, the Resident Engineer should notify the contractor, in writing, of the impending deadline and for an update on the VEP's status. The Department is under no compulsion to accept a VEP. The rejection or termination of a VEP by the Department should have no monetary or temporal ill effects on the contractor, as the contractor shall not bid a project anticipating approval of their VEP.

Once the contractor has formally submitted their VEP, the Department will need to begin their review of the VEP. Per specification, the Department has 30 days to review. During this time, the Resident Engineer will need to identify the parties needing to review the formal VEP and provide them with the contractor's documents. Once the review has been completed and a consensus has been reached, the Resident Engineer will need to respond, in writing, as to whether the Department accepts or rejects the contractor's VEP. If the Department elects to reject the VEP, the Resident Engineer should be thoroughly detailed in the response, noting the issues with the proposal, which led the Department's decision to reject it.

Administrative costs that can be included in a VEP:

Contractor	ADOT
engineering time	engineering review time
plans preparation	technical meetings and reviews
Estimating	additional inspections and testing
clerical work	additional maintenance and operating costs
reproduction expenses	

Administrative costs that cannot be included in a VEP:

Contractor	ADOT
Project Manager's time	Resident Engineer's analysis and review
home office or corporate reviews	management review
overhead savings or lost overhead	CE cost savings
lost profit	

When setting up a VEP change order (see 104.02), it is important to clearly show the savings to both the Department and contractor. The Resident Engineer needs to keep in mind that the contractor's portion of the savings is added back into the change order as a separate item. All bid item deletions, quantity adjustments, and new pay items are listed first, and then a new item called "VEP savings" is created to pay for the contractor's half of the savings. Separate pay items should be created for any administrative expenses the Department may have. However, the contractor's administrative expenses are usually included in any new items of work. VEP change orders shall utilize pay items 9248001 through 9248031 to memorialize the non-item specific costs/savings. Finally, any documents used to develop the VEP should also be referenced in the specifications section of the change order, along with any other stipulations that were agreed to as part of the VEP.

105 CONTROL OF WORK

105.01 Authority and Responsibility of the District Engineer

The District Engineer oversees all construction and maintenance activities within the district. The District Engineer represents ADOT on all transportation issues involving local and county governments and has input into what new projects are planned for the District.

All ADOT Construction Field Offices within a district fall under the District Engineer's management. Part of the District Engineer's job is to ensure uniformity in contract interpretation and consistency in how construction contracts are administered. The District Engineer decides which projects are assigned to each Field Office and assists the Resident Engineer in staffing each project.

The District Engineer can authorize contract supplemental agreements as high as $1,000,000. In addition, the District Engineer may delegate this authority to the Assistant District Engineer. The District Engineer, or the Assistant District Engineer also signs for the State of Arizona regarding change orders for Time Extensions. The District Engineer is the first point of contact in the partnering escalation process beyond the project level.

105.02 Authority and Responsibility of the Resident Engineer

The Resident Engineer has immediate charge of one or more construction projects. The Resident Engineer represents the Department on official business conducted at the project site. The Resident Engineer is seen by the contractor, local government agencies, the traveling public, and the media as a state official who can make (or get) decisions and conduct business on behalf of the State.

The Resident Engineer's main tasks are to administer and oversee construction contracts for the Department and ensure that projects are built according to the contract and the Department's requirements.

Administrative responsibilities involve managing the routine affairs of construction contracting such as recording work progress, paying the contractor, documenting changes, and ensuring compliance with state and federal regulations.

Oversight responsibilities include observation of construction activities, sampling and testing materials, interpreting contract documents, measuring work for conformity to the contract requirements, and tracking construction costs and contract time.

Senior Resident Engineers have the added responsibilities of administering more complex projects or many ongoing projects within a single highway corridor. They provide input into the project development process for upcoming projects within the District.

These are some specific responsibilities of the Resident Engineer:

- Creating and maintaining an atmosphere of trust and teamwork on the project. Good relations must be maintained with the Project Manager, Field Office Personnel, members of other ADOT groups, the contractor's staff, outside agencies, private citizens, and any other involved parties.
- Building and maintaining an organization that can administer the projects efficiently, effectively, and in accordance with ADOT policies and procedures. Sufficiently trained personnel must be allocated to provide all of the required inspection, sampling, testing, and documentation. In many cases the RE relies on staff from the Area/District lab to sample materials. In most instances the lab can accommodate the RE's request. However, it is ultimately the RE's responsibility to assure sampling occurs. A phone call between the RE (or designee) and the lab to schedule sampling is required; furnishing the lab a copy of the contractor's weekly schedule, leaving a voice mail or merely sending an email is not acceptable

notification. The lab should be notified at least 48 hours in advance. If the lab does not have personnel available, it is the RE's responsibility to provide the Inspector.
- Being involved first-hand in every major project-related issue. The Resident Engineer must visit each project as often as possible and attempt to view all the major work items underway.
- Ensuring the design is actually compatible with the conditions encountered at the project site.
- Communicating promptly and accurately—the Resident Engineer must manage the flow of project information and paperwork.
- Ensuring the Department's policies and procedures are followed in the area of construction administration.

Resident Engineers can authorize and approve contract changes that do not exceed $200,000. They can also suspend work and accept work on behalf of the Department. However, one of the most important duties of the Resident Engineer is to keep a project moving and maintain control. All highway projects (especially the larger ones) tend to get bogged down from time to time due to a major design change or differing site condition. Regardless of the cause, it's up to the Resident Engineer to lead the project team and contractor through the obstacle as most Resident Engineers are empowered with a wide range of authority so they can do just that.

The Resident Engineer should not make unilateral decisions that have a major effect on project scope, schedule, or construction costs. Under ADOT's project management process, the Resident Engineer is a member of the project management team assembled for that project. The project management process covers the entire life of the project from development and design through construction and maintenance. Administration of the project is a team effort and all decisions must be made within the framework of the project management process. The Resident Engineer should confer with other team members when making decisions affecting project scope, schedule, or budget. The Resident Engineer should realize that the Department is a large organization and that other groups that do not actually participate in building the project play an important role in achieving the final goal.

Suspension of Work

Due to the potential ramifications that it may cause to the progress and overall success of the project, suspension of work by the Department needs to be carried out in a most judicious manner and can either result from actions made on the part of the contractor, adverse weather, or unsafe/undesirable conditions of public interest. Reasons for suspension of work may include:

- Negligence by the contractor resulting in unsafe conditions for either the workers on-site or the general public, as described in Standard Specifications 107.07, project time will continue to be charged.
- Non-conformance of the construction activities with respect to the contract documents time will continue to be charged.
- Extended project delays outside of the contractor's control as described in Section 108.08 of this manual.

In the unlikely situation where a project is required to be halted or suspended for any reason, the Resident Engineer should reach out to the State Construction Engineer or the Assistant State Construction Engineer for guidance as it relates to charging time and contractor compensation.

When a stop work order is issued, the State Construction Engineer and Assistant State Construction Engineer must be copied.

105.03 Plans and Working Drawings

The definition of what constitutes working drawings or shop drawings can be found in Subsection 101.02 definitions for Plans. The Standard Specifications or the Special Provisions will specify when these types of drawings are required. The subsections of the Standard Specifications that require working drawings include:

Subsection	Drawing Description
601-3.02(A)	Falsework and Form Drawings and Calculations
601-3.02(C)	Formwork Drawings for Cast-in-place Bridge Girders
601-3.04(3)(b)	Deck Joint Assemblies Shop Drawings
602-3.01	Prestressed Concrete Shop Drawings
603-3.05	Timber Pile Splicing Detail
604-3.01	Structural Steel Fabrication Shop Drawings, Calculations, and Erection Details
605-3.01	Bar Bending Diagrams and Cut Sheets for Reinforcing Steel
606-3.01	Sign Structure Fabrication Shop drawings
608-3.01	Sign Panel Fabrication Shop Drawings (when supplements are needed)
609-1.03	Drilled Shaft Installation Plan
610-3.03	Painting Application Plan
701-1	Alternate Traffic Control Plan (when submitted by contractor)
730-4	Shop Drawings, Catalog Cut Sheets, Photometric Data Sheets for Lighting and Traffic Signal Equipment
732-3.01	The contractor changes in location and size of Electrical Conduit & Pull Boxes
734-2.01	Shop Drawings, Circuit Diagrams and Other Technical Information for Traffic Signal Controllers
806-3.01	Material and Equipment lists and Other Technical Information for installing Trees, Shrubs, and Plants
808-3.01	Material and Equipment lists and Other Technical Information for installing Water Distribution systems
808-3.05	Shop Drawings for Installation of Backflow Prevention Units
809-3.01	Material and Equipment lists and Other Technical Information for installing Sewerage Systems

There are specific time requirements in Subsection 105.03 for the Department's review of working drawings. If these time requirements are exceeded and result in a project delay, the contractor may be entitled to a contract time extension. It is important for the Resident Engineer to track drawing review times and minimize their effect on the contractor's progress.

The drawings are submitted in a reproducible format electronically to the Engineer for review. The Engineer may ask for up to three hard copies.

Some working drawings require the seal of the Professional Engineer (PE)—this means a Professional Engineer registered in the State of Arizona (see definitions in Subsection 101). The Department and the Arizona State Board of Technical Registration do not recognize out-of-state Professional Engineers. Do not accept working drawings stamped by out-of-state Professional Engineers.

105.04 Conformity with Plans and Specifications

Occasionally, contractors and Inspectors are uncertain when work is reasonably close to conformity. Although a definition of "Reasonably Close Conformity" is specified in Subsection 101, confusion still occurs. When a specific tolerance is described in the contract documents, there should be no confusion. The work is either in or out of specification. If the contractor claims they did not have to meet that specification on previous projects, then the issue is different. The issue is now the inconsistent enforcement of the contract specifications, which is something the Resident Engineer or District Engineer should handle.

When no tolerances or requirements are listed and the Inspector is dissatisfied with the workmanship or materials used, then the only recourse is to determine the industry standards for that type of work. Trade and material producer associations such as the Asphalt Institute, ACI, PCA, and AISC publish manuals that describe generally accepted practices for different types of construction work. The contractor is expected to follow accepted industry standards if the contract specifications are silent on a desired quality of materials or workmanship. For example, the Standard Specifications do not go into specific details on how to rake asphalt. This is covered in Asphalt Institute or National Asphalt Paving Association literature.

Some judgment is required in applying industry standards to the contractor’s work. Sometimes, local practices take precedence over industry standards when these practices are widely accepted by the contracting community.

The contractor has a duty to perform work in strict accordance with the plans and specifications, whether the Department inspects the work or not. The presence of an Inspector does not legally relieve the contractor of the responsibility to comply with all the contract requirements. Inspectors and Project Supervisors can’t catch everything. However, they do have a duty to point out defects in workmanship or materials to the contractor as soon as they recognize them.

On occasion, the Department accepts work at a reduced price that does not totally meet the specifications. This process usually involves the contractor submitting a proposal as described in Subsection 100 of this manual. The Resident Engineer then consults with the Designers and other technical experts regarding the merits of the contractor’s proposal. The Resident Engineer must examine the cost involved in accepting substandard work. This should include the life-cycle costs to the Department, especially any higher operational and maintenance expenses.

If the contractor's proposal is accepted, the Resident Engineer must document the acceptance by change order or letter agreement. Some form of documentation needs to take place.

Additionally, for federally funded projects, ADOT has a stewardship agreement with the FHWA which requires all work to be constructed in strict compliance with all plans and specifications, and materials sampled and tested in accordance with the ADOT Materials Quality Assurance Program. Any deviation from these requirements must be disclosed as an “exception” in the Final Materials Certification. The Final Materials Certification is completed in DocuSign and includes the Exception Report, Materials Sample Checklist, and Certification Log. The Resident Engineer and Materials Coordinator should document circumstances related to any exceptions at the time they occur for inclusion in the Final Materials Certification. For materials-related exceptions, contact the Regional Materials Engineer to ensure the exception is addressed properly to both minimize any decrease in quality or performance of the finished product and ensure consistent administration statewide. An Exception Report Template is available by contacting the Materials Group, and serves as a guide for properly documenting exceptions and includes examples for exceptions which are more common. A Materials Sample Checklist for each project may be downloaded from the Materials Group website. A Certification Log Template is available on the Materials Group website.

105.05 Restricted Performance Specifications

This is a seldom known and little-used specification which can save Resident Engineers and Project Supervisors much frustration when contractor field personnel keep trying to push construction tolerances to their limits. The most obvious example is the concrete foreperson who tries to save materials by forming and pouring everything 1/8 to 1/4-inch smaller in dimension. Clearly this is not the intent of the Project Plans or Standard Specifications. More subtle examples include equipment that arrives on the job site that is not correctly adjusted or designed to produce materials or a finished product in the middle of the tolerance range or at the target values specified.

105.06 Coordination of Plans, Specifications, and Special Provisions

This Subsection is used to resolve conflicting specifications or contract requirements found in different contract documents. The basic philosophy is that the project Special Provisions, Project Plans and Supplemental Agreements are site-specific and should take precedence over the more generic contract documents such as the Standard Drawings and Standard Specifications. In turn, these documents should take precedence over the MUTCD, AASHTO, and ASTM specifications when conflicts arise involving these documents.

On projects in which local government work is involved, city or county construction specifications are often cited as the requirement for certain portions of the work. When a discrepancy or conflict exists, the basic philosophy discussed above still applies; go from the site-specific to the more generic contract specifications. In the case of local government work, the order would be:

1. Supplemental Agreements
2. Special Provisions
3. Project Plans
4. City or County Standard Drawings
5. City or County Specifications
6. ADOT Standard Drawings
7. ADOT Standard Specifications

Keep in mind, local government specifications do not apply to general contract provisions such as bidding requirements, control of work, or prosecution and progress. In this case, the Special Provisions and ADOT's Standards Specifications apply exclusively.

Override Documents

There are some types of government documents that are not part of the construction contract that can override anything specified in the contract. State laws and federal regulations are examples. The contractor is not required to do anything that violates the law or a government regulation.

The more typical problem that a Resident Engineer or Project Supervisor encounters concerns prior agreements ADOT has made with other government agencies, local communities, or individuals. These could involve intergovernmental agreements (IGAs), 404 permits, Right-of-Way agreements, or environmental impact statements.

These documents obligate the Department to construct something or conduct construction operations in a certain way. When there is a conflict or discrepancy with the contract documents, a supplemental agreement is usually needed to bring the construction contract into compliance. For example, if the Project Plans show a 6 foot high noise wall and the Department has signed an IGA with the city to build a 8 foot high wall, the Resident Engineer must execute a supplemental agreement with the contractor to build the higher wall.

ADOT's Project Manager should be involved when these types of changes are needed. The Project Manager is responsible for coordinating and tracking these kinds of agreements on behalf of the Department.

105.07 Cooperation by Contractor

The intent of this subsection is to have someone from the contractor's staff who can represent the contractor at all times on site safety, traffic control, and quality issues. This representative does not need to be someone at the superintendent level. It's more important that this person be empowered to take immediate corrective action when instructed by the Department. If this person refuses or hesitates to take immediate action, then the only recourse may be to require the presence of a superintendent full-time on the project site.

105.08 Cooperation with Utility Companies

Utility relocation work is a common occurrence on most highway projects. In fact, several specifications have been set up to deal with utility related work. These subsections include:

Subsection	Description
104.06	Utility work done on the project by third parties under permit
105.08	Relocation work done by utility companies on the project site
105.12	Inspection of contractor's work by utility companies
107.15	Protecting utilities during construction

Subsection 105.08 deals with utility conflicts at the project when conflicting utilities are relocated by the utility company. The Department does its best to have all utilities that may conflict with the project work adjusted or relocated before the contract is awarded. The Department also tries to accurately represent what utilities are at the project site. Occasionally, utilities and utility work do conflict with the contractor's work.

Unless the Subsection 107.15 of the Special Provisions or Project Plans warn the contractor about specific utility work going on within the project, the contractor is generally entitled to additional compensation when utility work conflicts with project work. In addition, if the project's controlling item at the time is delayed, the contractor may be entitled to a time extension including costs for extended overhead.

Some utility conflicts are the result of utilities discovered by the contractor during construction that are not shown on the Project Plans or mentioned elsewhere in the contract documents. In these cases, the utility conflict is handled like a differing site condition (see Subsection 104.02 of this manual). Then the question is whether the contractor should have known about the utility and adjusted the construction work accordingly?

Utility conflicts can be a very costly matter for the Department. The Resident Engineer must take an active role in managing these situations. The Resident Engineer shouldn't hesitate to involve the Project Manager or ADOT's Utility and Railroad Section if help is needed in dealing with a utility company. The Utility and Railroad Section is responsible for coordinating proposed project work with utility and railroad companies, and preparing and processing agreements with these companies. See Subsection 107.15 of this manual for further information.

105.09 Cooperation Between Contractors

This subsection applies when:

- Two or more contractors are working at the same time on the same project
- Two or more contractors are working on different projects but have to tie their work together

Getting contractors to cooperate with each other can be challenging at times. Even with this subsection contractors may have difficulty cooperating. As soon as a contractor's access is restricted or the contractor has to perform work out of sequence, the contractor may attribute the difficulties to the adjacent contractor. Attempts by the Resident Engineer to order the contractors to cooperate may do nothing to diffuse the situation.

Resident Engineers must take a leadership role when contractors have difficulty cooperating. Anticipating areas of conflict and meeting ahead of time to resolve common issues are the best ways to keep contractors working together. Some Resident Engineers conduct regularly scheduled coordination meetings in an effort to get contractors to work together. Ultimately, if contractors do not cooperate and damage or hinder each other's work, it is usually the Department that ends up paying for the damages.

105.11 Authority and Responsibility of Project Supervisor and Inspectors

Project Supervisor

The Project Supervisor serves as the Lead Inspector for the project. The primary responsibility of the Project Supervisor is to oversee the Department's inspection operations at the site.

Most ADOT projects require a team of Inspectors, material testers, surveyors, and other specialists who must work together to inspect and document the project work. The Project Supervisor ensures that there is a single coordinated effort at the project site to effectively inspect and document the work. The Project Supervisor must handle other project oversight responsibilities such as safety, traffic control, and government regulation compliance.

Duties of the Project Supervisor include:

- Day-to-day inspection staffing and scheduling
- Project-wide monitoring of the contractor's operation and construction schedule
- Enforcing and explaining the Project Plans, Special Provisions, and other contract specifications
- Coordinating the documentation and payment of contract work
- Resolving site issues with the contractor's field staff
- Performing quality control over inspection work, site materials testing, and project documentation
- Maintaining the project as-built plans
- Interfacing with district surveyors, regional material labs, and other off-site ADOT groups that support the inspection and testing efforts for the project
- Inspecting and documenting the work as needed

One of the most important things the Project Supervisor can do on site is to anticipate the contractor's work, then figure out the inspection and testing requirements ahead of time.

The Project Supervisor should be the on-site expert for what is contained in the Project Plans, Special Provisions, and other contract documents. By proactively reviewing the plans and specifications, then discussing the contract requirements with the contractor's superintendent, the Project Supervisor can prevent many of the conflicts that arise between the Inspectors and the contractor's production staff. In most cases, these conflicts are either resolved ahead of time by the Project Supervisor or escalated to the Resident Engineer, limiting the Inspector's involvement. The Project Supervisor helps the Resident Engineer resolve site related issues with the contractor. The Project Supervisor does not have the authority to waive or alter the provisions of the contract, but can provide valuable information on how an issue developed and conduct the necessary research (contact Project Designers, review contract documents, talk to ADOT technical sections, etc.) to get the issue resolved.

Inspectors

Inspectors have two important responsibilities. The first and primary responsibility is to require the contractor's work and site activities to conform to the contract plans and specifications. Plans and specifications describe in detail the work that is to be constructed including the materials to be used, the workmanship required, and certain construction procedures to be followed. The plans illustrate graphically the various elements and components of the project. The specifications describe in words the materials and workmanship required.

The second responsibility is to accurately document the level or degree of conformity of the contractor's work with the plans and specifications.

Inspection duties include:

- Observing and measuring the contractor's workmanship, materials, and methods for compliance with the plans and specifications
- Communicating to the contractor's field staff the contract requirements for work under construction or about to be constructed
- Assisting the contractor with reading and interpreting the plans and specifications
- Determining the intent of the specifications when necessary
- Documenting inspection observations and measurements including summaries of labor equipment and material usage
- Measuring work for payment
- Observing construction operations for general compliance with safety regulations, traffic control requirements, and construction-related government regulations (air quality, noise levels, erosion control, equipment licensing, federal aid requirements, etc.)

Inspecting Work in Progress

Although Inspectors are not required to inspect an item until it is complete, the Department encourages Inspectors to periodically observe and inspect work in progress to assist the contractor in avoiding rework and stoppages. The contractor should be notified of noncompliant work as soon as it is detected. If the contractor fails to correct the non-compliant work, a verbal notice, then a written noncompliance notice may be issued in accordance with Exhibit 105.11-1.

For example, the inspection of reinforcing steel for a bridge deck can take place once all the rebar has been completely installed and tied. However, should there be an error in the bar spacing in the bottom mat, considerable time and effort would be expended by the contractor to correct this deficiency. Simple periodic checks of the rebar placement operation by the Inspector could potentially avoid this problem.

When conditions arise at the project site that make compliance with the plans and specifications impractical or completely unreasonable, the Inspector should immediately notify the Project Supervisor or Resident Engineer.

The Inspector as a Buyer for the Taxpayers

The Inspector is the Department's point of acceptance for most contract work. The Inspector is also a buyer of construction work. The Inspector accepts work the contractor produces and then fills out a diary to pay for that work.

The Inspector's objective should be to get the expected value or quality for the price the Department is paying. In other words, the Inspector's job is to ensure the Department and taxpayers are getting what they're paying for. This doesn't necessarily assume dishonesty on the contractor's part. The Inspector is there to assist the contractor with the contract documents and review work in progress so that produced construction work meets or exceeds the Department's standard the first time. This is how inspectors get the best value for the taxpayers and help avoid the rework, contract disputes, work stoppages, confrontations, and high risk associated with after-the-fact acceptance.

Inspector and Contractor Relations

The Resident Engineer and Project Supervisors should keep in mind that the most important relationship at the project site is between the Department's Inspector and the contractor's foreperson or superintendent. Part of the Resident Engineer and Project Supervisor's responsibility is to ensure that this relationship is a productive and cooperative one.

Some Project Supervisors go out of their way to cultivate and protect this relationship by ensuring two-way communication and timely feedback between the parties. They should guard against confrontation by mediating disputes, resolving personality conflicts, and escalating issues quickly so that the effectiveness of the relationship is not diminished.

Subsection 104.01 discusses ways in which the Inspector can effectively get along and enhance his relationship with the contractor's staff and how to enhance the Inspector's relationship with the contractor.

Cooperation by Contractors

The contractor has a duty to cooperate with the Department's Inspectors (see Subsection 105.07).

The contractor must provide:

- Adequate warning about work requiring inspections (105.12 & 108.04)
- Adequate time for inspections to be completed (105.12)
- Accessibility to the work to be inspected including assistance (105.12)

The contractors often get so focused on their work that they often overlook their obligations to the Inspector. The Inspectors and the Project Supervisor should be proactive in bringing up potential inspection issues such as sufficient warning, adequate time to inspect, and suitable access to the work. Sometimes it requires constant reminding to get the contractor to be a little more accommodating. But keep in mind, if the contractor is producing high quality work efficiently, then the Department is getting what they want most from the contractor and the Inspectors should be a little more flexible about timing and access requirements. It's only when contractors are producing marginal work that they should be fully obligated to cooperate with the Inspectors.

105.12 Inspection of Work

Inspection Fundamentals

Inspection, in its purest form, is simply a measurement for compliance. Measuring is the act or process of regulating to a standard, while compliance means conformity in fulfilling official requirements.

When you inspect, you measure (or observe) something and then compare your measurements to the requirements of the work. The requirements are described in the contract documents (Project Plans, Special Provisions, Standard Specifications, etc.).

Construction work requirements can be divided into five elementary categories:

1. Layout
2. Material Properties
3. Dimensions
4. Workmanship
5. Performance

Any contract specification that describes construction work will fit into one of these five categories, and completely describe the work.

Inspectors can use this important information to greatly improve their effectiveness. This will be discussed in greater detail later. For now, let's more fully describe the five categories and suggest a memory aid so you can instantly recall them in the field:

Category	Examples Include	Mnemonic
Layout	location, elevation, grade, horizontal control and other survey related information	Let

Material Properties	type, gradation, strength, compaction, density, grade, certification, stability, prestress, binder content, temperature, cure time, and color	Me
Dimensions	spacing, length, width, thickness, height, clearance, slope, diameter, and other shape related information	Detect
Workmanship	finish, appearance, cure, edge and connection treatments, texture, and handling	With
Performance	smoothness, pressure test, bacteria count, pour rate, flow rate, waterproof, and mortar tight	Pride

Now you may ask, "How can remembering these five inspection categories make me a better Inspector?" As mentioned earlier, all five categories completely describe the requirements of any work to be constructed or even manufactured (such as aircraft engines, furniture, and circuit boards). When Inspectors are examining work under construction, they should continually ask themselves these five questions:

1. What are all the layout requirements for this work
2. What are all the material properties that materials used in this work must comply with
3. What are all the dimensional requirements for this work
4. What are the workmanship requirements
5. What are the performance specifications the completed work must meet, if any

Then the Inspectors search through the contract documents for all the answers to these five questions. This should be a systematic search by answering one question at a time. By following this approach, Inspectors will gain a thorough and complete understanding of the contract requirements for the work to be inspected.

Most Inspectors take the opposite approach to determining the work requirements. They search in the appropriate sections of the contract documents for any type of specification related to the work. They may find a material specification in one section, a dimensional requirement in another, and eventually they find all the specifications related to the work. Then they may see something at the site that doesn't look right and do a brute-force search of the contract documents to find the requirement the contractor must meet. After much effort, they eventually get an overall view of the work requirements.

Although there is nothing wrong with randomly searching the contract documents to catch all the work requirements, this approach alone leads to a greater chance of overlooking important contract requirements when inspecting unfamiliar work. The systematic approach described previously is a more complete way of capturing all the contract requirements for a particular item of work.

Both approaches should be used together—a random search of the contract documents followed by a review of the five questions. This is the best way to ensure Inspectors have a complete picture of all the contract requirements.

Construction Rework and Additional Inspections

Occasionally it is appropriate to charge the contractor for additional inspection work. To be fair, the Resident Engineer should be careful about how and when contractors are charged for additional inspections.

The Department's policy on back charging contractors is based on the belief that we are partners with the contractor. Both the Department and the contractor must be flexible in accommodating each other's schedule. The other belief is that sometimes contractors make honest mistakes. Back Charging the contractor for additional inspections done when fixing honest mistakes only adds insult to injury and is inappropriate.

Back Charging is appropriate when:

- The contractor chronically refuses to cooperate with the Department's Inspectors about adequate warnings for inspections that result in additional overtime expenses
- The contractor repeatedly makes the same mistakes and won't change construction methods to eliminate or reduce defects
- The contractor attempts to alter already accepted work without notice to or the approval of the Department's Inspectors

District Engineers will usually support back charges to the contractor only when there is documented evidence of a chronic lack of cooperation by the contractor. Some prior attempt must also have been made by the Field Office to resolve the issue with the contractor through the partnering escalation process.

When inspecting unique items of construction (such as electrical and mechanical equipment installations) Inspectors should take advantage of the experience and expertise of the equipment supplier. Often these people have their reputation to protect and will help the Inspector ensure the contractor installs and uses their equipment correctly. In addition, ADOT may have its own in-house experts who can assist the Inspector with reading and interpreting specialized contract requirements.

Why Document Inspection Work?

Many Inspectors question how much documentation of construction and inspection activities is needed. Some Inspectors question why they need to document at all. Others are unclear as to the value of good inspection records.

Unfortunately, there is not one good reason why it's important for Inspectors to document contract work and inspection observations. However, there are several reasons when looked at together that offer a compelling argument for good record keeping by Inspectors.

Reason 1:

Historical information on how the work was constructed is valuable in the future if a project has to be modified or rebuilt to solve a future transportation or traffic problem. Good inspection documentation will instill in future Planners and Engineers confidence in what is there and how well it is built. In addition, if there is a failure of a structure, pavement, or other project component, the Inspector's diaries can be helpful in ruling out possible modes of failure.

Reason 2:

Recording of an Inspector's observations and measurements provides valuable quality control information. This information can be used to identify performance trends, as well as determine a level of confidence in accepting work that may be marginal in other areas. More importantly, inspection documentation indicates to ADOT management, taxpayers, the FHWA, and other customers that there was an authentic compliance and quality control effort at the project site. This documentation also indicates how effective that effort was.

Reason 3:

Pay quantities are required to be measured and documented for contract payment and tracking purposes. Part of the Field Office's role is to pay the contractor for work performed. Inspectors are best suited for paying for contract work since they are the closest to the work. Good documentation of pay quantities is needed to avoid underpaying, overpaying, or double-paying the contractor for completed work.

Reason 4:

Regardless of the notice requirements in Subsection 104.03, contractors often notify the Department after the fact regarding additional compensation for work already performed. The Inspector's diary should represent a summary of the day's construction activities assigned to the Inspector. In addition to recording inspection observations and measurements, Inspectors should summarize labor, material, and equipment usage, delays, breakdowns, idle time, inefficiencies, work accomplished, and other important events that affect or explain the contractor's progress. Proficient record keeping by Inspectors has saved the Department thousands of dollars in overpayments to contractors for extra work performed.

Reason 5:

An Inspector's diary is a communication device or tool. It tells others what the Inspector did that day and what went on at the construction site. Documenting inspection work directly communicates the level of professionalism and conscientiousness an Inspector applies to his or her work. Inspectors—more than anyone else in a state highway agency—are expected to document their day-to-day work activities. Secretaries don't keep diaries, nor do Materials Engineers or highway maintenance workers. Only Inspectors are charged with the daily duty of recording the activities and events that surround them. The taxpayers of this state and the Department place a lot of faith in their Field Inspectors to assure the quality and durability of our roads and bridges. A well-written, comprehensive diary is one of the best acknowledgments of that faith an Inspector can give.

Daily Project Diaries

The Resident Engineer is required to keep a daily diary on each project and each inspector and supervisor who is assigned responsibility for any project operation is required to keep a daily diary. Each inspector’s diary should provide detailed information concerning the specific phase of work they are assigned to.

Entries should be on the appropriate form, written legibly, in ink and signed at the end of each day or entered into PEN. Dairies should be kept in such detail and manner that new personnel could take over the work at any time.

A partial list of items to be noted in a dairy:

- Weather
- Orders given to the contractor
- Important discussion with the contractor or his representatives
- Official visitors and inspections
- Work or materials rejected and reasons
- Time of shutting down or resuming of work and explanations of the delays
- Work done by contractor’s forces during the day, including the location of the work
- Accounting for any time spent by contractor’s personnel or equipment on disputable items of work and especially any work, which might be the basis of a claim
- Arrival and departure of major equipment
- Record of important phone calls, conversations in the field and/or emails
- Unusual conditions, if any such as high water, bridge construction problems, slides, unsatisfactory sub grade or foundation conditions, detour conditions, etc. Care should be used when explaining hazardous conditions
- Progress of staking and surveys
- An up-to-date inventory of contractor’s equipment and list of the contractor’s work force
- If problems are noted, explain the steps taken to correct them

All diaries are the property of the Department and shall be filed as a part of the project records. A good diary can provide valuable information and evidence in the event controversies arise. There should be no personal information entered in the project diaries.

Construction Inspections with Quantlists

Construction Inspection Checklists AKA “Quantlist” have been developed to memorialize inspections at key points in the construction process. Quantlists also serve as a reinforcement to the Department's Standard Specifications and Construction Manual, while ensuring contractor quality and uniformity within their construction processes. quantlists assist inspectors in performing acceptance inspections on most disciplines involved in highway construction projects. Quantlists may also serve to assist new inspectors in learning what to look out for during an acceptance inspection. However, inspectors should not rely on the quantlist alone and must read all relevant contract documents to ensure necessary compliance.

At the ADOT Construction and Materials Group website you will find a downloadable guide titled “Quantlist: A Comprehensive Guide”, this guide provides a more detailed explanation on the following information.

What is a Quantlist

A quantlist is a quantitative checklist, which converts attribute information into a weighted number score according to the gravity or necessity of individual attributes and how the lack of completing said specific attributes may adversely affect the quality of a finished product. This in turn allows for an objective evaluation of construction processes and the review of specification changes. Each attribute in a quantlist references the most recent specification, each specification should be reviewed independently for additional details by the inspector prior to performing any acceptance inspection. The intent of a quantlist is to affirm quality requirements at the beginning of a project, assure construction processes are in control and stabilized throughout the duration of the project and that the final product meets the Departments quality goals. Quantlist attributes complement the Standard and Specifications, ADOT Construction Manual - Subsection 105.11 Authority and Responsibility of Project Supervisor and inspectors, 105.12 Inspection of Work, and inspectors daily diaries. In doing so, quantlists serve to reinforce the Department’s quality and craftsmanship requirements. It should be noted that quantlists were developed as an aid to the inspector and do not include all items to be inspected; inspectors should not rely on the quantlist alone and must read all contract documents to ensure necessary compliance.

Setting Expectations

One quantlist should be completed after each construction process change until the process is in control and stabilized to the satisfaction of the Engineer. Once the process is in control, the minimum number of quantlists must still be completed. Inspectors should always document any reason for reducing the quantlist frequency in their daily diary. Throughout the life of a project, the Resident Engineer and Project Supervisor should continuously track the project's quantlist frequency compliance.

Printable hard copies of all quantlists are available for inspectors to use in the field. However, quantlists can only be and must be completed in the PEN System on the daily diary associated with the work. It is not acceptable to only complete hard copies. Additionally, the inspector’s daily diary must identify that a quantlist has been completed and a quantlist must be reviewed by the Project Supervisor. Quantlist are to be completed at the required frequency. In order to obtain an accurate measurement of the contractor’s workmanship, the quantlist must capture the results of each attribute at the time of the inspection.

Quantlist Frequency

Each quantlists has its own specified time as to when it should be used to perform an acceptance inspection. These specified times vary greatly and should be strictly adhered to throughout the life of the project. The minimum quantlist frequencies can be found in the current Quantlists Versions and Minimum Quantlist Frequency chart. This information is available on the Construction & Materials Group, Quantlist web page on the ADOTNet or the internet. This guideline also shows the corresponding Standard Specification numbers and most recent versions of each quantlist.

Tracking Quantlist Frequency on a project

Quantlist frequency should be tracked and checked regularly by the Project Supervisors throughout the life of a project. The mandated frequency requirements are set by ADOT in Construction Bulletins 02-04, 06-01, 07-01 and are designed to meet the project documentation requirements set by the FHWA. It is paramount that the quantlist frequencies be consistently adhered to, failure to follow the mandated quantlist frequencies can cause issues with quality control on a project. Frequency compliance will be reviewed during the Department’s Internal Construction Quality Assurance Group audits, FHWA audits, and the Arizona Auditor General’s Office audits.

Quantlist Tracking Through Reports

Various statistical reports regarding past performance of completed quantlists that can be accessed on the ADOT Data Warehouse web page on the ADOTNet Reports will be found under “Pen / FAST Reports”, “Quantlist Tab Info”. The information gathered here can be compiled per project and by date utilizing the “Quantlist Frequency Table Processor” also found on the Construction and Materials, Quantlist web page.

Quantlist Scoring

Quantlist scoring is based on the severity of the attributes on the quantlist being used, e.g. an attribute requiring a certification of compliance or analysis will be weighed less than an attribute with a safety or environmental requirement. The weight definitions are as follows: Non Applicable (NA), Administrative, Minor, Major, and Critical each weight is assigned a value that is compiled after the quantlist is completed and submitted resulting in a percentage score.

After the submission of a quantlist a compliance percentage score will be displayed. Quantlist don't necessarily have a minimum passing score to be considered acceptable in the field. However, some projects may have a contractor Incentive associated with their overall quantlist scoring, this information will be found in the project specific special provisions. All narratives in a quantlist found to be in non-compliance, should be corrected by the contractor unless approved “as is” by the appropriate authority and Project RE.

Communicating Expectations With Your Contractor

Prior to a contractor starting work on any major construction disciplines, a pre-activity meeting should be held in accordance with a project's Special Provisions. The inspectors should obtain any and all current updated copies of quantlists that may be relevant to the discipline being inspected. The Project Supervisor and field inspector should discuss the Department’s quality expectations for each attribute covered by the quantlists with the contractor during these pre-activity meetings.

Before Performing Acceptance Inspections

Prior to performing any Acceptance Inspection utilizing quantlists, inspection preparation is crucial. Inspectors should investigate and or review the discipline being inspected, even if the inspector is already familiar with the discipline being inspected; specifications change and may be updated without notice. This discipline review process can be accomplished by utilizing the project guiding documents and ADOT specifications, e.g. Project Special Provisions, Project Plans, ADOT Standard & Specification, C-Standards & SD-Standards, ITS Standards, Electrical Standards, ADOT Sampling Guide - Appendix C, Construction Bulletins, and Policy Procedure Directives - AKA PPDs.

The inspector should also discuss the Department's expectations with the contractor; discuss what narratives are on each of the quantlist with the contractor in a pre-activity meeting. Additionally, some contractors may request a copy of the finalized quantlist after each inspection. This should be a formal process for project tracking purposes, utilizing email or DocuSign works best, this process should also be addressed and agreed upon in the pre activity meeting. Finally, if the contractor has not requested an inspection, then notification of the upcoming inspection to the contractor should be formally issued at least 24 hours in advance, earlier if at all possible. Surprising the contractor with an inspection can cause resentment and partnering issues on a project; remember your job is not to catch the contractor making a mistake, but instead to assist the contractor in preventing mistakes from ending up in the final product. It is beneficial to both parties to be open and transparent when performing any type of inspection.

Performing Acceptance Inspections

If at all possible, all “Acceptance Inspections'' should be performed with a contractor’s representative present. Clearly establish and agree upon the limits of the inspection with the contractor's representative, i.e. where does the inspection start & stop and what you will be looking out for. Remember to take note of who the contractor's representative was (full name & position), what quantlist narratives were found to be deficient, along with the location of each deficiency if applicable. Taking photos of any areas of concern can be extremely useful in relocating the deficiency, when performing a reinspection, discussing issues with the Project Supervisor / RE, when notifying the contractor of a non compliance, and if a representative was not present during the Acceptance Inspection.

Following Acceptance Inspections

Review quantlist results with the contractor’s representative. If a contractor representative was not present, the inspector should notify the contractor of any non-conformance items that were found in a timely manner. A concise description of the acceptance inspection should be documented in your daily diary. This description should include: Who requested the inspection or why Inspection is being performed, arrival time, ambient temperature, weather (sunny, cloudy, raining), the inspection location/limits, what discipline was being inspected, any non-conformance issues, what additional work was being performed within the immediate area, the contractor's representative present during the inspection, along with any discussions of note that were related to the acceptance inspection, and finally your departure time.

Non-conformance

For each Attribute the inspector is required to mark Yes, No, or NA (Non Applicable) under the compliance dropdown. If an Attribute is marked as “No” under the compliance dropdown, the inspector has the option to select “Follow Up Required” prompting a reinspection. If this follow up option is chosen, when creating a new quantlist of the same type you will be required and must perform a reinspection until the deficient attribute has been marked as “Yes” under the compliance dropdown. Followup inspections for each non-conformance attribute will also need to be documented within the inspectors daily diary capturing all of the aforementioned data. A followup quantlist should be completed (at a minimum) for any initial quantlist that was scored ‘No’ on any attribute(s) weighted 4 (major) or 8 (critical). All corrective actions should also be documented in the inspector’s daily diary.

Once the contractor has corrected the nonconformance, the inspector should create a new quantlist and perform a reinspection. Inspectors should note all corrections made by the contractor in their daily diary under the section the quantlist is noted within.

If the contractor disputes a narrative requirement that has been marked as NO by the inspector, the inspector should immediately contact their Project Supervisor per the partnering escalation process. The Project Supervisor will then review the contractor's non-conformance request with the RE. If after review and only after contacting the appropriate authority, a Resident Engineer may decide to accept the non-conformity. In this instance the inspector should still select the NO option but must explain the justification as to why the non-conformance was accepted and noting the authorizing authority within their daily diary.

In the rare instance that a non-conformance was not corrected and was not accepted by the RE, the inspector will retain the default value of NO and should comment as to why the attribute was not corrected by the contractor within their daily diary. Remember to include facts only, no comments related to your personal feelings should be included within your Daily Diaries.

Independent Quality Assurance Inspections

The Quality Assurance Group (QA Group) is tasked with performing the independent reviews of statewide ADOT construction projects utilizing quantlists. The QA inspector will contact the unit for an updated contractors schedule, If any activities are of interest, an onsite visit will be scheduled with the Project Supervisor. These inspections are required by the Federal Highway Administration (FHWA) to ensure the funding provided is receiving the best quality product from the contractor and the field office.

Once an independent QA inspection has been conducted, any non-conforming attributes marked as "NO" on the quantlist will be discussed with the Resident Engineer and the Project Supervisor in an out-briefing. A QA inspector will then generate an initial QA Inspection Report, listing the non-conformities from the same quantlist completed during the initial inspection. The project Unit will have 14 calendar days (more time can be formally requested by the RE or project supervisor, reason as to why must be provided) to provide any missing documents or provide proof that any non-conforming items were corrected by the contractor. After the allotted time frame, the QA inspector will compile any updated information received from the Unit and/or may perform a re-inspection (if necessary) to create a new quantlist reflecting the efforts to correct the non-conformance issues found in the field.

Quantlist Correlation Inspections

Inspection quantlist attribute results between field inspectors and QA inspectors can vary considerably. Interpretation of quantlist attributes and the time frame at which quantlist inspections occur were found to contribute to these discrepancies. This variation in interpreting attributes can cause a number of issues on a project, such as, missed deficiencies not conforming to the Departments expectations, contractor QC / ADOT inspector frustration, and considerable frustration from contractors who are told they need to perform work one way by an inspector only to have another inspector tell them they need to do the same work in another way. To combat the issue of varraying interpretation of attributes and to achieve consistency throughout the Department, Quantlist Correlation Inspections have been implemented.

Quantlist Correlation Inspection is an inspection of a product using quantlists that are completed by a field inspector and the QA inspector at the same time and same location but independent from one another. The quantlists are then compared to each other for discrepancies in an attempt to identify the misinterpretation of a quantlist attribute.

These inspections can be extremely useful for new inspectors in learning how to look up quantlist related specifications and interpret these specifications and project documents. In addition, this process can be a useful tool for more seasoned inspectors, by establishing what the Department’s conformance expectations are in relation to the work being performed on a project by the contractor. Additional Correlation Inspection information may be found in Construction Bulletin 07-01.

105.13 Removal of Unacceptable and Unauthorized Work

ADOT Inspectors can accept and reject contract work. They have a duty to immediately inform the contractor about any workmanship, methods, or materials that do not conform to the plans or specifications. When work or materials are rejected, the Inspector should make the reasons clear for the rejection. Whenever possible, don’t just quote specifications; explain the reasons why it is important for the contractor to comply.

Be careful not to make a rejection look like a failure on the contractor’s part. The Inspector should view rejected work as good intentioned work that was just misguided. The hardest part for most Inspectors who reject work is handling the contractor’s response. Here are some points to keep in mind as you and the contractor try to work through the difficulties:

- Maintain your respect for the contractor's field staff. If it seems they are not listening or they are attempting to do things underhandedly, give them the benefit of the doubt. Often they are under pressure to produce and occasionally lose perspective of what is best in the long run for the project
- Listen to the contractor's explanation. Acknowledge that you understand why the work turned out the way it did
- Be supportive of the contractor's predicament. Instead of shifting the problem entirely to the contractor, express your willingness to work through this problem
- Avoid personality conflicts. If you make a rejection look like a test of wills between you and the contractor, somebody ends up losing every time. Instead, stay focused on both the work and the specifications, and avoid assigning or shifting blame
- If you and the contractor can't work out a mutually acceptable solution, escalate the problem quickly. Don't let a confrontation or the threat of one postpone corrective action

At a fundamental level, you should view the contractor as a partner and equal. No matter how tough things get, if you can fix this perspective solidly in your mind and behave accordingly, most contractors will feel you are treating them fairly and impartially. Truly seeing the contractor as a partner and equal will make you say the right things and behave honorably and professionally without having to think about specific behavior patterns to follow.

When work has been rejected, the contractor has several options:

- Immediately fix the problem
- Remove and replace the rejected work
- Submit a proposal as described in Subsection 100 of this manual for acceptance of the work (usually some type of alteration to the work is involved)
- Fix the problem later, but before other work is affected

The decision as to which option to pursue is entirely up to the contractor. However, as the contractor's partner, you should assist the contractor in working through this decision, but in no way should you assume any responsibility for making the decision. Often the contractor will ask what you would like them to do and try to shift the problem over to the Inspector. Be careful. Inspectors cannot direct the contractor's work. All you should do is advise them on what the plans or specifications require and avoid telling them how to achieve those requirements.

The management and direction of the work are the contractor's business. However, if methods are employed which the Inspector has reason to believe will be detrimental to the quality of the finished work, give notice to the contractor accordingly and immediately advise the Resident Engineer. The Inspector should not attempt to supervise the contractor's work or give any appearance of doing so.

Suggestions can also be dangerous. If the contractor relies on your suggestion and the work doesn't turn out as everyone expected, guess who the contractor is going to blame? Inspectors and Resident Engineers should be helpful while thoughtfully assessing the risks involved before giving advice to the contractor.

105.14 Load Restrictions

On Public Highways

The Arizona Revised Statutes require that all loads hauled on public roads in Arizona comply with the limits stipulated in the statutes (except those which are authorized in writing by the Transportation Board to exceed such limits). The Transportation Board has designated the Enforcement Section of the Motor Vehicle Division (MVD) as its agency to administer this part of the law, determine policies pertaining to extra-legal loads, and grant permits for such loads and collect fees for the permits.

Any load restriction issues should be discussed with the contractor first. ADOT construction personnel are not expected to be MVD enforcement officers, but they are expected to notify and cooperate with the MVD when they believe anyone coming to or from the project site is violating legal load restrictions. ADOT maintains roads as well as builds them, and no one should be allowed to damage our pavements including our own contractors and Material Suppliers. The same applies to city and county roads.

Within Limits of Construction Projects

The following guidelines have been prepared for project personnel in allowing overweight vehicles to haul within the project. These guidelines may be considered written authorization for contractors to exceed legal loads. This written authorization is subject to modification or revocation by the Resident Engineer as provided below:

- Hauling overweight loads on subgrade and base courses (primed or unprimed) will be limited to an axle loading that will not result in undesirable stresses in the structures or the roadbed being crossed. Suitable cover and/or shoring must be provided over pipe culverts and small boxes to protect them from damage and excessive stress. A minimum of two feet of cover is required over any pipe or box culvert before crossing.
- Only legal loads will be allowed to cross bridges (including overpass structures) and hauling will be permitted only after the concrete has attained the anticipated compressive strength required by the specifications.
    - An exception is when structures have been designed in accordance with the "Bridge Construction Overload Policy" (contact ADOT Bridge Group) applied when economics, safety, or other reasons dictate that overload vehicles be allowed to haul excavation or borrow over bridge structures during construction.
    - When overloaded vehicles are used, it is standard practice to cushion the deck with a nominal thickness of twelve inches of suitable material to protect the deck. For additional information refer to the Bridge Design and Detailing Manual.
- Hauling operations over Lean Concrete Base (LCB) and Cement Treated Base (CTB) will be limited to legal loads.
- All hauling operations over new asphaltic concrete, asphaltic concrete finish course, or other types of bituminous mixtures will be limited to legal loads. (See #1 for prime coats)
- All hauling operations over new concrete pavement will be limited to legal loads. Absolutely no hauling will be permitted until:
    - The joints have been sealed
    - The concrete has obtained a compressive strength of at least 3,000 psi
    - The concrete has been in place for seven days
- Whenever practicable, hauling equipment will be routed so as to avoid concentrations of traffic (channelization) in any particular area.
- The weight of loads being hauled will be reduced, or all hauling operations will be suspended when, in the judgment of the Resident Engineer, continuation of the hauling operations being performed will result in distress to any part of the roadbed, base, or pavement structure.
- Special circumstances and conditions affecting structures that are not covered by these guidelines should be submitted in writing to the Structures Section for recommendation.
- Since hopper scales have become more common for weighing items such as AB and AC, a problem has developed in documenting and enforcing legal size loads. In the event this type of scale is proposed, it will be allowed if tare weights of individual hauling units are obtained and documented as follows:
    - Tare weight for each individual hauling unit will be considered acceptable if each unit has been tared within a twelve month period prior to or at the beginning of hauling operations.
    - Tare weights must be provided by an authorized state employee. An acceptable document of tare weights will include (but not be limited to) the date a unit is tared, truck and trailer number, license plate number of each individual unit (or combination)
    - Tare weight of each individual unit.

105.15 Maintenance During Construction

The contractor is expected to maintain finished work until it is accepted by the Department. This includes removing graffiti, sweeping sidewalks, maintaining landscaping, and repairing work hit by traffic.

The contractor may be reluctant to repair newly constructed work at their expense when damaged by the traveling public or by natural causes. However, both Subsection 105.15 and 104.04 place the responsibility of repairs on the contractor.

For example, guardrail and tubular markers have been hit on some projects only days after they were installed. The contractor is responsible for replacing these items at their expense until the roadway is accepted as part of either a partial or final acceptance in accordance with Subsection 105.20. Although the work itself may have been accepted by the Department, the responsibility of maintaining it does not shift to the Department until a formal acceptance of the project, or one of the following exceptions occur:

- The Department orders the roadway opened as specified in Subsection 105.18
- The Special Provisions specify payment for detour work per Subsection 104.04(A)
- Maintenance is required during winter shutdown per Subsection 104.04(B)
- The Resident Engineer orders the contractor to perform maintenance for public safety per Subsection 104.04(C)

Construction Bulletin 21-01 provides guidance to the Districts for when the Department will participate in the repair and when the contractor is to perform the repairs at their cost.

For example: The work to be performed for the project is in the median protected by the contractor’s workzone. There is a guardrail hit and damaged on the outside shoulders which is not within the contractor’s protected work area, the District should look to maintenance forces to repair this guardrail or pay the contractor to repair with an NFA change order.

105.18 Opening Sections of Project to Traffic

To help clarify when ADOT takes over responsibility for maintenance and repairs, project work can be divided into two general categories:

1. Work constructed under traffic
2. Work constructed away from traffic

Work Constructed under Traffic

In this situation traffic runs through the project exposing the work to potential damage by the traveling public. Common examples include shoulder improvements, lane widenings, and passing-lane construction. Lane closures and restrictions are used to control traffic, while phased construction is used to move traffic through different parts of the project. In most cases, a line of barricades and perhaps a small buffer zone are the only means that separate the traffic from the work.

In this case the contractor is responsible for maintaining and repairing work damaged by either the public or natural causes until formal partial or final acceptance is given. Regardless of what construction phases have been completed or what new lanes are opened to traffic, the contractor is still responsible until acceptance.

Work Constructed Away from Traffic

In this situation the work is physically separated from traffic and protected from damage. A detour may be used or the work may be on a new roadway alignment. Traffic cannot get to the area of work.

Under this scenario, the contractor is completely responsible for all damages and maintenance to the work until the roadway is opened to traffic. Of course, this includes maintaining any detours (Subsection 104.04).

When a roadway is opened to traffic, the responsibility for maintenance and repairs depends on why the road was opened.

- If the road is opened formally under a partial or final acceptance, then ADOT assumes responsibility.
- If the contractor (with Department consent) opens the road before all the work is completed or opens the roadway under a substantial completion described in Subsection 105.19, the contractor is still responsible for maintenance and repairs until final acceptance. This also applies to work constructed under traffic.
- If ADOT orders the road opened ahead of its scheduled opening, the Department assumes responsibility, regardless of the condition of the work.
- If the contractor has fallen behind schedule and ADOT orders the road opened after its scheduled opening date, the contractor is responsible for all maintenance, repairs, and traffic control until acceptance.

There are two reasons why the Department holds the contractor responsible for maintenance and repairs until some type of formal acceptance is given. The first has to do with damage to the work by the contractor's own operations. Until all work is completed, the Department does not want to get into a situation in which it has to determine whether damage done to existing work was done by the contractor or by traffic passing through the project. The second reason involves liability for the project. By assuming maintenance and repairs responsibilities, the Department is implying acceptance of the project. This can leave ADOT liable for the work before final inspection or acceptance has been made.

105.19 Substantial Completion

Substantial completion should not be confused with partial or final acceptance. Substantial completion is a point reached in the project where enough work has been completed to stop contract time. Subsection 105.19 defines what work needs to be finished to reach substantial completion. Substantial completion does not necessarily imply acceptance of the work. When the contractor reaches substantial completion, the Resident Engineer holds a final inspection. The final inspection has four objectives:

1. To determine if the project is in fact substantially complete as defined by 105.19
2. To review the completed project work for compliance with the plans, specifications, and the requirements of the district, local government, FHWA, or other important project stakeholders
3. To determine if the traffic can safely travel through the completed work
4. To develop a punch list of items that need to be completed before final acceptance

The Resident Engineer should invite, as a minimum, the District Engineer, the FHWA representative (if the project contains federal aid), local government representatives (when applicable), the Project Manager, the Maintenance Foreperson, and the contractor's superintendent.

The Resident Engineer and the inspection staff should try to be as thorough as possible during the final inspection, leave no stone unturned; check everything. The contractors allocate equipment and staff to finish the project based on the size and complexity of the Department's punch list. What contractors find most frustrating is how punch lists tend to grow after the final inspection. During the final inspection, there should be ADOT Inspectors and Engineers crawling all over the place so a thorough and complete punch list can be developed at the outset.

Substantial completion does not imply acceptance. It does not relieve the contractor of the obligation to finish the rest of the work nor does it relieve the contractor of the duty to maintain and repair work until acceptance.

Once the final inspection is complete, the Resident Engineer should write a letter to the contractor disclosing the results of the final inspection. If project time is stopped, the Resident Engineer should indicate the number of accumulated project days. If a punch list has been developed, the Resident Engineer should attach it. The Resident Engineer should close the letter with a statement to the effect that the contractor is still responsible for maintenance and repairs of any project work until final acceptance.

Within five working days after substantial completion is reached, the Resident Engineer must complete the DocuSign template "ADOT Start/ Completion Memo". The substantial completion notice will be distributed to a list of individuals who opt and/or require this notification. When ADOT's Field Reports Section receives this notice, the completion date is input in the Completion Memo field in the FAST - Contract Card. The completion date should be input into the End Date field in CPE, by the Field Office.

No traffic control shall be paid after substantial completion is given per 701.403(F) or after contract time has expired.

105.20 Acceptance

Acceptance is another important project milestone. This is the point at which all of the work has been completed to the extent that the Department is willing to assume responsibility. We are taking delivery; the work is ours.

This is the Department's last chance to have the contractor fix any problems, repair any damage, or perform any cleanup (see Subsection 104.14). Once the work has been formally accepted any repairs or alterations to that work will require a supplemental agreement.

Since the responsibility for the work shifts from the contractor to the Department, it is very important for the Resident Engineer to make certain that all the required contract work has been completed in accordance with contractor documents. This includes all punch list items and any cleanup work. Any performance tests should be rerun if possible, and the work should be re inspected for any signs of unusual wear, damage, deterioration, or missing hardware.

Keep in mind that the Department can always re-inspect the work even after a final inspection has been performed (see Subsections 105.19 and 105.04). Final inspections are used to determine substantial completion and may not result in final acceptance of the work.

Acceptance Letter

Once all the working drawings are submitted and accepted and all the punch list items and follow-up inspections are complete, the Resident Engineer should write an acceptance letter for the District Engineer's signature. Any assessment of liquidated damages should be discussed and any conditions attached to the acceptance. If there are any unresolved contract issues, they should be summarized as well. It is important to write a final acceptance letter. The letter clearly outlines when responsibility for the work shifts from the contractor to ADOT. Utilize the DocuSign template "Final Acceptance for Construction" to submit the letter. This will ensure all the pertinent individuals receive it. The distribution list includes FHWA on federal aid projects, Field Reports, BECO and many others. When ADOT's Field Reports Section receives this notice, the Final Acceptance date is input in the Acceptance Letter field in the FAST - Contract Card.

Requests for partial acceptance should be disapproved. Disapproval shall be in writing noting reasons for rejection including citing Construction Bulletin 15-04: Partial Acceptance.

Final Acceptance

The final acceptance process can become administratively complex and tedious for the Resident Engineer. Here is a partial list of the things the Field Office should do in preparation for a final acceptance and close-out of the project.

Inspection Before Acceptance:

- The contractor cleanup of: detours, roadway, contractor’s yard and processing sites, and adjacent private land should be completed. Pay particular attention to oil and air filters, material wrappings, crew trash, lumber fragments, AC, striping tape, and survey stakes/flagging
- Develop a punch list. This must be participated in by all project personnel, including the Electrical, Water, Utility, and Landscape Inspectors
- Utilities should be connected and working
- Salvage items are to be removed to a final location
- Any intergovernmental agreements drafted as part of the project must have been complied with. Contact the Project Manager
- Refer to 105.19

Accepting a Project:

- Remember that a project should not be accepted until all materials have been verified as acceptable. This includes certifications, but it also means that concrete poured toward the end of the project must have the cylinders broken before acceptance
- All quantity surveys and measurements must be completed (and preferably undisputed)
- All paperwork needs to be completed. Payrolls must be corrected, quantities checked and submitted to the contractor, and force accounts transmitted and approved
- Letters of acceptance should have been received from landowners, pit owners, etc
- All keys, etc. are to be handed over to the state, utility, or local municipality
- All bills must be paid such as electricity, water, and royalties
- Money is to be deducted for re-surveying, damaged salvage items or other property, or for liquidated damages
- As-built plans must be received and verified by project personnel
- The contractor or manufacturer must conduct meetings on how to operate, adjust, and maintain systems such as the irrigation system or a pump station
- All operating manuals and instruction sheets are to be accepted at the office
- All warranties and guarantees should be transferred to ADOT (or other final owner) as if they were the original purchaser, as specified
- ADOT specifications require the contractor to provide a 6-month warranty for in-service operation of electrical and mechanical components. This should be noted in the project acceptance letter, and a copy should be forwarded to the owner/operators of all the new equipment, along with the Operator's Manual. Include a cover letter that tells these people to route all ADOT complaints/claims through the Resident Engineer
- Final acceptance should only be given when all punch list items have been completed, and the Resident Engineer is satisfied that all of the contractor’s field work is completed. The Resident Engineer should contact both the District Engineer and the Maintenance Foreperson before writing the acceptance letter in case either wants to make one last tour of the project. The Maintenance Foreperson should accept the project before the District Engineer
- Final acceptance should not be given until all working drawings have been submitted and accepted in accordance with subsection 105.03
- Project Close-Out, Refer to Chapter 12

105.21 Administrative Process for the Resolution of Contract Disputes

This subsection is intended to be used on projects that are not partnered or when an issue on a partnered project has not been resolved to the contractor's satisfaction through the escalation process.

Notice Requirements

Subsection 104.03 requires the contractor to notify the Department regarding any work disputes or potential contract claims as soon as they arise. The Resident Engineer needs to be careful about notice requirements. Many inexperienced Resident Engineers have been caught off guard by claims filed for work already completed.

Failure to give adequate notice can be grounds for denying any additional compensation. Resident Engineers try to get the claims disallowed based on lack of notice (Subsection 104.03). However, it is the Department's policy to review any contract claim or issue under dispute, even if the contractor did not provide the notice requirements specified in Subsection 104.03. The Department will consider noncompliance with 104.03 as part of the decision to accept or deny the claim.

The Resident Engineer should inform the contractor of the notice requirements. If the contractor appears to be ignoring the notice requirements, then write a letter advising and warning the contractor of the consequences. Often the Department's contractual interests in a claim can be severely compromised because the Field Office staff did not know that the current work was under dispute and had no opportunity to both mitigate costs and adequately document the work. If in doubt, bring the issue to a head and escalate it (if you must). Most importantly, be proactive and up front with the contractor on any potential project issues.

Often the courts and arbitrators give the contractor much latitude in what constitutes notice. The contractor does not necessarily need to follow the Department's exact procedures in order to meet the written notice requirements. In some cases, a summary in the weekly meeting minutes or a contractor's letter requesting clarification has been interpreted as meeting the notice requirements. The best the Resident Engineer can do is find out the course of action the contractor intends to pursue when a dispute or issue arises.

Dispute-Resolution Process

Subsection 104.03 of this manual outlines the dispute-resolution process for partnered projects. The process is slightly different for projects that are not partnered. The main difference is that there are no escalation meetings. In their place are formal reviews by the Resident and District Engineers.

The dispute-resolution process and time lines are summarized below:

1. The contractor gives verbal notice in accordance with 104.03
2. The Resident Engineer and contractor have two days to resolve the issue
3. After two days, the contractor gives written notice in accordance with 104.03(A)
4. The Resident Engineer reviews written notice with the District Engineer and both attempt to informally resolve the issue within seven days
5. After seven days, the contractor provides a dispute resolution submittal in accordance with 104.03(A) and 105.21
6. The Resident Engineer conducts a formal review within 10 days
7. After the Resident Engineer's review, the contractor has 15 days to request a review by the District Engineer
8. The District Engineer must conduct a review meeting within 15 days of the contractor's request.
9. The District Engineer has 15 days to make a decision after the review meeting
10. After the District Engineer has made a decision, the contractor has 15 days to request a review by the State Engineer
11. The State Engineer must conduct a review meeting within 15 days of the contractor's request

12. The State Engineer has 15 days to make a decision after the review meeting
13. The contractor has 15 days to accept the State Engineer’s decision
14. After that, the contractor has up to 15 days to file for arbitration or mediation if the contractor does not agree with the decision (the contractor may file for litigation up to 2 years after the State Engineer’s decision)

The Resident Engineer should notify the contractor in writing of the result of each review at each level. If the Department denies the contractor's claim, the Resident Engineer should explain the next step and specify the time limits the contractor has for initiating the next step. The intent of the written notification is to avoid any misunderstandings the contractor may have regarding the status of the claim.

The State Engineer is the highest level a claim or dispute can go within the Department. The Director or Deputy Director does not review unresolved issues or contract claims. However, they typically do provide input to the State Engineer when an issue has been escalated to that level, and the State Engineer does discuss review decisions with the Director before they are rendered.

On federal aid projects, the FHWA should be included in the issue resolution process. See Subsection 107.04 of this manual for further information.

105.22 Arbitration of Claims and Disputes

Contract claims are merely unresolved contract changes. Upon project completion, issues arise on a project for a variety of reasons and can be classified as listed below.

Contractor Practices

- Inadequate investigation before bidding
- Incomplete cost estimating
- Unbalanced bidding
- Bidding below costs and over optimism
- Poor planning and use of the wrong equipment
- Failure to follow authorized procedures

Owner’s Practices

- Changes in plans and specifications
- Inadequate time for bid preparation
- Inadequate bid information issued by the owner
- Excessively narrow interpretation of plans and specifications
- Restrictive specifications
- Contract requirements for socioeconomic objectives unrelated to the construction process

Personnel Factors

- Perception of being treated unfairly
- Win-lose attitudes of construction personnel

Institutional Factors

- Lowest bid requirements
- The contracting process

A construction claim involves two key elements: entitlement—which refers to the merit of the claim, and quantum—which refers to the time and costs involved. The contractors can claim just about anything, there are no restrictions in the Standard Specifications for what a contractor can or cannot claim. Of course, what damages, if any, a contractor can collect depend on the merits of the claim and the degree to which the Department is responsible. The contractors cannot ordinarily refuse to do work under a claim unless the work is clearly outside the scope of the contract. The contractor must rely on the remedies in the contract to settle questions of time and costs.

Claims Analysis

The analysis of a contract claim follows the same approach described in Subsection 104.02 for analyzing contract changes. The entitlement element of the claim involves answers to the first two questions regarding what has changed and who caused the change. The quantum element involves answers to the last two questions regarding the impacts of the change and the costs.

Analyzing claims can become a tedious and cumbersome process. This is especially true of delay claims and earthwork claims; the two most expensive types of contract claims on transportation projects. ADOT's Construction Group can assist in claims analysis and preparation. If necessary, outside professional help may also be used by the Department in seeking satisfactory claims resolution. Although the Resident Engineer and Project Supervisor must still direct the preparation of a contract claim, they should be free from extensive and time-consuming forensic analysis so they can proactively run their current projects.

The Claim Defense Package

One of the best ways to present an effective claim defense and to ensure that all the necessary documentation has been assembled and presented is to create a claim defense package. This package can be in the form of a simple bound pamphlet. It should contain all of the appropriate claim information from an overview of the contractor's position to an in-depth cost analysis.

The following format has been used successfully by many Field Offices and is recommended as a good foundation for your claim defense.

Claim Documentation

Accurate and complete documentation is a key element in the successful settlement of contract claims. It has been said that the side with the best documentation wins 90 percent of claim disputes, and that winning a construction claim without good documentation is an uphill battle.

Documentation includes such things as copies of the original contract documents, any addenda, project schedules, inspection diaries, correspondence, telephone conversations, lab memos, pay records, and supplemental agreements. One of the very best forms of documentation is a picture, which can be extremely effective. Since all districts now have video equipment, still photographs can be supplemented by video. A 5- to 10-minute recording while driving through a project on a weekly basis will establish a project time record showing equipment, personnel, and material use as the project progresses. The result is a video "as-built" of the project.

Many claims are dropped or never pursued beyond the notice of claim when the contractor discovers that ADOT has sufficient documentation to successfully defend its position. One case in point is a claim filed by a contractor demanding payment for removal of an unsuitable portion of a bridge deck. At this point, ADOT requested a meeting to discuss the claim with the contractor. When the contractor's representatives arrived, they were confronted with an enlarged photograph that showed the contractor's staff frantically shoveling water and sloping off the bridge deck during a heavy rainstorm. The contractor dropped the $59,028.55 claim on the spot.

When a contractor indicates that a claim may be filed or when it becomes obvious that a claim is imminent, project personnel should enhance their documentation. Section 108 should be used as a guide when preparing claim documentation. This activity will discourage the contractor from filing speculative claims and will facilitate the achievement of agreeable settlements at the project level. Usually claims which are settled at the lowest level are the least costly to the Department. Far less time and effort are required to produce good documentation, including pictures, than to try to defend a debatable claim without them.

Claims Against Design Consultants

Because of the large number of highway and bridge projects administered by the Department in recent years, the services of outside Designers and other consultants have been used more often than in the past. As a result, the Department has experienced more claims filed by contractors based upon purported errors in plans and specifications created by consultants. Any resulting litigation, however, is brought against the Department. At that point, the right to pass damages on to the consultant comes into play.

It is the position of the Department to seek recovery from consultants when a claim is based on a wrongful act of the consultant. In order to recover actual (not merely potential) damages, legal liability must be shown. This could cause a problem as to the issue of liability, especially when ADOT personnel engage in settlement negotiations with a contractor. One way the Department can be protected against the awkward possibility of having to prove the liability issue is to offer the consultant the choice of:

- Approving the settlement
- Taking over the defense of the case and agreeing to hold the Department harmless before any settlement is concluded

If the consultant declines to take either course, then the Department will be free to proceed with the case and will be required to show only potential liability in order to support its claim against the consultant.

The Department requires the Resident Engineer and Project Manager to notify all outside consultants as soon as a design related claim arises. The consultant must be given the opportunity to participate and become involved in all aspects of the claim, even to the extent of offering the defense of the claim as stated above.

The Resident Engineer must coordinate all indemnity claims against design consultants with the Project Manager, who will involve the Engineering Consultants Section. There should be a consensus among the Resident Engineer, District Engineer, and Project Manager regarding the recovery of damages from design consultants. If federal aid is involved, the FHWA should be notified of all potential claims against design consultants. The Assistant State Engineers for both Design and Construction must approve any indemnity claims against design consultants.

106 CONTROL OF MATERIALS

106.01 Source of Supply and Quality Requirements

Subsection 106.01 requires the use of new materials unless noted otherwise elsewhere in the contract documents. New means unused, not previously placed in service, and the same appearance, quality, dimensions, and performance as material direct from the factory or fabrication plant. For example, corrugated pipe salvaged by the contractor from a previous project does not qualify as new pipe. The Resident Engineer may still allow the pipe, but at a reduced unit price. On the other hand, unused concrete pipe that has been sitting in a pipe supplier's yard for a few years may qualify as new if it is undamaged and in the same basic condition as the day it was cast.

Inspectors should be careful about the water the contractor uses for dust palliative, compaction, cleanup, or landscape establishment. Untreated effluent from industrial or mining operations must not be used. Effluent from these sources may contain hazardous microbes or chemicals that pose a health risk to everyone at the site. In general, potable water or water from an approved lake, stream, or irrigation canal is acceptable for construction work.

106.04 Tests and Acceptance of Material

When contractor Quality Control is specified it is the intent to place the responsibility of materials quality control (or process control) with the contractor. Only certain construction materials will fall under this quality control specification. When the bid quantity for the following items exceeds the minimum amount then Special Provisions will require contractor Quality Control: Subsections 106.04 (B) & (C) are geared toward the sampling, testing, and control of these materials. No quality control plans will be required. See Special Provisions for item 9240170 for contractor Quality Control measurement and payment.

Type of Material	Subsection	Minimum Bid Quantity
Earthwork	203-2.02	5,000 cubic yards
Aggregate Bases & Subbases	303-3.04	1,000 cubic yards
End Product AC & MA	416-5	Any and all
SHRP End Product AC & MA	417-5	Any and all
Pipe Bedding & Backfill	501-3.01(A)	60” diameter, or length>600 ft.
Concrete (Structural & Paving)	1006-4.01(A)	300 cubic yards

The specification requires the Quality Control Manager to be a qualified employee of the contractor. Qualified is interpreted to mean someone who is empowered at the project site to reject materials without the approval from someone else within the contractor's organization. This could be a superintendent, foreperson, quality control supervisor, or any other person who has management authority. However, this person must be at the project site during all construction activities related to the materials covered under the quality control specification.

The Quality Control Supervisor and the Testing Technicians are required to be employees of the same lab that has been certified for materials testing work on the project. This requirement ensures that only testing equipment and employees covered by the lab certification are used. The Contractor cannot use their own employees to do material testing unless they have their own approved testing lab.

The contractors often ask why ADOT needs to enforce the qualification requirements for the contractor’s quality control personnel. They point out that ADOT still does acceptance testing anyway.

One reason is that ADOT wants competent people doing the testing so the test results are accurate and unbiased by the testing procedure itself. Qualified people provide some assurance that a testing person is competent enough under various work conditions to minimize the influence of the testing procedure on the test results.

Another reason is that the contractor's materials testing procedures must consistently meet some minimum standards so ADOT's acceptance testing won't turn out to be the contractor's actual quality control. If the acceptance testing becomes the quality control for the contractor, the chances for rework are high since acceptance testing is usually done after work completion.

Resident Engineers may withhold payments for quality control work if the contractor does not follow the sampling and testing requirement in the Standard Specifications and Special Provisions. In addition, failure of the contractor to submit current Weekly Quality Control Reports will be grounds for the Engineer to deduct monies from the contractor's progress payment. Refer to Section 9240170 of the Special Provisions for determination of amount to be withheld. In some cases the Resident Engineer may need to temporarily shut down material processing operations until the contractor can comply with the sampling and testing procedures required by the Department.

Even though the contractor is performing quality control sampling and testing, Inspectors and Project Supervisors still need to sample and test for acceptance. This "side-by-side" testing may seem redundant; however, ADOT's testing should be done as the final and independent check of the materials. The frequencies for acceptance sampling and testing should be at the same rates as in the Sampling Guide Schedule of the ADOT Materials Testing Manual.

106.05 Certificates

Materials incorporated into the project and devices used during construction of the project - are accepted either by sampling and testing, or by certification. Materials accepted by certification are certified to meet project specification requirements (Certificate of Compliance) and may also require associated test results to confirm conformance (Certificate of Analysis). All components of the certification as stipulated in Section 106.05 must be included in the certificate.

When a certificate is required, the section of the specification associated with the bid item will state which type(s) of certification is necessary. For some materials, in lieu of a certification, sampling and testing by the Department may be performed and allowance for such will be stated in the specifications.

Some materials are pre-certified by the Department and the documentation for such resides with the associated technical group or section When pre-certified material arrives to the project, before it may be incorporated into the project, the construction unit must verify that proper documentation is on file with the Department for the production lot(s) to which the material is associated. If no certification is on file, the contractor must provide an acceptable certification or material must be sampled, tested, and certified by the Department prior to it being used on the project.

Some materials have additional certification requirements, such as "Buy America," which must be adhered to depending on funding sources. Refer to the "Buy America" section of the Project Special Provisions for more information on materials and bid items to which the Buy America requirements apply.

With regard to materials requiring certification and contractor payments, the Department should only pay for materials which have been properly certified, meaning the Construction Unit has received from the contractor an acceptable certification for the material and the material for which payment has been requested is represented by such certification. No payment will be made for materials which the Department does not have proper certification. Therefore, upon receipt of a contractor request for payment by the Construction Office, the list of items and quantities for which payment has been requested should be provided to the Materials Coordinator to confirm that acceptable certifications and test results are on file. In the event that acceptable certification or test results are not on file, the Materials Coordinator should notify the Office Manager immediately to afford the contractor the opportunity to gather and provide necessary documentation prior to the contractor payment deadline.

The project team must maintain a log of all materials/items on the project that require certification. The Certification Log is maintained by the Project Materials Coordinator and the completed Certification Log is included as an attachment to the Final Materials Certification. To ensure no certifications are overlooked, prior to the Pre-Construction Meeting, the Materials Coordinator should review the bid items included in the project and the associated sections of the Standard Specifications and Project Special Provisions and identify all materials, items, and ancillary features which require certification and pre-populate the Certification Log.

Sometimes overlooked are certifications for products which appear on the Department's Approved Products List (APL). Despite being on the APL, receipt of proper certification for the specific materials/products incorporated into the project must be provided by the contractor.

On occasion, commercially available products will be utilized for which no certification documentation is readily available and it is impractical for the contractor to attempt to provide such. If this occurs, consult with the appropriate technical section to determine if use of the material is acceptable or if further testing is necessary.

Some products such as release agents, geogrid, and other geotextiles have been evaluated by the National Transportation Product Evaluation Program (NTPEP) and project specifications may require use of products which have been certified under this program. For these products, if not provided directly by the contractor, the Materials Coordinator may access NTPEP's DataMine on the NTPEP website and confirm that the appropriate certifications exist for the specific product intended to be used by the contractor. This typically includes the requirement for a Certificate of Analysis to be on file with NTPEP, the Materials Coordinator should maintain a separate copy of the certification for the project file.

All Certifications are reviewed by the Materials Coordinator for correctness and completeness. Certifications that do not meet requirements should be returned promptly and the reasons for rejection communicated to the contractor. However, if at any time the validity of a certification for material is questionable, the Materials Coordinator should contact Materials Group to confirm adequacy.

106.09 Storage of Materials

Material stored on the project should be observed to determine whether the storage practices may be harmful. Potentially harmful practices include stacking too high (causing bending, denting, or crushing), exposing to weather, or providing inadequate base (causing soiling, staining, or rusting).

Aggregate and similar materials are also subject to certain storage requirements. Specific requirements are discussed in the section associated with the type of material for which the aggregate will be used. It is important to be aware of the condition of the stockpiled material at the time of sampling for acceptance and to ensure that the material has not deteriorated or become contaminated prior to being used for production.

No partial payments should be made if materials are not stored in a manner that will provide adequate protection. Adequate protection is that which will preserve materials in their original condition.

If material is damaged in storage, any payment for material allowance should be recovered until the damage is repaired or the material is replaced.

106.11 Unacceptable Materials

When materials that are incorporated into the project fail to meet the requirements of the Specifications, the standard course of action taken by the Resident Engineer shall be to order the contractor to remove and replace the failing materials with such materials meeting the requirements of the Specifications. In some cases, the Specifications allow for failing material to remain in place at a reduction in cost, otherwise known as a "penalty", depending on the property and severity of the deviation.

In instances when no penalty structure exists in the Specifications, but the Department allows for the material to remain in place, the Resident Engineer will need to obtain written concurrence from both the State Construction Engineer and the State Materials Engineer, stating that the material may remain at a reduced unit cost, and will then need to memorialize the penalty with a procedural change order.

106.12 Department-Furnished Material (DFM)

When ADOT furnishes material for the contractor to use on the project, the Department is responsible for the quality and quantity of the material supplied. When the contractor takes control of the material, the contractor becomes responsible for the material.

Requesting DFM for a construction project during the design phase:

- The project design team makes a determination that the normal process of bidding the project, and requiring the contractor to provide the traffic signal or lighting materials as part of the standard pay items, will not allow the work to be finished prior to the scheduled completion date.
- The Project Manager identifies whether there is federal funding for the traffic signal or lighting construction
    - If so, the Project Manager must submit a letter of justification to the Federal Highways Administration (FHWA) project administrator outlining the reason the project should use DFM
    - The letter of justification to the FHWA must be approved by the project administrator prior to advertising for bid
    - For federally funded projects less than 25 million dollars (<25M), the Project Manager submits a letter of justification to the State Traffic Engineer for approval
- Upon receipt of the FHWA approval, the Project Manager should forward the letter of justification to use DFM and the FHWA authorization to the Traffic Operations Manager for Signal and Lighting
    - The request to the Traffic Operations Section (TOS) should have a cover letter that identifies the anticipated project time frames and the estimated equipment and quantities that are needed
    - Note: Typically the traffic signal and lighting designer will be able to provide the estimated traffic signal and lighting equipment quantities that are needed at the 60% stage of the design. The request may require modification of the type and number of items by the PM when the project design is completed
- TOS will inform the Project Manager of their decision
- If the project does not have federal funding the FHWA authorization is not necessary and that entire step can be eliminated
- The traffic signal and lighting designer must insert project specifications that explain what procedures are required of the contractor to be issued the DFM from TOS. The specification is available electronically
- The designer must use the correct item number and description (identified on the Agreement Estimate) for those items being supplied by TOS
    - Typically the item number has “Department Furnished” in parenthesis following the item description
    - It is important that the correct bid item number is used to provide an audit trail
    - The designer must verify with the Traffic Design and the Contracts and Specifications representatives that the correct bid item numbers are being used in the estimate
- The designer must submit, through the Project Manager, the final and complete list of DFM to TOS when the project is advertised. This allows TOS to know what and how many items they must have on hand to issue to the contractor
    - Items that are not in stock, or normally not carried in stock, must be ordered and that process will not take place until the project is advertised
- During the design phase of the project it is important that the signal designer communicate through the Traffic Design representative to ensure that the type and quantity of materials needed for the design will be available for the project at the estimated construction date

- Once a project that requires DFM is advertised, the designer must provide the final plans, special provisions, and the complete list of all items to be furnished to TOS
- When the project is awarded and the pre-construction/partnering meeting is scheduled, the TOS representatives should be included so those specific questions relating to DFM can be resolved. It is also important that the initial construction schedule for the entire project be provided to the TOS representative. If TOS cannot send a representative, the Resident Engineer should provide a copy of the construction schedule to TOS
- When the time approaches for the contractor to receive the materials, the RE must submit to the TOS, in writing, the date and time that the contractor intends to pick up the materials. Before any materials are released from the TOS Warehouse, the RE must provide a copy of the Agreement Estimate showing the DFM. TOS should verify that all items released to the contractor are approved and included in the contract
  Note: The special provision requires "10 days written notice from the contractor before picking up the materials. The department-furnished materials will not be issued without a contractor supervisor and an ADOT inspector present at the supply center to verify and sign for the materials"
- After all the materials have been issued to the contractor, TOS submits an invoice, identifying the item number, description and quantity from the Agreement Estimate, and the purchased material cost charged against the project TRACS number to Contract Accounting (and a copy to the RE for filing in the project DFM folder), with a copy of the initial request/approval to use DFM, and the TOS response, if applicable. A copy of the FHWA letter approving the use of DFM must be provided along with the invoice, in order for the costs to be charged to the construction project TRACS number as a federally eligible cost
- Contract Accounting reviews the invoice and transfers the cost of the materials from the TOS TRACS number for DFM to the construction project TRACS number, accompanied by the appropriate construction Org number

Sometimes these project elements are identified as advance procurement items. The project manager still follows the outlined process with the exception of setting up a 01X subphase. This can only be done if this phase can be funded. If this path is chosen then the Field Office administering the construction project will need to be involved. The designer, project manager and the RE work together to provide the specifications and quantities to obtain quotes from vendors. An ADOT yard will need to be identified for delivery. Depending on where the yard is located drives what group will issue the Purchase Order. For instance, if an ADOT construction yard is available then the field office will have to issue the PO. If an ADOT maintenance yard is identified then that office will need to assist with issuing the PO.

Requesting DFM for a construction project during the construction phase:

- The Resident Engineer (RE), in consultation with the Regional Traffic Engineer, determines that a Change Order is necessary requiring additional, or different, traffic signal materials than what was originally called for in the project plans
- The designer or RE determines if the contractor can receive the necessary materials through his vendor in time to meet the project time constraints. If so, the materials are provided by the contractor
- If the contractor cannot provide the materials in time to meet the project time constraints the designer or RE contacts TOS to determine if the materials needed for the Change Order are available
- If the RE determines that DFM is necessary, the RE must submit a formal request to TOS outlining the justification for the request. The request must include the project description, project number, TRACS number and if the project is federally funded
- The contractor's bid item should be reduced by the invoice amount of the DFM in the Change Order
- Generally, the contractor shall not be eligible for any additional incentive payment due to their request for DFM that would not be earned without the DFM. All projects with this incentive situation should receive approval from the Assistant State Engineer for Construction prior to making any incentive payments
- If the project is federally funded, the RE must receive prior written approval from the FHWA administrator to use DFM on the project. For federally funded projects less than 25 million dollars (<$25M), the Project Manager must submit a letter of justification to the State Traffic Engineer for approval
  Note: Sample request letters to FHWA are available electronically

- The request for DFM is submitted to TOS, with the FHWA authorization if federally funded
- If TOS approves, TOS will respond to the RE with the time and date the requested DFM materials will be available for the contractor to be picked up
- The RE must execute a Change Order that includes sealed traffic signal sheets reflecting the design modifications. Other requirements are: DFM specifications, bid items that reflect the material and related installation cost of DFM, and price deduction for materials not used, (or salvaged to ADOT for the new materials no longer to be installed on the project)
- After the field office issues the Change Order the contractor can pick up the materials. The contractor must submit in writing the date and time that he intends to pick-up the materials. No materials will be released from the TOS Warehouse unless the fully executed Change Order is provided to TOS
  Note: The special provision requires "10 days written notice from the contractor before picking up the materials. The department-furnished materials will not be issued without a contractor supervisor and an ADOT inspector present at the supply center to verify and sign for the materials"
- After all the materials have been issued to the contractor, TOS submits an invoice for purchased materials charged against the project TRACS number and the applicable construction Org to Contract Accounting (and a copy to the RE for filing in the project DFM folder), with a copy of the Change Order to use DFM, and the TOS response, if applicable. A copy of the FHWA letter approving the use of DFM must be provided along with the invoice, in order for the costs to be charged to the construction project TRACS number as a federally eligible cost

Salvaged Material

Materials may be designated by the project plans and/or special provisions to be removed and salvaged from the project and delivered to the supervisor of a designated ADOT yard. In these cases the following must be adhered to:

- The project supervisor must coordinate with the Traffic Signal and Lighting Operations Manager to determine if any of the material is suitable to transfer to the Warehouse
- Inspection must occur to determine material condition is adequate prior to transport
- The determination should be documented
- If the determination is made that the material is not needed or the condition does not warrant transfer, it is imperative that a Change Order be executed to document the disposal of the material. Any questions should be directed to the Traffic Operations Manager for Signal and Lighting (MD013R)
- Complete the Receipt for Salvaged Materials form and keep in project files. At final closeout, submit a copy to Field Reports

The Resident Engineer should document the condition of the material and verify its quantity before it is released to the contractor. This protects the Department if the material is later mishandled. Some testing may need to be done on the material to accurately determine its quality. A letter or another form of documentation should be used to establish when the material was officially turned over to the contractor.

106.15 Domestic Materials

On projects with federal aid funding the Special Provisions will require the contractor to certify that certain materials were produced, or processed in the United States. The Inspector must read the Special Provisions for each project and ensure contractor compliance.

ADOT
Infrastructure Delivery and Operations

RECEIPT FOR SALVAGED MATERIALS

The miscellaneous salvaged materials listed below have been received as follows:

From Project No: ______________________

Contractor: ______________________

Materials were delivered to:

Location ______________________

Field Office (Unit) __________ Date Received: __________

Description of Materials:

Guardrail Panels: __________ LF End/Terminals: __________ Ea

Guardrail Posts: __________ Ea Block: __________ Ea

Bridge Rail: Type: __________

Traffic Signals: Type: __________ No. __________

Light Poles: Type: __________ No. __________

Sign Structures/Post: No. __________

Signs: __________

Drainage Pipe: Type: __________ Dia.: ______ inch __________ LF

Piling: Type: __________ __________ LF

Milled AC: __________ CY AB: __________ CY

Other: (BCT, assemblies, fence, gate, delineators, etc.)

Describe:

Received From:	Printed Name	Signature	Date	(Contractor Rep.)
Received By:	Printed Name	Signature	Date	(ADOT or LPA Representative)
Project Engineer/Inspector:	Printed Name	Signature	Date	

Original: Project Files
cc: Field Reports

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107 LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.02 Permits, Licenses and Taxes

The Department requires the contractor to comply with all local, tribal, county, state and federal regulations, laws, and ordinances, and bear any costs or inconveniences associated with those requirements. Regulations or permit requirements unfamiliar to either the contractor or the Resident Engineer do not relieve the contractor of the obligation to comply. The Special Provisions will often identify some of the requirements, but they should not be construed to be the only requirements.

Local ordinances such as noise limitations, haul restrictions, and permit fees are usually the most cumbersome for the contractor. For example, most cities require a connection fee and permit when a contractor taps into a city waterline. Some cities require a permit to use and haul explosives. Usually permits associated with construction and installation activities such as hauling, dust control, and connecting to utilities are the contractor's responsibility. Specialized permits that could not be foreseen by the contractor at bid time and royalties are usually the Department’s responsibility.

Permits required to construct the project in the first place, such as 404 Permits for the Corps of Engineers or utility relocation clearances, are usually the Department's responsibility.

The contractors are responsible for paying all existing federal, state, county, and local sales taxes associated with the work. This includes future taxes or tax increases passed into law before bid opening. Any new taxes or tax increases passed after bid opening will be reimbursed to the contractor through execution of a supplemental agreement.

107.04 Federal Aid Participation

Most of ADOT’s highway projects are funded by the U.S. Government. When federal funding is involved, a project has additional federal contract requirements that both the contractor and ADOT must meet. These additional requirements are numerous and contained in the project Special Provisions.

The requirements that have the biggest effect on administering a project are summarized below.

Disadvantaged Business Enterprise Program

Most federal aid projects require that a certain percentage of the contract work be given to a certified disadvantaged business such as a minority-owned or woman-owned business. The contractor is responsible for selecting a disadvantaged business enterprise (DBE) firm and subcontracting a portion of the work to them. Some DBE firms are material suppliers, so the contractor may purchase a portion of their materials for use on the project. The contractor is required to submit DBE affidavits when submitting a bid. These affidavits list the DBE firms the contractor intends to use and certifies that the DBE goal for the project will be met.

At the preconstruction conference the contractor is required to submit copies of all DBE subcontractors, purchase orders, or quotes to the Resident Engineer (see Subsection 108.03). During construction, the Resident Engineer should monitor the contractor’s use of DBE firms to ensure that the DBEs are performing their committed share of the project work. The Field Office should have a copy of the DBE’s approved subcontract or quote for materials. The Resident Engineer’s job is to ensure the contractor lives up to the terms of the subcontract or quote. DBE compliance and work should be discussed at each weekly meeting when DBEs are on the project. Any questionable situations or apparent non-compliance situations should be reported to ADOT’s BECO Office.

Compliance means meeting the numerical percentage shown in the Special Provisions and using all the firms shown on the DBE affidavit. The contractor is not free to drop or replace DBE firms without the approval of the BECO Office. The Special Provisions explain the requirements for changing DBE firm commitments on the project.

At the end of the project, the Resident Engineer must ensure that the contractor submits the required Certification of Final Payment form for each DBE. The certification must be forwarded promptly to the Business Engagement and Compliance Office. Once BECO accepts and approves the final certifications, BECO prepares a DBE & OJT Compliance Record letter and submits it to Field Reports for the project final.

Bulletin Board Requirements

Certain postings and notices are required on all projects that receive federal aid. These are supplementary postings beyond the usual postings required in a place of business. The Resident Engineer is cautioned to differentiate between those postings required by a business and those postings required to be on a construction project bulletin board. The Resident Engineer should ensure that the following postings (as included in the contract) are displayed prominently by the contractor on the bulletin board.

These are examples of the posters that need to be included on the Job Bulletin Board, the Resident Engineer should check for up to date requirements and available posters on the ADOT Construction Group’s webpage:

- Fraud Poster (Form PR-1022) required by Title 18 of the United States Code
- EEO Poster (Form GPO 1984 O. - 438-915) in English and Spanish
- Wage Rate Information Poster (DOL poster WH-1321)
- The Wage Decision listed in the project Special Provisions
- EEO Policy of the contractor and major subcontractors
- List of safety officers for the contractor and major subcontractors
- The Notice of Intent for Stormwater Discharges (EPA form 3510-618-98)
- Name and telephone number of contractor’s EEO policy enforcement officer
- Emergency contact telephone numbers
- OSHA postings and other project safety and security information

The Resident Engineer should see that the contractor furnishes a bulletin board of sufficient size to accommodate all of the required posters: generally, a minimum area of 12 square feet is sufficient. The bulletin board should be suitable for outside installation and covered with a transparent window for the purpose of displaying required posters on the project.

The Fraud Poster, required by Section 1020, Title 18, United States Code, must be displayed during the course of the work. The poster is normally displayed on the contractor's and subcontractor's bulletin boards, in the engineering office, and in the project laboratory. This poster points out the consequences of impropriety on the part of any contractor or Departmental employee working on the project. The Deputy State Engineer's name and address appear on the poster, as does the name and address of the Division Administrator of the Federal Highway Administration (FHWA).

NOTE: The size, location, lighting, and visibility are not specified in the contract, except as noted in the quotations below (taken from the federal requirements in a typical special provision):

The "contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the state highway agency setting forth the provisions of this non-discrimination clause."

"The wage determination...shall be posted at all times by the contractor and their subcontractors at the site of the work in a prominent and accessible place where it can easily be seen by the workers".

On-The-Job Training

Most federal aid projects have a requirement for on-the-job training (OJT) of construction trade workers. The intent of ADOT's OJT program is to build a competent workforce to meet current and future highway construction hiring needs with a focus on the recruitment and inclusion of those who have experienced historical underutilization: minorities, women and disadvantaged individuals The training must be part of a recognized apprenticeship program approved by the Department and FHWA. The Business Engagement and Compliance Office (BECO) is responsible for the oversight of the OJT program.

During construction, the Project Supervisor or Inspector should verify that apprentices are:

- Performing the type of work normally performed by their craft, e.g. carpenter apprentices should not be tying rebar or operating heavy equipment
- Being supervised by a journeyman or journeywoman of the same craft

During construction, the field office staff should:

- Verify the required submittals (outlined in the project Special Provisions) are uploaded to the Department's DBE & OJT Online Reporting System (DOORS)
- Verify trainee is enrolled in the OJT module of DOORS
- Reimburse all training hours approved in the OJT module of DOORS
- Use LCPTracker to verify trainees are being paid Davis Bacon Wages per approved trainee level
- Verify the total CPE payment for OJT hours match the total on the DBE Completion Cover letter at project close out
- BECO will notify Field Offices if any sanctions/liquidated damages are applicable

Apprentices are paid less than Davis-Bacon wage rates and each hour an apprentice works is partially paid for by the Department. The project Special Provisions establishes the minimum number of training hours the contractor must provide as well as the hourly rate at which the Department will subsidize on-the-job training.

Liaison with the FHWA

The Phoenix office of the FHWA oversees all federal aid projects in Arizona. Federal aid projects can be divided into two categories:

1. Delegated Oversight are projects in which the FHWA has very little involvement except at the final inspection and acceptance. Most projects off the Interstate Highway System are delegated oversight. These projects have an "A", "T" or "D" at the end of the federal aid project number
2. Full Oversight projects are projects in which the FHWA oversees the contract administration activities of the Department. These projects are typically the interstate highway projects and some other specialized or unusual projects. Full Oversight projects can be identified by the last letter in the project number; "N", "X", "S" or "F"

In recent years the FHWA has given the state more responsibility in administering federal aid funds. FHWA staff members conduct fewer reviews and inspections for specific projects than previously, focusing instead on reviewing operational processes. ADOT's own Construction Operations Section has been charged with ensuring compliance with federal requirements, including conducting periodic field inspections.

Local Public Agency Projects

Local government projects require special consideration. Coordination for project development is provided by ADOT's Local Public Agency (LPA) Section. The LPA Projects Manual will provide additional information.

Project sponsors may be cities, counties, towns, or tribes. Funds for local government project construction are provided by the FHWA with matching funds provided by the sponsor. Usually no state funds are involved.

The construction for all local government projects is administered by ADOT or by the LPA through Self-Administration (SA) and/or Certification Acceptance Program (CA). The CA Program sets forth the policies to be used by ADOT in the administration of projects financed with federal aid highway funds. An "A", “T” or “D” after the parentheses in the federal aid project number identifies CA Program projects. There are currently eight CA agencies within the State of Arizona, these agencies include: Maricopa County Department of Transportation, Pima County Transportation Department, City of Tucson, City of Phoenix, City of Scottsdale, City of Tempe, City of Chandler and City of Mesa.

On LPA projects administered by ADOT, the local and Regional standards are often used In lieu of, or in conjunction with ADOT Standards. Daily construction inspections and contract administration will normally be under the direction of an ADOT Resident Engineer. However, the sponsor's employees (who are adequately trained) may perform inspection and administration for the Resident Engineer. Additionally, ADOT’s Materials Independent Assurance and Construction Quality Assurance inspection groups will be required to perform random inspections on LPA projects.

Full Oversight Projects

The FHWA is an active partner with ADOT in the administration of full oversight projects. The FHWA Area Engineer will make periodic inspections of both the project work and the project inspection records (including test results and material certifications).

The FHWA Area Engineer is required to be contacted (per The FHWA and ADOT Stewardship and Oversight Agreement for Arizona) and concur on all supplemental agreements before an agreement is reached with the contractor. Also the FHWA Area Engineer should be invited to the preconstruction conference / partnering workshop, as well as to the final inspection.

It is important to involve the FHWA Area Engineer in all escalation hearings beyond the District level. Since the Area Engineer recommends federal aid participation on all contract changes, early involvement of the Area Engineer in a contract dispute is highly desired. Early involvement will help avoid any misunderstandings or courses of action that may result in the FHWA's withholding federal aid participation.

107.07 Sanitary, Health, and Safety Provisions

Safety is an integral part of construction. Every construction activity has specific safety considerations. Safety issues are inseparable from the construction activity. Safety is discussed throughout this manual in conjunction with the different activities.

The most effective safety programs include assessing the unique hazards associated with the actual work activity. This takes many forms, but a common one is a Job Hazard Analysis completed by the crew performing the activity. This analysis is critical for those work activities where there is no regulatory basis for safety program elements. Examples would be lowering falsework, temporary decking between bridge beams, or any work that is so specialized to the project that the regulations could not anticipate this. A hazard analysis can be completed on any activity that potentially affects worker safety and/or protection of the public.

In its most basic form, a job hazard analysis takes the following form:

- Identify the steps to complete the work
- Identify the hazards associated with each step
- Identify control measures to mitigate each hazard

Most worker injuries stem from two causes: an unsafe physical condition or an unsafe act. The unsafe physical condition is often a product of the environment; the general conditions at the site of the work, the equipment and materials used, or the process employed.

The unsafe act can usually be traced to inadequate training, a momentary lapse of attention or inexperience. Construction sites are unpredictable places and employees must be constantly aware of what is going on around them.

The rest of this subsection will introduce the various safety regulations that govern a construction site and indicate where to find additional information on safety.

Occupational Safety and Health Administration (OSHA) Standards for the Construction Industry (29 CFR Part 1926)

These standards apply to all construction sites in Arizona. This may include projects that ADOT defines as maintenance activity, but may be classified as construction by FHWA / OSHA. The Office of Safety & Risk Management can assist if there is any question about which standards apply to a particular project.

Everyone on a construction site must comply with these minimum standards. In many cases the general contractor will develop a safety plan with rules or policies more stringent than OSHA standards. In that case, ADOT and all subcontractors must comply with the contractor's safety plan. These policies can be enforced by an OSHA enforcement officer.

The state of Arizona generally adopts all federal OSHA standards verbatim. The standards are available at www.osha.gov or they may be purchased in book form from the Arizona Industrial Commission. Every Inspector and Resident Engineer should have access to these standards.

The Arizona Industrial Commission, Department of Occupational Safety & Health (ADOSH) is responsible for enforcement of the standards within the state. On tribal lands and some federal lands, the federal OSHA office in Arizona may have enforcement responsibilities. The Office of Safety & Risk Management can assist if there is any question about enforcement jurisdiction.

Hazardous Materials

All workers on a construction project, including ADOT, the contractor, and subcontractor must be informed about any hazardous material they may come in contact with at the workplace. The contractor is required by law and by the contract specifications to make available safety data sheets (SDS) to everyone at the project site. The location of these SDS must be identified and communicated to all personnel. Refer to Section 1926.59 of OSHA standards for further information on right-to-know requirements.

When hazardous materials are spilled, accidentally discharged, or encountered at the project site, Subsection 107.07 describes how ADOT requires the situation handled. When ADOT's field staff is notified of a hazardous material situation, the following actions should be taken:

- Ensure all workers are removed from the contaminated area
- Ensure the area is secured to the extent that no one else can become contaminated
- Call the Resident Engineer

Depending on the seriousness of the situation and how much the public is affected, contact 911. In addition, contacts should be made with the:

- District Office
- ADOT Office of Safety & Risk Management

- ADOT Traffic Operations Center (ask for hazmat response)

Resident Engineers and Lead Inspectors can download a copy of the Emergency Response Guidebook published by the U.S. Department of Transportation. This book helps identify hazardous materials, the potential danger of hazardous materials, and some basic precautionary measures that can be taken. However, experts should handle the more serious hazardous material incidents. Resident Engineers and lead inspectors should be to isolate and seal off the area containing the hazardous material until qualified help arrives.

ADOT Office of Safety & Risk Management

The ADOT Office of Safety & Risk Management (SRM) has full-time Safety Professionals whose sole responsibility is safety issues and regulations affecting the Department. The staff can be a valuable resource in interpreting OSHA standards, identifying safety hazards at the project site, and recommending reasonable protective measures.

ADOT SRM office should be notified when:

- An employee of ADOT or the contractor is seriously injured at the project site
- There is a serious injury or fatal crash on the project
- There is a chronic safety problem suspected at the project site which is not being corrected
- Dangerous hazardous materials are spilled or encountered

Safety Program Enforcement

Resident Engineers are empowered to shut down unsafe operations at the project site. However, some judgment is needed in deciding whether to shut down unsafe activities or to let them continue until corrective action can be taken. Here are some questions to consider as the Resident Engineer and Project Supervisor arrive at their decision.

- Is an unsafe condition away from the main site activities? Can the area be isolated or barricaded until the condition is made safe
- Most serious accidents are caused by unsafe acts. Are the workers' activities jeopardizing their own or other people's safety? How high is the risk of serious injury
- Assess the risk to the general public. Could the contractor's operation cause property damage or injury to those not associated with the construction
- Call the contractor's superintendent and safety supervisor to the site. Review the situation with them. Involve one of ADOT's safety consultants, if available
- Can something be done to make the hazard temporarily safe? Can someone be assigned to closely monitor the hazard full-time while people are at risk
- Consult the OSHA standards as well as any available safety experts. Do the standards or previous enforcement actions offer any direction on what to do

Answering these questions will help prepare the Resident Engineer for making a well-thought-out, carefully deliberated decision.

For example, an unsecured, infrequently used, 10-foot (3-meter) high ladder at a remote corner of the job site is probably not enough to warrant a stop work order. Even if the contractor does not rectify the problem for a few days, the most a Resident Engineer should do initially is to strongly warn the contractor in writing about the hazard.

On the other hand, workers found in an unprotected 10 foot (3-meter) deep vertical trench is a serious safety violation, which obviously warrants an immediate stop work order and a meeting with the contractor.

Unfortunately most safety hazards lie between these two extremes. Making a good decision that balances strict adherence to safety standards with the perceived risk of injury can be difficult. For those difficult decisions, the best words of advice are “err on the side of safety!”

Industrial Commission

The Industrial Commission’s Division of Occupational Safety and Health (ADOSH) is divided into two sections. The enforcement section makes site inspections, issues violation notices, assesses fines, and shuts down unsafe projects. Resident Engineers should call the enforcement section as a last resort when chronic safety problems cannot be quickly resolved with the contractor.

The other section is a consultation section that advises business owners, such as contractors, how to improve worker safety. This section has safety consultants who inspect job sites and point out safety hazards and violations. These Inspectors do not issue citations but are there to advise on safety issues. When there have been chronic safety violations, some Resident Engineers have required contractors to invite these Inspectors to the site instead of calling the enforcement section.

107.08 Public Convenience and Safety

Traffic Disruptions

Much of ADOT’s construction work is situated in and interfaces with traffic. As a result, there is often a conflict between how to construct the work and how to least disrupt traffic. The contractors sometimes want to perform the work in the most efficient manner, but at the expense of disrupting traffic. The Resident Engineer must then decide how much of a traffic disruption is tolerable.

A Resident Engineer’s number one concern is public welfare and safety. This is the Resident Engineer’s legal and ethical duty, both as a Professional Engineer and an ADOT employee. Traffic restrictions have two impacts on the public. First, they are an inconvenience that causes travel delay, extra fuel consumption, vehicle wear, economic loss, and driver stress. Second, they are a safety hazard. The restrictions eliminate some of the safety features of the road, e.g. shoulders, require quicker adjustments in driving behavior, and expose drivers to unusual situations resulting in higher vehicle accident risk.

In addition to decisions regarding safety, the Resident Engineer must carefully consider and investigate all the alternatives and weigh the impacts on public safety and the project work. For instance, shutting down the road for a day or two may be a significant disruption and inconvenience to the traveling public, but it may be preferred to several weeks of lane closures that might be more of a disruption and cause more accidents. On the other hand, a series of lane closures may be preferred to a full road closure. This situation can occur when previous full closures have resulted in accidents, frustrated motorists behaving erratically, and very long traffic lines. In deciding what to do, the Resident Engineer’s priorities should be:

- Risk to public safety (accident risk in particular)
- Major public inconvenience
- Construction efficiency

The risk of an accident involving personal injury must be weighed against the alternatives that are available. Assessing the risks ahead of time requires judgment, experience, and sometimes expert advice. Resident Engineers are often pressured by the contractor to favor construction efficiency. The Resident Engineer should also draw on the experience of traffic control experts including the Regional Traffic Engineer, a city or county Traffic Engineer, and the contractor’s own traffic control coordinator and barricade subcontractor in weighing the alternatives.

Sometimes there is no feasible alternative, and the disruption and accident risk must be endured. However, the Resident Engineer should be the one to make the decision. Do not remain passively silent and let the contractor do what they think is appropriate. The Resident Engineer should proactively approve or disapprove each closure or traffic restriction, even when there is a previously approved traffic control plan.

Liaison with Local Government Officials, Business Owners, and Residences

During construction, phasing of the site work and public information are crucial elements of ADOT's desired coordination effort with the surrounding community. Construction sequencing, local access, and traffic control should be outlined at the preconstruction conference and at other critical milestones during construction. The local government officials should be kept informed of these matters at least monthly or more often so all affected parties can be alerted to ongoing construction impacts.

The Resident Engineer should hold periodic meetings with local business owners/managers and neighborhood associations, preferably at one of the business establishments or at a local community center or school. The Resident Engineer should invite the contractor and all affected businesses and residences to attend. The Resident Engineer and the contractor's representative can explain the construction schedule and answer questions about ongoing work. The contractor needs to feel a sense of accountability to the community concerning project progress and construction impacts. ADOT's Communications and Government Relations office can assist the Resident Engineer in coordinating and conducting the meeting.

When construction is completed, the Resident Engineer should contact each business and resident to ensure that any cleanup or property damage issues are resolved. If there has been a significant involvement by local individuals or groups, then a letter expressing appreciation for their participation is recommended. ADOT's Communications and Government Relations office can assist.

Local Access and Signing

Adjacent businesses should be contacted to establish the level of access and hours of high use. Signs stating "Business Access" or "Driveway Entrance" may be used to denote access driveways to individual businesses or business complexes. Other special construction signing may be identified on a project-by-project basis. Signs should not identify business names and must not be furnished or altered by the businesses. Special signs can be made by ADOT if unavailable from the contractor.

Traffic control plans should require that local cross streets have access across construction activities whenever possible. This cross street access should be a smooth, well-graded subgrade material or base course material with a paved surface where feasible.

Temporary access must be provided to businesses, commercial and institutional properties during construction. Access roads should be made of a base course, material at least one half the width of the property's driveway. The minimum driveway width should be 20 feet (6 meters). If possible, driveway grades should be maintained at less than a 10:1 slope.

Whenever possible, open trenches for utilities or culvert work must be provided with steel-plate crossings for cross streets and driveways.

Stranded Motorists

Occasionally some of ADOT's customers need immediate help. ADOT field staff may give stranded motorists limited assistance.

This assistance may include:

- Notifying the Department of Public Safety (DPS) of the stranded motorist
- Telephoning a roadside service for the stranded motorist

- Making a phone call to get in touch with a relative or acquaintance
- Providing drinking water and other first-aid assistance

The assistance does not include:

- Phone calls to more than one relative or acquaintance
- Calling a towing company (DPS does this)
- Running errands
- Transporting stranded motorists, their passengers, or their cargo, unless there is an immediate safety hazard

Site Specific Safety Plan Submittal

The safety plan a contractor submits at the preconstruction conference must be site specific and customized for the project. A corporate plan that covers general topics as fall protection, scaffolding, crane safety, and confined spaces by itself is rarely adequate for a project.

ADOT and the AGC have developed a "Site Specific Safety Plan" checklist that can be a reference guide for reviewing contractor's safety plans. This is available from the ADOTNet Forms directory. The checklist is useful for identifying hazards on a project and what elements are required in a safety plan.

As the contractor develops the site specific plan, the safety issues specific to the type of work should be combined with general safety practices so a coordinated, unified plan is developed. The general contractor must also address all subcontractors in their plan, or may review and approve, then submit a subcontractor's safety plan for those specific exposures or work activities.

The Resident Engineer shall review and approve the safety plan. ADOT's office of Safety & Risk Management can assist with the technical questions. Their staff may make recommendations about whether to approve the plan and any suggested changes needed to make the plan acceptable.

Some of the key elements that the Engineer should look for in a site specific plan include:

- Hazard identification or Risk Assessment (Often called a Job Hazard Analysis)
- Site Security and Loss Prevention
- Contractor Safety Training and Education Program
- Contractor Medical/First Aid Services Program
- Contractor Fire Prevention/Protection Program
- Contractor Personal Protective Equipment Program
- Special regulatory programs such as Trenching and Excavation, Crane Operations, and Confined Space Entry.
- Contacts lists including: emergency, safety, and competent persons.
- Contractor Emergency Procedures and Reporting of Recordable Injuries or Fatalities to OSHA

Certain special activities may require additional planning or require special permits. For example, onsite living quarters on a project may require compliance with local zoning and building codes for a trailer park. Potable water, sanitary waste disposal and fire protective systems may be required that are beyond what is provided in a typical RV that may be brought onto the site.

Accident Notification

When any workplace incident occurs that seriously injures ADOT personnel or any construction worker, 911 emergency services should be called first. ADOT's office of Safety and Risk Management must also be notified immediately. The District should be notified as well. ADOT's Communications and Government Relations Office should be notified if the media covers any on-site emergency operation.

Incidents involving injuries to many people at the site or injuries involving the traveling public require more extensive notification requirements. ADOT's Traffic Operations Center can be contacted 24 hours a day via radio or telephone, and their staff will handle all the required contacts.

All serious project incidents should be documented regardless of who is involved (a construction worker, an ADOT employee, or the general public). The amount of detail and the form of the documentation depends on the seriousness of the incident and ADOT's potential liability. Documentation can take the form of:

- Diary entries
- Completed accident forms
- Police reports
- Photographs
- Video
- Drawing and sketches
- Measurements
- Approved traffic control plans in use

ADOT's Office of Safety & Risk Management can provide guidance regarding the documentation requirements for a particular incident.

Temporary Fencing and Protecting the Project Site

One of the intents of this subsection is to make our construction sites reasonably safe after working hours. Inspectors and project supervisors need to actively enforce temporary fencing requirements. During non-working hours, curious adults, transients, lost travelers, children, and others must be reasonably prevented from entering the more dangerous areas of the construction site. Temporary fencing will probably not stop the determined trespasser, but fencing should prevent people from accidentally entering a dangerous area and serve as a warning to those who try.

Children are impulsively drawn to construction sites and often do not understand the dangers involved. Under the "attractive nuisance" legal doctrine, the contractor and the Department must reasonably protect trespassing children from hazards at the project site. Temporary fencing is an effective method of keeping children away from these attractive nuisances. In addition, the contractor should take other precautions such as but not limited to removing ladders, blocking openings, locking equipment, etc. in order to make the site reasonably child and teenager proof.

Temporary fencing should be supplemented with barricades, flashing lights, flags, and other traffic control devices to direct motorists, bicyclists, and pedestrians away from the hazard.

In heavily traveled areas where trespassing is a chronic problem, "no trespassing" signs should be placed in key areas around the site. To be legally enforceable the signs should read:

State Property
No Trespassing
Violators Will Be Prosecuted
ARS 13-1502A.1 ARS 13-1503A ARS 13-1504A.1

The signs are usually 12 x 24 inches in size with black lettering on a white background. They should be posted at all possible entrances to the project site or in the more hazardous areas. Good coverage is important to make the signs enforceable. These signs can be ordered through the Regional Signing and Striping Supervisor or can be purchased by supplemental agreement from a signing subcontractor.

Inspectors should not allow the use and amount of temporary fencing to be minimized when public safety is at risk. Temporary fencing can become an acute problem for the contractor during trenching or mass excavating. Arrange to meet with the contractor ahead of earthwork operations so that both of you can discuss public safety and the precautions that should be taken.

Sometimes temporary fences can be eliminated by laying back slopes or by suitably covering excavations. Erecting permanent fencing where it will not conflict with the contractor's operations is another important method of protecting the public. The Inspector should communicate public safety requirements to the contractor ahead of time, and then work with the contractor to minimize temporary fence use.

107.10 Use of Explosives

See Subsection 203-3.03(C) of this manual.

107.11 Protection and Restoration of Property and Landscape

For erosion control and temporary drainage measures to protect adjacent properties refer to Subsection 104.09 of this manual.

The contractors sometimes use private property or adjacent public land as a staging area, construction yard, stockpile area, or for improved access to the project. Regardless of the reason, the contractor must have written permission from the property owner or the operating public agency (Subsections 106.09 and 107.11).

It does not matter where the property is located or who owns it. If the contractor needs to use the property in order to carry out or accomplish any activities for the project, then written permission is needed.

The written permission should clearly describe what the property is to be used for. This is important, because many times the Department has been drawn into disputes between the property owner and the contractor as to what can or cannot be done on the property. For instance, if the property owner is allowing the contractor to store a few materials, the contractor should not be setting up a fully equipped construction office on the property.

The contractor must furnish evidence that the owner is satisfied with the cleanup and restoration of the property at the completion of the project. Unless the owner states otherwise, private property should be cleaned and restored to its original condition.

Lack of written permission to use private or public property is grounds for withholding part of the contractor's monthly progress payment (5 to 10 percent range). In addition, any material stockpiled on private or public property should not be paid for until written permission is received.

107.12 Forest Protection

The primary intent of this subsection is to minimize the environmental impacts of construction activities on Forest Service land. This includes preserving the natural condition of the land and the vegetation in and adjacent to the project.

When working on Forest Service property, the Forest Service strictly regulates the Department's activities, including those of our Construction contractor. This Subsection, as well as requirements in the project Special Provisions, identifies what the Department and the contractor must do when working on Forest Service land.

The Department has a memorandum of understanding with the U.S. Forest Service on how we will cooperate with them in meeting their environmental objectives. The Roadside Development Section has a copy of this document.

The Department has a good working relationship with the Forest Service. The Resident Engineer, Project Supervisor, and Inspectors can help sustain this relationship by ensuring the contractor meets the environmental requirements and concerns listed in the Project Plans, Special Provisions, and Standard Specifications. The Department needs the continued cooperation of the Forest Service as the state continues to grow. How the Resident Engineer and inspection staff handle the Forest Service concerns on each project does have a long-term effect on our relationship with the Forest Service.

If the contractor enters into a special-use permit with the Forest Service, a copy should be furnished to the Resident Engineer.

107.14 Insurance

When a contract is issued for a project, the insurance requirements are detailed in that agreement. In all cases, every ADOT contractor is required to carry general liability and automobile insurance with certain minimum limits. They are also required to carry worker's compensation insurance.

A certificate of insurance from the contractor is required by the executed contract. ADOT's Contracts and Specification (C&S) Section will ensure all insurance requirements are met. C&S will coordinate with the Office of Safety & Risk Management on technical issues regarding insurance and meeting the contract requirements.

During the course of construction the contractor's insurance policy may expire. As a result, it is important for the Resident Engineer to check the insurance certificate for the policy expiration date. When the policy has expired, make sure the contractor submits a new certificate. The field office and Accounts Receivable office should get a copy of the new insurance certificate. To assist the field office, if the contractor's insurance policy expires within a few months of the execution of the contract, C&S will send a letter to the Resident Engineer advising of the expiration date.

The contractors must not be allowed to work without insurance. Lack of proper insurance is grounds for stopping all work on the project and withholding progress payments.

Third-Party Damages and Claims

Motorists, pedestrians, property owners, neighboring businesses, and others who come in contact with construction activities are sometimes harmed by those activities. They could be injured, their property could be damaged, or they could suffer some other type of loss.

Although the contract and contractor's insurance policy protects the Department from third-party damage claims, it is a good idea to document any third-party accidents or incidents. Documenting incidents that occur on weekends can be difficult. However, a police report can be obtained for the more serious incidents. The time you spend documenting an incident, even after the fact, can potentially save the Department thousands of dollars.

The level of documentation should depend on:

- The seriousness of the incident
- The potential liability for the Department and the contractor
- The documentation effort by others, such as the contractor or the law enforcement
- How much factual first-hand information you can obtain about the incident

For example, an Inspector's documentation of an incident that occurred over a holiday will probably be just a note or short paragraph in a daily diary. The police report should be the primary source of documentation. On the other hand, a serious traffic incident in the construction zone occurring during work hours should be well documented including photographs and sketches. In documenting a traffic incident or worker injury, avoid duplicating much of what would be found in a police or accident report. Instead, refer to those reports in your documentation and supplement their information. The important documentation that is often not included in a police report is the specific location of traffic control devices or temporary signs and structures.

It is important for the Resident Engineer to investigate any incidents involving third-parties in order to detect and correct any unsafe conditions or hazardous construction operations.

When the traveling public calls about property damage or injury alleged from an ADOT construction site, the caller should be referred to the ADOT's Office of Safety & Risk Management. They will ensure the caller receives the correct state of Arizona Notice of Claim form and filing instructions. Do not discuss the details of the claim or admit any liability for the caller's alleged damages. Instead, advise the caller that the State of Arizona Department of Administration Risk Management will review and adjust their claim. In order to do so, they must complete the State of Arizona Notice of Claim form in accordance with the instructions.

Do not refer a claimant to the contractor, even though the contractor has third-party liability insurance. The claimant must still file a claim with the Arizona Department of Administration in order to protect his or her legal rights should the contractor's insurance company refuse the claim. The Arizona Department of Administration Risk Management will tender the claim to the contractor for processing.

107.15 Contractor's Responsibility for Utility Property and Services

General

Arizona state law (ARS 40-360.21-.29) requires anyone excavating in public streets, alleys or utility easements to first identify the location of all underground facilities in the vicinity of the excavation. The contractor is responsible for contacting the Blue Stake Center (Arizona 811) and locating all utilities before excavating. See the Special Provisions for the Blue Stake phone number, and known utility conditions and arrangements. The Resident Engineer and Project Supervisor should have a copy of How To Locate Underground Utilities Before You Dig, published by the Arizona Blue Stake, Inc.

The preconstruction conference should deal with known conditions and discuss the arrangements for cooperation between the contractor and the utility company.

On projects where utility companies relocate their own utilities, the Resident Engineer should obtain copies of all permits. The Field Office is responsible for inspecting this work and ensuring that all requirements and conditions of the permit are fulfilled. The results of the inspection should be provided to ADOT's Utility and Railroad Engineering Section.

Notifications

When unforeseen problems are encountered or when a contractor serves notice of a potential claim due to utility conflicts, the Resident Engineer should follow these procedures:

1. At the first indication of a utility-related problem, the Field Office must notify the District and the Utility & Railroad Engineering Section
2. Utility & Railroad Engineering will provide the Field Office with copies of all related documents, agreements, permits, and utility company commitments, etc.
3. The project office should notify the appropriate utility company representative by certified mail of the potential claim. This will allow the utility company the opportunity to eliminate or mitigate potential damages by accelerating relocation work, rescheduling the work to avoid the conflict, or adjusting the

location to avoid a conflict, etc. The Resident Engineer should contact the Utility and Railroad Engineering Section to obtain the appropriate utility company representatives contact information

4. If the contractor files notice under 104.03, any negotiations conducted with the contractor should involve the utility company. Input from the utility company should be sought concerning proposed claim settlements or supplement agreements to which the utility company has liability
5. Under the terms of the construction contract, the contractor's claim is filed with the Department, not the utility company. The Resident Engineer should encourage the contractor and the utility company to resolve the problem between themselves. However, it is important for the Resident Engineer to receive the details of any settlement agreement in order to avoid possible ripple effects or future claims against the Department
6. The project office should send any utility claim settlements paid by change order, force account, or supplemental receiving report to the Utility and Railroad Engineering Section for review and processing
7. If the Department determines that there is a utility company liability, the Utility and Railroad Engineering Section will seek recovery. If the company does not reimburse the Department, the documentation may be transferred to the Attorney General's Office for legal action

Like any other potential dispute, the Resident Engineer and Inspectors are advised to keep good records of conditions relating to unforeseen problems.

108 PROSECUTION AND PROGRESS

108.01 Subletting of Contract

All subcontractors (regardless of the subcontracting tier) must be approved by the Department. This approval is required before a subcontractor mobilizes and begins any work on a project. If a subcontractor is found working on the project without consent of the State Construction Engineer, the Engineer will immediately stop the subcontractor from continuing work, and an early start sanction of $1,000 will be withheld from the next monthly pay estimate. In the event a contractor feels the sanction was unjust and formally disputes a sanction, the Engineer shall first obtain approval from the State Construction Engineer prior to waiving any such sanctions. Additionally, if the contractor does not include the subcontract with the subcontractor SRF, the subcontract must be submitted to the Department and be approved within 30 days of the original approved SRF. If the contractor fails to submit the subcontract then the approved SRF will be revoked and sanctions will apply.

The State Construction Engineer, through ADOT's Field Reports Section, approves and disapproves all subcontractors. Subcontracts are submitted by the contractor electronically to Field Reports.

ADOT has multiple definitions of subcontractor roles. The second paragraph of Subsection 108.01 of the Standard Specifications defines precisely who is considered part of the "contractor's own organization". Everyone else is considered a subcontractor, including those who provide services to a construction site such as barricade companies, cleanup and sanitation services, surveyors, material testing firms, and trucking firms. All are counted toward the subcontracted work, which cannot exceed 60% in the 2021 Standard Specifications. The intent is that everyone who works on the site for the contractor is either part of the contractor's organization or is a subcontractor.

Material Suppliers have to be careful how they deliver materials to the project, or they can be considered subcontractors as well. Material Suppliers can deliver and stockpile materials at the project site. However, they should not be allowed to set their materials in place either manually or by machine. For example, a commercial asphalt plant that supplies asphaltic paving materials cannot run the laydown machine. Their trucks can load the machine, and independent truckers can work for the Material Supplier, but either the contractor or subcontractor must place and compact the material.

Companies that supply temporary concrete barriers and other traffic control devices cannot set these materials in their final place without being an approved subcontractor. However, these companies can perform basic maintenance on their materials. They can pick up these materials from a storage area away from or adjacent to the work area. They cannot remove their materials from the roadway or directly from a work area.

For subcontract requirements, refer to Chapter 12 of this manual.

108.02 Start of Work

When the State Transportation Board awards a construction contract, a Notice-of-Award Letter is sent to the contractor by ADOT's Contracts and Specifications Section. The Field Office must obtain a copy of this letter so it can accurately track project time. Contract time begins on the date specified in the letter.

Special Provisions may require the contractor to "quick start" the project within a certain number of calendar days of the Notice of Award Letter. See subsections 103.08, 103.09, and 108.02 of the Special Provisions for "quick start" requirements.

108.03 Preconstruction Conference and Partnering

Most of the important contract issues are raised and discussed during the partnering workshop, although a preconstruction conference is still needed to:

- Allow the contractor to submit the required documents before construction can begin
- Give the contractor, ADOT construction office staff, and applicable stakeholders, the opportunity to discuss technical details prior to construction starting work.

Contract Submittals

The following is a list of key documents that the contractor must submit at the preconstruction conference according to the Standard Specifications:

Document	Subsections
Project Schedule	108.03
Authorized Signature Form	108.03
List of Proposed subcontractors and Material Suppliers	108.03
Traffic Control Plan(s)	108.03
Designated Traffic Control Coordinator	701-3.01, 108.03
Safety Plan	107.08, 108.03
Designated Safety Supervisor	108.03
List of Items of Special Manufacture	106.02
List of Items in Short Supply	106.02
Prime and subcontractor Equipment List to be used on the Project	109.04(D)(6)
Prime and subcontractor Equipment and Labor Rate Sheet	109.04(D)(6)
List of Materials and Equipment for Trees, Shrubs, and Plants	806-3.01
List of Materials and Equipment for Water Distribution Work	808-3.01
List of Materials and Equipment for Sewage System Work	809-3.01
Traffic Signal and Highway Lighting Materials List	730-4
Erosion Control Measures (for projects without a SWPPP)	104.09, 108.03
Designated Quality Control Manager (for projects in which 106.04 is applicable)	106.04(C)(1)
Additional Submittals for Federal Aid Projects	
DBE Subcontracts, Invoices, and Purchase Orders	108.01, 108.03
List of Trainees and Training Schedule	108.03
Designated DBE Program Representative	DBE Provisions
Designated EEO Officer	FHWA 1273
Disclosure Form to Report Lobbying (if applicable)	Form LLL
EEO/AA Policy and Statements	—
List of Supervisory Personnel and Emergency Contacts	—

The project's Special Provisions may have additional submittal requirements. The Resident Engineer should review the Special Provisions and inform the contractor of any additional requirements. Documents required after the preconstruction conference include:

- A temporary drainage plan (104.10)
- A letter securing all the plant material for the project (806-2.01)

It is important for the contractor to submit all of the required documents at the preconstruction conference. These documents are a direct reflection of how prepared the contractor is to begin the work. Missing or unfinished documents, such as an incomplete schedule or an off-the-shelf safety plan, demonstrate that the contractor has not put enough effort into preparing for the contract work. Although this is not enough to stop the contractor from beginning work on the project, it is enough to withhold mobilization payments (see Subsection 901-5).

The intent of withholding the mobilization payment is to encourage the contractor to demonstrate that some basic preparation has been done in the areas of scheduling, traffic control, safety, and federal aid requirements before the Department pays for any of the contractor's start-up costs. Usually, telling the contractor ahead of time that all mobilization payments will be withheld until complete preconstruction documents are received is enough to get prompt compliance.

Conducting the Conference

The preconstruction conference may be combined with the partnering workshop as long as the preconstruction conference is still documented. It is not necessary to invite everyone who attended the partnering workshop to the preconstruction conference. However, the Resident Engineer should consider inviting:

- The District Engineer
- All lead Inspectors and Project Supervisors
- The Design Engineers
- The Project Manager
- The contractor's project management staff
- All key subcontractors
- Major Material Suppliers
- Utility company representatives (gas, water, cable, sewage, telephone, power, irrigation)
- Local government officials (city, county, tribal)
- Local business owners and neighborhood leaders
- Federal representative such as the Forest Service, Park Service, the BIA, and the FHWA
- Environmental enforcement officials such as air pollution and ADEQ officials
- The Regional Laboratory Supervisor
- The Civil Rights Office
- Any other technical personnel from ADOT

The Resident Engineer is responsible for arranging the conference, inviting the participants, preparing the agenda, conducting the conference, and making a written record of the conference discussions. Copies of the written record should be distributed to the District Engineer, State Construction Engineer, State Materials Engineer, Field Reports, FHWA, Public Information Office, and the principal conference participants. A suggested preconstruction conference notification letter is shown in Exhibit 108.03-1. Exhibit 108.03-2 shows a suggested preconstruction conference agenda. The Engineer should check that the current letterhead is being used.

The Resident Engineer is given much leeway on what to discuss at the preconstruction conference. There is no sense in repeating issues covered in the partnering workshop unless it is for the benefit of those who did not attend. Current contract issues important to the District or ADOT should be brought up. In addition, any new contract specifications or provisions that require procedures unfamiliar to the contractor should be discussed. As a minimum, every preconstruction conference should cover the following:

- Review of the contractor's schedule
- Emergency contacts
- Introduction of key project members
  Quality control efforts by the contractor
- Utility coordination
- Plan and specifications clarification

- Traffic control issues
- Local government and neighborhood concerns
- Contract administration issues important to ADOT
- Scheduling the weekly construction meetings

The Resident Engineer should avoid covering boilerplate issues such as requirements for filing contract claims and inspection notifications. Try to stick to items unique to the project or unfamiliar contract provisions.

ARIZONA DEPARTMENT OF TRANSPORTATION

Address Line 1
City, State ZIP

KATIE HOBBS
GOVERNOR

JENNIFER TOTH
DIRECTOR

Month Day, Year

John A. Partner
Add title
Partnering Construction Co., Inc.
1111 Partnering Ave.
Anywhere, AZ 85009

REF: Project:
Termini
Location

Subject: Preconstruction Conference and Partnering Workshop

Dear Mr./Ms./Mrs,
A Preconstruction Conference for this contract has been arranged for *Time to Time* on *Month Day, Year* at *Location Name* located at *Location Address*.

Please be prepared to present the necessary submittals in accordance with the ADOT Standard Specifications & Special Provisions for the above mentioned project.

- Project Schedule (108.03)
- *Etc…prepare a list of all submittals required by the contractor and cite the appropriate subsection in parentheses*

NOTE: This list is not meant to be a complete representation of all submittals that must be submitted at the preconstruction conference, nor is the Department's furnishing of this list required by the contract. It is meant to assist *(add contractor name)* in preparation for the start of the project. *(add contractor name)* is responsible to submit all required material detailed in the contract documents or any other binding state or federal regulations.

The remainder of the Preconstruction meeting is outlined in the enclosed agenda: *Include meeting agenda below.*

The Partnering Workshop for this project will take place *(**Choose one or the other:** prior to / following the preconstruction meeting **OR** time, date, and location).*

The purpose of this Partnering Workshop is to:

- Begin building a good working relationship among project stakeholders.
- Identify potential issues/challenges within the project.
- Document action items.
- develop mutually agreed upon goals to help ensure the team completes a successful project.

Anyone who would like to learn more about Partnering prior to this meeting may contact their Partnering Facilitator.

You are encouraged to invite your subcontractors, major suppliers, and consultant engineers who will be stakeholders, as well. Please feel free to contact me at *555-555-0000* with any questions or concerns. We look forward to meeting with you.

Sincerely,
Sign here

Printed Name
Resident Engineer

Enclosures:

- *Include Authorized Signature form and others, as may be necessary agenda*

CC: *all those you intend to invite to the Precon Conference and the Partnering Workshop (include the Partnering Agent) by name and organization and send them a copy of this letter and the agenda.*
John Doe, District Engineer
Jane Doe, EEO/Affirmative Action Office
John Smith, Affected Utility Company
Jane Smith, City of…

ARIZONA DEPARTMENT OF TRANSPORTATION
205 S. 17th Avenue | MD 121F | Phoenix, AZ 85007 | azdot.gov
Phone: 602.712.7221

Exhibit 108.03-1 Preconstruction Notification Letter

PRECONSTRUCTION AGENDA

Time:

Location:

I. DISTRIBUTION OF AGENDA

II. INTRODUCTIONS

A. Sign-in Sheet
B. Individuals introduce themselves and identify their role on the project
C. Identify Project Supervisor for ADOT/Contractor

III. PROJECT OVERVIEW

Contracting Agency:
Funding Agency:
Contractor:
Letter of Award:
Contract Time Commences:
Number of Work Days:
Contract Completion Date:
Contract Amount:

IV. REQUIRED CONTRACTOR SUBMITTALS

A. Part I Project Schedule
B. Authorized Signature Form
C. List of major Material suppliers
D. List of subcontractors included executed contract and license numbers
E. Traffic Control Plan(s)
F. Designated Traffic Control Coordinator
G. Company Safety Plan & Designated Safety Supervisor
H. List of Emergency Telephone Numbers & Name of Contact Person
I. Company EEO policy and name of designated officer
J. DBE Subcontractors invoices, and purchase orders – Section 108.03 of Standard Specs.
K. Designated DBE program representatives – Section 108.03 of Standard Specs.
L. List of Items in Short Supply
M. Designated Quality Control Manager
N. Designated Fugitive Dust Control Plan in accordance with guidelines established in Rule 310 of Maricopa county Regulation III, Control of Air Contaminants
O. Storm Water Pollution Prevention Plan & Designated Erosion Control Coordinator

ADOT

Exhibit 108.03-2a Sample Preconstruction Agenda

P. Category I and Category II Traffic Control Device Certification
Q. List of proposed equipment with make, model and year
R. Survey Crew's certifications
S. Bulletin Board Location

V. ADOT SUBMITTALS

A. Bulletin Board Packet
B. Monthly Estimates & Deadline Dates
C. Emergency Contact Numbers & Names of Contact Person
D. Request for Time Extension Forms

VI. REVIEW OF PROJECT SCHEDULE BY CONTRACTOR

VII. DISCUSSION OF PLANS & SPECIAL PROVISIONS

VIII. UTILITY COORDINATION AND ISSUES

IX. MATERIALS

X. SAFETY

XI. TRAFFIC CONTROL

XII. LOCAL GOVERNMENT CONCERNS

XIII. ENVIRONMENTAL CONCERNS

XIV. ISSUES UNIQUE TO THE PROJECT

XV. CONTRACT ADMINISTRATION CONCERNS

A. Administration
   a. Written approval of subcontractors must be received prior to their start.
   b. Construction Survey & Layout – Contractor shall verify the project's horizontal and vertical control points. After verification of these points, the contractor shall notify the Engineer in writing the results of the verification.

B. Weekly Meetings
   a. When
   b. Where

XVI. ADJOURN

ADOT

Exhibit 108.03-2b Sample Preconstruction Agent

ADOT

Intermodal Transportation

Douglas A. Ducey, Governor
John S. Halikowski, Director
Dallas Hammit, State Engineer
Steve Boschen, Division Director

April 13, 2015

John A. Partner
Project Manager
Partnering Construction Co., Inc.
2222 E. Good Road, Suite D9
Anywhere, AZ 86018

RE: I-IR-40-301R / H243801C
I-40 Pavement Repair Preconstruction Conference

A Preconstruction Conference for this contract has been arranged for 1:00 p.m. on April 15, 2015 at the Flagstaff District Office located at 1801 S. Milton Road, Flagstaff, AZ 86001.

This contract specifies submittal of the following items at the Preconstruction Conference:

- Project Schedule (108.03)
- Etc.

(Prepare a list of all the submittals required by the Contractor and cite the appropriate subsection in parentheses.)

The remainder of the meeting is outlined in the enclosed tentative agenda. We can modify it to include any other areas that you might feel are necessary. This project meets the criteria to allow Partnering to be included in the preconstruction conference. An abbreviated Partnering workshop will be conducted during the preconstruction conference.

Please invite your suppliers and Subcontractors to attend since their expertise may be of help at the meeting. We would be glad to furnish any information that we can. Please feel free to contact me at 928-712-1111.

Sincerely,

[Delete this text before printing, and sign here.]

Build A. Road
Resident Engineer

Enclosures: Authorized Signature form and others, as may be necessary Agenda

John Doe, District Engineer
Jane Doe, EEO/Affirmative Action Office
John Smith, Affected Utility Company
Jane Smith, City of Flagstaff
(cc: all those you intend to invite to the conference by name and organization and send them a copy of this letter and the agenda.)

ARIZONA DEPARTMENT OF TRANSPORTATION
206 S. 17th Ave. | Phoenix, AZ 85007 | azdot.gov

Exhibit 108.03-3 Preconstruction/Partnering Notification Letter

PRECONSTRUCTION CONFERENCE /PARTNERING AGENDA

Time: April 15, 2015 at 1:00 p.m.

Location: ADOT Flagstaff District Office

I. DISTRIBUTION OF AGENDA

II. INTRODUCTONS

A. Sign-In-Sheet
B. Individuals introduce themselves and identify their role on the project
C. Identify Project Supervisor for ADOT/Contractor

III. PROJECT OVERVIEW

Contracting Agency:
Funding Agency:
Contractor:
Letter of Award:
Contract Time Commences:
Number of Work Days:
Contract Completion Date:
Contract Amount:

IV. PARTNERING

Partnering Champion
Partnering Evaluation Program (PEP)
Issue Resolution
Issue Escalation Ladder
Issue Escalation Binder

V. REQUIRED CONTRACTOR SUBMITALS

A. Part I Project Schedule
B. Authorized Signature Form
C. List of major Material Suppliers
D. List of subcontractors included executed contract and license numbers
E. Traffic Control Plan(s)
F. Designated Traffic Control Coordinator
G. Company Safety Plan and Designated Safety Supervisor
H. List of Emergency Telephone Numbers and Name of Contact Person
I. Company EEO policy and name of designated officer
J. DBE Subcontractors invoices and purchase orders – Section 108.03 of Standards Specs.
K. List of items in short supply
L. Designated Quality Control Manager
M. Designated Fugitive Dust Control Plan in accordance with guidelines established in Rule 310 of Maricopa County Regulation III, Control of Air Contaminants
N. Storm Water Pollution Prevention Plan and Designated Erosion Control Coordinator

Exhibit 108.03-4a Sample Preconstruction/Partnering Agenda

O. Category I and Category II Traffic Control Device Certification
P. List of proposed equipment with make, model and year
Q. Certifications of Survey Crew
R. Bulletin Board location

VI. ADOT SUBMITTALS

A. Bulletin Board Packet
B. Monthly Estimates and Deadline Dates
C. Emergency Contact Numbers and Names of Contact Persons
D. Request for Time Extension Forms

VII. REVIEW OF PROJECT SCHEDULE BY CONTRACTOR

VIII. DISCUSSION OF PLANS AND SPECIAL PROVISIONS

IX. UTILITY COORDINATION AND ISSUES

X. MATERIALS

XI. SAFETY

XII. TRAFFIC CONTROL

XIII. LOCAL GOVERNMENT CONCRENS

XIV. PROJECT ISSUES AND ACTION PLAN

XV. CONTRACT ADMINISTRATION CONCERNS

A. Administration
a) Written approval of subcontractors must be received prior to their start.
b) Construction Survey and Layout – Contractor shall verify the project's horizontal and vertical control points. After verification of these points, the contractor shall notify the Engineer in writing the results of the verification.
B. Weekly Meetings
a) When
b) Where

XVI. ADJOURN

Exhibit 108.03-4b Sample Preconstruction/Partnering Agenda

108.04 Prosecution and Progress

Asphaltic Concrete Mix Designs

Subsection 108.04 of the Special Provisions may require the contractor to submit an AC Mix Design within 30 calendar days after the Notice of Award Letter.

Weekly Meetings

The Resident Engineer should conduct a weekly meeting with the contractor. Topics discussed at the meeting should include:

- The contractor’s look-ahead schedule
- Project progress
- Safety and traffic control
- The status of contract submittals, supplemental agreements, and other project documents
- Project problems and new issues
- Contract requirements and interpretations
- Partnering issues and remedies
- Local community relations and environmental concerns
- Inspection, testing, and survey

The meeting should be held at the project site to encourage the attendance of both the contractor’s and the Department’s field staff. However, the meetings can be held at the ADOT Field Office or a site close to the project when the project has inadequate meeting facilities.

Minutes of the meeting must be kept. The aim is not to tape record and transcribe each meeting— this is too extreme in a partnering environment. Instead, the idea is to summarize major discussions and document important commitments. The minutes should also track:

- The status of contract submittals and other documents
- Project progress
- Unresolved project issues
- Other unfinished business

Contractor Look Ahead Schedule

The contractor's look-ahead schedule should be provided on or before the weekly meeting. It shall include the activities completed the prior week and at a minimum the next three weeks of anticipated work. If the contractor fails to provide an accurate schedule after a written notification is sent, $500 will be deducted from the progress payment per each occurrence thereafter. The look ahead schedule is vital for proper inspection staffing.

The Weekly Project Report

The minutes are usually kept in the weekly project report. An example template can be found on the forms tab The weekly project report is a document that captures and tracks all of the current project issues. The intent is that the Resident Engineer, the contractor’s superintendent, and their support staff can go to one document to find key tracking information about:

- Project progress
- Recently resolved and unresolved project issues
- Processing of contract submittals and other project documents
- Project changes

When used effectively, the weekly project report should not allow any important contract issues to fall through the cracks. As project issues are raised or administrative requirements are carried out, they are documented on the report. Tracking of these items continues until some type of resolution is reached or an administrative process is completed, e.g. review of a shop drawing.

By including important weekly meeting discussions and issue resolutions, the weekly project report serves as a historical record of agreements and commitments made by both the contractor and the Department. The weekly report updates the status of project time and progress, contract submittals, contract changes, and other routine contract administration procedures.

More routine procedures, such as force account transmittals and payroll submission, are usually tracked when problems or exceptions arise.

Much latitude is given to the Resident Engineer on how to set up and organize the weekly project report as long as these minimums are met.

- A method for accurately documenting contract time
- Tracking of contract submittals and supplemental agreements
- Minutes of the weekly meeting including a list of attendees

To ensure everyone gets the most use out of the report, it should be updated immediately after each weekly meeting and distributed to the contractor, ADOT's Project Manager, and other important project stakeholders.

Since project time, contract submittals, and supplemental agreements are tracked by the project report, the report still needs to be updated and distributed weekly, even when there is no weekly meeting.

Conducting the Weekly Meeting and Other Construction Meetings

Introduction

The Resident Engineer or one of his or her assistants conducts the weekly construction meetings with the contractor. Typical attendees include:

- The Project Supervisor and Lead Inspectors
- The materials coordinator for the Field Office
- The contractor's superintendent, lead foreperson and assistants
- Any key subcontractors
- Local government and utility representatives
- ADOT's Project Manager
- A consultant or some other special guests

The meeting size can range from 5 to 25 people.

Everyone is at the meeting for a different reason. Some want to hear about the contractor's schedule, while others may have an issue they would like to raise with ADOT or the contractor. For these meetings to be effective and good use of everyone's time, there needs to be a clear idea of:

- What the meeting is trying to accomplish
- Who should be there to help in that accomplishment

Know What Type of Meeting You're Having

There are basically two types of business meetings. The first type is called an informational meeting. The purpose of this meeting is to share information with others and collect different points of view about a topic.

For example, a review of the contractor's look-ahead schedule is meant to inform everyone about what the contractor intends to do on the project. Inspectors may ask questions about construction methods and discuss with the contractor the contract requirements for the upcoming work. There is an exchange of information taking place, but most of it is one-way with the intent to inform.

Informational meetings are best run in a controlled manner so time is closely monitored and the agenda is followed rigidly. In this way, participants are not wasting their time on things they need not know about. Any number of people can attend an informational meeting. However, to get the most feedback for the information presented and to allow effective questioning and answering, the meeting size should be limited to 30 people.

The second type of business meeting is a problem-solving meeting. The purpose of this meeting is to analyze a situation, generate ideas, solve a problem, and make a decision.

For example, when the contractor raises an issue about encountering an unexpected groundwater condition and needs the Department's help in resolving the situation; this is a topic requiring a problem-solving meeting.

This type of meeting is best run in an atmosphere in which people are encouraged to participate and the leader stimulates rather than controls the discussion. More importantly, the number of attendees must be limited to no more than 12 to give ample opportunity to express their ideas.

Two other important elements of problem-solving meetings are 1) have the right people at the meeting who can make substantial contributions in resolving the problem, and 2) eliminate any perceived outsiders so people can speak freely without the fear of being misunderstood.

Meeting Effectiveness

When problem-solving and informational type meetings are mixed together the result can be a meeting that is ineffective, burdensome, and frustrating for the participants. Some of ADOT's weekly construction meetings are like this, especially when the meeting size is large and there is a lot of material to cover. To make the weekly meetings more effective, here are a few suggestions.

Divide the meeting into two distinct phases.

1. An informational phase where:

    - The contractor's schedule is reviewed
    - Contract submittals and supplemental agreements are updated
    - Routine announcements and questions from outsiders are handled

2. A problem-solving phase during which:

    - Construction problems are discussed
    - Partnering issues are raised
    - Other project issues can be talked about and resolved

If the meeting is too big, divide it into two distinct meetings:

1. An information meeting that everyone attends

2. A smaller problem-solving meeting attended by only the Resident Engineer, Project Supervisor(s), superintendent, foreperson, and a few invited guests

If the problem-solving portion of the meeting takes too long, have a break so people not involved in the issues can leave, or end the weekly meeting and have a separate, smaller meeting just to solve the problems.

Partnering issues and other sensitive topics can be raised at weekly meetings but sometimes a smaller problem-solving meeting is best suited to resolve these kinds of issues.

The more formal the weekly meeting, the less problem solving and open discussion that takes place.

Pre-Activity Meetings

When not required, pre-activity meetings are encouraged for all new activities/phasing changes. This meeting can be in conjunction with the weekly meeting.

Pre-activity meetings must be scheduled sufficiently in advance of ordering materials to resolve all issues (a minimum of 20 days is recommended). Attendees should include the superintendent, the subcontractor(s) as applicable, the foreman installing or performing the work, the Resident Engineer, the Project Supervisor and Inspectors assigned to the work.

The Resident Engineer should assign discussion roles and times. The contractor should be requested to bring manufacturer's installation requirements, including manufacturer's drawings approved by ADOT to the meeting. If there are more recent standards approved by ADOT, the Resident Engineer should encourage the contractor to work to current approved standards (changes to Specifications require a Change Order). ADOT personnel will bring the current Quantlists to the meeting. An agenda similar to the pre-activity meeting for guardrail can be utilized (see Exhibit 905-1).

CPM Schedule Reviews

Objectives of Critical Path Method (CPM) Scheduling

All projects require the contractor to submit a CPM schedule. The schedule is submitted at the beginning of the project and updated monthly throughout the life of the project. The requirement for the contractor's CPM schedule can be found in Subsection 108.03 of the Standard Specifications or Subsection 108.12 of the Special Provisions

The intent of the CPM schedule is to get the contractor to determine which construction activities are critical to completing the project on time. These critical activities are called the controlling items for the project (see definitions in Subsection 101.2). Once the controlling items are identified, the contractor's superintendent, the Resident Engineer, and other project team members can focus their management efforts on ensuring these items stay on track and are not unduly delayed.

The CPM schedule demonstrates that the contractor has considered not only all the activities needed to complete the project in accordance with the contract, but the effect of each activity on project time and the contractor's resources.

Reviewing the CPM Schedule

There are two primary components to reviewing a construction schedule: the technical review and the constructability review.

Technical Review: The technical review of the schedule focuses on the detailed inputs into the CPM software to verify that the output list of start dates, finish dates, floats, etc. will be appropriately computed. You may use the Schedule Review Checklist to systematically verify that all technical parts of the schedule have been completed. Some of the key questions to consider are:

- Did the contractor submit the required electronic files
- Is the data date correct
- Does the start date match the award letter
- Is the finish date correctly shown based on the contract time
- Do all activities have a predecessor except for the first activity
- Do all activities have a successor except for the last activity
- Is the Total Float for each activity shown correctly
- Is the longest path (controlling items) clearly identified
- Are there unexplained gaps in the critical path

Constructability Review

The constructability review of the schedule focuses on the plans, specifications, and bid items that correspond to the schedule activities. In addition to the detail of the contract documents, the reviewer should consider the broader question of: Does this make sense? If anything is not easily understood, ask the contractor to explain what they included and why in the narrative.

Key constructability questions to consider are:

- Are the durations of activities realistic per the ADOT Production Rate manual
- Is the Work Breakdown Structure organized appropriately by phases
- Are all of the bid items included in at least one scheduled activity
- Does the relationship logic between activities make sense
- Do curing time frames match the specifications

It is the Resident Engineer’s responsibility to review and accept the schedule(s). On larger or complex projects, an independent schedule reviewer may be assigned by the District to the project in order to assist the Resident Engineer with schedule reviews. The schedule reviewer’s role is to review the schedule for contract compliance and advise the Resident Engineer on schedule acceptance. The coordination process between the Resident Engineer and the schedule reviewer is shown in Exhibit 108.04-4 below.

An independent schedule reviewer primarily focuses on the technical components of the schedule deliverables and verifies that the schedule meets the contract requirements. They may advise on suggested opportunities to improve the critical path or inquire about sequence and duration of activities. However, they are generally not on-site and may not be as familiar as the Resident Engineer with the constructability of the project, means and methods proposed by the contractor, or other project constraints. The Resident Engineer should review the schedule in conjunction with the schedule reviewer’s comments to ensure a more comprehensive review of the contractors schedule.

For example, the schedule reviewer notices that the bridge activities are split into 3 phases on the schedule, but the plans show 2 phases. Since the schedule activity names are not specific enough to understand which parts of the bridge are in each phase, the reviewer makes a comment for the contractor to provide unique names such that the schedule clearly shows which parts are built in each phase. The Resident Engineer, through discussions with the contractor, understands that the contractor actually intends to build the bridge in 2 phases per the plan, and the 3rd phase in the schedule is an error. The Resident Engineer should discuss this information with the schedule reviewer and the reviewer can update their comments accordingly.

The Resident Engineer should keep the schedule reviewer informed of any changes to the project that may impact the schedule. Any change orders that add, remove, or change quantities of an item will likely alter the duration or sequence of activities. If a Request for Extension of Time has been approved, send a copy to the schedule reviewer such that they can verify that the additional time has been included correctly during the next review.

The CPM schedule serves several purposes on the project such as a:

- Planning tool - It conveys how the contractor is planning to sequence the work
- Record tool - It includes actual dates of start and finish of each activity
- Communication tool - It informs subcontractors and project team members when their work is planned
- Risk tool - It shows which activities are controlling items and most likely to impact on-time completion
- Review tool - It provides an opportunity to identify time savings or analyze impacts of a delay

As a project partner, you should be of great service to the Contractor during the planning stages of the Baseline schedule. A key part of the Resident Engineer's review is to look at the sequencing of the work to determine if the contractor has considered:

- All the contract requirements, such as shop drawing reviews, traffic restrictions, access limitations, time constraints, etc.
- Any unusual site conditions
- Any regulatory impediments from local, county, state, or federal agencies
- Interface requirements with other Contractors
- Construction method limitations specifically described in the Project Plans and Special Provisions
- Any other unusual contract constraints

The Resident Engineer should review the schedule to see that activity durations appear realistic and that the logic makes sense. Any gaps in the critical path should be questioned unless explained by the contractor. A good critique of the contractor's schedule is a major contribution the Resident Engineer can make in helping the contractor correctly plan the contract work.

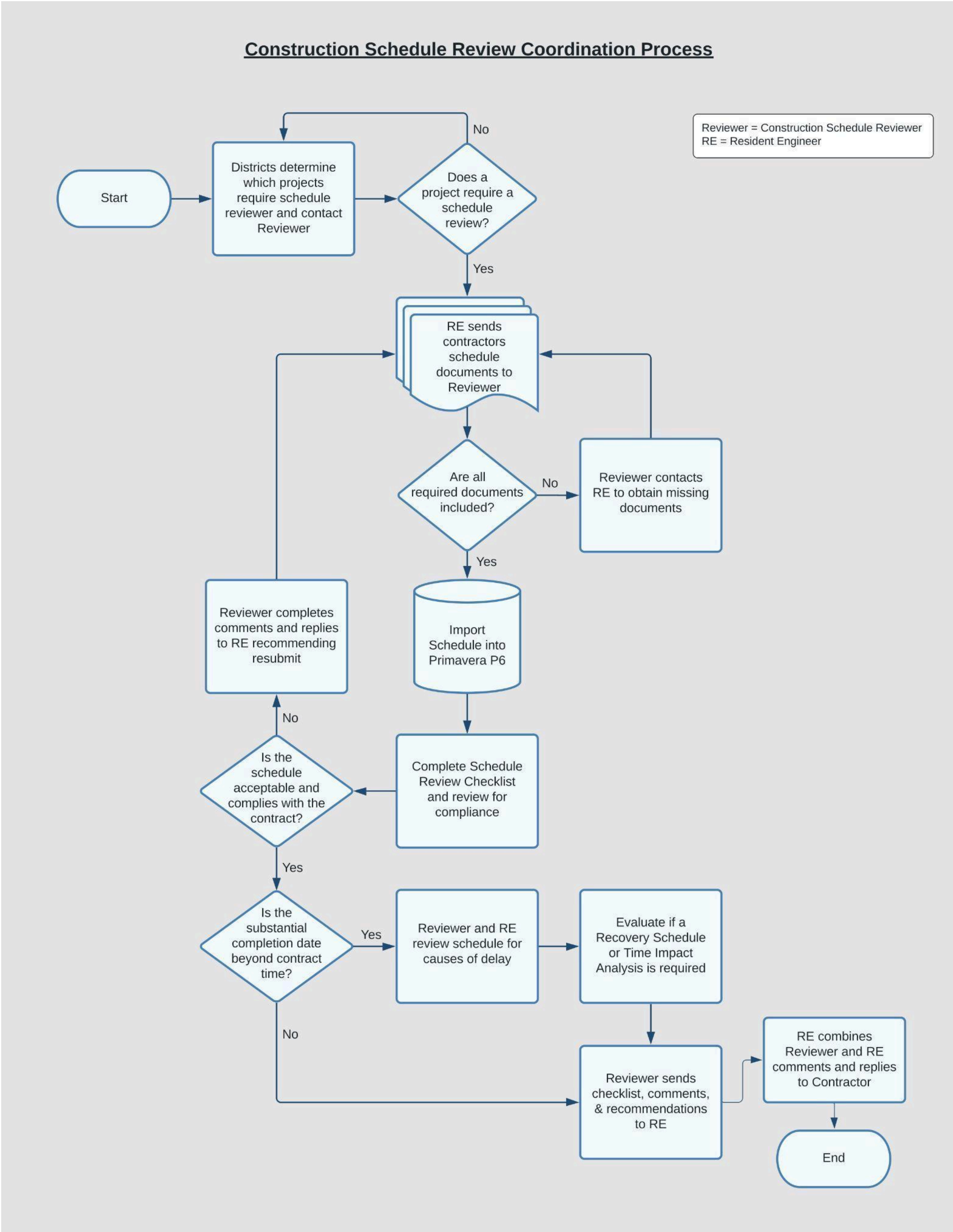


Exhibit 108.04-2 Construction Schedule Review Coordination Process

Submittal and Review Deadlines

It is important for the Resident Engineer to insist that the contractor submit the CPM schedule and the monthly updates within the time limits described. One reason is that schedules are time-sensitive documents, so information in a schedule starts becoming useless and outdated the longer the contractor waits to submit.

In addition, the CPM schedule determines the controlling items for the project ahead of time. This is very important for the Resident Engineer to know in advance so that the Department does nothing to unknowingly affect these items.

The following summarizes the submissions and review times for the contractor’s CPM schedule (all time is in calendar days unless noted otherwise). All projects will have a Progress schedule per the Standard Specification or a Baseline Schedule per Special Provision 108.12 for Level 1, 2, or 3 if included in the contract.

<table>
<tr><th>Schedule</th><th>Specification</th><th>Due</th><th>Recommended Review Time</th><th>Revision Time</th></tr>
<tr><td>Progress</td><td>Std Spec 108.03</td><td>at the Preconstruction Conference</td><td rowspan="7">7 days

(Baseline or complex schedules on large projects may take up to 15 days)</td><td rowspan="5">10 days or less is considered reasonable depending on the extent of revisions. No specific timeframe in the specifications.</td></tr>
<tr><td>Revised Progress</td><td>Std Spec 108.04</td><td>every 30 days throughout the contract</td></tr>
<tr><td>Baseline Level 1</td><td>108.12 SCHLVL1</td><td>at the Preconstruction Conference</td></tr>
<tr><td>Preliminary Level 2 or 3</td><td>108.12 SCHLVL2
108.12 SCHLVL3</td><td>before the Preconstruction Conference</td></tr>
<tr><td>Baseline Level 2 or 3</td><td>108.12 SCHLVL2

108.12 SCHLVL3</td><td>30 days after Preliminary approval</td></tr>
<tr><td>Monthly Progress</td><td>108.12 SCHLVL2

108.12 SCHLVL3</td><td>by the 15th day of every month throughout the contract</td><td>7 days</td></tr>
<tr><td>Recovery Schedule</td><td>108.12 SCHLVL2

108.12 SCHLVL3</td><td>within 10 working days of Engineer’s written direction</td><td>5 days</td></tr>
</table>

Withholding Progress Payments

The initial schedule submission is part of the preconstruction conference documents. This submittal demonstrates that the contractor has put together a basic plan on how to execute the contract work. If the contractor fails to submit the schedule or it is incomplete, the Resident Engineer should order the conference suspended until a schedule is submitted. A lot of detail is not required for Preliminary schedules, but the overall plan should be complete and understandable.

Withholding progress payments for an incomplete Preliminary submittal is based on the principle that the contractor should clearly communicate a work plan to ADOT in advance of any work being done for which they expect payment from the Department. A lot of detail is not required, but the overall plan should be complete and understandable.

The Baseline Schedule demonstrates to the Department that the contractor has planned the work in sufficient detail to carry out its execution without risking a major interruption or re-sequencing that would expose the project to unnecessary financial risk. The Baseline Schedule requires much more detail than the Preliminary Schedule, including reports and resource/cost loading for level 3 projects.

Withholding progress payments for an incomplete Baseline submittal is based on the fact that the project is well under way, and the contractor has still not adequately planned the work to reduce or eliminate unnecessary risks to the project.

Withholding a portion of the monthly progress payment for tardy update submittals reflects the fact that CPM schedules are time-sensitive documents, and getting them late diminishes their value to the project and the Department.

The contractor may say that partnering is based on trust, so the Resident Engineer shouldn't worry about the CPM schedule requirements. They point out that if there is really trust between the two parties, then the contractor should not have to continually demonstrate that he or she has adequately planned the work. The contractor may point out that the project work is not that complicated and does not require a CPM schedule as extensive as the one required in the Special Provisions.

In response to these concerns, it is important to understand that the CPM schedule requirements are not based on a lack of trust or faith in the contractor's ability to carry out the contract work, but a belief that a team effort in planning and scheduling large or specialized projects is crucial for their success. The Department needs to have a work plan in highly sufficient detail and clarity so it can better understand:

- The complexities of the work
- Its roles on the project team
- The impacts of the Department's actions (or a change condition) on the contractor's progress

Withholding of progress payments should never be a complete surprise to the Contractor. The Resident Engineer should always give the contractor adequate warning and ample time to respond before withholding payment. A face-to-face meeting, followed up by a letter, is the best way to get your point across. Escalating through partnering is highly recommended.

Project Delays

A CPM schedule gets the contractor to identify ahead of time the controlling items for the project. This is crucial information in the administration of any project since the Department needs to know how any changes or changed conditions affect the contractor's progress and work sequence.

Since delay claims can be the costliest of all contract claims, it is essential for the Department to have an updated and accurate project schedule that truly represents how the work will be prosecuted. If a contractor is planning to submit a Request for Extension of Time due to a delay, follow the procedures in Subsection 108.08.

The Resident Engineer should require the contractor to submit an updated project schedule whenever the contractor deviates significantly from the accepted project schedule. An updated schedule can be required at any point during the project. It does not need to wait until the following monthly update. This measure can prevent enormous frustration for the Department and the contractor whenever both are attempting to adjust the contract due to a perceived change.

An up-to-date schedule allows the Resident Engineer to deal with lack of progress on the project. If, in the Resident Engineer's judgment, there is a continual lag in the contractor's progress and no apparent effort is being made to improve the rate of progress, the Resident Engineer must notify the contractor in writing of the unsatisfactory progress.

In this notification the Resident Engineer should request that the contractor submit a detailed work plan for improving the rate of progress and provide evidence (usually a resource-loaded schedule) of the ability to complete the project within the time limit specified or as subsequently amended. Copies of such notification and the contractor's reply are to be sent to the District Engineer, the Project Manager and the Deputy State Engineer. Any further action on the part of the Resident Engineer should be on the advice of the District Engineer (also refer to Subsection 109.06 of this manual).

Subsection 108.04 of the Standard Specifications supports this with the following, "the work shall be diligently and continuously carried on to completion…" As such, the contractor is not allowed to have idle time and state it is part of their means and methods unless a thorough explanation in the schedule narrative is accepted.

Pacing delays are not allowed without a valid explanation in the schedule narrative to state why it is necessary. A pacing delay is when an activity is intentionally slowed down or deferred due to a separate delay to the controlling items on the critical path. It is not uncommon for the contractor to claim, "Why do I need to hurry up and wait?". Avoiding a pacing delay is not requiring any activity to "hurry up." It is the expectation that the contractor works continuously per their original schedule on all other activities that are not directly impacted by the delay. The problem with a pacing delay is that it:

- Unnecessarily consumes float
- May increase the number of controlling items, which adds risk to complete the work on time
- Defers the potential discovery of an additional delay that would have been known earlier
- May appear in the schedule as slow progress of the contractor's work

If a delay to the project is caused by the Department, a pacing delay by the contractor may look like a concurrent delay and could change an extension of time from compensable to non-compensable. It is in both the contractor's and Department's best interest to have pacing delays avoided or explained with the schedule so there is less confusion when determining entitlement from a delay. If no documentation is made available to justify a pacing delay, then consistent with the AACE International (AACEI) recommended practice, concurrent delays by the contractor should not be regarded as pacing delays, and instead are delays for which the contractor is responsible.

Let's look at an example of a project with construction of two interchanges. Interchange 1 encounters an unknown utility which delays the project by 6 months. Interchange 2 is dependent upon excavation from interchange 1 to be used as an embankment, which is not accessible until the utility has been relocated. In this case, there is a valid reason why interchange 2 is deferred. When the contractor explains the extent of the delays in the schedule, the Resident Engineer can then determine if a change to the contract is beneficial to the project. The Resident Engineer could choose to add Borrow to the project in order to keep interchange 2 on schedule.

Project Staffing

After the contractor's project schedule has been submitted, the Resident Engineer should determine the staffing needs for the project.

108.05 Limitation of Operations

This subsection reinforces much of the public safety and convenience issues raised in Subsection 107.08 and 104.04.

Often contractors will work weekends, holidays, and evenings to stay on schedule or to optimize resource usage. The contractors are required to give 24 hours' notice of weekend work. It has been the Department's policy to deny weekend work only when the work cannot be adequately inspected or it will cause undue hardship to the motorist.

When work is performed at night, adequate lighting needs to be provided by the contractor so that:

- Work can be performed safely
- The work can be adequately inspected
- Traffic can move safely around the work

OSHA Standard 1926.56 has minimum lighting standards for workers safety. However, the Resident Engineer has the right to ask for additional lighting above the minimum so Inspectors can adequately inspect the work. For example, equipping the Inspectors with flashlights is not good enough when large areas or large surfaces, such as concrete paving, need to be inspected.

If the work can be inspected and tested the following day without rushing the Inspectors, then work may be allowed to continue into the night as long as the OSHA standards are met.

108.07 Methods and Equipment

Whenever the contractor desires to change a construction method or piece of equipment required by the Standard Specifications or Special Provisions, the contractor should submit a proposal as described in Section 104.02 of this manual. If the Resident Engineer perceives a significant cost savings by allowing the change, then the contractor should be asked to submit a value engineering proposal in accordance with Subsection 104.13.

Before approving the change, the Resident Engineer can ask the contractor to perform a test section using the proposed methods or equipment to demonstrate satisfactory results.

108.08 Determination and Extension of Contract Time

Measuring Time

Time allowed for completion of the contract work will be specified in Subsection 108.08 of the Special Provision. One of the following methods will be specified for measuring time:

- Number of calendar days
- Number of working days
- Fixed completion date

Time allowed for projects with a construction phase and a landscape establishment phase will be specified separately.

Some projects may use innovative contracting methods such as A+B Bidding. A+B Bidding requires the contractor to bid both Cost-Plus-Time. The low bidder is selected based on a combination of the contract bid items (A) and the time (B) needed to complete the project. Contract bid items A and B are assigned a monetary value. Incentive/disincentive (I/D) provisions are used to encourage early completion and discourage unbalanced bidding. The Resident Engineer, or at least the District, should be involved during the development of an A+B contract with special attention to contract time. Specifications and procedures for A+B and other innovative contracting methods change often.

Some projects may have a milestone date for certain activities being completed by a fixed date or within a prescribed amount of days. These are separate from contract time and these often come with incentive/disincentive provisions.

The A+B, Design-Build, or other contracting methods do not change the time requirements for Department reviews, approvals, or inspections unless specified in the Special Provisions. There is not an implied duty on the Department to change the contract or expedite an action simply to help the contractor complete the work within contract time.

In the unique situation where contract time is reduced after a project has been awarded, a supplemental agreement must be completed to document the reduction in time. In addition, the Field Reports group should be notified and a Service Desk Ticket must be submitted by the Field Office to update the contract card and time reports.

The Resident Engineer should contact the Construction Group for guidance when negotiating a Supplemental Agreement containing extended overhead and or negotiating compensatory time extensions. In order to maintain statewide consistency, approval from the State Construction Engineer or the Assistant State Construction Engineer is required prior to the Resident Engineer agreeing to any: delay compensation, extended overhead compensation, or compensatory time extensions with the contractor.

Extended Project Delays Outside of the Contractor's Control

During the course of the project, there may be delays incurred by the project that are out of the Department’s and contractor’s control. These may be caused by any one of the following situations:

- Extended winter shutdowns
- A recognized differing site condition meeting the requirements of Standard Specifications 104.02(B)
- Acts of nature occurrence meeting the requirements of Standard Specifications 104.11(A)
- Labor strikes and public protests of the project as described in the FHWA Contract Administration Core Curriculum Manual (Time Extensions).
- A recognized nationwide shortage (force majeure) meeting requirements of Standard Specifications 108
- Government interventions
- Unexpected utility conflicts
- Archaeological or Native American finds as described in Standard Specifications 107.05
- Unexpected hazardous materials as described in Standard Specifications 107.07

In the unlikely situation where a project is required to be halted or suspended for any reason, the Resident Engineer should reach out to the State Construction Engineer or the Assistant State Construction Engineer for guidance as it relates to charging time and contractor compensation.

Contract Time and Controlling Items

The Department extends contract time based only on effects to the controlling items for the project (see Subsection 101.02 for a definition of controlling item). For example, suppose the controlling item for a project is the curing of a concrete box culvert, and let’s say it rains on the project for the next three days. Even though the project may be shut down, no extension of contract time is needed because the controlling item is unaffected by the rain.

The contractors may make time extension requests when non-controlling items are affected by changed conditions, directed changes, or other changes beyond the contractor’s control, and subsequently become controlling items.

For example, let’s say in the previous box culvert example, a non-controlling item such as preparing subgrade was delayed five days due to the rain. If the item had seven days of total float time before the rain began, then after the five-day delay, the item would still have two days of float. It is still a non-controlling item so no time extension is needed.

Sometimes a non-controlling item becomes a controlling item. In this case, the contractor may ask for a time extension due to uncontrollable past delays that consumed some of the float time.

In the previous example, a few days later, a key piece of equipment breaks down while the contractor is preparing the subgrade. The equipment will take at least a week to fix. The prepared subgrade item now becomes a controlling item because the remaining float time is gone. The project is now being delayed. The contractor will then contend that if it hadn't rained, the float would still be available for fixing the equipment.

In this case, the contractor is attempting to benefit exclusively from the use of float time. This is not fair to the Department since contract time does have a value, and neither party should have a monopoly over it. If the situation were reversed (the equipment breakdown occurred just before the rain) it would be just as unfair for the Department to contend that the rain would not have delayed the project had the contractor properly maintained the equipment.

A contractor that starts a project late may be considered as sequestering float, since they are benefitting from it exclusively. While a late start may be accepted by the Resident Engineer, the risk associated with consuming float is the responsibility of the contractor. If a delay occurs that is not the fault of the contractor after a late start and causes the project to finish late, it is not fair to the Department because float would have been available had the project started on time. As such, the project delay may be considered as non-excusable.

Delay Submittal Documentation

It is the contractor's responsibility to provide all documentation necessary to analyze a delay, identify the controlling items, demonstrate the impacts, and provide justification for an extension of time. At a minimum, the contractor shall submit a revised schedule and a detailed explanation, illustrating the impacts to the project.

Projects that include Special Provision 108.12 require the contractor to submit a Time Impact Analysis (TIA), if the contractor requires an extension of contract time due to an event, situation, or change that affects the critical path. A TIA is a specific type of analysis method. It is a forward-looking, prospective schedule analysis developed to demonstrate the impact of a change to the current schedule on its longest path. More information on the details of a TIA can be found in AACEI 52R-06 Prospective Time Impact Analysis. Contact Construction Group for a copy of this document.

Other types of delay analysis methods may be appropriate under certain circumstances. AACEI 29R-03 Forensic Schedule Analysis Recommended Practice is a good resource to understand how other methods may be applicable. It is beneficial to discuss the type of analysis with the contractor prior to preparing the delay documentation.

ARIZONA DEPARTMENT OF TRANSPORTATION

REQUEST FOR EXTENSION OF TIME

Project No. STP188-A-(001)B **TRACS No.** H615501C **Request No.** 1

Project Name Claypool Jakes Corner Hwy (US60) **Contractor** FNF Constuction, Inc.

Working Days ☑
Calendar Days ☐
Total Days Requested 5 **Fixed Date** ☐ **Requested Amended Fixed Date** ☐

The work has been impacted for the following **attached** reasons. Include a schedule (CPM if applicable) detailing the impact to the contract. **ALL ATTACHED JUSTIFICATION DOCUMENTS MUST SHOW TRACS NUMBER, REQUEST NUMBER AND CONTRACTOR.**

Compensatory Days Requested ☐ Non-Compensatory Days Requested 5

Contractor Signature Title Date of Signature

Contractor Signature — Title — Date

Contractor Printed Name

Contractor Printed Name

The days claimed and reasons thereof have been studied. If fewer days are recommended than claimed, attach explanation.

Compensatory Days Recommended ☐ Non-Compensatory Days Recommended 5

NOTE: If compensatory days are requested, attach the consultation e-mail FROM the Assistant State Engineer for Construction.

Senior RE Signature Date of Signature

Sr./Resident Engineer — Date

NOTE: This recommendation must be sent to the District Engineer for approval.

Compensatory Days Approved # ___ $ ___ Daily Rate $ ___ Total Approved Non-Compensatory Days Approved 5

District Engineer Signature Date of Signature

District Engineer — Date

NOTE: If approved date differs from Contractor's request, return for concurrence.

Contractor Concurrence Signature — Title — Date

Contractor Concurrence Printed Name

IF THE CONTRACTOR DOES NOT AGREE THE ESCALATION PROCESS MUST BE FOLLOWED.

After a review of the facts,
an additional _______ Compensatory Days and ______ Non-Compensatory Days are approved.

Federal Highway Administration — Date

After Signatures, a Change Order must be executed in accordance with Standard Specification 108.08.
The Request for Extension of Time and all documentation must be attached to completed Change Order. 05/2013

Exhibit 108.08-1 Time Extension Request

CM@R ☐
Design-Build ☐

ALTERNATIVE DELIVERY

CONTRACT MODIFICATION REQUEST

Page ____ of ____

Contractor:	**Project No.:**	**TRACS No.:**	**Date:**
Project Manager:	**Design Firm:**	**Initiator:**	

Requested Change (What):

Reason/Justification (Why):

General Supplemental Agreement Types *Choose from dropdown* *If Other, please explain:*	**List Technical Managers:**

ADOT Recommendation:

Concept Recommended ☐ Yes ☐ No ______________________ **Date:** ___/___/___
ADOT Sr./Resident Engineer

Concept Recommended ☐ Yes ☐ No ______________________ **Date:** ___/___/___
ADOT Asst. District Engineer/District Engineer

Concept Recommended ☐ Yes ☐ No ______________________ **Date:** ___/___/___
Assistant State Engineer, Construction

Concept Recommended ☐ Yes ☐ No **Eligible for Federal Reimbursement** ☐ Yes ☐ No

______________________ **Date:** ___/___/___
FHWA

Any decision to approve the change to contract terms will be within the sole discretion of ADOT and is dependent on the documentation that is submitted and entered into the Supplemental Agreement Tracking System (SATS).

Exhibit 108.08-2 Contract Modification Request Form

108.09 Failure to Complete the Work on Time

Liquidated Damages

Liquidated damages are assessed against the contractor when the project work is not substantially complete (Subsection 105.19) within the allotted contract time. Liquidated damages for failure to complete work with contract time are not a penalty, but a method for recovering some of the Department's costs and damages due to the additional time needed to complete the project.

The Department uses liquidated damages as a last resort. These damages should be the final result of a process during which the Resident Engineer has been communicating to the contractor the ramifications of not finishing within the contract time available.

Liquidated damages should be no surprise to the contractor. The contractor should receive plenty of warning about what could happen if the project is allowed to fall behind schedule. There should be letters written and escalation meetings held long before project time runs out.

It is important for contractors to receive a clear message from the Resident Engineer and the District Engineer about where the Department stands on assessing liquidated damages for each project. This message should not be received at the last minute when contractors have lost the opportunity to adjust their operations to make up for lost time.

When liquidated damages are assessed, the District Engineer should write a letter notifying the contractor of the assessment. The letter should come as soon as it is realized that the contractor will not achieve substantial completion within contract time. If retention is withheld on a project, the Resident Engineer needs to notify Field Reports in writing of any assessed liquidated damages before any retention is released. The Resident Engineer should attach a copy of the District Engineer's letter.

Constructive Acceleration

Resident Engineers should be very careful about how they communicate to the contractor the requirements for getting the project work back on schedule. Resident Engineers should not tell the contractor that the work has to be completed by a certain time or within a certain time period.

Some contractors may misinterpret this as a request to accelerate the work and then bill the Department for the acceleration costs. Instead, the Resident Engineer should warn the contractor about the consequences of not finishing on time, then let the contractor decide what to do. contractors do have a right to finish late and incur liquidated damages as a result.

109 MEASUREMENT AND PAYMENT

109.01 Measurement of Quantities

Method of Measurement

Highway construction work is divided into separate pay items. Each pay item represents a unique construction element of the project, e.g. guardrail, culvert pipe, roadway excavation, etc.

Each pay item has a method of measurement. A method of measurement is a procedure used to determine the quantity of work eligible for payment under each pay item. Usually the method of measurement measures the quantity of a key material for each pay item, e.g. cubic yards of structural concrete, or measures the completed work as a unit, i.e. each catch basin vs a lump sum structure.

Each pay item has a method of measurement clause or subsection, which can be found in either the Standard Specifications or the Special Provisions. The clause will describe exactly how the item is to be measured for payment. Subsection 109.01 more fully describes the method of measurement for pay items that have an undefined or incomplete description of how to measure the work for payment.

A method of measurement may or may not represent the actual quantities of materials used. For example, structure backfill is measured based on Standard Drawing B-19.40, which shows vertical fill limits adjacent to the structure. In reality, excavations are sloped next to structures so that the volume of structure backfill placed will always exceed the amount measured for payment.

Carefully review “Method of Measurement” and “Basis of Payment” sections in the Standard Specifications / Special Provisions to know exactly what is included in a pay item.

Measuring and Documenting Pay Quantities

The accurate measurement of pay quantities is a very important task for the Inspector. Field measurements for pay items are converted directly into dollars for the contractor. Because there is a direct relationship between what the Inspector measures and what the Department pays out, inaccuracies in measurements lead to underpayments or overpayments to the contractor.

ADOT has a training course to help inspectors in this area. The course is titled *Pay Item/Daily Diary Documentation (TCH3001)*. This is an excellent guide for all Inspectors on how to accurately measure and document pay quantities on ADOT projects.

Scales

Scale Operator

For many pay items involving bulk materials, e.g., aggregate base, asphalt, and mineral admixture, payment to the contractor is based on the weight of the material. Unlike other methods of measurement, measuring by weight can be a concern for the Department.

When paying for material by weight, ADOT has very little direct control or involvement in the weighing process. The material is weighed for payment on scales either owned or leased by the contractor or Material Supplier. The material is entirely handled by the contractor or Material Supplier before it is placed at the project site. Only when the material arrives at the project site does the Department exercise some control over it. As a result, the Department must rely on the accuracy of the contractor’s scales and the honesty of the contractor’s scale operators and trucking staff when this method of measurement is used.

To help ensure the integrity of this process, the Department requires a scale operator to monitor the weighing of materials for payment. When manually operated platform scales are used, a scale operator shall be assigned full-time to monitor weighing. When automatic scales are used (weights are automatically displayed and printed), the monitoring can be done part-time.

Regardless of whether scale monitoring is done on a part- or full-time basis, the scale operator has several important duties related to the weighing of materials.

- Ensuring the scales are properly certified.
- Ensuring the scales are being operated correctly and within their prescribed limits.
- Verifying the vehicle tare weights are correct if there is doubt about their accuracy (this could include weighing empty trucks on another scale).
- Verifying that the weight being measured is the same as the weight being recorded (more of an issue on manually operated scales).
- Tracking the accumulated amount of material used on a daily basis.
- Ensuring the contractor's weigh tickets are completed correctly.

The Resident Engineer or Project Supervisor may assign other duties to the scale operator to keep the person busy full-time. However, it is important that the scale operator has sufficient time to fully carry out the duties listed above so they can competently oversee the weighing process.

Scale Accuracy and Calibration

Like a tape measure, a scale needs to measure accurately and consistently according to accepted standards. A scale's accuracy directly reflects how accurately ADOT pays the contractor for work measured by weight.

To measure weight accurately, two things must occur.

- The scale must be calibrated correctly.
- The tare weight of the container holding the material must be accurately known.

Even when the scale weighs accurately and the correct tare weights are used, weights still need to be accurately recorded so payment can be made.

Policy on Scales:

- Truck scales must be licensed by the Weights & Measures Services Division (WMSD) within a period of 12 months preceding the date of weighing.
- The original setup of scales and all moves of scales should be licensed and certified by WMSD or a Registered Service Agency (RSA) before the scales are to be used.
- In the event ADOT personnel cannot satisfy themselves as to the proper accuracy of the scales, at any time prior to or during the weighing operations, weighing operations should cease and the WMSD or RSA should be called by the contractor to inspect the scales.
- ADOT personnel should not repair scales. An adjustment of the balance bar to maintain zero balance of the beam is the only adjustment that should be made by ADOT personnel. All other adjustments or repairs must be performed by an RSA.
- Scale certifications are good for 12 months. No grace period for recertification should be allowed. Commercial scales are required to be recertified by WMSD or an RSA within 45 days prior to expiration of the 12-month period.
- Responsibility for scale set-up, operation, maintenance, adjustment, and repair lies with the contractor.
- The WMSD maintains a list of current Registered Service Agencies. It is also important to ensure the RSA certification is current. An RSA certification search is available on the WMSD section of the AZ Dept. of Agriculture website.

Weighing Requirements:

- An acceptable load invoice or ticket should include truck number, time, source, date, type of material, and net pounds or tons. Each invoice should be signed by the ADOT scale operator and collected by the Inspector calculating the spread, who in turn should make a notation of station limits of the spread on the front of the invoice and initial. At the completion of the shift, the spread person should deliver the invoices to the project office for checking and totaling.
- In the event loads or portions of loads are rejected, notes explaining the reason should be made on the respective invoice, initialed, and dated by state and contractor representatives.
- Each day's totals and accumulated totals should be recorded on ADOT Pen Form - Truck Weight Record. Documentation, such as moisture deductions, should be shown on this form. Each weigh record will be signed daily by the scale operator or their deputy.
- The daily weigh record should be attached to the daily invoices and tapes. The invoices, checked tapes, and weigh sheet should be retained at the project office and kept with the project files.
- Spot checks of weighing operations and tare weights should be made. The frequency of these checks is dependent on the quantity of material being weighed daily, so the frequency of checking should be at the Resident Engineer's discretion.

109.02 Scope of Payment

Even though the Department pays for completed work on a monthly basis as the job progresses, this does not mean the work has been accepted. The Department has the right, until final acceptance (see Subsection 105.20), to require defective work to be corrected by the contractor, even after the Department has paid for that work.

109.03 Compensation for Altered Quantities

The quantities shown in the bidding schedule are just estimates of the amount of work required to complete the contract. In reality, the actual quantities are going to be different than the estimated ones. The contractors often ask for unit price adjustments when quantities run under the estimated amounts, items are deleted, or when work is added. Regardless of the reason, Resident Engineers should stay within the guidelines of 104.02 when making unit price adjustments.

As a Department, consistency is needed when allowing unit price adjustments. This ensures fairness to all our contractors, subcontractors and materials suppliers. Consult with the District Engineer when you feel a unit price adjustment is warranted outside the scope of 109.03, 104.02, or related subsections (see Subsection 104.02 of this manual).

109.04 Adjustments in the Contract Price

General

Supplemental agreements are used to make changes to ADOT construction contracts. They change work in the contract and adjust the contract cost accordingly. They CREATE new pay items or INCREASE, or DECREASE existing pay items or quantities. Supplemental agreements, specifically Change Orders, may also be used to change or waive specifications or add days to contract time, even when there is no effect on contract costs. Bid Items are never deleted; quantities must be adjusted to zero.

When signed by the contractor and the Resident Engineer, supplemental agreements are binding legal documents that supplement the original contract.

Three different types of supplemental agreements may be used to amend ADOT construction contracts:

1. Letter of Agreements are used if the cost of the extra work is less than $10,000. This is the simplest Supplemental Agreement. It describes the change and creates a lump sum Item No. 9240101, Miscellaneous Work (Resident Engineer Use Only), for payment. The Letter of Agreement is signed/authorized by the Resident Engineer and signed by the contractor. A Letter of Agreement is not to be used to change, add or delete plans or a specification or to add contract time extensions.
2. Change Orders uses existing items and unit prices in the bidding schedule or establishes new items and unit prices to pay for extra work. A Supplemental Agreement form is sent to the contractor describing the change and listing the pay items and unit prices affected by the change. Much supporting documentation such as a detailed cost analysis, revised design details, and plan sheets are contained in a Change Order package. A Change Order is also used to extend contract time, adding additional days to complete a project.
3. Force Accounts compensate the contractor for extra work based on the actual hours worked, equipment and materials used (time and materials). It is the most cumbersome and administratively complex Supplemental Agreement. It contains all the supporting documents found in a Change Order, plus additional record keeping requirements once the Force Account work begins.

The type of Supplemental Agreement used depends on the cost and complexity of the contract change. Simpler changes can be done by Letter of Agreement, while the more complex changes, for which costs are difficult to quantify, may need to be done by Force Account. The order of increasing complexity is:

1. Letter of Agreement, 109.04(A)
2. Quantity adjustments by Change Order using existing pay items, 109.04(B)
3. Detailed estimate (cost analysis) by Change Order, 109.04(C)
4. Force Account, 109.04(D)

The Letter of Agreement (LOA)

The Letter of Agreement is best suited when the changes are simple, can be easily identified and estimated, and cost $10,000 or less. A Letter of Agreement is the easiest for the Department to administer and does not require an extensive approval process. The Letter of Agreement can also be used to credit the Department for cost savings that result when the RE relaxes minor specification requirements. The intent shouldn't be to nickel-and-dime the contractor, but to recover legitimate cost savings when the contractor is clearly realizing a quantifiable economic benefit as the result of a change. A LOA can also be used to recover costs such as Partnering Workshop expenses.

The Change Order (CO)

A more formal documentation and approval process is needed for this type of Supplemental Agreement. If the change cannot be handled by adjusting the quantities of existing contract items—109.04(B), then a detailed cost analysis of the extra work must be performed—109.04(C). The Change Order is best suited when the work can be quantified ahead of time. Since Change Order prices are generally agreed on before the extra work begins, contractors may include many contingencies in their cost estimates to offset any perceived risks.

A Change Order is also used to add time to a contract. The contractor initiates this using the "Request for Extension of Time" form which categorizes the total time requested as compensatory and/or non-compensatory (see Construction Manual 108.08). The Resident Engineer reviews the contractor's request and recommends, to the District Engineer, the number of additional days to be added. In the recommendation, the Resident Engineer includes whether or not any time is compensatory. All Change Orders to extend contract time with compensation requires an analysis of the 'per day' rate of compensation. This analysis is prepared with the assistance of the State Construction Engineer, who reviews all compensatory time requests for guidance in price negotiations. Contract line item 1080800 Contract Time Extended Overhead with an Each-Day unit price is created. The District Engineer grants final approval for time extensions.

The authorization levels for time extension compensation remain unchanged. After the contractor signs the form, agreeing with the District Engineer's decision, the Resident Engineer prepares a Change Order. If the contractor does not agree with the District Engineer's decision, the Resident Engineer prepares an Escalation to the State Engineer.

Time Extensions add days to Working Day & Calendar Day contracts. Changes to FIXED DATE Contracts require that the contract's completion date be deleted and a new Fixed Date established for completion.

All Change Orders adjusting contract time shall be signed by the District Engineer or Assistant District Engineer.

Change Orders adjusting contract time can be combined with other contract changes as long as you do not lump different types of contract changes within one change order.

A Procedural Change Order is used when the cost of the change is zero – generally for additions or deletions to plans or specifications, or to extend contract time without compensation.

The Force Account (FA)

The Force Account should be the Supplemental Agreement of last resort because it is the most expensive and administratively tedious. The Force Account is used for contract changes in which the amount of work is difficult to quantify, emergency situation and work must start immediately or the financial risks of performing the work are too high for the contractor. The RE estimates ahead of time what they believe the extra work will cost and gets the necessary approvals to establish the force account. Once the work begins, daily records are kept of the labor, materials, and equipment used to accomplish the extra work. The contractor takes these daily records and invoices the Department for the work, based upon section 109.04(D) of the applicable Standard Specifications using the prime contractor Force Account Weekly Detail. The field office reviews and approves these details by comparing the contractor's documentation to the Inspectors documentation before paying the contractor.

To sum up, the Force Account is best used when:

- Defining the work clearly and accurately enough for a change order is too difficult
- The extra work needs to begin right away
- The RE and the contractor cannot agree on costs

Line item force accounts are not to be replaced by a supplemental agreement. In order to maintain Statewide consistency, if the Resident Engineer feels that a supplemental agreement is a more suitable administration tool for the element of work represented by the line item force account, concurrence from the State Construction Engineer or Assistant State Construction Engineer is required prior to generating a supplemental agreement.

Investigation and Preparation

Subsection 104.02, Revisions to the Contract, in the Construction Manual, describes the different types of contract changes and the process for analyzing any contract change. In 104.02 we said that the Resident Engineer must basically answer these four questions when analyzing a contract change:

- Was there a contract change (What was the change)
- Who caused the change
- What are the impacts of the change
- What are the costs

Subsection 104.02 should be referred to when investigating and analyzing any contract change.

The results of analyzing a contract change are documented in the supplemental agreement. See section on "Documentation" that follows.

Cost Analysis

An independent RE's cost analysis is required for all Supplemental Agreements including Force Accounts, Letters of Agreement and Change Orders (including Time Extensions). Cost analysis for time extension Change Orders with Compensatory time require consultation with the State Construction Engineer. Cost analyses for extra work are best done by carefully examining the impacts of the change first, then looking at costs last.

Here is a rudimentary procedure that can be used on any cost analysis that will keep you focused on analyzing the impacts first before you are ready to examine costs:

Quantify the Extra Work

This means calculating the amount of work that has to be performed: such as cubic yards of dirt to move, linear feet of guardrail to install, or pounds of rebar to eliminate. The trick here is not only calculating the quantity correctly, but also selecting the correct unit of measurement. Your selection should be based on industry practice and what unit of measurement best represents how the work will be performed. For example, excavation work is usually done on a cubic yard basis because excavation work involves moving volumes of material. On the other hand, structural concrete is usually estimated on a square yard basis and not by the cubic yard basis ADOT uses to measure it for payment; however, most of the expense in structural concrete is in the formwork and not in the amount of concrete used. Selecting the correct unit of measurement is an important element in producing an accurate analysis.

Analyze the Construction of the Work

Construct the work in your mind. Write down all the different steps that have to be followed (continuously ask yourself who will do what, where, when, and how?). This is where your analytical thinking as a technician or engineer is of prime importance. One reason project supervisors' estimates are usually less than the contractor's on extra work is that Project Supervisors fail to take into account all the little hidden extras that add to the cost of the work (e.g., additional crane time may be needed to lift extra rebar from a delivery truck to a bridge deck).

Select the Crew Size, Equipment and Materials Needed to Complete the Work

Once you have decided how you're going to build the work and have broken it down into smaller, definable units, then it is simply a matter of selecting the appropriate resources for the work. This selection is based on judgment as well as availability of the needed resources.

Estimate Production Rates

Here a lot of judgment is involved and often historical data can be used. Some of the more experienced inspectors may be able to help estimate how long the work will take. Sometimes you just have to assume a rate. Two things to remember are that no one works a 60-minute hour or less than half a shift.

Calculate Direct Costs

Up to this point, we haven't even mentioned costs and yet a lot of analysis has already been done. Good cost estimates are often the result of understanding how to build the work (steps 1 through 4) more than having accurate numbers on costs. On the other hand, don't be afraid to call material suppliers and to use the contractor's payrolls to improve your accuracy.

Another source of historical cost information is RS Means Heavy Construction Cost Data. This cost guide is published yearly and contains unit cost information as well as information on production rates and crew sizes.

Direct costs usually include project overhead, but not home office overhead. Don't forget incidental costs for things like haul roads, water, and waste disposal.

Add up all costs:

- Labor which includes burden and fringes. The use of Certified Payrolls for actual employees' pay data and fringe amount is preferred. The labor plus burden is calculated on Wages x 1.35. Labor burden is the total of all indirect labor costs necessary for an employee to perform the work that they are hired to do. It includes Social Security and Medicare Tax, Worker's Comp (Insurance the employer must purchase), State and Federal Unemployment Insurance, training, paid holidays, use of vehicles, computers, PPE, office, office furniture, equipment, supplies, etc. Fringes are the non-take home portion of wages which include Pension/401K, paid vacation and sick leave, contributions to health insurance, etc. ADOT verifies Fringe benefit rates from certified payrolls.
- Equipment costs: Here the Rental Rate Blue Book (Equipment Watch) is invaluable
- Materials: The delivered cost of AB, pipe, concrete, etc.

Add Markups and Arrive at a Grand Total or Unit Price

Profit and overhead is calculated as 15% of the total of all Labor, Equipment and Material costs for work done by the prime contractor. Work done by subcontractors is calculated as 20% of the total (assume a proposal from subcontractor already includes his 15% P & OH mark up, whether stated or not. The prime contractor receives an additional 5% to make the total 20% only on the portion of the work done by the subcontractor.

This is cost estimating in its most general form. Think of it as a central theme with many variations since the type of work and the needs of the estimator often have a great influence on the way in which the estimate is carried out. Applying these basic steps in order, for even the most complex analysis, will improve your accuracy by keeping you focused on the cost analysis process rather than on the bottom-line result.

Negotiating

Subsection 104.03 and the partnering process should be viewed as a valuable tool to negotiate the contract change amount, if any. If the extra work is not covered by an existing item, the Resident Engineer and the contractor may be able to negotiate a new unit price for the work and establish a new item or items in the supplemental agreement. If the contractor proposes a new item or unit price, a detailed cost analysis must be provided as directed in Subsection 109.04(C). The cost analysis should include a breakdown of the estimated time for labor (including labor classifications) and the estimated costs of materials and equipment. The total cost of the extra work is divided by the units of work to arrive at a unit price for the work.

The contractor's cost proposal must be analyzed by a thorough review by the RE. The contractor's analysis should be compared with the RE's analysis. The RE should be completely satisfied that the contractor's cost analysis is equitable and fair before accepting it as part of the supplemental agreement. Both the contractor's and the RE's cost analysis must accompany the supplemental agreement package.

Some REs think that contractors try to take advantage of the Department when a change order arises. This is usually not the case. The contractor is no longer in a competitive bid situation after they're awarded the project, so there is no reason for them to assume unnecessary risk. This lack of risk taking is typically reflected in contractors' change order prices.

Authorization

Authorization Levels:

1. Resident Engineers: REs are authorized to approve changes to the contract that do not exceed $200,000. This authorization will include changes in contract specifications, design and unit price adjustments. Contact and consensus with both the Project Manager and project designer will be required on design changes that are greater than $25,000. Project Managers should also be kept informed of all other significant changes. If the RE cannot reach a consensus with the Project Manager and designer on a change, then the issue should be immediately escalated.

2. District Engineer: The District Engineer will have authority to approve changes to the contract that equal or exceed $200,000 but are less than or equal to $1,000,000. This authorization will include changes in specifications, design, and unit price adjustments. Concurrence from the Project Manager and the designer will be needed on all design related changes. The approval of the State Construction Engineer is required for all Specification changes. In addition, the District Engineer may delegate this authority to the Assistant District Engineer. In the absence of the District Engineer, the State Construction Engineer will assume and may also delegate this authority.

3. Deputy State Engineer: The Deputy State Engineer will have authority to approve all supplemental agreements that exceed $1,000,000 but are less than $2,000,000. This authorization will include changes in specifications, design, and unit price adjustments. Concurrence from the Project Manager and designer will be needed on all design related changes.

4. State Engineer: The State Engineer will have the authority to approve all supplemental agreements that exceed $2,000,000 but do not exceed $25,000,000.. This authorization will include changes in specifications, design, and unit price adjustments.

5. ADOT Director: The ADOT Director will have the authority to approve all supplemental agreements that exceed $25,000,000.

When cumulative changes to the contract exceed 2% of the contract amount, a Resident Engineer or District Engineer must have concurrence from the State Construction Engineer. The easiest way to do this is to have the SCE initial the CRN. Nothing is triggered in the FAST system for this concurrence. The RE is responsible for monitoring the cumulative value of all changes to the original contract amount. The RE must verify the project budget can accommodate all supplemental agreement amounts by referencing the Finance Card found in the Contract Card of your FAST Desktop. If not, a Budget Increase Request must be submitted and approved by the State Construction Engineer.

Additionally, the FHWA should be notified If:

- A change order exceeds $1M
- There is an increase above 20%
- The addition of work is out of character or outside of the NEPA document

Signatures

The person approving for the State of Arizona (below the line) coincides with the dollar amount authorized. RE’s sign <u>below the line</u> when the CO does not exceed $200,000 or include a time extension, because they are approving for the State of Arizona.

RE's sign above the line when the CO is over $200,000 and/or includes a time extension because the DE, Assistant DE, Deputy State Engineer, or the State Engineer sign below the line (according to their authority level), approving for the State of Arizona.

NOTE: The RE only needs to sign the CO once. They do not need to sign both above and below the line.

FHWA APPROVAL is required for all FHWA Full Oversight projects, aka PoDI (Projects of Divisional Interest). FHWA approval is also required on major change orders and claims (over $1 million, 20% of total project costs, work outside project limits, or major changes of scope). FHWA Full Oversight projects can be identified by the last letter in the Project Number. N or S (National Highway System – NHS). X or F (non NHS). Project numbers that end in an A, T, or D are in the Certification Acceptance program. See the FHWA and ADOT Stewardship and Oversight Agreement for Arizona signed in effect April 2015.

Contacts For Supplemental Agreements

The authorization levels discussed previously apply to the financial approval of a supplemental agreement. Changes that require alterations to the specifications, ADOT design policy or design details have to be agreed upon by the appropriate ADOT technical section. Major design changes must receive technical authorization before the cost of the change can be approved. Any official letters, plan revisions or relevant documentation provided by the technical section should be included in the final supplemental agreement. Additionally, the technical contact must be documented in the Supplemental Agreement Tracking System (SATS) Contract Revision Notification (CRN) screen.

The ADOT technical managers include Project Management, Construction Group, Materials, Roadway, Environmental, Traffic Engineering, Engineering Technical Group, Right of Way and Bridge.

If any technical manager does not agree with the proposed Supplemental Agreement, the agreement must be escalated to the applicable Deputy State Engineer(s) for resolution and approval.

For all federally funded projects, the Federal Highways Administration needs to be advised that the supplemental agreement is being processed.

The District Engineer has authority to approve supplemental agreements for federal-aid projects in the certification acceptance program. Although FHWA does not need to approve these supplemental agreements, they do need to be advised that the supplemental agreement is being processed. FHWA contacts are required on all federal-aid projects not in the certification acceptance program. Any local government or agency participating on a project must also be contacted.

For any federally funded alternative delivery projects, the Federal Highways Administration must be advised that a supplemental agreement is being processed even if they are not participating in the associated cost of the supplemental agreement. This notification process requires a Contract Modification Request (CMR) be submitted by the RE, and be approved by FHWA prior to the contractor starting any work related to the supplemental agreement.

Additionally, local government or private agencies affected by changes made within a supplemental agreement must also be notified.

If applicable, the responsible Local Public Agency (LPA) should sign all supplemental agreements for contract changes they have agreed to participate in or pay for.

Escalation of Supplemental Agreements

Should there be an internal lack of consensus on any proposed supplemental agreement, the DE, RE, Project Manager, and the project management team should make every effort to reach a satisfactory solution. If necessary, the issue may be escalated to the State Construction Engineer or the Deputy State Engineer, who will then attempt to resolve the issue to the satisfaction of all concerned.

Documentation

Alternative Delivery Projects

For all Supplemental Agreements written on CMAR or Design-Build projects the approval process begins with the Resident Engineer initiating an Alternative Delivery Contract Modification Request form.

Contract Revision Notification Requirements for Supplemental Agreements

See Exhibit 109.04-1 Contract Revision Notification

The purpose of Contract Revision Notification Documents is to provide documentation that details ADOT approvals and contractor acceptance of contract changes. No payment can be generated until all required approval dates have been entered into the Contract Revision Notification Approvals SATS screen (and saved). The Initiation date is when the Resident Engineer reaches an agreement with the contractor to begin work, or directs the work to be done by Force Account. (See block “C” on the Timeline for Contract Modification diagram). The Contract Revision Notification is important because it documents that authorized approvals for contract changes have been obtained so that work and payment can proceed before a detailed Supplemental Agreement is signed as the official contract document. There are unique cases where emergency work necessary to provide for the safety and passage of public traffic, and such other emergency work necessary to mitigate damages to the facilities, is required. In these instances work may begin prior to having a cost agreed upon. For isolated instances when Supplemental Agreement work is discovered during times like night and weekend closures, and the work must be completed in the same shift, the contractor and the Resident Engineer shall document the work as if it were a force account.

The use of force account documentation is not intended to replace the Contractor's Cost Analysis or the Engineer's Independent Cost Analysis. The intent of the Specifications is not to track the work as a force account, and then convert it to a traditional Supplemental Agreement after the work is completed. Utilizing force account documentation for supplemental agreements puts the financial risk on the Department and not on the contractor as intended. Utilizing force account documentation for Force Account Supplemental Agreements should only be used in extenuating circumstances where work must start immediately due to public safety or the detriment of the project.

A force account (supplemental agreement) cannot be converted to a change order after the supplemental agreement has been created in SATS and/or payment has been made. A completed formal detailed Supplemental Agreement with exact cost shall be completed within 60 calendar days following the Initiation date on the Contract Revision Notification.

The Resident Engineer or their designee shall use the SATS program in the FAST Data Base to prepare the Contract Revision Notification Document. The following contacts will be made:

- The person authorizing the change (see “Authorization Levels” above)
- The State Construction Engineer and the Project Manager, if the Supplemental Agreement cost warrants (see “Authorization Levels” above)
- If the design was modified, the name of the registrant that was contacted as specified under “Sealing Change Orders” below

- The person contacted within the appropriate ADOT technical section if ADOT Standard Specifications, Special Provisions, or Standard Drawings were altered (see “Contacts for Supplemental Agreements” above)
- Federal Highway Administration:
    - Under current requirements with the ADOT/FHWA Agreement, FHWA personnel shall be kept informed of all changes to projects over $1 million on the interstate highway system.
    - For FHWA funded projects, a Contract Modification Request (CMR) may also need to be submitted and approved prior to submitting the CMR.
- Local government contacts

The original will be filed in the project files, with additional copies distributed to:

- Field Reports
- Local Government and/or FHWA as applicable
- All other contacts specified in the Contract Revision Notification

Office Procedure For Contract Revision Notification (CRN)

1. Start the coordination for the Contract Revision Notification as soon as you know that a contract change will occur. A guide to assist in creating CRN’s & SA’s can be found in the SATS User Guide.
2. As soon as you feel the document is complete, advise the RE for a final review to make any needed edits.
3. Place an electronic copy of the unsigned completed CRN in the project file.
4. Send the document to be initialed by the Resident Engineer and their upline manager via DocuSign.
5. The Supplemental Agreement Checklist found at Field Reports reference site and shall be attached as the front cover page of this package.
6. When the supplemental agreement document has been completed, attach a copy of the Contract Revision Notification document behind the Supplemental Agreement Checklist cover page.
    - NOTE: To avoid issues during project closeout, the current FAST Program requires the Contract Revision Notification (CRN) and the Supplemental Agreement (SA) dollars to match. If the final negotiated cost of the supplemental agreement has changed from the original estimated cost included in the original CRN, the estimated CRN dollar amount shown in FAST must be changed to reflect the final negotiated cost on the SA. The revised CRN should then be reprinted and resubmitted for signatures prior to attaching the CRN to the SA document.

Supplemental Agreement Forms

Immediately following distribution of the Contract Revision Notification Documents, the RE or his designee should proceed with the preparation of the formal supplemental agreement. The completed formal supplemental agreement will be completed 60 calendar days following the Initiation date on the Contract Revision Notification.

The text of a change order (see Exhibit 109.04-2 Change Order Agreement for Non-Compensatory Time) consists of:

- The Request (a list of the work items Increased, Decreased, or Created)
- The Reason for the work
- Specifications/Stipulations added, modified, or deleted to the contract. They can either be attached or referenced
- Pay item adjustments (Increased, Decreased, or Created item list with unit of measure and cost effects of the work

The text of a Change Order for an extension of contract time (see Exhibit 109.04-3 Procedural Change Order [Non-Compensatory] consists of:

- The Request – an extension of contract time
- The Reason for the additional time
- Specifications/Stipulations added, modified, or deleted to the contract. They can be either attached or referenced
- Pay item adjustment for a compensatory time extension only (establish Pay Item 1080800 Contract Time Extended Overhead at EACH/DAY cost established in agreement)
- The signed "Request for Extension of Time" form must be attached. If compensatory time is granted, then an analysis of the overhead per day cost, prepared in consultation with the State Construction Engineer must be included

Similarly, the text of a force account work request (see Exhibit 109.04-5 Force Account Agreement) consists of:

- The Request; a description of the extra work
- The Reason for the work
- The cost breakdown of the estimated labor, materials, and equipment required to perform the extra work

The RE should also consider using drawings, photographs, and quotations from the specifications or developing unique provisions to make supplemental agreements clearer and more authoritative.

An explanation of rate establishment may also be required on a force account work request if the hourly rate for a particular type of equipment is not covered in the Rental Rate Blue Book for Construction Equipment.

A Supplemental Agreement is usually signed first by the contractor, then sent to the RE for signature. The supplemental agreement is then sent to the District office for approval and signature (if needed), and to FHWA if a PODI. The supplemental agreement and all attachments are then forwarded to Field Reports for processing. All of this can be done through the SA template on Docusign.

Use the Supplemental Agreement exactly as it is printed from SATS. Do not modify it by clipping, cutting & pasting, or montaging. All printed pages must be signed (executed) by all parties to the Supplemental Agreement.

Each letter agreement of authorization will include the following information (see Exhibit 109.04-6 Letter Agreement):

- The TRACS number, project number and date of authorization
- A description of the work
- Reason for the work authorized
- The Lump Sum cost of the alteration

The Resident Engineer must make a thorough analysis of the contractor's cost proposal and be completely satisfied that it is equitable before negotiating the cost of the Supplemental Agreement.

The Resident Engineer's review will be in the form of a completely independent cost analysis, which will be attached to the Letter of Agreement package and forwarded to Field Reports with a copy retained in the project office.

The person signing for the contractor for all Supplemental Agreements must be listed on the Authorized Signature Form.

Arizona Department of Transportation

Infrastructure Delivery and Operations Division

Contract Revision Notification

04/15/2022

Approval Date: 5/5/2021 (RE)

To: Brenden Foley
Asst District Engineer

From: Brent Allman
Resident Engineer

Tracs #	Project #	Project Name
F024301C	160-A-(209)T	WARRIOR DRIVE - MP 324.5

Contractor	Contract Amt	Contingency %	Contingency Adjustment %	Contingency Amt
Mountain High Excavating, LLC	$707,699.00	5 %	0 %	$35,384.95

Estimated SA Amt	Estimated Percentage of Contract	SA Amt to Date	SA % of Contract to Date
$29,822.73	4.21 %	$14,696.00	2.08 %

Agreement Type	Document Num	SATS Doc Num	Initiation Date
Change Order		2	05/03/2021

Reason Code Plans, Revisions, and Oversights

Brief Description
Seeding and Wattles

SA Description
During construction it was discovered that seeding and wattles would be required for final stabilization due to the actual area of disturbance. This CO would compensate the contractor for the additional work. A time extension of seven calendar days has been been determined as the critical path is effected due to the additional work.

Prime Designer
ADOT Traffic Design

Contacts

Name	Title	Date Contacted	Comments
Ammon Heier	Federal	04/26/2021	via email
David Casselbury	Statewide Landscape Architect	04/26/2021	via email
Robert Stevens	District Env. Coord.	04/26/2021	via email
William P. Fay	State Construction Engineer	04/13/2021	concured

Exhibit 109.04-1 Contract Revision Notification

Arizona Department of Transportation
Infrastructure Delivery and Operations Division
Supplemental Agreement
04/15/2022

Change Order No. 2

Approval Date: 5/6/2021 (RE)

Tracs No: F024301C   Project No: 160-A-(209)T   Org: 4352   NorthCent

Project Name: WARRIOR DRIVE - MP 324.5   Contractor: Mountain High Excavating, LLC

_X_Federal Aid
__Non-Federal Aid

Request:
To create ITEMs: 8050003 Seeding (Class II), 8101021 Erosion Control (Wattles) (9"), 9010002 Mobilization

Reason:
During construction it was discovered that seeding and wattles would be required for final stabilization due to the actual area of disturbance. This CO will compensate the contractor for the additional work. A time extension of seven calendar days is warranted and agreed to, as the critical path is affected due to the additional work.

Specifications/Stipulations:
This Supplemental Agreement shall comply with Sec 8050003 or as directed by the engineer. This Supplemental Agreement constitutes full and final compensation for any and all costs, direct or indirect, related to this project, including but not limited to time, labor, services, overhead, profit, and damages. By executing this Supplemental Agreement the contractor expressly agrees to hold ADOT harmless and expressly waives the right to pursue any further claims or requests for compensation related to this contract modification. All other outstanding terms and conditions of the original contract and specifications are still valid towards this supplemental agreement.

Pay Item Adjustments

Sec	Item Nbr	Description	Unit	Unit Price	Quantity	Amount
1	8050003	SEEDING (CLASS II)	ACRE	6,010.92	4.000	$24,043.68
1	8101021	EROSION CONTROL (WATTLES) (9")	L.FT.	10.60	400.000	$4,240.00
1	9010002	MOBILIZATION	EACH	1,539.05	1.000	$1,539.05
					Total	**$29,822.73**

Date: __________ Date: __________ Date: __________ Date: __________

Resident Engineer   City/County Engineer   Field Reports

For valuable considerations, it is mutually agreed that the matter detailed above shall be done and payment made as shown herein for a Supplemental Agreement Change Order, all in accordance with the terms of the contract. For work being performed as a Supplemental Agreement Force Account Work Order, final payment shall be made as stipulated in the Standard Specifications and its supplements upon completion of said work.

Date: __________ Date: __________ Date: __________

Approved for:
Mountain High Excavating, LLC
Contractor

Approved for State of Arizona

___Approved without Federal participation
___Approved with Federal participation

By:__________. By:__________. By:__________.

Page 1 of 2

Exhibit 109.04-2a Change Order Agreement (Non-Compensatory Time)

Arizona Department of Transportation
Infrastructure Delivery and Operations Division
Supplemental Agreement
04/15/2022

Change Order No. 2

Approval Date: 5/6/2021 (RE)

Tracs No: F024301C **Project No:** 160-A-(209)T **Org:** 4352 NorthCent

Project Name: WARRIOR DRIVE - MP 324.5 **Contractor:** Mountain High Excavating, LLC

	Plus	Minus
Total Difference:	**$29,822.73**	

An Extension of Contract Time is Authorized for 7 days as a result of this Supplemental Agreement.

Date: ______ Date: ______ Date: ______ Date: ______

______ Resident Engineer ______ City/County Engineer ______ ______ Field Reports

For valuable considerations, it is mutually agreed that the matter detailed above shall be done and payment made as shown herein for a Supplemental Agreement Change Order, all in accordance with the terms of the contract. For work being performed as a Supplemental Agreement Force Account Work Order, final payment shall be made as stipulated in the Standard Specifications and its supplements upon completion of said work.

Date: ______ Date: ______ Date: ______

Approved for:
Mountain High Excavating, LLC
Contractor

Approved for State of Arizona

___Approved without Federal participation
___Approved with Federal participation

By:______. By:______. By:______.

Page 2 of 2

Exhibit 109.04-2b Change Order Agreement (Non-Compensatory Time)

DocuSign Envelope ID: 12FCA4AA-4562-443F-B85C-CF4B0547A30B

AH JB BA

ADOT

ARIZONA DEPARTMENT OF TRANSPORTATION

REQUEST FOR EXTENSION OF TIME

Project No. 160-A(209)T **TRACS No.** F024301C **Request No.** 001

Project Name Tuba City Four Corners Highway (US 160) **Contractor** Mountain High Excavating, LLC

Total Days Requested 7

Working Days ☐
Calendar Days ☑
Fixed Date ☐

Requested Amended Fixed Date 7/25/2021

The work has been impacted for the following **attached** reasons. Include a schedule (CPM if applicable) detailing the impact to the contract. **ALL ATTACHED JUSTIFICATION DOCUMENTS MUST SHOW TRACS NUMBER, REQUEST NUMBER AND CONTRACTOR.**

Compensatory Days Requested N/A Non-Compensatory Days Requested 7

Contractor Signature ______ Project Manager (Title) 4/1/2021 (Date)

Joseph B. Dutson
Contractor Printed Name

The days claimed and reasons thereof have been studied. If fewer days are recommended than claimed, attach explanation.

Compensatory Days Recommended N/A Non-Compensatory Days Recommended 7

NOTE: If compensatory days are requested, attach the consultation e-mail FROM the Assistant State Engineer for Construction.

SM DocuSigned by: Brent Allman
Sr./Resident Engineer 4/26/2021 Date

NOTE: This recommendation must be sent to the District Engineer for approval.

Compensatory Days Approved # N/A $ N/A Daily Rate $ N/A Total Approved Non-Compensatory Days Approved 7

DocuSigned by: Andrea Merrick
District Engineer BD 4/26/2021 4/26/2021 Date

NOTE: If approved date differs from Contractor's request, return for concurrence.

Contractor Concurrence Signature ______ Title ______ Date ______

Contractor Concurrence Printed Name ______

IF THE CONTRACTOR DOES NOT AGREE THE ESCALATION PROCESS MUST BE FOLLOWED.

After a review of the facts,
an additional _______ Compensatory Days and ______ Non-Compensatory Days are approved.

Federal Highway Administration ______ Date ______

After Signatures, a Change Order must be executed in accordance with Standard Specification 108.08.
The Request for Extension of Time and all documentation must be attached to completed Change Order. 05/2013

Exhibit 109.04-2c Change Order Agreement (Non-Compensatory Time)

Arizona Department of Transportation
Intermodal Transportation Division
Supplemental Agreement
03/27/2015

Procedural Change Order No. 13

Approval Date: 1/16/2015 (em)

Tracs No: H615501C Globe **Project No:** STP 188-A(001)B **Org:** 1111

Project Name: WHEATFIELDS - US 60 **Contractor:** FNF CONSTRUCTION, INC.

_X_ Federal Aid
__ Non-Federal Aid

Request:
To extend contract time by Thirty (30) Non-Compensable Working Days

Reason:
Avery Big Construction Company requested Thirty (30) Non-Compensatory Working Days be added to the contract time because of (put a short synopsis of reason here: e.g.: flooding in bridge foundation work area) as detailed in the attached Request for Extension of Time form and attached documents. The Department agrees with Avery Big Construction Company and will allow Thirty (30) Non-Compensatory Working Days be added to contract time.

Specifications/Stipulations:
Attachment A - Request for Extension of Time form signed by the District Engineer and Contractor.

This Change Order constitutes full and final compensation related to this extension of contract time as agreed to in the attached Request for Extension of Time form as described herein. By executing this Change Order, Contractor expressly waives the right to pursue any further claims or requests for compensation related to this contract modification, including, but not limited to, materials, labor, services, overhead, profit and damages.

Date: ______ Date: ______ Date: ______ Date: ______

Resident Engineer ______ City/County Engineer ______ ______ Field Reports

For valuable considerations, it is mutually agreed that the matter detailed above shall be done and payment made as shown herein for a Supplemental Agreement Change Order, all in accordance with the terms of the contract. For work being performed as a Supplemental Agreement Force Account Work Order, final payment shall be made as stipulated in the Standard Specifications and its supplements upon completion of said work.

Date: ______ Date: ______ Date: ______

Approved for:
FNF CONSTRUCTION, INC.
Contractor

Approved for State of Arizona

__ Approved without Federal participation
__ Approved with Federal participation

By: ______ By: ______ District Engineer By: ______

Exhibit 109.04-2d Procedural Change Order (Non-Compensatory Time)

Arizona Department of Transportation
Infrastructure Delivery and Operations Division
Supplemental Agreement
06/07/2023

Force Account No. 8

Approval Date: **11/19/2021 (RE)**

Tracs No: F012101C Project No: 101-B-(213)S Org: 4678 Central

Project Name: I-17 - PIMA RD Contractor: COFFMAN AMES JOINT VENTURE

__Federal Aid
X Non-Federal Aid

Request:
To create FA #08 – Repair Damaged Conduit at WB SR101 and Hayden:

Reason:
At approximate Sta. 1900+00 LT Sturgeon discovered a separated conduit coupler between conduit run #6 & #7. The damage to the conduit, the conductors and possibly the fiber contained within, was caused by poor craftsmanship and the improper use of a conduit coupler not designed for this type of application. This work was not performed by this project's electrical contractor, nor was the damage a direct result of any work performed by the contractor on the SR101 Design Build Project.

This repair work will consist of repairs to the 3" conduit connection with a project approved slip repair coupling, replacement of approximately 9,600 LF of Loop Detector Lead-in-cable and if necessary, the replacement of approximately 600 LF of 12 Strand Fiber.

Specifications/Stipulations:

All work shall comply with the SR101 I-17 - Pima/Princess contract documents including but not limited to:

- DR 309 - Traffic: Signals and Lighting
- DR 313 - ITS Improvements
- DR 2000 - Intelligent Transportation System (ITS)

Request for Information:
- RFI-226

Plan Sheets:
- T-22.114

Date: ______ Date: ______ Date: ______ Date: ______

______ Resident Engineer ______ City/County Engineer ______ ______ Field Reports

For valuable considerations, it is mutually agreed that the matter detailed above shall be done and payment made as shown herein for a Supplemental Agreement Change Order, all in accordance with the terms of the contract. For work being performed as a Supplemental Agreement Force Account Work Order, final payment shall be made as stipulated in the Standard Specifications and its supplements upon completion of said work.

Date: ______ Date: ______ Date: ______

Approved for:
COFFMAN AMES JOINT VENTURE
Contractor

Approved for State of Arizona

___Approved without Federal participation
___Approved with Federal participation

By:______ By:______ By:______

Exhibit 109.04-2e Procedural Change Order (Non-Compensatory Time)

Arizona Department of Transportation
Infrastructure Delivery and Operations Division
Supplemental Agreement
06/07/2023

Force Account No. 8

Approval Date: 11/19/2021 (RE)

Tracs No: F012101C Project No: 101-B-(213)S Org: 4678 Central

Project Name: I-17 - PIMA RD Contractor: COFFMAN AMES JOINT VENTURE

Force Account Adjustments:

Section: 1 1	**Labor:**	4,000.00		
	Equipment:	2,000.00		
	Materials:	14,000.00	**Original Request Amount**	
	Fa Amount:	20,000.00	20,000.00	
		Plus	**Minus**	
	Total Difference:	$20,000.00		

No Extension of Contract Time is Authorized for this Supplemental Agreement.

Date: ____________ Date: ____________ Date: ____________ Date: ____________

Resident Engineer City/County Engineer ____________ Field Reports

For valuable considerations, it is mutually agreed that the matter detailed above shall be done and payment made as shown herein for a Supplemental Agreement Change Order, all in accordance with the terms of the contract. For work being performed as a Supplemental Agreement Force Account Work Order, final payment shall be made as stipulated in the Standard Specifications and its supplements upon completion of said work.

Date: ____________ Date: ____________ Date: ____________

Approved for:
COFFMAN AMES JOINT VENTURE
Contractor

Approved for State of Arizona

___Approved without Federal participation
___Approved with Federal participation

By:____________ By:____________ By:____________

Exhibit 109.04-5 Force Account Agreement

Arizona Department of Transportation

Infrastructure Delivery and Operations Division

Contract Revision Notification

07/14/2023

Approval Date: 11/9/2022 (RE)

To: Kirk Kiser
Asst District Engineer

From: Sara Howard
Senior Resident Engineer

Tracs#	Project #	Project Name
F042401C	303-A-NFA	51st Ave and 43rd Ave Interch

Contractor	Contract Amt	Contingency %	Contingency Adjustment %	Contingency Amt
FISHER SAND & GRAVEL CO.	$70,057,597.22	5 %	0 %	$3,502,879.86

Estimated SA Amt	Estimated Percentage of Contract	SA Amt to Date	SA % of Contract to Date
$1,173.77	0 %	$.00	0 %

Agreement Type	Document Num	SATS Doc Num	Initiation Date
Letter of Agreement		1	11/08/2022

Reason Code Other

Brief Description
Partnering Workshop Cost

SA Description

The Partnering Workshop for the project was held on August 31, 2022. The cost of the catering was $2,347.54. The Department and the Contractor will equally share the catering cost per paragraph 104.01 (B) of the Standard Specifications. This letter of Agreement will compensate the Contractor for the amount of $1,173.77.

Prime Designer
Jacobs Engineering Group Inc.

Exhibit 109.04-6a Letter Agreement

Arizona Department of Transportation
Infrastructure Delivery and Operations Division
Supplemental Agreement
07/14/2023

Letter of Agreement No. 1

Approval Date: 11/9/2022 (RE)

Tracs No: F042401C Project No: 303-A-NFA Org: 4676 Central

Project Name: 51st Ave and 43rd Ave Interch Contractor: FISHER SAND & GRAVEL CO.

__**Federal Aid**
X **Non-Federal Aid**

Request:
To create:
Item 9240101 Miscellaneous Work (Resident Engineer Use Only)

Reason:

The Partnering Workshop for the project was held on August 31, 2022. The cost of the catering was $2,347.54. The Department and the Contractor will equally share the catering cost per paragraph 104.01 (B) of the Standard Specifications. This letter of Agreement will compensate the Contractor for the amount of $1,173.77.

Specifications/Stipulations:
This supplemental agreement is to compensate the contactor half of the partnering costs in accordance with 104.01 (B)

Pay Item Adjustments

Sec	Item Nbr	Description		Unit	Unit Price	Quantity	Amount
1	9240101	MISCELLANEOUS WORK (RESIDENT ENGINEER USE ONLY)		L.SUM	1.00	.000	$.00
		Subitem: 1	- Partnering Costs		1.00	1,173.770	$1,173.77
						Total	**$1,173.77**

	Plus	Minus
Total Difference:	**$1,173.77**	

No Extension of Contract Time is Authorized for this Supplemental Agreement.

Approved for ADOT

______________________________ ______________

Sara Howard Date

Approved for: FISHER SAND & GRAVEL CO.

______________________________ ______________

Contractor Signature Date

Cc: Field Reports

Page 1 of 1

Exhibit 109.04-6b Letter Agreement

ARIZONA DEPARTMENT OF TRANSPORTATION

OFFICE MEMO

08/23/2023

TO:	ELISE MAZA Finance Administrator		
FROM:	BILL FAY State Construction Engineer Construction Group, MD 172A	R.E. Name Resident Engineer	Date:
THRU:	MATT MOUL Deputy State Engineer Statewide Operations, 102A	ADE or DE Name Assistant District Engineer	Date:
RE:	Project #, TRACS # Project Name Project Location		
UNIT:	Unit No.		
Funding Source:	Be Specific - could be "Contingency" or "City of XX" or??		

Original Contract Amount "Construction":	1,131,980.00	
Five Percent Contingency:	56,599.00	
Public Relations:	5,000.00	
CE:	192,381.00	17%
Incentives:	-	
Other:	4,691.00	
Post Design:	9,056.00	
ICAP	138,571.00	
Original Construction Budget:	**1,538,278.00**	
Previous Requested Budget Increase(s)	227,562.72	
Revised Construction Budget:	**1,765,840.72**	
Actual Contractor Pay:	1,254,796.24	
Actual Other Construction:	387.82	
Actual Public Relations:	10,679.96	
Actual Total CE:	321,382.05	28.39%
Actual Post Design:	9,029.47	
Actual ICAP Charges	148,123.82	
Total Charges:	**1,744,399.36**	
Contract Work Remaining / Overruns:	25,000.00	
Additional Public Relations:	-	
Additional CE Costs:	15,000.00	1.33%
Additional Post Design:	5,000.00	
Additional Suppl. Agree:	-	
Additional Costs:	-	
Proposed New Construction	**1,641,275.54**	

Budget:

Requested Construction Amount:	**14,005.82**	**ICAP Request 10.7%**	**1,498.62**
Total Requested	**15,504.44**	**$ 15,504.44**	**$ -**
		FA Request	NFA Request

Reason for Increase:

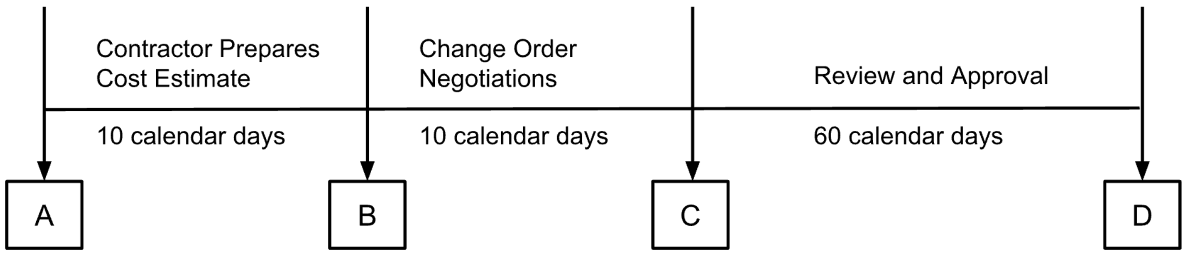
Be specific, do not use abbreviations. If Local Government Project, submit any written documentation from LPA agreeing to cover increase.

I recommend that the budget for this project be increased to accommodate this additional work.

Bill Fay State Construction Engineer	Date:
Matt Moul Deputy State Engineer	Date:
Elise Maza Resource Administration	Date:

Exhibit 109.04-7 Request for Budget Increase

Timeline for Contract Modification



A. The contractor or ADOT identifies additional work that is not included in the contract:

   1. The contractor is asked to prepare a detailed cost estimate or unit prices for the work, Std Spec 109.04C specifies 10 calendar days for the contractor to prepare a cost estimate
   2. ADOT will prepare an independent cost analysis
   3. If work is required to start prior to "C", ADOT starts documenting the work as if it were Force Account

B. Cost Estimate is received from the contractor:

   1. Start Change Order negotiations [see 109.04(C)]
   2. If the cost estimate is not received from the contractor on time or if a contract price adjustment cannot be agreed upon, the work is processed as a Force Account and the Resident Engineer will prepare the Force Account request. [see 109.04(D)]

C. Initiation Date:

   1. ADOT and contractor agree to proceed as either a Change Order or Force Account.
   2. Contract Revision Notification Document completed for a Force Account or a Change Order.

D. Change Order is completed and signed as the official contract document.

Sealing Change Orders

Resident Engineers are responsible for sealing Change Orders only when they have been in responsible supervisory charge of a design issue. Design issues include changes to or the creation of drawings or technical specifications covering the quality or performance of the finished construction work. For example, seals are not required for contract administrative issues such as quantity, cost, and time adjustments.

When the change is to a plan sheet/drawing sealed by a Professional Engineer or Landscape Architect, the RE shall coordinate with the registrant. When consulting designers develop changes, they shall send sealed drawings or specifications to the RE for inclusion with the Change Order. When a value engineering proposal requiring new drawings is submitted, it shall be sealed by the contractor's registered engineer prior to final approval of the proposal. When an issue has been escalated beyond the Resident Engineer, it shall be sealed by the responsible registrant making the final decision. Drawings and specifications must be sealed in accordance with Article R4-30-304(A)(3) of the Code & Rules of the Arizona State Board of Technical Registration.

All Change Order forms must originate from and be tracked by the RE in the same manner as all other Change Orders. Any new or revised sealed drawings or specifications shall be attached to the Supplemental Agreement forms or referenced on the first page of the form.

Force Account Work

Procedures

On a Force Account the Department has a right to direct the work. In other words, Inspectors, Project Supervisors, and the Resident Engineer can control how the work is performed and what labor, materials and equipment the contractor uses. They can also decide what to include and exclude on a Force Account. The contractor's foreperson should still retain day-to-day supervisory control over the labor and equipment to ensure their efficient and economical use.

Inspectors must track daily the contractor's labor and equipment hours as well as the materials used for Force Account work. The Force Account Daily Report form is used to track Force Account work. The Force Account Daily Report is found in PEN on the Daily Diary screen or in the Forms section of this manual.

A copy of the ADOT Inspectors Force Account Daily Report is given to the contractor. The contractor prepares the contractors Force Account Weekly Detail which is located on the contractors Website under Forms. Once completed the detail is submitted to the field office along with certified payrolls, Equipment Watch RRBB for each piece of equipment used, equipment rental invoices, and material invoices. The field office reviews the detail and back-up documentation attached. If there are charges on the detail that are not accompanied by the proper documentation or if information is incorrect on the detail, note the discrepancies and notify the contractor. Do not make the payment until the detail is accurate and complete.

The contractor shall use the 'Prime Contractor Force Account Weekly Detail Summary Sheet' when submitting any payment requests associated with Force Account Supplemental Agreements. This form is to be filled out and submitted by the prime contractor; not the ADOT Field Office. The ADOT Field Office will make no Force Account payments to contractors unless they submit a complete recap and provide all supporting documentation of associated costs utilizing the prime contractor Force Account Weekly Detail Summary Sheet. The prime contractor shall submit the Prime Contractor Force Account Weekly Detail Summary Sheets to the ADOT Engineer within 30 days following the end of each week of force account work, If the Detail Sheets have not been submitted within 90 days of the work week, an approval by the State Construction Engineer must be obtained prior to any payment being made by the field office to the contractor.

Partial payments for material on hand are not allowed on force accounts.

Force Account details are to be submitted to field reports no later than 5 days after the payment is made.

Force Account Markups

Hourly payroll labor rates (including the hourly fringe benefit amount) are multiplied by 1.5 to arrive at a gross regular pay rate for labor used on a Force Account. This 50 percent markup on labor is intended to cover the contractor's expenses for:

- Payroll taxes
- FICA
- Social security
- Medicare
- Workers compensation
- Liability insurance
- Project overhead and profit (including the administrative overhead for the Force Account)

No additional markups are allowed for the contractor's labor costs, even if the contractor can prove that actual costs for the expenses listed above are greater than the 50 percent markup.

Subsistence and travel allowances paid to the worker are not allowed this 50 percent markup.

The subcontractor work and the costs of materials supplied to a force account are also marked up to offset the contractor's administrative and handling costs. See Subsections 109.04(D)(7).

Outside rented equipment is eligible for reimbursement at the invoiced rate plus a 10 percent markup, plus the hourly operating cost (HOC). [(Rental Invoice X 1.10) + HOC]. No stand-by time is reimbursed to the contractor for outside rented equipment.

Should the Force Account have an owner-operator, the owner of a truck or water truck can be treated as an owner-operator only when the person who owns the truck is the one driving it. For example, if the contractor hires Steven Red of Big Red's Trucking to haul material, then Steven Red has to be the driver of the truck. The truck must be registered to Steven Red and a subcontract will be required. Steven Red cannot hire Joe Smith to drive Steven Red's truck and be considered an owner-operator.

Administering Force Accounts

Refer to ADOT's Force Accounting (TCH 3042) course for information on documenting and processing Force Account work. Registration for the course can be done through the ADOT Learning and Development intranet website on the ADOTNet.

The Rental Rate Blue Book is available on the ADOTNet located on the Construction Group intranet. Each user will need to obtain login credentials, provided by Equipment Watch, to view and lookup blue book rental rates. There is a link in the Construction Group intranet to "Request Access to RRBB".

109.05 Eliminated Items

Both 109.05 and 102.06 allow the Department to eliminate contract items (items not used – quantities reduced to zero). If items are not used by the Department, the contractor may request an equitable adjustment in the contract amount in accordance with Subsection 108.11.

It is very important for the Resident Engineer to notify the contractor in writing as soon as possible about an eliminated item. This ensures the contractor will stop any further work on the item. It is important for the contractor to immediately notify any subcontractors or materials suppliers affected by the elimination so they can stop any related work.

Under 108.11, the Department allows the contractor, subcontractors, and affected Material Suppliers to recover any direct expenses related to an eliminated item up to the notification date. Such expenses may include:

- Materials already fabricated that cannot be returned or used elsewhere, e.g. custom cut and bent rebar
- Restocking fees for materials already delivered to the contractor
- Labor time used in producing shop drawings, cut sheets, and other preparation costs directly related to the eliminated item
- Charges for delivering or picking up materials
- Plant setup or mobilization efforts for the eliminated item
- Reasonable profit and direct overhead for expenses incurred to date

Lost profit, lost home office overhead, and any other money lost due to the eliminated item cannot be recovered. Even if the contractor claims the eliminated item contains a disproportionate amount of overhead, profit, or uncut subcontract work, the item should be eliminated at its contract unit price (see Subsection 109.03). Only actual expenses directly related to the eliminated work should be added back into the contract.

109.06 Partial Payments and Retention

All contractor pay estimates are generated as a PDF and Docusign is used for all signatures required.

Monthly Progress Payments

Payment Procedures

Construction progress estimates are prepared monthly, compensating the contractor for work performed and completed and for materials furnished during the preceding month. The monthly cutoff date is 10 business days (excluding state holidays) prior to the third Wednesday of the month. The progress estimates are due at Field Reports Section by noon on the 5th working day after the monthly cutoff date. The contractors are paid on the third Wednesday of the month. The Monthly Estimate and Contractor Pay dates are shown on the ADOT calendar.

The Department does have the right to withhold part or all of the monthly progress payments if the project work or project progress is unsatisfactory or required certifications have not been received. If the Resident Engineer is suspicious of the contractor’s ability to complete the project, a meeting with the contractor and the District Engineer should be held to discuss the issue before any payments are withheld (also refer to Subsection 108.04 of this manual on project delays).

There are unique situations where cash flow payments may be made to the contractor in order to advance certain aspects or elements of work. A Supplemental Agreement is required to be generated in these situations. In order to maintain statewide consistency, approval is needed from the State Construction Engineer or the Assistant State Construction Engineer prior to the generation of the Supplemental Agreement for a cash flow payment.

Work performed under a supplemental agreement cannot be paid for until a pay item is established in CPE. Force account documentation shall be submitted to Field Reports in the same month payment is made. Please ensure that all documents are submitted to Field Reports in a timely manner. Payment may be made if emergency approval has been obtained in accordance with Subsection 109.04 of this manual.

If a supplemental agreement is considered “not eligible” for federal assistance, then the items included in the agreement must be shown in the non-FA portion of the monthly estimate.

Prescribed penalties for work items failing to meet specification requirements (e.g. PCCP smoothness or compaction on end-product AC) do not require a supplemental agreement. The field office creates a separate pay item found on the Spec. Pay Item List located in Chapter 12 and may notify the contractor in writing of the penalty adjustments. The same procedure applies to contract bonuses.

Agreed upon penalties not prescribed in a specification require a Procedural Change Order. The field office creates Spec. Pay Item 1090035 to apply the penalty.

Lump sum items in the original contract may be paid for on the monthly estimates if the amount of work, in the opinion of the Resident Engineer, is of sufficient magnitude to warrant partial payment. For lump sum structures, the contractor should submit an estimate of the quantities desired for partial payment at least two days prior to the cut-off date (see Subsection 109.10).

When the monthly progress payment is zero (negative and positive payment offsets) or negative, an estimate still needs to be saved and transmitted to Field Reports. For a negative estimate, the prime contractor needs to let the Department know how they would like that processed, whether writing a check or having it taken out of another current estimate.

Documenting Payment

Quantities developed for the monthly progress estimate should be based on sound engineering procedures rather than on arbitrary selection of quantities that help expedite payment. See Subsection 109.01 of this manual and the Pay Item Documentation for Inspectors cited in the references at the end of this chapter for further information on documenting pay quantities.

The monthly pay estimates are prepared on a computer program titled, Construction Progress Estimate. Pay item quantities taken from the Inspectors' diaries are entered into the program, which prepares a pay estimate for the Department.

As the pay estimate is prepared, the importance of entering only quantities documented in a daily diary cannot be overemphasized. Pay quantity entries and other entries should not just appear on the progress estimate. Sufficient backup documentation, e.g. diaries, supplemental agreements, invoices, and others, needs to support each entry.

If corrections need to be made for previously paid quantities that are incorrect, the corrections need to be documented (typically in a diary). All payment documentation must be kept as part of the project records and may be subject to periodic audit.

When preparing the monthly progress estimate, the Resident Engineer and the contractor's superintendent should review all quantities of work completed. Should there be pay item quantities on which the two parties disagree, the disagreement needs to be resolved (through escalation if needed) prior to transmittal of the next month's estimate. Before transmitting the estimate to Field Reports, the RE must assure there are enough funds to process. A supplemental monthly payment estimate may be transmitted if resolution occurs early within the next monthly payment period and considerable payment is involved. The subcontractors and Material Suppliers should be supplied with copies of the monthly progress estimate and/or MPT Traffic Control Sheets upon request.

Supplemental Estimates

Contact Field Reports for further instruction if there is a need to produce a supplemental estimate.

Payment Reporting and Sanctions

The contractor shall report on a monthly basis indicating the amounts that have been paid to all Reportable Contracts. Reportable Contracts is defined as any subcontractor, of any tier, DBE or non-DBE, whose work is performed on behalf of the prime contractor. The prime contractor is to report all payments made to the Department's web-based DBE & OJT Online Reporting System (DOORS) website. The reporting for payments made on all Reportable Contracts shall be recorded by the 15th day of the current month for all payments made from the previous month's monthly estimate.

If a zero or negative estimate is saved, the Field Office or the contractor needs to reach out to BECO to have an audit opened for the reporting month.

Example: Work performed in July is paid on the July Monthly Estimate. The July Monthly Estimate payments will be recorded on the August Audit in DOORS. The deadline for all reportable contracts to be entered into DOORS for the August Audit is September 15th.

For each month that a contractor fails to submit timely payment information in DOORS:

$5000.00 will be retained as sanctions from the monies due to the contractor regardless of how many reportable contracts were not made for that month

After 90 consecutive days of non-reporting, the sanctions will increase to $10,000.00 for each subsequent month that payment was not reported.

Sanctions are to be applied in the same month that non-reporting takes place, regardless if the sanction is being escalated by the contractor.

Only the State Engineer for Construction has the authority to waive payment reporting sanctions.

Prompt Payment

For any prompt payment questions or sanctions the Field Office is to contact BECO.

109.07 Partial Payment for Material on Hand

Subsection 109.07 provides a list of contract items that are eligible for a partial payment when the materials needed to construct those items are stockpiled by the contractor or a materials supplier. The partial payment factor is applied to the unit price of the item.

To qualify for a partial payment on stockpiled materials, the following conditions must be met.

- The Resident Engineer must be satisfied with the progress of the project
- When applicable, the stockpiled material should have been tested and the material must have passed the test(s)
- When applicable, acceptable certificates of compliance for the material have been received by the Department
- The material is stockpiled on the project, or if stockpiled off the project (including commercial material sources), the material is located in a separate area away from the main inventory

The purpose of this partial payment is to promptly compensate the Material Suppliers for materials produced for the project. The intent is not to finance their inventory. Once a partial payment is made, the Material Supplier should not be allowed to sell the material to other customers.

Resident Engineers have the authority to deny partial payment for material stockpiled at commercial sources if the material cannot reasonably be separated from the main inventory, or if the Resident Engineer suspects the Material Supplier is in financial trouble. In either case, the material should be delivered to the project site or the contractor’s yard before a partial payment is made.

When material is being produced or stockpiled on private property, the contractor must submit a letter to the Resident Engineer from the private property owner granting permission to produce or stockpile the material (refer to Subsection 107.11 of this manual).

Partial payments for materials not listed in the table can be made without the need for a supplemental agreement. The previous conditions for partial payment eligibility must be met, and both the Resident Engineer and contractor must agree on a partial payment factor. Partial payment for lump sum items or items measured individually (each) are to be based on Material Supplier's invoices or actual cost records.

If an item receives a material on hand payment and the quantity underruns in the field the inventory must be depleted in the FAST system. For example: the bid schedule shows 1,000 LF of fence and the contractor asks for the material payment for 1,000 LF of fence. After the item is complete only 900 LF of fence is needed, the material paid previously needs to be taken back since it wasn’t installed.

109.09 Acceptance and Final Payment

Once a final acceptance letter has been written for the project (see Subsection 105.20 of this manual), the Field Office can begin to close out the project.

Closing out a project involves verifying that all paperwork is complete for the project and preparing the final estimate.

Semi-Final Estimate

As the Field Office closes out a project and finalizes the documentation, additional payments may need to be made to the contractor as quantities are checked and documents received. Any monetary estimate that is submitted after project acceptance is called a "semi-final estimate." Prior to transmitting a semi-final, notify Field Reports. Semi-finals should be generated with an SF after the estimate number. The Field Office may submit as many semi-final estimates as needed to pay for remaining quantities.

Final Estimate and Support Documentation

The final estimate shows the total as-built quantities of all contract items. For an estimate to be considered final, it must entail no more than zero dollars in payments to the Contractor. All quantities shall be reviewed and approved by the Resident Engineer. The Field Office does not save the final estimate in FAST. The Resident Engineer and contractor sign it, certifying that the quantities reported are final and correct. For guidance, see the Project Final Checklist in Chapter 1207 of the manual. To expedite final processing and payment to the contractor, final estimates must be delivered to Field Reports no later than 45 calendar days after the date of acceptance of the project. If delays are anticipated, the Resident Engineer must notify Field Reports explaining the reason for the delay and providing an expected delivery date. Quantity calculations and other project records (payrolls, certifications, Force Account details, etc.) should be kept up-to-date throughout the life of the project so the final estimate can be submitted promptly.

109.10 Lump Sum Payment for Structures

(A) General

Measuring quantities for a large structure can become a very tedious and time-consuming undertaking. The intent of paying for structures on a lump sum basis is to minimize measurement and record keeping requirements. When significant quantity variations (± 5% or more) do occur in structural concrete, structural steel, rebar, structural excavation, and structure backfill, the Department does allow measurement for payment. However, the burden of proof is on the contractor, who must substantiate the variation.

In allowing compensation for significant quantity variations, the Department is purposely trying to discourage contingencies in contractors' bids. This protects the contractor from unexpected quantity variations because the Department is willing to take that risk.

(B) Adjustments Due To Quantity Variations

The Inspector should be aware that there are differences between the documented quantities of steel and concrete versus the actual quantities used. These differences are caused by:

- The yield effect of batched concrete
- Imperfections and deflections of formwork
- Concrete spillage and waste

- Rebar and steel that may be shown on cut sheets but are not needed in the structure or used as placement aids
- Approximations made by the Designers in calculating quantities

With this in mind, it is a good idea for the Inspectors to track the amount of concrete and steel that go into a structure not only for partial payment purposes, but in case significant quantity variations do occur. Inspectors should collect copies of all steel cut sheets and concrete tickets for future reference.

The contractor may use steel cut sheets and concrete batch tickets to substantiate quantity variations. When this occurs, the Resident Engineer should involve the Designer of the structure, who should verify the original quantity calculations and make any adjustment due to as-built conditions. If the Designers cannot find more than a 5 percent variation, then it is up to the contractor to produce detailed calculations showing the variations. Cut sheets and concrete tickets cannot be used alone in determining quantity variations. Instead, the contractor should use as-built dimensions and the plan sheets to calculate any quantity changes.

The Department's review of the contractor's calculations should be to ensure that sound engineering and mathematical procedures are used. The intent is not to do the calculations for the contractor, but to verify the accuracy of the calculations.

Variations in structural excavation and structure backfill quantities should be limited to changes in pay limits shown in Standard Details B-19.30, .40 and .50. A change in pay limits would occur only if the original ground line is different than the one used by the Designers, or if the Designers had made some type of calculation error or incorrect assumption when computing the pay quantities. Differences due to the contractor exceeding the pay limits for constructability reasons (e.g. sloping the excavation) do not qualify for quantity adjustments.

(C) Adjustments Due to Revisions Ordered By The Engineer

When Designers make changes to a structure, any bid item affected by the change is treated as a major item. As a result, the item should be increased or decreased up to 25 percent before an adjustment in the unit price is required, see Subsection 104.02(D)(4)(b). However, since the structure is paid for on a lump sum basis, a change order will be needed to adjust both the quantity of the affected item(s) and the lump sum structure price. Typically, any quantity adjustments are shown as a separate line item on a change order. The original lump sum structure item is deleted, and a new lump sum structure item is added.

(D) Payment

Partial payments for lump sum structures are usually made by collecting delivery tickets for materials incorporated into the structure. This includes concrete tickets, steel cut-sheets, weigh tickets for structure backfill, and invoices for girders and bearing devices. As mentioned in Subsection 109.10(B) of this manual, delivery tickets do not represent the actual amount of material used in a structure. However, for partial payment purposes, delivery tickets and invoices are a close approximation. The contractor is required to turn in a list of quantities for each structure before the monthly cutoff date. The Inspector or Project Supervisor should review this list with the structures foreperson and get an agreement on quantities before the Field Office processes the monthly pay estimate.

Final payment for a lump sum structure is based on the lump sum amount. The total of the extended amounts for all the quantities must equal the lump sum amount. The total cannot be higher or lower, regardless of their summation. If the Resident Engineer or the contractor believes there is an error in the bid quantities, then adjustments are handled under Subsection 109.10(B) or (C).

109.12 Fuel Cost Adjustments

General

When the Fuel Cost Adjustment is part of the contract, the Department will adjust the monthly progress payments up or down as appropriate for cost fluctuations in diesel fuel as determined in accordance with (109FUEL, 02/10/12).

If the 109.12 Fuel Cost Adjustment specification is not in the contract, Field Reports will check the “Excl Diesel” marker on the contract card when setting up the project. This will keep the Diesel Fuel Price Adjustments report from automatically generating.

The Diesel Fuel Price Adjustments Report is automatically generated per project, in FAST, Price Adjustment Program, after each monthly progress estimate is saved. The report will continue generating the adjusted fuel cost until substantial completion has been given.

The adjusted fuel cost is the monthly payment amount due to the contractor for the month prior.

After you have saved the first monthly progress estimate, you will go into the FAST, Price Adjustment program. Under the subtitle Tax Rates, choose Tax Rate Entry and enter the tax rate for your project. When entering the tax rate you will also be required to enter an “As of Date”; this will be the Date Bids Opened. If the tax rate for your project changes during the course of the project, you will go in and add the new tax rate. The “As of Date” will be the effective date of the new tax rate. If your project is on Tribal Land your contractor may be required to pay Tribal Tax. If applicable, you will enter the Tribal Tax as Other.

Go to the Office Managers web page, Price Adjustment Instructions for assistance.

For each month following the monthly progress estimate, go into the Price Adjustment Program and generate a Diesel Fuel Price Adjustments Report. If the total Adjusted Fuel Cost for that Monthly Estimate exceeds zero dollars plus or minus, this is the dollar amount of diesel fuel adjustment for the month.

To pay for these adjustments, the field office needs to create Pay Item 1090001, Diesel Fuel Price Adjustment. This Item should be created for a Unit Price of $1.00 and a Quantity of 0. This should be a lump sum open account where the price adjustments can be made. The field office shall also build Subitems for each pay estimate in which a price adjustment.

109.14 Increased Federal Share - Technology and Innovation Deployment Program (TIDP)

For projects that include innovative technologies and have been approved for Increased Federal Share, the project team should closely adhere to specifications established for use or inclusion of the innovative technology in the project. Once the application is approved by the FHWA, if any changes in project scope or procedural change orders are being considered, which directly or indirectly affect the deployment of the innovative technology, this must be discussed with the Project Manager and FHWA Area Engineer to confirm the project remains eligible to receive the Increased Federal Share.

At the conclusion of the project, a “lessons learned” meeting or workshop is held to review the implementation of the innovative technology and determine a course of action for subsequent use, adoption into standard practice, and/or refinement of the technology. Therefore, a collective effort to capture and document the effectiveness of the technology, challenges associated with its use, and strategies to more effectively use or deploy the technology should occur throughout the project. This effort should be led by a member of the associated technical group as well as a member of the construction unit who will be directly involved in monitoring activities or inspecting items which include the technology.

The project should discuss the innovative technology during the Partnering Workshop and Pre-Construction Meeting, as well as during any weekly or pre-activity meetings, as appropriate.

109.15 Draw Schedule

Projects that are programmed for over $18 million or have a contract time longer than 18 months will have this specification in their project Special Provisions. This needs to be provided at the Preconstruction meeting.

A sample draw schedule is as follows:

Draw No.	Month	Amount	% of Total	% Complete
1	March 2021	$369,686.13	1.08%	1.08%
2	April 2021	$533,038.86	1.55%	2.63%
3	May 2021	$802,432.05	2.33%	4.96%
4	June 2021	$1,238,865.36	3.60%	8.56%
5	July 2021	$2,690,461.82	7.83%	16.39%
6	August 2021	$3,692,664.18	10.74%	27.14%
7	September 2021	$2,787,485.87	8.11%	35.24%
8	October 2021	$3,657,234.84	10.64%	45.88%
9	November 2021	$3,844,081.98	11.18%	57.07%
10	December 2021	$2,091,211.53	6.08%	63.15%
11	January 2022	$1,403,978.95	4.08%	67.24%
12	February 2022	$1,381,300.93	4.02%	71.25%
13	March 2022	$892,959.33	2.60%	73.85%
14	April 2022	$341,820.38	0.99%	74.85%
15	May 2022	$1,653,591.34	4.81%	79.66%
16	June 2022	$2,353,877.50	6.85%	86.51%
17	July 2022	$2,156,895.20	6.27%	92.78%
18	August 2022	$2,279,593.55	6.63%	99.41%
19	September 2022	$158,161.63	0.46%	99.87%
20	October 2022	$43,652.57	0.13%	100.00%
	Total:	$34,372,994.00		

This form is to be provided to the FMS group upon receipt.

109.16 Bituminous Material Price Adjustment

Bituminous Material Price Adjustments Due to Market Price Changes

The price of crude oil and its byproducts change daily. Price fluctuations in crude oil can be volatile and influenced by world events. To eliminate the risk contractors take in bidding work that uses large amounts of bituminous materials, the Department allows monthly price adjustments to asphalt cement, liquid asphalt, and emulsified asphalt used on the project. The price adjustments are based on the selling prices of asphalt cement listed in the Asphalt Weekly Monitor. ADOT's Contracts and Specifications Section publishes a monthly Bituminous Material Price Adjustment bulletin which indicates the average price for asphalt cement that month.

The price adjustment is the difference between the asphalt cement price when the asphalt was used on the project and when the project was bid, times a factor for the type of bituminous material. For example, if the price of asphalt cement was $120 per ton when the project was bid and the price changed to $100 when the asphalt cement was purchased and delivered to the project, then a $20 deduction would be made for each ton of asphalt cement used. The adjustment for emulsified asphalt would be $20 x 60% = $12 per ton used, and the adjustment for asphalt-rubber material would be $20 x 80% = $16 per ton used. The method for calculating price adjustment is revised periodically, so always see the Special Provision for the latest method.

To pay for these adjustments, the field office needs to create pay item 4040000, Bituminous Material Price Adjustment. This should be a lump sum, open account where a price adjustment for different bituminous materials used on the project can be paid.

Exhibit 109-16-1 is an example of the recap the field office produces. This recap should be sent to Field Reports when submitting the final estimate for the project.

Note that a pay adjustment factor of 0.6 is shown in Exhibit 109-16-1 for emulsified asphalts. As mentioned previously under Tack Coats, emulsified asphalts contain only 60% asphalt cement. The pay factor adjustment accounts for the water in the emulsion. For the special type of emulsion, a pay factor adjustment of 0.3 is used since only 30% of the diluted emulsion contains asphalt cement.

The final recap, (Exhibit 109-16-1) should contain the following:

- Price of asphalt cement at bid time
- The pay times affected
- The month the material was used
- The price at the time of use
- Difference between current and bid prices
- Total tons for the month
- Pay factor (when applicable)
- Total net adjustment (should equal the lump sum amount for pay item 4040000)

Documentation Requirements for Bituminous Materials

Office documentation requirements needed for final payment include:

- Invoices
- Recap sheet(s) (Exhibit 109-16-1) of bituminous treatments used on the project containing:
    - Date material used
    - Pay tons
    - Weigh backs (when partial loads are used)
    - Cumulative totals

The office documentation should be submitted to Field Reports for review with the final estimate.

BITUMINOUS MATERIAL PRICE ADJUSTMENTS

ADJUSTMENT REPORT BY PROJECT

PROJECT	H668901C EHRENBERG - PHOENIX HWY CM-010-B(200)A
CONTRACTOR	COFFMAN SPECIALTIES, INC.
BID DATE	10/27/2006
SUBSTANTIAL COMPLETION DATE	08/08/2007
INITIAL COST	383.00

4040111 BITUMINOUS TACK COAT (SS-1)

Section 1

Lot	Date	Price	Diff	Tons	Factor	50:50	Pretax Adj	Sales Tax	Other Tax	Adjustment
01	04/29/2007	321.00	-62.00	0.73	0.3	Y	-13.58	-0.71	0.00	-14.29
02	07/02/2007	327.00	-56.00	1.54	0.3	Y	-25.87	-1.36	0.00	-27.23
02a	07/10/2007	327.00	-56.00	2.69	0.3	Y	-45.19	-2.38	0.00	-47.57
				4.96			**-84.64**	**-4.45**	**0.00**	**-89.09**

4040282 ASPHALT BINDER (PG 76-16) (PG 76-XX)

Section 1

Lot	Date	Price	Diff	Tons	Factor	50:50	Pretax Adj	Sales Tax	Other Tax	Adjustment
01	04/29/2007	321.00	-62.00	42.02	1.0	N	-2,605.24	-137.17	0.00	-2,742.41
02	07/02/2007	327.00	-56.00	39.63	1.0	N	-2,219.28	-116.85	0.00	-2,336.13
				81.65			**-4,824.52**	**-254.02**	**0.00**	**-5,078.54**
			TOTALS	**86.61**			**-4,909.16**	**-258.47**	**0.00**	**-5,167.63**

Exhibit 109-16-1. Bituminous Material Price Adjustment Example

200 GENERAL

Normally, the first stage of roadway construction is clearing and grubbing of the roadway area. The Inspector should review the Project Plans, Standard Specifications, and Special Provisions covering this phase and make certain that the work is performed as required. Survey and staking activities should be completed before clearing and grubbing takes place and conform with sections 105.01, 107.11 and 925-3.01 of the standard specification. Particular attention should be given to keeping the contractor's activities confined within the limits of the slope stakes. The disposal of the resulting materials should be as directed in the contract documents. However, if disposed of off site, a letter granting permission should be in the project files.

The Resident Engineer and Inspector should be thoroughly familiar with the Project Plans and Special Provisions, soil profile, all right-of-way (ROW) agreements, and borrow pits before grading operations are started. Together, the Resident Engineer (RE) and Inspector should make a plans-in-hand inspection of the project noting the following:

- Clearing limits shown on the Project Plans versus clearing actually needed
- Typical sections shown on the Project Plans
- Soil profile, cut slopes, and shrink and swell factors indicated
- Drainage profiles (check that existing drainage has not changed, proposed drainage does not flow off the right-of-way, and natural drainage isn't changed to adversely affect landowners or structures upstream and downstream)
- Utilities, fences, or other obstructions to be moved or protected
- Private property boundaries and other restricted areas
- Vegetation, survey monuments, archeological sites, or other physical features to be protected, preserved, or relocated
- Borrow sources and access roads
- Unusual soil/moisture conditions such as springs, seeps, or swamps
- Construction traffic control requirements
- Subgrade/embankment stabilization requirements and ROW infringements or unresolved ROW agreements.
- Noxious and invasive species within the disturbance area

As noted above, the Resident Engineer should inspect the drainage of lands adjacent to the highway and make certain that all drainage structures, inlets, outlets, channels, and dikes are properly located. The Resident Engineer should investigate the need for any additions to drainage infrastructure with the design team and Project manager.

Special care should be given to locations of material sources in streambeds. The impact on structures and other developments due to changes in the stream flow must be carefully considered. Impacts can extend a considerable distance from the point of disturbance so it is often necessary to consult with the hydraulics specialists before approving work in streambeds.

Highway construction projects have been identified as one of the primary sources of soil erosion and sedimentation. Construction of highways typically disturbs large areas of natural vegetation that can result in an accelerated rate of soil erosion. During the course of the grading and draining, frequent inspections should be performed to determine that the sequence of operations is such that damage to any of the work will be kept to a minimum in case of heavy rains (see Subsection 104.09).

For roadway excavation, the Inspector should review the soil profile while inspecting the work and should note radical variations in the actual soil conditions compared with those on the soil profile. Major differences in the soils encountered from those indicated could justify changes in the design. Should wide differences be found, it would be advisable to request a review of the conditions by the Geotechnical Services Section. Additional review may be needed by other Design Sections. This is especially critical at finished subgrade elevation. The plasticity index (PI) and amount passing the #200 sieve of the final subgrade material are checked against the design values to determine whether adjustments to the pavement structural section are necessary. This must be done as soon as possible since any increase in pavement section could mean extra surveying and additional work by the contractor, both may have an impact on the contractor's schedule. (See Subsection 203-3.03(D), Unsuitable Materials).

For embankment construction, the entire subgrade will be proof rolled as the lifts are being placed. The inspector should focus on watching the embankment as it interacts with the heavy construction equipment passing over it. Make notes and correct any areas where pumping (movement of the material), rock pockets (areas with excessive rock and very little fine material) and standing surface water (may lead to pumping later) are observed. Paying close attention to the effects the machinery has on the underlying grade will ensure uniform results as the grade approaches final elevation. The entire subgrade must be proof-rolled with a loaded water truck or any other heavy piece of equipment. The Inspector should see that any unstable spots in the natural ground are corrected before any embankment lifts are placed. Deep embankment fills, especially near structures, should be given special attention to reduce potential for excessive settlements.

The Inspector must be familiar with the location of approved borrow pits and the quantity and quality of materials to be removed.

The Inspector is responsible for seeing that the grade is constructed in accordance with the Project Plans to the limits indicated by the slope stakes. If there is any question concerning the placement or markings of a slope stake, the Inspector should contact the contractor’s survey party chief for clarification.

Construction of Detours

Many construction projects require detours prior to building the roadway. Usually, the need for such detours is foreseen, and detailed information about detour construction is given in the Project Plans or referred to in the Standard Drawings. An on-site inspection of all proposed detours should be made. Any recommendations that might serve to add to the safety of the traveling public should be referred to the Resident Engineer.

When changes are made to the detours shown on the Project Plans or new detours are added, the changes are to be submitted by the contractor and reviewed by the Regional Traffic Engineer. (See Section 701, Maintenance and Protection of Traffic)

The Department recognizes its obligation to provide safe, easy-to-drive detours. This, along with minimal delay, is a benefit to our public relations.

Proper signing, marking, and lighting of detours are extremely important. All detours should be signed and marked as directed in Part 6 of the MUTCD with the ADOT Supplement.

After the completion of detour construction including signing, striping, and lighting, the Resident Engineer should make a daytime and nighttime inspection of the detour. The traffic control coordinator for the project should do frequent re-inspections and documentation of the detour.

A complete record including diagrams, plans, photographs and/or video recordings must be kept showing all traffic control devices and the detour including any changes to either. Plans and diagrams should show the type, location, and sizes of all signs, barricades, and any other traffic control device. The photographs and video recordings should be taken to provide a sequence of pictures showing the detour from beginning to end.

201 CLEARING AND GRUBBING

201-1 Description

Normally this operation is the first phase of construction. It consists of clearing the area within the project limits of all obstructions and vegetation in accordance with the specifications prior to commencing any earth-moving activity. During the clearing and grubbing operations, care should be taken to limit the activity of the contractor to an area within the slope stake boundaries as much as possible. The intent is to preserve as much vegetation outside the slope stake limits as possible. When clearing limits are staked by the contractor, care must be taken to assure the slope rounding details in the Standard Drawings are followed and the additional distance for slope rounding is cleared.

When the contractor provides a material source, plant site, or equipment yard, he or she will be required to prepare an environmental analysis addressing the usage (refer to Special Provisions Subsection 104.12, 107.11, and 1001-4). In addition, the contractor must notify the Arizona Commission of Agriculture and Horticulture prior to any clearing operation. The purpose of this notice is to provide the opportunity for salvage and preservation as provided in the Arizona Native Plant Law. The Resident Engineer should bring these requirements up at the preconstruction meeting if it is applicable to the project. This applies to privately owned land as well as publicly owned land. Environmental conditions often restrict operations in watershed areas.

The Standard Specifications provides requirements for saving all trees and shrubs found suitable for roadside improvement and beautification if they will not interfere with construction. In order for the contractor to know which trees and shrubs are to be saved, the Resident Engineer (with the assistance of one of ADOT's Construction Landscape Architects) shall mark such trees and shrubs in a distinguishable manner. The contractor should be informed of this marking.

When sufficient clearing and grubbing has been done to permit the start of grading operations, an inspection of the area shall be made (including adequate removal of all roots and deleterious materials) and, if found acceptable, the contractor can be allowed to proceed.

201-3 Construction Requirements

201-3.02 Removal and Disposal of Materials

Disposition of cleared materials requires careful attention. All cleared and grubbed material must be removed and disposed of before earthwork operations can begin.

The Standard Specifications provide that all debris from the clearing and grubbing operations shall be removed from the project and disposed of. All disposal is to be made outside of the right-of-way, and the contractor must obtain written permission from the land owner (not the tenant) for such use of the land. A copy of such written consent must be given to the Resident Engineer.

The use of any disposal site and haul roads, public or private, may require an Environmental Analysis. If areas outside of the project limits are being considered and not commercially cleared, the Resident Engineer should consult with ADOT's Environmental Planning Group. Remember that impacts of activities off the project can be in conflict with the project environmental analysis on which the project approval is based. Prior to any clearing and grubbing a noxious and invasive species inspection needs to be completed to determine if any manual or chemical treatment should be done prior to any disturbance on the project site if required per the project plans. The ADOT Construction Landscape Architect will assist in determining what type of treatment shall be done if necessary prior to any construction activity.

201-4 Method of Measurement and 201-5 Basis of Payment

Clearing and grubbing may be paid for as a lump sum or by the acre. Measurements of the actual acres to be cleared should be made before the clearing operation begins. Quantities should be computed and the contractor advised so that a verification of the quantity can be made if required before the area is disturbed.

If clearing and grubbing are not paid for directly, the clearing limits should still be documented.

202 REMOVAL OF STRUCTURES AND OBSTRUCTIONS

202-3 Construction Requirements

202-3.01 General

This work consists of the removal and satisfactory disposal of all buildings, fences, structures, old pavements outside the slope staked areas, abandoned pipelines, and any other obstructions that are not designated or permitted to remain, unless they are covered by another portion of the contract. Normally, the items to be removed under this section are indicated under the miscellaneous removal item of the contract. Salvageable material that will be retained by the Department should be removed with care and inventoried in order to preserve its usefulness. Complete the “Receipt For Salvaged Materials'' form to document salvaged materials.

Before any removal work begins, a value should be established for each of the removed items. This is necessary to properly document the amount of work performed as a percentage of the pay item in the contract. The Resident Engineer and the contractor should mutually agree upon the value. Blue Stake the area to determine the exact location of underground utilities that may conflict with removal items.

In an effort to establish pre-existing site conditions, a photographic or video log of all existing conditions on the project needs to be established before work commences. This can be a valuable record when determining damage caused by the contractor.

All items to be removed, listed or unlisted in the Project Plans and Special Provisions, should be documented to show what was removed and when the removal was accomplished.

When the natural ground is disturbed by the removal of structures and obstructions, all depressions are to be refilled and compacted according to Standard Specifications before any embankment is placed over the area.

203 EARTHWORK

203-2 General

An excellent description of construction equipment can be found in the Caterpillar Performance Handbook (available online).

The inspector should check the Special Provisions for pre-wetting requirements when cuts are deeper than three feet. The inspector should review subsection 206-3 of the Standard Specifications when the contractor decides to pre-wet pay items that will be measured and paid on the basis of weight.

203-2.01 Earthwork Adjustments

On projects large and small, earthwork quantities have been a major source of contractor claims for the Department. Since these quantities are based on calculations made during design and are not field measured, the process through which adjustments are made to the project’s bid quantity require a fair amount of engineering analysis and cannot be addressed in the field, utilizing conventional measurement methods. Additionally, earthwork claims will not be validated with haul truck load counts .

In these instances, earthwork adjustments will need to be substantiated and verified via construction survey or photogrammetric survey. Due to this, when the prospect of an adjustment to earthwork quantities is imminent, the Engineer should get ADOT Statewide Survey Services involved at the earliest possible opportunity. ADOT Statewide Survey is able to provide standard construction survey services, as well as aerial surveys via survey-grade drones to assist the Engineer in determining the merit of the quantity adjustment.

It should be noted that investigations into whether an earthwork adjustment is warranted may be initiated by either the contractor or the Engineer. Investigations ordered by the Engineer can be utilized to verify finished elevations on large excavations, or they can be carried out as verification of anticipated earthwork quantities on the project.

When an earthwork adjustment is substantiated, the resulting change in quantity will be based on the project’s plan’s quantity, minus five percent, depending on the nature of the change. In instances where the earthwork quantity is decreased, said decrease will be made to the plans quantity, minus five of the plans quantity. When the earthwork quantity is increased, the revised quantity will be minus five percent of the plan's quantity as well. In essence, when earthwork quantities are decreased, the Department will bear the cost for the five percent variation of the plans quantity, and when earthwork quantities are increased, the contractor will bear the costs for the five percent variation of the plans quantity. The following tables offer further clarification as to how bid quantity adjustments are to be administered:

Example Calculation when Quantity Increases

Item Description	Plans Qty	Measured Qty	Change in Qty	± 5% of Plans Qty	CY Increase	Quantity to Pay
Roadway Excavation	35,140.00	51,911.00	16,771	-1,757.00	15,014.00	**50,154.00**

Change Order quantity will increase quantity by 15,014.00 CY's

Example Calculation when Quantity Decreases

Item Description	Plans Qty	Measured Qty	Change in Qty	± 5% of Plans Qty	CY Decrease	Quantity to Pay
Drainage Excavation	15,400.00	12,500.00	-2,900	770.00	-2,130.00	**13,270.00**

Change Order quantity will decrease quantity by 2,130.00 CY's

203-2.02 Contractor Quality Control

When the Special Provisions require that the contractor perform quality control, the contractor will be responsible for quality control measures necessary to provide acceptable quality in the production, hauling, and placement of materials.

203-3 Roadway Excavation

Roadway excavation involves loosening, digging, loading, hauling, placing, compacting, finishing, and disposal of the excess materials in the roadway cut sections as specifically described in the Standard Specifications and Special Provisions. Before beginning this operation, the Resident Engineer should have a discussion with the contractor on the removal and disposition of material excavated from specific areas within the project. There should be an agreement as to the placement of excavated materials.

203-3.03 Construction Requirements

(A) General

The Standard Specifications do not allow payment for materials excavated beyond the limits of the roadway, except in certain instances. If at any time the contractor excavates outside the slope stake limits, excavates below finished subgrade elevation, gouges, or over excavated slopes (except as required by the Project Plans), then the contractor needs to be notified in writing that this material will not be paid for. When the contractor excavates outside the Project Plans limits, the material will be replaced with a material of equal or better quality and compacted to an acceptable density at the contractor's expense.

Over Excavation below subgrade elevation might be ordered for the purpose of correcting an unstable condition, diverting water, or providing a more gradual change from cut to fill. Observation of numerous fill settlements in areas of abrupt changes indicates a need for over excavation at these locations. Other problems at grade cut points are caused by topsoil being an inferior subgrade material.

Any over excavation which the Resident Engineer has authorized should be measured for payment as roadway excavation unless there are extenuating conditions that warrant performance of the work as extra work. (See Subsection 109.04). However, if the over excavation was the result of the contractor's operation, no additional payment should be made.

Before the work is accepted, the roadway section affected by such over excavation shall be inspected to be corrected to true plans grade and section.

In cut sections, cut ditches may be constructed to prevent the pooling of water. The outlet ends of these ditches should be constructed so that the water will be discharged onto natural ground and not against the embankment slope. Cut ditch sections are staked in conjunction with the roadway excavation.

(B) Slopes

The contractor's selection of the type of equipment for finishing of slopes is predicated upon steepness, access, and type of material.

Rounding of slopes at the top and ends of cut sections is normally done as the excavation progresses, because of more ready access to those areas. Slopes should be trimmed and shaped as much as possible during the progress of the excavation operation.

Slope rounding is not always shown on the typical roadway section in the Project Plans since the typical section refers to Standard Drawings that do specify slope rounding.

There are some instances where slope rounding is not required. These areas are usually described in the Project Plans or Special Provisions.

(C) Blasting

(1) General

Overshooting, or blasting which loosens solid rock formations outside the limits of the planned slopes, may cause slides and overbreakage. The contractor can avoid overshooting by plotting the depth and direction of the drill holes and determining their relation to the slope line to ascertain that they are not beyond the slope line. The contractor should evaluate the amount and type of explosive and the spacing of the holes. The Resident Engineer should closely observe the drilling and shooting operations. If the method used results in overshooting or damage to the adjacent property, the contractor should modify the blasting plan. The Resident Engineer will not assume responsibility for the contractor's methods or procedures, but should become familiar with the properties, uses, and action of explosives and detonators used by the contractor. ADOT Geotechnical Services may be contacted for technical assistance. Each project office located on a job where blasting will be done should obtain information pertaining to the use and safety of commercial explosive material. Refer to the Reference and Additional Information section at the end of this chapter for publications available.

The Resident Engineer should see that good records are kept of blast hole patterns, loading rates, types of blasting agents used, and comments on the results of the blast. Did it throw a lot of rock outside the slopes, was there overbreakage, etc.? Good records of the blasting operations are often useful in resolving disputes about overbreakage and alleged changed conditions.

If blasting is near a developed area, a joint inspection should be made of the surrounding properties prior to blasting to assist in verifying any damage which may occur from the blasting. Photographs or a video recording of the area during this inspection should be made.

It is very important that the Resident Engineer review the blasting plan to ensure that the contractor has followed all requirements for a blasting permit. All required permits must be obtained prior to any blasting.

(2) Controlled Blasting

The contractor shall provide a written blasting plan prior to beginning any blasting work. This plan must be reviewed by the Resident Engineer to verify it contains the following minimum requirements:

- Method for transporting the blasting agent to the site
- Type of blasting agent used
- Size and depth of holes
- Size and loads of blast pattern
- Type of stemming material
- Ignition source
- Method of storage on site
- Procedures in case of a misfire
- Type of firing device (electrical, etc.)
- Type of security that will be used
- Name of blasting company or person doing the blasting, and copies of their certifications or license with the issuing agency

The Inspector should review all requirements for transporting and storage of the blasting agent and review the contractor's operation for compliance.

In an attempt to control the fracture of the rock along the slope line, presplitting is often required on many rock cuts. Presplitting or preshearing can be defined as the establishment of a free surface or shear plane by the controlled use of explosives and blasting accessories in appropriately aligned and spaced drill holes. Preshearing involves a single row of holes drilled along the neat excavation slope line. Presplitting involves a series of charges fired simultaneously in adjoining holes. Collision of the shock waves between holes places the web between the holes in tension and shears the rock between the holes. With proper hole spacing and charge to suit the type of material being blasted, the fracture zone between the holes will be a narrow sheared area through which the subsequent primary blasts can break.

The pre sheared plane reflects some of the shock waves from the primary blasts that follow, which prevents them from being transmitted into the finished wall and minimizes shattering and overbreak.

(3) Radio Frequency Hazards

Radio Frequency (RF) transmitters, which include AM and FM radio, cellular phones, television, and radar, create powerful electromagnetic fields, decreasing in intensity with distance from the transmitter antenna. If the electric detonator wires are in a strong RF field (near a transmitter that is radiating RF power) the unshielded leg wires or circuit wires, whether connected to a blasting machine or not, will act as an antenna similar to that on a radio or TV set. The RF field will induce electric current in the circuit wiring that will flow through the electric detonator connected to it and sufficient RF energy may be induced in the wires to fire the electric detonator. Tests have demonstrated that electric detonator wires, under certain circumstances, may pick up enough electric energy from such fields to cause them to explode.

Commercial Amplitude Modulated (AM) transmitters are potentially the most dangerous. They combine high power and low frequencies so that there is little loss of RF. Low frequencies induce more current than high frequencies so the potential to induce a current in the blasting wire is high.

Frequency-Modulated (FM) and TV transmitters are unlikely to create a hazardous situation. Although their power is extremely high and antennas are horizontally polarized, the high frequency currents are rapidly attenuated in detonators or lead wires. Also, these RF sources usually employ antennas on top of high towers and this has an additional effect of reducing the electromagnetic field at ground level.

Mobile radio transmitter units must be rated as a potential hazard because they enter directly into the blasting area. The Citizen Band radio is an unusual problem for several reasons.

- There are millions of units being used by the general public
- The operating frequency of these units is in the range that is considered to be the worst case for typical electric blasting circuits

- Some irresponsible operators use illegal linear amplifiers to increase their power output

Federal regulations require the posting of signs within 1000 feet of construction sites warning that two-way radios should be turned off because of blasting. Observance of the posted signs will provide the necessary degree of safety if the units are operating within the legal power output. Exhibit 203-3.03-1 shows tables of distances designed for the convenience of the commercial blaster. The selected groupings include all the obvious types of RF transmitters that may be encountered around blasting areas.

The safe distances recommended are for the FCC approved units; it is not possible to specify safe distances for the illegal units because they do not operate within any limits. When planning to blast electrically at a new location, the Resident Engineer should inspect the area for RF transmitters before blasting is started and follow the recommendations of Exhibit 203-3.03-1.

Recommended Distances of Mobile Transmitters
Including Amateur and Citizens' Band

Minimum Distance (feet)

Transmitter (1) Power	MF 1.6 to 3.4 MHz Industrial	HF 28 to 29.7 MHz Amateur	VHF 35 to 36 MHz Public Use 42 to 44 MHz Public Use 50 to 54 MHz Amateur	VHF 144 to 148 MHz Amateur 150.8 to 161.6 MHz Public Use	UHF 450 to 470 MHz Public Use Cellular Automobile Telephones Above 800 MHz
(Watts)	(Feet)	(Feet)	(Feet)	(Feet)	(Feet)
5	30	70	60	20	10
10	40	100	80	30	20
50	90	230	180	70	40
100	120	320	260	100	60
180 (2)	170	430	350	130	80
250	200	500	410	160	90
500 (3)	280	710	480	220	120
600 (4)	300	780	640	240	140
1000 (5)	400	1,010	820	310	180
1000 (6)	1,240	3,200	2,600	990	560

Citizens Band, Class D Transmitters, 26.96-27.41 MHz

Recommended Minimum Distance

	Type	Hand-Held	Vehicle-Mounted
Double Sideband -	4 watts maximum transmitter power	5 ft.	65 ft.
Single Sideband -	12 watts peak envelope power	20 ft.	110 ft.

(1) Power delivered to the antenna.

(2) Maximum power for two-way mobile units in VHF (150.8 to 161.6 MHz range) and for two-way mobile and fixed station units in UHF (450 to 460 MHz range).

(3) Maximum power for major VHF two-way mobile and fixed station units in the 35 to 44 MHz range.

(4) Maximum power for two-way fixed station units in VHF (150.8 to 161.6 MHz range).

(5) Maximum power for amateur radio mobile units.

(6) Maximum power for some base stations in the 42 to 44 MHz band and 1.6 to 1.8 MHz band.

Exhibit 203-3.03-1. Recommended Distances For Transmitters

There may be instances where the use of two-way radios will increase the overall safety of a blasting operation by providing instant communication. When radios are used for this purpose, the minimum separations specified, in Exhibit 203-3.03-1 for a particular transceiver, should be maintained.

Due to static electricity, firing of explosives should not be carried out during a thunderstorm or when one is approaching. During such a period, leading wires should be short-circuited and all persons should move to a safe distance. Short-circuiting is a safeguard; however, it may not prevent the firing of a charge if the wires are struck by lightning.

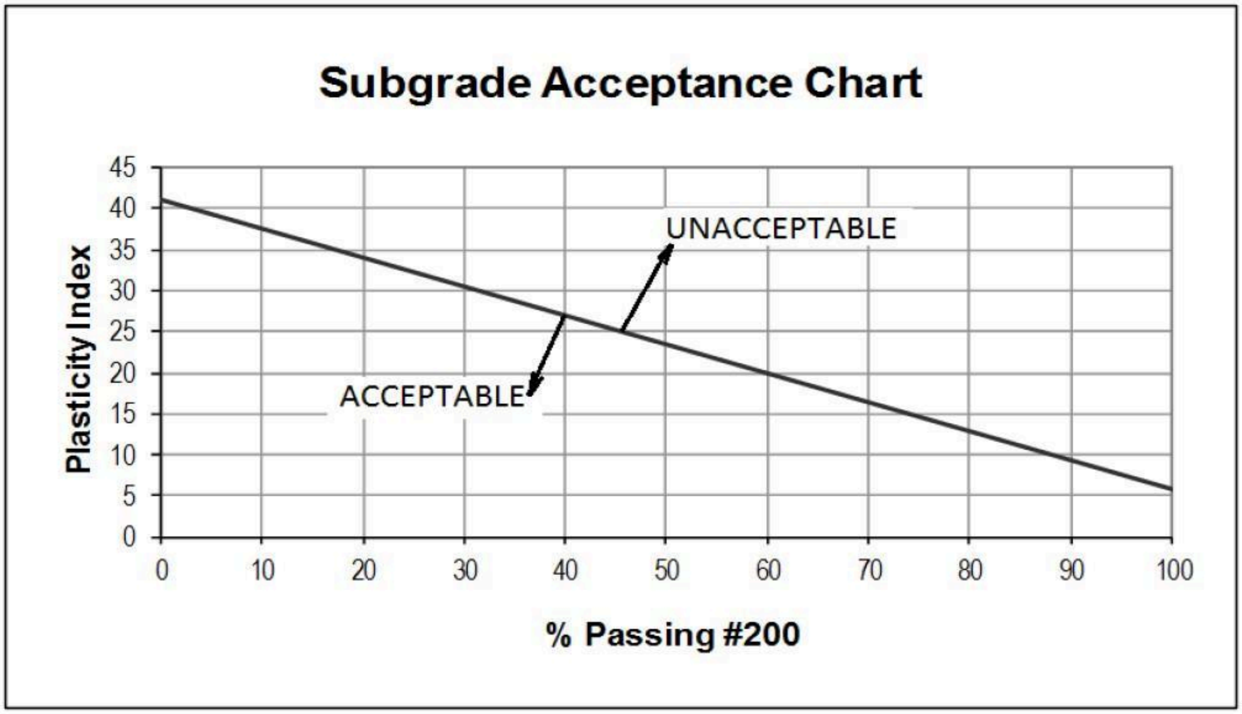
Safety should be the concern of all individuals in the blasting area. Shattered windows, flying boulders, moved railroad tracks, damaged forest and highways, and injured people could be the result of a poor blasting operation. Blasting is an extremely dangerous activity, and the contractor must have the proper respect for the havoc that negligence or errors can cause. Before blasting, the contractor should inform the local law enforcement agencies, inform neighbors in the area, post "Blasting Ahead - Turn Off 2-Way Radio" signs, purchase necessary permits, and use necessary personnel to cordon off the area.

The ADOT Safety and Health Section can assist in resolving safety issues related to blasting. In addition, each project office should have a current copy of the OSHA Safety and Health Standards for the Construction Industry.

(D) Unsuitable Materials

Unsuitable materials are defined as those materials that may adversely affect the stability of the roadbed. Any soils that may cause instability or have some other detrimental effect should not be used unless adequately treated to make them satisfactory. If unsuitable materials are encountered, they should be removed and replaced with acceptable material, or should be processed and placed in a manner that will make the material acceptable. Asphaltic concrete millings may be included in accordance with subsection 203-10.02(D).

The design of a pavement structure is influenced by many variables. One of the most important variables is the strength of the subgrade soils. Our present design method characterizes the subgrade soils by use of the "R" value test, or Resilient Modulus. In the AASHTO Test Manual, the "R" value test method is described as a "procedure for testing both treated and untreated laboratory compacted soils or aggregates with the stabilometer and expansion pressure devices to obtain results indicative of performance when placed in the base, subbase, or subgrade of a road subjected to traffic loads." The "R" value test takes three days to complete and requires specialized equipment. For that reason, all the "R" value tests are performed by the Materials Group. For design purposes, the design "R" value is determined from calculated "R" values, using the Plasticity Index (PI) and the percent passing the #200 sieve (PC) of the subgrade materials as well as from actual "R" value tests. Using this PI and material passing the #200 sieve (PC) information, a subgrade acceptance chart is developed (an example is shown Exhibit 203-3.03-2). This chart is used to determine whether the subgrade is suitable for the proposed design. The subgrade acceptance chart is included in the Final Materials Design Report distributed to the District and the project. When borrow is required to construct subgrade, the project Special Provisions will include the equation, “PC+(2.83xPI) shall not exceed XXX”, to determine its acceptability based on the PI and PC. If the chart or formula is not available at the District, a copy may be obtained by contacting Pavement Design Section.



Subgrade Construction Control R-value:	20
Design R-value:	20

Exhibit 203-3.03-2. Subgrade Acceptance Chart

Borrow placed within three feet of the finished subgrade elevation shall conform to the following requirement:

Value = PC + (2.83 x PI), and shall not exceed XXXX as stated in the project special provisions.

where:

PC = Percent of material passing the No. 200 sieve (determined in accordance with Arizona Test Method 201), and

PI = Plasticity Index (determined in accordance with AASHTO T 90).

Example of the Special Provision:

If during subgrade acceptance testing (other than borrow), the PI and materials passing a #200 sieve of the sample fall within the unacceptable region of the subgrade acceptance chart, Pavement Design Section should be contacted. The design may be affected by these results, necessitating a redesign of the pavement structural section. Meanwhile, efforts should be made to isolate the area of unacceptable material.

Isolating the area of unacceptable material is normally done by sampling on each side of the unacceptable material in increments of 100 feet until acceptable samples are obtained. Using this information, Geotechnical Service Section or Materials Group will determine the best method of dealing with the unacceptable subgrade material which may include chemical or bituminous stabilization, installation of geogrid, removal or replacement with more suitable material.

If borrow material fails to meet the requirements of the formula, the contractor will be required to locate another source of borrow.

Subgrade acceptance samples will normally be taken from the upper 3 feet of subgrade. In certain circumstances the sampling will extend to a greater depth if the conditions could affect the structural design.

(E) Surplus Material

Some projects may have an excess of excavated material after the required embankment work is completed. If this is known beforehand, a designated disposal site may be provided on the Project Plans. If no designated disposal site is provided, then it becomes the responsibility of the contractor to provide an acceptable means of disposing of this material. The Resident Engineer may approve of disposing of this excess material within the project limits. If the contractor intends to provide a disposal site, an Environmental Analysis may be required.

When left to remain on the project, surplus material should be used in widening embankments, constructing berms, emergency turnouts, view points, and dikes. If a large amount of waste appears to be developing due to errors in estimating shrinkage and swell factors or for any other cause, the District Engineer should be notified as soon as possible so that necessary steps may be taken for proper disposal of the surplus material. Unsightly waste piles of surplus material should not be allowed.

Waste material that is used for roadway items such as widening embankments, widening berms, turnouts, viewpoints, dikes, etc., will be placed in accordance with Specification 203-10. End dumping over the side of a fill will not be allowed. Widening of fills from the top will cause the fill to be unbalanced—a condition that can cause the fill to slide or crack from the unequal loading. This type of failure becomes more severe on steep side slopes.

Material shall not be wasted without the permission and direction of the Resident Engineer. When working within US Forest Service lands, US Forest Service officials must approve waste sites.

203-4 Drainage Excavation

It is important that much consideration be given to adequate drainage around and through the roadway prism. Expenditure for drainage control may prove to be well justified due to potential maintenance savings and protection of adjacent properties.

Evaluate not only what condition exists, but also what might occur during the life of the project. Bank protection is often overlooked when evaluating drainage channels, as is nearby urban development. Urban development reduces natural ground surface area, which dramatically increases precipitation runoff. Possible scour or erosion of streambeds is very important in determining proper grades for construction of bank protection. Always try to plan drainage so that no abrupt directional changes are made, but rather gradual changes that will allow the water to run its course with minimal erosion.

Occasionally, properly engineered drainage will require work outside of the established right-of-way. In such cases, additional drainage easement areas or construction easements will have to be secured from the ADOT Right-of-way Group.

Detailed staking of drainage work is required to ensure "puddling" does not occur on abutting private property. This is especially important in developed areas.

Channel changes that will direct the flow into a drainage structure should be completed by the time the structure is completed. To minimize embankment damage during construction, channel changes for the purpose of directing the water flow away from the roadway section should be constructed before completion of embankment. Adequate protection should be provided to prevent erosion due to diversion of water through new channels.

When failure to complete the needed channels and dikes endangers the work or other property, the contractor should be notified in writing. The condition should be well documented and photographed when the contractor does not take timely action to correct the situation.

Inlet or outlet channels to culverts should present a neat appearance upon completion and should be open and ready for use upon completion of the structure. The contractor is responsible for any damage and repair necessary due to inlets and outlets at structures not working properly.

Inspection of Drainage Facilities

After completion of all drainage structures, drainage ditches, and channels, the Resident Engineer should make an inspection of the entire project for the purpose of locating any areas where water might collect. If such areas are encountered, the necessary corrections should be made. Rainstorms during construction afford an excellent means of checking the adequacy of constructed drainage. Take advantage of them.

203-5 Structural Excavation and Structure Backfill

203-5.03 Construction Requirements

(A) Excavation

In most types of soil it is necessary to provide shoring, or slope the ground beyond the neat lines shown in the Project Plans or Standard Drawings in order to avoid caving. The contractor’s slope, shoring and trenching plan must be approved by the Resident Engineer. Side slopes must conform to the Occupational Safety and Health Administration (OSHA) standards. Therefore, all excavations will automatically be referred to the OSHA Standards for excavation. It is very important that the Inspector have a copy of the latest OSHA Standards for excavation when working in these areas.

When plans indicate the structure is to rest on rock, then excavate to a depth sufficient to expose sound material. The rock surface shall be rough, and approximately level, or stepped. Rock seams should be pressure grouted.

It is essential that the subgrade foundation under a structure be uniform and firm under the entire bearing surface. When unsuitable material is at the excavation planned grade then it must be removed and replaced with structure backfill material. When a portion of the structure is on yielding material and the other portion is on unyielding material, or rock then remove the rock to a minimum depth of 2 feet below grade, and replace with structure backfill material in accordance with Specification 203-5.03(B). If it can be avoided, culverts should not be placed partly on filled ground and partly on undisturbed natural ground because of the probability of unequal settlement. If any portion of a culvert must be placed on filled material, the filled material should be placed in accordance with Specification 203-10 Embankment Requirements.

When concrete is to be placed on material other than rock, special care must be taken not to disturb the bottom of the excavation. When suitable material in the bottom of the excavation is disturbed or over excavated, that portion of the foundation shall be restored by the contractor in accordance with Specification 203-5.03 (B) to a firm foundation without payment.

(B) Backfill

Specification 203 permits the contractor some latitude in selecting the material while still requiring a material that is free of frozen lumps, chunks of clay, or other objectionable material, and conforms to gradation, plastic index, and resistivity requirements.

The material should be placed in layers not to exceed 8 inches in depth before compaction. It is advisable to mark the wall or area being compacted in 8 inch increments as each lift is placed in order to assure proper lift thickness. Care should be taken to extend the compacted area as far as necessary in order to notch into firm material.

The Standard Specifications require cutting into compacted material both laterally and longitudinally, with all material to be compacted.

The minimum frequency of density testing should be in accordance with the Sampling Guide in the Materials Testing Manual. At the start of operations on a project, it is advisable to perform more frequent tests to evaluate the effectiveness of compaction methods, material, and moisture content, as well as the variability of the entire backfill and compaction process. The tests should be timely so that there is a minimum of delay to the contractor's operations.

Backfill material should not be placed adjacent to a concrete structure until the concrete has developed the minimum strength specified for that structure. Standard requirement is a minimum compressive strength of 2,000 PSI and in no case backfill before 72 hours after casting. Field cured cylinders and strength history are the basis for determining compressive strength. When placing backfill material around concrete structures care must be taken to bring the backfill material up uniformly on both sides of the structure. Backfill placement on one side must never be more than 2 feet above backfill placed on any other side.

Geocomposite Wall Drains conforming to Specification 1014-6 shall be installed on the soil side of abutment walls, wing walls, retaining walls, and culvert side walls. Care must be exercised to ensure Geocomposite Wall Drains are installed properly in accordance with Specification 203-5.03(C). If the drain fails to function properly it could cause the structure to fail. There will be no measurement for payment of Geocomposite Wall Drains, unless specified otherwise.

As an option the contractor may use a slurry backfill material that conforms to the requirements of Specification 203-5.03(B). The slurry should be placed in uniform layers not to exceed 4 feet in depth before compaction. It is advisable to mark the wall or area being compacted in 4 foot increments as each lift is placed in order to assure proper lift thickness. The water content should not exceed 40 gallons per ton of backfill material. Internal vibrators should be used for compacting slurry in accordance with Standard 601-3.03(D). Have the contractor excavate holes in the slurry so compaction can be tested at random depths. Direct the contractor to refill and compact test holes. Subsection 501-3.04 of this manual and the Specifications have additional information on the applications and use of slurry backfill.

203-5.04 Method of Measurement

The pay limits for structural excavation and structure backfill are shown on the Standard Drawings (or in rare instances, the Project Plans). These quantities are not meant to represent the actual quantity necessary to complete the work. Over excavation may be permitted, but no payment will be made for excavation due to slides, cave-ins, silting, or filling due to lack of side support, the action of the elements, or contractor carelessness. No deduction will be made when the contractor elects not to excavate material within the pay limits, but excavation that does not extend to these limits should not be permitted if it interferes with the setting of forms and braces or the proper backfilling, compacting, and testing operations. Footings that must be over excavated deeper than plan depth shall be measured as structural excavation up to 3 feet deeper than the Standard pay limit.

203-6 & 203-7 Grader Ditch & Crown Ditches

Grader ditches should be constructed as shown on the Project Plans or as directed by the Resident Engineer. Care as to size and general appearance should be exercised in the cutting of grader ditches. Ditches constructed through rock formations should be shaped and trimmed to leave a reasonably pleasing appearance.

Grader ditches will be constructed to the length staked in the field, but it is often advisable to let an experienced blade operator determine the alignment between stakes in order to provide proper drainage.

A properly placed crown ditch or grader ditch may not ordinarily parallel the centerline of the roadway. All ditches should be constructed to approximate natural contour lines. When it becomes necessary to go beyond the limits of the right-of-way to provide proper drainage, no work shall be performed off the right-of-way until the Right-of-way Group has obtained an easement. This need would normally be coordinated through the District Engineer.

203-8 Crown Dikes

Crown dikes are usually formed from material obtained from roadway, structural, drainage excavation, or borrow. The same precautions described in Section 203-6 should be considered in constructing crown dikes.

Placing and finishing of crown dikes shall be as shown in the Project Plans or Standard Drawings.

203-9 Borrow

When the excavation does not develop enough material to complete the embankment, a borrow source may be provided to make up the difference. The need for borrow is usually evident during the design phase, but may develop from unforeseen conditions.

When borrow is required, it shall be obtained from approved sources in accordance with requirements of Specification 1001. One of the major factors affecting the acceptability of a borrow source is the requirements placed on the material by the structural design of the pavement. Requirements for borrow placed within the top 3 feet of subgrade will be specified in the Special Provisions.

Borrow is measured in the original, or final space it occupies depending upon the pay item description shown in the contract. Borrow (Pit) items are measured in the original space occupied, whereas Borrow (In Place) is measured in the final space occupied. All roadway, drainage, or structural excavation shall be incorporated into the roadway embankment prior to the importing of borrow unless the Resident Engineer has given written permission to the contractor to do otherwise.

There will normally be no payment for either roadway or structural excavation that is wasted when borrow has been used, unless specified in the contract documents.

On projects with Borrow (In-Place), or projects with over 5,000 cubic yards of earthwork, the Resident Engineer should consult with the Roadway Designer or Project Manager to determine if the existing ground line should be re-measured. The primary consideration should be reasonable accuracy and validity of the existing topographic information prior to beginning earthwork operations. The Resident Engineer can also contact the ADOT's Statewide Survey Services to complete measurements before and after earthwork operations.

If a question or disagreement regarding quantities arises, then additional measurements can be performed covering that appropriate stage of construction. If there are no problems with quantities in the earthwork operation, no measurement will be necessary beyond the initial work except for Borrow (In-Place). Arrangements to have aerial photography taken for the project should be made at least 30 days prior to beginning any earthwork operation. If a survey crew can make remeasurement, the request should be made with enough lead time to obtain the necessary crew. Borrow sources may need to be measured before and after excavation when borrow is used for miscellaneous purposes such as shoulder widening or flattening.

Changes in borrow placement that result in:

- Material with different properties being used
- Substitution for excavated material
- Changes from a specified source

Are all changes to the contract requiring a supplemental agreement. Always remember written approval is required to change the borrow placement from that shown in the Project Plans.

203-10 Embankment

203-10.02 Embankment Materials

It is very important for the Inspector to ensure that no large rocks, boulders, broken concrete, or other large debris are placed in areas where piling and drilled shafts are to be constructed, e.g. in embankment for a bridge abutment. Subsection 203-10.02, and Subsection 203-10.03 limit the size and type of material that can be placed in these areas. Subsection 203-10.03 includes all drilled shaft, metal pile, abutment, wing wall, and anchor slab locations. The same precautions should be taken at locations for guardrail, underground conduit, and light and signal pole foundations. Some projects build embankments for other projects, so the Inspector needs to be aware of the impacts the contractor's embankment work could have on a future project.

Steel H-piles will corrode in disturbed soils that have a low resistivity or an extreme pH value. Subsection 203-10.02 places limits on embankment soil resistivity and pH for that reason. The key to understanding this specification is that embankment soils are disturbed soils. An undisturbed native soil, which the pile is driven through, may have a resistivity and pH value outside the specifications. As long as the soil is undisturbed, it is usually not a problem for the pile. It is only disturbed soils used for fill, embankment and structure backfill that threaten a pile with long-term corrosion (refer to Subsection 203-5.03[B]).

Two final points about piling and earthwork concern 1) the completion of all embankment work before piling driving begins (Subsection 603-3.04 [A]) and 2) the requirement of excavating to the top of the pile when the embankment has already been completed (203-5.03[A]). The first requirement is discussed further in Subsection 603-3.04 of this manual. The second requirement eliminates the risk of damaging or loosening of the piles as a result of exposing, cutting, and removing excessive lengths of piling.

Where millings are incorporated into embankment materials, it is important that the material consists of no more than 50% millings; it should be a mixture of soil or aggregate and millings. Difficulty compacting at ambient temperatures and long term consolidation may occur if it comprises more than 50% millings. This type of material must be thoroughly mixed to produce a homogeneous material; a pugmil type mixing apparatus is preferred.

203-10.03 Embankment Construction Requirements

(A) Placement

Embankment placed within top 3 feet of the finished subgrade elevation will have different requirements than embankment placed at greater depth. It is very important for the Inspector to ensure that material in the top layer meets all the standard requirements. Sampling and testing will be required in areas where embankment is covered by pavement or penetrated by bridge structures.

The contractor should not begin the removal and placement of borrow until all roadway, structural, and drainage excavation has been removed and incorporated into the embankment, unless otherwise authorized by the Resident Engineer.

The long-term smoothness of a road depends to a large degree on the proper preparation of the area upon which the embankment is to be placed (the embankment foundation). The presence of slippage planes, areas of unstable material, or water from irrigation, seepage, springs or just surface water retained in a clay basin, are some of the detrimental conditions that may be encountered. The presence of localized areas of heavier, lush vegetation is an indication of the presence of water. Such areas should be investigated with consultation of the Materials Group. If it is feasible, areas containing standing or running water should be removed, drained, or otherwise corrected before embankment is placed. In swamp areas where the subgrade is close to the ground line, it may be necessary to raise the grade. Corrective measures not included in the Project Plans or Special Provisions will require a supplemental agreement.

If the existing ground surface is highly irregular, the surface should be smoothed or otherwise restored to a reasonably regular surface.

When constructing embankments on steep slopes, attention should be given to preventing a slippage plane. Benching is required in such locations (see Subsection 2.03-10.03). Where embankments 5 feet or less in height are to be constructed. The top 6 inches of the ground on which the embankment is to be placed must be watered, processed, and compacted to 95% of maximum density in accordance with the Standard Specifications.

Earth embankments should be constructed in successive layers, not more than 8 inches thick before compaction. Thinner layers usually compact more readily. Roots and other unsuitable material should be removed before compaction. Layers of embankment on hillsides should be placed part width, beginning at the low side and decreasing in width as the embankment is raised. Earth embankments are generally built with scraper type equipment that haul, spread, and compact the embankment material.

Operators of large heavy equipment very rarely compact right to the outer edge of the embankment. They prefer to travel in a compacted area away from the edge. This leaves an uncompacted area several feet wide. The Inspector should watch for these areas and other areas where large equipment cannot maneuver, and require supplemental compaction. If supplemental compaction is not provided, the Resident Engineer should be informed and density tests should be taken in the uncompacted area.

When embankment slopes are to be seeded, surface cultivation to the specified depth is critical for minimizing erosion and achieving favorable seed germination. A minimum tillage of 6 inch depth is required on fill slopes and a minimum tillage of 12 inch depth is required on cut slopes. The seeding contractor generally doesn’t have the equipment to accomplish desired tillage. This is best achieved through the general contractor, who has access to larger equipment. The soil should be left in a loose, evenly roughened condition, free of dirt clods or large stones with the entire width of the tillage cultivated to the specified depth. This may require passing the equipment over the same area parallel to the contours several times to provide thorough soil cultivation. All tillage should result in furrows no more than 12 inches apart and directional along the contours.

Embankments should be constructed in such a manner that there will be no ponding of water that will soak into and soften the lower levels of the embankment.

Embankments can be constructed in cold weather, but the inspector must ensure no snow, or frozen chunks of earth are placed in the embankment. Snow and ice will eventually melt and cause the embankment to settle unevenly.

Changes in borrow placement that result in:

- Material with different properties
- Substitution for excavated material
- Change from a specified source

are all changes to the contract and may require a supplemental agreement. Written approval is required to change the borrow placement from that shown on the Project Plans.

Up to 50% milled asphaltic concrete may be included in embankment materials provided they are placed in accordance with subsection 203-10.02(D).

Subgrade Finishing

After all approved materials have been incorporated into the subgrade and compacted to the required density, "blue top" grade stakes, wire control line, or another method approved by the engineer shall be used to provide the finished subgrade elevation. Before the placement of any further materials, the Inspector shall verify that the roadway has been trimmed or slight fills made to bring the subgrade to desired grade and section. The final subgrade density tests must be performed and tests made on the subgrade materials (PI and materials passing a #200 sieve before any base material is placed on the roadway.

The subgrade is to be finished in conformity with the elevations called for in the Project Plans. When asphalt or concrete pavements are placed directly on the subgrade, without select or aggregate base, it is very important to construct the subgrade to the proper cross slope and grade. Subgrade tolerances are shown in the Standard Specifications.

(B) Compaction

(1) Earth

Ideal conditions for obtaining compaction with the least effort would be a material that contains uniform moisture content near optimum (-2% to +2%). Maintaining the moisture slightly below optimum often works better for some materials. With the use of heavy rolling equipment, moisture above may cause the material to pump and not compact properly.

In rare circumstances, fine, non-cohesive, silty soils found near river banks and alluvial fans may exhibit pumping behavior despite being at/slightly below optimum moisture content. Rather than reducing moisture further below optimum, testing to verify compaction may need to be delayed until compaction of a subsequent lift has occurred.

Fine, cohesive, clay soils may be more appropriately compacted at or slightly above optimum moisture content (-1% to +3%) to reduce the potential for further expansion. In most cases a vibratory padfoot compactor, known as a “sheepsfoot roller”, is the most efficient method of compaction.

Most soils compact more readily in thin layers. This is the reason for the maximum lift thickness requirement of 8 inches that appears in the Standard Specifications. In some cases it may be in the contractor's interest to further reduce the lift thickness.

Embankment placed near a bridge abutment must conform to special compaction requirements that will prevent settlement of approach slabs and anchor slabs.

Prewetting of roadway excavation and borrow pits is common practice among contractors: distribution of water is usually better, dust is controlled, loading of scrapers is aided, and compaction can be obtained easily with a minimum of loss by evaporation. (See Subsection 206-3 for the method of computing the weight of materials to which water has been added).

The amount of watering and rolling required in the construction of rock embankments depends on the amount and character of fine material contained between the rock fragments. Close observation of the placement of the material and good judgment will determine the amount of water and type of compaction needed. Normally, if the fine material does not fill the voids between the rocks, watering and rolling will not be effective. Since compaction tests can seldom be performed in rock embankments, the Inspector must give this type of work more attention than normally required for other embankments.

Stability and support of soils is directly affected by the degree of compaction. The lower the compaction, the lower the support, especially when moisture is present.

As mentioned in the discussion of embankment, the Inspector should keep the contractor advised of possible problem areas involving drainage and the roadway prism.

Saturated areas are to be drained, dried out, and compacted before being covered. Sometimes it is more efficient to just replace the material.

Filling in with dry material is usually not an acceptable method of stabilizing wet earth because complete mixing of the wet and dry material seldom occurs. The mixed area will look stable and may temporarily support construction equipment, but it will eventually fail under repeated loading.

Do not allow the contractor to bridge over a soft spot by covering the spot with dry, stable material. Soft, unstable areas do not meet specifications and must be corrected.

The removed material can be wasted in areas outside the roadway prism, or if sufficient embankment is available, it can be spread out to dry in thin lifts. Before being placed within 3 feet of finished subgrade elevation, the material is to be tested to be sure it meets subgrade acceptance requirements.

The Inspector needs to keep good records of the areas needing corrective work and how the work was accomplished.

Soils will vary widely as to the amount of effort necessary to achieve a uniform degree of compaction. It is the contractor's responsibility to provide the equipment needed to obtain the required density.

Compaction tests should be performed so that they represent any area where it is suspected that there may be inadequate compaction (such as near outside edges of roadway or near structures). The outside edges of fills should be given extra attention to assure density. Each lift of material placed must be tested and approved before placing additional lifts.

The contractor should be immediately advised of the results of the compaction tests.

Testing equipment, e.g. "Speedy" moisture testers, scales, molds, proctor hammers, nuclear gauges, and volume measuring devices, are to be checked or recalibrated before the start of each project and at suitable intervals during the life of the project.

(2) Rock

Rocky fill material should not be deposited in large piles and leveled off. Dumping the material on top of the layer being built and shoving it ahead with a dozer can obtain a more uniform arrangement of the different rock sizes. This method will provide a more effective placement of the material in the fill so that there will be a minimum of voids. When possible, rock should be placed, spread, and leveled in 24 inch thick layers. The ideal layer will cover the full width of embankment and contain sufficient earth or other fine material to fill the interstices between rocks. The top layer of the rock embankment should be built with the most care since this layer serves as the subgrade. Where suitable material is available within the cut area, it may be set aside for finishing the final layer. However, such material should be used only after tests have been performed to prove that its use is acceptable per Section 203-10. The use of material containing clay or frozen earth must be avoided for plating rocky subgrade. If satisfactory quality plating material is not available, it is better to use a greater thickness of subbase material for filling any irregularities in the surface of the subgrade.

In rocky material the Inspector should seek out areas that can be tested. There is a tendency to easily dismiss the need for compactive effort simply because the material is rocky. Vibratory compaction is best for rocky soil, but almost any type of compactive effort will be beneficial.

204 RESHAPING AND GRADING EXISTING IMPROVEMENTS

Under this section, all work is performed that is necessary to modify or restore existing features (such as embankment slopes, dikes, ditches, medians, and other features). Finishing the subgrade or existing surfacing is not included under this section.

The Project Plans are to be checked carefully to determine the extent of the work to be done under this section. A complete list of the work should be made to aid in tracking completed work and for the development of partial payments.

205 GRADING ROADWAY FOR PAVEMENT

205-3 Construction Requirements

The use of staged construction often makes it necessary to reshape a previously constructed subgrade or to modify a design pavement structural section. The contractor should scarify the entire road surface within the roadway prism, if necessary, and rebuild, recompact, remove, or reshape it to the cross-section shown on the Project Plans.

The inspector should check the bid schedule to see if removals of existing concrete medians, curb and gutter, or other obstructions are included in payment for grading roadway for pavement.

Shifting of material may be necessary in some cases and in others it may become necessary to import additional materials. Complete and satisfactory compaction of the entire reshaped cross section must be achieved before placement of base material.

Where necessary, the surface material at approaches to structures shall be removed to a depth sufficient to allow the placement of the designed thickness of subbase, base, and pavement.

205-3.04 Compacting and Finishing

When asphaltic concrete or Portland cement concrete is to be placed directly on the subgrade, it will be necessary to finish the subgrade to specified tolerances. It may be necessary to import a select borrow material to obtain the degree of finishing needed. Finishing tolerances are the same as for subgrade discussed in Section 203-10. The finish should be as uniform as possible. This prevents nonuniform compaction and the uneconomical use of paving materials to fill in low spots.

206 FURNISH WATER SUPPLY

206-1 Description

Furnishing a water supply is a lump sum item and consists of either developing or obtaining an adequate water supply and providing all water sufficient for the needs of the project including the hauling and applying of all water required in the compaction of embankment, base, and surfacing material, special backfill, and other fill and backfill. The “Furnish Water Supply” bid item should be used on remote projects where it is difficult to obtain water.

206-3 Construction Requirements

The inspector should check the Special Provisions for pre-wetting requirements when cuts are deeper than 3 feet. The inspector should review subsection 206-3 of the Standard Specifications when the contractor decides to pre-wet pay items that will be measured and paid on the basis of weight – the specification’s intent is that the contractor be paid the weight of this material prior to pre-wetting.

206-5 Basis of Payment

Generally payment for this item is made at the contract lump sum price. The Inspector should carefully review this item in the Standard Specifications and Special Provisions to ensure proper procedures are followed. The cost of providing a water distribution system and the cost for applying water to aid in compaction of materials are considered to be included in the prices paid for those items of work requiring water.

When the “Furnish Water Supply” pay item is omitted from the bid schedule, developing or obtaining an adequate water supply and furnishing all water for project work is included in the payment of the items of work requiring the use of water.

207 DUST PALLIATIVE

207-1 Description

Water required for dust control to protect public safety, or air quality, or for any other purpose directed by the Engineer is included in this item. Water used for compacting materials, or to control dust at commercial material sources, or used for the sole convenience of the contractor, or used for any purpose not specifically authorized by the Engineer is not included in this item. Application of all water authorized for dust control is included in this item.

When the Special Provisions state that the contractor may use water from the watershed area of the Salt River Valley Water Users' Association, then a construction water exchange permit must be completed. Permit arrangements are the responsibility of the contractor and shall be made through the office of the Construction State Engineer. The contractor is required to furnish the Resident Engineer with a copy of the permit.

207-3 Construction Requirements

Special attention shall be given to eliminating dust on haul roads, plant sites, and pit areas. Maintaining clean air and a dust-free environment is an essential element to maintaining our air quality. The contractor shall obtain any necessary air pollution permits prior to starting grading operations.

Often the results obtained from applying dust palliative may be improved by the use of certain additives in the water. Any use of additives must be approved by the Resident Engineer.

207-4 Method of Measurement and Basis of Payment

There is no measurement or payment made for Dust Palliative, the cost being considered as included in contract items.

208 SEPARATION GEOTEXTILE FABRIC

208-2 Materials

A Certificate of Compliance must accompany all geotextile fabric delivered to the project. If the delivered materials are not on the ADOT Approved Products List, then the fabric must include a Certificate of Analysis along with supporting documentation. Each roll of fabric must be tagged, and the Engineer must approve each lot, or shipment before the materials are incorporated in the work.

The inspector should ensure all requirements of Standard Specification and Special Provision sub sections 208-2 and 1014 are met. Particular attention must be given to protecting the fabric from sunlight since ultraviolet rays will rapidly destroy the fabric. At no time, shall the fabric be exposed to sunlight for a period exceeding 14 days.

208-3 Construction Requirements

Detailed installation instructions are included in the Standard Specifications and Special Provisions. Additional installation instructions should be available from the manufacturer or local supplier. The Resident Engineer should obtain and review this information before construction begins.

Adequate anchoring is required to prevent haul trucks from pushing or shifting the fabric out of position. Always back dump on the fabric and spread the material over the fabric. Dump subsequent loads onto the leveled fill material and advance by spreading; do not mix material on the fabric.

Should the fabric be damaged in any way during or after installation, it may be repaired by patching. The recommended repair procedures are to remove the damaged area and place a piece of fabric of appropriate dimensions to cover the damaged area and extend three feet beyond in all directions, followed by replacement of the aggregate.

208-5 Method of Measurement

Separation geotextile fabric will be measured by the square yard in-place. Measurement will be to the nearest square yard. No allowance will be made for material in laps.

209 FURNISH WATER

209-1 Description

As determined by the project's size and scope, the Furnish Water specification will be included within the contract documents. A major determining factor for its inclusion in a project is the amount of earthwork involved. Typically, if the total estimated amount of water needed for the project exceeds 50,000 MGAL, the Furnish Water specification is included. Regardless of estimated or actual project water utilized, the contract documents shall govern. Furnish Water covers the cost for the supply and utilization of all water required for construction activities on the project. However, there are limits as to which activities are eligible for reimbursement, e.g. water utilized in onsite mixing and materials production.

209-3 Construction Requirements

When utilized for dust control, Furnish Water is to be applied as approved and directed by the Resident Engineer. The Inspection team should be cognizant of the level of water usage in this endeavor and should be coordinating with the contractor when dust control is not particularly needed, e.g. dust control during and immediately following a rain event.

209-4 Method of Measurement

Quantities of Furnish Water are most often determined through the use of sealed and certified flowmeters. Flowmeters are typically attached to fire hydrants that are in close proximity to the project, and the flowmeters are supplied by the water utility owner. Flowmeters that are utilized for work covered under the Furnish Water specification shall be isolated and used solely for that purpose. Any other water uses requiring a flowmeter will need to have a separate flowmeter. In rare cases in which a flowmeter or an isolated flowmeter is not feasible, the Resident Engineer may allow for other methods of tracking water usage on the project. Whatever the resulting process, it should be easily tracked by the project team and should be as transparent as possible to all parties involved.

300 GENERAL

A highway pavement is said to be only as good as the base under it. This material is generally of lower quality than any course placed over it, but it still carries and distributes the wheel loads. The need to be concerned with its quality and finish is very important.

The thickness of the future pavement is determined by the soil-support capabilities of the underlying subgrade. The soil-support value of this material can be found in the Final Materials Design Report.

Verification testing of the subgrade material by the field office should be done quickly so that possible design changes in overlying structure sections can be analyzed. Design adjustments at this time could be very expensive. Early verification of the subgrade will provide the needed time to consider all options so that quality versus economy can be evaluated.

When the contractor is working a pit or quarry, quality control is the contractor's responsibility. Nevertheless, The Resident Engineer (RE) should be aware of the methods used to work the pit and produce the materials.

Most material sources contain materials that should be avoided or wasted. Blending or selection of material from various areas of the source may be required.

The Resident Engineer cannot direct that a contractor furnished source be worked in a particular manner, but can advise the contractor when the methods or materials may not produce an acceptable product. Comments of this type should be supported by test results.

The subgrade will be finished using natural materials. However, it may be treated with lime or cement if conditions require. Cement is normally used for the binding agent when the subgrade materials are granular, or have a very low P.I. content. In cases of high P.I., or higher degree of clay particles, lime would normally be used as the binding agent.

Geo-composite materials are being used favorably by the department throughout the state to achieve acceptable subgrade stabilization. Approval should be obtained from ADOT Materials Group, Pavement Design Section, and Geotechnical Section prior to using geo-composite materials. There are many different types of geo-composite materials. ADOT Geotechnical Section will select the proper geo-composite material for your project.

The time needed to check the grade for acceptance usually depends on the contractor's method of operation. Checking grade for compliance with finishing tolerances can usually be done rapidly if it has been previously checked or string lined by the contractor. However, the time required to check subgrade material for design acceptance (PI and material passing a #200 sieve) and to decide whether design changes are necessary could cause a delay in the acceptance of a section of subgrade. The contractor should be kept informed of subgrade test status in order to modify the operations if necessary.

If at any time that hauling equipment leaves wheel impressions due to excessive moisture or drying, the subgrade needs to be refinished and re-compacted. It may also be advisable to retest for compaction.

All major work needed to complete the roadway to the design cross section should be completed before the subgrade is accepted. Major work includes operations that will cause re-excavation within an area where the base or pavement will be placed, or operations that will result in contamination or disturbance of the base or pavement.

Examples of work that should be completed prior to aggregate base placement include:

- All cross drains and edge drains
- All storm drain pipes
- All conduit crossings for electrical, landscape irrigation, and freeway management
- System components
- All utility relocation work

Exhibit 300-1 shows a typical pavement section.

Finishing Tolerances

The standard specifications will provide the allowable tolerances that must be met by the contractor in order for the Resident Engineer to accept the base or subbase work. The Inspector and the contractor should string line the grade together for acceptance. Tolerances may vary depending upon the type of surface being placed, e.g. Portland cement concrete pavement or asphaltic concrete pavement.

TYPICAL PAVEMENT SECTION

A. Subgrade - The roadbed materials beneath the pavement structure. May be constructed from existing project materials or from imported borrow.
B. Finished Subgrade Elevation - The top prepared surface of the subgrade.
C. Subbase Course - One or more layers of specified material of design thickness, placed on a subgrade to support a base or surface course. A subbase is not often used.
D. Base Course - One or more layers of specified material of designed thickness, placed on a subbase course or a subgrade to support a surface course.
E. Surface Course - The upper portion of the pavement structure consists of a mixture of mineral aggregates and bituminous material or Portland cement concrete. This includes all wearing courses, i.e. asphaltic concrete friction courses.
F. Pavement Structure - The combination of subbase course, base course, and surface course placed on the subgrade to support the traffic load.

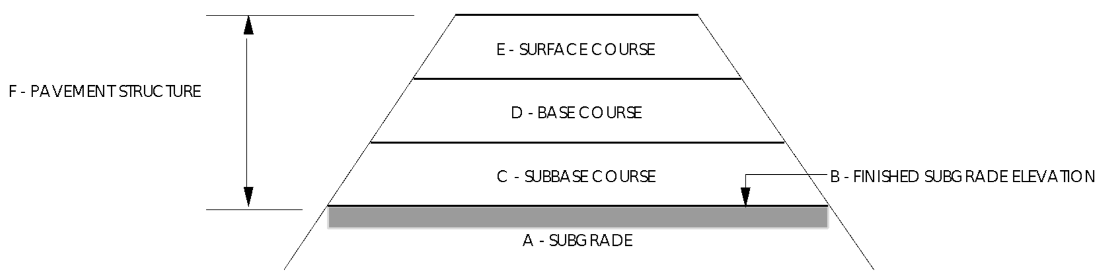


Exhibit 300-1. Typical Pavement Section

301 LIME TREATED SUBGRADE

The subgrade may be treated to improve its ability to support traffic loads. The improved load carry capability occurs because the lime admixture reduces the volume change characteristics and plasticity of the soil.

301-2 Materials

The Special Provisions will specify which type of lime to use. Two kinds of lime may be used for lime treatment: dry hydrated or commercial (granular or pelted) quicklime.

Dry hydrated lime has had water added and chemically combined. Quicklime has not been combined with water.

The Standard Specifications allow the use of lime from different sources, but not from different sources to be mixed. The problem with mixing lime from different sources is that they may react differently and result in non-uniformity. Hydrated lime and quicklime cannot be mixed together, even if they are from the same source, because of the very different water demands, curing time, and general handling procedures.

Whatever kind of lime is used, it must be kept dry and free flowing. Storage time should be as short as possible.

301-3 Construction Requirements

301-3.01 Preparation of Roadbed

Before adding lime, the subgrade material to be treated is scarified, pulverized, mixed, and windrowed or re-laid. It may be necessary to remove oversize material (see Standard Specification Subsection 301-3.01). It is necessary to determine how much moisture is present in the existing subgrade to ensure a sufficient amount of water is processed into the material to facilitate both the mixing of lime and the pozzolanic reaction with the soil.

Windrows should be sized so that the mixer can easily process all the material at once. This may mean that several windrows will be needed. Running the mixer at its capacity limit, generally, means the mixer has to slow down to achieve thorough mixing. Even with the slow down, a nonuniform mix may result.

301-3.02 Application of Lime

The Special Provisions will specify the application rate for adding lime to the treated material. Whether applied to a windrow or on the shaped grade, the lime is applied by a mechanical device that can be adjusted to provide the correct spread within 10% of the amount specified.

Favorable weather is very important to the process. Cold weather will slow the reaction of the lime, and freezing will deprive the mix of the water needed. Rain can result in too much water that can either stop the process by dilution or wash out the lime. Windy conditions may cause safety and environmental problems especially when quick lime is used.

301-3.03 Mixing

Water is to be added only through the mixing machine so that optimum moisture can be closely controlled.

Quicklime needs more water than hydrated lime because the larger particles have to slake and become fine enough to hydrate. Slaking is the sloughing and falling apart of large pieces until only a fine powder results. A curing period is often necessary.

The tolerance specification for the lime applied should be followed closely because the benefit of adding extra lime is not proportional to the amount added. A minor increase is unnecessarily expensive without a proportional increase in quality. A minor decrease in the lime greatly decreases the quality.

After mixing and laying, the finished subgrade is to be kept moist (not sloppy wet) until the bituminous curing seal is applied. The cure should be applied as soon as possible.

All traffic, including the contractor's and ADOT's, must be kept off the treated area for three days.

301-3.04 Compaction and Finishing

Lime treated material should be compacted to a density of at least 100 percent of the maximum density unless the Special Provisions specify otherwise.

301-3.06 Safety Program

Both kinds of lime must be handled carefully because they can cause severe chemical burns, especially to the eyes. The Standard Specifications require the contractor to have first-aid treatment available. The minimum precautions are described in the Standard Specifications.

The Resident Engineer is responsible for providing the same first-aid facilities for ADOT employees. If a satisfactory arrangement can be worked out, it is acceptable for ADOT personnel to use the contractor’s safety facilities.

302 CEMENT TREATED SUBGRADE

The specification requirements and construction practices related to cement treatment are similar to those of lime treatment.

302-3 Construction Requirements

The Special Provisions will specify the application rate for adding cement to the treated material. Cement must be applied by a mechanical device that can be adjusted to provide the correct spread within 10% of the amount specified.

Cement treatment differs from lime treatment in the four following areas:

1. The amount of cement that can be spread is limited to an area that can be mixed and compacted in a half-day work shift. This restriction is related to the rate at which cement will hydrate and set up and should be strictly adhered to.
2. The words related to thoroughness of mixing are different, but both specifications promote uniformity. The cement specification warns of cement balls. They are to be eliminated by continuing the mixing of the cement until all the balls have been broken.
3. The cement treatment specification has a limitation of 2 1/2 hours of time that can elapse from the time water is added to the final compaction and trimming. This time restriction must be complied with and is related to the rate at which cement will set up.
4. There is no delay allowed for the application of a curing seal on a cement treated subgrade. Prompt sealing is important to preserve the moisture needed for continued hydration. Also, rapid repair of a damaged curing seal or treated subgrade is stressed. Only light construction traffic is permitted on the curing seal. This means that it cannot be used as a haul road.

Cement treated subgrade is more sensitive to moisture. This means that not only is the curing seal important, but care must be taken to prevent over wetting during the mixing process.

302-3.03 Mixing

Do not allow the mixer to be overloaded. Mixers are most efficient when operated at the rated mixing capacity. Attempts to force a little more in because the windrows are too large are self-defeating. Either a non-uniform mix will result or the mixing time will be increased to more than it would have taken if windrows were properly sized.

303 AGGREGATE SUBBASE AND AGGREGATE BASE

303-2 Materials

The Special Provisions may allow use of salvaged asphaltic concrete or Portland cement concrete materials for aggregate subbase and aggregate base. Requirements for salvaged materials are not the same as Standard Specifications for aggregate subbase and aggregate base. The contractor may request use of salvaged materials on a project where specifications were not included in the Special Provisions. A copy of the normal requirements can be obtained from the Contract and Specifications Section. If Special Provisions do not include salvage material specifications, then the engineer should contact Materials Group before initiating a Supplemental Agreement to allow use of salvage material for aggregate subbase and aggregate base.

All material sources will fall into one of the following categories:

- Department Furnished Source
- Contractor Furnished Source
- Commercial Source

When the contractor furnishes pits, the Resident Engineer has the responsibility to approve the source in writing. Conditions for the Resident Engineer’s approval are detailed in Section 1001-4 of the Standard Specifications.

The Resident Engineer is required to observe the contractor's sampling of the pit and may furnish general comments about any special treatment or restrictions. The contractor is responsible for both the quality and quantity of material in their own pits, but the Resident Engineer is expected to monitor the pit operations and assist the contractor in producing a quality product.

Stripping Pits

When clearing or stripping of a pit is required at a Department Furnished Source, the Resident Engineer should direct where the waste is to be placed. Stripping may be deposited beyond the area intended for use, but not beyond the pit right-of-way boundaries. A survey should be performed to establish pit boundaries beforehand. Some material sources may have environmental restrictions that are shown in the licensing agreement. See the Standard Specifications for final placement of stripping.

The crushing plant should not be erected over a portion of the pit containing usable material unless there is a large surplus of material in the pit area. It is the responsibility of the contractor to select a location that will enable them to produce the quantities required.

Haul Roads

When the contractor prepares an environmental statement for an aggregate source, all haul roads must be included. No other roads are to be used for hauling or access.

Haul roads are to be kept to a minimum and must be located in such a manner as to cause the least amount of damage to the natural vegetation. In order to promote the best possible public relations, the owners of all lands traversed should be contacted before actual work in any pit or on any haul road is started. Fences are not to be cut or gates left open without the owner's permission. After completion of the pit use, the pit and haul roads should be cleaned up, and all damages repaired as required by the specifications, pit agreements, and the owner's requirements.

When the contractor furnishes the pit or a private pit is obtained, the contractor is expected to provide evidence in writing that the owner is satisfied with cleanup and/or restoration work.

Inspection of Aggregate Production

In the production of subbase and base course aggregates, if for any reason it is deemed advisable to depart from the requirements of the Standard Specifications or Special Provisions, a supplemental agreement shall be submitted. If it is found that the grading specifications or some other test requirements cannot be met, the District Engineer and Materials Group shall be advised without delay. Even one day's delay could be expensive, due to the large quantities that can be produced in a single day.

The contractor's operations in the pit shall be in accordance with both the Standard Specifications and any environmental requirements. The contractor shall be required to operate in such a manner as to produce a uniform product with a minimum of waste and leave the pit in such a condition that future use of the pit will not be adversely affected.

Sufficient tests shall be made during the production of base materials to determine the quality of the produced material. The contractor should be aware of any unsatisfactory test results and should make any necessary corrections in their operation. The final placement of any material that does not meet the specifications should never be permitted. When test results indicate that material does not meet specifications, the contractor will be required to make corrections to bring the material produced into compliance.

Sampling

Material samples of any type should always be taken by, or at the direction of, experienced personnel that are aware of the proper methods of obtaining representative samples. Production of base material requires close control. It is extremely important that the specifications covering the amount of material passing the #200 sieve and the plasticity index of the material are rigidly enforced.

Information pertaining to material sampling frequency, methods, and testing may be found in the Materials Testing Manual and in the Materials Policy & Procedures Directives Manual.

Subsection 106.07 of the Standard Specifications requires a sampling device on all secondary crushers and screening plants. This device is a requirement to reduce the physical problems of obtaining a representative sample in a safe manner and without interrupting the contractor's operation. The sampling device should be tested under operating conditions before production is started. The contractor should be advised of this requirement at the preconstruction conference.

Stockpiling and Handling of Aggregates

Stockpiles shall be located within the right-of-way limits of pit areas or within an area that the contractor has secured from the owner for that purpose. The site should not be subject to flooding or an excessive amount of blowing dust (such as on the downwind side of an asphalt or crushing plant).

The Standard Specifications do not have requirements for stockpiling aggregates, but there are stipulations against segregation of materials.

The following comments pertaining to stockpiling are generally accepted as good practice in the industry:

- In order to minimize segregation, stockpiles must be constructed in layers, rather than in cones, and the thickness of the layers should not exceed 5 feet.
- If stockpiles are formed with a conveyor belt, they are to be leveled at intervals in order to avoid "coning". The same suggestion is applicable to stockpiles formed by stackers.
- Crawler tractors should not be used on stockpiles because of breakdown of the aggregate due to the abrasive action caused by the steel tracks.
- If the stockpiling methods or methods of handling will contribute to segregation, the contractor should be advised of the problem and probable consequences of having material fail the grading specifications.

303-3 Construction Requirements

303-3.01 Placement

Watering of base courses must be done with care. Excess watering is wasteful, but more importantly, it may result in serious damage to the subgrade. Most of the water that falls on granular material penetrates to the subgrade almost immediately and this could create serious problems. This "sponginess" and resultant movement under wheel loads is usually first noticed as excessive looseness of base materials. The Inspector should be on guard for any soft spots that may develop in the roadway following rains or excessive watering. If this condition should occur, a thorough investigation shall be made and corrective measures taken before paving.

The subgrade upon which the first course is to be constructed must be thoroughly compacted and shall conform to the required cross section and grade. Subbase and base materials are usually more expensive than the material in the subgrade and should not be needlessly used to correct irregularities in the subgrade.

Each layer of material must be finished to the required tolerance in order to avoid unnecessary use of the more expensive material to properly finish the grade.

When finishing to blue tops, the machine operator has a tendency to hit right on grade at the blue top, and be high in between. This condition should always be looked for and can be checked quickly by means of a string line. The contractor should be aware of this and make adjustments or corrections during the grade check.

If soft spots are found in the subgrade, they shall be corrected. If springs or seeps are present, they shall be drained by the use of perforated pipe or by other acceptable means. A sufficient amount of subgrade shall be approved ahead of the placement of base at all times.

303-3.02 Compaction

Each layer of base course applied to the roadway must be watered and compacted to the required density prior to the placement of successive lifts.

In most cases, pneumatic rollers or vibratory rollers will be used to compact the base material. The most positive means of determining the adequacy of water and compactive effort is by taking density tests. More frequent testing at the beginning of the work will usually pay off by preventing over-watering and over-rolling and by providing the contractor and Inspector with a "feel" for the material. During compaction, it is important that the Inspector closely observe the performance of the material. If it compresses and springs back (a condition known as “pumping”) the subgrade has been over-saturated and will require repairs.

If water from either rain or the contractor’s operation has penetrated the base course and saturated the subgrade prior to paving, proof rolling should be performed. This will require the contractor to run heavy equipment over the base material with the Inspector checking for “pumping.” Any “pumping” areas observed must be repaired prior to paving. It cannot be overemphasized that the Inspector needs to be alert to over watering which can damage the subgrade.

303-3.03 Finishing

To a great extent, the riding surface of the completed pavement is dependent on the base surface upon which it is laid. Since smoothness of the pavement is one of the qualities most desired by the road users, the Resident Engineer should be satisfied that every means possible has been expended to obtain a finished base course having a cross section true to line and grade within the specified tolerance.

Upon completion of leveling the surface to the desired smoothness, the aggregate base should be watered and rolled to the required density. A string line is an effective tool to use in checking the grade and cross section of the compacted base for acceptance.

When asphaltic concrete is placed directly on subgrade, the use of a leveling device is not required. However, it is extremely important to finish the subgrade to as smooth and uniform a plane as possible.

Thickness measurements shall be made and recorded following the compacting of each course and prior to placing any succeeding course. The method and frequency of these measurements shall be as indicated in the Sampling Guide Schedule of the Materials Testing Manual.

303-3.04 Contractor Quality Control

The Special Provisions may require the contractor to perform special quality control measures necessary to provide acceptable quality in the production, hauling, and placement of materials. Quality control is always the responsibility of the contractor.

304 CEMENT TREATED BASE

Cement treated bases are used to improve the quality and strength of a road base. Cement treated base (CTB) has sufficient cement content to develop considerable cohesion and strength.

The strength of the cement treated base should be kept within designated strength limits. Slabs with strengths higher than specified develop wider shrinkage cracks, and the cracks are usually reflected through any bituminous pavement that is placed immediately over it. Excessive shrinkage cracks should be corrected before placing any top layers. Slabs that are too weak may not have the necessary load carrying ability.

To reduce the potential for the development of shrinkage cracks, a microcracking process should be implemented which will provide relief from the accumulation of significant tensile stresses in the CTB.

Regardless of the method of construction or the type of equipment provided, the construction of cement treated base should include:

- Properly shaped and compacted subgrade (the Standard Specifications require the subgrade to be finished in reasonably close conformity to the lines, grades, dimensions, and cross sections shown on the project plans or established by the Resident Engineer; also check the tolerance specifications)
- Uniform distribution of the cement in the aggregate
- Uniform and rapid mixing with proper moisture content
- Prompt laydown and compaction to specified uniform density within the specified time limits without compaction planes, and with a surface conforming to smoothness tolerances
- Prompt application of an effective curing seal without allowing the surface to become dry
- Microcracking after approximately two days of curing
- Maintenance of the curing seal

To achieve these results, it is necessary that sufficient equipment is provided in good working order and the contractor's personnel and ADOT Inspectors are well instructed in their responsibilities.

A wide range of aggregates and soil aggregate mixtures may be used for cement treatments. Materials that contain large amounts of clay or silt require excessive amounts of cement to develop desirable strengths and are very difficult to mix. Furthermore, extremely clean granular materials normally require excessive amounts of cement for binding purposes.

304-3 Construction Requirements

304-3.02 Mixing

(B) Batch Mixing

The Standard Specifications require a stationary mixing plant. Occasionally, the Special Provisions will allow road mixing. When the stationary plant mix method is used, adequate facilities must be provided for efficiently storing, handling, and proportioning the materials. The contractor may provide either a batch type plant or a continuous mix type of plant. Either type is satisfactory provided the plant is in good condition and properly adjusted. The mix shall be observed as it leaves the plant to ensure that the color and grading is uniform. The Resident Engineer and the Inspector should give the contractor every reasonable assistance, but the responsibility is on the contractor to provide a mixture that is uniform as to grading, moisture, and cement content.

The mixing paddles and mixing chamber should be cleaned daily to prevent a build-up of hardened material that would adversely affect the efficiency of the mixer.

It is desirable, especially in hot, windy weather or when humidity is low, to place more water in the mix than the theoretical optimum. The extra water is used to offset the loss of moisture which will take place before compaction begins. However, this must be done carefully as relatively small amounts of water in excess of the optimum have serious effects on ultimate strength and stability of the base.

(C) Continuous Mixing

Where road mixing is used, it is essential that proper amounts of aggregate are placed and that the aggregates are uniformly distributed along the roadway. When aggregates are placed in windrows, the windrows must be accurately sized before mixing to ensure proper proportioning of the cement, aggregate, and water. Care must be taken in sizing each windrow so that the mixer will be able to handle the entire windrow without difficulty. A continuous "V" ditch shall be cut in the top of each windrow to receive the cement. This prevents wasting over the sides of the windrow and minimizes cement losses that may occur from wind.

There should be sufficient moisture (without exceeding optimum) in the aggregate before spreading the cement to prevent loss of the cement through the voids between the aggregates.

When the aggregate is spread uniformly over the roadbed and mixed with a flat-type road mixer, the cement should be spread with a spreading device that will lay the cement over the entire surface uniformly. Cement should not be spread when the wind will cause cement loss.

When bulk cement is used, roofing paper or a trough type device should be placed on the material ahead of the cement spreader to occasionally check the cement spread. The cement spread should be checked when the cement level in the dispensing unit varies to determine if that affects the spread. When the traveling mixer is the type that does not elevate the aggregate off of the subgrade, frequent checks should be made to determine that the materials are being mixed uniformly and to the proper depth. When a flat-type mixer is used, samples for strength determination shall be taken occasionally at different depths.

When the mixture is produced in a stationary plant, suitable haul vehicles must be provided to make certain that the mixture arrives at the point of deposit without excessive moisture loss or segregation. Covers shall be provided when deemed necessary by the Resident Engineer. The laydown equipment should be ready to receive and lay the mixture as rapidly as possible.

When the mixture is produced by a single pass or multipass travel plant operating on the roadway, the length of the sections must be controlled so that the time lapse between the spreading and compacting on adjacent lanes will not exceed the time permitted.

To form a construction joint, it is generally advisable to spread the fresh mixture slightly above the desired grade, and then trim to that grade after final compaction. It is not permissible to raise the grade by placing a thin layer of mixture on a previously compacted base. Thin layers will not adhere and will form planes of weakness.

304-3.03 Compacting and Finishing

If compaction has distorted the joint on a previously laid section, the material shall be cut back to a vertical cross section before the next section is placed.

All joints are to be cut vertically and into solid material. When preparing a joint in hardened material, it may be necessary to use hand methods to trim the joint.

Any moisture loss during the operation, as indicated by graying of the surface, shall be replaced promptly with fog sprays of water as often as necessary to maintain the proper moisture content in the mixture. It is best to maintain a constant moisture condition by regular applications rather than allowing the material to surface dry before rewetting. Sprays that deliver water with such force, as to wash the cement off the aggregate, shall not be permitted.

Pneumatic rollers or vibratory compactors are considered best for compacting granular materials. Sheepsfoot rollers, followed by pneumatic rollers, are satisfactory only if the material is such that the sheepsfoot rollers will "walk out" in a reasonable number of passes. This will depend on the grading and plasticity of the aggregate and the unit weight on the feet of the roller. Sufficient tests are to be taken to ensure that the specified density of the mixture and specified strengths has been attained.

The frequency of sampling and testing should be in conformance with the Sampling Guide. However, in the early stages of the work, it is advisable to sample more frequently than is required. Finishing within contract tolerances shall be done promptly after the compaction.

To a great extent, the riding quality of the finished pavement depends on the smoothness of the cement treated base. Therefore, care shall be exercised in the spreading and trimming of the base and in checking the surface of the base.

All transverse joints should be tested with a straightedge and the results documented. Any locations in the surface that appear to be high should be checked with a straightedge and cut to proper grade before hardening of the base occurs.

Low areas cannot be corrected except by placing additional thickness of material in the overlying course. Thin lifts and feathered edges are not permitted, so removal may be warranted.

Proper spreading operations will keep the trimming to a minimum. After final shaping and compacting, the surface should be dampened and trimmed lightly, placing the trimmed material into the next lane or wasting it on the shoulders. A final pass should be made with the pneumatic or smooth-wheel roller. Normally, when spreading with blades, the longer the length of spread, the smoother will be the riding surface.

The strength of a cement treated base is affected by the density obtained. The density obtained depends on having the proper moisture content in the mixture at the time of compaction, followed by prompt and adequate compaction with the correct type and weight of the compactor. An excess of moisture may cause a spongy condition to develop under the roller. If this condition develops, a check should be made to determine if there is an excess of moisture in the base or in the subgrade under the base. Any spot that might show a spongy condition because of excess moisture shall be opened to allow the excess moisture to evaporate. Traveling mixers and water distributors should be checked for leaks that might cause wet spots in the base. Moisture determinations should be made at frequent intervals during the period of mixing, laying, and compacting.

The Standard Specifications require a maximum time lapse allowed between the time water is added to the aggregate/cement mixture and the time of final compaction. This time limit is to be strictly adhered to and very important to the strength and durability of the treated base.

304-3.06 Curing Seal & Microcracking

As soon as the surface has been trimmed and given the final compaction pass, the bituminous curing seal should be applied. If for any reason the curing seal cannot be applied immediately, the surface must be kept damp by frequent applications of a fine spray of water until the curing seal is applied. A damp surface, but without any free standing water, is desirable at the time of applying the bituminous curing seal. Deep penetration of the curing seal into the cement treated base is not desired. Any traffic that would cause a pick-up or a break in the curing seal should not be permitted during the curing period of three days. If traffic should inadvertently enter onto a fresh seal and cause breaks in the seal, repairs should be made promptly.

The contractor should perform microcracking approximately two days following completion of compaction; wait up to four days if the average daily high temperature is 60°F or less. Microcracking is performed with a heavy steel drum vibratory roller operated at high frequency, high amplitude, and at a low speed for at least three passes. Additional passes may be necessary so that fine and closely spaced cracks are observed on the surface, but not to the extent that the surface becomes broken and/or displaced. Observe that adequate moisture remains present and the curing seal is re-applied as necessary to allow the CTB to heal.

305 LEAN CONCRETE BASE

Lean concrete base (LCB) is rarely used on ADOT projects. Lean concrete base is made with concrete aggregate and sufficient cement (about three sacks) to achieve a strength of at 500 psi in seven days. Mix design, testing, and inspection are handled the same as with concrete paving. Water reducers, fly ash, and air entrainment agents are allowed, but are not generally required.

On some projects, the use of air entraining agents has caused tearing of the base surface. It is advisable to be alert to this possibility. As it gains strength, the lean base will crack naturally. No attempt should be made to control or seal the cracks.

305-3 Construction Requirements

305-3.08 Placing and Finishing

LCB is placed and finished the same as Portland cement concrete pavement, except surface texturing is not required.

The base is mixed in conventional concrete mixers, hauled to the grade in open bed dump trucks, and placed with a slip form paver. Dump trucks are used primarily because of the speed with which they can be loaded and unloaded.

The Special Provisions or Project Plans will supply the width of the base. This is usually the full width of the Portland cement concrete pavement (PCCP) plus an added increment for edge support. A smooth float finish is all that is required.

305-3.09 Curing

White pigmented curing compound is applied as soon as finishing is completed. Another application of curing compounds may be specified just before placing the PCCP. The last coat must be protected from damage because it serves as a bond-breaker between the base and the pavement.

305-3.12 Opening to Traffic

Keeping all traffic off the LCB for at least 72 hours, including the contractor and ADOT, is very important because of the low strength developed by the base. Even after 72 hours have elapsed, traffic should be restricted to the absolute minimum needed to complete the PCCP.

306 GEOGRID BASE REINFORCEMENT

Geogrids have become an alternative to subgrade stabilization via lime or cement. The geogrid material can improve the ability of the subgrade to carry traffic loads and reduce rutting of pavement failure over weak soils. ADOT's Pavement Design Section has incorporated in their Design Manual that geogrid only be used when soils have an R-value between 10 and 19 and an increase of 10 to the Mean R-value, which is used for accepting subgrade soils. Also, to improve the separation between the base and subgrade materials and avoid loss of fine material into the base, a Separation Geotextile Fabric may be used (refer to Section 1014-4 of the Standard Specifications). However, the benefits of geogrid performance depend upon correct installation as well as proper design.

306-3 Construction Requirements

306-3.04 Geogrid Placement

The Standard Specifications give detailed installation instructions. Additional instructions should be available from the manufacturer or local supplier. The Resident Engineer should obtain this information and review it before construction begins.

Adequate anchoring is required to prevent haul trucks from pushing or shifting the geogrid out of position.

Always back-dump fill onto the geogrid and spread the material over the geogrid. Dump subsequent loads on top of the leveled fill material and advance by spreading.

Longitudinal joints should be located the same as pavement joints. See Standard Specification Subsection 406-6 for longitudinal joint requirements.

Should the geogrid be damaged in any way during or after installation, it can be repaired by patching. The recommended repair procedures are to place a piece of geogrid over the damaged area and extend the geogrid 3 feet beyond, in all directions.

Since geogrids are made of polymers (plastics) they will break down or become brittle under exposure to sunlight as a result of the ultraviolet (UV) radiation. Therefore, it is crucial to avoid unprotected storing of these types of materials or rolling them out on the grade until the contractor is ready to cover them with the base materials.

307 GEOCOMPOSITE EDGE DRAIN

Today's pavement design may include the use of a geocomposite edge drain. An edge drain system is a very efficient way to remove water trapped in the aggregate base and/or subbase. The Project Plans and Standard Specifications are very clear concerning the installation of an edge drain system.

307-3 Construction Requirements

307-3.04 Construction Method

Detailed installation instructions should be available from the manufacturer or local supplier. The Resident Engineer should obtain this information and review it before construction begins.

A critical component of the edge drain system is the outlet pipes. All outlet pipes should have:

- Soil-tight joints
- Positive grade for proper drainage
- Resistance to deformation from installation and construction loading

If the edge drain is damaged or torn, it can be repaired by taping over small areas or by placing a geotextile material over larger areas and then taping. Waterproof tape must be used, and a patch must have a 4-inch overlap. All patches must provide a watertight seal.

401 PORTLAND CEMENT CONCRETE PAVEMENT

401-1 Description

High quality concrete pavement requires characteristics of durability and structural soundness in order to withstand the destructive forces of traffic, changes in moisture, temperature, and variable soil conditions. Current requirements for smoothness are very demanding. To meet these demands, it is necessary to have vigilant inspection of many operations concurrently.

It is essential that only specified materials are used and that the equipment, methods, and procedures are satisfactory in every respect. Resident Engineers (RE) and inspectors of a concrete paving project have the responsibility of building a paving project that will render many years of service. They are also responsible for many thousands of dollars of complicated work that must be done quickly and right the first time.

The best way to direct attention to the necessary interaction required to achieve quality work is through communication. Before every paving operation, the Resident Engineer is encouraged to hold two pre-paving meetings; the first meeting is held with the contractor and ADOT project staff, the second meeting is with the Engineer and the ADOT project staff.

The purpose of the first meeting will be to:

- Review the contractor's paving plan (see subsection 401-3.01) including discussions on organization, coordination, schedule, traffic control, construction procedures, materials, equipment, and personnel.
- Reinforce the ‘ground rules’ necessary for an uninterrupted operation.
- Introduce the Department's inspection team and establish the lines of communication between the contractor's personnel and the Department.
- Review safety procedures.

Review of the Contractor's Paving Plan

The minimum requirements for a paving plan include:

- Paving layout drawing(s) showing the beginning, end, length, width, thickness and area of each paving pass, the areas to be hand poured, and the location of longitudinal, transverse and construction joints. Check for conformance with the project plans for ultimate pavement width, thickness, location of joints, tapers, and breaks, as well as ensure hand pours are only called for in areas inaccessible to the paving machine.
- Bar chart schedule showing when each pass will be poured, cure times, expected production rates, and days and hours of operations. Check the realism of this schedule based on crew size, equipment production rates, temperature specifications, allowable cure times, haul rates, batching capacity, and traffic control requirements.
- List of proposed equipment including manufacturer's operational specifications on key pieces of equipment such as the paving machine, vibrators, and finishing equipment. Check to ensure the contractor uses the correct type of equipment called out in the specifications, ensure the contractor is operating equipment within the limits specified by the manufacturer, and that the equipment meets any ADOT performance specifications, as well as have an inspector check the condition of the equipment.
- Discussion regarding Quality Control testing of concrete aggregate to ensure testing is leading and not lagging so that material is sampled and tested prior to material being used for production to allow deficiencies to be identified and corrected. Aggregate testing must include sand equivalent, and elutriation (wash) for both coarse and fine aggregate to ensure the flexural strength of the concrete is not compromised due to dirty aggregate or excessive fines.
- Discussion on stockpiling and batching procedures, including storage of aggregate to prevent contamination, how aggregate moisture will be monitored, batching procedures, mixing times, and control

of water so that a concrete mix is as consistent as possible while still meeting the specifications. Identify who will be the contractor's representative authorized to make adjustments to the mix. A plan needs to be in place for handling rejected concrete; not meeting the target range for slump, or temperature. Check to ensure the contractor can produce consistent, high quality concrete to the Department's satisfactions; order trial batches if you're unsure.

- If concrete operations will occur during hot weather and it is expected to approach/exceed the 90°F limitation, discussion regarding options available to mitigate excessively high concrete temperatures and what will result in concrete being rejected.
- Specifications on proposed concrete hauling equipment and the expected haul route. Check to ensure hauling equipment will not segregate or otherwise adversely affect the mix; consider traffic control requirements, flaggers, signing, legal load limits, and haul and cycle times.
- Staging plan showing how the paving will be accomplished while maintaining traffic through the project. This is sometimes integrated into the traffic control plans or paving layout drawings and requires careful attention on both the contractor's part and ADOT's inspection staff so that traffic disruptions are kept to a minimum; check the project traffic control plans and construction phasing diagrams for conformance.
- Traffic control plan conforming to subsection 701-1 showing how the work will be safely separated from traffic including ingress and egress points as well as protection of the concrete during curing; it is important that the work and traffic are clearly separated and that entrance and exits are well delineated and do not confuse motorists.
- Discussion on the tining and curing methods to be used (check subsections 401-3.04 (F) & (G) for conformance).
- Discussion on sawing and sealing procedures including how joints will be located, what equipment will be used, when the joints will be cut, cleaned and sealed, and the manufacturer's installation requirements for the sealant (check subsections 401-3.05 & 3.06 for conformance).
- Detailed staking plan showing the spacing and offset subgrade control stakes and the methods used for setting the wire line and verifying its accuracy before paving (should conform to generally accepted survey and PCCP procedures).

The Department is not expecting the contractor to produce a large, bound report. As a minimum, the contractor needs to submit layout and staging drawings, traffic control plans, a schedule, and several pages of narration on covering stockpiling, batching, hauling, placing, finishing, curing, sawing, sealing, staking, and any other special areas of which you may want additional information. Information on equipment can be attached to the submittal. The pre-paving conference is used to review and clarify the paving plan to the extent that you understand it, and to prevent an endless cycle of re-submittals.

The Ground Rules Necessary for Uninterrupted Paving

It should be very clear to the contractor what circumstances would lead the Department to not allow a paving operation to begin, or halting a paving operation in progress. A PCCP paving operation is a very expensive undertaking involving many pieces of equipment and an increase in labor. Shutting down or suspending these operations often creates disputes between the contractor and the Department's field personnel. One of the objectives of the pre-paving meeting is to avoid such a circumstance. The review of the paving plan is a good start, but you need to let the contractor know what malfunctions in the paving operation could lead to a shut down.

There is no set of rules that outline when to halt or suspend the contractor's paving operation. Base your decision on the particular circumstances and the ability of the contractor to quickly rectify the problem. However, it is best for the Resident Engineer and the contractor to create a list of ‘red flags' that could affect the quality of PCCP and discuss the list with the paving crew and the inspection staff. The list could cover such things as out-of-spec materials, target values, changes in plan by the contractor that conflict with his or her proposed procedure, equipment that doesn't perform, emergency vehicles, weather, safety, insufficient lighting, traffic, and changes to such operations as finishing, sawing, and previously encountered problems. It's better to have these discussions in a meeting room than in the field during a paving operation.

The importance of this pre-paving meeting with the contractor cannot be over emphasized. The aim must be to sit down with the contractor's crew and obligate them to explain their plan to your satisfaction. In effect, ADOT and the contractor are building the pavement on paper. This should be the forum where you talk about problems, and expectations for the contractor's paving operation. There should be complete agreement on methods, materials, workmanship, and equipment before concrete is placed. The Department wants no surprises out on the grade. Talk about the details. The meeting should be a discussion of any potential problems suspected by the inspectors, and any solutions proposed by the contractor.

Introducing the Department's Inspection Crew

Historically, the Department's paving inspection team has worked very closely with the contractor's paving crews. The intensity of the work, as well as the unusual working conditions, requires teamwork by ADOT and the contractor. The pre-paving meeting should also serve as an introduction of the key personnel on both sides. It is important to highlight the duties and responsibilities of each member, as well as establish the lines of authority on various issues. You may want to establish goals for the paving team and articulate how each member's duties will contribute to achieving these goals. It is important that each member of the team meets the other members and has an idea of their duties and expected actions.

The second meeting held with ADOT project staff only covers responsibilities, assignments, and contingency plans. It is important to clearly describe the expectations, assignment, and schedule for each inspection role.

Operations that require inspection include:

- Subgrade trimming and approval
- Wire line checking and grade stabbing
- Base material placement
- Batching and stockpile operations
- Paving
- Tining and curing
- Initial saw cutting
- Profilograph measurements
- Grinding
- Construction joint preparation
- Sawing and sealing
- Core layout and coring

The Resident Engineer and Project Supervisor have flexibility in how they assign inspectors to each of these operations. However, the goal is to ensure each operation is adequately inspected so that the contractor is complying properly with the specifications. Lines of authority should be established as well as an issue escalation procedure that can be utilized by both the inspectors and the contractor. Scheduling and shift staggering should be discussed, as well as who will pick up cylinders on non-work days.

Paving operations run the smoothest when decisions are made at the lowest possible level and inspectors are empowered to make those decisions. Their ability to make well-informed, timely decisions is based on their level of training and experience in PCCP. More importantly, their effectiveness as empowered decision makers depends largely on how clearly the Resident Engineer and Project Supervisor have communicated what corrective actions may be taken when the contractor's work does not meet the specifications. Documentation and equipment requirements and issues should also be discussed

Paving Book

Maintaining a paving book is an excellent method of documentation. This not only provides a history of the project, but more importantly, it assists quality control. The following items should be periodically checked and documented to assure a quality pavement.

- Thickness
- Edge slump
- Offset distance
- Tining depth
- Vibrator frequency
- Cure application rate
- Rebar placement
- Air temperature
- Remarks as needed

Most items listed above should be measured and entered into the paving book every 50 to 100 feet so corrective action can be taken immediately.

401-2 Materials

Concrete

The details for batching, hauling, and mixing materials for Portland cement concrete used in concrete pavements will be discussed in Section 1006 of this manual and the applicable portions of Section 401-3.

One of the most important requirements for obtaining a smooth and durable concrete pavement is maintaining a uniform slump in the concrete mix. The optimum slump for fixed form pavement is usually about 3 to 4 inches. For the slip-form method of paving, the optimum slump is usually 1 inch. Dry batches cause high spots and surface tearing which cannot be corrected by the necessary hand finishing. Batches which have slumps appreciably higher than the optimum will result in excessive shrinkage and low spots in the pavement.

In order to obtain the necessary slump uniformity, it is essential that there be good control of aggregate grading, moisture content, proportioning of all ingredients, mixing, and frequent testing of the fresh concrete. The inspector at the batch plant must be alert to see that the gradation and moisture content of the aggregates, particularly the sand, does not vary without making compensating adjustments.

Subsection 1006-4.02 (C) of the Standard Specifications requires that variations of moisture in the aggregate shall not exceed 3% during any day's concrete production. In order to meet this requirement, it is essential that the sand be inspected for moisture content as it is brought from the washing plant. It may be necessary to delay mixing operations until the entire stockpile reaches a stable moisture content. The ideal moisture content is a saturated condition where no further absorption of water is occurring. If the contractor does not maintain sufficiently large stockpiles, or sprinkle the stockpile to assure uniformity of moisture in a saturated condition, the Resident Engineer may suspend mixing operations until the necessary uniformity is reached and can be maintained. Uniformity in concrete consistency cannot be maintained unless there is uniform moisture in the aggregate from batch to batch. The importance of moisture control at the plant should be discussed at the pre-paving conference. This is especially important when the concrete is furnished by an independent material supplier.

Commercial plants present problems in the control of aggregate moisture. Aggregates from several sources, as well as the lack of time these stockpiled aggregates have to reach a uniform moisture, are the major contributors to poor moisture control at commercial plants. Aggregate not saturated will continue to absorb water and admixtures during and after the batching process. This will result in fluctuating properties of the freshly mixed concrete often resulting in failure to meet slump and entrained air requirements. Excess or free water in the aggregate is not a concern because it is measured by the batch plant moisture probe and is compensated for by reducing the amount of water added to the mix during batching. The potential problems should be thoroughly discussed and solutions arrived at before the paving is started.

The importance of not adding water to the concrete after batching should be continuously emphasized, especially for air entrained concrete in hot weather. There is a tendency for concrete in truck mixers to be re-tempered by adding water (during transport) to the batch without rotating the drum at mixing speed which results in an inconsistent mix. Even if water is added and the drum rotated at mixing speed, this may result in a phenomenon known as air void clustering in air entrained mixtures. This significantly reduces the strength and durability of the concrete and the likelihood of such increases as concrete temperature rises.

During hot weather, concrete temperatures will run at or near the specified limit. The contractors and suppliers may be able to mitigate excessively high concrete temperatures to some extent. If not mitigated, high temperatures may accelerate cement hydration which should not begin prior to concrete placement. Prior to concrete placement, temperature forecasts should be reviewed and discussed during the pre-activity meeting. Inspectors should closely monitor concrete temperatures and slump during hot weather for compliance with the specifications and determine if concrete is acceptable for placement. Once at the specified limits, rejection should be considered for concrete that experiences further increase in temperature or reduction in slump. Once placed, hot concrete is susceptible to evaporation of surface moisture and shrinkage cracking which directly affects durability and longevity of concrete pavement. A fog spraying method (fogging) can be used when conditions are particularly hot or windy to mitigate evaporation.

There are two strength requirements called out in the Standard Specifications. A compressive strength of 3000 psi must be attained before traffic is allowed on the pavement (including construction traffic), and a strength requirement for acceptance based on the minimum 28-day design strength of 4000 psi. The strength requirement for acceptance is determined statistically by sampling and testing per subsection 1006-7, then calculating the Lower Quality Index (QL), the Percent of lot Within Limits (PWL), and the Pay Factor per subsection 401-6. The Pay Factor will determine if the concrete lot will be accepted, or rejected, or allowed to remain in place at a reduced price in accordance with Standard Specification table 401-3. Pay Factors for thickness and compressive strength are applied separately and totaled to determine a total pay factor for each lot. Any lot with a total Pay Factor less than minus $5.00 will be rejected. Unit price adjustments for pavement smoothness, and cracked pavement slabs which require repair may also be required, but they are not included in the Total Pay Factor calculation for compressive strength and thickness. Approval to leave rejected pavement in place shall be reviewed with the District Engineer and ADOT's Materials Group, Pavement Design Section.

Unless otherwise approved by the Engineer, traffic is not allowed on the pavement before these three conditions have been met (see subsection 401-3.07):

- 7 calendar days of cure time
- All joints have been sawed and sealed
- The concrete strength has reached a minimum of 3000 psi

Joint Filler and Sealant

The Approved Products List has a list of accepted filler (backer rod) and sealant materials. The Material Laboratory Supervisor can find out if the contractor's filler and sealant have been pre-approved. If not, samples will have to be taken and tested prior to the use of these materials on the project.

Certificates of Compliance are required for these materials. Materials that were not pre approved must be sampled as specified in the ADOT Materials Testing Manual.

Tie Bars and Dowels

These are short pieces of steel bars that are used for the various types of joints. The type and spacing will be shown on either the Project Plans or in the Standard Drawings. These bars shall be accompanied by certificates of compliance.

When the bid schedule, or plans include Load Transfer Dowel Assembly then see the Special Provisions for additional requirements.

When epoxy coated dowels are used, a certificate of compliance for the coating is required. Random samples shall also be taken for checking coating thickness in accordance with subsection 1003-5. The powdered epoxy resins are pre approved material and must be on the Approved Products List maintained by the ADOT Research Center.

Curing Compound

This may be a pre approved material and if so, a Certificate of Analysis is required for all production lots to which the material is associated. Materials that are not pre approved must be sampled per lot and submitted to Central Lab for testing and acceptance prior to use. For PCCP, curing compound with white pigment (Type 2) is required, for which the certification is good for six months from the production date.

401-3 Construction Requirements

Prior to paving, the contractor is required to submit a paving plan, which will be reviewed and approved by the Resident Engineer. Section 401-1 of this manual establishes the guidelines for accepting a paving plan.

All mainline PCCP paving shall be done by the slip-form paving method with ramps and irregular areas done by either slip-form or fixed form methods. Crossroads may be done by fixed form methods.

The Department has allowed the fixed form methods for mainline paving on short, narrow, isolated stretches of pavement no more than 300 feet long. The width would depend on the type of screed used: rolling and Texas (vibratory) screeds are limited to a maximum of 18 feet, while Bidwells are usually allowed to run up to the same width as slip-form pavers. The Contractor must still meet the smoothness specifications regardless of the equipment used.

Subsections 401-3.04 and 1006-5 of the Standard Specifications describe the weather limitations under which PCCP may be placed. When hot, cold, or rainy weather is anticipated, the Resident and Project Supervisor should discuss the requirements with the contractor and schedule the paving operation accordingly.

401-3.02 Pavement Base

The first requirement of an acceptable and successful concrete pavement is a well-prepared, stable, and adequately compacted base and subgrade.

Grading of the base should be a primary concern to the contractor because the base has a significant effect on the thickness pay factor.

The base may be subgrade, aggregate base, lean concrete base, cement treated base, bituminous treated base, or asphaltic concrete. Normally only a well graded, well-compacted, granular base is required. However, certain conditions may require a treated stabilized base in order to provide additional load support capacity.

Keeping the base or subgrade moist is important because a dry base will pull moisture from the fresh concrete. This causes the same shrinkage and durability problems as does rapid surface moisture loss. Subsection 401-3.02 requires the surface to be uniformly moistened immediately prior to placing concrete.

Cement treated materials require a minimum cure time with the application of either a bituminous material or curing compound, as stated in the project special provisions.

Before any base material is placed, the entire subgrade should be proof-rolled with heavy, rubber-tired equipment such as a loaded water truck or dump truck. The inspector should observe for any soft spots in the subgrade. Corrective actions should include removing any soft or wet subgrade material and replacing it with an approved aggregate base (see subsections 203-3.03(D), 305-3.01, and 304-3.01 of the Standard Specifications). Any backfilling of trenches that has been necessary in the preparation of the subgrade should also be proof-rolled and corrected before pavement is placed.

Expansive clays are potentially damaging to any pavement and especially to concrete pavement since they may cause serious pavement distortion and poor riding qualities. If any subgrade soils are encountered which are suspected of being of this type, samples should be promptly submitted to the ADOT Materials Group for tests. Corrective measures will depend on the results of tests, the extent and the location of the expansive material with respect to subgrade elevation, and other factors. If corrective measures are needed, it may become a design problem at which time the ADOT Materials Group and or Geotechnical Services Section will provide recommendations. Estimate the quantity of unsuitable material and the size of the affected area as this may determine how the deficiencies are mitigated.

It has become common practice among paving contractors to use automatic grading machines in the preparation of bases for concrete pavement principally because they facilitate finishing to very close tolerances in a minimum of time. These machines can do excellent work when they are in good mechanical condition and are properly operated.

401-3.04 Placing and Finishing

Paving trains are made up of several units of equipment having gears, hydraulic systems, fuel lines, and water systems that can leak or malfunction. Leaking equipment should not be allowed to continue operating since it is harmful to the pavement.

(B) Slip-Form Method

The slip-form method of concrete paving involves spreading, consolidating, and finishing concrete pavement with a self-propelled machine on which short sections of side forms are attached. The machine operates on a previously prepared base. The surface grade is controlled by means of a tightly stretched guide wire. The equipment consists of a slip-form paving machine, texturing devices, curing machinery, and hand tools. A diagonal pipe float has been used on some slip-form paving projects for additional smoothness of surface.

The paving machine is self-propelled and equipped with:

- A crawler track assemblies which are outside the pavement section
- A device for regulating the amount of fresh concrete fed to the primary screed, which may be an initial strike off blade or a distribution hopper
- A system for vibration of the concrete
- A screed system, which may be a pan, belt, auger, or other devices
- Short lengths of side forms for each edge which hold the edge vertical for a short time and move forward with the paver

The function of the slip-form paver is to receive freshly mixed concrete, spread it to the required width and thickness, consolidate it by vibration, screed or float it to the proper cross section and profile, and final finish all in one operation.

Slip-form machines must be stable to prevent deviation from line and grade. The form faces must be in good condition to minimize dragging and displacement of the concrete. The slip-form must be long enough to provide support until the concrete edge can stand behind the trailing form end.

It is very important that the Resident Engineer and inspectors become familiar with the equipment being utilized. Care must be taken to ensure that the equipment is assembled according to the manufacturer’s recommendations and is operated accordingly. Key requirements to assure proper assembly and preparation include:

- Assuring the main pan is flat from side to side. Check it with a straight edge or string line. Several adjustments may be necessary, and this is where manufacturer's recommendations and instructions are important.

- The tamper bars should be adjusted so that they are in the lowest position, with the bottom of the tamper bar even with the bottom of the main pan.
- Adjust vibrators up or down so that the tip of the vibrator is centered in the thickness of the concrete slab. If placing over steel mesh or dowels, it may be necessary to position the vibrators above center. The vibrators should be positioned at a maximum of 24 inches on center. The vibrators shall be checked to verify they operate at a minimum of 8,000 impulses per minute. The contractor shall be able to provide proof of vibrators calibration performed within the previous 12 months.
- When adjusting the machine to line, the frame should be parallel to the string line guide.

The specification tolerances for edge alignment and edge slump should be carefully checked and adhered to throughout the paving operation.

When automatically controlled slip-form paving is used, the guide wires are the grade control of the pavement surface, similar to the form edges in fixed form paving. The pavement surface cannot be any smoother than the degree of accuracy in the installation of the control wire. The setting of accurate control grades and the care in installation of the wires from these grades is of utmost importance.

The wires should be carefully checked against the survey stakes for alignment and grade. They should be firmly held in the brackets, free from kinks and bends, and they should be uniformly taut to avoid sags between supports. A final visual check and adjustment of the wire should be made immediately before paving operations are allowed to begin. The wires should also be checked occasionally throughout the paving operations because they are easily disturbed by workers.

After the wires have been checked, ADOT Inspectors and the contractor's field staff should stab the grade. This involves running a string line across the grade to each wire line and then measuring the height of the string line above the grade. Record all stab measurements in your daily diary and your field book (if one is used). The grade stabbing serves as a final check on the wire line placement so that the correct concrete thickness is obtained.

The wire line should be clearly delineated by the contractor by means of ribbon or tape. The line is not only a tripping hazard but can be run over by heavy equipment and other construction traffic.

Paving

The slip-forming operation should be smooth and continuous. The Department does not allow frequent stopping and starting of the paver—this directly affects the pavement smoothness. Often an insufficient number of delivery trucks or recurring problems with the batch plant are the trouble. In the past the Department has let the operation continue until the end of the shift, but after a few occurrences, the contractor has not been allowed to start a paving shift until assurances were given to the inspectors of a smooth continuous operation with the paver maintaining a constant speed.

Slip-form machines are equipped to receive concrete either in a hopper or on the grade immediately ahead of the paver. When the hopper method is employed, care must be taken to deposit the concrete without causing sudden shock loads or unbalancing of the paving machine.

When concrete is placed upon the grade in advance of the slip-form paver, the pattern of distribution becomes very important. Pavers that receive concrete in this manner are normally equipped with augers. The action of the strike-off device is under the control of the operator. It is important that adequate material be maintained ahead of the paver at all times. The contractor should maintain an even distribution or uniform head of the concrete during placement. An even push across the width of the paver is the desired outcome. Mounding of the concrete in one area should be avoided since this tends to twist and surge the paver as it tries to push through the mound. Backing up the paver to correct grade deficiencies can usually be done but should be avoided if possible.

Non-agitating trucks are often used to deliver the concrete. Cleanliness and good repair are very important since caked concrete, bends, dents, roughness, cracks, and other imperfections can cause segregation. Insist that the load containers are kept clean and in a smooth, well repaired condition. Good coordination is needed when non-agitating trucks are used since only 45 minutes are allowed to dump the concrete once the cement is added.

Consolidation of concrete in slip-form paving is accomplished by spud vibrators mounted on the rear of the paver. They are spaced up to 24 inches apart and in such a manner that the concrete will be vibrated full depth and width. On some equipment, the lowest point of the vibrators will be near the top of the concrete to prevent tearing. The efficiency of each spud should be observed by the inspector, at least once each hour during operation.

Vibrator failure is immediately evident by observing lack of vibration waves in the fresh concrete around the spud. The frequency can be checked with a frequency indicator. Amplitude is variable and can be adjusted to fit the speed of the paver which is directly related to the consistency of the concrete. Under no conditions should the frequency of the vibrators be lowered below the minimum allowed by the specifications.

Checking the efficiency of each spud is important. Serious consequences have resulted from malfunctioning of one spud. Experience indicates that spud motors fail frequently. Spares should be kept on the project site at all times to avoid interruptions in the paving. The Department has shut down paving operations because the failure of a single vibrator with the contractor having no spares. Vibration of the concrete must cease at the instant that forward movement of the paver ceases.

The Project Supervisor should be alert to paving operations that may damage existing or newly placed concrete pavements. This includes:

- Driving equipment over freshly placed concrete
- Placing heavy equipment on concrete too weak to carry the weight
- Dropping materials or equipment on the pavement
- Running equipment over the pavement that gouges or scars the surface

The last item usually involves dragging the pan of the paver over a previously placed section of pavement. Regardless of the cause, it is the Department’s policy not to accept scared, indented, or cracked pavement (see Subsection 108.07). Patching is not an acceptable alternative since patched pavement becomes a long-term maintenance problem.

When the contractor’s operations damage existing pavements, the procedure to be followed involves full depth removal and replacement of the damaged areas to the nearest transverse joints. See subsection 401-4.03 for help in evaluating pavement cracks. In some cases entire slabs have been removed to the nearest longitudinal joint. In other cases, where the damage is near the edge, only a 1-foot strip of pavement has been removed similar to an edge slump correction and poured with the adjacent pass.

During placement, the inspectors should be periodically checking edge slump, pavement thickness both at the ends and in the center of the slab, straight edge tolerance, and concrete slump. Record all edge slump measurements in your daily diary and your field book (if one is used).

The placement of concrete at a construction joint is particularly critical. Care must be taken to ensure that only the best concrete is used at the joint.

Finishing

The primary screed is rigidly attached to the frame of the paver. It gives the top surface of the pavement its shape and preliminary finish. The finish is completed by a secondary transverse ironing screed or oscillating belt, sometimes followed by a free-floating smoothing float. Very little hand finishing is necessary if the slump of the concrete remains constant and the paving operation runs at a smooth, steady pace.

Mechanical equipment is specified for finishing because its consistency and uniformity is superior to hand finishing when all the equipment is operating properly. If handwork is needed to supplement or replace the machine work, the operation should be stopped so that replacement, repairs, or adjustments can be made, and machine finishing resumed. Hand finishing should be necessary only beyond the limits of the machine capabilities and for minor touch up. Excessive hand finishing, particularly at the edge, is grounds for ADOT Inspectors to halt any further PCCP placement after the end of that shift. The contractor must be able to slip-form concrete without having to continuously hand finish the edge and other areas. Continuous hand finishing weakens the concrete surface.

Pipe Float

A pipe float is used with some pavers but is not required by the specifications.

The pipe float consists of an aluminum pipe 6 to 10 inches in diameter and of sufficient length to span the full width of the pavement when oriented at approximately 60 degrees to the centerline. It may be towed forward and backward over the pavement either by a self-propelled carriage running on rubber tire wheels alongside each edge of the pavement, or it may be towed by two workmen, one on each side of the pavement.

If the pipe float is the type which is towed by workmen, the towing ropes should be long enough that there is not the slightest vertical movement of the pipe--only a smooth horizontal movement. When not in use, the pipe should rest on the bridges spanning the pavement. Resting the pipe on the fresh concrete surface creates a depression when it settles.

The function of the pipe float is to cut off small bumps and fill small depressions with grout. Because of its light weight, it cannot cut off large bumps. It is sometimes desirable to insert uniform weight (such as rebar or pipe) inside the pipe for additional weight.

If there are isolated areas of considerable size where the pavement is low (which may be evident after one or two passes of the pipe float), the contractor must place a sufficient amount of fresh concrete into these areas, rather than to build them up with excessive thickness of mortar. It is also sometimes desirable to spray a fine mist of water on the pavement surface to prevent tearing by the float. This should be done only with the Resident Engineer's approval. The amount of water applied should never be more than that necessary for efficient functioning of the floating operation since any water applied to the surface tends to reduce the strength and scaling resistance of the surface mortar. The water applied by fog spray is intended only to compensate for rapid evaporation due to wind, high temperature, or low humidity.

The timing of the operation of pipe floating is important. It is desirable to make the first pass or two as close behind the paver as possible. Also, it is desirable to make the last pass somewhat later to accomplish the best results, but not so late as to require more than one or two light applications of mist. The use of the float should be discontinued as soon as a uniform surface has been achieved.

Hand Finishing

Hand finishing is necessary but should be kept to a minimum. It is vital to ensure that finishers do not overwork the surface of the concrete, bleed water, evaporation retarders (90% water), or any other water that may have been applied to the surface. Doing so increases the water/cement ratio of the surface paste and will result in significantly reduced durability of the surface which will delaminate after only a few freeze-thaw cycles while in a moist condition.

Edge Slump

One of the earliest and best indicators of the quality of a PCCP paving operation is the variation in edge slump. Excessive edge slump causes bumps and water to pond over the longitudinal joints; both reduce the long term durability of the pavement. The paving machine must produce an edge that is within tolerance. Continual fixing and finishing of the edge is not acceptable to the Department and is grounds for either halting paving immediately or allowing no more after the end of the shift. Record all edge slump measurements in your daily diary and your field book (if one is used) so that areas needing to be corrected later can be easily located.

(C) Fixed Form Paving

The fixed form method involves installing steel headers or side forms at the precise line and grade for each edge of the pavement, then placing, consolidating, and finishing concrete to the reference plane established by these headers.

The equipment necessary when this technique is employed consists of a spreader, screeding/tamping finisher, machine float finisher, texturing device, and hand tools.

It is best to obtain prior approval of the forms before they are delivered to the project site. The forms should be checked for smoothness with a straight edge and with a tape measure for the correct depth. Do not allow the contractor to berm-up under the forms in order to achieve the desired depth. The forms need to rest on a well-compacted, level base for stability reasons.

Fixed form methods involve self-propelled mechanical equipment—machines that move forward along the forms by themselves. A Bidwell is an example of a self-propelled paver. Fixed form manual methods involve equipment that is not self-propelled and must be handled by the finishers in order to move it along the forms. Rolling and Texas screeds are examples.

The intent of the specifications has always been that the Department prefers self-propelled paving equipment wherever possible - it produces the best PCCP. Mainline must be done by slip-form pavers, while ramps and crossroads must be done by either slip-form or self-propelled, fixed form pavers. Manual methods should be used only as a last resort. Many contractors continue to dispute this specification, however keep in mind that manual methods must be approved by the Resident Engineer because the Department wants these methods to be used on a very limited basis.

(F) Surface Texturing

A satisfactory skid resistance is very important. There are a number of ways that the skid resistance can be developed, but texturing the surface is the most common method.

The intent of texturing is to obtain a series of grooves that are cut into the surface and spaced far enough apart to assure a strong wall between the grooves. Grooves formed by windrows of grout raised above the concrete surface are not acceptable. They break off and wear down quickly. The groove depth specified is necessary to allow for wear without losing the groove.

When testing the groove depth, the plane of reference is the undisturbed surface. The timing of the grooving operation is most important. If the concrete is too wet, the grooves will flow together. If it is too dry, the grooving will dig out material that will be ragged and weak. Either extreme will result in less groove depth than is needed.

It sometimes improves grooving if the tines of the grooving tool are set at a 10 to 15 degree angle vertical to the pavement surface. This arrangement will allow greater pressure without tearing the surface.

Texturing is usually done by using a burlap drag followed by longitudinal texturing using steel tines. Tinning size and spacing is very important in obtaining an effective, long wearing texture. Texturing equipment should be carefully inspected prior to use to assure that it conforms to the specifications.

It is important that the steel tines are correctly spaced. The tinning on the finished concrete surface must meet the required tolerances in Subsection 401-3.04(F) and 601-3.05(D) of the Standard Specifications.

The contractor should be aiming for the mid-range specified for tinning depth. If the contractor is continually tinning too lightly or too heavily, the operation should be adjusted so that the mid-range tinning depth can be achieved.

The burlap drag and the tinning texture device are required to be supported on separate bridges.

It is necessary to have tools for hand texturing available for use in areas inaccessible to equipment or when equipment breaks down.

Friction Course (AR-ACFC or ACFC) Overlay

Some PCCP pavements receive at least a ¾ inch lift of rubberized asphaltic concrete friction course (AR-ACFC or ACFC) on top. The rubberized friction course absorbs traffic noise, thus making it quieter for adjacent residential neighborhoods. In addition the ride is quieter and smoother for the driver. AR-ACFC with inclusion of crumb rubber asphalt (CRA) is typically used below an elevation of 3,000 ft. At 3,000 ft and above, ACFC with a TR+ (tire rubber and polymer modified) binder is utilized.

The requirements for tinning as described above are not necessary should the plans specify friction course. If traffic is required to temporarily use the new PCCP, prior to placement of the friction course, tinning is required.

Some sort of texturing on the PCCP is required so the friction course adheres to the pavement. This is developed by dragging a mat of Astroturf, extending the full width of the new pavement, behind the paving operation. Placing weight in the form of 2 x 4's on top of the Astroturf mat assists in developing the required texture.

Prior to placing the friction course, the PCCP needs to be thoroughly cleaned, removing any curing compound; otherwise the friction course may not bond to the PCCP. Additionally, the tack coat for friction course must be applied correctly at the required application rate with either PG asphalt or concentrate and allowed to fully break to ensure an adequate bond with PCCP surface.

Where construction traffic and ambient conditions are such that the tack is significantly tracked off of the PCCP, the use of a trackless tack should be considered to ensure the tack coat remains in place at the time the friction course is paved. Trackless tack is also formulated to break faster than conventional tack and may reduce standby time, especially during periods of cool or humid weather and for night paving.

(G) Curing

Curing the concrete is as important to achieving strong, durable concrete as any of the other phases of concrete construction. Whatever method of curing is used, the purpose is to seal off the surface to retain moisture that is needed for hydration and to reduce drying stress. Loss of moisture, particularly at the surface, will result in weak concrete that will be subject to shrinkage cracking with reduced durability.

The specifications provide for only the membrane method of curing Portland cement concrete pavement. This method consists of spraying the entire surface of the freshly placed concrete pavement, including the edges, with a liquid membrane curing compound (Type 2 with white pigment for PCCP). The curing compound must be applied without delay as soon as the finishing operation is complete to prevent moisture loss due to evaporation. This ensures complete hydration of the concrete, particularly at the surface, and reduces the potential for shrinkage cracking. This application of compound must be sprayed by equipment capable of applying a smooth, even textured coat. Care must be taken to see that all exposed surfaces and edges receive an application of the curing compound applied at the rate specified. Application at the specified rate should be insisted on because a continuous seal is vital to the eventual toughness of the pavement surface.

A visual confirmation that there are no dull or grayish looking areas when viewed from different directions is a good indicator that an adequate amount of curing compound has been applied, However, the rate of application of curing compound should be checked several times daily by calculating the area of pavement to be covered versus the amount of cure used. This amount should then be compared to the required application and noted in a diary or paving book for future reference.

To ensure a uniform content of white pigment in the curing material, it is necessary that the curing compound be applied in an agitated condition. It must be either freshly or continuously agitated, because the pigment has a higher specific gravity than the emulsifier and tends to settle.

If the curing membrane is being applied during wind, shielding (a burlap drape) should be provided to prevent loss and avoid bare spots on the surface. If the application of curing membrane should be delayed for any reason, water in the form of a mist should be applied until the curing membrane can be applied to maintain moisture

Note that whenever the ambient air temperature is above 85°F, the contractor will continually fog mist the concrete surface until the initial saw cutting is completed. Even if the contractor wants to double the amount of curing compound sprayed, there are no exceptions.

401-3.05 Joints

The performance of concrete pavement depends to a large extent upon satisfactory performance of the joints. Most concrete pavement failures can be attributed to failures at the joint, as opposed to inadequate structural capacity. Pavement distresses that may result from joint failure include faulting, pumping, spalling, corner breaks (D-cracking), blow-ups, and mid-panel cracking. Both research and field experience has confirmed that adequate load transfer and proper concrete consolidation contribute significantly to joint performance.

Stresses in concrete pavements come from two principal sources; the force applied by vehicles, and the volume changes that take place during curing and temperature changes. When the top of the pavement shrinks more rapidly than the bottom, stresses are set up in the slab, which tend to warp the edges upward. This tendency to warp results in severe stresses since the pavement is actually lifted off of the subgrade a slight distance at all four edges. Studies indicate that the critical loading in a pavement slab is highest in the corners due to the accumulation of edge stresses.

Joints control cracking and expansion of concrete slabs, which allow the concrete to release the build up of internal stresses. There are basically four types of joints:

1. Weakened Plane
2. Expansion
3. Construction
4. Edge seal

The characteristics of each type of Portland cement concrete pavement (PCCP) joint is described in Exhibit 401-3.05-1. See Standard Drawing C-07.01 for further details.

Transverse expansion joints are located at pavement junctions with bridge approach slabs and at other locations shown on the plans. The plan detail for expansion joints shows a reservoir for joint filler. It is important that the joint is correctly made so that a good seal will result.

Load transfer dowel bars are sometimes specified for transverse weakened plane joints so that loads will be transferred between slabs after a crack has formed. It is important that these dowels are lightly coated with heavy waterproof grease approved by the Resident Engineer, which will allow the dowels to slide after they are cast into the pavement. This is necessary in achieving a truly weakened plane joint that will control random cracking. Thick coatings of grease should be avoided since they may result in large voids in the concrete around the dowels.

When load transfer dowel basket assemblies are specified, a predetermined alignment system is necessary to assure accurate layout of the basket assemblies and to assure centering of the initial saw cut over the dowels. Experience has shown that a nail on each side of the pavement slab highlighted with paint works well. The references should be set back far enough to avoid their loss under concrete slobbers and curing compound application (recommend 6 to 12 inch offset). Consolidation around the dowel basket assemblies is critical. Check for proper consolidation with a straight edge on the concrete surface over the dowels approximately one half to one hour after concrete placement. Any depressions under the straight edge would indicate that good consolidation is not being achieved during placement.

Joint Type	Description	Direction	Reinforcing	Remarks
Weakened Plane, or Contraction (most common) **TWP** = transverse weakened plane joint **LWP** = longitudinal weakened plane joint	Serves to control random cracking in concrete slabs; a saw cut of 1/3 of the slab depth is made in a predetermined pattern, both transversely and longitudinally. The saw cut weakens the concrete at the joint and, thus, any cracking in the slab occurs at the joint and under the saw cut; longitudinal (LWP) joints promote cracking caused by warping stresses in the slab.	transverse and longitudinal	***transverse:*** none, except on interstate projects where load transfer dowels are used in TWP type joints. ***longitudinal*:** tie bars are used in LWP type joints	
Expansion **E** = Doweled transverse expansion joint **H** = non-doweled longitudinal expansion joint **K** = non-doweled; constructed around the perimeter of a misc. structure	Preformed Expansion Joint Material allows for thermal expansion and contraction of PCC pavements near fixed objects such as bridge approaches, box culverts, and where ramps meet cross roads.	transverse and longitudinal	***transverse:*** E type joints have load transfer dowel. ***longitudinal*:** K & H type joints do not have dowels.	A sufficient gap must be left to allow the joint to both close and open.
Construction **TC** = transverse construction joint **LC** = longitudinal construction joint	Used to join a new Portland cement concrete (PCC) pavement to an existing PCC pavement.	transverse and longitudinal	***transverse:*** TC type joints use epoxy coated smooth dowels ***longitudinal*:** LC type joints use epoxy coated smooth dowels	Joints are saw cut and sealed like a weakened plane joint. However, the saw cut is 11/4” (32 mm) rather than 1/3 the slab depth
Edge Seal **S** = AC / PCCP edge joint	Used to join the edge of Portland cement concrete pavement (PCCP) to edge the of Asphaltic concrete (AC) pavement.	transverse And longitudinal	*none*	Saw cut or routed joint in AC and seal with rubber sealant.

Table 401-3.05-1. Joint Types

The dowel basket detail should be checked to make sure the dowels are held firmly at proper grade and alignment during concrete placement. No dowels should deviate more than 1/4 inch from being parallel with the surface or edge of pavement. Significant deviations in dowel alignment may restrict the movement of the pavement at the transverse joints. This movement is needed to prevent cracking that can result from temperature changes in the slabs, as well as subgrade movements and long term shrinkage.

Some of the important points to keep in mind relating to joints are:

- Transverse construction joints are placed at the end of a run or whenever operations will be interrupted for more than one hour.
- When adjoining lanes are placed separately, the TWP joints must match.
- All construction and weakened plane joints shall be sawed.
- When two or more lanes are placed concurrently, the tie bars in the longitudinal joint are placed automatically by the paving machine. The bar placing operation should be checked to be sure that the equipment is working properly. Tie bars for longitudinal construction joints are to be placed by acceptable mechanical methods while the concrete is still plastic or other approved process after the concrete has hardened. In addition, the inspector should perform random measurements of how deep each tie bar is placed in the fresh concrete. Consistently placing the bars at the incorrect depth is grounds for halting any further concrete placement.
- Smooth epoxy coated dowels are used for longitudinal construction joints to provide load transfer and to allow for some joint movement. The epoxy helps prevent corrosion of the dowel should the joint sealant fail.

Joint details should be thoroughly discussed prior to start of work, preferably as part of the pre-paving meeting. The items to review should include the following:

- The contractor's responsibility for timely and proper sawing of joints (since saw blades are round, it is necessary for the center of the blade to be over the edge of pavement or the last point to be sawed, otherwise, the proper depth of cut will not be obtained. On fixed form pavements, the contractor may have to remove the forms in order to achieve the proper depth cut at the edge.
- The sawing plan to ensure that the contractor keeps a spare saw of the proper type on site at all times when initial sawing is to be performed (see subsection 401-3.06).
- Spacing of construction joints.
- How joints will be made around openings and other appearances in the pavement.
- Tolerances of sawed joint locations versus the center of dowel baskets when load transfer dowels are used.
- The proper matching of transverse weakened plane joints with adjacent lanes; this will require some thought when dealing with transverse construction joint
- The importance of having joints of correct width and depth along with having clean joints before sealing
- The test results on the sealant with attention to the age of the material. If sealant has a limited shelf life, test results and certifications of sealant should be required prior to beginning paving operations. The backer rod material should be compatible with the sealant manufacturer's recommendations, backer rod is required to be expanded closed cell polyethylene foam, backer rod materials that hold excessive amounts of moisture such as paper products are not desirable; they may reduce the effectiveness of the sealant.
- Stress keeping the top of the sealant 1/4 inch below the surface.
- Discuss any additional requirements of the Special Provisions, Plans, and Standard Drawings (C-07.01, 07.02, 07.03, and 07.04).

401-3.06 Joint Construction

Pavement joints provide a means to allow for expansion and contraction and to control cracking. If constructed without joints, a concrete pavement will crack in a random pattern wherever the stresses get too great for the concrete strength.

The dimensions of the saw cut should conform to the project plans or Standard Drawings C-07.01, 07.03, and 07.04. The minimum depth is important for directing any crack that will develop below the saw cut.

It is required that sawing be done before random cracking develops, but not so soon that tearing or raveling of the concrete occurs. It is the contractor's responsibility to determine the time to saw. Different aggregates, weather conditions, and other factors can require changes in sawing procedures; what was workable on one project may not be best for the next. The proper time will have to be found by the trial and error method. Sawing should be avoided when the slab is under tension because uncontrolled cracking can develop. Concrete is in tension when it rapidly cools - such as in the early morning. The amount of tension will depend on temperature differences so experimentation will determine if there is a problem. Early morning is a good time to examine the pavement to see if there are any uncontrolled cracks. The contractor should be discouraged from attempting to perform the sawing by a predetermined schedule because changing temperatures, humidity, and wind speed may alter the optimum time for sawing. If a crack should open up at a joint where sawing is being performed, the sawing at the joint should be stopped. Otherwise, there could be two cracks causing spalling of the concrete between the cracks.

Sawing is usually performed with a circular diamond blade saw. The specifications require the contractor to keep an additional saw on the project site in case any of the saws in use breakdown. Exceptions have been made if the contractor or concrete sawing subcontractor has a saw at their yard, which is less than 20 minutes from a project site and it is not dedicated to another project. The specifications also require that the additional saw to be a span saw. This type of saw spans the entire width of the slab and cuts the slab much more quickly than a circular saw. If the contractor has not had chronic problems with random cracking before or during the initial saw cuts then exceptions have been made to not require the contractor's standby saw to be a span saw.

Placement of PCCP should not exceed the contractor's ability to keep up with the saw cutting. In the0 event a contractor falls behind on sawing, it may be necessary to increase the joint spacing up to 60 feet to control early cracking. Intermediate joints can be cut later, once early cracking has been controlled. The Project Supervisor or Resident Engineer should be alerted to this condition.

Joint Sealant

The purpose of a joint sealant is to deter the entry of water and incompressible material (such as small stones and pebbles) into the joint and the pavement structure. Minimizing the amount of water that enters the pavement structure will reduce moisture-related distresses such as pumping and faulting. Incompressibles, if allowed to enter the joint, will prevent it from closing normally during slab expansion. This will lead to joint spalling and blow-ups.

Sawed joints should be cleaned and filled with joint sealant as soon as possible while they are still relatively clean and to help promote curing. It is recommended that any required grinding be completed prior to joint sealing. However, contractors have been allowed to seal before grinding with the understanding that any ground joints will be cleaned and resealed.

Careful attention should be given to the manufacturer's recommended installation procedures. Joint preparation and sealant installation are very important to the successful performance of the joint. Therefore, it is strongly recommended that the inspector pay particular attention to both the construction of the joint and installation of the sealant material.

Key inspection items include:

- Regularly check joint depth while joints are being cut
- Ensure sandblasting of the joints to help promote bonding of the sealant
- Ensure cleanliness of the joint and removal of all loose material while joints are being cleaned, and check the joints again just before the backer rod and sealant are applied
- Closely monitor the installation of the sealant to ensure conformance with every aspect of the manufacturer's recommendation; sealant properties, application rate, correct equipment, etc.

- Randomly remove small sections of sealant after it has hardened to check for the required thickness, the contractor must reseal areas where you have removed joint material.

Hydraulic jetting of the joints is required in areas where fugitive dust is a recognized air pollution hazard. The common practice is to hydraulic jet one day, then air jet the joint the following day just prior to sealing.

401-4 Pavement Evaluation and Remedial Measures

401-4.02 Pavement Smoothness

Arizona Test Method 801 and 401-4.02 of the Standard Specifications outline the procedures for measuring and evaluating the surface profile of the pavement and for correcting any deficiencies by the removal of high areas or bumps in the surface through grinding with a multiple diamond blade machine.

The surface profile of all sections of pavement placed shall be tested with the profilograph furnished by the Department and by other means required by the specifications as soon as possible. Straight edging should be done while the pavement is being placed so that any deficiencies can be repaired immediately. Straight edging can be accomplished from the back of the paving machine and along the edge of the pavement. It is not necessary to straight edge every square yard of pavement. However, much of the straight edging should be done when the contractor first begins the daily paving operation and then random straight edging should be done thereafter at a rate acceptable to the Project Supervisor.

The Department has allowed the use of the contractor's profilograph to measure pavement smoothness as long as Arizona Test Method 801 is strictly followed and the work is witnessed by an ADOT Inspector. The inspector should check the calibration of the contractor's profilograph for conformance with current Department policy. The inspector may want to verify the accuracy of the profilograph by running a test section and correlating the results with one of the Department's profilographs. Currently, the trend in the Department is to favor the use of the automated profilographs since their readings tend to be less subjective and open to interpretation than the manual instruments.

All PCCP shall be measured for smoothness with a profilograph. The results should be reported to the contractor within 48 hours of placement, when possible. The intent is to get feedback on the smoothness of the pavement to the contractor's paving operation as quickly as possible. This allows the contractor time to fine tune the paving operation before many thousands of square yards of pavement have been placed. Locating areas of the pavement that are to be ground can be simplified if the operator of the profilograph will mark areas for grinding on the pavement and on the profilogram when he or she makes the initial profilograph test. It will also be helpful if stationing is well marked prior to profiling the pavement by using paint or on stakes alongside the pavement.

Bumps required to be ground to meet specification requirements can be located approximately by correlating the profilogram with the stationing. A straight edge should be used to define the exact location and limits of the bump. The bump cutter or grinder is then set for the proper depth of cut and operated over the bump, moving parallel with the centerline. The machine is moved repeatedly over the bump making parallel cuts until the entire area and depth of the bump has been removed. A straight edge should be used repeatedly during the operation to check the depth of cut and the uniformity of the profile. After the cutting operation has been completed, the profilograph should be used again to determine if tolerances have been met. If not, the grinding should be repeated until the tolerances have been met. The profilograph should be run again over the corrected sections as a documentation record.

401-4.03 Pavement Cracks

Large concrete slabs have a tendency to crack. This is a natural process as the concrete shrinks. Tensile stresses build up in the concrete, and cracking is the means by which the concrete releases those stresses. We cannot stop cracking, but we can control it. Jointed slabs cause the cracking to occur at the joints where the concrete thickness has been reduced by sawing. Sometimes, however, the concrete cracks away from the joint. This random cracking may be due to many causes such as lack of a uniform water/cement ratio between batches, segregation, improper curing, or not sawing joints early enough. Regardless of the cause, the procedures outlined in Subsection 401-4.03 of the Standard Specifications must be followed to ensure long lasting, low maintenance pavements.

On or just before the 28th day after the concrete has been placed, the inspector will perform a crack survey of the PCCP showing the location, orientation, and length of each visible crack on a diagram. A copy of this diagram must be given to the contractor. In turn, the contractor will submit to the Department a crack repair plan which needs to be reviewed and approved by the field office. Crack repair procedures must begin seven days after the pavement crack survey, so an expeditious submittal and review process will be needed.

The crack repair procedure depends upon the orientation and location of the crack. In general, transverse cracks are repaired by the routing and sealing method, except when the transverse joints contain load transfer dowels. Then the crack is epoxy injected and the joint is cut deeper. Longitudinal cracks that do not fall within the wheel path (this area is wider than the wheel path for the profilograph) can also be routed and sealed. However, longitudinal cracks that do fall within the wheel path are not repaired; instead the entire slab is removed. Slabs with multiple cracks should always be rejected in accordance with subsection 401-4.03(C), even when each crack would be acceptable if evaluated individually. The goal is to have the largest slab possible by keeping cracks and joints to a minimum. The crack repair requirements are summarized in Table 401-4.03-1 and Exhibit 401-4.03-1.

Before the pavement is opened to traffic under either a final or partial acceptance of the project, the inspectors shall perform another crack survey as described previously. The cost of any repairs is shared equally between the contractor and the Department.

It's important for inspectors to note that the amount of crack repair in lieu of slab replacement should be kept down to the absolute minimum required by the specifications. When there is doubt about whether the inspector should allow the contractor to repair a crack, err on the side of removing the cracked concrete from joint to joint. The Department refrains from buying cracked or patched PCCP wherever possible, since both present long-term maintenance problems.

Crack Type (Exhibit 41)	Crack Repair Methods	
	PCCP Joints With Load Transfer Dowels	*PCCP Joints Without Load Transfer Dowels*
1	a.	a.
2	d.	d.
3-a	f. and g.	a. and b.
3-b	g.	a
4	g.	a. and c.
5	f. and g.	a. and b.
6	e.	e.
7	d.	d.

Crack Type (See Exhibit 401-4.03-2 for an illustration of crack types):

1. Longitudinal crack more than 54 inches, or less than 12 inches from a longitudinal joint.
2. Longitudinal crack inside the wheel path. The wheel path is the surface area between 12 inches and 54 inches of a longitudinal joint.
3. Transverse crack that is approximately parallel and within 5 feet of a transverse contraction (weakened plane) joint.
    a. The transverse contraction joint has not cracked.
    b. The transverse contraction joint is cracked.
4. Transverse crack more than 5 feet away from a transverse contraction (weakened plane) joint.
5. Transverse crack crossing or terminating in a transverse contraction (weakened plane) joint.
6. Diagonal crack (intersecting the transverse and longitudinal joints within 1/3 the width and length of the slab).
7. Multiple cracks separating the slab into three or more parts.

Repair methods:

a. Rout and seal crack.
b. Epoxy uncracked portion of transverse contraction joint.
c. Resaw and reseal the transverse contraction joints on each side of the crack.
d. Remove and replace the entire slab.
e. Remove and replace a smaller portion of slab.
f. Deepen uncracked transverse contraction joints on each side of the crack to ½ inch above the load transfer dowel and seal joint.
g. Repair transverse crack by epoxy injection method.

Notes:

- Slabs with multiple cracks (type 7) should always be rejected even when each crack would be acceptable if evaluated individually.
- Cracks at angles less than 45 degrees to the direction of travel and longer than 3 feet are considered to be longitudinal cracks.

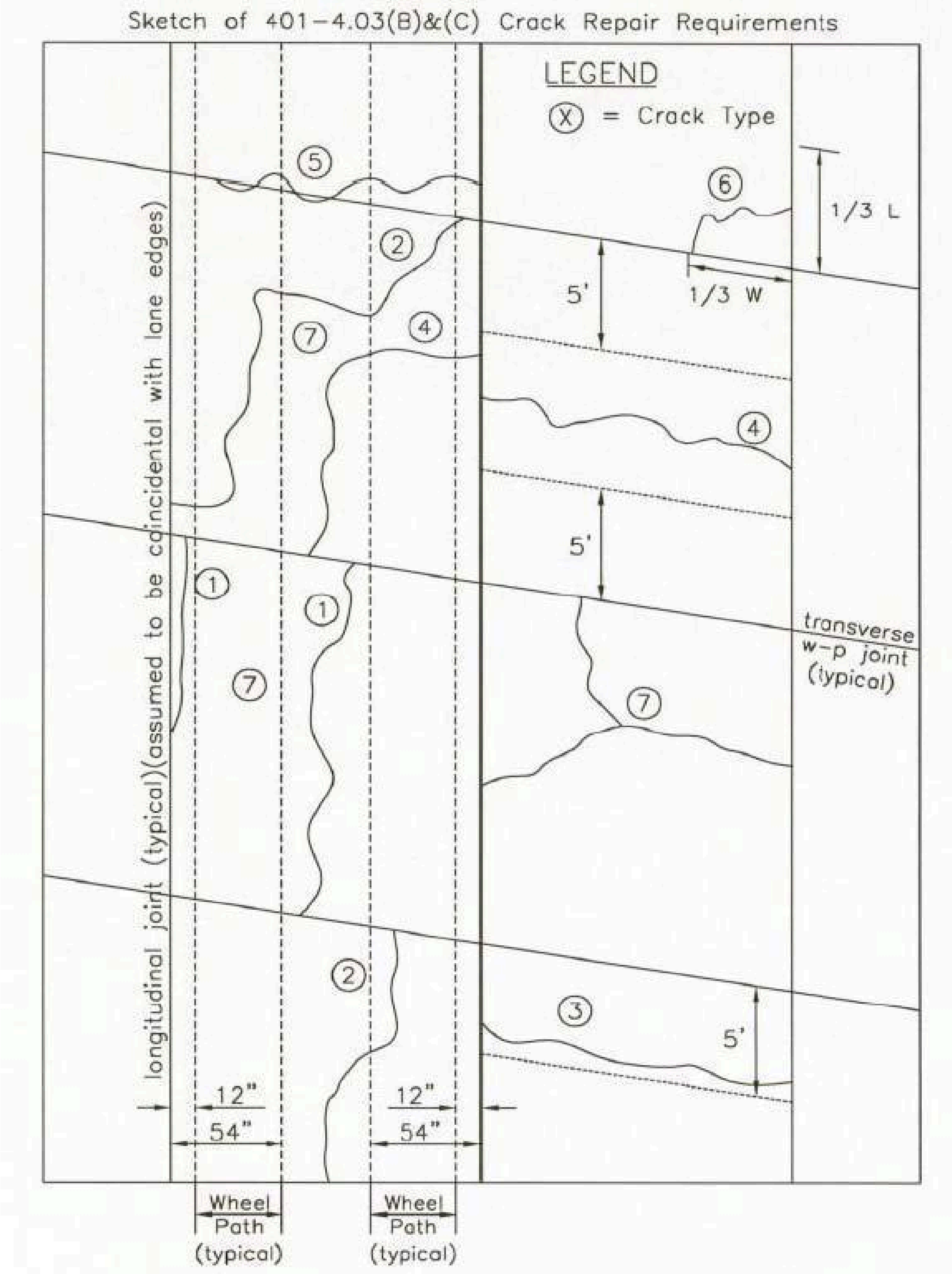


Exhibit 401-4.03-1. Crack Repair Diagram

401-4.04 Pavement Thickness

Pavement thickness is evaluated for acceptance by lot. Lot limits are identical to those specified in subsection 1006-7.03 for compressive strength acceptance of class P concrete. The contractor must obtain ten cores per lot at random locations determined by the Engineer. The inspector must observe the coring operation, and immediately take custody of the cores. The inspector must be familiar with requirements of AASHTO T 24 to ensure the contractor removes the cores properly. All cores obtained for thickness acceptance shall be clearly identified as to lot and location, then sent to the Regional or Central Lab for measurement by appropriate measuring device according to AASHTO T 148. Cores should be returned to the project and retained for inspection by interested parties until final acceptance of the project. Cores taken in areas requiring grinding must be re-cored to determine lot thickness. Additional acceptance cores are required if any core indicates a deficiency in thickness of 0.60 inches or more. The additional cores must be obtained at intervals not exceeding 10 feet in each direction from the deficient core, until one core is obtained in each direction which is not deficient by 0.60 inches or more. The pavement between these cores shall be rejected. Any thickness checks made in the field are approximate and are for informational purposes only. The inspector or Project Supervisor shall prepare a log showing precise lot, location, and thickness of all cores. From this log, the determination can be made as to the need for and location of additional cores. These cores shall be taken and their locations and measurements entered in the log. Copies of the log shall be supplied to the contractor and to ADOT Materials Group.

The contractor should be notified in writing when pavement is rejected in accordance with Section 1006 or 401 of the Standard Specifications. The rejected pavement must be removed and replaced, unless the contractor submits a written proposal to accept the pavement at a reduced price. The contractor’s proposal must be received within 10 days of the rejection notice. The Resident Engineer and the ADOT Materials Group, Pavement Design Section shall evaluate the acceptability of the contractors proposal for rejected sections of the pavement and shall determine the proportion of the unit bid price to be paid to the contractor. The State Materials Engineer or the Materials Pavement Designer shall be consulted before any action is taken with respect to the acceptance of any section of the pavement without pay.

401-6 Basis of Payment

PCCP is paid for by the square yard but adjustments are made to the unit price for:

- Thickness
- Compressive strength
- Cracking
- Smoothness

These adjustments can become complicated, and Project Supervisors should use a computer-generated spreadsheet to track these adjustments for each section of pavement. Because the unit price adjustments to PCCP is so complicated, it is very important that the Project Supervisor document to the fullest extent possible the justifications for the price adjustments. Profilograph measurements, marked up drawings, computerized spreadsheets, core measurements, and test reports should be part of the documentation kept with the Project Supervisor’s diaries that support the pay adjustments.

402 PORTLAND CEMENT CONCRETE PAVEMENT REPAIRS

Rehabilitation of Portland cement concrete pavement to comply with safety standards and extend the durability and life of an existing pavement may involve several types of repairs. It is essential that the Resident Engineer and inspectors become familiar with the applicable methods and specifications for materials.

402-2 Spall Repairs

Spall repair shall be performed prior to any required pavement grinding or grooving and shall include removing all loose material and temporary bituminous patch material from potholes, damaged joints, and spalled areas of concrete. Cleanliness and the removal of loose material are of the utmost importance.

The Resident Engineer should ensure that the accelerated strength Portland cement concrete patch material is in accordance with the specifications when required, or rapid setting patch material meeting his or her approval is being used. The Arizona Transportation Research Center maintains the Approved Products List which contains approved patch materials.

When rapid setting patching materials are used, check to ensure that the contractor has a qualified manufacturer's representative at the site who can inspect the preparation work and oversee the mixing, placing, and finishing of the patching material. The Standard Specifications require the concrete surface being repaired to be clean and dry, however, for hydraulic cement based repair products, unless otherwise stated by the product literature or manufacturer’s representative, the surface should be kept moist prior to application of the repair material to ensure the repair material is not starved of water where it will bond to the existing concrete.

Heavy-duty jackhammers should not be used for patch repair, or against existing concrete in full depth repairs. These hammers impart too much energy and can micro-crack the existing concrete.

The Resident Engineer or authorized representative will mark those areas designated as spall areas. These areas will then be saw cut, removed to the minimum depths called for in the specifications or the project plans, and patched material applied accordingly.

When load transfer dowel bars are used, their alignment and orientation is critical to the success of the joint and the repair. The bars must be aligned and well greased so that they can slip when the pavement expands and contracts at the joint.

402-3 Full Depth Slab Repairs

The Resident Engineer will designate which areas require full depth replacement. These areas will be shown on the project plans and marked on the slab. Repair work must be completed before any specified pavement grinding or grooving.

Prior to construction, the Resident Engineer or Project Supervisor should thoroughly investigate the existing Portland cement concrete pavement in order to determine what portion of pavement slabs require replacement and whether this will be a complete replacement or partial only. The specifications provide details to determine the amount of replacement necessary.

The inspector must ensure that care is taken in the removal of slabs to avoid disturbing granular subbase and concrete which is to remain in place. Any damage to the subbase or concrete which is to remain in place shall be corrected by the contractor at no additional expense to the Department.

For areas where the roadway will be opened immediately to traffic, the specifications require that the patching material for this work be an accelerated strength Portland cement concrete mixture which includes Type III Portland cement and an accelerator. The resulting mix should attain a compressive strength of 2000 psi in 6 hours. When the areas to be repaired will be closed to traffic to allow normal Portland cement concrete pavement placement and cure conditions, the patch material may conform to Class P concrete, and shall be placed and cured accordingly.

402-4 Pavement Grinding

Before grinding, spalled areas and areas requiring full depth slab replacement shall have been repaired to the satisfaction of the Resident Engineer. Grinding shall be performed prior to any specified sawing and sealing of transverse and longitudinal joints. The Resident Engineer should be satisfied that the equipment used by the contractor will provide the specified surface texture. This will require that a test section be set up at the beginning of the operation, to demonstrate to the Resident Engineer that the resulting surface will be in conformance with plans and specifications.

The Resident Engineer and inspectors should thoroughly review the methods, disposal plan, and equipment proposed by the contractor to remove residue and excess water from the roadway. Consideration should be given to ensure the contractor has several methods available to control this operation in the event changes are necessary once construction starts.

The Resident Engineer should check that all equipment conforms to the specifications and will not damage the existing pavement. This equipment must be capable of providing a uniform surface without requiring overlapping of previous passes. Pavement surface shall be ground longitudinally.

402-5 Pavement Grooving

Prior to grooving, spalled areas and areas requiring full depth slab replacement shall have been repaired to the satisfaction of the Resident Engineer. Grooving shall be performed prior to any specified sawing and sealing. The Resident Engineer should be satisfied that the equipment used by the contractor will provide the specified pattern and depth of groove.

Project personnel should thoroughly review the methods, disposal plan, and equipment proposed by the contractor to remove residue and excess water from the roadway. The contractor should be prepared with an alternate plan in the event changes must be made during construction.

The Resident Engineer should check that all equipment conforms to the specifications and will not damage existing pavement. This equipment must be capable of providing a uniform pattern at the depth specified. A test section should be established at the beginning of work in order to demonstrate that the specifications can be met.

Pavement surfaces shall be grooved longitudinally

402-6 Joint and Crack Repair

The Resident Engineer should thoroughly inventory the project under construction in order to designate those areas requiring repair. These areas must be cleaned of all loose material and prepared in accordance with the plans or specifications. The materials used must be applied in accordance with the manufacturer's recommendations and must be acceptable to the Department.

When load transfer dowels are used for joint repair, the alignment and orientation of the dowels is critical to the success of the joint.

404 BITUMINOUS TREATMENTS

A bituminous surface treatment is not a pavement in and of itself. Rather, it provides a protective cover that helps to resist traffic abrasion, and provides a waterproof cover over the underlying structure. Specifically, surface treatments:

- Prevent surface water from penetrating pavements that have become weathered or cracked.
- Plug voids, coat, and bond loose aggregate particles in pavement surfaces.
- Renew a surface and restore skid resistance to traffic worn pavements.
- Provide a temporary cover in cases of delayed or staged paving.
- Control dust on low volume roads.
- Promote adhesion of subsequent asphalt courses to aggregate bases.
- Ensure a bond between new or existing asphalt courses.

Special Provisions will normally have requirements that supplement the Standard Specifications for bituminous treatments. For example, type of material, spread rate, and basis of payment are usually specified in the Special Provisions. Some bituminous treatments, such as Slurry Seal or Microsurfacing cannot be found in subsection 404 of the Standard Specification. Never assume a new project has the same bituminous treatment requirements as another project you are familiar with. Always carefully read the Special Provisions, including bid items, and review the pavement structural sections in the plans for each project to understand the bituminous treatment requirements.

Prior to starting any asphalt operation, the contractor's equipment should be checked to see that it is working properly and that no badly worn parts exist which would have an adverse effect on the finished product. The Project Supervisor is responsible for seeing that necessary Department personnel are on the project to perform the weighing and inspection operations without undue delay to the contractor.

Bituminous materials are measured for payment by the ton, but the application rate is calculated in gallons per square yard. Therefore, inspectors must complete a Project Asphalt Report for each type of bituminous material applied during their shift. Refer to Exhibit 404-1 for an example of the completed form. A blank form is included in the Construction Manual Forms page online and can be copied as needed.

At the end of each day's operation, the Lead Inspector shall collect all weight sheets, weight tickets, ticket books, and Project Asphalt Reports (spreadsheets) and balance them before turning them into the field office for checking and pay purposes. This should be done before leaving for the day.

The specifications for some items allow a choice of grades or types of asphalt while others do not. If circumstances indicate that a change from the specified type or grade of asphalt is desirable, the Resident Engineer (after consulting with the District and the ADOT Materials Group) will prepare a change order for the work. Consultation on changes is very important because a change in type or grade of asphalt may cause a serious modification of the qualities desired from the bituminous treatment.

When a specific application rate for prime, tack, and fog coats is not indicated in the Special Provisions, the Resident Engineer will determine the rate. It is recommended that the Resident Engineer talk to ADOT Materials Group when deciding on a specific application rate. Application rates are generally a function of the pavement or base conditions, weather, traffic, and the bituminous material being used.

Inspection and Observation Guidelines:

Bituminous Materials:

- Is the type and grade of asphalt in accordance with the project specifications?
- Are asphalt samples being witnessed and taken in accordance with methods that assure representative samples?

- Are test results and certificates of compliance satisfactory?
- At what temperature is the material being applied or mixed?
- Are checks being made to verify delivery and complete emptying of cars or tank trucks?

Aggregate Materials:

- Have the aggregates been tested and approved before use on the project?
- Does the blotter sand meet the gradation requirements?
- Has the cover material for a chip seal operation been tested for;
    - loss of Abrasion (AASHTO T 96),
    - percent carbonates (ARIZ 238),
    - percent (crushed faces) fractured coarse aggregate particles (ARIZ 212),
    - flakiness Index (ARIZ 233), and bulk Oven Dry Specific Gravity (ARIZ 210)?

Release Agents:

- Wheels and tires of compactors shall be wetted with water, or if necessary soapy water, or a release agent. All other equipment surfaces shall be treated when necessary with a release agent.
- Release agents which degrade, dissolve, or in any way damage the bituminous material shall not be used.
- Solvents such as Diesel fuel or WD40 shall not be used as a release agent.
- Only release agents evaluated through NTPEP are acceptable for use in accordance with the requirements of Section 407-7.04 of the specifications.

PROJECT NUMBER: ____________ DATE: ____________ TYPE OF APPLICATION: ____________

PROJECT NAME: ____________ SPEC. PROV. RATE OF APPLICATION: ____________

SUPERVISOR: ____________ TYPE & GRADE OF ASPHALT: SS 1H 1:1 CHANGE ORDER NOS. ____________ SUPPLIER: ____________

LBS PER GALLON = 8.33

CAR OR TRUCK & TRAILER NUMBERS	AIR TEMP	OPTIMUM MOISTURE OF AB / IN PLACE MOISTURE OF AB	START TIME / STOP TIME / ACCUM HRS & MINS	STATION TO STATION & LOCATION WITH RESPECT TO CENTERLINE	LENGTH / SPRAY BAR WIDTH	AREA (SY)	GAUGE READ / GAUGE READ	FIELD MEASURED GALS	TEMP. OF ASPH. (FAREH.) / ASPH. CORR. FACTOR	CORRECTED FIELD MEASURED GALLONS	GALLONS PER SQUARE YARD	SUPPLIERS TICKET NUMBER	ACTUAL WEIGHT USED (TONS)	REMARKS (INCLUDE VISUAL OBSERVATIONS OF PENETRATION OR CONDITION OF ROADWAY SURFACES WHERE POSSIBLE)
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		

BOOT TRUCK TOTAL TIME		
Start Time:	SHEET TOTALS	
Ending Time:	TOTALS OF ALL PREVIOUS SHEETS	
Hours:Mins	ACCUMULATIVE TOTALS & USAGE	
	TOTAL CORRECTED FIELD MEASURED GALS. =	
	ACTUAL TONS=	
	TOTAL APPLICATION TIME (HRS:MINS) =	

INSPECTOR: ____________ DATE: ____________ SHEET ______ OF ______

SUPERVISOR: ____________ DATE: ____________ LOT NO: ______

CC. FIELD REPORTS, PROJECT FILES & DISTRICT LAB

Exhibit 404-1. Project Asphalt Report Example

404-3 Construction Requirements

404-3.02 Equipment

(A) Distributor Truck

The single most important piece of equipment on any surface treatment operation is the distributor truck. The field office should, whenever possible, pre-approve all distributor trucks for use on the project. Subsection 404-3.02(A) covers requirements of the asphalt distributor and its operation. These requirements are all important and should be reviewed by every inspector prior to starting work on which a distributor is to be used. All of these requirements shall be enforced. Insist on getting test results for spread rates. Older trucks that do not have gauges and accessory equipment that meet specification should not be allowed on the project.

In order to prevent streaking in a seal coat, care must be exercised to see that the spray bar is operated at the proper distance from the pavement surface and that each nozzle is functioning properly and turned to the proper angle. Ensure the contractor has a spotter during each day's initial application who can alert the distributor truck operator to stop should the spray bar not be functioning properly.

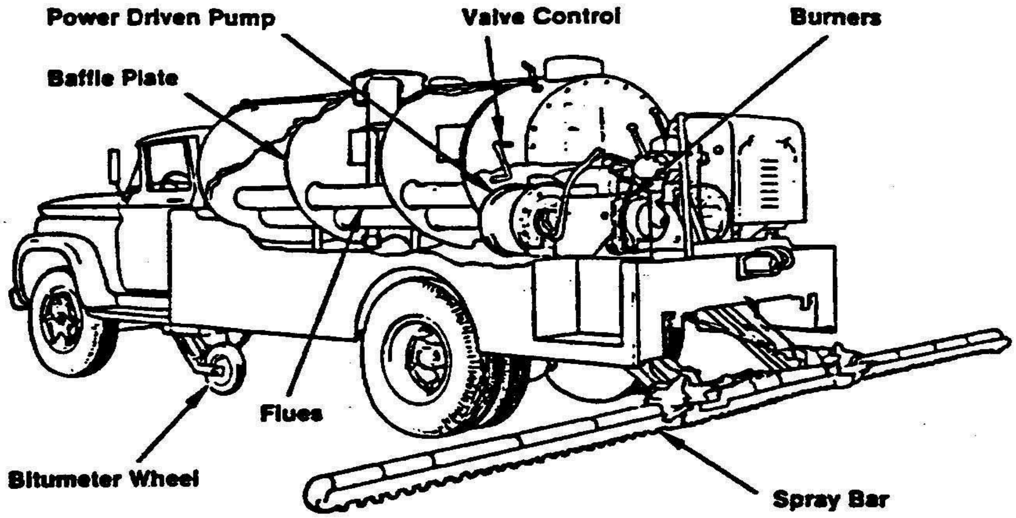
The contractor is required to furnish evidence that the distributor has been tested and found to be capable of a uniform rate of application. The testing must have been done within the previous twelve months. Distributors used for chip seals should be retested in accordance with Arizona Test Method, ARIZ 411, unless only a short time has elapsed since the last test by the contractor. Even a recently tested distributor may not provide a uniform rate of application if the nozzles or bituminous material has changed. ADOT Materials Group maintains a list of all certified distributor trucks in the state.

The most important part of the distributor truck is the spray bar. The spray bar height, the type of nozzles, and the nozzle angle all affect the uniformity of the asphalt coverage. A spray bar that is set at the incorrect height causes streaking. If it is set too high, the wind may distort the spray causing spotty coverage. If the height varies along the roadway, the coverage width will not be uniform (see Exhibit 404-3.02-1). For best results, the spray bar height should not vary by more than 1/2 inch.

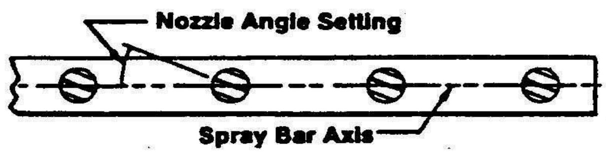
The correct nozzle sizes for the type and grade of asphalt must be used. It may be necessary to change nozzles to get acceptable coverage or rate of application. Distributor truck operators are sometimes reluctant to change nozzles. However, if uniform coverage at the required rate of application cannot be achieved, the Resident Engineer should not allow the work to proceed. If all other adjustments have been tried, it will probably be necessary to change the nozzles. Damaged nozzles shall be removed.

The nozzle angles are usually set between 15 to 30 degrees so that the spray from each nozzle does not interfere with the spray from adjacent nozzles. A wrench specific to the distributor truck exists to ensure the angle is set properly; this is the wrench the operator should be using to ensure the nozzle angles are all uniform.

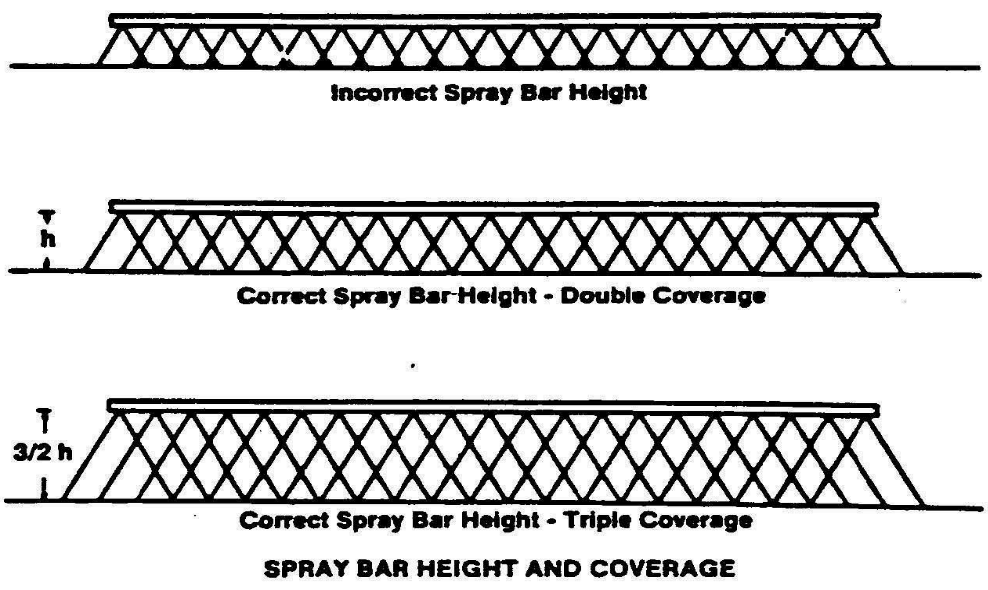
Project Supervisors and Lead Inspectors should not hesitate in removing distributor trucks from the project which are not operating acceptably.



A TYPICAL ASPHALT DISTRIBUTOR



PROPER ANGLING OF NOZZLES



SPRAY BAR HEIGHT AND COVERAGE

NOTE:
On occasion, some operators will set end nozzles at a different angle (60 to 90 degrees with respect to the spray bar) in an attempt to obtain a good edge. This practice should NOT be permitted as it will produce a fat streak on the edge and rob the adjacent spray fan of the lap from this nozzle. A curtain on the end of the bar for a special end-nozzle with all nozzles set at the same angle will provide more uniform coverage and make a better edge.

Exhibit 404-3.02-1. Asphalt Distributor Spray Bar Height and Coverage

Preparation of Pavement Surface (all bituminous treatments)

The application of the bituminous treatment should have been anticipated weeks if not months in advance by the District Engineer, and needed pavement repairs should have been made. Use asphaltic concrete to build-up any low areas and fill any holes in the pavement surface well in advance of seal coating so proper compaction can be obtained by traffic, and the surface will be comparable to pavement surrounding the patches. It is important that pavement repairs, especially crack sealing, be made as far in advance of the treatment as possible to prevent fresh asphalt from bleeding through the treated surface. This is also true for slurry type treatments, asphaltic concrete overlays, and thin bonded overlays such as bonded wearing course.

Pavement markings with glass beads will likely need to be removed/obliterated prior to the treatment, especially when the treatment includes polymer modified asphalt. The glass beads do not provide a good surface for the asphalt in the treatment to adhere to and these areas will be prone to delamination. The centerline on a road with a crown cross section where snow plow activity occurs and skip lines with recessed pavement markers are particularly vulnerable to delamination.

Just prior to application of asphalt, the surface of the pavement must be cleaned adequately to the satisfaction of the Engineer. Cleaning methods should be discussed at the pre activity meeting and approved by the Engineer in advance. The use of a good power/kick broom supplemented by hand brooming is usually adequate. If a film remains adhered to the surface after milling, or if dirt or mud is tracked onto the surface to be treated, a broom alone may not be sufficient to adequately prepare the surface; it may be necessary in these and other instances to wash the surface with high-pressure water. If water is used, the surface must be allowed to sufficiently dry, as appropriate, prior to the treatment being placed.

If there are areas where motor vehicles have dripped accumulations of oil and grease, it may be necessary to burn off the deleterious materials. If asphalt is spilled on the pavement, the spill area should not be sealed over without first cleaning the surface. Don't apply an extra heavy treatment to cover contaminated areas; clean it up. Any areas of contamination or from where dust or other deleterious substances/coatings remain on the surface will be prone to delamination and premature pavement failure. Do not afford the contractor any leeway on proper surface preparation.

Utility covers for manholes, valves, and any other feature in the pavement surface that must remain accessible after the treatment has been applied must be identified and properly covered to prevent adherence of the surface treatment to the feature. This may include applying release agents or securing a thick construction paper or similar material to the surface of the feature. Drains and catch basins must also be adequately protected to prevent material from the surface treatment infiltrating the drainage system or blocking/clogging inlets. The location of any features that are not identified on the plans should be recorded/documented on the plan sheets to ensure these are found and made accessible following the treatment. After curing treatment is complete, all protective material, as well as any loose material, shall be removed and disposed of properly. All loose material after treatment shall be cleaned from manholes, valves, gutters, and drainage systems.

404-4 Prime Coat

Prime coats may be eliminated from the work in those cases where the aggregate base surface is tightly bound and will not displace under the laydown machine and hauling equipment. Except, never eliminate the prime coat on a secondary road project that has a chip seal, or an asphaltic concrete friction course applied directly on top of the prime coat. A change order is required to eliminate the contract item.

The purpose of the prime coat is to protect and stabilize the surface of the base and provide a uniform, firm-working platform for the next course. The prime coat is designed to:

- Coat and bond loose mineral particles on the surface.
- Waterproof the surface of the base.
- Provide adhesion between the base and the next course.

Before a prime coat is applied, the base should be tested for proper compaction and cross section tolerances. Since the prime coat can frequently be eliminated, the Resident Engineer should evaluate the condition of the base before allowing the application of the prime coat. ADOT Materials Group is available for consultation.

The surface of the aggregate base must be smooth and true to grade and cross-section. The surface should be slightly damp (no free water on the surface) when the prime coat is applied. A water application one to two hours ahead of the prime coat application generally causes deeper asphalt penetration, which is highly desirable.

The type and grade of asphalt to be used and its approximate rate of application will be indicated in the Special Provisions. The rate of application should be determined by observing the rate and the depth of penetration; bearing in mind the traffic conditions and schedule of paving operations. After applying a section of prime, look at the results and then adjust the rate of application as necessary. An excessive rate of application is not only wasteful but may cause a slippage plane between the base and pavement, or may cause instability and bleeding of the pavement since the extra surface asphalt will migrate upwards in warm weather through the action of traffic. Too light a rate of application may cause raveling of the surface, requiring repairs prior to paving. Asphalt in thin films is an adhesive, but asphalt in thick films may act as a lubricant.

A prime coat should not be applied until all specified weather and temperature requirements can be met.

In some cases it may be desirable to establish a guideline for the distributor operator to drive by for the first pass.

The bituminous material for prime coat is applied by means of a distributor truck, allowed to cure, and then compacted, preferably with a pneumatic compactor. Traffic is permitted on the primed surface only after compaction. Adequate cure time for prime coats is essential (usually 24 hours) to allow volatilization of solvents prior to placing an asphalt overlay. If the primed surface is picked up by tires, sanding or blotter shall not be used unless the initial designed cure period has passed. Instead, all traffic should be removed from the primed surface until it has cured sufficiently.

Note that there is no method of payment for compaction provided in the prime coat item. When compaction of the primed surface is started, the condition of the surface should be watched closely and if the compactor damages the surface, the operation should be altered or stopped. Sometimes the compactor action will roll a larger aggregate around and break it loose.

During the curing period, the primed surface should be protected from traffic (including all construction traffic) until there is no tackiness to the surface. The surface should then be examined for lean or rich areas. Small lean areas should be hand sprayed. Any rich areas should be corrected before any pavement is laid over them. The corrective measures should depend on the degree of richness and the size of the areas involved.

Following the initial cure period, sanding the areas which are only slightly rich is adequate. Small areas under 50 square feet can be hand worked. In some cases, it has been necessary to pick up the primed surface together with an inch or more of the base, and blade mix the prime coat throughout long sections. This added expense is justified in preference to laying a pavement on a prime coat where there is free asphalt on the surface.

The prime coat application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online.

Inspection Guidelines:

- Does the surface need a prime coat?
- Will the surface hold up against construction traffic?
- Does the surface need to be sealed for poor weather?
- Is the surface to be primed of acceptable smoothness?
- Is the surface damp?

- What is the application rate?
- Does the application need adjustment?
- Are the asphalt applications uniform?
- Is the bituminous material suitable for its intended use?

404-5 Tack Coat

A tack coat is a light application of asphalt applied to a pavement, primed base, or stabilized base immediately prior to laying a course of asphaltic concrete (AC) pavement. Its purpose is to lessen the possibility of a slippage plane or delamination at the interface of the two courses. The structural capacity of the pavement is dependent on the pavement behaving as a single layer of asphaltic concrete, any discontinuity in the pavement section will significantly reduce the strength of the pavement and will result in premature fatigue cracking and potholes.

Tack coats are applied e with a concentrated asphalt emulsion or paving grade (PG) asphalt. The application shall be uniform, whether applied by hand spray or distributor truck. If the tack coat is streaked or stringy, something is wrong with the equipment or with the material being applied. The work should not be allowed to proceed when the tack coat is not uniform. Adjustments should be made and the spread checked before resuming the work.

Exposed contact surfaces, including curbs, should always be tacked. If the existing AC surface exhibits excessive asphalt content (but will be allowed to remain in place), the tack coat may be eliminated from typical paving operations. A prime coat that has been in place for a long period of time may need to be tacked. The Resident Engineer should evaluate the condition of the grade after traffic has used it. AC can be placed directly on an unprimed aggregate base (AB). It is not required for most AC mats to bond to the AB; therefore, tacking the prime coat is usually unnecessary. Materials Group is available for consultation, and should a tack coat be necessary, it would probably be a light coat.

The contractor should protect all adjacent facilities, construction, or traffic from possible damage from over spray during application of a tack coat.

Spreading the tack too far ahead of the AC paving operation is to be avoided because it easily gets dirty or may be tracked off, losing its adhesive properties. Traffic shall not be permitted on the tack coat. If tack coat is tracked off of the grade prior to being paved, tack coat should be reapplied. Excessive tracking is likely to occur when daytime temperatures are warm (pavement surfaces reach or exceed 140 degrees F).

If weather and traffic conditions likely to result in excessive tracking of the tack coat are expected, consider use of a trackless tack to ensure proper bond between layers of asphalt pavement. Trackless tack may also be advantageous where it is desired to maintain the aesthetics of nearby pavements and driveways, and during cooler weather or nighttime paving because of the chemical formulation which results in a much faster break time (potentially less than 20 minutes in sub-40 degree F temperatures).

Under no circumstances should the tack coat be omitted unless the exposed AC has a flushed surface.

If an emulsified tack coat is used, and it has not yet broken, the paving train must halt. The water in the emulsion must evaporate freely, i.e. by itself before it is covered with new AC, the thickness of which is too great to allow all moisture to escape.

The type and grade of asphalt, as well as recommended rate of application are typically shown in the Special Provisions, and as required by Section 1005 and Subsection 404-5 of the Standard Specifications. If the Resident Engineer is given a choice, he or she should not guess which one is the best. Each type of tack has its advantages. If the Resident Engineer is given a choice, then ADOT Materials Group will advise the project as to which would be best suited for the climate and circumstances. Changing the rate of application beyond the limits specified should be done cautiously and with the advice of the District office and ADOT Materials Group.

Adjustments to the application rate may be appropriate depending on pavement type, age, and surface texture. If unsure, perform a short test strip to confirm the application rate is appropriate .

When paving grades of asphalt are used, a more uniform coverage will be obtained by heating the asphalt to the upper limits of the recommended range. Care should be used in heating because flash points differ between the various asphalt types.

The tack coat application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online.

Inspection Guidelines

- Is the surface clean and free of dust? Did the broom get against the curb or pavement edge?
- Is the application of tack uniform?
- What is the rate of application?
- Are haul truck tires free and clear of debris?
- Is the contractor making continuous effort to minimize tracking?

404-6 Fog Coat

A fog coat is a very light (about one pint per square yard single application of asphalt material without a cover material. Over application will cause the surface to bleed or become unstable, resulting in rutting. This treatment is often called a flush coat. It is occasionally used to rejuvenate deteriorated pavement ahead of chip seals (to prevent too much absorption of the chip seal's asphalt). Fog coats may also be applied using various emulsions to help retain the chips on an older seal coat, which is beginning to strip. Considerable use has been made of fog coats as an asphalt rejuvenating agent, sealing small cracks, and surface voids and inhibiting raveling. This material has a petroleum resin oil base, emulsified in water. The asphalt in asphaltic concrete goes through an aging process, which starts immediately when the asphalt is exposed in thin films to heat and air. An asphalt-rejuvenating agent prolongs the life of old and new pavements by rejuvenating the aged asphalt. The material is applied through a distributor; heating of the material is not required. The rate of application depends on the condition of the surface. The Special Provisions will specify the type of bituminous material and the approximate application rate determined by the ADOT Materials Group. The Resident Engineer should contact the ADOT Materials Group before changing the type of material or application rate.

Caution should be exercised when recently placed or excessive crack seal material exists in an area that will receive a fog coat. These materials often contain a high percentage of asphalt rubber and if a rejuvenating fog seal is placed, the solvents in the rejuvenating asphalt emulsion may cause the crack seal material to become extremely tacky, especially during warm weather. This typically results in the crack seal material getting picked up by traffic and tracked down the road causing a significant and immediate maintenance issue.

Before applying the fog coat, the surface should be cleaned by brooming or by some other cleaning method. Areas of oil and grease drippings should be removed by burning off with a weed burner or by other means. Holes or badly eroded areas should be patched prior to applying the fog coat

In most cases the fog coat leaves the surface extremely slippery, so it is sanded (referred to as blotting) in order to permit earlier use of the pavement. Blotting also appears to have beneficial effects in that it aids in healing cracks and pitted surfaces. The Special Provisions will indicate an approximate application rate for blotter. Either under applying, or over applying, the blotter can be hazardous to traffic. Never open to traffic without sufficiently blotting to eliminate the slippery surface. Over application may require brooming to keep excessive blotter material from damaging vehicles, or personnel.

The Resident Engineer is strongly urged to familiarize himself or herself with the ADOT Materials Group Practice and Procedure Directive (PPD) 6, Provisional Seal Coat. This document will answer most questions concerning the need and desirability of fog coats.

Since fog coats may be necessary on short notice while on a paving project, the Resident Engineer should consult with the contractor prior to beginning the paving operation in order to ensure the availability of acceptable materials on short notice.

Traffic is kept off fog coats for at least 2 hours except as needed to accommodate turning or crossing traffic. Use of a fog coat is not recommended for new pavement surfaces that are to receive a chip seal or friction course. This is because the surface is softened, causing excessive aggregate embedment.

The fog coat application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online.

404-7 Chip Seal Coat

General

A chip seal coat consists of an application of bituminous material followed by cover material. This type of surface treatment is used to provide a new watertight non-skid wearing surface. The source of the cover aggregate normally is not specified so it is the contractor's responsibility to locate a source and to furnish samples to be tested by ADOT. All the specification requirements pertaining to pits must be complied with, and the contractor must pay all costs involved in the use of the source. Chip sealing consists of a single application of asphalt, either a hot-applied PG or emulsion, followed immediately by a single application of cover material. The approximate rate of application for both the asphalt and the cover material will be in the Special Provisions.

Sampling Materials

Bituminous materials are sampled as is typically done for emulsions or PG. Cover material for emulsion chip seals is sampled at the final stockpile. Cover material for hot-applied chip seals is sampled at the final stockpile prior to pre-coating. Regardless of the type of chip seal, it is important that the condition of the cover material does not change after it has been sampled and prior to delivery to the chip spreader or hot plant for pre-coating. If contamination (exposure to dust) or other change (moisture content) in material is suspected, additional samples must be taken.

Cover material is often produced and placed in designated stockpiles which are clearly identified. This allows each individual stockpile to be qualified for acceptance, and for correction of stockpiles with deficiencies; once pre-coating is performed, it is difficult to assess the quality of the cover material.

After the pre-coating process for hot-applied chip seals, the chips should be inspected to ensure adequate coverage with 0.40% to 0.60% asphalt (by total weight); chips near 0.40% asphalt will have a speckled appearance to nearly complete coverage at 0.60%. While we do not sample and test to verify asphalt content, the supplier's hot plant report for tons of cover material and tons of asphalt may be used to confirm. If the pre-coated chips contain adhered conglomerations of sand or finer material, the virgin stockpile should be inspected to ensure the absence of contamination or adhesions of dust or other coatings.

Application Rates of Bituminous and Cover Material

The application rates shown in the specifications for bituminous material and cover material are estimates only. The initial bituminous and cover material application rates will be determined by the contractor using the chip seal coat design formula (See ARIZ 819) and must be approved by the Regional Materials Engineer. The design rate should result in the asphalt/chip relationship shown in Exhibit 4-4. The depth of embedment of average size particles should be 70% to 80% depending on the anticipated traffic volume and the climatic conditions. For light traffic and high altitude, 80% embedment would be proper. The contractor should identify areas where the surface conditions of the pavement changes, as well as areas that will experience increased slowing/stopping/turning movements, to determine appropriate adjustments in application rate.

The initial application shall consist of a test strip to ensure proper application of materials and adequate embedment of cover material without excessive chip loss or tracking of bituminous material. The test strip may include multiple application rates to better optimize the process.

The contractor and the Resident Engineer may adjust the application rates slightly at the time of construction based on field conditions and observation during placement. Special attention should be given where chip seals are to be applied to new AC as the rate of bituminous application may need to be either increased, due to the new surface absorbing more asphalt than typical, or reduced since some embedment into the new surface may occur. This is especially important for hot-applied chip seals when the cover material has retained a significant amount of heat at the time applied.Excessive amounts of chips above the desired single layer can also have a detrimental effect on the overall quality of the chip seal coat. The excess chips can act as wedges during the rolling process, which in turn will dislodge, or weaken the bond of embedded chips. Ideally, no more than about 5% of the cover material will be swept off and no wedged or stacked chips will remain, and there will exist no empty spaces with exposed asphalt.

ADOT Inspectors should be actively involved in overseeing and inspecting the entire operation continuously. The Project Supervisor should rotate inspectors so that lunch and restroom breaks can be provided. The inspector should continually check the completed chip seal coat to determine if there is satisfactory embedment of cover material and if the surface is completely covered. The surface should be examined immediately after rolling and also after the seal has cured enough to withstand having the excess cover aggregate brushed away by hand. This evaluation requires good judgment and experience.

Embedment can be verified by using a needle nose pliers and plucking an average size chip from the surface and visually assessing the percent of its depth which has been covered with asphalt. This should be repeated in a few areas representative of the placement, at frequent intervals during the chip seal placement.

The bituminous material application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online. Actual roadway widths should be checked against those shown in the plans before starting the seal coat, and the contractor should be notified of any quantity adjustments.

Application of Binder

Section 404 indicates the necessity for checking the distributor against the requirements of the Standard Specifications. In addition to determining that the distributor has the required equipment and accessories, it must be determined that this equipment, accessories, instruments, etc., are in proper working order. Nozzles are all to be of the same type and size and set at the proper angle. The spray bar is kept at the proper elevation so that the desired spray pattern will result. Verify there is no excessive dripping when the nozzles are closed and each nozzle remains free of slugs while in operation. The proper functioning and operation of the nozzles and spray bar is the responsibility of the operator but the inspector should be certain that all equipment is operating properly. If equipment is not operating properly, the chip seal operation must cease immediately until corrections have been made.

When applying emulsified binder in areas with steep grades or sharp curves, it is very important to have the chip spreader as close to the distributor truck as possible to prevent the binder from running down the cross slope or grade. The truck should have adequate power so that a constant speed can be maintained, even on hills, while in the process of spraying. Hydraulic pumps on some newer distributors have resolved many problems including uniform flow at the bar tips. The same is true for hot-applied PG and to ensure adequate heat is maintained to facilitate embedment.

The distributor driver should be able to operate the truck in a manner that will result in longitudinal and transverse joints that have no overlaps or skips. Building paper can be used to make transverse joints when starting and stopping the distributor truck.

When the distributor runs out of asphalt, the flow may not stop abruptly. The flow may sputter and spurt as differing amounts of air and asphalt enter the flow. Emptying the distributor truck is called blowing and should never be permitted on the pavement. The spray bars should be cut off when 200-300 gallons of asphalt are still in the tank. The results of blowing are an extremely spotty and uneven application with everything from grossly over-rich areas to no asphalt at all. Blowing is to be done in an approved area where the asphalt can be safely disposed of.

SPEED OF THE DISTRIBUTOR AND LENGTH OF SPREAD

Distributor speed may be determined by:

$v = \frac{9Q}{WA\,(1+c)}$	v = road speed, feet per minute Q = spray bar output, gal per min W = spray bar width, feet A = application rate, gal per sq yd c = expansion coefficient resulting from heating the asphalt

$c = \frac{T-60}{30\,(100)}$	T = application temperature, F

Based on the number of loaded aggregate trucks on hand when operations begin, the length of spread may be determined by:

$L = \frac{9V}{WA}$	L = length of spread, feet V = total gallons to be applied to the surface

The number of gallons sprayed is limited by the capacity of the tank. But, for the loaded aggregate trucks on hand, the number of gallons, V, may be determined by:

$V = \frac{AW_a}{S}$	W_a = weight of aggregate on hand, Ib S = spreading rate of aggregate, Ib per sq yd

Asphalt should be at the proper temperature for spraying viscosity. If it is, application at the correct rate presents no problem. The driver merely maintains the predetermined speed as indicated on the dial of the bitumeter.

Checks on the amount of asphalt used are made after each run with the distributor. This is done quickly and easily by calculating the gallons per square yard applied, using the formula:

$A_1 = \frac{9TM}{WL}$	A_1 = actual rate of application, 60 F, gal per sq yd T = total gallons spread from the distributor at spraying temperature (H equals gauge stick reading before spread minus gauge stick reading after spread) M = multiplier for correcting asphalt volume to basis of 60 F, from temperature-volume tables (See Section 1310)

RELATIONSHIP OF QUANTITY OF ASPHALT REQUIRED TO SIZE OF CHIPS

	Correct asphalt quantity, voids 70% to 80% filled
	Insufficient asphalt, screenings not firmly held
	Excess asphalt submerges chips and causes bleeding

Exhibit 404-43.14-1. Speed of Distributor & Length of Spread

No bituminous material shall be spread when weather conditions are unsuitable or when the temperature of the pavement surface is below 85 degrees Fahrenheit. The application of bituminous material shall not be permitted unless there is complete assurance that cover material will be available to immediately cover the application in its entirety. No matter how hot the asphalt is when sprayed, it will cool to the temperature of the pavement in one minute or less.

When the chip spreader stops, the distributor should stop. There are some methods of constructing a joint on the run that allow the spreader to keep moving. The contractor must supply some way of signaling the distributor driver to stop the spread of bituminous material in case there is any delay in the application of the cover material.

Inspection and Application of Cover Material

Cover material for a chip seal coat must meet all the requirements described in Subsection 404-2.02(C). Aggregates should be as uniform in size and shape as possible so that the seal coat will have essentially one layer of aggregate.

Care must be exercised in the stockpiling and handling of cover material to avoid contamination from dust, intermingling with other aggregates, and other contaminants. This includes picking up underlying soil or stones when cover material is being loaded from stockpiles. If the particles are coated with dust, silt, or clay, the coating forms a film that prevents asphalt-aggregate adhesion. A very small amount of certain contaminants can render a large amount of cover material unusable. Oversize stones can plug the spreader box.

The specifications require cover material, when used with emulsified asphalt, to be wet but free from running water at the time of spreading. The purpose of requiring the wet cover material is to nullify the effect of any dust on the aggregate particles. The wet aggregate also reduces the absorption of the water in the emulsion. Dusty aggregate and absorption of water tend to cause an early break which may reduce embedment and the effectiveness and uniformity of the asphalt coating.

When the bituminous material is a PG asphalt for hot-applied application, the cover material, at the time of spreading, shall be dry. Wetting stockpiles for dust control is not permitted. Do not use wet aggregate with cutback or paving asphalts.

Cover material for chip seal is measured by the square yard. However, for the Resident Engineer to determine/confirm the application rate (pounds per square yard), the weight of the cover material must be known. Therefore, cover material is weighed as it is delivered or as produced if pre-coated for hot-applied and transported immediately, and the weight of water is deducted to determine the dry weight per ton; not necessary if pre-coated for hot-applied. Dry weight is determined in accordance with the requirements of AASHTO T 19. This also provides the Resident Engineer with the means by which he or she can determine the actual rate of application whether by the load or over an extended distance. This can be compared with the theoretical rate.

Any deficiencies or any excesses in the application of the cover material should be remedied by hand methods where necessary in order to avoid bleeding areas or build-up areas.

Careful operation of the chip spreader and the hauling equipment is essential to obtaining a uniform surface. Truck drivers should be instructed before the work starts that they are to:

- Stay off asphalt which has not been covered with aggregate,
- Avoid speeds in excess of 15 mph and driving in the same wheel tracks repeatedly when driving on new seal coats,
- Avoid turning movements and sudden applications of brakes on new seal coats, and
- Avoid lining up a number of trucks behind the spreader and preventing the rollers from working as close to the spreader as possible.

The spreader box should not be allowed to be emptied completely between loads because the spread rate is usually affected.

Because of the rapid cooling of the asphalt as it hits the pavement, it is necessary to apply the cover material immediately to get good embedment and chip retention. The entire operation must be organized to achieve a rolled chip surface as quickly as possible after the asphalt is applied; if lag between operations is not minimized, the operation should cease immediately until corrected

The distance between the distributor trucks and the chip spreader should always be the minimum distance that safety will allow. A good operating range is 50 to 75 feet. Close coordination between the distributor truck and the chip spreader will assure that when the chip spreader stops the asphalt distributor will stop; the distributor truck must not outrun the chip spreader and the rollers must not fall behind the chip spreader.

Joints

The specifications permit the contractor some latitude in the method used in making transverse joints. The use of building paper has been a generally accepted method to make a clean bituminous material cut-off. With proper coordination, the contractor may also switch distributor trucks in one of two ways that eliminate the use of paper. If the chip spreader is stopped just before the end of the shot of emulsion it can then be backed out of the way and the second distributor truck can tie onto the fresh end of the previous shot. This must be done quickly enough to allow the chips to be dropped onto the emulsion before it breaks. The variation on this theme is to allow the spreader to fall back 100 to 200 feet and then move as slow as practical while the distributor trucks are switched out. This works better in cooler weather since the emulsion will not break as fast. If the distributor truck operators are not able to tie onto the fresh edge without overlapping the emulsion, then the contractor must use the paper stop and go method.

It is important that the distributor is at proper speed when application of asphalt starts; also, the spray bar should be shut off before it blows or pumps air at the end of each application.

It is important that the Resident Engineer and the contractor work out a satisfactory procedure to be used when the threat of rain requires the work to be stopped. Equally important is an agreement between the inspectors and the contractor's paving crew as to what constitutes a dry pavement after the pavement has become wet.

The specifications are clearly defined in requiring the butt-type longitudinal joint. This method requires the full rate of application of both asphalt and cover material to the extreme edge of the lay ribbon. Care must be taken to not get too much asphalt along the butt joint. A cut off nozzle should be used to attain a sharp cut off of asphalt at a butt joint rather than using a shield. Turning the end nozzle 90 degrees is not acceptable.

The correct speed is also important in the operation of the chip spreader. The rate of application will usually be heavy until the spreader gets up to speed. When starting the spreader, there is also a slight delay until the full flow of chips begins. The spread at the joints should be overlapped enough to allow for the delay in the flow of chips. If the contractor tries to hit the joint too close, it will probably result in a strip having little or no chips that must be covered by hand and will commonly result in a bump.

If the operator is not careful when starting a spread, the wheels of the spreader will slip slightly before getting traction. The wheel slip usually leaves a spot the size of the tire print that will be stripped of cover aggregate and/or asphalt. The stripped areas cannot be patched without leaving a permanent mark.

It is often difficult to get contractors to perform the necessary handwork to get a first-class job. When necessary, handwork needs to be done in a timely manner. Typical of handwork often needed is the cleanup of piled aggregate spilled when trucks dump into the spreader. The piles are to be cleaned up before the roller gets to them. Areas deficient in aggregate also need to be corrected before being rolled. A hand-sprayer, aggregate, and labor should be available just behind the spreader so that handwork can be done without delay and before rolling.

Rolling

The specifications require that a sufficient number of rollers be provided to cover the width of the material in one pass and that rolling will continue for a specified number of passes. The number of rollers needed will be governed by the speed and width of the spreader. The optimum time for rolling is immediately after spreading chips so that it will be done before the emulsion breaks, or the asphalt cools. Remember, the asphalt cools to the pavement temperature in less than a minute. One pass coverage immediately behind the chip spreader is a key requirement for a successful chip seal coat.

If a roller breaks down, the operation should be stopped at once until repairs are made or a replacement is in operation. Furthermore, rolling should not stop to wait for pavement repairs to keep rolling, even if it means they have to remove part of the seal coat later to make the repairs.

The completed seal coat should be examined at intervals after the rolling has been completed. The aggregate should be properly embedded without excessive asphalt showing through. Complete coverage should be achieved, see Exhibit 4-4.

Traffic Control on Chip Seal

Subsections 404-3.03 and 404-7.05 cover the handling of traffic through or around work which involves the application of bituminous treatments. For safety and inspection considerations, the chip seal operation should be completed in time to return traffic to normal by sunset. The contractor should organize his or her work to avoid the sunset hazard and to only rarely restrict traffic after sunset. Most seal coat projects require the use of pilot cars and flaggers. Attention should be paid to the Special Provisions of each chip seal coat contract since traffic control features are often changed for particular job conditions, or to reflect the most recent revisions in traffic safety policies.

Subsection 404-7.05 provides that the speed of motor vehicles shall not exceed 15 mph when it is necessary to travel on a new chip seal coat. This includes the pilot vehicle, the vehicles being piloted, the contractor's vehicles, and ADOT vehicles. The minimum 3 hour traffic-free period shall be observed for emulsion chip seals. For hot-applied chip seals, depending on conditions, it may be appropriate to return the traffic in as little as 30 minutes provided the reduced speed limit is strictly enforced.

Often ADOT and contractor's vehicles are the worst offenders. It is necessary that the Resident Engineer be firm in enforcing the speed limit and the traffic-free period. If weather conditions are adverse to rapid curing of the asphalt, an extended traffic-free period may be required. It is mandatory that the contractor's and ADOT’s drivers, as well as the public, observe all traffic controls. Sharp turns and hard braking on fresh chip seals are to be avoided. The contractor should not be allowed to turn his or her trucks around on a fresh seal.

Removal of Loose Cover Material

For hot-applied applications, loose cover material is removed prior to returning to traffic and at least 30 minutes after placement. Therefore, because this happens in a rather short period of time, it is extremely important to ensure removal equipment does not mar the surface during warm/hot conditions; provide additional time for the surface to cool if necessary.

Specifications state that all loose cover material shall be removed in not less than two hours but no more than 36 hours except when conditions dictate a longer period is desirable. Power brooms are required for removal. Broom pressure that dislodges material from the asphalt is not permitted. The surplus material should not be allowed to remain on the pavement edges. It should be removed completely from the paved surface. In the event there are curbs alongside the pavement, it will be necessary for the contractor to pick up the surplus cover material and remove it from the road.

Extra care is necessary when brooming chips in town, or in front of businesses or homes close to the roadway.

Chips and dust thrown out by the broom can cause damage and inconvenience, so a change in procedure may be needed. Speeds should be adjusted to eliminate throwing chips and dust. It may be necessary to hold down the dust by watering lightly. Running the broom so as to leave the chips in the center of the pavement is effective but it may require more handwork. The primary thing to consider is that the comfort and convenience of the property owners are at least as important as the contractor's convenience.

Brooming during hot weather is generally limited to cooler morning hours. Heat will loosen the chips so that they are either torn out or rolled over. Stop the brooming at the first sign of chip loss. The inspector will need to be out on the road to observe the operation properly.

The number of brooms provided by the contractor will govern the distance he or she can seal and still remove the excess chips in time. The number of brooms required can be quickly determined by the following procedure:

Assume:

- Three passes are needed for one broom to sweep a 12-foot wide pavement.
- Broom speed is 15 mph.
- 4-1/2 hours are available for brooming.

Calculate what one broom can cover:

- 15 mph x 4 1/2 hours = 67.5 miles per shift.
- 67.5 miles / 3 passes per lane = 22.5 miles of 12 feet wide pavement per day.

Determine the required brooming operations:

- One broom is needed for cleaning up in front of the sealing operation.
- One broom is needed to remove the previous day's loose cover material.
- One broom should be available as a spare or to speed up the other operations.

Therefore, three is the minimum number of brooms normally needed for a chip seal coat covering up to 23 miles of 12 feet wide pavement per day.

After the brooming is completed, the centerline is replaced, usually by state forces. The Resident Engineer is responsible for keeping the District informed so that the centerline can be repainted as quickly as possible. Temporary reflective markers must be placed until the painting has been done, and they must be placed before dark. Do not neglect necessary warning signs.

Chip Seal Inspection Guidelines

- Is the contractor contaminating the cover material with the loading operation?
- How is the weighing of cover material being handled? Is there adequate documentation to determine dry tons of cover material to verify application rates?
- If using emulsified asphalt, are the chips wet, but free of running water?
- If hot-applied, are chips adequately pre-coated?
- Are weather conditions suitable and is the surface temperature within specifications?
- Has the surface been properly prepared?
- Has the absorptive property of the surface been inspected and is the asphalt application rate proper for the existing surface conditions?
- Have areas requiring a change in application rate been identified (painted/marked on shoulder)?
- Are the asphalt distributor and the spreader box mechanically capable of making a uniform application?
- Have tests been made to determine uniformity of application of the asphalt and of the cover material?
- Are proper precautions taken to prevent spattering of asphalt on curbs, handrails, traffic, etc.?
- In making transverse joints, is the contractor using roofing paper or some other suitable material to ensure a proper junction with the preceding work?

- Does the contractor have sufficient labor force to do the necessary brooming and disposing of surplus cover material?
- Is the cover material being promptly and properly rolled after application?
- What types of rolling equipment are being used?
- Are rollers staying close behind the aggregate spreader?
- Is embedment adequate? Check rollers for proper ballasting.
- Is traffic control effective in keeping traffic off of the fresh seal?
- Are the contractor's haul units damaging the fresh seal by excessive speed, sharp turns, etc.?
- Is the initial brooming operation sweeping off more than 5% of the chips to the shoulder? Are there any empty spaces on the surface not filled with chips?
- Is traffic kept off the fresh seal the minimum time required by the specifications?

Slurry Seal Coat & Microsurfacing

Slurry systems consists of a mixture of sand, Portland cement, water, set controlling admixture, and emulsified asphalt mixed to a rich, creamy consistency. It is spread in a thin layer over the pavement. Portland cement is added to aid in stabilizing and setting the slurry. Relatively fast setting polymer modified emulsified asphalt is used to facilitate a quick return to traffic.

A contractor-furnished mix design is necessary for slurry seal and microsurfacing mixtures, which must be reviewed and approved by the Engineer prior to placement. See the Special Provisions for slurry seal coat/microsurfacing mix requirements.

In addition to sealing the surface, slurry seal coats are normally used to fill minor cracks and surface irregularities in AC pavement to prevent further deterioration and to provide a quieter riding surface. Slurry seal coats have also been used to improve surface friction, including pavements where bleeding has occurred.

Microsurfacing is often used to extend the life of older pavements with mild to moderate surface distresses including cracking, raveling, and minor rutting. Microsurfacing may be placed in two separate passes, the first being a scratch coat to fill in minor to moderate irregularities, followed by a second pass, material for which, is applied to the entire width of the area (lane) receiving the treatment. Initial scratch coats must be allowed to cure sufficiently and opened to traffic for at least 24 hours prior to placing the second coat.

Both slurry seal coats and microsurfacing may be placed as the upper most application for a Cape seal for which the initial treatment is a chip seal. In this instance, the chip seal should be exposed to traffic for several days to allow the chips to reorient and become fully embedded prior to placing the slurry seal or microsurfacing.

Most slurry work is now being applied with continuous flow mixing and spreading units. Such units must be equipped with metering devices and feeders that will introduce the aggregate, Portland cement, water, other additives, and emulsion into the mixing chamber in predetermined, specified proportions as determined by the mix design. The emulsion is introduced into the mixing chamber by means of a positive displacement pump which is synchronized with the aggregate feeder belt. There should be an active control for the amount of water introduced that can be used to quickly adjust the flow rate of water.

In general, these slurry type treatments allow for rapid surface treatment and return to traffic provided mix formulation, equipment calibration, field adjustments, and weather conditions are considered.

Calibration Check of Slurry Seal/Microsurfacing Machine (Example)

The following is a sample calculation the inspector can use to check the emulsified asphalt content of the slurry seal mix relative to the approved mix design. A similar calculation is done for microsurfacing, however, the application rate of aggregate will be greater than that for a slurry seal.

Determine the following values:

- Width of Belt = 20 inches
- Length of Belt Travel per Revolution = 3 feet
- Depth of Material (Gate Opening Height) = 3 inches
- Density of Aggregate = 100 pounds per cubic foot
- Emulsion added per Revolution = 1.92 gallons
- Density of Emulsion = 240 gallons per ton (see Standard Specification table 1005-6)

Calculate Weight of Aggregate Per Revolution

- (belt width) x (belt travel) x (material depth) x (density) = Aggregate Weight
- (20/12) x (3) x (3/12) x (100) = 125 pounds

Calculate Weight of Emulsion per Revolution

- (gallons per revolution) x (gallons per ton) = Emulsion Weight
- 1.92 x 2000 / 240 = 16.0 pounds

Calculate Emulsified Asphalt Content

- (Emulsion Weight) / (Aggregate Weight) x 100 = Emulsion Content
- 16.0 / 125 x 100 = 12.8%

The specifications require approximately 13% emulsion per weight of dry aggregate (sand), and approximately 22 pounds of dry aggregate per square yard of pavement for slurry seals, and 30 pounds for microsurfacing. ADOT's interpretation is approximately ± 1% for the emulsion and ± 1 pound for the dry aggregate. These application rates should remain fairly consistent with placements of uniform thickness on relatively even surfaces; adjustments are typically made to the additional water and set controlling admixture to achieve the desired consistency and set times.

The slurry seal machine will have an adjustable squeegee at the rear of the mixer that spreads and squeezes the mixture into any cracks and holes both on grades and level pavements. Sufficient water should be sprayed on the pavement ahead of the machine so that the surface is damp by the time the slurry seal is applied.

Other Inspection Points:

All materials including the emulsion, sand, Portland cement, and source of water should be approved before work begins. Aggregate quality is critical to the performance of slurry type seal systems. Aggregate quality should be determined by sampling the final stockpile prior to delivery to the mixing unit and at the required frequency. Quality requirements and gradation limits for mineral aggregate are provided in the Special Provisions.

Water from irrigation canals or wells that are unfit to drink (regardless of the reason) should not be allowed, unless tested for impurities, as this may affect the chemistry of the emulsion formulation and/or durability of the treatment.

Mixing, placing, spreading, and surface preparation shall conform to Subsections 404-3.04 and 3.05 of the Standard Specifications. Proper preparation/cleaning of the existing surface is paramount to ensure proper adhesion of the slurry to the existing pavement. Any pavement markings with glass beads should be obliterated/removed prior to placement as polymer modified asphalts may not adhere adequately to glass-like surfaces. The spreader box should be equipped with a canvas, or burlap drag to provide a rough surface texture. The drag must be replaced daily in accordance with the Special Provisions.

Oversized aggregate may get caught and dragged by the equipment causing streaks in the surface. Such aggregate must be cleared immediately and any streaks or depressions immediately repaired by hand. If dragging of oversized aggregate is a frequent occurrence, attention should be given to measure and correct deficiencies in the mineral aggregate stockpile(s).

Special care must be taken with longitudinal and transverse joints to prevent either excessive buildup of slurry (ridging) or streaking. The adjoining lane should be allowed to completely cure before making the joint.

Test Strip

At the start of production, a test strip should be constructed to ensure placement and behavior of the material is as expected given surface and weather conditions. Allow the contractor the opportunity to make adjustments to ensure proper mix consistency and to control set time. If adjustments are thought to be excessive, or behavior/appearance of the material is not as expected (too runny, bulky, dry, or wet), or the emulsion does not break or the slurry set up within the expected amount of time, consult with the Regional Materials Engineer and ask the contractor to contact the emulsion supplier and/or mix designer.

Weather

Changes in weather often require adjustments to the mix and will affect break/set times, including throughout each day as the temperature changes. This should be considered and weather monitored as in some instances, the daily work schedule may need to be modified in order to return traffic to the road by the required time.

Opening to Traffic

Slurry seals and microsurfacing must have had time to completely set/cure prior to allowing traffic on the material. As with fog seals, the initial mix will be brown in appearance but will become black as moisture evaporates from the material. Once the emulsion has broken, additional time should be allowed to facilitate curing/setting of the material; it should not be easily marred under foot. The contractor should first test the material under construction traffic before removing traffic control. Additional time should be afforded in areas where stopping/turning movements are likely to occur. Typically, one to four hours is needed to achieve adequate cure prior to return to traffic.

Bonded Wearing Course

Bonded Wearing Course (BWC), also sometimes referred to as a Nova Chip, consists of a relatively thin application of a polymer modified asphaltic concrete mixture that resembles properties similar to both a dense graded AC as well as an open graded friction course, with construction techniques adapted from chip seal coats. It is a hot mix asphalt placed at a thickness of either 1 or 1-½ inches with a spray paver that places a polymer modified emulsion membrane. The membrane is a heavy tack coat, sprayed at an increased application rate compared to conventional tack, immediately ahead of the paving screed. The mixture is embedded into the emulsion membrane during compaction with conventional compaction equipment to ensure a strong bond with the existing pavement.

BWC is an appropriate treatment for roads which are experiencing mild to moderate surface deterioration where a more robust treatment than a slurry seal or chip seal is needed, and it is desired to extend the service life without milling and removing a significant depth of the pavement. BWC is a good treatment option for older pavements with sound pavement structure and support, but will not prevent distresses, e.g. potholes or significant fatigue/alligator cracking, where pavement support is inadequate due to base or subgrade issues or disintegrated pavement. The existing AC must be sound with no evidence of stripping or delaminated layers of pavement.

BWC course typically has greater air voids than dense graded asphaltic concrete, but fewer than an open graded friction course, and provides sufficient friction and will reduce, to some extent, the spray effect behind vehicles during inclement weather. The material relies on a proper bond to the existing pavement surface and a thick asphalt film thickness with a polymer modified binder, the PG of which is typically one grade higher than that used for the dense graded AC (similar to friction course), to ensure stability and performance.

A contractor furnished mix design, to be reviewed and approved by the Regional Materials Engineer, is required for BWC construction. The contractor's quality control facility must be inspected by the ADOT Materials Group Quality Assurance Section to ensure properly working equipment including a calibrated nuclear asphalt content gauge, used to measure asphalt content similar to that performed for acceptance of friction course. The contractor's QC must calibrate the gauge with the materials to be used for the BWC.

The mineral aggregate must also be verified to be in compliance with sand equivalent, fractured faces, and the gradation requirements prior to production (similar to that for friction course, but only a single test for gradation).

The BWC may be placed on either the existing pavement surface or a milled surface. A pre-activity walk through should be performed to ensure the exposed or milled pavement surface is in proper condition to receive the BWC, and any areas requiring adjustments in application rate for the emulsion membrane identified. Proper preparation of the surface is absolutely critical to ensure proper bond and performance. Any areas with residual dust or films must be cleaned.

A test strip of approximately 1,000 feet in length should be placed by the contractor. During construction of the test strip, all equipment must be verified to be operating properly with particular attention toward delivery of the mixture to the material transfer vehicle (required to be used for BWC) in such a manner that there is no interruption, or disturbance to the paving screed, which would reduce smoothness. It is also important that the spray bar is applying a complete and uniform emulsion membrane to the surface (approximately 0.24 gal/sq.yd.). The application rate of the emulsion membrane and spread lot of BWC of approximately 100 lb/sq.yd per inch should be verified at the conclusion of the test strip. When all is confirmed to be in order, paving may resume.

Any spray nozzles that become plugged or spray intermittently must be immediately cleared and corrected or the operation must cease immediately. This can be a dangerous task and it may be necessary that the contractor have a spotter who is visible to the paving screed operator to alert the operator if any workers become immobilized ahead of the paving equipment.

Where BWC differs significantly from typical paving with hot mix asphalt is that the tack coat will not yet have broken at the time the mixture is placed with the paving screed. The reason for this is that the BWC must be embedded into the polymer modified emulsion membrane (heavy tack coat) that is applied with the spray paver. This would not be possible if the emulsion was left to break and cool prior to paving. Because the BWC is relatively thin but thicker than a friction course, and is also somewhat open graded, the intent is that moisture in the emulsion membrane will be flashed out and escape prior to compaction. For this reason, sufficient heat must exist within the existing pavement, asphalt emulsion, and hot mix asphalt.

To ensure sufficient heat exists during placement and compaction, the following requirements must be strictly adhered to:

- Ambient temperature of at least 60 degrees F and rising.
- Surface temperature of at least 75 degrees F.
- No sustained wind speed forecasted to be in excess of 15 mph (unless ambient temperature is 75 degrees and rising, as approved by the Engineer).
- Emulsion temperature of at least 120 degrees F (preferably near but not exceeding 180 degrees F)
- Asphaltic Concrete placed within 5 seconds of applying emulsion membrane
- Mix temperature of 290 to 330 degrees F at time of placement.
- Minimum mat temp of 275 degrees F prior to compaction.

Although a vibrating screed is required, this may result in surface/quality irregularities, and vibration may be discontinued to resolve such issues if so directed by the Engineer.

Compaction should immediately follow placement and be performed with ballasted steel double drum compactors operated in static mode only; 2 to 3 roller passes are required and there must be a sufficient number of rollers for initial breakdown to cover the entire width of the mat in a single pass when staggered. A separate roller is required to finish rolling. Every effort should be made to complete compaction prior to the mat cooling to 250 degrees F; with the finish roller off the mat when the temperature has dropped below 220 degrees F. The use of a warm mix additive is permitted and this may result in the recommended rolling completion temperatures being slightly lower; discuss with the Regional Materials Engineer if warm mix additive is utilized.

Sampling for acceptance includes a gradation sample for the mineral aggregate and a sample for asphalt content every 500 tons or fraction thereof. Gradation must meet the production tolerances in Table 9, and asphalt content must meet both the single and triple specification requirements.

After placement of the test strip, and periodically throughout paving, the BWC should be checked to confirm embedment of the mix into the emulsion membrane. This is impossible to do by looking at the surface of the BWC, but may be accomplished by looking at the edge of the mat, potentially removing a very slight amount of material from the edge with a shovel or trowel, and visually inspecting the vertical profile of the emulsion membrane and BWC. There should be some evidence that the emulsion membrane has migrated up into the lower portion of the BWC mixture rather than the aggregate riding only on the surface of the membrane. Little to no evidence of embedment may suggest that the emulsion membrane application rate should be increased slightly, or that there is insufficient heat present to facilitate embedment of the mixture during placement and by the breakdown rollers during compaction.

The presence of fractured aggregate may indicate that too thin a placement is being paved in which case the spread lot should be determined and thickness increased as appropriate.

Similar to friction course, which is also a very binder rich material, excessive drain down may occur for loads that are delayed and remain in the haul vehicle for an extended period of time. To prevent this from occurring, and to maintain as much heat as possible, it is critical that the contractor balance the rate of material supplied from the hot plant with the forward speed of the paver, and have a sufficient number of haul vehicles to maintain a continuous paving operation of 30-50 feet per minute.

If rain is likely during the scheduled day of placement, or if temperatures dropping below 40 degrees the evening or day following paving are forecast, placement of the BWC should be delayed or temporarily suspended until more favorable conditions are expected.

Crack Sealing (Asphaltic Concrete Pavement)

See the Special Provisions for Crack Sealing requirements. Cracks are sealed in asphaltic concrete (AC) pavements to reduce the rate at which existing cracks will propagate and prevent what will otherwise become rapid deterioration of the road by preventing both of the following:

- Intrusion of incompressible materials (like small stones or sand).
- Intrusion of water into the underlying pavement layers.

Asphalt-rubber sealant is used by ADOT as crack sealant. A certificate of compliance must accompany the material before the use on the project. Several commonly used products are on the Approved Products List. Ensure the correct type of sealant is being utilized based on project location/elevation.

Prior to sealing, it is absolutely necessary that all cracks be thoroughly cleaned to remove incompressible material by either high-pressure air or by routing. Heavily oxidized/weathered material exposed within the cracks must be removed by routing or sawing to ensure the crack seal material will be applied to competent pavement. If grass or weeds are growing through the crack, those areas should be marked prior to cleaning and an approved liquid herbicide should be injected in the crack after cleaning.

The surfaces to which the crack seal material will be applied must be completely dry. Any moisture in the pavement must be allowed to dissipate or torches may be used to heat the pavement in the vicinity of the cracks to facilitate drying. Any moisture remaining in the crack will result in failure of the crack seal application.

The inspector shall spot check the depths of the cleaned cracks for conformance to the specifications prior to sealing. In addition to routing to remove incompetent material from the surface of the cracks, the contractor may have to rout some of the cracks in order to achieve the specified depth. Depth is important in order to achieve a long lasting seal.

Once the crack has been properly prepared, and is completely dry, the crack should be completely filled with the crack sealing compound with a heated wand from the bottom up. If no overlay or surface treatment will occur following the crack sealing, an overband should be made with heated disk or squeegee so that as the pavement expands/contracts (warms/cools), the crack remains sealed. If an overlay, wearing course, or seal coat other than a fog seal will be placed, no overband should be created but the crack seal material should be kept flush or perhaps slightly below the surface of the pavement.

Slightly underfilling the crack when an additional paving application will be placed over the crack sealed surface is necessary to avoid both of the following:

- The presence of an excessive amount of asphalt material at the location of the cracks which may then result in flushing/bleeding of excess asphalt to the surface, or slippage of the overlay during periods of hot weather.
- A phenomenon where the tenacity of the crack seal material grabs onto the slight mound of hot mix asphalt being pushed ahead of the forward wheel of the roller, resulting in a slight accumulation of material and a bump in the overlay.

Ideally, any crack sealing operations are completed well in advance of the surface treatment or overlay to minimize these two potential effects. Where crack fill on the surface of the pavement will be subject to traffic for an extended period of time during hot weather, it may be necessary to apply what is commonly referred to as a bond breaker or blotter sand to prevent the material from becoming adhered to traffic tires and getting picked up. Once this begins, the issue will quickly propagate and cause a significant amount of damage to a crack sealed road.

404-8 Method of Measurement

Tack Coats

Asphalt cement is the only approved tack coat for Specification 407 ACFC, 413 AR-AC, and 414 AR-ACFC. Emulsified asphalts are typically used for all other tack coats. Emulsified asphalt is a mixture of asphalt cement and water. This asphalt/water ratio is about two-thirds asphalt. Sometimes a special type of emulsified asphalt is specified in the Special Provisions or by the Resident Engineer. The special type of emulsified asphalt is a 50/50 mixture of water and emulsified asphalt. The effect is to further dilute the asphalt cement reducing the asphalt/water ratio. Diluted emulsions are used where it is desired for the emulsion to further penetrate the existing asphalt

When the special type of emulsified asphalt is used, a pay factor adjustment (see the Standard Specification table in Subsection 404-5) is needed to account for the dilution. Since the pay item in the bid schedule is for undiluted emulsified asphalt, a cost adjustment needs to be made to the pay item 4040111. The field office should create a subitem for the cost adjustment and pay at a rate of 70% of the unit price for the bituminous tack coat item. The payment amount should be adjusted to the nearest dollar (see Section 404-9 of the Standard Specifications).

407 ASPHALTIC CONCRETE FRICTION COURSE (ACFC)

Asphaltic Concrete (AC) and Asphaltic Concrete Friction Course (ACFC) serve very different purposes in the pavement structural section. AC gives the roadway strength to carry wheel loads and it can be used as a base course, or for leveling. ACFC is used as the final riding surface on high speed roadways where superior skid resistance is needed; such as rural highways and interstates. ACFC thickness is typically at least ½ inch on asphalt concrete overlays and 1 inch on PCCP. ACFC is never used as a leveling or base course since it should never be overlaid. ACFC mixes are open graded which means the mineral aggregate is all approximately the same size with very little fines. This type of mix produces a porous surface that not only provides excellent skid resistance but improved drainage as well.

ACFC is more inspection intensive than other AC operations. It is almost entirely a materials and method type specification requiring both the inspectors and Project Supervisor to closely monitor the plant and paving operations, and to also know and enforce each parameter of the specifications thoroughly.

For the sake of brevity, many inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements specific to specification 407.

Here are some important differences:

- ACFC mix properties are different from AC properties, including the aggregate gradations, asphalt content, abrasion, percent of limestone in the aggregate, and specific gravity.
- A higher percent of fractured coarse aggregate particles (crushed face) is specified for ACFC and there is a flakiness index requirement.
- Acceptance of the ACFC mix is based on grading and asphalt content as with AC, but there are no requirements for voids, stability, or flow.
- The requirement that the mix be free flowing and homogeneous is reinforced by the citing of special measures that the contractor may have to take to assure these characteristics.
- There are ACFC placement date restrictions and surface temperature requirements.
- Paving machine grade control devices are limited to short and long skis. Longitudinal pavement joints are permitted only at the centerline between adjacent lanes.
- There is no ACFC compaction density requirement.
- ACFC mixing, placement, and compaction temperatures are lower than AC. This is important to be able to place a mix with the higher amount of voids as intended.
- ADOT develops the mix design based on the aggregate and asphalt cement samples provided by the contractor. There are time constraints placed on the Department for producing the mix design. The Resident Engineer is responsible for ensuring that the time periods for reviewing and verifying a mix design by the Department are strictly followed unless different arrangements are made in writing with the contractor.
- Add in any changes specific to 407 from section 407-604 from the Standard Specifications.

407-6.04 Material Spread

See Asphaltic Concrete Section for requirements.

407-8 & 407-9 Method of Measurement & Basis of Payment

- Asphaltic concrete is measured by the ton and paid for at the contract unit price per ton, adjusted as necessary for waste and spread.
    - If the quantity in a spread lot is found to vary by more than +5%, no payment will be made for the material that exceeds the +5%, including the asphalt cement and the mineral admixture.
- Asphalt Cement will be measured and paid by the ton.
    - Subsection 407-9 does not allow the 407-6.03(B) nuclear gauge test results to be used as a

method of measurement for asphalt cement.
   - Asphalt binder penalties apply if the asphalt binder does not meet the requirements of section 1005-3.01.
   - A bituminous material price adjustment may be applicable if the 109.16 specification is included in the special provisions for each contract.
- Mineral Admixture is measured and paid by the ton, at the predetermined price established in the bidding schedule.
- When required in the Special Provisions, payment for smoothness shall be made in accordance with the requirements of Subsection 109.13 of the specifications.

408 COLD RECYCLING (BITUMINOUS SURFACE)

Cold recycled asphaltic concrete may be 100% reclaimed asphalt pavement from millings (RAP) or may be a combination of RAP and virgin aggregate (corrective aggregate). Additionally, Cold in-Place Recycling recycling (CIR) may be performed in place, or performed by transporting millings to a location away from the grade for processing, or processing previously existing millings already stockpiled; referred to as Cold Central Plant Recycling (CCPR). Both processes are very similar in terms of materials, but are deployed differently depending on project vicinity, equipment maneuverability and horizontal roadway alignment, depth of which it is desired to remove material from the existing grade, and the quantity of suitable RAP already stockpiled and the distance from this material to the project.

For example, a project with numerous tight curves will be difficult to perform CIR due to the length of the equipment to perform this process. Therefore, it is likely the millings will be transported to a central plant where the millings are fractionated to become RAP, and then treated and mixed with an engineered asphalt emulsion prior to hauling back to the project. Projects with gradual geometry are most often recycled with a CIR train, which is a mobile process that performs the operation directly on the grade, thus eliminating the need to haul millings from the project; this is ideal for remote projects. Depending on project length and quantity of materials, both processes may be deployed and central plant recycling may be performed by use of the CIR train set up to operate stationary.

CIR is not recommended where the base aggregate is poor. In poor base areas, another recycling technique may be used called Full Depth Reclamation (FDR). FDR is the process of pulverizing and blending asphalt pavement with the underlying aggregate base material to provide a homogenous material upon which to place new asphalt pavement. FDR is generally six to eighteen inches thick and is commonly designed to be a 50/50 blend of asphalt and aggregate. FDR is commonly recommended where the pavement has excessive cracking, rutting, frost heaving, or high percentage of fines in the aggregate causing subgrade drainage issues. FDR may be bladed on the surface in order to correct minor variations in the roadway profile or cross slope prior to placing new layers of asphalt.

In some instances, it is desirable to deploy both CIR and CCPR or FDR together for the same project. For example, if a rather thick pavement has full depth cracks, it is more desirable to address the full depth of the asphaltic concrete pavement to prevent reflective cracking rather than a conventional mill and overlay which leaves underlying cracked pavement in place. To accomplish this, all but the lower four inches of AC may be removed by milling and transported to a central plant for processing, while the remaining three or four inches is recycled in place by means of CIR.

If all remaining AC will not be recycled, CIR works best when there is at least two inches of existing asphalt remaining below the CIR layer to serve as a working platform for CIR operations. The mixture of underlying aggregate base with the CIR is not desirable and needs to be monitored during the milling operations if any thinner than expected asphalt sections are encountered, if not accounted for during development of the mix design.

If base or subgrade stabilization is desired, rather than performing CIR for only the lower portion of the AC, FDR may be utilized to process the remaining AC as well as substantial depth of base and/or subgrade material. Once the lower portion of the AC and any underlying issues have been addressed, the CCPR material is then hauled to the grade and placed and compacted with conventional paving equipment.

One of the challenges with FDR is that the finished grade is often many inches higher than existing. Adjacent intersections and driveways must be reconstructed to match the new grade. Vertical tapered sections are required at the project limits and at bridge structures. In addition to drainage considerations, curb, barriers, and guardrail are typically required to be replaced as a result of FDR. Similarly, CIR also has a slight bulking effect. A preliminary mill of the existing pavement may alleviate some of the need to address changes in elevation.

When combined, these processes (CIR, CCPR, & FDR) completely address all distresses in the existing pavement and provide a new pavement section upon which a relatively thin, two or three inch, mat of new asphaltic concrete pavement may be placed. For lightly traveled roads, a chips seal or other surface wearing course may be all that is needed. Cold recycling minimizes the use of virgin materials, minimizes costs associated with hauling materials, and provides a long lasting pavement suitable for use on any transportation facility including interstates.

There is a misconception that recycled material will only perform well on lightly traveled rural routes. While this may have been true for cold recycling performed with the initial technologies developed for the process nearly half a century ago, this is certainly not true for the modern practice of cold recycling, as is evident by numerous state DOTs performing pavement preservation and pavement rehabilitation each and every year by means of cold recycling with much success at a substantially reduced cost.

Materials, testing and inspection procedures, and construction requirements for cold recycling are very different from both typical asphaltic concrete materials as well as what was performed previously for cold recycling. This subsection of the manual contains inspection procedures and contract administration requirements for Specification 408 that are both in addition to those for typical asphaltic concrete and what was performed previously for cold recycling. The differences are brought about by the use of millings or existing RAP, the need to perform a mix design with an engineered asphalt emulsion and conduct mixture performance testing, and the need to continuously confirm proper processing of material, compaction, readiness to open to traffic, and behavior once opened to traffic. Therefore, 408 is primarily a method specification but includes an end-product-like compaction specification for acceptance.

408-2 Cold Recycle Materials

Materials used in cold recycling include millings or RAP, engineered asphalt emulsion or a solventless emulsion, mineral admixture, either hydrated lime or portland cement, water, and may include corrective aggregate.

RAP is either screened, crushed, and re-screened during the CIR process, or is screened, fractionated, and placed in two or more stockpiles for CCPR. Once screened, RAP typically has a top size of either 1 or 1-¼ inches. Deleterious materials including crack seal material and cold patch material in excess of that which has been accounted for in the mix design must be removed prior to the CIR process if the CIR train is unable to adequately screen out these materials.

Corrective aggregate, i.e. virgin or processed/screened RAP, may be placed on the grade ahead of the CIR train, or stockpiled for inclusion in CCPR. Corrective aggregate is used to address any inadequacies in RAP gradation or fractured faces to ensure a dense, stable recycled mix.

Engineered emulsion is mixed with the RAP during the process to provide an additional coating of new asphalt cement to produce an asphalt bound material similar to hot mix asphalt. An engineered emulsion is one which both meets the PG requirements for the project location and climate, is capable of sufficiently coating the aggregate during the process, and will break within a reasonable amount of time to facilitate compaction and return to traffic. Engineered emulsions are often referred to as solventless emulsions because they exhibit good ability to coat aggregate without the inclusion of no more than 1% of a solvent such as kerosene or diesel fuel, which are found in cutback asphalts or high float emulsions that were previously used for cold recycling operations.

Mineral admixture is used to enhance the performance of the cold recycled material including anti-stripping, increased strength, and more rapid development of strength for stability when returned to traffic. The performance of recycled material which includes a mineral admixture is superior to that which does not; ADOT now requires a mineral admixture be included in the recycled material. The mineral admixture is most commonly added near the cutter head as a lime slurry to both facilitate adequate distribution within the mix, but also to cool the teeth of the cutter head.

Water is added within the pugmill mixer of the CIR train to facilitate both coating with the asphalt emulsion, also added at the pugmill, as well as compaction after lay down.

It is critical that all materials added be metered and/or quantified to confirm conformance to the mix design prepared for the segment of road or fractionated RAP being recycled.

408-3 Mix Design

The mix design is the contractor's responsibility and must be prepared by a licensed professional engineer with cold recycling experience.

The quantities of each additive/material that will be included in the cold recycled mixture are determined by development of a mix design for the project, and for each unique segment of the project as determined by the presence of different materials. Material is systematically obtained from within the roadway and then undergoes mixing at different gradations with different quantities of additives and liquids content, and is then subjected to mixture performance testing to both identify optimum additive dosages, as well as ensure compaction and performance once constructed. For this reason, it is imperative that material be produced in accordance with the mix design.

Both the percentages or addition rates of all materials/additives is provided on the mix design, as well as the volumetric and performance characteristics of the cold recycled mixture. Fortunately, due to the improvements now utilized for design, and the control of material during construction, performance characteristics need not be tested during construction unless a change in material is suspected. The mix design process requires high temperature verification if the mat temperature is expected to exceed 85 degrees F to ensure stability for construction in warm weather.

408-4 Equipment

CIR Train equipment requirements, including those for calibration, are provided in subsections 408-4.01. CCPR requirements are provided in subsection 408-4.02. In addition to having all of the necessary functionality, what is of the utmost importance, is the verification of metering and control mechanisms to ensure proper addition of each of the materials prescribed in the mix design. If any component, control, or metering device is suspected of being faulty or inaccurate, the operation should halt until a calibration is performed and proper operation is confirmed. Specific requirements are found in 408-4.01 for trains and 408-4.02 for central plants. Requirements for other necessary equipment are found in 408-4.03 thru 4.10.

The equipment needed for cold recycling in addition to that for typical hot mix asphalt production and paving most commonly includes an agitated storage tank for mixing the lime slurry, and both heavy steel drum rollers and pneumatic tire rollers. Rollers must be adequately ballasted in order to achieve compaction of the recycled material. If Portland cement is used as the mineral admixture, it is most often placed ahead of the mill head on the existing pavement surface provided the wind is sufficiently calm to facilitate such placement.

Pre-Activity Meetings and Submittals

Because the modernized practice of cold recycling is unfamiliar to many within the Department, the contractor is required to provide 'Just-in-Time Training' to project personnel (both working for the contractor or subcontractors, and the Department) who will be involved in cold recycling operations. The training must be provided by a person with extensive cold recycling experience on projects with similar mixture and construction requirements. See section 408-5 for specific requirements.

A Pre-Cold Recycling Meeting is required to discuss cold recycling operations, equipment that will be used and calibration thereof, production sequences, road preparation, weather, safety, quality control, and any other pertinent items. During this meeting, a Cold Recycling Operations Plan is submitted to the Department to detail how the recycling will progress and any expected changes that will occur during the recycling operation. A Quality Control submittal will also be provided to the Department to identify the personnel charged with performing quality control related duties as well as how necessary changes in dosage/addition rates will be determined. See section 408-6 for specific requirements.

Quality Control

Quality control for cold recycling is an intensive process that relies on the timely obtaining of processed material, testing this material, and also testing in-place compacted material at multiple times prior to full acceptance. The specific quality control measures to be performed by the contractor are provided in subsection 408-9. Most notable, are the needs to confirm quantities of materials and establish that processed material is adequately compacted. There is no time for standing around during the recycling operation and there must be a sufficient number of QC personnel to perform all of the required tasks, adequate QC personnel should be addressed with the contractor at the pre activity meeting.

All gauge and control monitor readings for all materials/additives must be confirmed accurately by measuring the actual quantities used to ensure production is both consistent and as prescribed by the mix design.

Compaction control is performed by obtaining a sample of processed material, field compacting this into a 6-inch proctor mold, determining the wet density of the compacted specimen, and then subsequently using this information to ensure that the maximum attainable compaction is being achieved in the cold recycled mat. This includes determining the moisture content necessary for compaction and proctor density of processed material from the windrow at 1,000 ft intervals, and subsequently measuring the wet density with a thin lift nuclear density gauge.

Additionally, the dry density of the mat is determined at these locations and this value is compared to the maximum theoretical density shown on the mix design to ensure adequate compaction is being achieved or if perhaps the mix design is no longer representative of the material being produced.

Prior to opening to traffic, both shear-vane (ARIZ 429) and flow strength (ARIZ 430) tests are performed to ensure the cold recycled material has achieved adequate strength to resist deformation once opened to traffic.

Prior to full acceptance and the contractor placing the surfacing or asphaltic concrete overlay on the cold recycled material, the contractor must again measure the density with a thin lift nuclear density gauge, following secondary compaction, discussed below and core the cold recycled material to determine the in-situ moisture content, both of which must meet the criteria in subsection 408-10.02

408-7 Construction Requirements

The contractor should perform a pre-construction investigation (see 408-7.01 of the Standard Specifications) that may include additional coring and milling to aid in developing their cold recycling operations plan. Any areas milled must be patched by the contractor.

The contractor must adequately prepare the road ahead of in-place recycling operations. See section 408-7.02 of the Standard Specifications.

Once cold recycling operations have begun, there are very specific requirements for the addition of each material. These requirements are provided in sections 408-7.03 through 408-7.07.

After all additives have been thoroughly mixed, the cold recycled material is placed with a paving screed similar to a hot-mix asphalt. Both cold recycling trains and central plants are equipped with alarms and lights should any part of the process not stay within tolerances. The cause of any such sounding of an alarm must be addressed by the contractor to the satisfaction of the Engineer; do not ignore sounding alarms.

The placed material should appear homogeneous without any segregation or conglomerations/pockets of asphalt-saturated aggregate. Raised pavement markers and loop detectors should have been removed prior to recycling, and if paving fabric is encountered, the contractor must adjust the operation accordingly. Handwork should be kept to a minimum and work should cease if the placed material requires constant attention from handworkers.

Any material with emulsion that begins to break prior to being placed by the paver must be removed. Once acceptable material is placed however, compaction does not begin until after the emulsion has begun to break. The time for this to occur is dependent on the specific emulsion used but usually breaks between 30 minutes to 2 hours.

Prior to compaction, the contractor's QC must collect recycled material from the grade and compact specimens at 1,000 foot intervals. A thin lift nuclear density gauge must be used to monitor compaction of the cold recycled material . See section 408-9 for specific requirements.

Compaction rollers must be properly ballasted, and operators should be careful to not stop/start on any uncompacted cold recycled surfaces. The rolling pattern must be constantly monitored by the contractor (500 ton intervals max). The rolling pattern should be that which achieves the maximum density without inducing cracking.

To confirm compaction, the wet density of the thin lift nuclear gauge measurements is compared to and should achieve at least 98% of the wet density determined by compacting specimens in the 6-inch proctor mold. The dry density is also compared to that in the mix design to confirm air voids and consistency in the mix. See section 408-7.08.

Once compacted a fog coat is applied with blotter sand to help reduce raveling of the surface once returned to traffic. To return to traffic, shear vane testing (ARIZ 429) and in-place flow testing (ARIZ 430) must be performed and be within acceptable tolerances (see Sections 408-7.09 & 7.10). These tests help ensure the recycled material has attained sufficient strength to withstand deformation under traffic. However, it is imperative that traffic control resulting in repeated stop and go traffic be avoided.

Once opened to traffic, the contractor is required to both monitor and maintain the surface of the cold recycled pavement including removing loose material and patching any potholes that develop. If corrugations or instability of any kind are observed in the recycled material, the operation must cease immediately until the contractors QC has investigated to determine the cause, which may include confirming the metering system is functioning properly, that the correct quantities of materials (primarily the emulsion) have been used, and possibly a new mix design.

Prior to placing surfacing or an asphalt overlay, the recycled mat must be allowed to fully cure and be accepted by the Department. Sufficient cure is achieved when the moisture content is no more than 2.0% after three days without precipitation. The contractor will take nuclear density gauge readings and core the recycled material to collect specimens to determine moisture content and compaction. See sections 408-7.12 & 408-10.02.

Secondary compaction may be necessary if the density achieved after the initial compaction is determined to be inadequate. Secondary compaction is performed with both pneumatic and double steel drum rollers after sufficient cure is attained and the pavement temperature is at least 80 degrees F. Secondary compaction should be performed on the warmest day possible, unless directed otherwise by the Regional Materials Engineer.

These requirements, up to curing, must be demonstrated satisfactorily during placement of a test strip at least 1,500 ft in length. Adjustments must be made by the contractor as needed to facilitate placement and satisfaction of the compaction requirements. Once the Engineer is satisfied, full production may commence.

During placement of the test strip and during full production the contractor may adjust the engineered emulsion rate by 0.1% increments provided the addition rate remains within 0.3% of the mix design target. The QC must closely monitor and adjust the rolling pattern, if necessary, any time such an adjustment is made. The intent is to maximize the density achieved.

Periodic monitoring of the test strip is required for the duration of the day during which it was placed to confirm no adverse effects once returned to traffic.

Section 408-7.15 provides ambient weather condition requirements, within which, cold recycling may be performed. Be aware that high temperature verification of the cold recycled mixture must have been performed during the mix design if the mat is expected to exceed 85 degrees F; this is likely to occur for nearly all cold recycling projects. Cold recycling operations must cease any time the existing pavement reaches or exceeds 160 degrees F, and traffic should not be allowed on any cold recycled material that exceeds 160 degrees F. Cold recycling is not allowed when ambient temperatures are expected to drop below 35 degrees F or rise above 95 degrees F within 48 hours following placement. Unexpected high or low temperatures should be discussed with the emulsion supplier.

408-10 Acceptance

Cold recycled material is accepted based on adequate emulsion content as measured during production, compaction and moisture content, as confirmed by testing, and surface requirements and tolerances immediately prior to placement of the surface wearing course or asphalt overlay. Be careful not to indicate acceptance until equipment and mixture is ready to be placed on the cold recycled material. The surface should be visually inspected for defects and checked with a 10 foot straight edge to ensure variations are within a ⅜ inch tolerance.

For acceptance of compaction, it is extremely important that locations of field compacted specimens and cores are accurately documented since final core or nuclear gauge density measurements are compared to the closest field compacted specimen.

This section provides means for corrective action should any of the acceptance criteria not be met, including re-recycling the material or removal and replacement with asphaltic concrete. Of particular note is that any areas removed and replaced with asphaltic concrete are accepted as cold recycled bituminous mixture and paid as the same.

409 ASPHALTIC CONCRETE (MISCELLANEOUS STRUCTURAL)

Miscellaneous structural AC is used in areas where a lower strength asphaltic concrete is acceptable to the Department, or a smaller amount of asphaltic concrete is required and it would not be practical to use a percent within limits (PWL) calculation to accept the material such as that done for end product AC. Applications include guardrail pads, temporary paving such as detours, erosion control measures, and areas where constructability issues limit compaction, spot milling, leveling, narrowing or widening of the roadway, turnouts, etc. Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. Most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for Specification 409.

Here are some important differences:

- Acceptance is based on reasonable conformance instead of sampling and testing.
- The asphalt cement and mineral admixture are not paid separately, but are included in the basis of payment for Asphaltic Concrete - Miscellaneous Structural.

Where a Miscellaneous Structural Special Mix is required, both mixture properties and compaction remain critical. However, because conditions are likely not conducive to a consistent paving operation in a linear fashion, and possibly with relatively small quantity of production, compaction will inherently be inconsistent and low tonnage precludes applying the PWL calculation. Therefore, the compactive effort must be to the satisfaction of the Engineer, and the mixture must meet the specification requirements. The Engineer may core the AC if compaction is thought to be inadequate.

409-2 Materials

Two Gradations are given in the Standard Specifications, one for lifts of two inches or less and the other for lifts greater than two inches. The mix design should be checked against this table. Both 416 and 417 mixtures may be approved for use as 409. Generally, ½ mixtures should be used for thicknesses of 2 inches or less and ¾ mixtures may be used for 2.5 inches or thicker.

For Special Mixes, the mineral aggregate must also meet the requirements for Sand Equivalent and Uncompacted Void Content. These are to ensure both durability and stability of the pavement.

The contractor may also make self directed target changes in accordance with the limitations in 409-2.04 of the stored specifications.

Bituminous material shall be a PG grade shown in the Special Provisions.

409-2.05 Sampling and Testing

While miscellaneous structural material is not required to be sampled and tested, miscellaneous structural special mix is sampled at 500 ton intervals.

409-3 Construction Requirements

The temperature of the mix discharged at the plant cannot exceed 325 degrees F. The surface temperature must be 65 degrees F or higher in order to pave.

The paver is required to have automatic screed controls and paving must be stopped if the system does not function properly.

This specification does not require the contractor to submit the daily pyrometer record.

409-3.02 Compaction

The inspector shall ensure that the surfaces on which the asphaltic concrete is to be placed is acceptable and in accordance with the Contract Plans or Special Provisions. The Resident Engineer shall select the compaction option and verify that the contractor complies with the specified procedures. In order to compact the asphalt concrete properly, the contractor should have the right type of equipment and it must be of the size required to properly perform the work specified. There is no density specification, only a method specification; so careful monitoring of the compaction operation is an important task of the inspectors. Rolling pattern and number of coverages shall be documented in the daily diary.

409-3.03 Acceptance

Test results must be within the allowable variation shown in the table, otherwise, price reductions are enforced. Similar to end product AC, an Engineering Analysis is required for the Department to consider material that failed to meet requirements to be allowed to remain in place.

410 ASPHALT-RUBBER STRESS-ABSORBING MEMBRANE

Stress-absorbing membrane interlayers (SAMIs) containing asphalt-rubber mixtures and cover material are used to reduce the onset of reflective cracking in new asphaltic concrete overlays. SAMIs are effective for pavement surfaces with general age related block cracking; they are not effective against transverse thermal shrinkage cracks or cracks that remain excessively active.

A stress-absorbing membrane is designed to both seal cracks and absorb minor future crack movements and stresses that would otherwise concentrate in the asphalt overlay. Because the membrane is rather thick, it is expected to remain intact between the two layers of asphaltic concrete without breaking or deteriorating.

The Standard Specifications for the work are quite detailed and should be followed closely. The Special Provisions for stress-absorbing membrane will identify the asphalt-rubber type and the placement dates. Stress-absorbing membrane requirements are similar to hot-applied chip seals, but there are differences that must be carefully adhered to. Proportioning of the rubber, asphalt, and extender oil must be done carefully. Chips must be pre-coated with asphalt cement; never wet the chips for dust control. Chip Seals are considered a bituminous treatment and are discussed in Chapter 404.

Covering the asphalt-rubber with chips and initial compaction must be done in the least possible time. The timing of the asphalt chip rolling operation is even more critical than with a regular chip seal and there are time and temperature limitations that must be adhered to, refer to the Table in Section 410-3.04 of the Standard Specifications. The asphalt-rubber is very sensitive to temperature variations and can be placed only at certain times of the year, depending on elevations. If the various steps in the operation are not timed correctly, there may be a loss of chips. Unlike a regular chip seal, the membrane requires approximately 4 inches of lap on the longitudinal joint.

If placed as a hot applied chip seal, the surface must be dry. If the surface has been milled, it must also be clean and meet mean macrotexture requirements.

Once placed, there is a minimum three-hour traffic free period to allow the membrane to set. Prior to the overlay, it is imperative that any loose cover material be removed by sweeping. Under most circumstances, a tack coat should be applied prior to the overlay and this is required if traffic has been allowed on the SAMI. The overlay must be placed within seven days of placing the membrane, but there is no minimum wait time beyond the initial three-hour traffic free period.

411 ASPHALTIC CONCRETE FRICTION COURSE (MISCELLANEOUS)

Miscellaneous asphaltic concrete friction course does not require that a formal mix design be developed or approved; the requirement is for the contractor to provide mineral aggregate that has been shown to meet the gradation and aggregate quality requirements in the specification. The Engineer is responsible for reviewing the proposed composite gradation and, in consultation with the Regional Materials Engineer, selecting an appropriate target binder content for production. A target binder content of 6.0% is commonly used, which is communicated to the contractor via written or email correspondence.

If a previously used aggregate composite or 407 mix design is proposed, unless the data for the aggregate is very recent, i.e. from the same paving season, the contractor must submit recent test data to confirm the properties of the proposed aggregate remain consistent with the previously approved material.

Typically, projects with a miscellaneous friction course involve small quantities or specialized work. See Subsection 407 of this manual for recommended methods and inspection checkpoint items. For instance, 407 specifies that the temperature of the mix discharged at the plant cannot exceed 325 degrees F. Although a maximum discharge temperature of 275 degrees F is provided in 411, a discharge temperature of up to 325 degrees F is frequently approved for mixtures with rubberized or polymer modified binders because these binders are less workable and more difficult to compact and achieve smoothness at lower temperatures.

411-3 Construction Requirements

Temperature just prior to compaction must be at least 200 degrees F. However, a minimum temperature of 250 degrees is recommended to ensure adequate time for compaction, especially for mixtures with rubberized or polymer modified binders. The surface temperature must be 75 degrees F or higher in order to pave. This is because ACFC is placed in thin lifts and is also very porous; it will cool very fast.

One of the most critical items to look for with significant lengths of 411 paving is to make sure that delivery of the material, if placed in windrows with belly dumps, does not outrun the paver, and also that the rollers are able to keep up with the speed of the paver, which can be rather quick compared to typical paving with dense graded AC.

The paver is required to have automatic screed controls and paving must be stopped if the system does not function properly or rollers fall behind.

The contractor is not required to submit a daily pyrometer record.

No sampling is required unless a significant deficiency in the material is observed or suspected.

413 ASPHALTIC CONCRETE (ASPHALT-RUBBER)

Asphalt-rubber asphaltic concrete (ARAC) is a dense graded hot mix similar to 406, 416, and 417, asphaltic concrete (AC), except the binder is Asphalt-Rubber instead of asphalt cement. Crumb rubber is blended with the asphalt cement to form the asphalt-rubber binder. The blending takes place in a reaction tank at temperatures between 350 degrees F and 400 degrees F for at least one hour. During this time, the rubber partially melts and is thoroughly mixed with the asphalt cement to form a binder material known as Crumb Rubber Asphalt or CRA.

Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. For the sake of brevity, most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 413. Subsection 1009 Asphalt Rubber Material will also be useful.

413-3 Materials

413-3.02 Mineral Aggregate

Existing stockpiles can be used if satisfactory documentation, and testing, for uncompacted voids (ARIZ 247) can be provided by the contractor. Samples should be taken so that the Department can perform verification testing. However, it is important to note that the use of existing stockpiles should be the exception, not the rule. The Project Supervisor needs to be in contact with the contractor early on in the project to ensure that crushing is not performed without the Department's oversight.

Another important element of mineral aggregate production is the requirement that no individual stockpile shall have more than 6.0% passing the number 200 sieve. This requirement provides the higher consistency in aggregate fines needed for asphalt-rubber. The contractor may offer to adjust the feed rates from different cold feed bins to offset the effects of an out of specification (dirtier) stockpile. This is unacceptable. Even if the contractor manages to keep the composite gradation within specifications, the resulting material will likely be near one of the gradation limits for the intermediate sieve sizes. This is not the intent of the specification, and is a violation of subsection 105.03. The intent is to provide a quality mineral aggregate for the pavement that is properly crushed and stockpiled.

413-3.03 Mineral Admixture

ARAC requires 1.0% mineral admixture to help prevent stripping. There are only two types allowed. The type will be stipulated in the mix design. The Portland cement, type II must be added as a dry powder to the mineral aggregate for mixing in the pugmill. Blended Hydraulic cement is not allowed. The lime must be hydrated and can be added as a dry powder or as a slurry (with water). Large chunks of mineral admixture are not allowed into the mix and the inspector should look for signs that these dry materials have been wetted during storage. There is another lime product called quicklime or burnt lime (CaO) that cannot be added to the mix. When CaO is mixed with water it is slaked (hydrated) which means the water is chemically combined with it. The hydrated lime called for in the specification has been slaked. It may still look like a dry powder, but there is still some water that has now been combined in it. The inspector is made aware of these differences because CaO is caustic and dangerous to handle, if blended into the asphaltic concrete it will damage it.

413-3.04 Bituminous Material

The specifications for asphalt-rubber are found in Subsection 1009 of the Standard Specifications. Type B crumb rubber is the only type allowed for ARAC. Material properties, as well as mixing, temperature, storage, and certification requirements are all found in Subsection 1009.

The contractors must submit an asphalt-rubber design showing the amount of rubber that will be blended with the asphalt cement. This must be done before a mix design can be developed.

413-4 Mix Design

Unlike AC, the Department's Pavement Materials Testing Section develops the mix design for ARAC. Some modified test procedures are used. However, a mix design cannot be performed until the contractor does an asphalt-rubber design. It is important for the Project Supervisor or Resident Engineer to make the contractor aware, as early on in the project as possible, of the need for an asphalt-rubber design.

The Resident Engineer is responsible for ensuring that the time periods for reviewing and verifying a mix design by the Department are strictly followed unless different arrangements are made in writing with the contractor. Therefore, it is important that the Resident Engineer checks with the acceptance lab to ensure that they can complete the verification testing within the prescribed time.

413-5 Mix Design Revisions

Occasionally, a revision to the mix design will be required to adjust for unanticipated or changing field conditions, or for a change in aggregate properties. When the change to a mix design is an adjustment to the asphalt-rubber content, then the contractor is not entitled to any additional costs for operating the plant or equipment. If more asphalt-rubber is needed, the Department will pay for the material at a unit price below or at the contract unit price.

Cases where a contractor is entitled to additional plant and operating costs include changes in the aggregate source, required changes in the asphalt-rubber properties, or changes in the aggregate properties themselves without changing sources. These are situations where the properties of the mix may change significantly enough to affect plant procedures and lay down or compaction methods.

413-6 Acceptance of Materials

It cannot be emphasized enough that ADOT field staff must closely monitor the crushing operation and stockpile production. Even though aggregate sampling and testing have been done during stockpile production, samples still need to be taken and tested from the cold feed during asphalt production. This serves as a final check to ensure the mineral aggregate will stay within acceptable tolerances for gradation, sand equivalence, and fractured coarse aggregate particles.

Asphalt-rubber content shall be checked at least four times a day using the contractor's nuclear gauge. See Subsection 414-6 of this manual for further information.

413-7 Construction Requirements

Please note that the requirements for incorporation of the mineral admixture into the mix are the same as for most other types of asphaltic concrete. Refer to the Construction Requirements subsection in the Asphalt Concrete section of this manual for further information and instructions.

The method in which the asphalt-rubber is introduced into the mix must be carefully inspected. On a typical batch mix or drum mix plant (refer to Exhibit AC-3), asphalt cement is stored in a storage tank, and a series of lines and pumps move the asphalt cement from the storage tank to the pugmill or drum mixer. There is an automatic feedback system that controls the amount of asphalt cement based on flow of mineral aggregate and admixture. When asphalt-rubber is used, a reaction tank is introduced between the asphalt cement storage tank and the pugmill or drum mixer. The reaction tank is used to blend together the asphalt cement and crumb rubber. The inspector may discover a line leading directly from the reaction tank to the pugmill or drum mixer with no automated control system that regulates the flow of the asphalt-rubber based on the flow of the mineral aggregate and admixture. This type of setup is unacceptable to the Department. An automated control system needs to be in place for asphalt-rubber asphaltic concrete (ARAC) mixing just like it does for regular asphaltic concrete (AC) mixing. Do not allow the contractor to manually control the addition of asphalt-rubber. This method is imprecise and prone to human error that will adversely affect the consistency of the mix produced by the plant. It is recommended that the Resident Engineer address this point at the pre-paving conference.

Another important difference in asphalt-rubber paving is that surfaces need to be tacked with asphalt cement; no cutbacks or emulsions are to be used. Although not harmful to asphalt-rubber, volatiles in asphalt-rubber can react with cutbacks and emulsions, so they will not bond as well as asphalt cement.

Specification 413 ARAC has strict air and surface temperature requirements that must be followed. There are two conditions. The first condition applies to start-up. Both the surface temperature and the air temperature must be at least 65°F, with the air temperature rising before paving can begin. The second relates to when paving must stop. In this case, if the air temperature is at or below 70°F and falling, the paving must stop.

It is important to note that this second condition does not have a surface temperature requirement. The contractor may argue that as long as the surface temperature is above 70°F, then it should be OK to continue paving, especially when it’s acceptable to begin paving when the surface temperature is only 65°F°. The inspector should not accept this argument. A falling air temperature is a good indicator that the surface temperature is beginning to fall as well; there is lag time between the two. By the time the contractor gets the plant shut down, all the asphalt placed and compacted that was delivered, the surface temperature will have dropped significantly. This is why the specification is based on a falling air temperature rather than a falling surface temperature.

Compaction requirements for ARAC are method specifications. Regardless of the lift thickness, the contractor must follow a prescribed compaction procedure and rolling pattern. All compactors must be steel wheel (no rubber tires allowed), and for lifts greater than 1 inch two of the compactors must be vibratory. Inspectors are required to continually document the contractor’s rolling operation since there are no density requirements for the finished mat. Compaction acceptance is based on rolling pattern, not density. Rolling pattern and number of coverages shall be documented in the daily diary.

The specifications require construction of a transverse construction joint if the paver is stopped for more than three minutes. This is to ensure that there is adequate time to place and compact the mix that is held in the laydown machine before the mix cools. Field personnel occasionally show some leniency in this regard for thicker lifts only, especially if weather conditions are favorable. It is suggested that the temperature of the mix in the laydown machine be closely monitored if paving is stopped for more than three minutes. Never allow an exception for thin ARAC lifts, or for AR-ACFC where the same language is found in subsection 414. Thinner lifts have more exposed surface area per volume than thicker lifts, so they will cool faster.

The Project Supervisor and Resident Engineer have some latitude in specifying how many rollers are required behind the laydown machine. Even if the production exceeds 250 tons per hour, engineering judgment may be used to determine if an additional roller is needed to obtain density.

ARAC is placed at a higher temperature than regular AC. This results in more pick-up by the steel wheel compactors. The specifications address this problem by requiring the compactor wheels to be wetted with water to prevent pick-up. Specifications also permit soapy water, or release agents evaluated through NTPEP in accordance with the requirements of Section 407-7.04 of the specifications. The Department discourages the use of lime water since it can’t be sprayed in a fine mist. The high alkalinity of the lime tends to sterilize the surrounding soils and makes landscaping or re-vegetation more difficult later on.

Additional inspection points include:

- Verify that the crumb rubber and asphalt cement have been in the reaction tank at 325°F to 375°F for at least one hour prior to use in the mix. See Subsection 1009.
- Keep a daily count of the number of bags of crumb rubber used.
- Asphalt-rubber that has been kept in the reaction tank for more than 10 hours above 325°F should not be used. Carry-over must be cooled before the 10-hour time limit and then re-heated. The specifications only allow one re-heating cycle for any particular batch. In some cases, the Central Lab can test carry-over

to see if it is still suitable. See Subsection 1009 of the Standard Specifications for further information.

For asphalt-rubber paving, the Department generally requires a full time inspector at the plant to oversee the stockpiling and batching operations, including the blending of the asphalt-rubber. The Project Supervisor should carefully outline the duties of the inspector at the plant so that the most effective use can be made of this person. Section 304 of the ADOT Training Manual for the Inspection of Bituminous Roadway Construction should serve as a guideline for assigning inspection duties.

413-8 & 413-9 Method of Measurement & Basis of Payment

The method of measurement and basis of payment for ARAC is similar to other AC except as follows:

- Asphalt-rubber is measured and paid instead of asphalt cement.
- Subsection 413-9 does not allow the 413-6.03(B) nuclear gauge test results to be used as a method of measurement for asphalt-rubber. Asphalt-rubber must be weighed directly, or calculated from the weight of asphalt cement and crumb rubber used, minus the waste.
- There are no price adjustments for compaction since the acceptance is based on rolling pattern only.

414 ASPHALTIC CONCRETE FRICTION COURSE (ASPHALT-RUBBER)

Asphalt-rubber asphaltic concrete friction course (AR-ACFC) is the asphalt rubber version of the 407 Standard Specifications for ACFC. Crumb rubber is blended with the asphalt cement to form an asphalt-rubber binder. The blending takes place in a reaction

tank at temperatures between 325 degrees F and 375 degrees F for at least one hour. During this time, the rubber partially melts and is thoroughly mixed with the asphalt cement to form a binder material.

AR-ACFC Standard Specifications are similar to the 407 Standard Specifications for ACFC in both plant and field inspection requirements. Subsection 1009 (Asphalt Rubber Material) of the ADOT Standard Specifications will also be useful. The other plant processes and field operations are nearly identical to non-AR asphalt paving. Most of the inspection procedures and documentation requirements are covered in Subsection 407 and the Asphaltic Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 414.

414-3 Materials

414-3.03 Mineral Admixture

Like ARAC, AR-ACFC uses 1.0% mineral admixture to help prevent stripping. The type will be stipulated in the mix design. Mineral admixture certification and documentation requirements are identical to those in the Mineral Admixture subsection of the Asphalt Concrete section of this manual.

414-3.04 Bituminous Material

The requirements for asphalt-rubber are found in Subsection 1009 of the Standard Specifications. Type B crumb rubber is the only type allowed for ARACFC. Material properties, as well as mixing, temperature, storage, and certification requirements are all found in Section 1009.

The contractors must submit an asphalt-rubber design showing the amount of rubber that will be blended with the asphalt cement. This must be done before a mix design can be developed.

414-4 Mix Design

ADOT produces a mix design for all asphalt-rubber products. The mix design procedure is the same as described in Subsection 413-4 of this manual. This requires the contractor to provide necessary materials to the Department, sampled under the observation of the Engineer. An asphalt rubber blend design must first be performed to confirm conformance of the asphalt rubber to Subsection 1009-2. The Resident Engineer is responsible for ensuring that the time periods for reviewing and verifying a mix design by the Department are strictly followed unless different arrangements are made in writing with the contractor.

414-5 Mix Design Revisions

Occasionally, a revision to the mix design will be required to adjust for unanticipated or changing field conditions, or for a change in aggregate properties. When the change to a mix design is an adjustment to the asphalt-rubber content, then the contractor is not entitled to any additional costs for operating the plant or equipment. If more asphalt-rubber is needed, the Department will pay for the material at a unit price below or at the contract unit price.

Cases where a contractor is entitled to additional plant and operating costs include changes in the aggregate source, required changes in the asphalt-rubber properties, or changes in the aggregate properties themselves without changing sources. These are situations where the properties of the mix may change significantly enough to affect plant procedures and lay down or compaction methods.

414-6 Acceptance of Materials

One of the primary functions of field personnel in any asphalt paving operation is the acceptance of the materials used to produce the pavement. Specifications 407, 413 and 414 are based on instructing the contractor how to produce the asphalt and how to place it. The Department takes a very active role in overseeing production and placement. The inspector must be actively involved in the acceptance of materials as they are both produced and placed. This is especially true for asphalt-rubber products.

Mineral aggregate must be sampled and tested on a daily basis as the stockpiles are being produced. Don't wait until asphalt production to start aggregate testing, it is usually too late; friction course paving progresses very rapidly. Experienced inspectors in asphalt paving know that the crushing operation has the single biggest influence on mix properties and will concentrate their efforts in that area to ensure uniformity and consistency.

If there is an existing stockpile the contractor wishes to use, then the stockpile should be sampled in several places and tested for gradation, sand equivalent, and fractured course aggregate (crushed faces). Ask the contractor for test results that were performed on that stockpile. Mineral aggregate must meet both the single and triple spec requirements. Failure to meet these requirements necessitates recalibration. If reasonable to do so, in the opinion of the Engineer, the contractor may be allowed to recalibrate on the fly, however, recalibration typically requires halting of production and running only the cold feed bins to confirm acceptable material prior to resuming production.

In addition to the mineral aggregate, the granulated crumb tire rubber, virgin asphalt, and asphalt-rubber material must be sampled and tested for acceptance. Refer to Sampling Guide, Appendix C, of the Quality Assurance Manual for specific sampling and testing requirements.

Asphalt-rubber content for process control must be measured by the contractor and witnessed by the inspector at least four times per shift using the contractor's nuclear gage. It is important for the inspector to check the contractor's nuclear gage at the beginning of the job for correct calibration to the mix (preparation of the knowns) and if desired, correlation with the Department's gages. The daily standard counts should be checked for significant variations. The equipment used by the contractor to perform this testing must be verified by the Quality Assurance Section; a complete lab inspection is not necessary.

Subsection 1009 of the Standard Specifications requires the contractor to have equipment at the plant that can be used for checking the viscosity of the asphalt-rubber. The contractor must test each batch of asphalt-rubber binder and the results are documented. Material that fails to meet the viscosity requirement is an indication of improper reaction, overheating, or inadequate crumb rubber content; material represented by failing viscosity tests should not be used.

414-6.04 Material Spread

See Asphaltic Concrete Section for requirements.

414-7 Construction Requirements

Please note that the requirements for incorporation of the mineral admixture into the mix are the same as for most other types of asphalt. Refer to the Construction Requirements sub-section in the Asphalt Concrete section of this manual for further information and instructions.

The method in which the asphalt-rubber is introduced into the mix must be carefully inspected. On a typical batch mix or drum mix plant (refer to Exhibit AC-3), asphalt cement is stored in a storage tank and a series of lines and pumps move the asphalt cement from the storage tank to the pugmill or drum mixer. There is an automatic feedback system that controls the amount of asphalt cement based on flow of mineral aggregate and admixture. When asphalt-rubber is used, a reaction tank is introduced between the asphalt cement storage tank and the pugmill or drum mixer. The reaction tank is used to blend together the asphalt cement and crumb rubber.

Typically a line will lead directly from the reaction tank to the pugmill or drum mixer with no automated control system that regulates the flow of the asphalt-rubber based on the flow of the mineral aggregate and admixture. This type of setup is unacceptable to the Department. An automated control system needs to be in place for asphalt-rubber asphaltic concrete mixing just like it does for regular asphaltic concrete mixing. Do not allow the contractor to manually control the addition of asphalt-rubber. This method is imprecise and prone to human error that will adversely affect the consistency of the mix produced by the plant. It is recommended that the Resident Engineer address this issue at the pre-paving conference.

Another important difference in asphalt-rubber paving is that surfaces need to be tacked with asphalt cement; no cutbacks or emulsions are to be used. Although not harmful to asphalt-rubber, volatiles in asphalt-rubber can react with cutbacks and emulsions, so they will not bond as well as asphalt cement.

The temperature requirements and placement dates are much more restrictive for AR-ACFC than for other types of asphaltic concrete. Strict adherence to the temperature specifications is required because AR-ACFC is placed in thin lifts that cool very rapidly. The rate of cooling is directly related to surface temperatures and weather conditions. Time available for compaction could be less than five minutes following laydown.

This quick cooling characteristic makes early compaction of the mix an important task. It is important that the right equipment be used and kept within the prescribed speed and distance from the paver. The compaction process including rolling pattern and number of coverages should be well documented in the daily diary. Pick up of the material is often a problem with compaction equipment. Do not use blotter sand to prevent pick up since the sand only clogs the pores of AR-ACFC and reduces its drainage ability. The specifications address this problem by requiring the compactor wheels to be wetted with water to prevent pick-up. Specifications also permit soapy water, or release agents evaluated through NTPEP in accordance with the requirements of Section 407-7.04 of the specifications. Although permitted by the specifications, the use of lime water should be discouraged since it can’t be sprayed in a fine mist. The high alkalinity of the lime tends to sterilize the surrounding soils and makes landscaping or re-vegetation more difficult later on.

The specifications require construction of a transverse construction joint if the paver is stopped for more than three minutes. This is to ensure that there is adequate time to place and compact the mix that is held in the laydown machine before the mix cools. The thin lift as well as the greater surface area due to the voids will cause this mix to cool very rapidly.

Some other inspection points include:

- Verify that the crumb rubber and asphalt cement have been in the reaction tank for at least one hour prior to use in the mix.
- Keep a daily count of the number of bags of crumb rubber used.
- Asphalt-rubber that has been kept in the reaction tank for more than 10 hours at temperatures above 325°F should not be used. Carry-over should be allowed to cool before the 10-hour time limit and then reheated. In some cases, the Central Lab can test carry-over to see if it is still suitable. See Subsection 1009 of the Standard Specifications for further information.

For asphalt-rubber paving, the Department generally requires a full time inspector at the plant to oversee the stockpiling and batching operations including the blending of the asphalt-rubber. Blending may occur at the asphalt terminal in the transport tankers in lieu of the contractor using a blending plant at the hot plant. The Project Supervisor should carefully outline the duties of the inspector at the plant so that the most effective use can be made of this person. Section 304 of the ADOT’s Training Manual for the Inspection of Bituminous Roadway Construction should serve as a guideline for assigning inspection duties.

414-8 & 414-9 Method of Measurement & Basis of Payment

- Asphaltic concrete is measured by the ton and paid for at the contract unit price per ton, adjusted as necessary for waste and spread.

- If the quantity in a spread lot is found to vary by more than +5%, no payment will be made for the material that exceeds the +5%, including the asphalt cement and the mineral admixture.
- Asphalt-rubber will be measured and paid by the ton.
    - Subsection 414-9 does not allow the 414-6.03(B) nuclear gauge test results to be used as a method of measurement for asphalt-rubber. Asphalt-rubber must be weighed directly, or calculated from the weight of asphalt cement and crumb rubber used minus the waste.
    - Asphalt binder penalties apply if the asphalt binder does not meet the requirements of section 1009-2.03.
    - A bituminous material price adjustment may be applicable for the asphalt cement in the asphalt-rubber blend if the 109.16 specification is included in the special provisions for each contract.
- Mineral Admixture is measured and paid by the ton, at the predetermined price established in the bidding schedule.
- When required in the Special Provisions, payment for smoothness shall be made in accordance with the requirements of Subsection 109.13 of the specifications.
- There are no price adjustments for compaction since the acceptance is based on rolling pattern only.

416 ASPHALTIC CONCRETE – END PRODUCT

It is the intent of the 416 end-product specification to allow the contractor the freedom to control the production and placement of asphaltic concrete in its entirety. With few exceptions, the contractor is responsible for meeting the specified properties of the final product and is free to determine the best way to achieve those results. It is important to note that the contractor performs the quality control. The inspector's role is more of an overseer who documents construction methods, as well as the accepting of the final product. However, when problems with the contractor's plant or paving operation arise, the inspector should closely monitor the situation and assist the contractor in reaching an expedient solution.

Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. For the sake of brevity, most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 416.

Please reference the supplemental chapter for Asphaltic Concrete for important information relating to asphaltic concrete; the subsections within this chapter are specific to only the 416 specification.

416-2 Mix Design Criteria

Specification bands are given to identify acceptable starting points for mix design; they are found in 416-2 and are not for production control. Once the mix design is complete and approved for use by the Regional Materials Engineer, there is no need for the inspector to refer to this subsection unless the contractor initiates a Self-Directed Target Change. The allowable variations to upper and lower limits of production control bands are found in 416-7.04 and are based on the target values given in the particular mix design for each individual project.

The allowances for contractor self-directed target changes are provided in the table in 416-4. Targets must remain with the design upper and lower limits found in the table in 416-2. It is good practice to forward such requests to the Regional Materials Engineer for review, however RME approval is not required.

416-3 Materials

416-3.01 Mineral Aggregate

Fine aggregate must be obtained from crushed gravel or crushed rock in accordance with subsection 416-3.01 of the Standard Specifications. All uncrushed material finer than the #4 sieve must be removed before crushing the aggregate. This will ensure that the fines are manufactured and less rounded. This helps achieve higher stability in the mix. The contractor may blend back as much as 15% natural sand (10% if the mix includes RAP) but the natural fines cannot have more than 4% passing on a #200 sieve.

Additional requirements exist for mixtures referred to as a Special Mix. This is to ensure improved stability and to accomplish this, the blend of all the fine aggregate must meet the uncompacted voids requirement, and that for both one and two crushed faces stipulated in the table notes in 416-3.04(D).

416-3.02 Mineral Admixture

For additional information see the ASPHALTIC CONCRETE GENERAL GUIDANCE Section.

416-3.03 Bituminous Materials

For additional information see the ASPHALTIC CONCRETE GENERAL GUIDANCE Section.

Prior to use, acceptable certificates of compliance will be required for each load of asphalt cement, as well as for any mineral admixture before these materials are incorporated into the project.

416-4 Mix Design

The contractor will submit the finished mix design, with the split samples used to develop it if new, to the field office. Ideally, the Materials Coordinator will witness the sampling performed and obtain material at that time for ignition furnace calibration. Before the field office forwards the mix design to the Regional Materials Engineer, the Materials Coordinator should review the mix design to ensure that all the information required by subsections 416-2 and 416-4 have been met. In addition, checking for compliance with the mix design criteria, aggregate gradation limits, and asphalt to dust ratio, the Materials Coordinator should check that the method of adding the admixture to the aggregate (with wet or dry aggregates) matches the method that will be used at the plant. Only mix designs with complete information that meet the specifications should be forwarded to the Regional Materials Engineer.

For a previously used mix design, the Resident Engineer/Materials Coordinator should still submit the design to the Regional Materials Engineer for review to determine if additional testing is needed or if recent issues have occurred when using a particular mix design.

When the Department has reviewed the mix design, the target values for each mix property (such as AC content, stability, compaction, etc.) will be established from the results of the mix design. The Project Supervisor, Materials Coordinator, and inspectors should become very familiar with these target values and a copy of the mix design should be available at the project site. The Materials Coordinator or hot plant inspector should track the target values on a daily basis in the daily diary to ensure any self-directed target changes are properly accounted for. This will make sorting out any discrepancies much easier.

416-6 Construction Requirements

Although the 416 Standard Specifications allow the contractor significant latitude on how asphalt is produced and placed, some inspections at the plant and at the project site will still be required. It is also a good idea to document the contractor’s materials handling procedures for future reference even if we do not control the individual steps of this process. For this reason, a designated hot plant inspector, who has received the proper training and experience is critical. For safety purposes the hot plant inspector must make his presence known during activities to both the plant manager and the ADOT project supervisor.

Hot plant inspection should include the following (see current Quantlist for list):

- Stock Pile Management; both mineral aggregate and RAP
- Fractionation of RAP
- Loader Operations and condition of Cold Feed Bins
- Certification of weigh and belt scales
- Water available/moisture condition of mineral aggregate prior to pugmill
- Condition of mineral admixture and means of adding to mineral aggregate
- Mix Design on hand and Hot Plant Control Room Production Targets and any adjustments made
- Sampling of Mineral Aggregate and Bituminous Material
- Introduction of any additional materials, e.g. RAP, Fiber, WMA, etc.
- Condition & Accuracy of Temperature Sensing Probe at point of discharge from mixing drum
- Temperature at Discharge from mixing drum
- Release Agent on Hand
- Cleanliness of Haul Trucks
- Method of loading Haul Trucks
- Interruptions in production or supply of a material
- Document any deviations from standard practices
- Equipment breakdown and failures

Since the contractor has the responsibility for quality control, the contractor's staff should do most of the routine inspection work. ADOT Inspectors still have some involvement during paving, but most of their effort should be focused on ensuring that both the contractor's production and QC work are done properly and consistently. See Subsection 416-6 of the Standard Specifications:

- Describes the requirements for admixture mixing and control.
- Requires the use of the automatic screed control device on laydown machines.
- Requires the contractor to submit a copy of the pyrometer record at the end of each shift.
- Specifies the use of a system to stop the mixing if mineral admixture flow is stopped.
- Requires all core holes to be patched within 48 hours
- Requires all vertical edges to be tacked as directed.
- Specifies the authority to stop the work to prevent weather conditions from damaging the asphaltic concrete pavement.

416-7 Acceptance

Although acceptance testing is done by random sampling, the inspector still has the authority under 416-7.01 to take plate samples and cores at any time and from any place if the material appears to be defective. If the inspector observes what appears to be defective material coming from behind the paver or out of the delivery trucks, then take additional samples. This direct sampling is allowed under any of ADOT's paving specifications even though some are end products. Directed samples by the Department are not allowed for any part of the statistical analysis for the lot. The inspector is reminded to review the information on stratified random sampling and to be familiar with the proper use of random number tables (see 1331-1) or a calculator as a random number generator.

For acceptance, rejection, and payment purposes, asphaltic concrete paving production is broken down into lots. The inspector must always read the specifications to determine the lot size. Under the quality lot, ADOT compares mix properties such as aggregate gradation, asphalt cement content, effective voids, and stability, with the values specified in the mix design and contract documents. If any one of these properties is in rejection, the entire lot is rejected and not just the area of pavement where the particular sample was taken. Compaction lots are handled in the same way.

Sand equivalent, fractured (faces) coarse aggregate particles, uncompacted void content, and smoothness are part of the acceptance testing, but when failures occur only the sections of pavement represented by that particular test are rejected. The contractor has the option of submitting a revised mix design or reworking the stockpiles to correct the deficiencies. Continual retesting until a passing result occurs is not a valid solution.

Significant deviations in asphalt content from the percentage called for in the design (more than ±0.2%) should be discussed and resolved with the contractor. If the plant is dedicated to exclusive production for one project, the Engineer can evaluate the asphalt content reported from the acceptance lab and compare it with the contractor's hot plant report. If the discrepancy is greater than 0.1%, a correction value should be applied.

Once a section of paving has been completed, the inspectors are now in a position to accept or reject that portion of the work. They should:

- Check for straight edge tolerances, particularly at the joints.
- Layout the compaction core locations.
- Mark lots which are rejected due to any failures in mix properties, e.g. asphalt cement content, gradation, or stability.

For each mixture-properties lot, the acceptance lab will test for gradation, AC content, effective voids, and stability; from the four plate samples. For each compaction-lot the acceptance lab will test density from the cores. They will issue the results on a form similar to the one shown in Exhibit AC-4. This form will have the pay factors computed for the lot. If an individual test result indicates failure of any of the mix properties or compaction requirements, the area represented by the samples should be observed to ensure acceptance is appropriate. However, keep in mind that lot acceptance and the pay factor adjustments are based on the percent of the lot within limits (PT value) for each respective acceptance property, not the individual test results; they pertain only to isolated areas.

Plate Sampling

Four random plate samples are taken behind the laydown machine during each lot (shift) to determine the mix property pay factors. Samples must be 75 pounds minimum. It is important that samples are indeed taken randomly and that the contractor is unaware ahead of time when the samples will be taken. Advance notice to the contractor may defeat the purpose of random sampling. During an 8-hour shift, a mix sample should be taken in each 2-hour period on a random basis within that period. This is called Stratified Random Sampling, it is generally the best method for ensuring the most representative distribution of random samples. Stratified Random Sampling is not discussed in the ADOT Standard Specifications and therefore it is neither required nor prohibited, however Stratified Random Sampling may be utilized to avoid clustering of sample locations on a project. Regardless of what method is used, it must be discussed at the pre-paving meeting, because any method used must be applied consistently and not switched to and from throughout the project.

The contractor shall have the necessary personnel on the site at all times during paving so samples can be taken on a moment's notice; 20 minutes maximum notice is permissible. The Project Lab should have the samples promptly delivered to the acceptance lab; whether that is the regional lab, the central lab, or a consultant's lab.

Unless specified otherwise, the method of administering low tonnage lots, or lots where a sufficient number of samples were not obtained should be mutually agreed upon with the contractor. Options available include obtaining additional samples through coring or jack hammering, evaluating with n = 3, or combining lots with the next day’s production. Combining this with the following day’s production is the most preferable choice.

The referee mixture-properties lot sample must be a split of the acceptance sample. The referee sample should not be taken from a separate plate. Extreme care should be taken in the handling, transporting and storage of referee samples.

ADOT must furnish acceptance test results to the contractor within four working days of receipt of the samples. The test results are reported to the contractor as soon as they are available. This allows the contractor to quickly correlate test results in order to produce the best pavement for the project. Occasionally, the acceptance lab (with the Resident Engineer's permission) may fax results directly to the contractor and the Engineer at the same time.

416-7.03 Material Spread

See ASPHALTIC CONCRETE GENERAL GUIDANCE Section for spread

416-7.05 Compaction

For lifts of 1 ½’’ or less the compaction of the AC follows a method specification and the inspector will have to monitor the temperatures and the rolling to ensure compliance with the specifications. Rolling pattern and number of coverages shall be documented in the daily diary. Although there is no compaction lot in this case there will still be a quality lot that is to be evaluated by the 4 random plate samples.

For lifts greater than 1 ½ inch there will be a compaction lot that is identical to the tonnage of the quality lot. The contractor is responsible for the compaction technique and the lot is evaluated statistically by end product methods. 20 cores will be taken from each lot at random locations. The 10 that are not used will be held for 15 days in case of a request for referee. After that time they must be discarded. Results will be furnished to the contractor within 5 working days of receipt of the samples.

Carefully review subsection 416-7.05(B) of the Standard Specifications before laying out the core locations. Inspectors must mark the exact core locations as calculated from the random numbers since bonuses and penalties are associated with the compaction core results. Furthermore, inspectors should be watchful over the contractor's coring operation so that the exact location specified is cored.

In addition to responsibility for compaction methods, the contractor is responsible for the compaction characteristics of the mix design. Field personnel should not advise the contractor on compaction procedures, so it will remain the contractor’s responsibility. The inspector should not give tacit (implied) approval of any method.

417 ASPHALTIC CONCRETE (END PRODUCT) SHRP VOLUMETRIC MIX

SHRP is the abbreviation for the Strategic Highway Research Program. The 417 specification is similar to the 416 specification in some ways but it takes advantage of new technology in the testing of the asphaltic concrete mix.

Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. For the sake of brevity, most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 417.

417-2 Mix Design Criteria

Specification bands are given to identify acceptable starting points for mix design; they are found in 417-2 and are not for production control. Once the mix design is complete and approved for use by the Regional Materials Engineer, there is no need for the inspector to refer to this subsection unless the contractor initiates a Self-Directed Target Change. The allowable variations to upper and lower limits of production control bands are found in 417-7.04 and are based on the target values given in the particular mix design for each individual project.

The allowances for contractor self-directed target changes are provided in the table in 417-4. Targets must remain within the design upper and lower limits found in the table in 417-2. It is good practice to forward such requests to the Regional Materials Engineer for review, however RME approval is not required.

417-3 Materials

417-3.01 Mineral Aggregate

Fine aggregate must be obtained from crushed gravel or crushed rock in accordance with subsection 417-3.01 of the Standard Specifications. All uncrushed material finer than the #4 sieve must be removed before crushing the aggregate. This will ensure that the fines are manufactured and less rounded. This helps achieve higher stability in the mix. The contractor may blend back as much as 15% natural fines (10% if the mix included RAP) but the natural fines cannot have more than 4% passing on a #200 sieve.

417-3.02 Mineral Admixture

For additional information see the ASPHALTIC CONCRETE GENERAL GUIDANCE Section.

417-3.03 Bituminous Materials

Prior to use, acceptable certificates of compliance will be required for each load of asphalt cement, as well as for any mineral admixture before these materials are incorporated into the project.

417-4 Mix Design

The contractor will submit the finished mix design, with the split samples used to develop it, if new, to the field office. Ideally, the Materials Coordinator will witness the sampling performed and obtain material at that time for ignition furnace calibration. Before the field office forwards the mix design to the Regional Materials Engineer, the Materials Coordinator should review the mix design to ensure that all the information required by subsections 417-2 and 417-4 have been met. In addition, checking for compliance with the mix design criteria, aggregate gradation limits, and asphalt to dust ratio, the Materials Coordinator should check that the method of adding the admixture to the aggregate (with wet or dry aggregates) matches the method that will be used at the plant. Only mix designs with complete information that meet the specifications should be forwarded to the Regional Materials Engineer.

The SHRP mix design must be formulated using the coarse or fine grading bands shown in the specifications. These bands pass below or above (respectively) the restricted zone on the gradation chart.

Overall the voids in the mineral aggregate (VMA) is lower in this type of mix. Specifications require that the lab compacted test specimens, except for Arizona Test Method 802, shall be prepared using the Gyratory Compactor in accordance with AASHTO Provisional Standard TP-4.

Fractured faces in the coarse aggregate (+ No.4 sieve) are 85% minimum with two faces instead of 70% minimum with one fractured face as under the 416 Standard Specifications. There is also a requirement for flat and elongated particles (5:1 ratio) not to exceed 10%.

417-6 Construction Requirements

Although the 417 Standard Specifications allow the contractor significant latitude on how asphalt is produced and placed, some inspections at the plant and at the project site will still be required. It is also a good idea to document the contractor's materials handling procedures for future reference even if we do not control the individual steps of this process.

For this reason, a designated Hot Plant Inspector, who has received the proper training and experience is critical. For safety purposes the Hot Plant Inspector must make his presence known during activities to both the plant manager and the ADOT project supervisor.

- Hot Plant inspection should include the following:
- Stock Pile Management; both mineral aggregate and RAP
- Fractionation of RAP
- Loader Operations and condition of Cold Feed Bins
- Certification of weigh and belt scales
- Water available/moisture condition of mineral aggregate prior to pugmill
- Condition of mineral admixture and means of adding to mineral aggregate
- Mix Design on hand and Hot Plant Control Room Production Targets (and any adjustments made)
- Sampling of Mineral Aggregate and Bituminous Material
- Introduction of any additional materials, e.g. RAP, Fiber, WMA, etc.
- Condition & Accuracy of Temperature Sensing Probe at point of discharge from mixing drum
- Temperature at Discharge from mixing drum
- Release Agent on Hand
- Cleanliness of Haul Trucks
- Method of loading Haul Trucks
- Interruptions in production or supply of a material
- Document any deviations from standard practices
- Equipment breakdown and failures

Since the contractor has the responsibility for quality control (QC), the contractor's staff should do most of the routine inspection work. ADOT Inspectors still have some involvement during paving, but most of their effort should be focused on ensuring that both the contractor's production and QC work are done properly and consistently. Subsection 417-6 of the Standard Specifications:

- Describes the requirements for admixture mixing and control.
- Requires the use of the automatic screed control device on laydown machines.
- Requires the contractor to submit a copy of the pyrometer record at the end of each shift.
- Specifies the use of a system to stop the mixing if mineral admixture flow is stopped.
- Requires all core holes to be patched within 48 hours
- Requires all vertical edges to be tacked as directed.
- Specifies the authority to stop the work to prevent weather conditions from damaging the asphaltic concrete pavement.

417-7 Acceptance

Although acceptance testing is done by random sampling, the inspector still has the authority under 417-7.01 to take plate samples and cores at any time and from any place if the material appears to be defective. If the inspector observes what appears to be defective material coming from behind the paver or out of the delivery trucks, then take additional samples. This direct sampling is allowed under any of ADOT's paving specifications even though some are end product. Directed samples by the Department are not allowed for any part of the statistical analysis for the lot. The inspector is reminded to review the information on stratified random sampling and to be familiar with the proper use of random number tables (see 1331-1) or a calculator as a random number generator.

For acceptance, rejection, and payment purposes, asphaltic concrete paving production is broken down into lots. The inspector must always read the specifications to determine the lot size. Under the quality lot, ADOT compares mix properties such as aggregate gradation, asphalt cement content, effective voids, and stability, with the values specified in the mix design and contract documents. If any one of these properties is in reject, the entire lot is rejected and not just the area of pavement where the particular sample was taken. Compaction lots are handled in the same way.

Sand equivalent, fractured (faces) coarse aggregate particles, uncompacted void content, and smoothness are part of the acceptance testing, but when failures occur only the sections of pavement represented by that particular test are rejected. The contractor has the option of submitting a revised mix design or reworking the stockpiles to correct the deficiencies. Continual retesting until a passing result occurs is not a valid solution.

Significant deviations in asphalt content from the percentage called for in the design (more than ±0.2%) should be discussed and resolved with the contractor. If the plant is dedicated to exclusive production for one project, the Engineer can evaluate the asphalt content reported from the acceptance lab and compare it with the contractor's hot plant report. If the discrepancy is greater than 0.1%, a correction value should be applied.

Once a section of paving has been completed, the inspectors are now in a position to accept or reject that portion of the work. They should:

- Check for straight edge tolerances particularly, at the joints.
- Layout the compaction core locations.
- Mark lots which are rejected due to any failures in mix properties, e.g. asphalt cement content, gradation, or stability.

For each mixture-properties lot, the acceptance lab will test for gradation, AC content, effective voids, and stability from the four plate samples. For each compaction-lot the acceptance lab will test density from the cores. They will issue the results on a form similar to the one shown in Exhibit AC-4. This form will have the pay factors computed for the lot.

If an individual test result indicates failure of any of the mix properties or compaction requirements, the area represented by the sample should be observed to ensure acceptance is appropriate. However, keep in mind that lot acceptance and the pay factor adjustments are based on the percent of the lot within limits (PT value) for each respective acceptance property, not the individual test results; they pertain only to isolated areas.

Plate Sampling

Four random plate samples are taken behind the laydown machine during each lot (shift) to determine the mix property pay factors. Samples must be 130 pounds minimum, requiring two plate samples. This is because the samples compacted in the gyratory compactor are much larger and require more material. It is important that samples are indeed taken randomly and that the contractor is unaware ahead of time when the samples will be taken. Advance notice to the contractor may defeat the purpose of random sampling. During an 8-hour shift, a mix sample should be taken in each 2-hour period on a random basis within that period. This is called Stratified

Random Sampling and it is generally the best method for ensuring the most representative distribution of random samples. Stratified Random Sampling is not discussed in the ADOT Standard Specifications and therefore it is neither required nor prohibited, however Stratified Random Sampling may be utilized to avoid clustering of sample locations on a project. Regardless of what method is used, it must be discussed at the pre-paving meeting, any method used must be applied consistently and not switched to and from throughout the project.

The contractor shall have the necessary personnel on the site at all times during paving so samples can be taken on a moment's notice (20 minutes maximum notice is permissible). The Project Lab should have the samples promptly delivered to the acceptance lab; whether that is the regional lab, the central lab, or a consultant's lab.

Unless specified otherwise, the method of administering low tonnage lots, or lots where a sufficient number of samples were not obtained should be mutually agreed upon with the contractor. Options available include obtaining additional samples through coring or jack hammering, evaluating with n = 3, or combining lots with the next day’s production. Combining this with the following day’s production is the most preferable choice.

The referee mixture-properties lot sample must be a split of the acceptance sample. The referee sample should not be taken from a separate plate. Extreme care should be taken in the handling, transporting and storage of referee samples.

ADOT must furnish acceptance test results to the contractor within four working days of receipt of the samples. The test results are reported to the contractor as soon as they are available. This allows the contractor to quickly correlate test results in order to produce the best pavement for the project. Occasionally, the acceptance lab (with the Resident Engineer's permission) may fax results directly to the contractor and the Engineer at the same time.

417-7.03 Material Spread

See ASPHALTIC CONCRETE GENERAL GUIDANCE for spread

417-7.04 Gradation, Asphalt Cement Content, and Effective Voids

The requirement for Stability testing is eliminated. Arizona Test Methods 416 and 424 are modified to replace all references to Marshall testing with Gyratory testing in accordance with the AASHTO Provisional Standard TP-4.

The UL and LL for acceptable production limits are given in four different tables depending on the maximum aggregate size and the type of mix (coarse or fine band). The inspector must be sure of which mix is being produced for the project before utilizing these tables.

Generally speaking, these mixes are allowed to be designed with larger particles and some bands are allowed a little more variation from the target value. The idea being that strong support and rock-to-rock contact along with better control of the other parameters (especially voids and compaction) will ensure a more durable pavement.

417-7.05 Compaction

For lifts of 1 ½’’ or less the compaction of the AC follows a method specification and the inspector will have to monitor the temperatures and the rolling to ensure compliance with the specifications. Rolling pattern and number of coverages shall be documented in the daily diary. Although there is no compaction lot in this case there will still be a quality lot that is to be evaluated by the 4 random plate samples.

For lifts greater than 1 ½’’ there will be a compaction lot that is identical to the tonnage of the quality lot. The contractor is responsible for the compaction technique and the lot is evaluated statistically by end product methods. 20 cores will be taken from each lot at random locations. The 10 that are not used will be held for 15 days in case of a request for a referee. After that time they must be discarded. Results will be furnished to the contractor within 5 working days of receipt of the samples.

Carefully review subsection 417-7.05(B) of the Standard Specifications before laying out the core locations.

Inspectors must mark the exact core locations as calculated from the random numbers since bonuses and penalties are associated with the compaction core results. Furthermore, inspectors should be watchful over the contractor's coring operation so that the exact location specified is cored.

In addition to his or her responsibility for compaction methods, the contractor is responsible for the compaction characteristics of the mix design. Field personnel should not advise the contractor on compaction procedures, so it remains the contractor’s responsibility. The inspector should not give tacit (implied) approval of any method.

ASPHALTIC CONCRETE GENERAL GUIDANCE (ACGG)

Description

The following acronyms are used in this chapter:

- AC Asphaltic Concrete
- ARAC Asphalt-Rubber Asphaltic Concrete
- ACFC Asphaltic Concrete Friction Course
- AR-ACFC Asphalt-Rubber Asphaltic Concrete Friction Course
- SMA Stone Matrix Asphalt
- CIR Cold In-place Recycling
- HIR Hot In-place Recycling
- BWC Bonded Wearing Course
- CRA Crumb Rubber Asphalt
- RAP Recycled Asphalt Pavement

ADOT has developed a wide variety of hot mix asphaltic concrete (AC) specifications due to the different needs, objectives, and limitations that may exist for a given project or asphalt mixture. There are dense graded hot mixes (AC,ARAC, SMA) versus open graded hot mixes (ACFC and AR-ACFC). There are hot mixes (AC and ACFC) that use asphalt cement versus hot mixes that use asphalt rubber (ARAC and AR-ACFC) for the binder. BWC is similar to both dense graded and open graded hot mixes in some respects.

Some AC specifications use similar or even identical hot mix designs, but use different contract administration requirements depending on quantity, geometric confining limitations, and need to validate acceptability. For example, end product specifications allow the contractor more freedom to control the production and placement of asphaltic concrete (416 is an example), but method specifications require the contractor to follow prescribed procedures (407 is an example). Under end product specifications, the contractor is responsible for meeting the specified properties of the final product and has more flexibility in determining the best way to achieve those results.

Materials, testing procedures, and construction requirements are basically the same for the various types of hot mix asphaltic concrete (AC) specifications used by ADOT. For the sake of brevity, most inspection procedures can be found in this manual. Subsections 407, 408, 409, 411, 413, 414, 416, and 417 of this manual will have additional instructions that supplement, or refer back to this asphaltic concrete section of the manual. The material has been condensed so the inspector can quickly review the manual.

Although materials and processes for products such as CIR or HIR may share some commonality with requirements for those materials discussed above, they may be substantially different depending on the material and application. Regardless of which material is specified, never assume the current project has the same specification as last time you used it. Always read the Special Provisions carefully to determine which specification(s) apply to the current project. This manual supplements, but does not replace the Standard Specifications, or project Special Provisions, and it is NOT a part of the contract. The inspector should review the appropriate subsections of the Standard Specifications, project Special Provisions, and this manual at the start of each new project.

The 300 (Asphalt) Series of ADOT's construction training and certification manuals, as well as the Asphalt Institute publication listed at the end of this chapter, and the AASHTO Technical Training Solutions which can be accessed online, provide excellent information on the how to of asphalt production and paving operations, hot plant and paving inspection, and quality assurance. These references describe in great detail some of the key elements of asphalt paving and plant inspections. It is highly recommended that the inspector who may be unfamiliar with recent changes in asphalt construction carefully review these references in conjunction with the material presented in this manual.

Application	Specification	Description
Asphaltic Concrete (AC)	408 (recycled) 413 (rubber) 415 (rubber) 416 (end-product) 417 (end-product) SHRP	General purpose, hot mixed, paving materials used for leveling, and base courses as well as surface courses; broadly graded, dense mixes.
Stone Matrix Asphalt (SMA)	924 (end-product)	Used where increased pavement strength, fatigue resistance, and durability are necessary. May also serve as a surface course. Is a gap graded dense mix
Asphaltic Concrete Friction Course (ACFC)	407 414 (rubber)	Open graded mixes used for riding surfaces only; expensive, but provide superior skid resistance when needed.
Bonded Wearing Course	404 (stored spec)	Used as an overlay alternative to ACFC. Mix design is similar to that for dense graded but includes some requirements similar to friction course, including quality assurance and acceptance criteria.
Miscellaneous Structural	409 (AC) 411 (ACFC)	AC with broad material bands and method rolling. Used for small project applications. Also used for special situations such as temporary detours and erosion control.

The Resident Engineer and Project Supervisor should have a basic understanding of the design concept behind each type of AC specification. For large projects, material under Section 416 or 417 Asphaltic Concrete (End-Product) is used. These paving mixtures are the workhorses of ADOTs asphalt structural paving bid items and are used relatively equally, and are in some instances interchangeable or may be substituted where other materials may have been specified. For smaller placements or where the pavement's structural strength is not critical, Section 409 and 413 miscellaneous structural mixtures are specified. If pavement structure is vital, but statistical end-product acceptance is not practical, Section 409 or 413 (Special Mix) may be specified.

Specification 407, 411 and 414 are asphaltic concrete friction courses (ACFC & AR-ACFC). These are open graded asphalt mixes that are porous and used as the final riding surface in areas where it is desirable to have enhanced wet-weather skid resistance. BWC may also be used for this type of application. Specification 414 (AR-ACFC) is the asphalt rubber version of 407. Specification 411 is only used for miscellaneous work.

ACFC 407, AC 409 and ACFC 411 paving specifications have several things in common; they are method specifications where the contractor must follow a set of prescribed procedures in producing and placing the asphalt. End product 416 and 417 specifications also use method requirements for compacting thin lifts, 1 ½" or less.

These materials have very similar inspection procedures because the specification requirements are nearly identical for production and placement, only the material properties are different with a few additional tests for rubberized asphalt mixtures. Their method of measurement and basis of payment are also similar. The Resident Engineer is responsible for identifying the need to adjust construction methods to fit field conditions.

The following table summarizes the various asphaltic concrete specifications.

Asphaltic Concrete Mix Design Criteria

Specification bands (design limits) are given to identify acceptable starting points for the mix design, but they are NOT for production control or acceptance. Once the mix design is complete and approved for use by the Regional Materials Engineer, there is typically no need for the inspector to refer to this subsection unless the contractor makes a permissible self-directed target change. End-product specifications, such as 416-7.04, will have production control bands (upper and lower limits) that are based on the target values given in the particular mix design for each individual project. Production control bands should not be confused with mix design specification bands. The production control bands are found in the acceptance subsection of the specifications.

The contractor is afforded some flexibility in the production targets for 409 (special), 415, 416, and 417, which is realized by means of a self-directed target change. These allow for reasonable adjustment of mix design targets without necessitating development of a new mix design. Because this impacts the design and possibly other mix parameters, it is always a good idea to forward such requests to the Regional Materials Engineer to ensure the change is acceptable. The Materials Coordinator must retain this documentation with the mix design and inform the laboratory supervisor to allow for the new targets to be established for determination of acceptability and pay factors for subsequent placements.

Self-directed target changes are not retroactive but apply to the subsequent paving lots, as indicated by the contractor in written correspondence to the RE. However, if applying a self-directed target change removes a lot from reject status, the original pay factor will remain unchanged prior to the target change. An Engineering Analysis will no longer be required for the Department to consider allowing the material to remain in place however the contractor must still submit a letter to the Engineer to request that the material be allowed to remain in place.

Mineral Aggregate

The biggest factors that affect the variations in asphalt mix properties are the aggregate crushing, screening, and stockpile operations. Often problems in compaction and gradation can be traced back to poor controls during crushing resulting in excessive variability. It is very important for ADOT Inspectors to carefully monitor this operation and ensure the contractor is doing all the sampling and testing properly. The contractor has complete control of the crushing operation and ADOT does not usually interfere with this unless there is a regulatory violation referred to in Subsection 1001.

It is very important for the field office to verify contractor compliance with all environmental regulations and permit requirements (local, state, and federal) for the mineral aggregate source(s). Refer to Section 1001 of both the Standard Specifications and this manual for further information and instructions. Verification is not required for established commercial sources, however, the contractor must provide a completed and signed Materials Source Environmental Analysis Update, the form may be found on ADOT's Environmental Planning web page under Materials Source Guidance. As the contractor produces the aggregate stockpiles, their QC should be closely monitoring the properties of the material to ensure both consistency and acceptability for use in asphaltic concrete mixture. This includes crushing, stockpiling methods, and stockpile management. It is appropriate for the inspector to periodically observe these processes and if any material is suspected of being deficient, sample the stockpiles to confirm properties.

Materials produced for End Product and Special Mix specification items have requirements in addition to those for Miscellaneous items. Be sure to familiarize yourself with what these requirements include.

Mineral Admixture

Typically the Department does not test mineral admixture unless a problem is suspected. Each load of mineral admixture delivered to the plant must be accompanied by a Certificate of Compliance and a Bill of Lading. The Daily Mineral Admixture Report form is found at the end of this chapter.

All asphaltic concrete items require mineral admixture as an anti-stripping additive to facilitate good adhesion of the asphalt cement to the aggregate to ensure pavements are durable during moist conditions. The mineral admixture will be 2.0% by weight of the mineral aggregate unless Immersion Compression (moisture sensitivity) testing indicates a satisfactory Index of Retained Strength, in which case it may be reduced to as little as 1.0%.

The specifications allow three types of mineral admixture (Portland Cement Type I or II, Blended Hydraulic Cement - Type IP, and Hydrated Lime). The two types of cement must be added as a dry powder to the mineral aggregate for mixing in the pugmill. The lime must be hydrated and can be added as a dry powder or as a slurry (with water).

Large chunks of mineral admixture are not allowed into the mix and the inspector should look for signs to determine if these dry materials have been wetted during storage. Contaminated mineral admixture may also cake itself to the inside of the hot plant mixing drum and then break off in chunks which become asphalt coated. Conglomerations of such defective mineral admixture may present themselves as a raveled surface or deteriorating weak aggregate and become apparent in the surface of completed pavements several days after placement

There is another lime product called quicklime (CaO) that cannot be added to the mix. When CaO is mixed with water it is slaked (hydrated) which means the water is chemically combined with it. The hydrated lime called for in the specification is slaked, but it can still look like a dry powder even though it has been hydrated with water. The inspector must be aware of these differences because CaO is dangerous to handle and if blended into the asphaltic concrete it will damage it since it remains reactive.

It is of the utmost importance that the mineral aggregate contains an adequate amount of moisture in order for the mineral admixture to remain adhered to the aggregate and serve its purpose. Look for adequate mixing in the pugmill, and if dry mineral admixture is observed blowing off the cold feed belt prior to entering the drum, require the producer (contractor) to make adjustments as needed. Under no circumstance should production be allowed without the inclusion of the mineral admixture; hot plants must be equipped with an alarm and automatic shut off if the supply of mineral admixture is interrupted, refer to section 4.03 for these requirements.

Bituminous Material

Bituminous material will be a performance grade (PG) asphalt cement or crumb rubber asphalt (CRA) and the required type will be found in the Special Provisions for the project. If the PG grade/CRA Type in the specials does not match that in the bid item list, consult the Regional Materials Engineer to determine the appropriate PG, then discuss with the project manager and contractor as soon as possible. A procedural change order may be necessary depending on which PG was included on the bid item list; the change order will be predicated on if sufficient funds exist to cover any potential cost increase.

Certificates of Compliance (CoC) or Certificates of Analysis (CoA) must accompany each load of PG asphalt along with a weigh ticket or bill of lading. Sampling and testing for PG asphalt acceptance may begin with AC production unless the asphalt cement is from a new source/supplier or recent issues with a particular material have been identified by ADOT Materials Group. For such instances, samples should be sent to the Central Lab for preliminary acceptance testing as soon as possible. The viscosity of CRA must always be verified in the field after the reaction period and prior to use.

Pretesting on material that has not been previously used is recommended, as well as when serious problems have recently been experienced with a particular source. The ADOT Central Lab may request this and will determine when pretesting will no longer be necessary.

Mix Design Procedure

Specifications require the contractor to be responsible for obtaining an acceptable material source and producing mineral aggregate that will meet all of the specifications. Utilizing mineral aggregate, crushed, processed, separated, and stockpiled, the contractor shall formulate a mix design which meets all of the specified design criteria. The mix design shall be submitted to the Resident Engineer. If CRA is being used, a rubber blend design is also required.

The Resident Engineer will submit the mix design to the project's designated Regional Materials Engineer or the State Bituminous Engineer for their review; allow up to 5 days. Before the mix design is submitted, the Resident Engineer should verify that all the information contained in the mix design is complete and meets the requirements shown in the specifications. This includes checking for an approved testing lab (identified on ADOT's List of Approved Labs) the test results on aggregates and the mix itself. A list of material sources and suppliers will be on ADOT's List of Commercial Materials Sources having completed an Environmental Analysis and the inclusion of the required certifications. The best way to check a mix design is to carefully read the Special Provisions and Standard Specifications to verify that each provision is included in the mix design.

ADOT Materials Group does not test and verify the contractor's mix design for material or volumetric properties unless there exist very specific circumstances such as the use of a new mineral aggregate source or source which has recently been problematic, e.g highly absorptive aggregate. The Regional Materials Engineer will confirm mix properties meet the project requirements and that calculations and volumetrics are correct.

When a new mix design will be prepared and submitted, the Project Supervisor should have the Materials Coordinator or an inspector witness the contractor's sampling of the aggregate stockpiles. At the same time, the materials should be gathered for the ADOT acceptance lab to perform any necessary calibrations and/or verifications for the mix.

If the contractor proposes to use a previously used mix design, samples may not need to be submitted but confirm this with the project lab. The contractor's paperwork still needs to be reviewed for compliance with the specification before forwarding to the Regional or Central lab. Occasionally the Resident Engineer or Regional Materials Engineer may want to sample the contractor's aggregate stockpiles to ensure that each material still meets the original tolerances for gradation, fractured coarse aggregate particles (crushed faces), and sand equivalent. If appropriate, the Regional Materials Engineer will approve a previously used mix design for use on a particular project. The contractor must state clearly in a written correspondence cover letter to the Department, their intent to use the previously used mix design, for what purpose (mix type/bid item), and for which project (TRACS No., Route, and Name).

The contractor may propose the use of a mix design that includes an asphalt cement of a grade that is different than that specified due to limited availability from local hot mix suppliers, or request that a mix design be approved, but with a different PG than what is shown on the design for the same reason. In either event, the Regional Materials Engineer will determine if the proposed design and/or PG are appropriate for use on the project, which may require a change order to account for a material different than what is on the bid item list.

In some instances, a 1-pt verification will be necessary to confirm volumetrics remain acceptable if a PG and PG source other than those indicated on the mix design are proposed. If the Index of Retained Strength on the original mix design is less than 90%, Immersion Compression testing is also required. The testing for a 1-pt verification typically takes at least one week. The Regional Materials Engineer will review the 1-pt verification and compare to the original mix design to ensure production will result in a viable mix for the project.

Contractor Quality Control

The Resident Engineer should discuss the contractor's quality control (QC) procedures at each weekly meeting.

QC Procedures Checklist:

- Is the sampling frequency the same or greater than frequencies shown in the Standard Specifications or Special Provisions?
- Does the QC Supervisor(s) meet all of the certification and experience requirements listed in Table 2 of *P.P.D #19 - ADOT SYSTEM FOR THE EVALUATION OF TESTING LABORATORIES*.
- Are all the testing technicians ATTI certified with the appropriate certifications as required by Table 3 of P.P.D. #19?
- Are all the elements of the contractor's QC operations adequately discussed to evaluate conformance to current industry or ADOT practices? Refer to ADOT's applicable Technical Training workbooks on bituminous pavement construction and the appropriate Asphalt Institute/FHWA publications and training workshops.
- Are there plans to do adequate testing of the mineral aggregate during crushing? As previously mentioned, crushing has the biggest impact on mix variations.

- What are their procedures for checking equipment such as the rollers, laydown machine, and plant both before and during production?
- Are the lines of authority and communication clearly established; who has the ability to reject unsatisfactory materials and workmanship, and how are necessary changes communicated?

If needed, ADOT Materials Group will provide guidance to the Materials Coordinator for evaluating the contractor's quality control (QC) procedures. However, it is the Resident Engineer who must be satisfied that the contractor's procedures (as described in the weekly meetings) are complete, credible, and an accurate portrayal of how the contractor will actually carry out the work.

Inspectors should periodically check the contractor's QC operations to ensure the procedures being used are as stipulated in the specifications..

Construction Requirements

Construction requirements for an end-product specification are often similar to a method specification, but most of the responsibility is shifted to the contractor. End-product specifications allow the contractor significant latitude on how asphaltic concrete is produced and placed, but some inspections at the plant and at the project site will still be required. Miscellaneous paving is performed under a method-specification and therefore, it is necessary for the inspector to observe and confirm paving is accomplished in accordance with specification requirements. Regardless, iIt is always a good idea to document the contractor's materials handling procedures for future reference even if we do not control the individual steps of this process. LIkewise, any conditions or actions that deviate from what would be expected given the particular bid item should be thoroughly documented.

Pre-paving Meeting

It's always a good idea before any paving operation, whether it's an AC, ARAC, ACFC, AR-ACFC, or chip seal, to hold a pre-paving meeting. The intent of the pre-paving meeting should be to have the contractor describe:

- how the plant and paving operations will be conducted
- how the work will be sequenced
- how quality control will be performed
- what are the lines of authority
- what equipment will be used
- any areas/locations thought to be structurally deficient or inadequate to support paving equipment
- what contingency plans are in place for equipment failures and weather disturbances

The Resident Engineer should be prepared to discuss how the work will be inspected, who will inspect it, and how acceptance sampling and testing will be performed. A sample agenda is shown in Exhibit AC-1.

Some important points to bring up at the pre-paving meeting include:

- how the test results will be reported to the contractor
- who will be responsible for each type of test
- procedures for joint construction
- how grades will be controlled and what type of shoes or skis should be used on the paver
- any areas of the project that require special treatment such as hand work or blade leveling
- how random sample times and locations will be established
- establishing a correlation between contractor's lab and ADOT's
- procedures for changing any of the target values
- sampling dry screened RAP for gradation and RAP binder content correction
- limitations of RAP content and RAP binder content
- how/when samples will be delivered to the lab
- haul trucks and approved release agents

- traffic control set up/take down, hot plant fire up, mix on grade times
- surface preparation and tack coat
- mat/joint compaction requirements

RE's should refer to the asphalt paving pre-activity meeting agenda and include any additional items not covered above.

Hot Plant Inspection

Hot plants used in the production of asphaltic concrete are of two general types: batch mix and drum mix (see Exhibit AC-2). Drum mix plants provide for continuous production and produce asphaltic concrete at a higher rate than do batch mix plants, and therefore, drum mix plants are the most common. The most important basic controls necessary to produce high quality asphaltic concrete within the required specifications are uniformity of grading, asphalt content, temperature, and moisture content.

If the Project Supervisor or Lead Inspector seriously doubts the ability of the contractor's plant to consistently produce asphaltic concrete that will meet all of ADOT specifications (Section 403), then a plant inspection should be performed to assure conformance with AASHTO M 156. This type of plant inspection should be the exception and not the rule and used only in situations where plant operations are clearly marginal or expected to be so. When deciding whether to place full time or part time inspector(s) at the hot plant, the Resident Engineer or Project Supervisor should consider the following:

- the quantity of asphaltic concrete to be produced
- the type of asphaltic concrete to be produced, e.g. 407, 409, 415, 414 416, or 417.
- where the asphaltic concrete will be placed, e.g. mainline, shoulders, guardrail pads, etc.
- the plant's hours of operation
- the track record of the hot plant including the consistency in producing specification asphalt
- the contractor's quality control efforts
- the current condition of the plant's equipment and the past performance of the plant operators
- long haul times and the tendency to overheat the asphaltic concrete
- the materials and equipment requirements of the inspector(s)
- the duties the inspector(s) will perform and the procedures for acceptance and rejection of materials
- how the inspector(s) will coordinate plant inspections with the site inspectors and the acceptance lab

The inspector at the hot plant has a role in producing a quality pavement that is just as important as the inspector behind the laydown machine. Experience in asphalt paving has shown that the highest quality pavements are the result of both a consistent mix that is produced at a skillfully operated plant and tight controls over placement conditions and compaction. Production is a continuous process which means the inspector must be continuously monitoring and documenting hot plant operations. The use of quantlists by inspectors can be useful in establishing these processes.

Although calibration of the plant is the contractor's responsibility, scales need to be checked for certification before production begins. This is a matter of checking for a tag or sticker from the Weights and Measures Services Division (WMSD), or a designated authority. It is best to have the scales calibrated and certified after the plant has been up and running the trial batch or lot for a few hours or a day if possible. This allows time for the scales to settle into place as the vibrations of the plant and the weight of moving aggregate or trucks can cause settlement of the scale assembly.

Control of the mineral admixture is another area that needs to be carefully checked. In a drum mix plant, the aggregate and mineral admixture is mixed together in a pugmill before being loaded into the drum. In a batch mix plant, the admixture is loaded into the batching pugmill and mixed with the dried aggregate before the asphalt cement is added.

Daily documentation of the amount of mineral admixture incorporated into the mix must be furnished. Prior to paving, the inspector should verify:

- the positive signal system and limit switch on the admixture feeder is working so when no admixture is fed into the pugmill, the plant automatically shuts down
- there is a positive means of weighing the admixture before it goes into the pugmill
- calibration of the admixture feeder. The inspector should do a manual calculation to prove that the correct number of pounds of admixture is being added to each ton of asphaltic concrete.
- Adequate moisture in mineral aggregate when combined with mineral admixture
- That the admixture will be introduced without significant loss of the product during mixing or moving on the cold feed belt

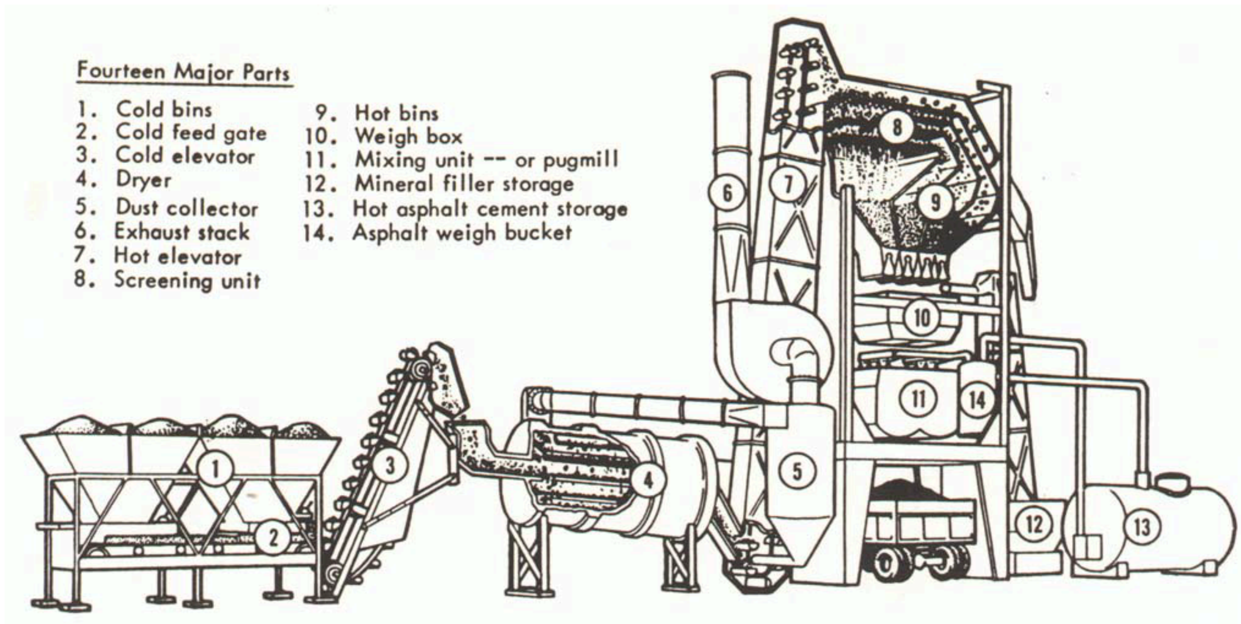
Pugmills should be checked to ensure that the material is carried at least 3 feet horizontally and that the blades are not overly worn.

The pyrometer at the discharge chute needs to be checked periodically to ensure it is accurately recording temperatures and the temperatures are within the specified maximum limits. Typical maximum temperature limits are 325^{o}F for AC (some high temperature PGs such as 76-XX may require 335^{o}F, and 350^{o}F for ARAC.

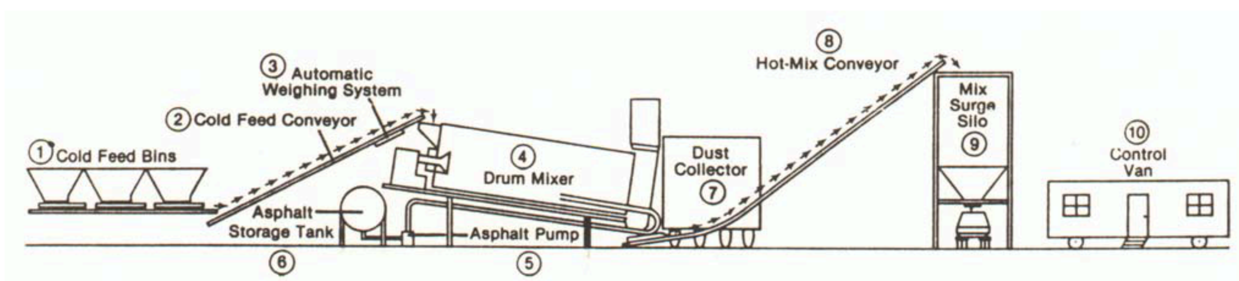
The cold feed sampling device should be checked to ensure that a representative sample can be obtained safely from the belt discharge per Arizona Test Method 105 while the plant is running. If not, the belt should be stopped and samples taken in accordance with Arizona Test Method 105. The stopped belt method is the control method in case of disagreement between the results. It is important to indicate if the sample includes mineral admixture.

Pre-paving Meeting **Project No. XXX-XXX-XX** **00/00/00** **00:00 AM to 00:00 AM** **ADOT XXXX Field Office**			
Facilitator:	Resident Engineer (RE)		
Attendees:	RE, Superintendent, paving foreman, Project Supervisor, inspectors, testers		
Please review:	Section 406, the Construction Manual, Special Provisions, Project Plan Sheets X to Y, Materials Testing Manual		
Please bring:	paving schedule, layout diagrams, TC plans, list of equipment, QC plan, sample forms and test reports, list of contacts		
----- Agenda Topics -----			
1. Introductions		RE & Superintendent	8:00-8:03 AM
2. Contractor's Schedule & Paving Layout		Superintendent	8:03-8:13 AM
3. Haul Routes & Traffic Control		TC Coordinator	8:13-8:18 AM
4. Proposed Equipment		Superintendent	8:18-8:23 AM
5. Contingencies – damaged subgrade, equip., plant failures, weather		Superintendent & RE	8:23-8:30 AM
6. Quality Control		QC Administrator	8:30-8:37 AM
7. Inspection Procedures		Project Supervisor	8:37-8:42 AM
8. Acceptance Sampling & Testing		RE & Project Supervisor	8:42-8:45 AM
9. Subgrade/Base Acceptance		RE & Project Supervisor	8:45-8:48 AM
10. Target Values & Changing Targets		RE	8:48-8:51 AM
11. Other ADOT Concerns		RE	8:51-8:54 AM
12. Safety		RE & Superintendent	8:54-8:58 AM
13. Lines of Authority & Site Escalation		RE & Superintendent	8:58-9:02 AM
14. Documentation & Payment Procedures		RE	9:02-9:05 AM
15. Q&A / Adjourn		RE & Superintendent	9:05-9:10 AM
Other information			
Observers:			
Special notes:			

Exhibit AC-1. Pre-paving Meeting Agenda



Cutaway View of Typical Batch Plant



Typical Drum Mix Plant

Exhibit AC-2. Batch And Drum Mix Plants

The following subsections describe how each element of a hot plant operates and how to inspect it.

A. Stockpiles and Cold Feeders

Stockpile management and loader operations are essential to avoid segregation, contamination, running the cold feed bins empty or causing them to become overfilled, and doing these things properly help ensure consistent asphalt production.

In order to prevent intermingling of material in the stockpiles, it is necessary to have good bulkheads or adequate separation of stockpiles. A bulkhead that does not prevent intermingling of the aggregates is of little or no value. The bulkhead should start at ground level and extend above the highest contact point of either stockpile. It should also be long enough to keep the piles completely separated.

Uniform stockpiles and good feed control are also important because a weight sensor on the feed belt monitors the aggregate flow and adjusts the asphalt cement being added.

The loader operator must not gather materials from the lowest 12 inches or so of a stockpile. Doing so may increase the amount of fines going into the mix and will interfere with gradation and mix volumetrics. This is because fines tend to accumulate in the lower portions of the stockpile as the stockpile is manipulated and sprinkled with water or it rains, and underlying soil can also become disturbed and find its way into the cold feed bins.

On drum mix plants, the cold feed control is especially important because it is the only gradation control in the plant and for ACFCs this is the point of acceptance for gradation. The stockpiles for drum mix plant operation must be very uniform. If there is moisture in the sand, it may not flow freely. A vibrator may be necessary to keep the damp sand from bridging over the gate opening. Frozen sand may also give similar trouble.

If using a batch plant, the Resident Engineer must verify the batch weights used in sampling a batch-type plant so that the composite grading can be accurately calculated.

B. Sampling of Mineral Aggregate

All samples for the purpose of accepting materials shall be taken from the hot bin, or cold feed. The sample size shall reasonably conform to the minimums recommended by the Sampling Guide Schedule.

Batch Mix Hot Plants: The inspector shall observe the contractor sample each size as the mineral aggregate is falling from the hot bin into the weigh hopper.

Drum Mix Plants: Samples of the mineral aggregate shall be taken after the various sizes are combined, by interrupting the full flow of material as it is delivered to the mixer. The contractor shall take the sample under the observation of the inspector and shall immediately furnish it to the inspector. A bucket with a sealable lid must be used to ensure accuracy of testing for moisture content.

The mechanical or manual device used for sampling must interrupt the full flow of material. It will be considered acceptable if the contractor can demonstrate to the Resident Engineer that the full flow of material can be interrupted in such a way that all portions of the flow are diverted for an equal amount of time. The ideal sampler moves laterally across the flow without excessively disrupting the large particles. This type of device satisfies the requirements, providing its speed is uniform through the flow, see Exhibit AC-3.

Other devices that travel into the flow and back out along a path perpendicular to the flow obviously have a move in time, a residence time, and an exit time. Considerable judgment may be needed to determine if the sum of the move in and move out time in ratio to the residence time is excessive. The ratio of travel time to residence time should be minimized by fast-acting systems such that the combined travel time is not greater than 10% of the residence time.

If a representative sample cannot be obtained while the belt is in motion, then the inspector has the right to direct the contractor to stop the belt so that a representative sample may be removed from a stationary section of the belt as per Arizona Test Method 105. Comparative samples may be taken at the start to reasonably assure that the sampling device does not create unacceptable systematic error, i.e. catch more rock or fines than is truly flowing into the mixer.

It will be necessary to reduce the field sample conforming to the required minimum size by a process described in AASHTO T-248. The portion selected for testing shall reasonably conform to the minimum size specified in the respective test method.

C. Drum mixer

The Drum mixer (see Exhibit AC-2) is a revolving steel drum or cylinder where aggregate is dried and heated by burning fuel oil or gas in the upper end and the asphaltic concrete is mixed in the lower end. This drum must be set up with some amount of slope along the axis of the drum or the material will not move through it efficiently. The drum at a batch plant is shorter since it is only for drying material, not mixing. The cylinder walls have cups or channels called, flights or lifting flights, spaced at intervals on the inside wall of the cylinder, in rows down the full length of the drum. The flights raise the aggregate as the cylinder turns, and drop the aggregate through the hot gasses. The heat is generated at the burner. Air is necessary to atomize the fuel oil as it is ejected from the burner nozzle to provide complete combustion, and to provide draft or suction necessary to carry combustion gasses through the drum. Mixing flights are positioned at the lower end of the drum.

When the fuel oil is not completely burned, it tends to deposit a black, oily residue on the hot aggregate particles making it difficult to coat them with asphalt. An indication of incomplete combustion of fuel oil in the drier is heavy, black smoke coming from the dryer exhaust stack. Indications of insufficient draft through the drier are spasmodic puffbacks at the combustion end of the drier, or flame entering the drum only a short distance. The flame should penetrate about one-third the length of the drum.

Common drum mix plant problems involve temperature. Either it fluctuates, or it is too high or too low. The main causes for these problems will usually be found in the cold feed. It could be moisture variation in the cold aggregates, variation in the feed rate, overloading the drier beyond its capacity to dry and heat, or a change in the character of the material. Additional causes that may contribute to the problem are over control of the burner flame, insufficient draft, and an inaccurate heat-indicating device.

D. Heat Indicating Device

It is desirable to hold the temperature of the aggregate in the drier to the minimum that will effectively dry it, allow the individual particles to be uniformly coated with asphalt, and allow for the mix to arrive at the job site at the recommended temperature. The temperature-indicating device is probably the most important single plant control accessory because the service life of the pavement is shortened if the asphalt is overheated. The following types are common:

- Thermometers (mechanical). Metal thermometers with large face dials are inexpensive, rugged, durable pieces of equipment that can be easily replaced.
- Indicating Pyrometers (electrical). This type of heat indicating device is generally a galvanometer that measures a very small electrical current induced by the heat of the aggregate passing over the sensing element.
- Recording Pyrometers (electrical). This type of instrument is similar to the indicated pyrometer except that the head is a potentiometer. Temperatures are recorded on paper in graphic form providing a permanent record. The contractor is required to give a copy to ADOT at the conclusion of each shift of production

All asphaltic concrete specifications except miscellaneous ACs, e.g. 409 & 411, require a recording pyrometer.

The sensing element should be installed at the discharge end of the drier in such a manner that the element protrudes into the flow of the mix. It may be held by set screws inside a short sleeve that is attached to the walls of the drier discharge chute. It should be located so that it is not affected by the reflected heat of the burner and is insulated from the sleeve. The sleeve may shield the element but should not delay, distort, or alter the accuracy of the temperature readings.

To check the accuracy of the heat-indicating device, an accurately calibrated thermometer and the heating device are inserted together into a hot asphalt bath that is slowly heated above the temperature range expected of the dried aggregate. The readings of the two instruments are compared. Alternatively, material from the discharge of the drum can be captured with a shovel and placed in a metal bucket and a thermometer or temperature probe inserted immediately into the material.

E. Dust Collector

Exhibit AC-2 shows typical dust collector systems. The purpose of the dust collection system is:

- Collect the fine aggregate particles floating about in the drum and various parts of the plant
- Provide the draft that carries the hot gasses through the drum via the blower for the dust collector system

Dust collectors may be the bag house type, cyclone type, or one of many different styles of wet collector.

The specifications require that the dust collector system be capable of removing dust from the aggregate, either wasting this material, or returning it uniformly to the mixer when authorized by the Department. The dust in the mix is an important fraction of the aggregate that must be strictly controlled to narrow tolerances.

Significant changes in the percent passing the #200 sieve for the mix report could be an indication that either the dust collector system is not functioning as intended, or the MA is inconsistent. The MA cold feed results should be able to capture inconsistencies in the MA (increased sampling frequency may be necessary) to isolate the cause to the dust collection system.

F. Aggregate Bins

Exhibit AC-2 shows typical aggregate bins for both drum mix plants and batch plants.

The specifications require low-level bin detectors on both batch type and drum mix type plants. Make certain that this equipment is in place and that it is operating before allowing the plant to start. On drum mix plants, the device will automatically stop the feed of aggregate and asphalt to the mixer when the level of the aggregate in any bin approaches the strike off capacity of the feed gate. On batch plants the device consists of a mechanical arm or a set of lights, one for each bin.

Typical aggregate bin problems include a shortage/excess of material in one bin or another, worn gates at the bottom of the bin which allow a leakage of aggregate into the weigh hopper, and sweating of the bin walls. This sweating condition normally occurs only at the beginning of a day's operation and does not cause much trouble after the bins reach a stable temperature.

In batch plants, the screened aggregate falls from the screens to the hot bins below. The purpose of the hot bins is to hold the heated and screened aggregate in the various desired size fractions for proportioning into the mix. It is a good practice to verify the overflow chutes from each hot bin are functioning properly and that the bin partitions have no holes in them so that the material from one bin cannot flow into and contaminate the material in an adjacent bin.

G. Mineral Admixture Feeders

Most aggregate sources in Arizona have an adequate amount of fines (- #200 sieve) to provide dense asphaltic concrete. More often than not, dust has to be removed by the dust collector or other means in order to maintain sufficient air voids in the compacted pavement.

Mineral admixture, in the form of dry lime or cement, may be added to the mineral aggregate for the purpose of improving the affinity of the aggregate for asphalt and reducing the potential for stripping.

Control of the mineral admixture is another area that needs to be carefully checked. In a drum mix plant, the aggregate and mineral admixture are mixed together in a pugmill before entering the drum. In a batch mix plant, the admixture is loaded into the batching pugmill and mixed with the aggregate before the asphalt cement is added. Subsection 403-2 describes in detail the requirements for admixture mixing and control. Before paving, the inspector should check for:

- a working interlocking device on the admixture feeder, so if no admixture is fed into the pugmill, the plant shuts down
- a positive means of weighing the admixture before it goes into the pugmill
- calibration of the admixture feeder, the inspector should do a manual calculation to prove that the correct number of pounds of admixture is being added to each ton of asphaltic concrete

H. Sampling Device

On batch mix plants, the samples of aggregate are taken from each bin as they are discharged into the weigh hopper. The specifications require that adequate facilities be provided for sampling at this location. Make certain that the facility is safe and also that representative samples are assured.

Sampling equipment should be checked with the plant operating before production is started.

As mineral aggregate flows over the plant screens, the finer particles fall through the screens first and deposit near the wall of the bin next to the head of the screen. The coarser material will travel farther across the screen and deposit on the other side of the bin. This is most common in the fines bin. This tendency is important to remember when analyzing the methods used to obtain a representative sample of the material in the bins.

It is recommended that a sampling device be used similar to that illustrated in Exhibit AC-3. Using a shovel or pan as a means of obtaining samples is not allowed because of the problem of obtaining representative samples.

On some batch mix plants, the sampling devices are a part of the plant and representative samples are secured from the material diverted into the separate compartments of the hopper.

I. Asphalt Storage Tanks

All asphalt storage tanks, feeder lines, and pumps (See Exhibit AC-2) must have heating devices and insulation to effectively maintain the asphalt at the desired temperature. The temperature of the stored asphalt should be near the required mixing temperature of the finished mix and should be checked frequently. Return lines discharging into storage tanks must be submerged below the asphalt surface level in the tanks at all times. This prevents oxidation and hardening of the asphalt since it has less exposure to oxygen in the atmosphere.

It is important to note that Crumb Rubber Asphalt (CRA) and other asphalt cements that contain granulated crumb rubber (for bituminous mixtures such as ARAC or AR-ACFC) require agitation in addition to heating. If not adequately agitated while stored, the granulated rubber and asphalt cement will separate resulting in a non-homogeneous material that will cause significant production, construction, and pavement performance problems. However, rubberized asphalt such as TR+, is not susceptible to separation/settling and therefore, agitation is not needed for TR+ binders.

Complete permanent records shall be kept of all asphalt cement delivered to the storage tanks as well as the quantity of asphalt used during the paving operation.

J. Avoiding Incorrect Asphalt Content

One of the most common causes of failure in asphaltic concrete pavements is incorrect asphalt content and the associated variability in the effective voids. The reasons for incorrect asphalt content can stem from inaccurate scales (either asphalt or aggregate), variations in aggregate grading, porosity of aggregate, incorrect mix design values, or poor interpretation of preliminary test results.

Constant attention must be paid to the scales at the asphalt plant to be sure they are functioning properly. It is a good practice to check how the asphalt cement is weighed and dispensed into the mix. The plant operator should show the inspector how the asphalt cement is weighed and the dispenser calibrated. At a batch plant this will be a type of weigh bucket with its own scale dial. On a drum mix plant the continuous flow is measured with a mass-flow meter in the supply line. Asphalt cement weights should be checked against those computed from the mix design. Whenever it is suspected that the asphalt delivery system is malfunctioning, tests should be run to verify the condition of the system.

Be aware that until a volumetric correction for the asphalt content is established by the Materials Coordinator using the RAP Spreadsheet to compare laboratory determined asphalt content to volumetric measurements of the actual quantity of asphalt used (as reported on the hot plant reports) for the first five lots of representative production, the laboratory reported asphalt content is preliminary.

K. Batch Mix Plant

Exhibit AC-2 shows a typical batch plant. The aggregate travels up a hot elevator to the screen deck of the asphalt plant. The screen deck separates the aggregate into sizes and drops each size into the proper bin. The arrangement of screens on the screen deck of a plant is usually such that the fine material is screened first, followed by increasingly larger sizes. The capacity of the fine screen is generally the limiting factor in plant production rates. A ¼ inch screen will separate approximately one ton per hour per square foot of screening area. When an attempt is made to increase production beyond the capacity of the screens causing carry-over; aggregate that does not get screened, but spills over into the next bin. Carry-over can be corrected by decreasing the rate of production, increasing the available screening area, or modifying the screen sizes and arrangement.

The capacity of the screens will be exceeded at normal production rates if the openings become plugged with material. This condition demands constant inspection and cleaning of the screens involved. Someone should inspect the screens at least once each day to make sure they are not plugged and to see that they are cleaned when necessary.

Positive evidence of carry-over is obtained from the individual bin gradation analysis. Even before sieve analysis, excessive carry-over will show during visual inspection of aggregate samples drawn from the bins. In the event such an observation is made, or a carry-over shows from test results, the material affected should be completely discharged and wasted, and the condition corrected.

The purpose of batch plant scales is to weigh the batch ingredients. The aggregate hopper and the asphalt bucket have separate scale systems. The indicators for the scale systems are usually load cells. One of the most common causes for scale malfunction is the buildup of asphalt, dust, etc. In addition, particles of aggregate can lodge in the scale supports and obstruct the free movement of the levers. Sometimes the asphalt bucket or the weigh hopper for aggregate will not swing freely, causing it to bind against another plant part.

The coarser aggregate is withdrawn from the batch plant bins first so it is deposited at the bottom of the weigh hopper and reaches the pugmill first. The tips of the mixer paddles readily pick up the coarse aggregate allowing it to scour the bottom of the pugmill, and through the movement of the coarse aggregate, to also ensure a thorough mixing of the entire mass. The sand is last because, if it were withdrawn first, it would be deposited on the bottom of the weigh hopper with the coarse aggregate on top. If the pugmill is worn so that there is an excessive clearance between the paddle tips and the liner, the sand could lay in a dead area below the reach of the paddle tips and never be picked up and mixed into the batch.

An obscure, infrequent situation may arise that could influence the bin withdrawals. In the event the aggregate being used in the mix is of low specific gravity, a much larger volume of material is needed for the same batch weight. This can cause insufficient weigh hopper capacity. If the sand is on the bottom, the coarse aggregate will sit on top rubbing against the bin gates, thereby preventing further flow of material into the weigh hopper. This results in insufficient coarse aggregate in the batch, and an inaccurate scale reading. If, on the other hand, the coarse aggregate is withdrawn first, the smaller aggregates will infiltrate into the spaces, thereby taking up less of the volume available in the weigh hopper.

At this point in the batch plant production, a timing device indicates how long the combined materials stay in the pugmill mixer. The inspector should note exactly when the timing device begins its operation. Most plants are equipped so that the timing cycle starts when the weigh hopper gates open to allow material to fall into the pugmill. This means that the mixing timing cycle has started before all of the material has entered the pugmill. It normally takes about five seconds for all the material to fall from the hopper to the pugmill. These five seconds should be deducted from the actual mixing time. Mixing time should be computed only from the time that asphalt is introduced into the pugmill. From this, it can be seen that if the timer is set for a 35 second mixing time, the actual mixing time will be approximately 30 seconds. In most cases, this need not be considered a critical item as long as the inspector realizes what is happening. The actual mixing time should be only that length of time necessary for complete coating of the aggregate particles with asphalt, and to provide a uniform homogeneous mixture. The shorter the time that the mixture remains in the pugmill, the less oxidation of the asphalt will occur. The longer the mix remains in the pugmill at elevated temperatures, the harder the asphalt becomes and, theoretically, the shorter the service life of the finished pavement.

It is important that the proper material level be maintained in the pugmill mixer. When a mixer is overloaded, a part of the material will float above the paddle tips and not be drawn down into the mixing mass. Conversely, a mixer with too little material in it will not thoroughly mix, as the tips of the paddles will rake through the material, providing little mixing action. With a proper size batch it should be possible to see the paddles as they rotate. In no instance should the depth of material in the mixer, during operation, be such that the paddles are invisible. Under most conditions, it is good practice to keep the batch sizes close to the capacity recommended by the plant manufacturer.

It is a good practice to make frequent visual checks of the mix as it is being discharged from the pugmill to the truck, and observe the top of the load as it leaves the plant. Any serious problems in the mix will probably be visible, such as segregation, too much/little asphalt, too much or insufficient heat, chunks of deleterious materials, or poor mixing. The inspector should attempt to watch as many of the discharged loads as possible, since early rejection or sampling of problem loads is clearly to everyone's benefit. The contractor may not appreciate this until it saves him or her several rejected loads at the paving site.

Some of the common causes for visible non-uniformity in the completed mix are as follows:

- insufficient mixing time
- poor distribution of asphaltic concrete across the pugmill
- poor distribution of fines in pugmill
- improper aggregate temperature
- worn paddles or liner in the pugmill
- leaking pugmill gate
- The finished product everyone is striving for is an asphaltic concrete mixture:
- with well blended aggregate having a uniform asphalt content
- mixed at a minimum temperature to allow thorough coating of the aggregate particles with the asphalt
- hot enough to allow for proper handling and compacting on the roadway

This is a difficult responsibility for both the producer and the inspector at the plant.

L. Drum Mix Plant

The principle of the drum mix plant is totally different from batch mix plants. Exhibit AC-2 shows a typical drum mix plant. There are several drum mixer designs, but they all have the common feature of simultaneous drying, heating, and asphalt coating of the aggregate. The plant consists of a cold feed system, pugmill, asphalt storage, dust collection, drum mixer, and a surge silo.

Aggregate gradation is controlled entirely by the cold feed. To be adequately controlled at the cold feed, it is imperative that very close production control is maintained when manufacturing and stockpiling the aggregate. Multiple bin feed arrangements are usually provided using individual gate controls adjustable from the control console. The aggregate feed belt incorporates a belt scale that continuously monitors the tons per hour being delivered into the plant. This aggregate delivery information is used in the asphalt pump control to meter the correct amount of asphalt cement into the mix. The belt scale must be certified for accuracy and kept in good working condition.

It is important that the proper material level be maintained in the pugmill mixer. When a mixer is overloaded, a part of the material will float above the paddle tips and not be drawn down into the mixing mass. Conversely, a mixer with too little material in it will not thoroughly mix, as the tips of the paddles will rake through the material, providing little mixing action. With a proper size batch it should be possible to see the paddles as they rotate. In no instance should the depth of material in the mixer, during operation, be such that the paddles are invisible.

The initial drying is accomplished in the upper end of the drum and as the drum rotates the aggregate falls, advancing to the lower end. In a parallel flow drum (see Exhibit AC-2) some type of shielding is used to prevent the direct flame from extending into the area where the asphalt is added. In a counterflow drum the burner extends into the drum such that the asphalt is added behind it.

The asphalt spray bar can be moved within the drum to adjust for particular problems such as a need to capture more fines or asphalt smoking because of hot aggregate. When the aggregate reaches the asphalt spray pipe, it has not lost all of its moisture. The small amounts that remain are sealed into the mix when it is compacted.

The time the aggregate is in the drum can be controlled to some extent by changing the slope of the drum. Adjusting the drum slope involves adjustments to plant accessories so it is usually not done except during the initial setup. Although it is not a popular adjustment, the Resident Engineer should know that it can be done and may effectively solve some problems.

The plant control console can adjust the aggregate asphalt proportioning, burner control, and pollution control.

When the plant is operating close to the pollution limits, small changes in the plant operation or materials can cause failure to meet air quality standards. The pollution control equipment used on a drum mix plant is similar to the types available for other kinds of plants.

Placing and Finishing

A. Plans and Specifications

ADOT field personnel are responsible for most of the inspection and quality control when acceptance is based on method specifications. One primary benefit of an end-product specification is the reduction in inspection that is required by ADOT field personnel. Since the contractor has the responsibility for quality control, the contractor’s staff should do most of the routine inspection work. ADOT Inspectors still have some involvement during paving, but most of their effort should be focused on ensuring that both the contractor's production and QC work are done properly and consistently.

The first thing the Project Supervisor and inspectors should do is become completely familiar with the plans and specifications for the job. This may sound odd as a beginning statement in describing the duties and functions of paving inspection. However, too frequently it has been observed that the inspector is merely satisfied that the material is being placed just like on the last project. The common assumption that this job specification is exactly the same as the last one is rarely true. Whether the specification is the same or not, it should be reviewed in the light of what is to be accomplished on the present job. Even with end-product specifications it is not sufficient that he or she merely sit by and observe operations as they progress. The inspector must take an active part in the actual functioning of the paving operation. The inspector should be adequately equipped with the tools for the job, such as a notebook, thermometers, string lines, straight edge, etc.

It is important for the Resident Engineer to allow adequate time for the Project Supervisor and the assigned inspectors to review the Standard Specifications, the Project Plans, Special Provisions, ADOT's training manuals on asphalt paving, and this chapter of the Construction Manual. In fact, the Resident Engineer should actively encourage the inspection staff to review all these documents prior to paving. An inspector's effectiveness can be increased enormously if that inspector has carefully read all the information available on the items of work to be inspected.

The inspector should also have a working knowledge of the construction equipment being used by the contractor. This means that he or she should know enough about it to be able to determine by visual inspection whether or not the equipment is in good mechanical condition and properly adjusted.

In addition to being present to see that the job specifications are complied with, the inspector should always be alert to see that the construction crew follows good practices and that workmanship is not substandard. Each little detail of workmanship in itself may seem insignificant, but when all the details are added together, they assume considerable magnitude. It is the attention to these seemingly minor details that can make the difference between a poor job and a good job. According to the Asphalt Institute, and assuming design and base preparation are adequate, 80% of pavements performing poorly can be traced back to poor workmanship during construction.

B. Job Site Safety

Job site safety must be observed. Often inspectors and construction workers are so absorbed in the details of their work that they overlook basic safety precautions and may take unnecessary risks. Project Supervisors should be especially on alert for safety violations during the first few days of paving. Until the operation settles into a routine where everyone is aware of what others are doing, the risk of an accident is high. In addition, it's always good to emphasize safety at the very beginning of every project so that no bad habits are overlooked.

C. Traffic Control

Before the paving begins, the Project Supervisor or Lead Inspector must ensure that the work can be done without jeopardizing the safety of the traveling public. The contractor must have traffic control devices set in place in accordance with an approved traffic control plan. Field adjustments to the plan are often needed to enhance safety and improve the continuity of the paving operation. The Project Supervisor should drive through the project a few times with the contractor's traffic control coordinator to check for conformance with the plan and make any necessary adjustments, see Subsection 701 of this manual for further instructions.

D. Subgrade and Base

Inspectors need to pay close attention to pavement subgrade and base. By now, the subgrade or base should have been inspected and approved. The inspector's job is to ensure that the subgrade and base are not damaged, disturbed, or contaminated by the contractor's paving operation. Talk to the contractor ahead of time about how delivery trucks will enter the project and reach the laydown machine. What measures are going to be used to ensure that no damage to the base occurs? What will be done if damage does occur?

The inspector will make certain that the surface upon which the asphaltic paving is to be placed is reasonably true to grade and cross section, being sound and with no soft areas or excess loose material. The smoothness of the finished riding surface is dependent to a large degree on the smoothness and firmness of the grade on which the paving is placed. Asphalt is considerably more expensive than base or subgrade materials; therefore, it should not be used as a leveling course over the less expensive materials.

It is very beneficial for the contractor and the inspector to pay attention to base density ahead of the paving train since this can in some cases affect the AC density. Any areas that appear to move under normal loads are not stable and therefore unsuitable, necessitating corrective action such as aeration, re-compaction, replacement, prime coat, cement/lime treatment, etc. It is not acceptable to pave over these areas.

Occasionally, the subgrade, base, or milled pavement will become damaged by heavy equipment traffic. The Project Supervisor, inspector, and contractor should meet before paving begins to discuss how damaged areas will be identified and repaired. It is important to have a contingency plan in place with the necessary resources so as to not unduly hold up the paving operation.

Finally, failing compaction densities for AB and/or AC, are often blamed on less than perfect subgrade conditions. Typically, the responsibility is the contractor's; however, the inspector should periodically observe the condition of the subgrade and note it in the daily diary. Observe the delivery trucks rolling over the surface to check for pumping or deflection of the base or subgrade. Report the observations in the diary. If you observe other disturbances, report them. This information could be invaluable in resolving pavement problems at a later time.

Some projects allow for only very minimal corrective work to base and/or subgrade and if such conditions prevent quality construction of the pavement, to minimize the potential for escalation or claims against the Department, the circumstances must be identified, documented, discussed with the contractor, and means of resolution determined by Partnering prior to performance of the work.

E. Scale-person (when applicable)

The scale-person will check weigh procedures at the hot plant and sign each delivery ticket. The scale-person will check delivery trucks for conformance with MVD length and weight restrictions, as well as authenticating tare weights shown on the delivery tickets. Refer to Subsection 109.01 for further information.

F. Transporting Asphaltic Concrete

The asphaltic concrete is normally transported from the central mixing plant to the spreading operation in trucks. Uniformity as to type and size of hauling equipment on the job is desirable and is often necessary for a given operation. If spreading and finishing machines are to receive the materials in their hopper directly from the trucks, the trucks must be of the end dump type, or be adaptable to the hopper to prevent spillage. They must not jar or place any vertical load on the paver while it is placing AC.

If material is windrowed in front of the paving machine by bottom dump trucks, the trucks must be of a type that will permit controlled sizing of the windrow. In this operation, the windrow is picked up by means of a windrow elevator, aka Kol-cal, and placed in the hopper of the laydown machine. The windrow elevator must be designed to carry all its weight and not put a load on the laydown machine.

More advanced equipment such as a material transfer vehicle (MTV) may be used to transfer material from the haul truck or windrow to the paver hopper. The use of MTVs is generally favorable due to the ability to reduce/eliminate both aggregate and thermal segregation as well as supply additional heat to the material during cold weather paving operations. This also may eliminate the need for haul vehicles to drive and disturb or contaminate tacked surfaces.

The problem of temperature control of the mixed materials may become acute due to:

- bunching of the trucks prior to arriving at the paver and dumping

- retention of mixed materials in the paving machine hopper
- cooling of the mixture in transit
- spreading or windrowing too far ahead of the paving machine

Any material that has cooled enough to cause it to be out of specification limits or cause poor workmanship should be rejected. The inspector should be aware that load temperatures vary according to time. Some hot plant operators do not want to run the first load any longer than normal, nor do they want to waste material. Often, the first load (possibly up to three) of the day may not meet specification. Every load should have its temperature checked at the beginning of AC shifts until they begin arriving consistently within the required temperature range. This should be documented. Also, do not hesitate to take samples for gradation and asphalt cement content testing if you suspect the first few loads don't meet the specs. If the samples fail, the pavement area represented by the samples should be rejected.

Adequate density becomes extremely difficult to achieve when the mix cools to below 180°F. Scheduling of the work to provide for completion of rolling before this temperature is reached is necessary for a durable, long lasting pavement. To achieve this in the morning is often difficult if the contractor insists on high production starts. The operation should start off slowly so that necessary joint raking/rolling/straight edging/re-raking/re-rolling are accomplished before the paver goes very far. Online or mobile app based tools such as Pavecool or Multicool are available to help inspectors estimate the time available for compaction based on mixture, grade, project, and ambient conditions.

Weigh tickets shall be collected by the inspector or the contractor's QC at the time of delivery of the material to the grade. If the contractor is taking weigh tickets for spread lots (416-7.03 and 417-7.03) the completed spread form must be turned in at the end of each spread lot (twice a day). By definition there are two spread lots per shift. The time and station should be written on the back of each ticket as it is taken. This can be invaluable when attempting to evaluate any particular situation at a later date.

G. Balancing Plant and Paver Operations

Nothing is gained by having a paving machine placing an asphaltic mixture at a rate faster than the plant can produce the mix; paving must be a continuous, uninterrupted operation without frequent stops and starts of the paver in order to achieve a smooth and uniform pavement. This condition will cause a non-uniform operation that may result in roughness and cold joints and therefore it is beneficial to pace the paving to match the operation of the plant and the delivery of the mix. When AC cools under the screed, or in the augers, it is usually below specification temperature by the time the paver moves ahead. The rollers cannot compact AC in this condition, and a high spot develops which is noticed by traffic. Balancing the loads prevents this. The paver speed (forward speed of the paver) is maintained at a rate that is in balance with the plant production and the capacity to deliver the material to the paver. Usually, it is preferred that the paver adjusts its speed. If the contractor's operations result in long delays and proper compaction is not achieved in accordance with the contract, the Resident Engineer or inspector should take action to reject non-specification material and provide proper cold joints.

When material is supplied from a commercial plant, especially when quantities are small, it will probably not be possible to balance the plant and paver. On large paving projects the Resident Engineer should expect reasonable cooperation from the supplier and contractor. A simple calculation can be made to determine the appropriate forward speed of the paver (in feet per second) based on the bulk unit weight of the AC, thickness and width of the mat being paved, number of haul trucks and truck capacity, and production rate at the hot plant. Refer to the Asphalt Institute's literature if more information is needed.

H. Correct Use of Paving Machine

The inspector should be familiar with accepted practices of operating the laydown machine, and with the principles of its mechanical operation. Teamwork between the Paving Inspector and the contractor's Foreman usually results in the best finished product.

There are several points of importance with all paving equipment that have a bearing on the quality of work that may be performed. These points of importance are concerned with the mechanical condition of the paver, as well as the adjustment of working parts. Adjustments will not mean much if the machine is in poor mechanical condition; therefore, the first and most important part of checking a machine is to see that the parts are not excessively worn or otherwise damaged.

There are several parts on a paving machine that should be checked prior to the start of paving operations, some of which should be examined periodically thereafter during progress of the job. These parts involve moving or working parts of the paver such as the tracks, tamper bar, screed, distributing augers, the engine governor, and the feeder bars in the hopper. A single check of most of these items will usually be sufficient during the life of any job. Others, however, should be checked almost daily to make sure they remain in proper operating condition.

For example, if the tracks on which the tractor portion of the paver moves are not snug, it is possible for the paver sprockets (on which the tracks are mounted) to climb the tracks with a rhythmic, bumping movement. This movement may be reflected to the screed in the rear, which in turn, may cause a ripple effect on the surface of the pavement. Normally a simple adjustment of these tracks will correct the problem.

The tractor unit and the screed unit of a laydown machine are essentially two separate units, joined by the tow arms that are connected to the tractor at the tow point with a pin. Probably the most important portion of the paving machine to observe is the screed unit. The screed unit consists of:

- The leveling arms mentioned before
- A screed plate which gives the ironing action to the mat
- On some machines a tamping bar, which is the compacting medium as well as the strike off medium for The screed (most pavers now have a vibratory screed instead)
- The thickness control (hand crank) by which the tilt of the screed plate is changed in order to increase or decrease the thickness of the mat being placed
- The augers in front of the screed, which distribute the material transversely in front of the screed plate

The augers are actually mounted on the tractor unit but function with the screed. The screed mechanism is also equipped with a heater that is used prior to starting the operation, or when air temperatures or mix temperatures are low. Heating the screed plate, when necessary, results in a smoother texture of the mat.

Control of mat thickness is maintained by adjusting the tilt of the screed plate. When the laydown machine is operating uniformly without an increase or decrease in thickness being necessary, the path of the face of the screed plate is parallel to the path of the hinge pins at the front of the leveling arms where the screed unit is connected to the tractor unit. If the screed is tilted up, it allows more material to crowd under the nose of the screed causing it to build a ramp for itself to climb until its path is again parallel to the path of the hinge pins. The distance required for this change to take place is normally 8 feet to 15 feet. Most paving machines in use now require this approximate distance to make a thickness change.

Over manipulation of the manual thickness control handles have the same effect as over controlling a motor grader or any other piece of paving equipment. Since it is known that it takes 8 feet to 15 feet for a thickness change to occur, one should then make the thickness control changes accordingly. It is quite common for inexperienced screed operators to over manipulate the controls and repeatedly overcorrect because they do not realize what is happening.

For example, they turn the handles and measure the material thickness directly behind the screed. They find no change in thickness because they measured too soon. They increase the tilt of the screed plate and measure again. By this time they may notice a thickness change resulting from the first adjustment. Suddenly, they realize that they have increased the thickness excessively. This causes them to spin the handles in the opposite direction in order to decrease the thickness. This same procedure is repeated. The result is that they have built waves into the surface of the mat being placed. Naturally, if they continue to operate in this manner, the result is a series of waves and a surface having poor riding qualities. Proper control by a skilled screed operator who looks ahead rather than behind can do much to improve the surface smoothness of the finished pavement. Too much emphasis cannot be placed on the proper operation of the thickness control handles and the trust of the automatic controls.

With the advent of the automatic screed control, the problems described above have been practically eliminated. The specifications require that all pavers have functioning automatic controls. It is useful, however, for the inspector to know the principles involved in manual control and the problems that can be encountered.

Good paver operators carefully control both the paver and haul units. In the case of a hopper-dump paver, the operator should signal the haul units to stop slightly in front of the paving unit. He or she should then move the paver slowly into the haul unit (which is waiting in neutral with the brakes off). The load can be lifted to dump while the haul unit is being pushed forward. This eliminates the sharp shove that the paver is often given when the dump truck hits the paver. It also eliminates the resulting indentation in the mat caused by the screed being shoved in reverse.

Seldom used in Arizona, but an asphalt paving best practice, is utilization of the vibrating screed feature, of which, most pavers are now equipped. If the contractor is struggling to achieve the expected initial breakdown density, turning on the vibratory screed may be all that is necessary to facilitate improved compaction. It should be noted that some materials such as Bonded Wearing Course may not benefit from the use of a vibratory screed.

The ADOT spread-person should watch the dump units to ensure that the rear wheels stay on the ground. Enforcement of this has proven to be difficult. Usually, neither the paver operator nor the driver can see those wheels, and often they don't feel that it is important. The contractor's spread-person should then assume this responsibility. The Resident Engineer should cover this with the contractor, and take action to ensure proper procedures are being followed in the event the paving crew ignores these precautions.

I. Automatic Screed Control

This device is designed to maintain desired grade and slope by automatically raising or lowering the pivot points of the screed arms to control the screed angle of attack. The elevation is controlled by a reference independent of the tractor unit of the paver, which may be a traveling ski, a string line, or a matching shoe. If this device is not working the contractor will not be allowed to pave.

Close control of transverse and longitudinal slope needs to be considered when establishing the initial control grade. When using method specifications, the Resident Engineer should work with the contractor to decide which leveling sensor will be needed if it is not specified. When using end-product specifications, the contractor is responsible for ensuring the leveling sensor will achieve proper grade control.

Cross slopes that will provide adequate surface drainage must be maintained or restored on overlay projects. Cross slope correction may result in substantial quantity variations so the District should be kept informed of the situation.

The four main components of an automatic screed control are the sensor, control box, command panel, and motors or cylinders to adjust the tow point height. The sensor gets its information from a sensing device riding on a grade reference, a ski, or shoe riding on the grade itself. The type of external reference to be used depends upon the existing surface and the desired results. If the existing surface does not provide the desired riding qualities or if it is desired to pave to a predetermined profile grade, an effective string line reference is usually a necessity. When paving a single lift, where a minimum thickness is required, a long ski should be used. The longer ski will cause the paver to lay the mat down thicker in the low spots usually giving the surface smoothness desired. The matching shoe is designed to match a previously laid adjoining mat and can also be used to match a gutter grade, providing the gutter grade is satisfactory. Remember that the laydown machine will only pave to the accuracy of the reference. It will not correct any errors in the reference. The paver itself must correct any undesirable surface texture and short span irregularities that may exist. Automatic screed controls are not designed to do this.

A paver with automatic screed control is capable of being operated in a manual, semi automatic, or fully automatic position. In manual position, the thickness of the mat is controlled with the thickness control screws - where conditions dictate. In semiautomatic position, one side of the screed is controlled manually while the other is controlled by the system – this is not allowed. In automatic position, both sides of the screed are controlled by the system and the screws are not used as overrides to change the mat thickness. In the automatic position, one side of the machine may be controlled by the sensor and the other side by the pendulum, or both sides may be controlled by sensors on separate external references.

To begin a paving operation with automatic screed controls, the screed is blocked up at the correct height, and the thickness control screws are set to give proper screed angle of attack to obtain the desired mat thickness. The slope control is set, if the pendulum is being used, and the height of the sensor is set for the external reference being used.

Once the operation has started, adjustments in mat thickness should be made with the sensor control screw. Adjustments can be made with the grade control knob on the command panel but this is not as easy or convenient. The manual screed control screws should not be used.

In order to understand the operation of the automatic screed control and to know whether it is working properly, an inspector should acquire an operation manual for the machine with which he or she is working. The contractor should be required to furnish the manual until the paving operation is completed.

J. Joints

The transverse joint is made whenever the paving is stopped long enough for the asphalt in the hopper and screed to cool below the specified temperature, during bad weather, or for any other reason. Transverse joints are usually constructed by hand. The most common way is to end the ribbon with a hand-worked face that is cut to nearly vertical, covering this with roofing paper, and throwing more AC over it to form a ramp. The next day, the material over the roofing paper is removed to expose the vertical face, the area is tacked, and paving is resumed. Sometimes boards that are the mat thickness are placed against the vertical face, and AC is ramped down from there. The inspector must be aware of the tendency to thin out the mat at the end, and should straight edge the end of the day's run. Any thin or wavy sections should be removed before continuing.

Often the ribbon will begin by butting against a sawed joint. If the sawing is very old, it will be broken-up and ragged. In this case, the butt must be re-cut. It has been found effective to wheel cut at the project limit, remove this AC, and do the work as planned. Just before paving, a saw cut can be made a couple of feet farther back, the AC removed, and the new mat butted to the existing pavement. Only the final saw cut is paid for since the first was for the contractor's convenience.

For good joint compaction, the importance of the vertical face cannot be overemphasized. In any instance where the contractor has ramped up or down, material must be cut back to vertical before paving.

Longitudinal joints shall be formed by a slope shoe,hot-lapped, or may be saw cut/milled back to a vertical face. If materials is to be removed from an unconfined edge prior to placing the adjacent mat, the Resident Engineer must first determine an appropriate width and if the removed quantity or portion thereof will be included in the lot quantity on which payment is determined. Any edge of new AC, confined or unconfined, must be compacted with a pneumatic rubber tire roller unless prohibited by the specification (BWC, SMA, etc.), or the material at the joint will be subsequently removed prior to paving the adjacent mat.

The use of a pneumatic roller is seldom enforced, but in addition to being required, is vital to ensure adequate compaction at a longitudinal joint, especially in instances where the joint is both confined and starved of material. When the joint is starved of material, there is the likelihood that the majority of the compactive effort will bridge across the joint and onto the existing adjacent surface (previous mat of AC, gutter, etc.). A pneumatic roller is better suited to compact starved joints because each tire is independent rather than a straight rigid surface.

It is a best practice to begin paving at the low end of the pavement cross section and with each adjacent ribbon placed toward the high end, place sufficient material so that the new mat is 1/16 to 1/8 inch higher at the joint (when fully compacted) than the previous adjacent mat. This ensures no starvation of material at the joint and does not interrupt the shedding of surface water during precipitation events. If the two adjacent mats are perfectly flush, there is a high probability that the joint did not have an adequate thickness of material prior to compaction. The necessary amount of material at the joint should be determined during construction of the test strip with slight adjustments made thereafter as necessary.

To ensure good compaction at a joint, the best practice is to pinch the joint so that dense material exists to both the hot and cold side of the joint before the joint itself is compacted. Compaction should first be performed with a steel drum roller as part of the initial breakdown sequence, the pneumatic roller is most often positioned as an intermediate roller or an additional roller between the breakdown and intermediate steel drum rollers.

Poor longitudinal joint compaction will present itself as either deterioration at the joint itself, or fatigue (alligator) cracking in the adjacent wheel path because a poorly compacted joint allows surface water to drain through the joint and into the base and subgrade, compromising the structural capacity of the pavement section adjacent the joint.

When possible, ADOT tries to reduce traffic exposure to unconfined edges, or vertical edges and a trench condition. Traffic should be properly maintained away from all such areas with cones or barricades, and in some instances protected by temporary concrete barrier. Exposed edges are a safety hazard to the traveling public because the abrupt drop-off may cause motorists to momentarily lose control. Work out a plan at the pre-paving meeting with the contractor so that no exposure to these joints occurs. This sometimes complicates traffic control procedures and shortens time available for construction but in the end, it is the best thing for the traveling public.

K. Outside Edges

The sloped outer edges of pavement require compaction. This part of the specification has not been uniformly enforced in the past so there may be reluctance on the part of the contractor to provide the necessary equipment to compact it in a timely manner. The Resident Engineer should not let this affect his or her enforcement of this specification.

The sloped joint for an unconfined edge that will remain in place, or a safety edge, is formed with a shoe attached to the end of the screed to form a slope of about 1.8:1 (30 degrees) beyond the screed. The width and slope will vary with the depth of the pavement being laid. The sloped edge is then compacted using a pneumatic roller. As with the rest of the pavement, the compacting must be done while the mix is hot. The density required on the sloped edge is the same as for the rest of the mat. Steel rollers cannot compact the slope. Insist that the contractor provides equipment that will do an acceptable job.

It should be noted that once the thickness of the AC becomes less than 3 to 4 times the maximum aggregate size, compaction becomes increasingly difficult and mat integrity is reduced. Therefore, attention to grading to try and accommodate an adequate thickness with consideration for the slope at an unconfined edge is appropriate.

L. Rumble Strips

The new standard for rumble strips is to cut them into the surface of the paved shoulder after the mix has been compacted and cooled. This eliminates the under-compacted shoulder issues that often occurred when forming the indentations with a special roller. Rumble strip requirements will be found under Subsection 928 of the Special Provisions.

M. Quantity and Quality Issues

The Project Supervisor should check on a daily basis, the information received from the plant on the amount of admixture and asphalt cement used. The daily batch weights for both materials should be compared with the amount of asphaltic concrete batched at the plant. The admixture can be checked against the mix design value, while the asphalt content can be checked against the daily ignition furnace values. When RAP is used in the mix, it is also important to ensure that the quantity of both the RAP aggregate and RAP binder does not exceed that indicated on the mix design.

Proper workmanship and paving practices are important, whether or not an end product specification is used. The following items should be brought to the attention of the Project Supervisor or Resident Engineer and rectified should they occur:

- paving in weather conditions unsuitable for paving
- placement and handling practices which result in segregation of the mat leaving coarse rock pockets
- rolling practices, such as vibratory rolling at cool mat temperatures or excessive pickup on a rubber tire roller, which will have a detrimental effect on the pavement surface
- excessive roughness in the finished mat
- pavement thickness measurements inconsistent with plan dimensions

Acceptance

Acceptance requirements vary for each type of asphaltic concrete specified. The inspector must always read the Standard Specifications, and Special Provisions to determine the requirements for each type of asphaltic concrete used on the project.

Directed Sampling Versus Random Lot Sampling

Although acceptance testing is done by plate sampling and coring, the specifications still give the inspector authority to take plate samples and cores at any time and from any place if the material appears to be defective. If the inspector observes what appears to be defective material coming from behind the paver or out of the delivery trucks, then take additional samples. This direct sampling is allowed under any of ADOT’s paving specifications even though some are end-product. Directed sampling by the Department is not allowed for any part of the statistical analysis for the lot. This also applies to coring. Any areas outside the random locations that appear to be under compacted should be cored.

Coring

Carefully review the specifications before laying out the core locations. An inspector should spray paint a 1-foot by 2-foot box (with the longest dimension parallel to centerline) to limit the area where cores can be taken at each location.

If the inspector doubts the authenticity of the cores, the Resident Engineer should be alerted. If it is determined that the contractor should re-core, the project personnel shall collect all the existing cores from that lot and have them promptly destroyed so they cannot be tested. The lot should be entirely re-cored using a new set of random numbers. It is important not to test two sets of cores for the same lot, since this would distort the statistical basis for the incentive/disincentive specification. Do not allow the contractor to keep the cores. Coring a second time should be done on an extra work basis, regardless of the reason.

After coring, the inspector delivers the cores to the acceptance lab. They will determine the density of each core and calculate the compaction pay factor for each lot. They will issue the test results on a form similar to the one shown in Exhibit AC-4. The form shown in Exhibit AC-4 includes the computed mixture properties, lot pay factors and the compaction lot pay factors. Plate samples are used for mixture property lots, not cores.

Retesting of Samples and the Determination of Outliers

Referee testing is used for end-product specifications. Retesting per this subsection should only be used for method specifications on an as-needed basis. When acceptance test results indicate that a contractor's material is unacceptable, the contractor may request a retest or question if some of the test results are determined to be outliers. The Resident Engineer must determine if a sample should be retested, or be regarded as an outlier. The following guidelines shall be used to determine retesting or discarding a test result as an outlier.

A. When to Retest

Retesting of a contractor's material should normally occur only after the contractor has taken corrective action. Retesting of a material that has not received corrective action should be the exception, not the rule. Certainly a material should not be retested when the sole basis is that the material failed the test, or that the test result was close to acceptable. However, there is some legitimate basis for retesting. They are:

- The test method was not followed in performing the test
- The test data was recorded in error
- The sample or area tested was clearly unrepresentative
- The sample was damaged prior to testing

In fairness to the contractor, the Resident Engineer should inquire as to the possibility of variations in testing and sampling procedures that may have skewed the test results. Testing labs are naturally apprehensive about discussing their procedures when failures do occur, so it's important that the Resident Engineer approach them as a neutral fact-finder and not one who is trying to assign blame and seek retribution.

Arizona Department of Transportation
Materials Section
Mix / Compaction Report

Project No.	Federal Project No.	Sample Date	Lot No.	Tons in Lot	Station		Station	Lane	Lift	Plans Thickness
F009201C	008-A-(233)T	01/11/2021	22	2726.96	2165+00	to	2085+00	W.B.	1	4.00

Location: Avenue 36E - MP 46

Mix Design **Effective Date** 11/12/2020

					Asphalt %	Voids	3/8	#8	#40	#200	In-Place Voids
Material Type	3/4	**with RAP**		UL	5.70	7.0	83	46	20	6.9	9.0
Marshall Density	142.4	**Admixture**	1.0	TV	5.20	5.5	77	40	15	4.9	7.0
Rice Density	150.8	**Stability**	5010	LL	4.70	3.5	71	34	10	2.9	3.5

Samples Lab - Yuma Lab

Lab Test #	Sample No.	Sample Date	Mat Code	3/8	#8	#40	#200	Stability	Bulk Density	Asphalt Content	Voids	Rice Density
21-0041	1	01/11/2021	AC	77	41	15	5.1	3350	143.9	5.31	4.3	150.4
21-0042	2	01/11/2021	AC	76	41	16	5.4	3780	145.0	5.32	3.3	150.0
21-0043	3	01/11/2021	AC	76	38	14	5.0	3410	145.0	5.17	3.8	150.7
21-0044	4	01/11/2021	AC	76	40	15	5.0	3900	144.1	5.32	4.4	150.7

Cores Lab - Yuma Lab

Core No:	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Inplace Voids:	4.4	4.7	4.7	6.0	3.7	3.9	5.6	5.9	4.5	5.7

Pay Factor Calculations - 416

	Avg	Std Dev	QU	QL	PU	PL	PT	PF
3/8"	76.3	0.50	13.400	10.600	100	100	100	$ 0.00
#8	40.0	1.41	4.255	4.255	100	100	100	$ 0.00
#40	15.0	0.82	6.098	6.098	100	100	100	$ 0.00
#200	5.1	0.19	9.474	11.579	100	100	100	$ 0.00
% Asphalt	5.28	0.07	6.000	8.286	100	100	100	$ 0.00
%Voids	4.0	0.51	5.882	0.980	100	83	83	$ -0.50
Compaction (Inplace Voids)	4.9	0.83	4.940	1.687	100	96	96	$ 0.50
Stability	3610.0	271.17						
Bulk Density	144.5	0.58						
Rice Density	150.5	0.34						

* - "% Asphalt" results includes a Tank Stick correction.

	Tons	Reject	Refereed	QLPF	Pay Adjustment	Source
Mix	2726.96	No	——	$ -0.50	$ -1363.48	ADOT Results
Compaction	2726.96	No	——	$ 0.50	$ 1363.48	ADOT Results

Mix PF Comments: ______

Compaction PF Comments: ______

[redacted]	1/12/2021	[redacted]	1/13/2021
Lab Supervisor \ Mix Pay Factor	Date:	Lab Supervisor \ Compaction Pay Factor	Date:
DocuSigned by: [redacted]	2/10/2021	[redacted]	1/25/2021
Contractor Signature:	Date:	Res Engr/Proj Supr:	Date:

Exhibit AC-4. Materials Lab Sheet

B. Outliers

Provided there is not a known testing error, a test result can only be discarded as outlier for one of two reasons. The first reason would be that the test results are outside the range of possible results. An example of this type of results would be an embankment density of 75% of the maximum density when the test area appeared to be thoroughly compacted. The second reason for eliminating a test result as an outlier, when sufficient test data is available, is on the basis of a statistical analysis. If a statistical analysis is performed, it should be performed in accordance with ASTM E 178 for a 1% significance level. A minimum of ten test results should be available in order to perform the analysis. Any test results that are outside the range of possible results should be removed prior to making the analysis. Clearly, a test value should not be regarded as an outlier if there is an assignable cause, such as plant malfunction, which results in the questioned test result.

The following table should be used as a screening tool to evaluate the potential for outliers:

Characteristics	Deviation from the Average
3/8 inch sieve	7.0%
No. 8 sieve	6.0%
No. 40 sieve	3.0%
No. 200 sieve	1.0%
% asphalt	0.5%
% voids	1.5%
Compacted Density	5 lb.

This table is intended as a screening tool only. The values in this table are based on the analysis of actual lot data. If the values in this table are exceeded, a statistical calculation for outliers should be made. Exhibit AC-5 is a form with a completed example that can be used for a statistical outlier analysis.

If a test result is determined to be an outlier for the reasons noted above, the results should be discarded. If an outlier is determined, there may be sufficient data available in the remaining samples to calculate pay factors. Provided the contractor is agreeable, as few as 3 mix samples or 7 cores may be used to calculate lot pay factors. Calculating the lot pay factor on a reduced number of samples is preferable to attempting to obtain additional samples, because of the difficulty in obtaining a representative sample from a completed roadway. Retesting of a sample to replace an outlier should only be attempted if the test area is accessible and a representative sample can be obtained.

There is no substitute for good judgment in review and use of test results to determine the acceptability of material. When not abused, the prudent use of a retest to fairly evaluate material acceptability or the elimination of test data that is clearly incorrect are both actions that are necessary for good contract administration.

Table for Critical Values for T									
Number of Observations n	Upper 1% Significance Level	Number of Observations n	Upper 1% Significance Level	Number of Observations n	Upper 1% Significance Level	Number of Observations n	Upper 1% Significance Level	Number of Observations n	Upper 1% Significance Level
10	2.410	20	2.884	30	3.103	40	3.240	50	3.336
11	2.485	21	2.912	31	3.119	41	3.251	55	3.376
12	2.550	22	2.939	32	3.135	42	3.261	60	3.411
13	2.607	23	2.963	33	3.150	43	3.271	70	3.471
14	2.659	24	2.987	34	3.164	44	3.282	80	3.521
15	2.705	25	3.009	35	3.178	45	3.292	90	3.563
16	2.747	26	3.029	36	3.191	46	3.302	100	3.600
17	2.785	27	3.049	37	3.204	47	3.310	110	3.632
18	2.821	28	3.068	38	3.216	48	3.319	120	3.662
19	2.854	29	3.085	39	3.228	49	3.329	140	3.712

STATISTICAL ANALYSIS FOR OUTLIERS USING ASTM E178 AT A 1% SIGNIFICANCE LEVEL

Definition of Terms:

Term	Description
T	Test Criterion (Obtained from the Table Below)
Avg.	Average of the Test Data
Std.	Standard Deviation of the Test Data
LO	Lower Outlier Limit
UO	Upper Outlier Limit
n	Number of Samples

Statistical Analysis Procedure:

1) The average and standard deviation for the test data is calculated.
2) Using the following formulas and the table below, the lower and upper outlier limits are determined.

   LO = Avg. - T*Std

   UO = Avg. + T*Std

3) Test data which falls outside of the lower and upper outlier limits is discarded, provided there is no assignable cause for the occurrence of the result in question.

Example:
Assume: Avg. = 145.0 Std. = 2.1 n = 10 Then T = 2.41 - and -

LO = 145.0 - 2.1*2.41 = 139.9 UO = 145.0 + 2.1*2.41 = 150.1

Exhibit AC-5. Statistical Outlier Analysis

Changes to the Mix Design

On occasion, contractors may request revisions for certain measured characteristics of the mix design. Two methods are normally utilized for such requests:

A. New Mix Design

In accordance with the specifications, a new mix design is fully allowable. However, the new mix design should be thoroughly reviewed to assure that it contains all the required information, and that the mix design values comply with the specified requirements. A maximum of one working day is allowed for this review. Please note that it will be necessary to determine a new sand equivalent, fractured coarse aggregate particles, uncompacted void content, and ignition furnace calibration if new materials are utilized and/or percentages of existing stockpiles are revised.

B. Mix Design Changes Based on Asphaltic Concrete Test Values

In some instances, contractors may request revisions (referred to as a self-directed target change) based on production test results, especially if they are producing material that tends to vary significantly from the mix design and may possibly subject them to penalty. Therefore, this type of mix design change should only be approved on the basis of an engineering evaluation, and with the concurrence of the ADOT Materials Group.

Changes to Compaction Requirements

A. General

The most-often-requested change by the contractor usually contends that the specified compaction requirement cannot be met because of one or more of the following reasons:

- The underlying surface does not provide a suitable platform for compaction
- The existing pavement surface is too variable to obtain compaction
- The mix is stiff and difficult to compact
- The mix is tender and can be over-rolled before compaction is attained
- Unknown, however, every possible means has been utilized to obtain compaction, without success

If these reasons do not get to the cause of the compaction problem, several different factors may affect how well an asphalt mix is compacted.

B. Factors Affecting Compaction

Normally, the following influence the ability to compact a lift of asphaltic concrete:

- Air temperature and wind speed
- Temperature of the mix and underlying pavement during the compaction process
- Lift thickness
- High stability/low flow mixture
- Tender mix (usually a very fine graded mix or one with well-rounded fine aggregate)
- Type and number of compaction equipment, including ballasted weight
- Sequence and timing of compaction equipment
- Number of passes and amount of coverage of each piece of equipment
- Operation of equipment including:
    - Speed (should be operated within the manufacturer's recommended speeds)
    - Tire pressures on pneumatic rollers
    - Frequency and amplitude on vibratory rollers
- Inconsistent compaction effort (constant stopping/starting of the laydown machine results in some areas receiving greater rolling than others and inconsistencies in temperatures during rolling)

- Condition of underlying material (subgrade, base, previous lift, or old pavement)
- Plant production rate
- Mixture and temperature segregation

The consistency of the compactive effort and the values obtained are also very important. It is possible (via highly variable results which indicate inconsistent compaction) to have most of the core densities show results above the target and still have to assess a significant penalty. This is directly related to the statistical basis for the PU and PL tables found within the specifications. The inspector must understand that consistent compaction is the solution to this problem.

C. Procedure for Resolving Requests for Revision of Requirements

In most cases, requests to waive the compaction requirements will begin after the contractor is notified of material with a penalty or rejection due to compaction. This ordinarily occurs at the beginning of paving or after the weather cools. Upon notification by the contractor that relief is being requested, the District and acceptance lab shall be advised. The Resident Engineer shall contact ADOT's Pavement Materials Testing Section for assistance and input at this time, and at each further step as outlined below. In addition, the FHWA Area Engineer should be advised if the project funding includes federal-aid.

At the earliest notice that the contractor is experiencing difficulties in obtaining compaction, the Resident Engineer may begin to monitor and document the efforts made by the contractor to obtain compaction.

Most specifications advise the contractor that quality control is his or her responsibility. Therefore, it is expected that he or she will be actively engaged in this function through test strips, nuclear densities, and informational cores.

The following items should be included if relief is requested by the contractor:

- Written justification
- Documentation of compaction operations including:
    - Temperatures of the mix at discharge from the hot plant and during each stage of compaction. This should be documented several times throughout the day
    - Production rate in tons per hour
    - Roller weights (from truck scales)
    - Rolling pattern-sequence, amount of coverage, number of passes and speed of each roller (include manufacturer's recommendations)
    - Tire pressures, frequency, and amplitude during various roller sequences and coverages
    - Statement regarding operating conditions of rollers
    - Analysis of weather conditions, specifically temperatures, winds, and effect on compaction
- Nuclear gauge and core results for each contractor test strip, and for other compaction quality control measures taken by the contractor
- Analysis of mix data for factors influencing compaction such as stability, flow, asphalt content, and gradation

Upon receipt of the written request, the Resident Engineer shall immediately review it to assure that it contains sufficient documentation, and that the contractor has made a comprehensive effort to obtain compaction. If not, the written request shall be promptly returned to the contractor with a letter outlining the reasons for rejection.

Among the factors most easily overlooked by the contractor in obtaining compaction are the characteristics of the mix he or she has provided. Should test results indicate a stiff or tender mix, the contractor has the responsibility to submit a revised mix design. A poorly conceived mix design is not justification for lowering density targets.

Frequently, the contractor's compaction difficulties can be traced to marginal weather conditions. In some cases, the logistics of construction, or the safety and convenience of the motorists make postponement of paving a less desirable alternative than the completion of the paving with a lowered compaction requirement. Such a decision can only be made with the concurrence of the District, Deputy State Engineer, and the FHWA (if applicable).

Should it be determined that adequate justification and documentation has been provided, the contractor's request should be promptly reviewed and accepted by the Engineer. This may be accomplished in the following manner:

- Verify roller weights
- Verify operating conditions of rollers
- Verify hot plant pyrometer readings and production rates
- Verify mix temperatures during compaction
- Verify weather conditions

Should this verification indicate discrepancies or deficiencies that, in the opinion of the Resident Engineer, are sufficiently significant to invalidate the contractor's justification, the request shall be promptly returned to the contractor with a letter outlining the reason(s) for the rejection.

Compaction

Adequate compaction is vital to the success of asphalt pavements. Good compaction can often offset some of the other deficiencies in asphalt mixes and lead to a long lasting durable pavement. Asphalt pavements are designed to achieve a critical range of effective voids in the mix when compacted as specified. Too much or too little compaction can be harmful to the performance of the pavement.

Compaction methods are specified according to the nominal thickness of the layer being placed. The nominal thickness referred to in the specifications is the thickness of each individual layer shown in the typical section drawing of the project plans. For thick lifts the end-product specification will apply. For thin lifts, the method specification will apply. The definition and treatment of thick lifts and thin lifts varies so the inspector must read the specifications for each type of asphaltic concrete.

The contractor may request permission to place the pavement in a thickness less than or greater than the nominal lift thickness shown on the plans. They may be permitted to do so provided that compaction, testing, and acceptance of density is done in the manner required by the plan's original nominal thickness.

Which types of compactors should be used, and in what sequence, can vary. The ADOT specifications approach the problem in several different ways. The end-product specification will require a density to be achieved and leave it completely in the contractor's hands to select the type, size, and application of the equipment. Method specifications allow several different options. Each option will state which type and size of equipment must be used and will require a specific number of coverages by each type. ADOT may require end-product and/or method specifications to best fit the particular needs of the project. End-product specifications are used to ensure quality of high production paving operations. Method specifications are normally used for thin lifts, small quantities, or areas that are hard to construct such as turnouts, narrow widening, and leveling courses. When the Resident Engineer has the option to select the compaction method, it should not be based entirely on the contractor's available equipment. Pick a method that is best for the pavement taking into account subgrade condition, mix properties, weather conditions, available equipment, and constructability.

A. Types of Compaction Equipment (Rollers)

There are three basic types of compaction equipment used on asphalt pavement:

1. The pneumatic compactors have rubber tires and may be equipped so that tire pressure can be changed on-the-run. To be acceptable, the tires must be enclosed to retain the heat, which prevents asphalt sticking to the tires. The compactors are equipped with a means of wetting the tires, usually by spraying water onto mats that uniformly wet the tires. The mats are retractable so they can be raised when the

machine is running with dry tires. The individual wheels are built to move up or down (oscillate) so that they will conform to irregularities in the roadway while still maintaining compactive forces. The rubber tires impart a kneading motion that some authorities believe improves inter-particle contact and helps to fill surface irregularities in the base. It is important that all tires are inflated to the same pressure and that the correct amount of ballast is being carried. It may be necessary to adjust the tire pressure but the highest possible tire pressure will usually give the best performance. Rubber tired equipment will often heal cracking or surface looseness that has developed under steel wheeled compactors.

2. Steel wheel compactors are simply large, smooth steel cylinders equipped with a device for wetting the drum to prevent pick up of asphalt. The cylinders are designed to be ballasted, which may be necessary to meet the individual wheel loading called for in the contract specifications. The manufacturer's operator’s manual contains information on weights carried by each axle; empty and ballasted. The contractor should allow the Resident Engineer to check this information to be sure the drive wheel carries the specified weight. Most steel wheel rollers are designed to be loaded heavier on the drive wheel than on the guide wheel. The gross weight must be obtained within the manufacturer's recommendations. This makes it important to check the operating literature of the roller.

3. Vibratory compactors used on asphaltic concrete are steel wheel compactors having an internal vibration mechanism. The control for the frequency and amplitude of the vibration function can be turned off and the unit used as a static compactor. The contractors generally like the vibratory units because, for most situations, they achieve density faster and with less equipment than other combinations of machines. If the contractor proposes using a vibratory compactor in the static mode, the manufacturer's literature should be checked to determine whether the unit will meet the weight requirements. Some vibrators will not be heavy enough to meet the static load specification.

All compactors tend to pick up asphaltic concrete, especially when the compactors are cold, so they have been designed to minimize the problem. Steel wheels are usually kept wet with clean water. After they get hot, a minimum amount of water should be used. Pneumatic tired compactors are required to have skirting which will reduce heat loss so the machine can be run with hot dry tires. The tires will pick up asphalt pavement until they are heated adequately. A built in water system is used to prevent pickup until the tires are heated. The wetting should be stopped as soon as possible.

Some roller operators feel the reason that they can't get close to the paver is the AC is too hot. They think the proof is that their rollers are picking up the AC. The truth is the AC is rarely too hot, but the roller wheels are just too cold. The operators should gradually get closer, heating their wheels as they do. The pick-up will stop when the wheels get hot enough. Eventually, rollers can usually operate immediately behind the screed, where they should be.

If the contractor elects to use release agents other than water to wet rubber or steel tires, the specification requires the release agent to be approved by the Resident Engineer. Acceptable agents are usually some kind of detergent or non-solvent. Fuels and solvents may not be used. Release agents previously approved for use may be found on the Approved Products List.

B. Rolling Pattern Calculations

It is necessary to consider a number of factors other than density when a rolling pattern is set up. When using vibratory equipment, the frequency being used must be matched to the speed of the compactor if pavement ripple is to be kept under control.

Speed of the compactors has to be matched to the paver speed and time available for compaction as governed by the temperature of the asphaltic concrete. Slowing the last couple of passes is preferable to stopping the rollers, since resting on the mat causes it to sink into the mat and a sitting roller has tires/wheels that are cooling off. When a roller has to stop, it should be moved off the hot mat.

In some cases, it may be necessary to adjust production rates or add compactors in order to meet all the criteria relating to time, temperature, and equipment requirements.

Widely accepted top speeds of compactors are 3 mph for steel wheel rollers, and 5 mph for rubber tire rollers. However, observation and manufacturer's literature may modify these initial estimates.

The first concern is the compaction time: How much time is available to compact the pavement under the conditions of a given base temperature and mix temperature at the time of laydown?

Although there are no end-product specifications for lift compaction to be finished within a given temperature range, the Resident Engineer and inspector should be aware of the factors involved. On thin lifts ADOT requires that initial (or breakdown) and intermediate compaction be done before the mat cools to less than 200°F.

Exhibit AC-6 shows rolling time available for various combinations of base temperature and temperature of mix at laydown. The table is based on mix temperatures that have been adjusted to provide at least 15 minutes to complete compaction. The controlling conditions reflected in the chart are a wind speed of 11.5 mph, an air temperature at 40°F, a dense cloud cover, and a minimum compaction temperature of 175°F. The cutoff point is 175°F, because after this point, the mat temperature is so low that compaction possibilities decrease rapidly. Exhibit AC-6 shows that even with fairly high base temperatures and increasing mix laydown temperature, the time available to complete rolling becomes more and more critical as the depth decreases. The problem is even more acute when wind is considered.

Other compaction estimating tools available and recommended for use when conditions become questionable are MultiCool, maintained by Auburn University, and PaveCool, developed by MnDOT. More specific project and mixture information can be accounted for to estimate available time for compaction. A smartphone app is available for PaveCool while MultiCool is a web-based program.

When the wind chill reduces the apparent temperature to the range so that rolling time is drastically reduced, it becomes necessary to cease operations or increase the number of rollers. If the contractor is operating with the minimum number of rollers under marginal weather conditions, the Resident Engineer should treat any predictions for worse weather seriously. The contractor should be notified that it is unlikely that compaction can be achieved, and the operation should be modified or stopped by the contractor. Specifications allow the Resident Engineer to direct the contractor to stop work or adjust paving operations in marginal weather, see the weather limitations subsection. Possible modifications are a higher mix temperature, reduced production, more compaction equipment, or a combination of these.

Time available to complete compaction before the pavement cools to 175°. The table is based on: cloudy weather, Wind of 11.5 miles per hour, and an air temperature of 40°.						
Table A - Recommended Minimum Laydown Temperature						
Base Temp.	**½”**	**¾”**	**1”**	**1” - ½”**	**2”**	**3” and greater**
20 - 32	—	—	—	—	—	285
+32 - 40	—	—	—	305	295	280
+40 - 50	—	—	310	300	285	275
+50 - 60	—	310	300	295	280	270
+60 - 70	310	300	290	285	275	265
+70 - 80	300	290	285	280	270	265
+80 + 90	290	280	275	270	265	260
+90	280	275	270	265	260	255
Rolling time, in minutes	**4**	**6**	**8**	**12**	**15**	**15**

Wind speed MPH	**Actual Thermometer reading**								
	65	**60**	**55**	**50**	**40**	**30**	**20**	**10**	**0**
Equivalent Temperatures									
Calm	65	60	55	50	40	30	20	10	0
5	63	58	54	48	37	27	16	6	-5
10	59	43	46	40	28	16	5	-9	-21
15	56	49	43	36	22	9	-5	-18	-36
20	54	47	39	32	18	4	-10	-25	-39
25	52	45	37	30	16	0	-15	-29	-44
30	50	44	35	28	13	-2	-18	-33	-48
35	49	41	34	27	11	-4	-20	-35	-49
40	48	42	33	26	10	-6	-21	-37	-53

Exhibit AC-6. Laydown Temperature Charts

The number of compactors needed for a given production rate can be determined as follows:

1. Determine the paver speed based on the contractor's proposed production.

   Example: Assuming the plant production is 300 tons per hour and the paver will lay a 1-½ inch mat 13 feet wide, then if the material weighs 150 pounds per cubic foot, the paver will be able to operate at rate of 42 feet per minute:

   Weight of pavement per foot = 1.5 / 12 x 13 x 150 / 2000 = 0.12 tons per foot

   $$\text{Paver speed} = \frac{\text{plant production/60}}{\text{tons per foot}} = \text{feet per minute}$$

   $$\text{Paver speed} = \frac{300 / 60}{0.12} = 42 \text{ feet per minute}$$

2. Estimate production rate per compactor.

   Example: Assume 3 mph for steel wheel compactors, and 5 mph for rubber tire compactors. Assume 85% efficiency to allow for direction changes, reloading with water, etc.

   Compactor production rate = compactor speed x efficiency = feet per minute

   $$\text{Steel wheel} = \frac{3 \text{ mph} \times 5280 \times 0.85}{60} = 225 \text{ feet per minute}$$

   $$\text{Rubber tire} = \frac{5 \text{ mph} \times 5280 \times 0.85}{60} = 375 \text{ feet per minute}$$

3. Calculate the total number of passes each type of compactor in the rolling train must make to obtain all the required coverages.

   Example: Assume 406 asphaltic concrete is specified. Option Number 1 in Subsection 406-7.05(A)(3) of the Standard Specifications requires one initial steel wheel breakdown coverage, four rubber tire intermediate coverages, and about two steel wheel finish coverages. Assume the compactors are six to eight feet wide and must overlap the previous pass by at least two feet.

   $$\frac{\text{width of mat}}{\text{compactor width – overlap per pass}} = \text{required passes per coverage}$$

   $$\frac{13}{8 - 2} = 3 \text{ passes per coverage (always round up, not down)}$$

   Passes per coverage x required coverages = total required passes

   3 x 1 = 3 initial passes by steel wheel compactors

   3 x 4 = 12 intermediate passes by rubber tire compactors

   3 x 2 = 6 finish passes by steel wheel compactors

4. Calculate the number of compactors required.

$$\frac{\text{Paver speed x total required passes}}{\text{Compactor production rate}} = \text{required number of compactors}$$

$$\frac{42 \times 3}{225} = \text{1 steel wheel compactor for initial rolling}$$

$$\frac{42 \times 12}{375} = \text{2 rubber tire compactors for intermediate rolling}$$

$$\frac{42 \times 6}{225} = \text{2 steel wheel compactors for final rolling}$$

The use of these calculations in the pre-paving meeting is helpful in assisting the contractor in determining the equipment requirements before work starts. Starting out with the necessary amount of equipment, operated under favorable weather conditions, will save all parties a lot of frustration.

After the paving operation is balanced, the roller operation must also be balanced. To achieve the maximum density, the asphalt pavement must be compacted while the temperature is high enough to keep the viscosity of the asphalt low. This allows the rock particles to move around under pressure and reposition into a dense mass.

C. Inspecting Vibratory Compactor Operation

Vibratory compactors have their own special peculiarities and operating techniques. The Inspector should read the equipment's operator manual carefully so he or she can be sure the machine is being operated correctly.

The specifications prohibit using vibratory compaction on lifts under 1 inch thick or when the mat temperature is less than 180°F. Vibratory compaction of thin lifts can cause the aggregate to fracture.

The vibrators should be checked to see that they operate over the full range of amplitude and frequency.

Generally, a higher frequency and lower amplitude are used for thin lifts and the amplitude is increased as the lifts get thicker. Vibrators on the newer units turn off automatically when the machine stops. On older machines, make certain that the operator knows that he or she has to turn the vibrators off before the machine stops. Before changes in amplitude or frequency are made, be sure that the effects of the change are understood. Industry studies suggest that to achieve maximum smoothness and compaction, the distance between impacts should not exceed 1½ inches and there should be a minimum of eight impacts per foot. To help maintain the desired spacing, the following relationships can be used as a guide.

Millimeters Between Impacts						
Speed	Frequency of Vibrator (Hz)					
mph	**20**	**25**	**30**	**35**	**40**	**50**
1.5	<u>35</u>	28	24	20	18	14
2.0	45	<u>36</u>	30	26	23	18
2.5	56	44	<u>37</u>	<u>32</u>	28	22
3.0	69	56	46	<u>40</u>	35	28
3.5	80	64	53	46	<u>40</u>	32
4.0	90	72	60	52	45	<u>36</u>
5.0	111	89	74	63	56	44

Vibration of thin lifts can cause the aggregate to fracture.

D. Resolving Compaction Problems

In some cases, the material is too hot to be properly compacted. This is noticeable from the instability of the material under the roller. Indications are: it shoves out from the sides of the wheels, produces a wave ahead of them, or is still unstable after the roller has passed over it. The inspector should be aware that some mixes are more tender than others. If the mix is too hot, a delay in the breakdown roller should correct the problem. A change in roller weight, type, or pattern may also work.

Cracking is very common when using steel wheeled compactors. There may be several reasons for cracking. Thermal cracks are usually small surface cracks caused by the surface of the mat cooling faster than the interior. These cracks can be usually removed by additional rolling. A tender mix may crack under normal rolling effort due to its inability to bind together. The problem could be the rollers, but the inspector should not rule out a problem with the subgrade. Cracks caused by subgrade problems are usually long and deep cracks that are much wider than other types of cracks. If just one area is cracking, the contractor may have to skip that section until the subgrade can be corrected. Cracks on a good base can be kneaded together with a pneumatic roller, however, it is best to correct the subgrade since the healing may only be on the surface. The remaining unhealed portion of crack leaves the pavement weakened and exposed to weathering.

Unless the types of equipment and compaction sequence are specified, the contractor has the option of using rubber or steel rollers. Regardless of the type of equipment used for the initial breakdown compaction, it is essential that the first pass be made as soon as possible so that the temperature relationships mentioned above will be maintained. The greatest part of compaction is attained with the first breakdown pass.

In order to eliminate or minimize compactor marks the final finishing passes may have to be delayed until the mat cools to the proper temperature. Trial and error testing of equipment and procedures is necessary to achieve the specification density in the least time.

Weather Limitations

Construction Requirements, e.g. 407-10.06(A)(1), 413-7.06(A), 414-7.06(A)(1), 416-6, and 417-6, give the Resident Engineer the ability to suspend paving operations if weather conditions, either existing or expected, would adversely affect the quality of the asphaltic concrete pavement.

Adverse weather conditions include:

- Frozen subgrade as evident by the fact that a shaded surface thermometer reads 32°F or less, or the subgrade is excessively hard- the entrapped water has turned to ice.
- For thin lifts and friction courses, temperature requirements such as an 85°F surface for AR-ACFC are not being met.
- Muddy subgrade due to the material being too wet.
- Standing water on the subgrade. This can usually be remedied by using pumps and/or an air hose.
- Precipitation. A light rain or snow is sometimes OK as long the mat does not cool down too quickly.
- Threat of precipitation. It does not have to be actually raining or snowing to stop the work. During seasons where precipitation is common, the Resident Engineer should discuss with the contractor what set of weather conditions would lead to a shut down. This would help prevent the contractor from going through the unnecessary expense of firing up the hot plant and sending out a paving crew only to have the project shut down before the first truck arrives
- Cooler temperatures with a lot of wind. The heat loss from the pavement can be too much for the rollers to keep up, especially on thin lifts

Obviously the Resident Engineer and the Project Supervisor will have to exercise some judgment. If you shut a paving operation down, you should document the reason(s) for your decision and list the sources you used, such as weather forecasts, in arriving at your decision. Paving and plant operations are expensive affairs and back charges by construction companies, especially if it doesn't rain, are not uncommon. However, keep in mind that pavement will be there long after the plant and equipment are gone, and its quality should come first.

Smoothness

Specifications for asphaltic concrete surfaces contain tolerances that must be checked with a straightedge. Straightedge tolerances vary, so the inspector must refer to the appropriate specifications. Pavements on selected interstate and major highways must also meet smoothness requirements based on International Roughness Index (IRI) values. These numbers are an indicator of pavement roughness.

A specialized van that contains an inertial profilometer measures pavement roughness and computes the IRI values. ADOT's Materials Group, Pavement Management Section, operates the van and may help the contractor with interim measurements during paving if requested and availability permits.

The Special Provisions will have a maximum IRI value called a correction value or (CV) that the contractor must meet (the smaller the number, the smoother the pavement). The maximum IRI value requirement depends on the type of riding surface. ACFC riding surfaces on top of new AC will have stricter smoothness requirements than new AC pavements without an ACFC.

The Special Provisions contain information that is used to calculate the bonus or penalty for payment or reduction in payment to the contractor. The bonus or penalty is applied to each 1/10 of a lane mile.. Bridges and the transverse joints at the project limits are usually excluded from smoothness testing for bonus or penalty but they still must meet the straightedge requirements.

Special provisions for pavement smoothness are used to distinguish between the different riding surfaces. Carefully check the smoothness requirements in the Special Provisions since they may be different from the requirements of the last project.

The IRI values correlate well with the public's perception of pavement ride quality. ADOT uses an incentive/disincentive payment approach to encourage contractors to build a smoother pavement. A look at the payment schedule reveals that the bonus payments are much better than the penalties. This payment structure may appear to favor the contractor, but we must keep in mind the difficulty of eliminating all roughness. While the formula for the incentives and penalties is mathematically a linear function, the effort the contractor must add to achieve a unit improvement in smoothness is not. The ability to achieve a two unit improvement in smoothness is proportionally more difficult than a one unit improvement, at or near the required level of smoothness. However, as lower and lower IRI values are achieved, it continues to become progressively more difficult to achieve the next incremental increase in smoothness.

Several publications contain excellent recommendations on how to achieve pavement smoothness. Following the recommendations is no guarantee that the contractor will produce a smooth pavement. Inspectors should not actively assist the contractor in constructing smoother pavements, or take any action that could shift responsibility for smoothness from the contractor to ADOT.

Several past projects have shown that contractors can meet the minimum non-penalty smoothness level, even on rough existing pavements. By using the recommended tools and best practices of the trade, some contractors have earned significant bonus payments.

A separate lump sum pay item (1090010) is created in the project estimate to handle bonuses and penalties. The Pavement Management Section will calculate the bonuses and penalties for each 0.1-lane-mile increment of pavement and the total payment or deduction for the project. The report you receive from the Pavement Management Section is used as the supporting documentation for the pay estimate. A copy of all reports should be submitted with the final estimate.

Method of Measurement and Basis of Payment

Measurement and payment techniques vary depending on whether the asphaltic concrete (AC) is specification 407, 408, 409, 411, 413, 414, 415, 416, 417, or a special design for local government work. Always check the Special Provisions and Standard Specifications carefully to determine the method of measurement and basis of payment for each type of asphaltic concrete used on the project.

A. Asphalt Cement

Methods used for determining asphalt cement content vary. For example:

- AC 407 asphalt content is determined with a nuclear asphalt content gauge
- AC 409 Miscellaneous Structural; bituminous material is not measured for payment
- AC 411 ACFC (Miscellaneous); bituminous material is not measured for payment
- AC 413 asphalt-rubber content is determined with a nuclear asphalt content gauge
- AC 414 asphalt-rubber content is determined with a nuclear asphalt content gauge
- AC 415 asphalt-rubber may be measured by invoice quantities, adjusted as necessary for waste. Waste generated from startup of the asphalt plant will be considered to have a binder content of 3.0 percent. In no case shall the measured amount of asphalt cement for payment be greater than the total of the invoice quantities, adjusted for waste.
- AC 416 and 417 asphalt cement may be measured by invoice quantities, adjusted as necessary for waste. Waste generated from startup of the asphalt plant will be considered to have a binder content of 3.0 percent. In no case shall the measured amount of asphalt cement for payment be greater than the total of the invoice quantities, adjusted for waste. Applies to both AC mixes, with and without RAP.

B. Mineral Admixture

The Special Provisions will indicate the percent of mineral admixture, if it is required in the mix. Specifications require the contractor to submit documentation on a daily basis to the Resident Engineer showing the approved amount of mineral admixture has been incorporated into the asphaltic concrete. This requirement is to verify that the mineral admixture is being added at the required rate and to furnish information to allow the contractor to adjust the process.

It is intended that the contractor submits the following information on a daily basis:

- Tracs No. or Project No.
- Contractor
- Date of Asphaltic Concrete Production
- Tons of Asphaltic Concrete (AC) Produced
- Tons of Asphaltic Cement Used (plant information)
- Tons of Mineral Admixture Used (Use A or B below)
    - Hot Plant computer printout indicating actual weight (attach printout to the submittal)
    - Silo weight at beginning and end of shift plus Mineral Admixture added to silo during the shift (attach invoices to the submittal)
- Contractor's Signature

Exhibit AC-7 is an acceptable example of a Daily Mineral Admixture Report form. This specific form doesn't have to be used, and any submittal giving the above information is acceptable. The advantage to this form is that it provides the equations to check the percent admixture. Note that the weight of admixture is divided by the weight of the aggregate, so the weight of both the asphalt cement and the admixture must be subtracted from the weight of the asphalt concrete to find the weight of aggregate.

The quantity of mineral admixture to be paid should be a summation of the tons of mineral admixture used, taken from the Daily Mineral Admixture Report submitted by the contractor. The daily quantities can be added up monthly for progress payments and totaled for final payment.

Verification of the asphalt content should be made by the ADOT Field Office upon receipt of the test data (see Exhibit AC-4) to assure the payment quantities for mineral admixture are not significantly different from the mix design requirement.

The following formula can be used:

$$\text{Percent Admixture} = \frac{\text{(Admixture)}}{\text{(AC) - (Verified Asphalt) - (Admixture)}}$$

where:

Admixture = Tons of Mineral Admixture Used (Daily Mineral Admixture Report)

AC = Tons of Asphaltic Concrete Used (tickets or scale sheets)

Verified Asphalt = Tons of Asphalt Cement Used (test values)

It is reasonable that the percent admixture be within approximately five percent of the mix design values. If the results are outside this 5% tolerance, the contractor should adjust or revise his or her process for handling mineral admixture, and the field office should assure that the process and measurements are valid.

This approach for the payment of mineral admixture is based on the best information available. The data is in tons and is more precise than multiplying the mix by a percentage. It would be more desirable to have a value from the actual mix as in the case of asphalt cement, because this is more of a performance approach; but tests for the mineral admixture in the mix are very expensive and not available in a timely manner.

Quantities for both the asphalt cement and mineral admixture need to be adjusted for asphaltic concrete that has been wasted or rejected.

C. Documentation

At the end of each day's operation, the inspector shall collect all weight sheets, weight tickets, and spreadsheets. The inspector must balance the quantities and turn them into the field office for checking and payment purposes before leaving the project for the day.

DAILY MINERAL ADMIXTURE REPORT

TRACS NO. (or PROJECT NO.): F123401C

CONTRACTOR: ABC Contractor, Inc.

DATE PRODUCED: 11/20/2023

TONS OF ASPHALTIC CONCRETE (AC) PRODUCED: 2,220.29

TONS OF ASPHALT CEMENT (Asphalt) PRODUCED: 93.48

TONS OF MINERAL ADMIXTURE (Admixture) PRODUCED: 21.82

Attachment (A or B) A

A) Hot plant computer printout indicating actual weight

B) Invoices showing silo weights (beginning and end of shift) plus admixture added

PERCENT ADMIXTURE = $\frac{\text{(Admixture)}}{\text{(Aggregate)}} = \frac{\text{(Admixture)}}{\text{(AC) - (Asphalt) - (Admixture)}}$

$= \frac{(21.82)}{(2{,}220.29) - (93.48) - (21.82)}$

$=$ 1.05 % Admixture

This percentage

☑ complies with the approved mix design.

☐ does not comply with the approved mix design.

Contractor Signature

Signature (Contractors Representative)

01/08

Exhibit AC-7. Daily Mineral Admixture Report Example

The ADOT Asphalt Unit Price Adjustment course provides guidance in how to field document AC paving operations. Field Office documentation includes:

- AC Summary Report, recap of asphaltic concrete payments by lot (see Exhibit AC-8). As a minimum, the recap should include:
    - date material used
    - lot number
    - asphaltic concrete pay tons
    - percent asphalt cement from the materials lab sheet (see Exhibit AC-4)
    - asphalt cement pay tons
    - percent admixture
    - admixture pay tons
    - bonus/penalty pay factors
- Cumulative totals for the above items
- Daily Mineral Admixture Report (see Exhibit AC-7)
- Hot Plant Report
- Bituminous Material delivery invoices
- Mineral Admixture delivery invoices
- ADOT Mix and Compaction Report (see Exhibit AC-4)
- AM and PM Spread Determinations
- ADOT RAP Material tabulation - Ignition Oven Lab Report
- Disposition memo from Materials Engineer for end product AC production lots, or 409 Misc. structural special mix material represented by failing laboratory tests.
- Asphalt Binder Failure summary spreadsheet, along with the failing lab reports.
- Documentation for penalties/bonuses (any changes to the Standard Specifications or Special Provisions will require a change order or a procedural change order).
- The above documentation should be submitted to the Field Reports Section for review with the final estimate. The following documents are recommended as part of any asphalt paving operation:
- Mix temperature and pavement depth field book.
- Straightedge and rolling pattern field book.
- Daily pyrometer readings from the plant.
- Daily reports from AC Forms.
- Summary report from AC Forms.
- Daily inspection diaries complete with weather conditions and air temperatures.

416 Summary - Asphaltic Concrete - End Product

Project: [redacted]

Contractor: [redacted]

Date of Report 11-20-2023

Mix Design		
Percent Admixture	Required	1.00
	Maximum	1.05
Percent Binder Target Value		4.68

Sec	Date Produced	Lot	AC Prod.	AC Waste	AC Placed	Avg. % Oil	Asphalt Cement Based on Lab or UL	Virgin Binder	RAP Binder	Virgin + RAP Binder	% Admix Paid	Admix Paid	Mix Excl. From Mix Props	Mix QLPF	Mix Pay Adj.	Mix Excl. From Comp'n	Comp. QLPF	Comp'n Pay Adj.	AM Spread	AM Spread Penalty	AM Spread Penalty Amount	PM Spread	PM Spread Penalty	PM Spread Penalty Amount
4160004 - ASPHALTIC CONCRETE (3/4" MIX) (END PRODUCT) (SPECIAL MI (Section: 1 - ROADWAY)																								
1					4160004		4040266	4040000		4040266		4160031			1090011			1090011			1090011			1090011
	07/09/2020	01	967.76	16.00	951.76	5.49	52.25	43.64	10.36	54.00	0.98	8.73	0.00	$1.00	$951.76	0.00	$0.50	$475.88	517.08	$0.00	$0.00	434.68	$0.00	$0.00
	07/13/2020	02	1,819.96	24.00	1,795.96	5.44	97.70	81.54	18.72	100.26	0.98	16.48	0.00	$1.50	$2,693.94	0.00	$0.00	$0.00	861.25	$0.00	$0.00	934.71	$0.00	$0.00
	07/14/2020	03	1,182.40	7.00	1,175.40	5.51	64.76	54.07	12.74	66.81	1.05	11.54	0.00	$2.00	$2,350.80	0.00	$0.00	$0.00	616.32	$0.00	$0.00	559.08	$0.00	$0.00
	07/15/2020	04	2,152.70	19.09	2,133.61	5.77	123.11	100.56	22.80	123.36	1.05	20.89	0.00	$2.00	$4,267.22	0.00	$0.50	$1,066.81	1,053.62	$0.00	$0.00	1,080.00	$0.00	$0.00
	07/16/2020	05	1,177.41	12.00	1,165.41	5.71	66.54	51.59	10.67	62.26	1.05	11.42	0.00	$2.00	$2,330.82	0.00	$0.50	$582.71	584.89	$0.00	$0.00	580.52	$0.00	$0.00
	07/20/2020	06	1,767.55	8.00	1,759.55	5.60	98.53	79.62	15.08	94.70	1.01	16.61	0.00	$2.00	$3,519.10	0.00	($1.00)	($1,759.55)	869.41	$0.00	$0.00	890.14	$0.00	$0.00
	07/21/2020	07	1,766.29	9.41	1,756.88	5.47	96.10	79.21	15.46	94.67	1.01	16.61	0.00	$2.00	$3,513.76	0.00	$0.00	$0.00	798.15	$0.00	$0.00	958.73	$0.00	$0.00
	07/22/2020	08	2,429.96	16.00	2,413.96	5.58	134.70	110.32	19.24	129.56	1.05	23.68	0.00	$2.00	$4,827.92	0.00	$2.00	$4,827.92	1,108.00	$0.00	$0.00	1,305.96	$0.00	$0.00
	07/23/2020	09	1,341.40	16.00	1,325.40	5.73	75.95	59.10	12.25	71.35	1.01	12.49	0.00	$0.50	$662.70	0.00	$0.50	$662.70	583.77	$0.00	$0.00	741.63	$0.00	$0.00
	07/27/2020	10	2,424.73	7.00	2,417.73	5.73	138.54	111.80	21.69	133.49	1.02	23.01	0.00	$2.00	$4,835.46	0.00	$0.50	$1,208.87	1,197.64	$0.00	$0.00	1,220.09	$0.00	$0.00
	07/28/2020	11	1,793.92	11.50	1,782.42	5.73	102.13	85.13	15.98	101.11	1.02	16.97	0.00	$2.00	$3,564.84	0.00	$0.50	$891.21	892.56	$0.00	$0.00	889.86	$0.00	$0.00
	07/29/2020	12	2,313.52	15.00	2,298.52	5.75	132.16	105.80	23.29	129.09	1.02	21.87	0.00	$2.00	$4,597.04	0.00	$0.50	$1,149.26	1,197.00	$0.00	$0.00	1,101.52	$0.00	$0.00
	07/30/2020	13	2,134.11	15.00	2,119.11	5.85	123.97	98.35	21.21	119.56	1.02	20.14	0.00	$1.50	$3,178.67	0.00	$0.50	$1,059.56	1,103.60	$0.00	$0.00	1,025.51	$0.00	$0.00
					23095.71		1306.44	1060.73	219.49	1280.22		220.44			$41,294.03			$10,165.37			$0.00			0.00
1					4160004		4040230	4040000		4040230		4160031			1090011			1090011			1090011			1090011
	08/13/2020	3A	2,412.79	18.00	2,394.79	5.37	128.60	108.69	20.17	128.86	1.01	22.66	0.00	$2.00	$4,789.58	0.00	($0.25)	($598.70)	1,129.00	$0.00	$0.00	1,265.79	$0.00	$0.00
					2394.79		128.60	108.69	20.17	128.86		22.66			$4,789.58			($598.70)			$0.00			0.00
	Total				25,490.50		1,435.04	1,169.42	239.66	1,409.08		243.10			$46,083.61			$9,566.67			$0.00			$0.00

Exhibit AC-8. Recap Sheet

D. Spread

407, 414, 416 and 417 mixes require spread lots for payment.

For 407 and 414:

For spread compliance, a lot represents a half shift of production; this is called a spread lot. Under a spread lot, ADOT compares the actual amount of material placed versus the targeted amount that should have been placed. At the end of each spread lot, either the Project Supervisor or Lead Inspector should receive and review the contractor's completed spread lot forms. These forms must be reviewed and approved on a daily basis. Do not wait until the end of the week, month, or project. Agreements should be reached on how much material was wasted, what areas are to be excluded from the spread, and how the material on any sloped edges will be handled.

Spread Control

The estimated target spread rate will be as shown in the table in Subsection 414-3 of the Special Provisions. The Engineer may adjust the estimated target spread rate, and establish a new target spread rate, as necessary to maintain a suitable thickness. Target values for the spread— widths and length—should be agreed to before paving begins, so the target values can be calculated. Once the paving begins, the contractor is responsible for continuously measuring the thickness behind the screed throughout each spread lot to ensure that the minimum compacted thickness specified in subsection 414-3 of the Special Provisions is being met. Exhibit 414-7.03-1 should be used by the inspector to get a daily agreement on the spread quantities. The Resident Engineer can obtain permission to delete this portion of the specification if conditions warrant.

The calculated quantity required in each spread lot will be compared to the actual quantity placed. A spread lot will be considered to be acceptable if the actual quantity placed does not vary by more than +5.0 percent from the required quantity.

Determination of Lot Material Spread Quantity Required for Acceptance and Payment of ACFC (407) and AR-ACFC (414)

Project Number: ____________ Material: ____________

Tracs Number: ____________ Lot Number: ____________ ☐ AM ☐ PM

Date: ____________

CALCULATION OF QUANTITY REQUIRED (Tons)

Target Spread Rate (in Special Provisions) ________ pounds per square yard

Location	From Station	To Station	Length (SF)	Average Width (SF)	Calculated Quantity (SF)	Calculated Quantity (SY)
					Total Calculated Square Yards in Lot =	

Calculated Tons Required = $\dfrac{\text{Total Calc. Sq Yds in Lot} \times \text{Target Spread Rate}}{2{,}000.00}$ = ______ Tons

$\dfrac{\quad \mathbf{X} \quad}{\mathbf{2{,}000.00}}$ **=** **TONS**

CALCULATION OF VARIANCE

Actual Quantity Placed = ________ Tons

$\dfrac{\text{(Quantity Placed)} - \text{(Quantity Required)} \times 100}{\text{(Quantity Required)}}$ = % Variance from Required Quantity

- X 100 = ______ %

If the quantity in a spread lot is found to vary by more than +5.0 percent from the required quantity, as determined in accordance with Subsection 414-6.04, no payment will be made for the material which exceeds the +5.0 percent, including asphalt-rubber and mineral admiixture.

Remarks:

Asphalt Cement Deduction (If applicable): ________ Ton

Mineral Admixture Deduction (If applicable) ________ Ton **Tons over 5%** -

Contractor's Signature: ____________________ Inspector's Signature: ____________________

Exhibit 414-6.04-1 Spread Determination

416 and 417:

For spread compliance, a lot represents a half shift of production; this is called a spread lot. For compliance with the material properties of the asphalt mix itself, a lot represents an entire shift of production and is called a mix-properties lot in the specifications. The mix-properties lot is often called the quality lot in the field.

Under a spread lot, ADOT compares the actual amount of material placed versus the targeted amount that should have been placed. At the end of each spread lot, either the Project Supervisor or Lead Inspector should receive and review the contractor's completed spread lot forms. These forms must be reviewed and approved on a daily basis. Do not wait until the end of the week, month, or project. Agreements should be reached on how much material was wasted, what areas are to be excluded from the spread, and how the material on any sloped edges will be handled.

Spread Control

Target values for the spread—pavement depths, widths, and lengths—should be agreed to before paving begins, so the target values can be calculated. The target value is determined using the bulk unit weight in the mix design for the mix being used. Production bulk density (determined by laboratory testing of acceptance samples) may be slightly different than that shown in the mix design. In such instances, the contractor may request that ADOT use the average bulk density of the first three production lots not in reject (and representative of the mix being produced). The Regional Materials Engineer should be included in this discussion to ensure values utilized do not differ excessively from the mix design.

The inspector may occasionally check pavement thickness and width dimensions in the field to verify that target values are being met. Once the paving begins, the contractor is responsible for controlling the spread and laydown operation. The Project Supervisor may exclude irregular areas from the spread. Irregular areas are defined as uneven surfaces where placing uniform depth of asphalt would be too difficult. Some gore and taper areas fit into this category where deep depressions exist due to severe rutting or subgrade settlement. While the spread gets more difficult to control as the existing surface becomes rough and irregular, the specifications can still be enforced on all but the roughest surface conditions. Conditions such as swelling clay areas may cause such a high degree of roughness to make the application of the spread specification impractical. One key method to avoiding problems in enforcing the specification is to explain carefully to the contractor exactly how the day’s tonnage will be calculated. Exhibit 416-7.03-1 should be used by the inspector to get a daily agreement on the spread quantities and penalties for each spread lot. Flexibility should be exercised in the interpretation of this specification so that the contractor can expect to obtain compliance without minute-by-minute screed adjustments. The Resident Engineer can obtain permission to delete this portion of the specification if conditions warrant.

Asphaltic concrete is measured based on a day’s production including the quantities that were excluded from the spread lots or mix properties lots for irregular areas. Waste quantities, quantities in rejection, and quantities over the 5% spread limit are excluded from measurement. The AM and PM spread lots are usually combined to allow for unit price adjustments. Typically there are no price adjustments due to spread variations, since contractors will avoid underrunning the spread. However, if there were a spread penalty, the AM and PM lots would have to be analyzed separately (see example calculation). Payments are best calculated on a daily production basis. Deductions or bonuses are calculated separately and added to the contractor’s payment:

Placed Quantity x bid unit price	= initial amount owed to Contractor
AM Spread Quantity x AM spread pay factor	= AM spread price adjustment
PM Spread Quantity x PM spread pay factor	= PM spread price adjustment
Mix Prop Quantity x Mix prop pay factor	= Mix prop. price adjustment
Compaction Quantity x Comp. pay factor	= Comp. price adjustment
	______________________________
	= Net amount paid to contractor

The placed quantity is the amount of asphalt placed that day (from the weigh tickets) less any amounts wasted and less any amounts above the 5% spread quantity limit. This may be different than the mix property and compaction pay quantities if there are rumble strips or isolated areas the Resident Engineer elects to exclude from these lots (see subsection 417-9).

The calculations can become quite tedious since some quantities are not included for some types of lots (spread versus compaction for example) and excluded from others. A spreadsheet has been provided with this manual (see Exhibit 416-7.03-1) to assist the Field Office in making these calculations. Please keep these points in mind:

- When a formed rumble strip is specified, the last lift placed on that shoulder is excluded from the compaction pay factor adjustments, but included in the spread and mix properties pay factors adjustments.
- Irregular areas identified as being excluded from the AM or PM spread lots may or may not be excluded from the compaction lot and/or mix property lot quantities (check with the Project Supervisor or Resident Engineer).
- Spread quantities that exceed the 5% spread limit are not included in any pay factor adjustments since the Department does not pay for them — this includes the asphalt cement and mineral admixture.

In some instances, depending on the bulk density (unit weight) used to estimate the quantity of AC needed on the project for bidding purposes, and the actual bulk density of the AC produced for the project, the cost of the AC may result in an overrun for the bid item or a substantial savings may be realized which could be used elsewhere on the project. Be mindful that if the bulk unit weight increases during production, and a heavier unit weight is used to to determine spread lot, this combined with the 5% allowance may grossly exceed the bid item cost for the material.

Example Calculation

A contractor places 1,260 tons of asphalt concrete in the morning and 1,460 tons in the afternoon. During the morning shift, 10 tons were wasted and the inspector and the contractor agreed to exclude an additional 25 tons from the spread lot, but include in the compaction and mix properties lots. During the afternoon, 15 tons were wasted and the inspector determined that 750 tons were placed in a formed rumble strip area. Also, the inspector calculated the theoretical spreads for the morning and afternoon to be 1,210 tons and 1,510 tons, respectively. The calculated PTs for that day's quality lot were done by the acceptance lab, with the respective pay factors taken from table 416-1 of the Standard Specifications.

	PT	**PF (from table 416-1)**	
3/8 inch sieve	75	-$0.50 (disregard - not the lowest)	
No. 8 sieve	100	$0.00	
No. 40 sieve	98	$0.00	
No. 200 sieve	70	-$0.75 (lowest pay factor)	
% asphalt cement	90	$0.00	
% voids	97	<u>+$0.50</u>	
Total Mix Pay Factor Adj.			-$0.25 (sum of voids plus lowest pay fact for sieve and % asphalt)
Compaction	95	+$0.50	

If the contractor's unit price for asphaltic concrete is $70 per ton, how much is owed to the contractor for that day's production?

Solution

Compute the Spread Lot Pay Factors per 416-9(A) of the Standard Specifications:

AM Spread				PM Spread		
Batched	1260	tons		Batched	1460	tons
Waste	10			Waste	15	
Placed	1250			Placed	1445	
Excluded	25			Excluded	0	
Net Spread	1225	tons		Net Spread	1445	tons
Calc. Spread	1210	tons		Calc. Spread	1510	tons
Yield	1.24%	= net- calc. calc.	x 100	Yield	-4.30%	
Pay Factor (Table 416-1)	$0.00			Pay Factor (Table 416-1)	-$0.30	
				Note: the rumble strip quantity is included in the spread lot.		

Mix. Prop. Lot Quantity (416-9(B))	2695	ton (1250+1445)	PF =	-$0.25
Compaction Lot Quantity (416-9(C))	1945	ton (1250+1445-750)	PF =	$0.50

Calculate Pay Adjustments

	Quantity	Unit Price	Amount
Placed	2695	$18.00	$48,510.00
AM Spread	1225	$0.00	$0.00
PM Spread	1445	-$0.30	-$433.50
Mix Prop.	2695	-$0.25	-$673.75
Compaction	1945	$0.50	$972.50
Total Price Paid			$48,375.25

Determination of Lot Material Spread Quantity Required and Pay Factor for End product Method of Acceptance and Payment for AC (Standard)

Project Number: ____________ Material: ____________

Tracs Number: ____________ Lot Number: ____________

Date: ____________

CALCULATION OF QUANTITY REQUIRED (Tons)

Laboratory Mix Design Density = ________ pounds per cubic foot

Location	From Station	To Station	Length	Average Width (ft)	Average Thickness	Cubic Feet
			Total Calculated Cubic Feet in Lot			

Calculated Tons Required = $\dfrac{\text{Total Calc. Cubic Ft in Lot} \times \text{Lab Mix Design Density}}{2{,}000.00}$ = ______ Tons

$\dfrac{\mathbf{X}}{\mathbf{2{,}000.00}}$ **= TONS**

CALCULATION OF VARIANCE AND PAY FACTOR

Actual Quantity Placed ________ Tons

$\dfrac{\text{(Quantity Placed) - (Quantity Required)} \times 100}{\text{(Quantity Required)}}$ = ________ % Variance from Required Quantity

- X 100 = %

- The calculated quantity required in each spread lot will be compared to the actual quantity placed. A lot will be considered to be acceptable, with a zero pay factor, if the actual quantity placed varies by no more than -2.0 to +5.0 percent from the required quantity.
- If the quantity in a lot is found to vary from the required quantity by -2.1 to -12.0 percent, the appropriate pay factor will be determined in accordance with Table 416-1. This pay factor will be utilized in determining the pay adjustment as outlined in Subsection 416-9 of the specifications.
- If the quantity in a spread lot is found to vary by more than +5.0 percent from the required quantity, no payment will be made for the material which exceeds +5.0 percent, including asphalt cement and mineral admixture.
- If the quantity is found to vary by more than -12.0 percent from the required quantity, the spread lot will be rejected.

Table 416-1

Negative Variance	Pay Factor (dollars) per ton
2.1-3.0	-0.10
3.1-4.0	-0.20
4.1-5.0	-0.30
5.1-6.0	-0.40
6.1-7.0	-0.50
7.1-8.0	-0.60
8.1-9.0	-0.70
9.1-10.0	-0.80
10.1-11.0	-0.90
11.1-12.0	-1.00

PAY FACTOR ________

Remarks:

Asphalt Cement Deduction (If Applicable): ________ Ton

Mineral Admixture Deduction (If applicable) ________ Ton **Tons over 5%** -

Contractor's Signature: ____________ Inspector's Signature: ____________

Exhibit 416-7.03-1. Spread Determination Form

E. Lots in Reject

Lots in reject due to failure to meet mixture, compaction, or spread lot requirements, or which include asphalt materials that failed to meet requirements, are subject to one or more of the following below. However, if applying an allowable self-directed target change to the mixture production targets results in the mixture no longer being in reject, the mixture is no longer in reject, i.e. not subject to removal and replacement at no cost to the Department. In this instance, an engineering analysis is not required for the Department to allow the material to remain in place, and no disposition is issued, but the entire quantity in the lot is subject to the maximum disincentive being applied for the pay factor(s) representing the quality characteristic(s) in question, i.e. the target change is retroactive for reject status, but the pay factor remains. The same applies to 409 miscellaneous structural (special mix).

- Maximum Penalty - Reject status results in the maximum disincentive being applied to the end product lot or quantity of material represented by a failing 409 sample; if allowed to remain in place. However, if the lot/material is removed by the contractor and replaced, the new material is subject to determination of a new pay factor on its own merits. The lot/material removed and quantity therein not incorporated into the project is no longer of concern for any further action by the Department. For 409 mixtures, the quantity of material represented by failing test results is most often determined by interpolating between consecutive passing and failing samples based on the tonnage at which the samples were taken, but may also be based on time if there occurred significant disruption to or production was not continuous for the material represented by the samples being considered.
- Referee testing - If requested by the contractor within 15 days of receiving the Department-furnished Mix/Compaction Payfactor Report for the respective end product lot, the portion of the mixture acceptance samples and/or AC cores set aside for referee testing will be sent to an independent laboratory for referee testing. The referee test results are binding and the associated pay factors replace those on the initial Mix/Compaction Payfactor Report. It should be noted that asphalt content for mixtures containing RAP cannot be refereed.

If referee testing is requested by the contractor, it must be in writing and specifically state if mixture or compaction, or both, is to be refereed. the materials coordinator must notify the acceptance lab, which will then furnish the referee materials and specimens to the materials coordinator, or designee from the project, to transport the materials and a copy of both the contractor’s request letter and the mix design including any subsequent target changes, to the Mix Design Laboratory at ADOT’s Central Lab. The Mix Design Lab Supervisor will coordinate referee testing and will provide notification of the results to the Materials Coordinator and Regional Materials Engineer. Note that the contractor may request to referee mixture or compaction even though the lot is not in reject. The non-prevailing party is responsible for the cost of the referee testing.

- Removal and Replacement - material that is in reject status, or remains in reject status subsequent to referee testing, is subject to removal and replacement at no cost to the Department. Exceptions to this may occur upon the Department receiving an Engineering Analysis (see Item 4 below). from the contractor, performed by a qualified firm, which substantiates that the associated pavement will perform satisfactorily or to a degree considered acceptable by the RE and the State Materials Engineer.
- Request to allow reject material to remain in place by means of an Engineering Analysis 416-9(E) - If requested by the contractor within 15 days of receiving notice of a mixture, compaction, or a spread lot, or miscellaneous structural special mix material in reject, the contractor may propose that the material remain in place at the maximum applicable negative pay factor(s) and submit to the Department, an Engineering Analysis (EA) that substantiates acceptable pavement performance for the lot/material in question. Upon review of test results and the EA, the State Materials Engineer has the sole authority to

determine if the material represented by the lot in reject will be removed or allowed to remain in place. However, before making this determination, much input will be requested from the construction unit.

In such an event, the project should be prepared to provide any information related to the material in question that will aid in determining whether or not the material should be allowed to remain in place. The opinion of the RE and observations of construction personnel are taken into serious consideration. This includes entries in daily diaries describing issues with production, delivery, placement, weather/ambient conditions, or otherwise, as well as a visual assessment of the condition of the pavement with any defects or indication of poor quality noted. The location of the pavement and if subject to mainline traffic, stopping/slowing/turning movements, heavy trucks, or if generally outside of traffic areas/shoulders, etc. Also considered is the position within the pavement structure and if additional lifts are yet to be placed or have already been placed.

Occasionally, depending on the properties in question, the decision to accept or require removal will be delayed until additional investigation/testing can be performed and/or the pavement has received traffic and been observed to be unaffected. This is most common when air voids are low and/or asphalt content is high, but neither are excessively outside of the production limits.

When a lower lift of AC is determined to be in reject, this may pose a difficult decision for both the contractor and the construction unit regarding, if paving a lot which will cover up a lot in reject should commence. When it is necessary to continue paving operations and such an instance occurs, guidance from the Regional Materials Engineer should be sought to aid in confirming the likelihood that material will be allowed to remain in place or if removal will be required. Typically extremely low mix and in-place air voids in areas that receive traffic, low asphalt content, or excessive in-place air voids require removal, while gradation issues, high asphalt content, and low mix voids, especially from areas that do not receive regular traffic, will be allowed to remain in place. It should never be assumed, regardless of location, traffic, or other conditions, that pavement will be allowed to remain in place.

Once the Regional Materials Engineer has received the engineering analysis, and gathered all pertinent information from the construction unit, the RME will make a recommendation to the Bituminous Engineer and State Materials Engineer, who will then confer to make a determination on the matter. The decision is provided by issuing a disposition memo that states if the material shall be removed and replaced at no additional cost to the Department, or if it will be allowed to remain in place and at what pay factor(s), and any additional stipulations such as a performance monitoring period followed by re-evaluation or other corrective action.

Any lot or material in reject and allowed to remain in place must be identified and described in the Materials Exception Report, including reference to the associated disposition memo, to be submitted to the FHWA as part of the Final Materials Certification process.

501 PIPE CULVERT AND STORM DRAINS

501-1 Description

Several types of pipe are used for storm drain and culvert applications. They are:

- Precast Concrete Pipe
  Includes:
  - RCP or RGRCP - (Rubber Gasket) Reinforced Concrete Pipe
  - NRCP- Non-Reinforced Concrete Pipe (up to 24")
  - HERCP- Horizontal Elliptical Reinforced Concrete Pipe
  - RCB- Reinforced Concrete Box
- Corrugated Metal Pipe (CMP)
  Includes:
  - Corrugated Steel Pipe (CSP)
  - Corrugated Aluminum Pipe (CAP)
  - Plate Arch (see section 502)
  - Slotted drains and perforated pipes
- Black Steel Pipe (BSP)
- Corrugated High Density Polyethylene Plastic Pipe (CHDPEPP)
- Non-Reinforced Cast-In-Place Concrete Pipe (NRCI PCP)

The pipe summary sheets in the Project Plans will indicate which type of pipe may be used for each pipe run. The contractor may have an option on the type of pipe to use, pipe types not shown as an option shall not be used. At each location where a pipe is to be installed, the project plans will specify the size and approximate length along with the requirements for each approved option at that location, such as the wall thickness, corrugation configuration, coatings, linings, class, and strength. At each such specified location, pipe of one kind and material shall be selected by the contractor from the options shown. All contiguous pipe and all metal pipe in close proximity shall be of the same kind and material.

Each proposed pipe installation should be carefully reviewed to ensure that the planned location, skew angle, and length are proper to meet ultimate configuration of the street or roadway. The grade of the channel, both upstream and downstream from the pipe, should be checked to determine the proper elevation for each end of the pipe. Often, changes in excavation or embankment limits needed to meet field conditions cause changes in pipe lengths, grades, elevations and alignments. The length of each pipe run should be checked before the Contractor orders the material. Significant changes made to pipe lengths, grades, and elevation should be discussed with the Project Designer before installation. This will allow the Designer to analyze any changes in the hydraulic or structural capacity of the pipe.

Other factors to consider before installation include:

- Blue Stake notification and the marking of all existing underground utilities and structures, including those belonging to ADOT
- OSHA safety requirements for trenching and confined space entry, including preparation of a shoring plan
- Notification of utility companies affected by trenching and pipe installation, including coordination for possible shutdowns or temporary interruptions
- Protection of existing utilities and structures
- Securing any necessary local permits
- Locations of benches and other survey monuments

When there are changes to pipe run lengths and grades, the Contractor may ask for additional compensation beyond the bid unit price. Extra costs may include additional excavation and backfill because of a deeper trench or a restocking fee for quantities of pipe not needed. The Resident Engineer must keep in mind that changes in pipe lengths needed just to meet field conditions does not necessarily justify unit price adjustments and extra costs. Only when the site differs materially from what is represented in the Project Plans (see Subsection 104.02), or when the Department makes design changes that significantly impact pipe runs, should additional compensation be considered.

On longer pipe runs, ADOT will have a soils report that is available to the Contractor. The Resident Engineer or Project Supervisor should review this soils report before construction with the intention of anticipating any installation or safety problems that may occur.

The specifications require the contractor to submit a written trenching plan prior to constructing trenches deeper than 5 feet. In most types of soil it is necessary to provide shoring, or to slope the ground beyond the neat lines shown in the Project Plans or Standard Drawings to avoid caving. Side slopes should conform to the Occupational Safety and Health Administration (OSHA) standards. See section 501-3 of this manual for more detail about OSHA requirements.

501-2 Materials

The Contractor should carefully unload, store, and handle all pipe sections (joints). Careful handling of coated pipe is necessary to keep coating scars and repairs to a minimum. The Inspector shall examine each pipe joint before it is placed in the trench.

The Inspector should check for:

- Correct diameter and material Standard Specifications including wall thickness
- Spalls, dents or chips around the ends of each pipe segment
- Cracks; both on the interior and exterior of the pipe
- Fabrication date stamped on precast concrete pipe
- For precast pipe:
    - Check the class or D-load, plant ID, and type of reinforcement (elliptical or quadrant)
    - Verify from pipe summary sheets whether pipe will be used for trench or non-trench condition
- Identification marks on the pipe indicating the same lot or production number as shown on the certificate of compliance
- Certificate of Compliance for the pipe, gaskets, banding material, and hardware
- Water tightness requirements stated on the Certificate of Compliance; when water tight joints are specified in the Project Plans or Special Provisions.

Inspectors may reject any pipe damaged during handling and storage, even if there is an ADOT stamp on it and certifications have been submitted.

Corrugated Metal Pipe (CMP)

Make an additional check on CMP being delivered to your projects for the proper markings and diameters. According to AASHTO M 218, Section 12, the following are the criteria for markings on CMPs.

Each two to five feet of sheet in coils or cut lengths shall be identified by showing the following:

- Name of sheet manufacturer
- Brand name
- Specified thickness
- Specified weight of coating
- Identification symbols relating to a specific heat number and coating lot number
- The 12.1.6 AASHTO designation number

When control tests do not show conformance to this specification, the brand will be removed, obliterated, or re-branded: “Non-Specification Material” on each 2 to 5 feet of material in a lot or heat.

Any corrugated metal pipe delivered on a project should have the above information stamped on it at the required locations.

Verify that the information on the pipe matches the information on the certifications.

According to AASHTO M 36, the following are criteria for pipe dimensions:

- 8.1.1 "The average inside diameter of circular (helical and annular corrugated) pipe and pipe to be reformed into pipe-arches shall not vary more than one percent or one-half inch, whichever is greater, from the nominal diameter when measured on the inside crest of the corrugations." (For example, a 36-inch pipe that measures 35-3/8 inches inside is not acceptable).
- For helical and annular corrugated pipe, two inside measurements are taken at 90 degrees to each other (usually horizontally and vertically) and the results are averaged. There is an alternative for measuring annular corrugated pipe. (An annular corrugation closes on itself). The minimum outside circumference can be measured in accordance with Table 6, which is shown in Exhibit 500-2-1. Measurement on the outside is on the sag of the corrugations.

Suppliers may furnish arch pipe shaped by deforming a circular pipe rather than actually machine forming an arch. The vertical dimension from the invert to the line through the widest horizontal dimension should be checked for compliance with AASHTO-M-36. It is not unusual that an arch pipe will not meet M-36 requirements. Arch pipe made with crimped spiral joints often tends to warp longitudinally and has ends that do not match well. Great care is needed in making joints to ensure a good match of abutting sections and tight joints. It may be necessary for the Contractor to replace pieces to get a good joint. Since the supplier is responsible for supplying matching pieces, the Inspector or Project Supervisor should insist that the Contractor provide nothing but quality joints.

Nominal Inside Diameter		Corrugation Sizes[A]					Minimum Outside Circumference[B]	
in.	mm	1-1/2 by 1/4 in 38 by 6.5 mm	2-2/3 by 1/2 in 68 by 13 mm	3 by 1 in. 75 by 25 mm	5 by 1 in. 125 by 25 mm	Ribbed Pipe[C]	in.	mm
4	100	X					11.4	284
6	150	X					17.7	441
8	200	X					24.0	598
10	250	X					30.2	755
12	300	X	X				36.5	912
15	400	X	X				46.0	1,226
18	450	X	X			X	55.4	1,383
21	500		X			X	64.8	1,540
24	600		X			X	74.2	1,854
---	700		X			X	---	2,169
30	800		X			X	93.1	2,483
36	900		X	X	X	X	111.9	2,797
42	1,000		X	X	X	X	130.8	3,111
48	1,200		X	X	X	X	149.6	3,739
54	1,400		X	X	X	X	168.4	4,364
60	---		X	X	X	X	187.0	---
---	1,600		X	X	X	X	---	4,987
66	---		X	X	X	X	205.7	---
72	1,800		X	X	X	X	224.3	5,609
78	2,000		X	X	X	X	243.0	6,231
84	2,200		X	X	X	X	261.7	6,853
90	---			X	X	X	280.3	---
96	2,400			X	X	X	299.0	7,475
102	---			X	X	X	317.6	---
108	2,700			X	X	X	336.3	8,408
114	---			X	X		355.0	---
120	3,000			X	X		373.6	9,341
---	3,300			X	X		---	10,274
---	3,600			X	X		---	11,207

- [A] An “X” indicates standard corrugation sizes for each nominal diameter of pipe.
- [B] Measured in valley of annular corrugations. Not applicable to helically corrugated pipe.
- [C] Rib sizes 3/4 x 3/4 x 71/2 in. [19 x 19 x 190mm] and 3/4 x 1 x 111/2 in. [19 x 25 x 292mm].

Source:
Standard Specification for Corrugated Steel pipe, Metallic-Coated, for Sewers and Drains
AASHTO Designation: M 36 [M 36M]
ASTM Designation: A 760 [A 760M]

Exhibit 501-2-1. Pipe Sizes

Precast Concrete Pipe

ADOT's Materials Group inspects precast concrete pipe at the manufacturing plant. When the precast pipe arrives at the project site the Inspector shall obtain the casting dates stamped on each pipe joint. The Inspector shall then inform the materials laboratory coordinator for the project of these casting dates. In turn, the materials laboratory coordinator shall contact ADOT Materials Group (Structural Materials Testing Section) who will verify that the precasting plant was inspected and materials used for the pipe were tested on those casting dates. Pipe that was made during days where plant inspection and testing were not performed is unacceptable and shall be rejected by the Inspector.

Pipe inspected at the plant can still be rejected at any time; poor handling and latent defects are often the cause of damage that shows up later. The Inspector should encourage the Contractor to inspect the deliveries, since any damage appearing after installation is cause for rejection and may interrupt the installation process.

501-3 Construction Requirements

Contractor Quality Control

Special Provisions may contain Contractor Quality Control requirements for pipe if the project includes any of the following:

- 60-inch diameter, or greater pipe
- Total of more than 600 feet of pipe
- Contractor Quality Control for earthwork

Salvaged Bedding Material

The Special Provisions may contain requirements for pipe bedding material composed wholly or in part of salvaged asphaltic concrete or Portland cement concrete material.

Safety

Trench safety and confined space entry are the two major safety concerns for any pipe installation operation. OSHA has strict standards to which Contractors must adhere for anyone inside a trench or a confined space.

Subpart P of the OSHA regulations (29 CFR 1926.650 - 652) applies to excavation safety. The first section of Subpart S (29 CFR 1926.800) applies to confined space entry. Each ADOT Field Office should have a copy of these standards as part of the collection of all the OSHA safety standards related to construction.

Although OSHA requirements apply to trenches of any depth, the standards become quite involved for excavations 5 feet and deeper. The flow chart in Exhibit 501-3-1, which is reproduced from the OSHA standards, summarizes the safety evaluation process. The full set of subpart P standards should be consulted when investigating a safety concern.

Special attention should be given to trench side wall stability during periods of changing moisture content.

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with *1926.652(b) and (c).

Figure 1. Preliminary Decisions

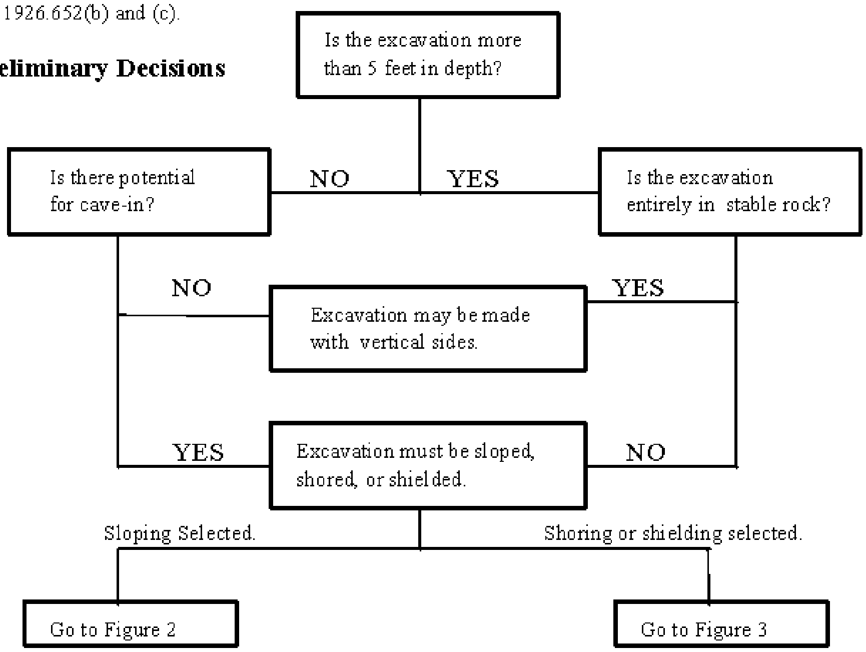
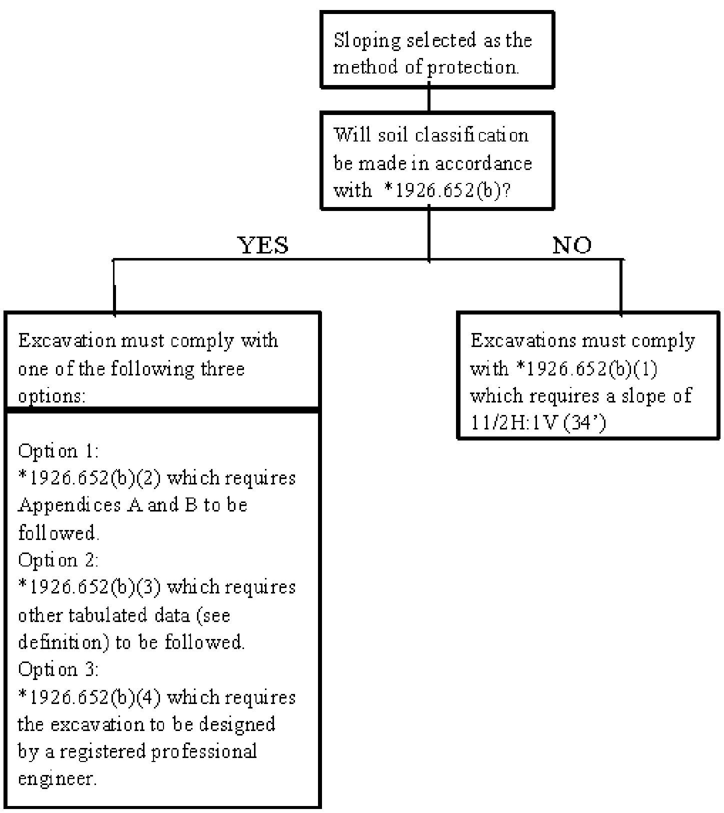


Figure 2. Sloping Options



EXCAVATION STANDARD
Figure 3. Shoring and Shielding Options

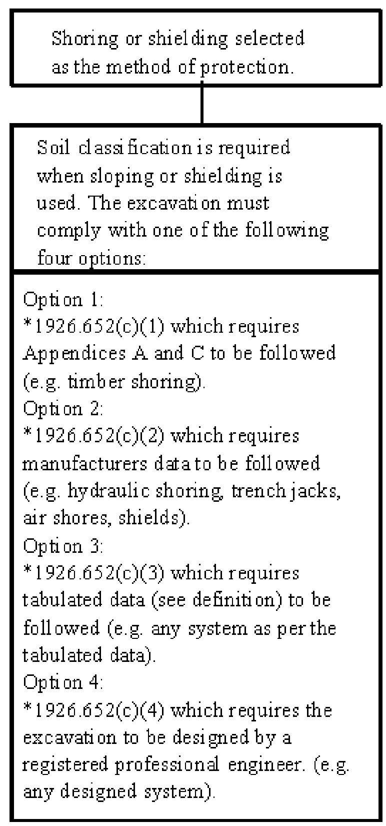


Exhibit 501-3-1. Excavation Safety Requirements

Some important highlights of the OSHA excavation safety standards:

- The Contractor must have a competent person on the job site whose duties include:
    - Classifying soil and rock deposits
    - Evaluating the potential for cave-ins when excavations are less than 5 feet
    - Removing exposed employees found in hazardous conditions
    - Making daily inspections of excavations
    - Monitoring dewatering equipment
- The Resident Engineer should ensure that the Contractor's designated competent person does meet OSHA's definition of a "competent" person (see section 1926.650(b)). In reviewing the individual qualifications, the Resident Engineer should check for demonstrated experience or ability in:
    - Classifying and investigating soils
    - Selecting, installing and inspecting trench protection systems
    - Installing and operating dewatering equipment
    - Recognizing situations that may present atmospheric hazard (oxygen deficiency or The presence of toxic gasses)
    - Having monitoring and rescue equipment readily available
- A Professional Engineer must be used for slope, shoring and shield designs when trench depths are greater than 20 feet in accordance with §1926.652(b) and (c). A Professional Engineer is also needed to determine that nearby structures are not affected by the excavation.
- Soils are classified as a stable rock or type A, B, or C soil. The soil classifications must include manual testing (gradation, soil strength, etc.) as well as visual testing of the soil. Sloping, shoring, and shielding requirements are based on the soil type.
- The competent person must evaluate the effect of spoil piles near the trench on its stability.
- For excavations less than 5 feet, a competent person must decide if there is a potential for cave-in, and either slope, shield, or shore the trench walls if the potential for a cave-in exists.

ADOT's Standard Specifications require the Resident Engineer to review the sloping, shoring, or shielding the Contractor proposes to use for trenches 5 feet or deeper. For trench sloping, the Resident Engineer should verify that the Contractor has identified the soil correctly and selected the appropriate slope rate. If the Contractor proposes to use a trench shield, then all the Resident Engineer needs to do is ensure that the shield has been certified by a Professional Engineer for the type of soils expected in the trench. When the Contractor elects to shore the trench, the Resident Engineer should check that the Contractor's proposed shoring method meets the requirements of OSHA.

When excavations are greater than 20 feet, a Professional Engineer must design, sign, and seal the method of stabilizing the trench walls (sloping, shielding, or shoring). ADOT's Geotechnical Operations Section or Bridge Design Section can assist in reviewing these designs. The Project Designers will have staff who can perform this type of review.

Adequate ventilation, and the monitoring of oxygen and methane gasses are the primary considerations for working in confined spaces. Usually, air monitors are placed in the pipe that measure oxygen levels and the amounts of methane and other explosive gasses. In many cases, certain types of gasses are heavier than air. Therefore, the oxygen levels in deep, narrow trenches should also be measured to ensure adequate ventilation. Manhole covers are usually removed upstream and downstream of the workers. Forced air is required when natural drafts through the pipeline are inadequate. See Section 1926.800 of OSHA Subpart S for more details.

All areas of the trench, which will contain one or more persons, must be inspected by a “competent” person (as defined by OSHA) prior to entry. If the Inspector is unsure about the safety of a particular section of trench, have the Contractor’s “competent” person inspect it. The Inspector shall escalate to the Engineer any unresolved concerns about the Contractor’s trenching and confined space safety procedures. ADOT’s Safety and Health Office is available upon request to assist with consulting any trench and confined space issues.

501-3.01 Preparation of Foundations, Trenches, and Embankments

The Inspector who is overseeing the pipe installation should review Subsections 203-5 & 10 of the Standard Specifications since both are applicable to pipe. City of Phoenix projects will have additional requirements in the Special Provisions.

Reinforced concrete pipes (RCP) are installed in either a trench or non-trench condition. The pipe summary sheet in the Project Plans will specify where pipes can be installed in a trench condition. A trench condition exists only when the Contractor limits the width of the trench to the dimensions shown in Standard Drawing C-13.15. When a trench condition is specified, the proper width must not be exceeded, or adequate side support will not be obtained. All other cases are considered a non-trench condition. Most pipes are installed in a non-trench condition.

If groundwater is encountered during excavation, the Contractor has several options to control groundwater. They include tight sheathing, trench drains, pumping, or a well point system. The selection of a dewatering system is up to the Contractor. However, the Resident Engineer should realize that dewatering might lead to greater trench instability. Lowering the water table may cause ground subsidence in the surrounding area affecting nearby structures and pavements. The Resident Engineer should ensure the Contractor takes precautions in accordance with OSHA requirements, and any additional Federal, State, and Local laws, if either of these situations is likely to occur.

Standard Drawing C-13.15 shows a minimum of 1 foot of material over the top of the pipe. The 1 foot of cover is to be increased when construction traffic will pass over the pipe. It is the Contractor's responsibility to protect the pipe during construction by placing additional material for a temporary construction ramp. The amount of extra cover depends on the weight of the vehicles, the types of vehicles, the type of material, the speed of the vehicles, and other factors under the Contractor's control. The Inspector or Resident Engineer should not establish the amount of cover, since it is the Contractor's responsibility to protect the work (see Subsection 105.04, 105.13 and 105.14).

The Inspector should pay attention to the trench widths obtained during excavation. The Standard Specifications have minimum widths allowed to the Contractor for pipe installed in a non-trench condition. Sufficient width is needed to allow bedding material to be easily placed and compacted around the pipe haunches. On the other hand, pipe installed in a trench condition limits how wide a trench can be so that the walls of the trench can be used to help support the pipe. In this case, a flowable fill is used to backfill around the pipe haunches.

It is important for the Inspector to examine and approve the pipe subgrade before any bedding material is placed. A firm subgrade free of any soft or unstable material is needed to adequately transfer the loads placed on the pipe. Soft yielding subgrades cause excessive shifting or settlement of the pipe. A rocky subgrade is just as undesirable as this would result in concentrating the loads at the very bottom of the pipe. This point loading of the pipe would cause cracking along the invert or crown, much like squashing an egg between two fingers.

When pipes are placed in embankments, it is important to have the embankment built before or at the same time the bedding is placed for the pipe. This will provide confinement for the bedding during compaction and result in a much more stable base for the pipe. Do not permit the Contractor to place the bedding and pipe first then build the embankment around them. See Standard Drawing C-13.15 for further details.

501-3.03 Installation

After the bedding has been placed, graded, and compacted, the Inspector should spot check the profile and alignment of the trench for a uniform grade with no dips or high spots, and a pipe alignment free of any unnecessary bends. The Inspector should be free to use an ADOT survey crew if needed, although the Inspector should be skilled in using the Contractor's references and offset stakes as a check.

Suitable equipment must be provided for handling and lowering the sections of pipe. Unless otherwise permitted by the Resident Engineer, all pipes shall be laid upgrade. This helps seat each pipe joint since the mating force is applied in a downhill direction. It also helps prevent the joints from pulling apart from accidental movements of the pipe as the installation continues. It is important to ensure that the bell or groove (female) end of the pipe points upstream to reduce the chance of leakage through the pipe joints. The Inspector should review the Standard Specifications, read the Special Provisions, and obtain the manufacturer's recommendations on the procedures for joining pipes. This should include the recommended equipment and materials. Standard Specifications for CMP coupling bands are extensive and important. Leaky joints are a common problem with storm drains and culvert pipes. It is important for the Inspector to closely monitor jointing procedures. On occasion, Inspectors have had the pipe manufacturer's representative visit the site to clarify installation procedures.

Watertight and Water Resistant Joints

Before mortaring any joints, each joint should be washed clean with a wet brush. Immediately prior to placing the mortar, the ends shall be thoroughly wetted. Free water shall not be allowed to come in contact with the mortar until well after the initial set. (More than 1 day is recommended). The grout shall be protected from rapid moisture loss (cured), and grouting must be done far enough behind the placing operation to avoid movement of the joints. (Minimum of two pipe lengths is recommended).

When rubber gaskets are used, they shall be installed in the manner and at the time specified by the manufacturer. The Inspector should have the manufacturer's written recommendations on hand at the time of inspection.

Extending Existing Pipe

When an existing pipe is to be extended, the existing pipe end must be in such condition that the new pipe can be firmly joined. The "Pipe Extension Summary Sheet" may include removing a nominal 1 foot of existing pipe to ensure a good joint. The inspector must determine if the removal is necessary, or sufficient. If the existing pipe end is not damaged, and removal per the Pipe Summary is only 1 foot, then removal is not necessary. If the existing pipe end is damaged, then remove as much pipe as necessary to ensure a sound joint. The galvanized coating on CSP must be repaired after removal in accordance with Subsection 501-3.03(B)(1).

501-3.04 Backfilling and Compacting

Improper bedding, backfilling, and compaction of trenches are one of the major causes of roadway settlements and pavement damage.

There are three different classifications of granular materials used in pipeline construction. They are bedding, pipe backfill, and trench backfill. Standard Drawing C-13.15 illustrates the relative positions and limits of each in a typical trench.

Bedding and Flowable Fills (CDFs)

Pipe bedding starts at the bottom of the trench and ends at the pipe springline (halfway up the pipe). Two types of bedding materials are generally acceptable: an aggregate bedding material (which is similar to Class 2 AB), or a cement-treated slurry (known as controlled-density fill (CDF), controlled low-strength material (CLSM), or flowable fill). Bedding material and bedding placement must conform to the requirements of Subsection 501-3.02, as modified by the Special Provisions.

When pipes are 36” or greater in diameter, constructed in trenches, a cement-treated slurry bedding material must be used from the bottom of the pipe to the springline.

Bedding materials should be tested prior to use. However, acceptance sampling and testing is still done at the project site.

Aggregate bedding shall be tested for:

- Gradation
- PI
- pH
- Resistivity

The last two tests are important since bedding and backfill materials can promote pipe corrosion under certain conditions.

Aggregate bedding material can be compacted by either mechanical means, by jetting, or by placement as wet slurry (with no cement).

When the use of jetting is allowed on the project, the Inspector should check to see that the sides and bottom of the trench are free draining. Free draining is defined as having a coarse gradation of existing side and bottom trench material that allows water to drain through it rather than run along it. It is not acceptable to have the water flow along the bottom of the trench, since this removes fines from previously placed bedding.

Cement treated slurry bedding or flowable fill (CDF) is the same as aggregate bedding material, but a small amount of cement is added to help the material flow better. The improved flow characteristics reduce the likelihood of voids under the pipe haunches and eliminate the need for compaction or internal vibration; however, the Inspector may request the use of vibrators if the mixture is not sufficiently fluid enough to fill all the voids in the trench. A check of the slurry’s slump can also be used to determine if the material is adequately flowable. Slump values for slurry bedding are shown in 501-3.02(A)(3).

CDF is required for pipe installed in the trench condition because the trench width is generally too narrow to allow proper placement and compaction by other means.

There are two major problems that can happen with CDFs. The first is with cement content. If too much cement is added, the material will be difficult, if not impossible, to excavate through in the future if the pipe ever needs to be serviced. On the other hand, too little cement does not improve the flow characteristics sufficiently to fill all the voids in the trench without some form of compaction. Inspectors should closely monitor CDFs for both flowability and cement content. Do not allow the Contractor to add more or less than the amount of cement specified in Subsection 501-3.02(A)(3). It is better to err on the side of having too little cement, and requiring the Contractor to vibrate rather than creating an impenetrable tomb for the pipe.

The second problem with CDFs can occur with their density. The flowability characteristics of the slurry make it behave more like a liquid than a granular material. The denser this liquid, the more buoyant force it exerts on the pipe. When these materials have been used as trench backfill, there have been cases, especially with plastic pipes, where buoyant forces have caused the pipe to float in the backfill. When the Contractor intends to use a CDF as backfill, the Contractor should consider the buoyant forces expected on the pipe. When the buoyant force is greater than the weight of the pipe, then floating may become a problem, and the pipe may need to be anchored prior to backfilling. This is especially the case when using CDFs with flexible pipes CMPs and CHDPEPP.

Regardless of the type of bedding material used, it is imperative that the material under the pipe haunches is properly compacted and free of voids. Most structural failures of pipe have been attributed to poor consolidation and compaction of the bedding material under and around the pipe.

Pipe and Trench Backfill

After the pipe has been laid, and before pipe backfill is placed, the remaining bedding material is to be placed up to the pipe springline and compacted. The Inspector (and Contractor's Quality Control Representative where applicable) should make visual spot checks and perform density tests on the completed bedding material. Once the Inspector has approved the bedding, then the Contractor may proceed with the pipe backfill. Pipe backfill has similar material requirements to structure backfill, and are used interchangeably when pH and resistivity requirements are met. The material shall be sampled and tested for gradation, pH, resistivity, and PI. As an alternative, the Contractor may use pipe bedding materials as pipe backfill. Pipe backfill does provide additional rigidity and load carrying capabilities to flexible pipes such as CMPs and CHDPEPPs. The Inspector should be as careful as how pipe backfill is sampled, placed, compacted, and tested, as with pipe bedding.

Trench backfill is typically the native material removed from the trench. However, the Contractor is free to use pipe bedding or backfill materials as trench backfill. Sometimes the Contractor will elect to do this when these materials can be placed more quickly and more efficiently.

Heavy vibratory equipment should not be allowed to operate directly over the pipe until there is a least 3 feet of cover. Excessive vibration can cause the pipe to crack and shift in the bedding, thus, opening up the joints. Pipe or trench backfill should not be placed on top of any flowable fill until it has at least 24 hours to cure and develop some cohesiveness.

When a pipe is placed under a roadway or other structure, the Inspector must carefully monitor the backfill operation to ensure that the material is both placed in proper lifts and adequately compacted. There have been many pavement failures over pipe trenches. Strict enforcement of the backfill and compaction specifications is necessary on the Inspector's part.

Slope plating material is required around all pipe culvert inlets and outlets according to Standard Drawing C-13.10. This includes pipe with end sections. Slope plating material is not required when:

- Headwalls are installed
- Some other type of protection is specified (such as dumped rip-rap)
- The slopes will be plated with 2 feet of topsoil

The plating material must meet the material requirements of 501-3.04(A)(3). It is important that this material is both cohesive enough and compacted well enough to keep water from moving around the pipe and into the pipe backfill. The end sections are provided for scour and erosion protection.

Pipe should be inspected during and after any earthwork operation, or any heavy hauling over the pipe to detect any distortion or cracking of the pipe. Contractors must provide adequate cover over all pipes to avoid damage from heavy loads during construction. Section 105.14 provides guidance on enforcement of load restrictions.

The Inspector should perform a final inspection on the pipe checking for:

- Debris or obstructions
- Cracks exceeding specified widths and/or depths
- Properly sealed joints (especially around manholes)
- Pipe invert free of sags or high points
- Pipe ends or stubs properly plugged
- Connections and hookups properly made
- Catch basins, inlets, and drains connected properly

- Manhole frame and covers properly installed
- Patching and crack repairs completed

501-3.07 Non-Reinforced Cast-In-Place Concrete Pipe (NRCI PCP)

(A) General Requirements

Only Contractors or Subcontractors with previous experience in cast-in-place pipe should be allowed to use this option over other allowable pipe options such as RCP or CMP. If the Resident Engineer doubts the ability of the Contractor to perform the work adequately, then request the Contractor to submit a list of the proposed equipment and personnel including their experience on similar projects. The Resident Engineer is encouraged to visit these past projects and talk to the agency personnel. The intent is to get an idea of the level of skill and the quality of the workmanship to expect with this Contractor. Any decision not to allow the Contractor to use the proposed cast-in-place pipe crew or equipment should be discussed first with the District Engineer.

The Contractor will be required to have a Quality Control Administrator who will oversee the Contractor's quality control (QC) efforts and complete the "NRCI PCP Daily Observation Report" (see blank forms for this chapter). The Resident Engineer shall verify the qualifications of the proposed Quality Control Administrator.

Shoring plans are also required for NRI PCP if personnel are expected to enter trenches deeper than 5 feet. Although the operation might not be designed for this, the Engineer should be aware that personnel do enter the trench for such things as anchoring the deadman, cleaning the trench bottom of sloughed material, pulling the forms, and digging out the joint collar.

Inspectors should oversee the Quality Control Administrator's completion of the "Daily Observations Report". Ensure the Administrator is there to witness or perform the various quality control activities shown on the form. The Administrator should turn in a copy of the form the following day. The completed original form should be turned in after that section of pipe has been cored and accepted.

(B) Excavation

In the construction of cast-in-place pipe, the walls and bottom of the trench serve as forms and permanent bedding. The trench must be in stable soil that will retain its slope during the casting operation. When excessive sloughing occurs, the trench is filled with pipe backfill, compacted, and re-excavated to the exact pipe slope. The pipe must be cast against solid ground. For safety reasons, the length of an open trench should be limited to 1,600 feet. However, to prevent excessive drying and sloughing of the subgrade material, it is recommended that the amount of open trench be kept to a minimum.

If unsuitable material is encountered, it must be removed and replaced with pipe backfill compacted in lifts to 95% of the maximum density. The newly compacted material will then be excavated in the same way as the original material.

The trench is dug with a round bottom bucket having the same dimensions as the outside diameter of the pipe. Bucket teeth need to be sharp to cut a trench to the proper shape and grade. Over excavation will require extra concrete; which will result in uncompensated expenses for the Contractor. If the Contractor inadvertently over-excavates, only approved pipe backfill shall be used to refill the trench.

A trench that is too narrow or shallow may cause the casting machine to wedge in or to decrease wall thickness. Thin-walled areas may result in added expense to the Contractor for removing concrete, reshaping the trench, and recasting the removed pipe.

Smooth trench alignment, both horizontal and vertical, is needed to maintain the minimum wall thickness and a uniform flowline. The Contractor shall use laser guided alignment instruments to control line and grade. The inspector should measure (via straightedge, smart level, survey level, ADOT Survey, etc.) variation in grade, alignment, and degree of pipe support at 10 feet intervals to verify conformance with the Standard Specifications.

(C) Concrete Placement

The casting machine fits the shape of the trench. A winch with its cable attached to some fixed object propels the casting machine.

It is intended that the casting machine will have been specifically designed for constructing cast-in-place concrete pipe. The equipment must be acceptable to the Engineer. As a part of the proof-of-performance, the Contractor can be required to furnish certified load tests and hydrostatic test data.

The casting machine must be designed to continuously maintain minimum wall thickness and to distribute, tamp, vibrate, or consolidate the concrete resulting in concrete free of rock pockets and well bonded to the trench walls.

The Inspector should watch for sloughed material in the trench bottom caused by unstable materials and workers and equipment beside the trench. If the machine does not push this loose material ahead of it, the Contractor must clean it out ahead of the machine.

Two types of casting machines are usually used. One uses an inflatable tube ("balloon") form inside the pipe, and the other connects thin metal forms along the top 270 degrees of the pipe's interior as the pipe casting work progresses.

The balloon form is a heavy inflatable bag approximately 600 feet long made of canvas-like material. Normally, there is no need for hand finishing when using the balloon. The outside top portion of the pipe is finished smooth and free of rock pockets and cracks. The air pressure in the balloon must be monitored and kept uniform so that the form will stay firmly in place until the concrete attains initial set. After the concrete has set, the form is deflated and moved ahead for the next run.

The extruded method uses steel forms 4 feet long and shaped to the curvature of the inside of the pipe. The sections are installed manually by a worker "feeding" the sections into the machine and hooking them onto the previously placed section. A brace is then set to support the forms until the concrete sets, usually in 2 to 6 hours. After the concrete has its initial set, the forms are dropped, removed, cleaned, and reset. Workers finish the bottom inside and the top outside surfaces of the pipe during the pour.

It is important for the Inspector to ensure that the sides of the trench are kept moist during casting. This will help to prevent dry shrinkage cracking, which is a common problem with cast-in-place pipe.

When balloon forms are used, it is impossible to see if concrete is being adequately placed around the pipe invert. One way to check is by tracking the yield of the placed concrete. The Contractor should estimate in advance how many cubic meters of concrete will be placed for every linear meter of pipe. The actual quantities of concrete placed should be compared to the estimated quantities. The Inspector should spot check the Contractor’s calculations. Any underrun in yield (actual quantities less than estimated) should be a cause for concern.

Whenever the placing operation is stopped long enough that the concrete will set, a construction joint must be made as described in the Standard Specifications. The Inspector will make the determination of when the concrete has set, to the extent that a construction joint is needed. This joint will be of the rebar dowel or collar type. Before approving the pipe operation, the Engineer should come to an understanding with the Contractor as to when joints will be made. The Inspector should insist that the Contractor has the tools and materials at the site necessary for making unplanned construction joints.

When reinforcing dowels are required, they must be placed while the concrete is still plastic. With the stiff mix used for this operation, the Inspector should be aware that the bars would not be fully surrounded by concrete unless the Contractor applies some means of tamping or vibration.

When the Contractor resumes work at the construction joint, the Inspector should carefully inspect the condition of the joint and have it cleaned or trimmed, as may be necessary. The Standard Specifications call for standard construction joint cleaning. The collar around the joint must bear on firm ground and shaped to the full dimensions called for in the Standard Specifications. Note that the Standard Specifications call for a "collar" and not a "cap." The difference in labor and time is significant, and the Inspector must enforce this requirement.

Construction joints and joints for manholes, risers, and pipe junctions are constructed differently. The Engineer and Inspectors must have a detailed submittal for this operation. The submittal will include dimensions, rebar, time lapses, and curing.

(D) Finishing

With the "balloon" form, only the outside top section needs to be finished. When using steel forms, the inside bottom section and the outside top are finished. The finisher should use the laser to obtain a smooth flowing invert free of depressions that would hold standing water.

(E) Curing

Curing should be applied within 15 minutes following concrete placement. The top of the pipe is sprayed with curing compound, or in hot weather, covered with a polyethylene film and covered entirely with up to 6 inches of loose, moist dirt. Many of the pipe casting machines are equipped with fixtures for dispensing polyethylene film. In addition to keeping the cover dirt moist, it is important to close the ends of the pipe to keep a high humidity condition inside the pipe during the 7 day curing period. The Contractor should close the ends of the pipe in a manner that prevents air drafts through the pipe that would cause rapid drying. However, manholes and other openings should be left uncovered to dissipate any build-up of heat. Ventilation has to be provided when work is being done inside the pipe. The length of time that the pipe is left open shall be kept to a minimum. Standing water trapped in the pipe invert can also be used when excessive drying or heat build-up is anticipated.

(F) Backfilling

Backfilling may be done after the concrete attains 2500 psi, which may take about 48 hours. The usual procedure in these cases is to fabricate "field cured" cylinders for breaking before allowing backfilling.

Native material may be used, if acceptable, for backfill. Layer placing and compaction is the same as is required for the other types of pipe. Care is needed to keep heavy loads away from the pipe during backfilling. Also, excessive water should not be allowed to saturate the backfill.

(G) Pipe Repair

Patching rock pockets and voids should be done as soon as possible with an approved patching material. Typically, a non-shrink grout is used that will not pop out once the pipe is in service. ADOT’s Material Testing Section can be helpful in approving patching materials. It is not unusual to have to patch honeycombs and rough areas between form sections. Occasionally, the Contractor will run into a wet portion of a load and the concrete will not set up as well as anticipated. If possible, an Inspector should be present during any form-pulling operation to look for top areas that drop when the support is lost. Patching should be used as a means to remediate isolated imperfections and not as a repair method to correct improperly constructed CIPCP.

An important part of the quality control for CIPCP is the check for cracking inside the pipe. This should be done after all other repairs are completed and the pipe will no longer be subjected to any more loads from the Contractor’s heavy equipment. This inspection is usually done near the end of the project or when a partial acceptance is requested. The Standard Specifications set down detailed criteria on what cracks are acceptable. Generally, regardless of the length of a crack, when it fails to meet the depth and width specifications at any location, the entire section of pipe between the nearest transverse cracks is rejected. Transverse cracks 0.05 inches or more in width will be filled with an elastomeric sealant, however there are three conditions noted in the

Standard Specifications to reject pipe having longitudinal cracks. The Resident Engineer, after consulting with ADOT Materials Section and the District Engineer, may allow the rejected pipe to remain in place. The contractor in such a case will be required to epoxy inject the full depth at his expense. Generally, when a deficiency is discovered, it is the contractor's responsibility to propose to the Resident Engineer the repair method, and materials to be used, or remove the pipe. The Resident Engineer will either approve or reject the proposal.

(H) Pipe Wall Thickness

The contractor has complete responsibility for quality checks to ensure adequate wall thickness is achieved. These checks will be determined at the pipe invert and crown at a minimum of 25-foot intervals, and recorded on the Daily Observation Report (see blank forms for chapter V). Since there is no tolerance provided in the Standard Specifications, the contractor needs to target above the minimum wall thickness to ensure variations during the casting operation will not cause thin areas, possible rejection, and removal.

ADOT has the responsibility for the acceptance of pipe wall thickness through a process of marking hole locations to be drilled by the contractor. Holes should be marked at the invert and springline, plus other locations if directed by the Resident Engineer. The contractor will drill the holes a minimum diameter of ¾-inch. The inspector will use a gauge or measuring tape to determine the pipe wall thickness. If less than the minimum thickness is measured, then 3-inch diameter, or larger, cores will be taken adjacent to the drilled hole and isolated per the Standard Specifications. Repair procedure for drill or core holes shall be as approved by the Engineer.

Jack and Bore

Pipe Installation

Jack and bore is a form of trenchless pipe construction that requires the contractor to tunnel/bore underneath an existing roadway/railway/structure/etc., which cannot be closed or otherwise disturbed, in order to install storm drain or utility pipes. As a broad synopsis, a contractor will either use an auger-boring machine or manpower to tunnel underground, excavating and removing earthen material, and then insert/"push" a casing pipe, using a hydraulic-powered jacking system, to support the surrounding soil. After the casing pipe has been fully inserted, a carrier pipe will typically be inserted inside of the casing for use as the storm drain pipe or utility conduit.

Preconstruction Considerations

Jack and bore is an atypical form of construction that requires additional design considerations to be taken. ADOT Geotechnical Services should be consulted in the design and specification development for the work, and the ADOT Geotechnical Project Development Manual outlines additional requirements for subsurface exploration.

Factors to be mindful of when designing for jack and bore include:

- Percentage of rock cobbles that may be encountered
- Cohesiveness of the soil to be bored through

While these factors and design considerations will need to be addressed prior to construction beginning on the project, the Inspection team should be aware of said considerations and should take care in monitoring the soil being removed from the boring operation. A change in soil type may require the contractor to amend their means and methods so as to keep either loose soil from collapsing into the bore hole or the line and grade of the pipe from being thrown off due to the presence of large rocks.

Contractors performing this type of work are expected to provide a work résumé of previous projects within which they performed work of this nature. The Special Provisions should have experience requirements for both the company and key personnel on the crew.

On projects in which the casing pipe (most often made of steel) will also act as the carrier pipe, further considerations will need to be taken regarding the design of the jack and bore. This includes whether more stringent steel properties/cathodic protection/pipe coating will need to be specified. Additionally, as with all pipe construction, maintenance access will need to be considered and addressed. Careful consideration needs to be given to this access, for it follows that, if the pipe run was difficult to initially install (requiring jack and bore), it would be just as difficult, if not more so, to reinstall.

Pre-Activity Meeting

Prior to the work commencing, a pre-activity meeting should be held with the Department's Inspection team, prime contractor personnel, and subcontractor personnel. If the work is for a utility or other third-party, a representative should be present at the meeting as well. At the meeting, an overview of the activity and sequence of work should take place.

Topics to cover include:

- Pipe jacking and tunnel boring method and equipment
- Pipe profile and alignment quality control and verification
- Safety considerations
- Staging locations and site access
- Use of lower-tier subcontractors to perform the work
- Contingency plans if conditions change
- Contractor's working hours and schedule

An example of a pre-activity meeting agenda can be found in the "Forms" section of this chapter.

Safety Precautions and Considerations

As with other types of trenchless pipe construction, the work area for jack and bore may be within some pretty tight quarters. Due to this, many of the jacking/receiving pits, let alone the pipe tunnel, will be considered a "confined space," thereby introducing a myriad of safety requirements in performing and inspecting the work. In spite of the safety requirements, some of which may keep the Inspection team from performing their duties hands-on, the contractor needs to be reminded that the Inspection team shall have either have access to, or have information furnished of, the work activity as it progresses, per Section 105.12 of the Standard Specifications.

Depending on the size and depth of the jacking and receiving pits, shoring may be required. In instances when engineered shoring is required, the contractor will need to submit their shoring design for the Department's review prior to installation. Once cleared for use, as with any shoring plan, a copy should be provided to the Inspection team for their use and record.

Construction Procedure

As stated previously in this section, jack and bore is a form of trenchless pipe construction that requires the contractor to tunnel/bore underneath an existing roadway/railway/structure/etc. The tunneling operation is typically performed using an auger-boring machine. In rare instances, when the soil conditions are either non-cohesive or contains higher amounts of rock cobbles, the contractor may elect to perform the work via hand-tunneling, which entails having contractor personnel hand-excavate the soil inside the casing pipe. Whether excavation is performed via auger or hand-excavation, neither method should advance outside the end of the casing pipe, so as to help protect any personnel in the pipe and help minimize the risk of soil collapsing during the tunneling operation.

As the excavation advances along the pipe's line and grade, the contractor will then push/jack the casing pipe into the soil, providing the support for the surrounding soil. This jacking operation will continue until the pipe run is completed and the casing pipe outlets into the receiving pit. During the jacking process, care should be taken so as to not create excessive voids outside of the casing. Unless described in the Special Provisions, the contractor should be tasked with how voids outside of the casing will be both minimized and repaired. In many instances, this is completed by pressure-grouting outside of the casing, through pre-drilled grout ports at the top of the casing, once the casing's installation is complete.

After the casing has been installed, if specified, the carrier pipe will be installed. The carrier pipe is typically installed by being slid in on rails installed inside the casing pipe. Care should be taken to not damage the carrier pipe during installation. After installation is completed, the space between the outside of the carrier pipe and inside of the casing pipe, otherwise known as the “annular space,” will be filled with pea gravel.

Once the jack and bore operation has been completed, including the collection and furnishing of the surveyed pipe profile and video inspection record, the jacking and receiving pits are to be backfilled per the project specifications.

502 STRUCTURAL PLATE PIPE, PIPE-ARCHES, AND ARCHES

Prior to fabrication of the structural plate sections, shop drawings, and detailed erection instructions (showing the position of each plate and the order of assembly) are submitted to the Resident Engineer for review. These documents are in turn forwarded to the Project Designer for their review and comment.

Manufacturer's installation requirements for plate lapping shall be followed during erection. In some cases, the structure plan may call for various lengths of bolts for the different parts. A bolt length that will result in a full nut grip is required. The structure should be assembled with as few bolts as possible until all the plates are in place. Three or four untightened bolts placed near the center of each plate along the longitudinal and circumferential seams are sufficient. After several rings have been assembled, the remaining bolts can be inserted, always working from the center of the seam to the corner of the plate. Corner bolts should be inserted only after all other bolts are in place and tightened. After all the plates have been assembled and bolted, the nuts are to be tightened progressively and uniformly, starting at one end of the structure. When a power wrench is used, high torque is not required. Uniformity of tightening is more important than high torque. The minimum and maximum allowable torque depends upon the type of structural-plate. The specified torque range for aluminum structural-plates is 100 to 200 foot-pounds, but the torque range for structural plates with steel bolts is 100 to 300 foot-pounds. For inspection purposes, the acceptable torque should be within the specified range but, as stated before, uniformity of tightening is more important than high torque. Do not overtighten. The tightening sequence must be repeated to ensure that all bolts are tight. The Contractor should use a calibrated torque wrench.

Some damage to galvanizing generally occurs during structural plate erection. Repair of minor damage with two coats of zinc paint, or hot asphalt paint is permitted. Damage sometimes occurs around bolt holes when they are being aligned during bolting. Zinc paint should be on hand at the beginning of erection so the damage can be corrected as it occurs.

When specified, strutting shall be done according to the Project Plans and Standard Specifications.

Equally placed layers of backfill, on either side of the structure, are very important to prevent warping and movement.

Arches have a tendency to shift if backfill is uneven. The specification requirements for backfill sequence are to be followed carefully to minimize stresses. Heavy loads must be kept away from structural plate installations. Extra depth of fill over the structure is necessary to carry construction loads.

Although the structural plates are made from heavy gauge metal, the ends of beveled sections can be easily damaged so extra care should be taken when backfilling. Consult the reference section at the end of this chapter for additional information on good installation practices.

503 CONCRETE CATCH BASINS

Standard Drawings C-15.10 through C-15.92 show several types and sizes of catch basins to fit varying situations and requirements. Project Plans prepared for local governments may include drawings that may differ from the ADOT standard drawings. The Project Plans and bidding schedule will indicate the type or types to be constructed.

Precast catch basins must be from an approved supplier. A list of approved precast units may be found on the Department's Approved Products List. Testing of the precast units will be conducted by the Materials Group (Structural Materials Testing Section) for dimensional compliance and compressive strength requirements, as determined by the rebound hammer (ASTM C 805). Calibration of the rebound hammer may be necessary; the Structural Materials Testing Section should be notified as soon as a precast source has been selected by the contractor. ADOT Field staff should verify test results upon delivery of precast units. All precast units tested and approved by Materials Group will be stenciled "ADOT" in black letters. Project personnel are to verify that the ADOT stencil is authentic by contacting the Materials Group.

Care should be taken to construct catch basins to the proper gradient so they will function as they are designed. Finishing and curing of concrete above the ground level should conform to the requirements of structural concrete. When required, catch basin surfaces should meet adjacent sidewalk, curb, and gutter surfaces.

It is important that the contractor determine the "H" dimension (and ADOT verify) for catch basins in the field prior to casting.

Some important inspection points for catch basins are:

- Do the materials conform to the Project Plans and Standard Specifications and are material certifications available for those items requiring them?
- Was the "H" dimension determined and verified prior to precast?
- Is backfill around structures thoroughly compacted in 8 inch lifts before compaction?
- Does backfill material notch into firm material?
- Are connections with new or existing pipe water tight?
- Are the reinforcement bars in the walls as specified?
- When the forms are stripped, is the basin cleaned out?
- Has the invert been constructed to ensure the proper flow of water?
- Is an approved patching compound used for any patching necessary to bevel pipe/wall junctions?
- Is the catch basin at the correct elevation and height?
- When precast basins are used, have the units been checked for the ADOT stamp and inspected for any damage before installation?
- Is the gutter opening per the Standard Drawing? If the height of the opening is greater than shown on the Standard Drawing then a safety hazard is created.
- Does the grate rest securely on the frame?

504 STANDPIPES

A standpipe is a freestanding pipe fitted with a tap which is installed outdoors to dispense water in areas which do not have a running water supply. Standpipes are constructed for irrigation or drainage pipes and normally have metal or wood covers. Installation of metal gates is sometimes required.

Excavation for standpipes must be made to the required depth and of sufficient size to allow for construction forms. When unsuitable soil is encountered for the foundation, it shall be removed and replaced with suitable material.

For a standpipe using reinforced concrete pipe, proper equipment should be provided for lowering the pipe into the excavated area. The pipe should be placed so that the bell end is up to receive the cover. Mortar joints at connections should be made according to the Project Plans and must be water tight.

Some important inspection points for standpipes are:

- Do the materials conform to the Project Plans and specifications and are material certifications available for those items requiring them?
- Is mortar in conformance with the specifications?
- Is mortar used within the required time limit?
- Is stiff mortar discarded rather than re-tempered?
- Is the backfill around completed structures compacted in eight inch lifts?
- Is the backfill notched into firm material?
- Is the top of the standpipe covered at night

505 MANHOLES

Standard Drawings C-18.10 shows several types of manhole installations including special details for adjusting rings, manhole covers, pavement cut sections, etc.

All materials must be tested and approved and all required certifications must be in the project files before materials are incorporated into the work.

It should be noted that the sand required for use in the mortar is not the same as the sand used in Class S concrete. It must conform to ASTM C 144. Requirements of this specification may be obtained from the Materials Group or Regional Lab.

Often, when the forms are stripped from around the area where the pipes meet, the manhole will not have the desired smooth, rounded edges. Finishing is usually necessary to give this the desired look. The Engineer and Inspector are cautioned that the use of mortar to achieve this is not allowable. To avoid the history of flaking of these areas, the Contractor must be required to use an approved epoxy compound, either as the patch or as a bonding layer, per Specification 505-3.01.

Joints in precast sections are required to be watertight and should be finished smooth and neat on the inside.

Care must be taken in the backfilling operations so that no damage will occur to the manhole. The backfill material must be thoroughly compacted, in level 8 inch layers, around the manhole and out until it notches into firm material.

The frame of the manhole should be set very carefully to the grade and slope of the pavement so that there will be no roughness in the pavement because of the manhole. Frames and covers should be inspected to see that the covers fit, in any position, without rocking.

Testing of the precast units will be conducted by the Materials Group (Structural Materials Testing Section) for dimensional compliance and compressive strength requirements, as determined by the rebound hammer (ASTM C 805). Calibration of the rebound hammer may be necessary; the Structural Materials Testing Section should be notified as soon as a precast source has been selected by the contractor. Test results are shown on a test card that is sent to the project. All precast units tested and approved by Materials Group will be stenciled “ADOT” in black letters. Project personnel are to verify that the ADOT stencil is authentic by contacting the Materials Group.

Engineers, Inspectors, and Contractors should be aware of hazards involved when working in confined spaces and take necessary precautions to prevent accidents. The Engineer should keep personnel current on safety, and anyone involved in the inspection of manholes should have "Confined Space Entry" training.

Some important inspection points for manholes are:

- Do the materials conform to the Project Plans and specifications, and are there material certifications available for those items requiring them?
- Is the bearing face of the frame and cover machined so that the cover will lay flat in any position in the ring and has a uniform bearing throughout its entire circumference?
- Are the bricks wetted before use?
- Is the mortar mixed as specified, and is it used before the specified time limit?
- Are approved patching materials being used for all patching done to bevel pipe/wall junctions?
- Is the backfill material placed in layers not over 8 inches before compaction, and notched into firm material?
- Is compaction equipment sized appropriately and capable of closely following the contours of the manhole?
- Are the frames and covers set after the top course of asphalt pavement has been placed?
- Will there be any appreciable roughness in surface due to the setting of the ring and cover?

- Are pedestrians and traffic protected from the manhole excavation when the Contractor is not working?
- Are all necessary precautions being taken to prevent the water pumped from manholes from flooding the streets, alleys, sidewalks, and private property?
- Is fresh concrete properly protected from all traffic?
- If the manhole cover has an ADOT logo, ensure that it is the most current design

601 CONCRETE STRUCTURES

601-1 Description

A structure is an arrangement of materials that sustains loads. Loads can be the weight of an automobile, the force of the wind, or the pressure of soil and water. A structure must withstand loads without collapsing or deflecting excessively. A safe structure is one that can carry its intended loads without the risk of injury to the people using the structure.

Structures can be made up of different materials. For example, bridges can be built out of timber, steel or concrete. Sometimes these materials are combined to form composite structures where two or more materials share the loading.

The structures that ADOT builds are made primarily of structural steel or structural concrete.

Structural steel is a group of ASTM designated steels with material properties that are specifically intended for structural applications such as buildings and bridges. Structural steel is very different from the steel found in automobiles, washing machines, and hand tools. Structural steel is of higher grade, designed to have high strength, and stretches or yields just before failure as a warning to those in or near the structure.

Structural concrete is a composite material consisting of concrete and steel. It must meet higher standards of quality than concrete found in sidewalks or driveways. Like structural steel, it is designed to have a high strength and yield before failure.

Types of Structural Concrete

Structural concrete can be divided into two types: reinforced concrete and prestressed concrete.

Reinforced concrete consists of concrete and reinforcing steel. Concrete is strong in compression and weak in tension. Reinforcing steel is generally used to carry the tensile loads placed on a concrete structure. These tensile loads may be due to the bending of a concrete member such as a beam or due to shrinkage of the concrete itself. Reinforcing steel is used to help concrete carry compressive loads and shear stresses that develop when loads move through a structure.

Prestressed concrete is a mixture of concrete, reinforcing steel, and high strength steel wires or strands. The reinforcing steel serves the same purpose as in reinforced concrete. The steel wires, which are woven into steel strands, are designed to induce compressive loads in the concrete. By inducing compressive loads, the steel strands allow the structure to carry more tensile loads. In other words, before any portion of structure can go into tension, all the induced compression must be overcome first by the load. The steel strands can be either pretensioned or post-tensioned depending on whether the strands are tensioned before or after the concrete is placed in the structure.

Prestressed concrete requires less reinforcing steel since there is a smaller tensile stress developed in concrete. The result is thinner and lighter structural concrete members. The concept is further discussed in Section 602-1 of this manual.

Understanding Structures and the Importance of Inspection

Additional information on how structures perform and the materials used in them can be found in the references listed at the end of this chapter. Inspectors and Project Supervisors assigned to inspect concrete structures should have some basic understanding on how these structures are intended to perform. Discussions with the Designer of a structure can go a long way to clarify why the Special Provisions for a structure are written the way they are and why the Project Plans contain various details, which appear unnecessary or excessive. If the construction staff understands how the various structural members such as abutments, piers, and girders are designed to function, they are less likely to overlook key inspection areas.

The Department cannot overemphasize the importance of thorough and timely inspections on all concrete structures. Failures of concrete structures can result in significant damage to private and public property, and may ultimately lead to injury or death to members of the traveling public. The inspector is the guardian of public safety in this respect and should carry out inspections with the appropriate care and due diligence. An inspector is responsible for understanding how to read and interpret contract documents such as bridge construction plans, specifications, details and related drawings. For these reasons, an inspector who is unable to understand these documents or cannot confidently perform their required duties should notify their supervisors of their concerns immediately. Even experienced inspectors can encounter specifications and details that they are unfamiliar with or not confident in their understanding of the intent. For this reason all inspectors should seek clarification with the Project Supervisor or Resident Engineer on specifications and details that they have any questions or concerns about.

Resident Engineers and Project Supervisors have a duty to assign well-trained and experienced inspectors to structural concrete work. Inspectors who are being coached/trained in inspecting and accepting structural concrete items should be well supervised during this process. The Resident Engineer or Project Supervisor should sit down with the inspectors and review the Project Plans and specifications prior to construction. The inspector should know how each structural member is to be built and designed to fit together as a whole

The Role of the Designer and ADOT Bridge Group

During construction, the Designer of a structure, whether it be a Consultant Engineer or one of ADOT's own bridge design teams, will deal with questions regarding plan clarifications, shop and working drawing reviews, and routine construction problems involving design details. The ADOT Bridge Group develops design and construction policies for bridges and other major structures. Policy and procedural changes related to bridge construction and bridge construction specifications must be cleared through the Bridge Group regardless of who designed the structure

The Bridge Project Engineer

ADOT Bridge Group assigns a Bridge Project Engineer to each project who is available to answer any questions Resident Engineers or Project Supervisors may have about any aspect of the bridge construction. This is a valuable resource that the Department encourages the field staff to use.

Major construction problems, significant design and specification changes should be discussed with the Bridge Project Engineer regardless of who designed the structure. The Bridge Design Guidelines describe the Bridge Group's and the Bridge Project Engineer's role during construction.

Minor Structures versus Major Structures

Section 101.02 of the Standard Specifications define what ADOT calls a structure. The intent is that anything that sustains a load is called a structure. This could be a buried pipe that carries soil loads from above or a catch basin that holds the weight of water within it. This distinction is important since certain specifications (for example Sections 202, 203, and 601) require the contractor to do certain things when working around a structure. Subsection 601-1 further subdivides structures into two main groups: Minor structures are small easy-to-install structures that can be either precast or cast-in-place. Major structures are the larger heavier structures that are usually cast-in-place, but can be precast. The following table lists the most common minor and major structures:

Minor Structures	Major Structures
Cattle guards	Box culverts
Catch basins	Bridges and bridge members

Barrier wall	Walls
Headwalls	Slabs
Manholes and manhole risers	
Utility vaults and pull boxes	

Although concrete pipe is considered a structure and can be precast, it actually falls under the 501 specification.

Other Specifications Related to Concrete Structures

Section 601 and 602 of the Standard Specifications do not encompass all aspects of structural concrete construction. In fact inspectors should frequently refer to other sections of the Standard Specifications and Special Provisions. In addition to the component materials of structural concrete such as cement, sand, water, and fly ash, structural concrete has many related materials such as reinforcing steel, joint materials, bearing pads, and prestressing strands that become integral parts of the structure. Relevant Standard Specifications sections include:

- Subsection 109.10 - Lump Sum Payment for Structures
- Subsection 202–3.04 - Removal of Miscellaneous Concrete
- Subsection 202–3.05 - Removal of Bridges
- Subsection 203-5 - Structural Excavation and Structure Backfill
- Section 605 - Steel Reinforcement
- Section 1003 - Reinforcing Steel
- Section 1006 - Portland Cement Concrete
- Section 1011 - Joint Materials
- Section 1013 - Bearing Pads

601-2 Materials

Concrete structures are the product of different types of materials, utilized to maximize their strengths and negate their weaknesses. Each of these materials has its own specification, standards and inspection requirements.. Because of this, the inspector must be well prepared for the inspection process and know what contract documents take priority for each material item, where these documents are located, and how to access these documents to complete the necessary inspections. It must be emphasized again that inspectors must be experienced at structural concrete inspection or be well supervised if they are being coached/trained in inspecting and accepting structural concrete items.

The following table summarizes all the materials used in concrete structures and lists where to find the installation and material requirements in the Standard Specifications. The Project Plans and Special Provisions should be consulted first when researching specification requirements for each material.

Material	Installation Specifications	Material Specifications
Concrete		
In general	601, 1006	1006
Cement		1006-2.01, ASTM C150
Water		1006-2.02, ASTM C1602
Fine Aggregate		1006-2.03(B), AASHTO M 6
Coarse Aggregate		1006-2.03(C), AASHTO M 43
Admixtures		1006-2.04, AASHTO M 154 & M 194, ADOT's Approved Products List
Fly Ash		1006-2.04 (D), ASTM C618 & C311
Related Materials		
Reinforcing Steel	605, 601-4.02(B)	1003, AASHTO M 31 (ASTM 615)
Tie Wire	605-3.01	1003-3, AASHTO M 32
Form Ties	601-3.05(B) (for finishing)	None
Precast Mortar blocks	605-3.01	Same 28 day strength as surrounding concrete when blocks sampled and tested, Arizona Test Method 315
Chairs and Bar Supports	605-3.01	None
Mechanical Couplers	605-3.02, manufacturer's recommendations	605-3.02, ADOT's Approved Products List
Welds	605-3.02, 605-3.01(B)(3)(d) ANSI/AASHTO/AWS D1.5-88	604-3.06 ANSI/AASHTO/AWS D1.5-88
Welded wire fabric	605	1003-4, AASHTO M 55
Epoxy-Coated Reinforcing Steel	605-3.03	1003-5
Steel Plates and Bars	Project Plans or shop drawings, 601-4.02	1004, ASTM A 36 or A 588
Galvanizing when exposed:	601-3.04(B)(3)(f)	ASTM A123 and A125
Bolts: Nuts and Washers:	Project Plans or shop drawings	601-3.04(B)(3)(f), 604-2.03, 606-2.05, or 731-2.02(G), otherwise for bolts ASTM A325, nuts and washers ASTM A563 Exposed parts are galvanized
Prestressing Steel -Wire: -Strand: -Bars:	602-3.06, 601-4.02	602-2.01 AASHTO M 204 AASHTO M 203 AASHTO M 275
Post-Tensioning Ducts	Approved shop drawings, 602-3.05, 601-4.02	602-2.02
Post-Tensioning Hardware & Anchorages	Approved shop drawings, 602-3.04	See steel plates and bars Bars may be designated AASHTO M 275
Post-Tensioning grout	602-3.07	602-2.03, 1006-2.01
Styrofoam	Project Plans	
Hardboard	Project Plans	
Bearing Pads	1013	1013
Vertical Restrainer - Tempered hardboard: - Expanded Polystyrene:	601-3.09	601-3.09(B), ASTM A603 601-3.09(B), ANSI/AHA Std. A135.4, Fed Spec LLL-B-810 601-3.09(B), ASTM C 203
Joint Materials	601-3.04, see Project Plans and Special Provisions	1011

Water Stops	601-3.04(C)	1011-1
Material	**Installation Specifications**	**Material Specifications**
Curing Compound	1006-6.01(C)	1006-2.05, AASHTO M 148, ADOT's Approved Products List
Patching Mortar	601-3.05	601-3.05(B), 1016, 1017, ADOT's Approved Products List
Non-shrink Grout	1017-3	1017-1, 2, & 4 and ADOT's Approved Products List
Epoxies and Adhesives	Project Plans or Special Provisions, 601-3.04(B)(3)(g), 601-3.05(B) & 3.09(B), 605-3.04, 1101-5.01	1015, ADOT's Approved Products List
Concrete Stain and Paint	Special Provisions	Special Provisions, ADOT's Approved Products List
Conduit	732-3.01	732-2.02
Pull Boxes	Special Provisions or Project Plans	732-2.04
Grounding Wire	Special Provisions or Project Plans	Special Provisions or Project Plans
Structure Backfill	203-5, Standard Drawing B-19.40 & 19.50	203-5.03(B)
Geocomposites	203-5.02(A) & (B)	1014

Precast Units

When the contractor chooses to use precast units for minor structures, the Project Supervisor or Lead Inspector should ensure that the units have been approved for use on the project in the contract documents, by the engineer of record, or by the appropriate ADOT technical staff. Only precast units that have been pre-inspected at the contractor's precast plant and bear an ADOT stamp shall be allowed for use on the project, refer to section 601-3.07.

601-3 Construction Requirements

601-3.01 Foundations

There are three different types of foundations for major concrete structures:

1. Spread footings consist of a cast-in-place reinforced concrete pad that is poured on the subgrade soil. The pad spreads the load carried by the structure so as not to exceed the bearing capacity of the soil. The construction of spread footings must also meet the requirements of a concrete structure as specified in Section 601.

2. Piling (driven piles) are long, H-shaped, structural steel sections driven vertically into the ground much like a nail is hammered into a piece of wood. The piles are spaced only a few feet apart and are driven to depths of up to 65 feet. A reinforced concrete cap is usually poured on top of each group of piles. The cap transfers loads from the structure to the piles. The piles transfer the load to soil through end bearing and friction between the soil and the pile. The specifications for piling are found in Section 603.

3. Drilled shafts are designed to behave much in the same way as piles. Both rely on friction between the soil and the pile or shaft to support the structure. Drilled shafts are constructed by drilling a deep vertical hole in the ground and filling it with reinforced concrete. Drilled shafts are used in highly cemented soils

or soils with large boulders that would make drive piling difficult to nearly impossible. The specifications for drilled shafts are found in Section 609.

Foundation Inspection

The most important thing an inspector can do when inspecting foundations is to ensure that the foundation is placed on the same soils as shown in the Project Plans. This means comparing the soils encountered in the field with the soils descriptions shown in the boring logs contained in the Project Plans. If the material encountered does not match what is shown in the boring logs, the inspector should bring this discrepancy to the attention of the Resident Engineer who in turn should contact the Designer. Even if a soil appears firm and stable, the wrong type of soil can adversely affect the long-term settlement and load transfer characteristics of the structure.

The same process of soil identification and comparison should be done for drilled shafts using the auger trimmings as a means of soil sampling and identification.

Approving Foundation Subgrades

Spread footings should not be placed on soft yielding soils even if this is the same soil shown on the Project Plans. The project supervisor should contact the Designer to verify that the soil conditions in the field are the same as they anticipated during their design. When bedrock or highly fractured decomposed rock is encountered, a Geologist retained by the Designer should be consulted to ensure the geologic conditions are the same as anticipated. This may involve a site visit by both the Designer and Geologist to verify site conditions. The inspector should document their visits and any instructions to the Department that will be carried out by the contractor. The foundation subgrade should be inspected and approved before any work begins.

Structural Excavation and Dewatering

Subsection 203-5 of the Standard Specifications describe the requirements for structural excavation and structure backfill. See Subsections 601-3.07 and 203-5 of this manual for further information. In foundation work where water is present, the water should be pumped out before concrete is placed. When water is pumped out of the forms during the placement of concrete, the pump inlet should be in a sump outside the forms. Drainage of the forms should be arranged so that no water will be flowing through the forms.

The concrete should not be shoveled or pulled through the water. If it is not possible to remove the water completely, the placement of concrete should begin at one end by means of a tremie, bringing the concrete above the water. The water should be forced ahead of the concrete mass by placing the concrete with as little disturbance as possible, using moderate vibration to settle the leading edge. Additional cement may be needed in the concrete mix when placing it under water. Check with the Designer.

601-3.02 Falsework and Forms

(A) Design and Drawings

Resident Engineers, Project Supervisors, and inspectors who oversee structural concrete construction must clearly understand the differences between falsework and forms (or formwork). The second and third paragraphs of Subsection 601-3.02(A) define both.

Forms (or formwork) simply contain the concrete and give it shape. Fresh concrete behaves like a fluid and forms contain the concrete until it has time to harden. The forms resist the lateral fluid pressure fresh concrete exerts on its container. Forms give shape to the concrete until it hardens and can be used to provide a desired surface texture like rustication.

Falsework does not contain concrete. It holds up concrete until it has enough strength to support itself. When concrete is suspended in the air, falsework is used to carry the vertical loads induced by both the weight of the fresh concrete and any formwork used to contain the concrete.

In the simplest of terms, falsework holds it up and formwork holds it in. The best way to visualize the difference is to think of a water tower. The tank at the top of the water tower contains the water. It is the formwork. Its only job is to hold the water without leaking. The tower itself is the falsework. It holds up both the tank and the water in the air.

Exhibit 601-3.02-1 shows the formwork for a wall. Note that the wall is sitting on the ground on top of a footing. The vertical load (weight of the fresh concrete) is supported by the footing that rests on the ground. This structure has no falsework. It would be like the tank from a water tower sitting on the ground.

Exhibit 601-3.02-1 shows the typical components of falsework. You might see this type of falsework under a cast-in-place box girder bridge or slab bridge. Concrete is usually placed directly on top of the plywood sheathing. The sheathing contains the concrete and keeps it from spilling to the ground, along with supporting the concrete by transferring its weight evenly across the joists. In this case, the sheathing acts as both formwork and falsework. The joists transfer the weight of the concrete and the sheathing to the stringers. The stringers transfer their loads to the vertical shores until the loads reach the mudsills, which in turn, pass all the loads to the ground.

Inspectors and Resident Engineers often confuse formwork with the falsework. The following are examples of formwork and falsework:

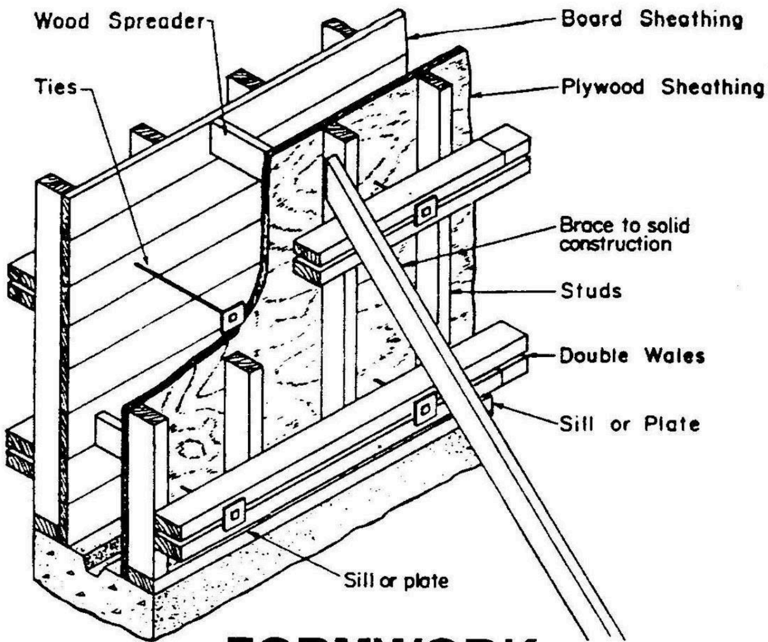
Formwork:

- Catch basins and manholes
- Abutment walls and spread footings
- Retaining and noise walls; regardless of height
- Pier columns; both vertical and curved
- Box culvert bottom slabs and side walls
- Interior cast-in-place girders

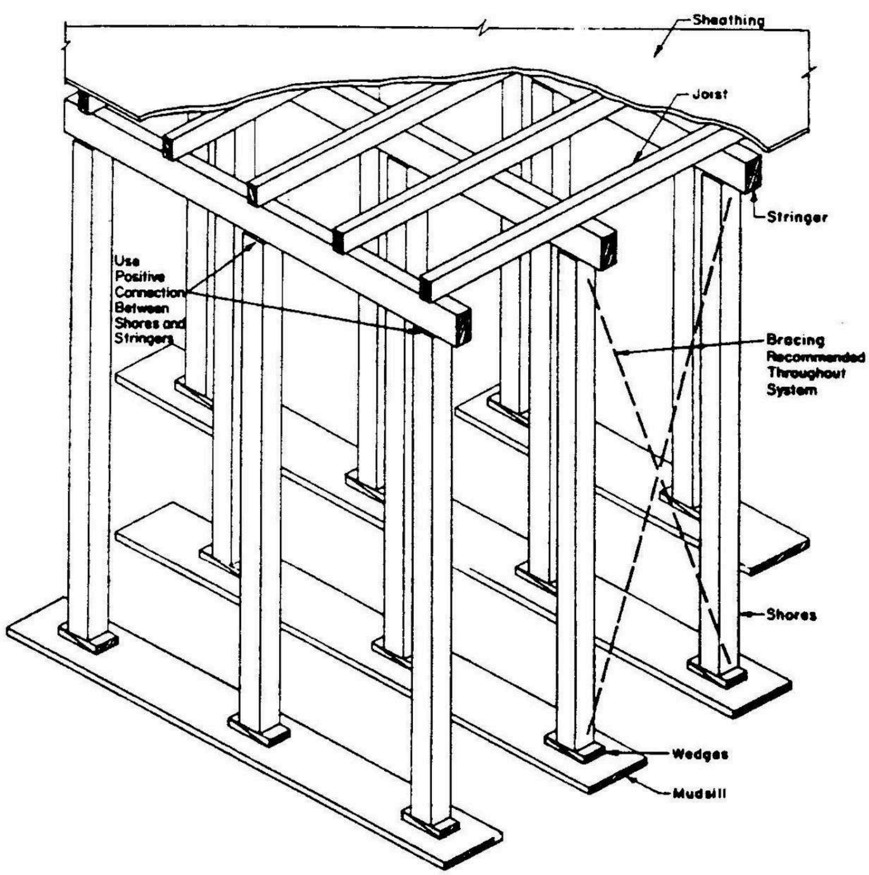
Falsework:

- Bridge decks; only the sheathing acts as formwork and falsework
- Deck overhangs; only the sheathing acts as formwork and falsework
- Exterior cast-in-place girders
- Pier caps / cap beams / bent caps
- Abutment wing walls with sloping bases
- Box culvert top slabs
- Shoring systems for cast-in-place box girder bridges
- Soffit fills

Drawings and calculations, referred to as working drawings in section 105.03, must be submitted by the contractor for all falsework on the project in accordance with Subsections 601-3.02(A) and 105.03. Exhibit 601-3.02-2a and 601-3.02-2b are examples of falsework drawings for a bridge superstructure. The falsework is a combination of steel and timber members that is typical for most bridge falsework. The stringer, joists and cap beams are steel I-beams, while the shores, decking, bracing, corbels, sills and wedges are timber.



FORMWORK



FALSEWORK

Exhibit 601-3.02-1 Formwork and Falsework

Falsework designs must bear the seal of a Professional Engineer registered in Arizona. This includes shoring systems supplied by out-of-state manufacturers.

A few exceptions are:

- All minor structures
- The top slabs for box culverts less than or equal to 12 feet wide
- Abutment wing walls with sloping bases

Falsework drawings and calculations shall be submitted to the Designer of the structure for review and approval. Before submitting these documents to the Designer, the Resident Engineer should check for:

- Five sets of drawings and calculations
- Legible drawings and calculations sealed by a Professional Engineer registered in Arizona
- Correct drawing size and border requirements including a blank space on the drawing for approval stamping

See Subsection 105.03 for further information. A reproducible set of falsework drawings is not required unless requested by Bridge Group.

The design and detailing requirements for falsework are listed in Subsection 601-3.02(A). The Resident Engineer may want to review the submitted drawings and calculations for general conformance to this subsection before submitting them to the Designer. The Resident Engineer may choose to review and approve falsework plans for very simple structures where there is no doubt as to the adequacy of the falsework.

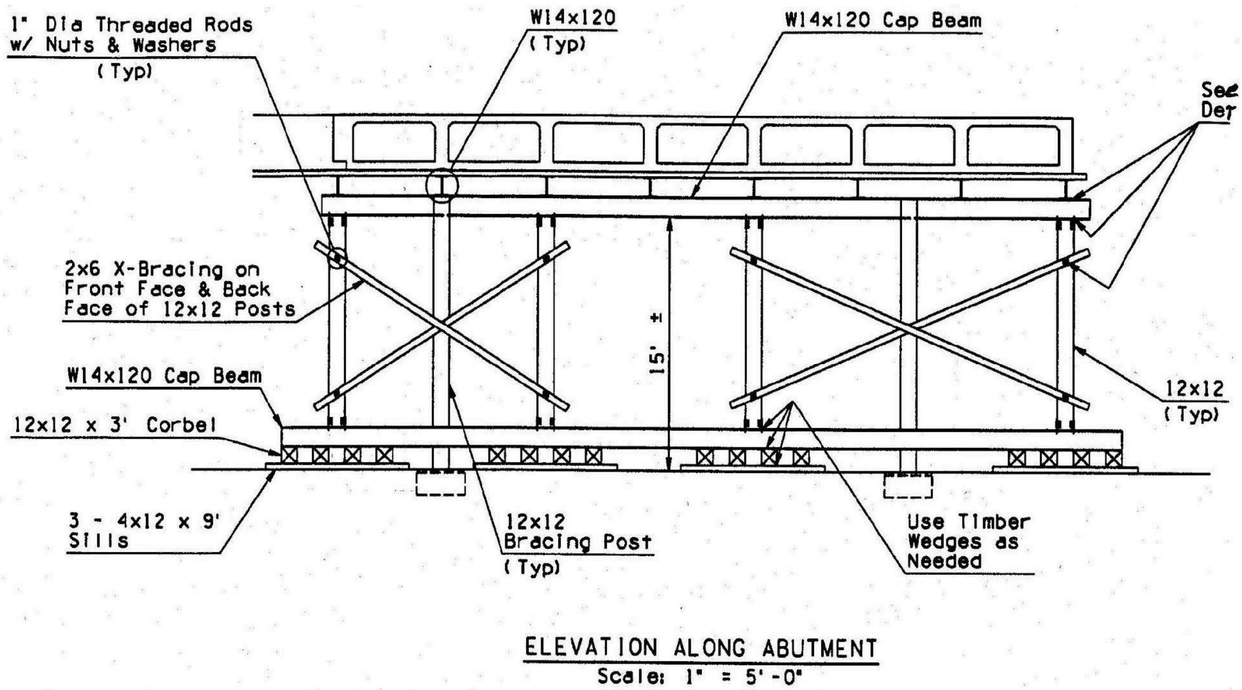
On railroad grade separation structures, a copy of the falsework plans must be sent to the Railroad Company's Engineering Department for approval. The railroad companies need long lead times for review and approval.

ADOT’s falsework policy can be found in Section 16 of the Bridge Design Guidelines that describes some of the geometric and clearance tolerances of falsework.

Other Submittals

On precast girder bridges, the contractor shall submit survey data for each precast girder showing the elevation at each tenth point along the top of the girder after it has been set on the bridge. In addition, data collected on camber and camber growth at the fabrication yard should be submitted, see Project Plans and Subsection 602-3.06(A) of this manual. This information must be submitted and reviewed prior to deck forming. The Project Supervisor shall forward this information to the Designer.

The Designer will check to ensure that the girders do not encroach into the deck slab due to excessive camber. Sometimes adjustments to the deck profile or girder bearing seats are needed to maintain a minimum deck thickness between each girder. If the deck forms and reinforcing steel are already in place, these adjustments could become very time consuming and costly. It is a good practice to check the elevations on top of the girders ahead of time and make any field adjustments if necessary.



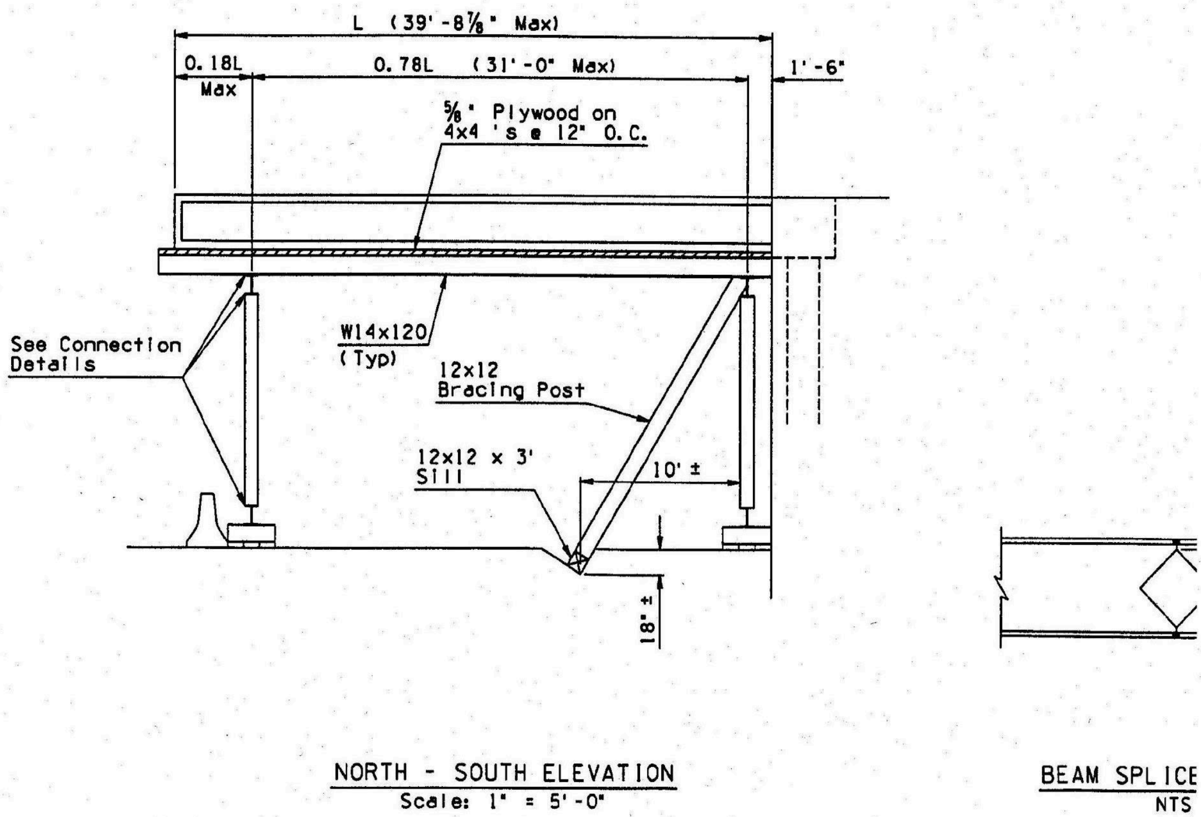
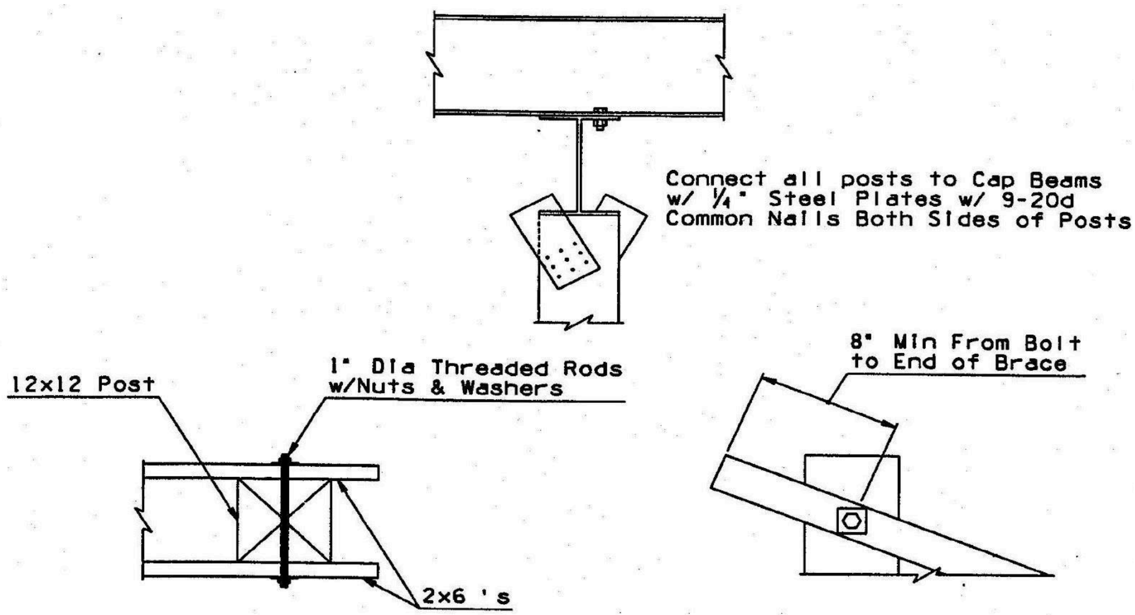


Exhibit 601-3.02-2a Falsework Drawings



TYPICAL TIMBER CONNECTIONS

NTS

NOTES:

1. Construction specification - Arizona Department of Transportation Standard Specifications for Road and Bridge Construction, Edition of 1990.
2. Materials:

   ⅝" Plywood - APA Exterior-type STR I
   4x4 Dimension Lumber - Douglas Fir-Larch No. 2
   2x6 Dimension Lumber - Douglas Fir-Larch No. 1
   12x12 Dimension Lumber Post - Douglas Fir-Larch No. 1
   Structural Steel - ASTM A36

3. Soil Allowable Bearing Stresses are assumed to be 3000 psf on natural and field compacted materials.
4. All materials shall be in new or good condition.
5. Members shall be nailed, bolted, clamped, or welded where slippage is possible.
6. All steel members must be connected by means of welds and/or bolts. Use ⅝"Φ A325 bolt or 3" long ¼" fillet weld.
7. For beam splice, use complete-penetration groove weld butt joints on the flanges. Use weld plates on both sides of the web. Each weld plate shall be ½ the thickness of the beam web. Apply a fillet weld all around each plate the thickness of the plate.
8. All electrodes shall be E70xx, and all welding is to be done by a certified welder.
9. The deflections of all beams are limited to L/270.
10. No changes are permitted without the Engineer's approval.

	NAME	DATE	
DESIGN	YC	05/99	
DRAWN	TST	05/99	
CHECKED	KTD	05/99	
ENTRANCO			RAMP SHORING
ROUTE	MI POST	STRUCTURE NO.	

Exhibit 601-3.02-2b Falsework Drawings

Formwork drawings and calculations, referred to as working drawings in 105.03 are required for the cast-in-place girders (webs) on box girder bridges (see Subsection 601-3.02[C]). These drawings shall go through the same submittal and review process as falsework drawings. As a minimum, formwork plans should include:

- Type, sizes, and grade of materials used for form ties, spreaders, sheathing, studs, wales, and braces
- Formwork layout drawings including spacing of ties, studs, wales and braces
- Connection details
- Assumed concrete pressure distribution, rate of concrete placement, concrete temperature, and height of concrete drop into the formwork
- Allowable capacities of form ties and anchors and their calculated factors of safety
- Design stresses, deflections, and allowable capacities for the individual formwork members, including braces, in accordance with Subsection 601-3.02(A)

The girder webs are the most important structural concrete members for cast-in-place box-girder bridges. In the past, the Department has experienced form blowouts and significant lateral movement of the forms due to inadequate bracing. This can result in significant deviations in girder alignment that can over-stress the girder webs and cause significant friction loss in the post-tensioning cables. Formwork drawings are intended to assist the contractor in developing a well thought-out plan and avoid unforeseen problems during the concrete pours of these very important and difficult to repair bridge members.

See Subsection 601-3.02(C) of this manual for further information on formwork.

(B) Falsework Construction

Once falsework drawings have been reviewed and approved, the Resident Engineer or Project Supervisor should distribute copies to the inspectors. Inspectors should oversee the falsework construction and inspect the work to eliminate obvious defects and safety hazards. Falsework failures and collapses are not common but do happen; proper initial and frequent followup inspections assist in assuring structural stability. All inspections, performed by an ADOT Inspector or by the designer, should be documented in the inspectors daily diary.

Common falsework failure causes include:

- Inadequate bracing
- Lack of attention to falsework details during erection
- Using inferior materials compared to what is specified
- Shores or vertical members not plumb
- Unstable soils under mudsills
- Vibration due to construction traffic or concrete placement
- Inadequate control of concrete placement, i.e. pouring too fast or loading the structure unevenly
- Improper stripping and shore removal

Keep these reasons in mind as you observe the contractor erect and remove falsework. Even though the contractor will have a Professional Engineer certify the falsework construction, it is still necessary for the inspector to observe the work and ensure the falsework is erected correctly without large amounts of rework. The contractor is still ultimately responsible. Any rework to correct deficiencies or a failure that shuts down the project benefits no one and causes a lot of unnecessary aggravation.

Additional conditions that should be monitored are as follows:

Footings and Mudsills

- Soil type is the same as identified in the approved falsework drawings.
- Soil is firm, stable, and has uniform contact under the mudsill.
- The top surface of the mudsill or footing is level.

- Mudsill and/or footings are protected from wash-out or undermining with proper surrounding drainage.
- Mudsill or footing are set back reasonably far enough from the edge or toe of slopes.

Sand Jacks

- Are the sand jacks placed on a sound, stable, plumb and level surface?
- Check that the sand jacks are the correct dimensions shown on the design plans; if they are too small, they may not be able to accommodate the designed load capacity.
- Has a ¾ inch piece of plywood been placed between the sand and the falsework post? The cap/plate should be smaller than the inside dimensions of the jack but not smaller than the falsework member resting on it. This allows for movement when the sand is released during removal.
- Are the materials used in the construction of the sand jacks of the correct type, size, thickness, and grade as shown on the design plans?
- For metal jacks:
  - Are the nuts, bolts, and washers of the correct grade per design specifications?
  - Are the nuts and bolts torqued or tightened to the designed specification?
  - Is the angle iron or pipe used of the correct thickness and grade?
- For wood jacks:
  - Is the wood of the correct type (struck #), is the wood being used sound and free of cracks, splitting and knots? Knots can blow out and suddenly release sand; never allow split or knotted wood to be utilized when constructing jacks.
  - Are the bands of the correct size?
  - Are there a correct number of bands being used on each jack?
  - Is the banding tight with no signs of slippage?
- Regardless of the sand jack type used, it is good practice to keep the immediate area around the jacks clean and free of excess sand. This allows for easy identification of sand leakage from a jack.

Pilings

- Piles are placed within specified driving tolerances.
- Piles are driven to the allowable bearing values.
- Pile caps are properly set and level to ensure uniform bearing over the pile group.

Timber Falsework Members

- Timber is free of noticeable defects for the grade specified (splits, open knots, rots, and cuts).
- Timber appears well seasoned so warping and shrinkage will be minimal.
- All members are in full contact with each other.
- Size, spacing, length, and grade of members are the same as shown in approved drawings.
- Diagonal bracing is installed as per drawings.
- Connections are checked for tightness with no loose hardware.
- Vertical members are plumb and horizontal members are level.
- Camber is provided when required to offset dead load deflections.
- Full bearing connections are examined for crushing.

Only double wedges shall be used between the mudsill and the supporting posts, see Exhibit 601-3.02-3. The wedges must be kept tight and placed so that there will be no eccentric loading. They should be examined frequently during the placement of concrete in the deck and adjusted when necessary to conform to design elevations of the deck floor. Wedges should not be stacked more than two high. If two wedges will not serve the purpose, a longer vertical member is needed.

Structural Steel Falsework Members

- Salvaged beams and other steel shapes are examined for section loss, web penetrations, rivet, or bolt holes, and local deformation that could affect the member's load carrying capacity.
- Column or pile bents are set plumb and beams are placed level.
- Member size and spacing in conformance with the shop drawings.
- Bracing is installed per drawings, especially where called out on beam compression flanges.
- Bolted connections are sufficiently tightened with the proper number of bolts.
- Welded connections are done to prescribed standards by a certified welder, see Subsection 604-3.06 of this manual.
- Splices are located only at locations shown in the drawings.
- Allowances made for jacking the bridge structure for members are located under a hinge, see Project Plans and Subsection 601-3.04 of this manual.

Manufactured Steel Shoring Assemblies

- The manufactured shoring system is in full compliance with manufacturer's recommended usage.
- Base plates, shore heads, extensions, or adjusting screw legs are in firm contact with the foundation or support.
- Shoring tower assemblies are set to the correct spacing.
- Cross-bracing is in conformance with the drawings, including frame-to-frame braces and tower-to-tower braces.
- Screw leg extensions are within the allowable limits or adequately cross-braced, and snug to tower frame.
- Tower frames are checked for plumbness.
- Top U-heads are in full contact with the joist or ledge, and hardwood wedges are snug.
- Frames are examined for section loss, kinks, broken weld connections, damaged cross-bracing lugs, or bent members.
- Loads on shore heads are applied concentrically, and not eccentrically.
- All locking devices are in the closed position.
- Guy wires are adequately attached to towers and ground support.
- Allowances are made for jacking the bridge structure for members located under a hinge, see Project Plans and Subsection 601-3.04 of this manual.

Falsework Protection

- Barriers and crash attenuators are placed in correct locations, lengths, and numbers.
- Warning and clearance signs are up.
- Safety or banger beams (if required) are set at the correct height and offset distance from the structure. All roadway clearance issues will need to be identified and entered into ADOT's Event Reporting System (ERS) prior to work affecting said roadway begins.
- Horizontal clearances are maintained between shores and barriers.
- Falsework members adjacent to barriers are properly bolted or mechanically connected, see Subsection 601-3.02(A) and approved drawings.
- Falsework bracing and bolted joint connections are installed as the falsework is going up and not left until the entire structure is completed.
- Lane widths are correct under the falsework.
- Signing, striping, barrier, and barricades are set in accordance with approved traffic control plans.

Construction personnel are reminded that the lower clearances over traffic, caused by the falsework, will necessitate early warning signs, possible detours, and notification of the District Permits Supervisor so that loads exceeding 14.5 feet may be warned and rerouted. An inspector should verify the height of falsework over traffic openings and record the measurements in their daily diary.

AASHTO's Construction Handbook for Bridge Temporary Works is an excellent reference guide for Resident Engineers and Project Supervisors who oversee falsework construction.

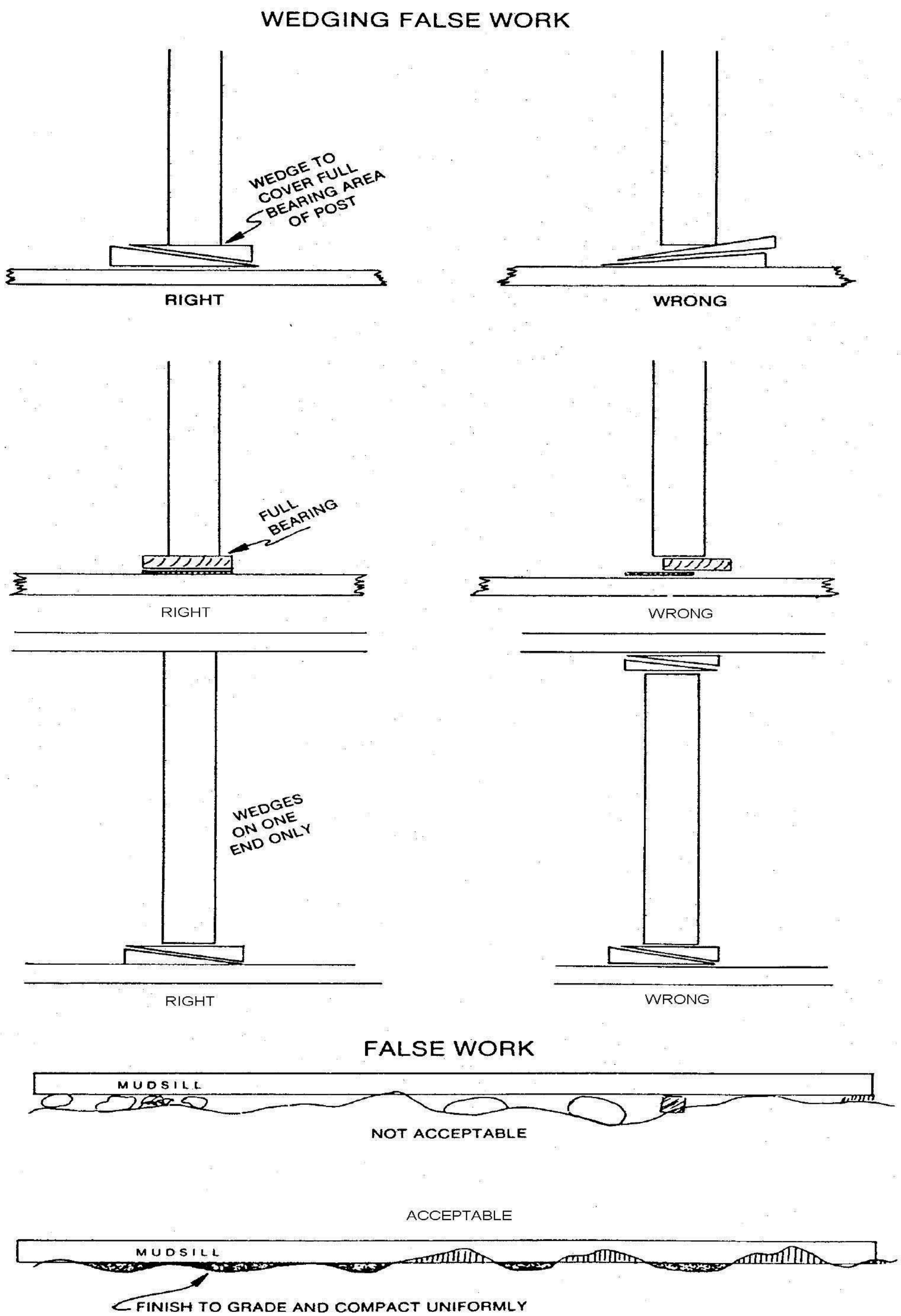


Exhibit 601-3.02-3 Falsework Foundations

Pour Certificate

The contractor's Engineer shall provide a letter certifying that all falsework has been constructed according to the approved drawings. This letter should include the signature and seal of the Engineer with a statement that the erected falsework was in accordance with the approved falsework drawings. Do not allow the contractor to place concrete in any forms above falsework until you have received the Engineer's letter, reference Section 601-3.02 (B)(2).

Setting the Falsework Accurately

Inspectors and contractors often overlook the importance of setting falsework. The elevation, slope, cross fall, and shape of the entire structure is based on how accurately the falsework is placed. Carpenters use the falsework decking or waste slab as a reference for sizing all their formwork for each structural member and ironworkers use it to set their bar supports for reinforcing steel in the beam and deck slabs.

Tolerances for falsework decking are based on Subsection 601-4.02(A)(2). Since the falsework decking is used as the bottom form for slabs, girders and beams, the decking has a – 1/8 inch to +1/4 inch elevation tolerance everywhere on its surface. Wedges and screw jacks are used to help meet these tolerances. The inspector should have the contractor's survey crew verify that the falsework has been set to this accuracy. Some allowances are made by the contractor, usually in the falsework drawings, for falsework settlement and joint crush. Camber is added to account for dead load deflections once the structure is poured.

Soffit Fills and Waste Slabs

One method for constructing a cast-in-place box girder bridge is to cast the bridge piers and abutments first. The area between the piers and abutments is filled with dirt. A thin concrete slab, called a waste slab, is poured on top of this dirt. The waste slab acts as the bottom form for the bridge superstructure while the dirt, called a soffit fill, acts as the falsework.

Working drawings, similar to falsework, must be submitted by the contractor (see Subsection 601-3.02[A]) for soffit fill and waste slab construction.

Information should include:

- Soil type
- Fill placement and compaction methods
- Compaction densities to be achieved
- Fine grading methods
- Grade control for the waste slab
- Placement and finishing methods for the waste slab
- Waste slab thickness and strength
- Quality control and repair procedures for out of tolerance areas

Although the soffit fill and waste slab are temporary, the contractor must construct both to very close tolerances. Like falsework decking, the waste slab is used as a reference for constructing the entire bridge superstructure, see the previous discussion on setting falsework accurately.

Subsection 601-3.02(C)(3) requires ± ¼ inch tolerance on the waste slab for both grade and smoothness. The soffit fill should be constructed to similar tolerances.

There are no thickness or strength requirements for waste slabs. Typically contractors will pour a slab 2.5 inches thick with 2500 psi concrete. However, waste slabs must meet the requirements of 601-3.05(A) since they are the formed surface for the bottom slab of the bridge. Severe cracking and faulting at the cracks are cause for rejecting the waste slab. The intent is to have a waste slab that presents a pleasing appearance of uniform color and texture commonly achieved by the use of clean smooth plywood forms. This is the standard that inspectors must use to gauge the appearance of waste slabs.

Verify the waste slab is carefully surveyed. It should be checked with a straight edge before any forming or ironwork proceeds. It is very important for the inspector to work closely with the contractor to ensure both the soffit fill and waste slab are built correctly. Other requirements for waste slabs can be found in Subsections 601-3.03(A) and 1006-5.01, which refer to slab requirements in general.

Telltales or Tattletales

Some type of telltales should be provided by the contractor to indicate the amount of settlement occurring during the placement of deck and pier cap concrete. Telltales are usually firmly attached to the bottom of the forms at various locations and are extended to a reference mark, easily observed by a person positioned under the structure. A reference mark is placed on a stake driven firmly into the ground. The telltale and the ground reference provide a direct indication of falsework movement that can be checked against the calculated deflection. Maximum allowable deflections, both vertically and horizontally, are 1/240th of the unsupported span of the falsework. For example, plywood forms spanning 68 inches between girders should only deflect to a maximum of 1/4 inch.

It’s important for inspectors to enforce maximum falsework deflection requirements. Excessive deflections can:

- Result in structural members that sag and end up below the desired finished elevation
- Produce unsightly bulging in the hardened concrete
- Add more weight to the structure than anticipated by the Designer
- Result in significant concrete quantity overruns

Safety

Bridge construction continues to be one of the most dangerous activities in public works construction. Some of the hazards are obvious, such as the risk of falling, while others are not, e.g. the overturning of a crane. OSHA has numerous safety standards related to concrete construction (Subpart Q is the main one). These standards apply both to the contractor and ADOT’s field staff. The standards specifically related to bridge and concrete work include:

Description	Standards
Fall Protection	Subpart M
Safety Belts, Lines and Lanyards	1926.104
Safety Nets	1926.105
Working over Water	1926.106
Formwork and Falsework	1926.703
Concrete Equipment	1926.702
Cranes	1926.550
Masonry Walls	1926.706
Illumination	1926.26, 1926.56
Fire Protection	1926.24 & Subpart F
Housekeeping	1926.25, 1910.176
Personal Protective Equipment	1926.28
Foot Protection	1910.136
Head Protection	1926.100
Eye and Face Protection	1926.102
Signaling	1926.201

Slings	1910.84
Hand Tools and Jacks	Subpart I
Scaffolding	Subpart L
Pile Driving	1926.603
Demolition	Subpart T
Ladders and Stairways	Subpart X

This is not a complete listing. It is meant to point out some of the key safety standards you should be aware of when working in and around any structure under construction.

The Resident Engineer or Project Supervisor has a duty to meet with the inspectors during each phase of bridge construction and discuss safety procedures. As a minimum, the inspectors should be made aware of:

- Tripping, falling, and impalement hazards
- When fall protection equipment will be required
- How to obtain and properly use fall protection equipment
- Safety procedures around heavy equipment, especially cranes
- Procedures for climbing formwork and falsework
- Standards for handrails, ladders, stairways, platforms and when they are required
- Required personal protective equipment (PPE) such as hard hat, safety shoes, eye and ear protection, etc.
- Procedures for reporting accidents and near misses

An important OSHA provision applies to fall protection when erecting formwork or falsework, 6 feet above the ground for a new structure and 4 feet for work on an existing structure. It also applies to setting of precast girders. OSHA Standards 1926.501 and 1926.502(k) require the contractor to implement a fall protection plan and safety monitoring system for work where it is not feasible to use handrails, safety nets, or personal fall arrest systems (belts and lanyards). Inspectors need to be aware of the procedures involved in this fall protection plan since it applies to them as well.

Please note:

Other than designated tie-off points on forms, decks, girders, or fixed vertical lifelines, ADOT Employees are not to utilize the contractors fall protection equipment, e.g. harness, lanyards, self retractable lifelines (SRL), positioning hooks, etc. Units should purchase their own PPE, and keep it in a dry cool location between use. Prior to each use of any personal fall equipment, qualified trained personnel should inspect and issue the equipment as needed.

Once an ADOT Inspector has been trained and has been issued personal fall protection equipment, it should be discussed with that employee, if their inspection duties do not require them to work on an elevated surface requiring the use of fall protection, then don’t. In other words, if you can perform your inspection from the ground then do so; the best safety practice is to eliminate the fall hazard altogether.

(C) Forms Construction

In forming concrete, the contractor’s objective is to obtain the maximum reuse of forms and to use standard material sizes with a minimum of cutting and fitting. The appearance of finished concrete is largely controlled by the condition of the form facing, the accuracy of the carpentry, the strength of the forms, and the adequacy of the bracing or falsework. There is a trade-off between form reuse and appearance. Maximizing form reuse also maximizes the amount of pointing and patching done after the forms are removed which detracts from the appearance. Inspectors and the concrete foreperson should agree ahead of time when formwork has reached a condition that is no longer acceptable. The following information in this subsection is intended to provide the inspector guidance in this area.

Form Appearance and Mortar Tightness

Generally the contractor is not required to submit forming plans to the Department for review. The exception is girder webs on box-girder bridges, see Subsection 601-3.02(C)(1) of the Standard Specifications and Subsection 601-3.02(A) of this manual. On more complicated structural elements, the contractor may develop a set of forming plans for internal use to minimize the amount of forming materials used. The Resident Engineer and inspectors should meet with the contractor's concrete foreperson ahead of time to answer questions about formwork requirements and discuss the levels of workmanship and concrete appearance acceptable to the Department. Once the contractor has ordered the forming materials, it will be much more difficult to change forming procedures.

Mortar tightness is often an issue that comes up between an inspector and a foreperson. This is due to the fact that carpenters try to make the same size form fit as many different spaces as possible. Mortar tightness is not the same as water tightness and depends on the slump of the concrete, its temperature, the amount of vibration the concrete receives, and the amount of fluid pressure it exerts against the form. A foreperson and the inspector will have different opinions on what is mortar tight. These differences should be resolved ahead of time before the first form is placed. Inspectors need to insist on mortar tightness for the following reasons:

- Leaking mortar can cause voids around the rebar next to the leak.
- Leaking mortar results in an uneven appearance of the concrete surface including dark form lines.
- Loss of mortar weakens the concrete in the area near the leak.
- Mortar is considered a pollutant and must be kept out of all washes and rivers.
- Mortar that leaks into internal cells of box girders and beams will add dead load to the structure.

Applying tape or strips of tin over form joints is preferred to using a backer rod. Backer rod often becomes loose and allows mortar to flow when the concrete is vibrated. Form joints are most prone to leaking during concrete vibration. Do not allow the contractor to cut back on vibration in an effort to reduce form leakage.

The Standard Specifications describe the requirements for concrete forms. There are general requirements that apply to all types of forms. There are special requirements for wood forms as well as for metal, fiberglass, and other types of forms. Metal and fiberglass forms must meet all the requirements specified for wood forms.

When inspecting formwork, the inspector should be concerned with these three outcomes:

1. Can the forms safely hold the concrete without shifting, leaking, falling apart or deflecting excessively?
2. Will the forms give the correct shape and dimensions to the hardened concrete, including the correct elevation and location?
3. Will the surface of the concrete have the desired appearance?

More detailed information on inspecting formwork can be found in ADOT's training manuals as well as in the references cited at the end of this chapter.

Form Finish

The formwork specifications regarding the appearance of the hardened concrete often cause the most difficulty for inspectors and the contractor's carpentry staff. Formed concrete surfaces require either a Class I or Class II finish. See Subsection 601-3.05 of this manual and the Standard Specifications for further details on these finishes.

Questions often arise as to how many imperfections, patches, openings, and other defects in the contractor's forms are needed to cause a rejection on the Department's behalf. To answer these questions, the Department has published the Concrete Finish Reference Manual on the ADOTNet Guidelines/Construction and Materials page. Inspectors should refer to this manual when inspecting formwork to anticipate any problems the contractor's forms may cause with the desired finish.

Forms have been rejected for not producing an acceptable finish in accordance with the Concrete Finish Reference Manual. If there was any doubt that the contractor's forms would not produce the desired finish, Resident

Engineers have used the reference manual's guidelines instead of complying with the formwork specifications in Subsection 601-3.02(C). Strict compliance to Subsection 601-3.02(C) actually produces a formed finish of higher quality than what is generally shown in the reference manual.

Form Release Agents

The Contractors use form oil or a chemical to preserve the forms for reuse and to reduce the adhesion between the form and the concrete. Excessive use of such material may discolor the concrete and should be avoided particularly on sections of the structure where appearance is important. The form oil must not adversely affect the concrete. When architectural concrete is specified, the form liner manufacturer should approve the form release agent. The Department leaves the approval of the form release agent to the Resident Engineer who usually delegates that authority to the inspector.

Rate of Pour

Forms must be designed and constructed to withstand the fluid pressure of fresh concrete plus any live loads including vibration and worker activities. The horizontal fluid pressure against forms on walls, columns, piers, etc. is very high if the concrete is placed too rapidly. Slower placement referred to as a lift, allows the bottom concrete to settle and partially set before the top section is placed. This lowers the horizontal pressure near the bottom forms. The contractor must control the rate of placement so that the side forms do not bulge excessively or fail. Bulging can adversely affect the appearance of concrete while form failures jeopardize the safety of everyone working around the forms. It is suggested the inspector check with the contractor's foreperson regarding the maximum pour rate that the forms are designed to handle.

(D) Removal of Falsework and Forms

The importance of distinguishing between falsework and formwork becomes apparent when discussing the removal of either one after the concrete has hardened. Refer to Subsection 601-3.02(A) of this manual if you are not sure of the difference between the two.

Forms

Formwork can be removed once the concrete has set and has adequate time to harden. Concrete columns as high as 21 feet have had their forms removed the next day once the concrete stood up on its own. The contractor must obtain the approval of the Resident Engineer before any forms can be removed.

Upon form removal, the contractor must continue to cure the concrete until seven days after the pour, see Subsection 1006-6.

When a Class II finish is required, the contractor cannot spray the exposed concrete with curing compound until the Class II finish is completed and inspected. When no other acceptable curing method is available, inspectors have required the contractor to leave forms on for seven days unless the contractor can complete the Class II finish in a reasonable amount of time (usually the same day the forms are removed). For bridge barriers and other concrete surfaces above the bridge deck, the contractor is allowed up to four days to complete the Class II finish when early removal of the forms is allowed.

Falsework Removal

Falsework removal must follow strict requirements for both concrete strength and age. The strength requirement ensures that the concrete can adequately support its own weight without cracking or deflecting excessively.

The age requirement ensures that the concrete is mature enough to resist the long-term effects of creep. Creep is the prolonged deformation of concrete due to sustained loading. Creep is what causes concrete bridges to sag.

Once the falsework is removed, the concrete begins to creep under its own weight. Young concrete will creep much more than mature concrete even when the strengths are similar. As a result, it is important for the inspector to enforce the time limitations in the Standard Specifications even if the contractor can show early cylinder breaks equal to or greater than the required strength.

Occasionally the contractor will want to temporarily remove parts of the falsework in order to remove the formwork that can be used elsewhere on the project. No temporary removal of falsework supports such as stringers, joists, shores, or mudsills shall be allowed even for a few moments. The concrete must be continuously supported until the strength and time requirements are met. Occasionally lateral braces can be removed early with the approval of the Resident Engineer.

Any early age concrete compression testing to facilitate removal of falsework and forms after the age requirement has been satisfied, but prior to 28-day acceptance of strength, should be performed by the contractor with concurrence from the Resident Engineer. The Department may elect to perform such testing when doing so is of benefit to the Department and the traveling public.

On post-tensioned box girder bridges, falsework (except for the deck overhangs) must stay in place until after the grouting of the post-tensioning ducts. This is a safety precaution in case there is an anchorage failure. Until the prestressing strands are bonded to the post-tensioning ducts, the ends of the bridge carry all the prestressing loads. If the anchors fail (and this can happen), the falsework is in place to catch the superstructure as it falls. The falsework is also there to serve as a working platform during grouting. If there is a leak in any of the post-tensioning ducts, the contractor will need to have access to the underside of the bridge to find and repair the leak. Partial removal of some of the falsework members is allowed to provide access to a bottom portion of the bridge.

The Resident Engineer should discuss the falsework removal procedure with the contractor to verify each element can be done safely both in terms of the traveling public and the on-site workers. The falsework drawings may have a specific removal sequence that the contractor must follow. The inspector should keep a schedule of placement dates and projected dates for removal of falsework in order to avoid any premature removals.

601-3.03 Placing Concrete

(A) General Requirements

The Resident Engineer may suspend a pour due to weather limitations. Like other types of concrete, structural concrete has both temperature restrictions and precipitation limitations. Subsections 105.02 and 1006-5 can be used by the Resident Engineer to suspend work if it is in the best interest of the Department. Keep in mind that only the threat of precipitation is needed to justify suspending the work. You don’t have to wait until it is actually raining or snowing.

The quality of the project work should always come first in the inspector’s mind. Quality is the main reason why inspectors are assigned to a project. Inspectors must not worry about the schedule when it comes to compromising the requirements of the Project Plans and specifications. Let the Resident Engineer worry about the schedule. Stay focused on the Project Plans and specifications and help the contractor to achieve 100 percent compliance.

Inspectors need adequate time to inspect structural concrete forms, falsework, and steel reinforcement prior to concrete placement. This amount of time will vary from just a few minutes for a concrete catch basin to a few hours for a large bridge deck. The contractors on the other hand want to place concrete the moment the forms are up and the last piece of reinforcing bar is tied in place.

The inspectors and the contractor’s foreperson should meet ahead of time to discuss pour schedules, steel placement activities, steel and formwork inspection requirements, and traffic and safety issues. The contractor’s foreperson is often under enormous pressure to meet deadlines and stay on schedule. Shortages of materials and labor, which are usually not the fault of the foreperson, just add to the pressure.

When there is a finite amount of time to place forms and steel, the foreperson may try to make up for any delays by shortening the inspection time. Inspectors then feel rushed and pressured to accept sub-standard work in an effort to help out their partner. Partnering was never meant to allow relaxation of the contract specifications.

Here are some do’s and don’ts to help the inspector and the contractor get through these tough situations:

Do:

- Frequently perform inspections as forms are going up and steel is placed to catch errors early on.
- Meet with the contractor's foreperson daily to discuss quality issues and progress.
- Point out recurring non-compliance issues to the contractor no matter how unpleasant it becomes.
- Keep the contractor informed of your inspection time requirements.
- Adjust your inspection schedule if the contractor experiences delays (be flexible).
- Escalate chronic, unresolvable, non-compliance issues no matter how small they are.
- Develop a feel for how the foreperson plans and executes the work, and adjust your daily work hours accordingly.
- Go through the project plans with the various trade forepersons to verify they haven’t missed some important details you may have noticed.
- Keep ahead of the contractor by looking through the project plans and specifications to see what could get the contractor into trouble later on.
- Build a relationship based on cooperation and professional courtesy.
- Always be willing to help the contractor clarify and interpret the project plans and specifications.

Do Not:

- Allow the contractor to rush you by cutting short your inspection time.
- Close the lines of communications between you and the contractor no matter how tough things become.
- Take the contractor’s lack of attention to the contract specification requirements personally.
- Delay inspections to the very last minute.
- Keep defects you see or find in the contractors' work to yourself.
- Compromise yourself or the specifications just to meet a schedule, escalate instead.
- Become reactionary if the contractor ignores you or does not take you seriously.
- Get into a power struggle with the contractor over pour scheduling versus inspection time.
- Direct the contractor how to perform the work.

Skewed Bridges

All bridges that are built on a skew have special requirements that are sometimes overlooked by contractors and inspectors. Exhibit 601-3.03-1 shows the basic configuration of a skewed bridge. Typically the abutments are not perpendicular to the centerline of the roadway. They are set at some angle other than 90 degrees and can be as low as 45 degrees. However the girders run parallel to the roadway centerline. As a result, the angle between the abutment and the girders is not 90 degrees.

The concern here deals with the pouring and finishing of bridge decks. The bridge deck must be poured and finished in the direction of the skew angle and not perpendicular to roadway centerline.

Typically bridge decks have camber built into them to offset the long-term effects of creep. Creep affects the girders under the deck and causes the girders to sag with time. To ensure this sag does not show up in the deck, the Bridge Designer will set the deck elevations higher at the midpoint of the girders than at the ends where the girders come in contact with a pier or abutment. In order to build this camber into the bridge deck, the finishing machine must come in contact with the same point of each girder at the same time, see Exhibit 601-3.03-1. The girders must be loaded uniformly so they all deflect evenly.

The best way to achieve the proper deck camber is to set the finishing machine at the same skew angle as the piers and abutments, not perpendicular to the roadway centerline. On bridges with a slight skew (less than 20 degrees), the Designer may allow the finishing machine to be set perpendicular to centerline. However, the Resident Engineer should obtain the Designer's approval before allowing the contractor to finish in this direction.

Setting the finishing machine to finish along the skew angle requires a longer machine and some rail adjustments on the contractor's part. Finishing along the skew is usually something most concrete forepersons do not anticipate. Notify the contractor about this requirement at the pre-pour meeting.

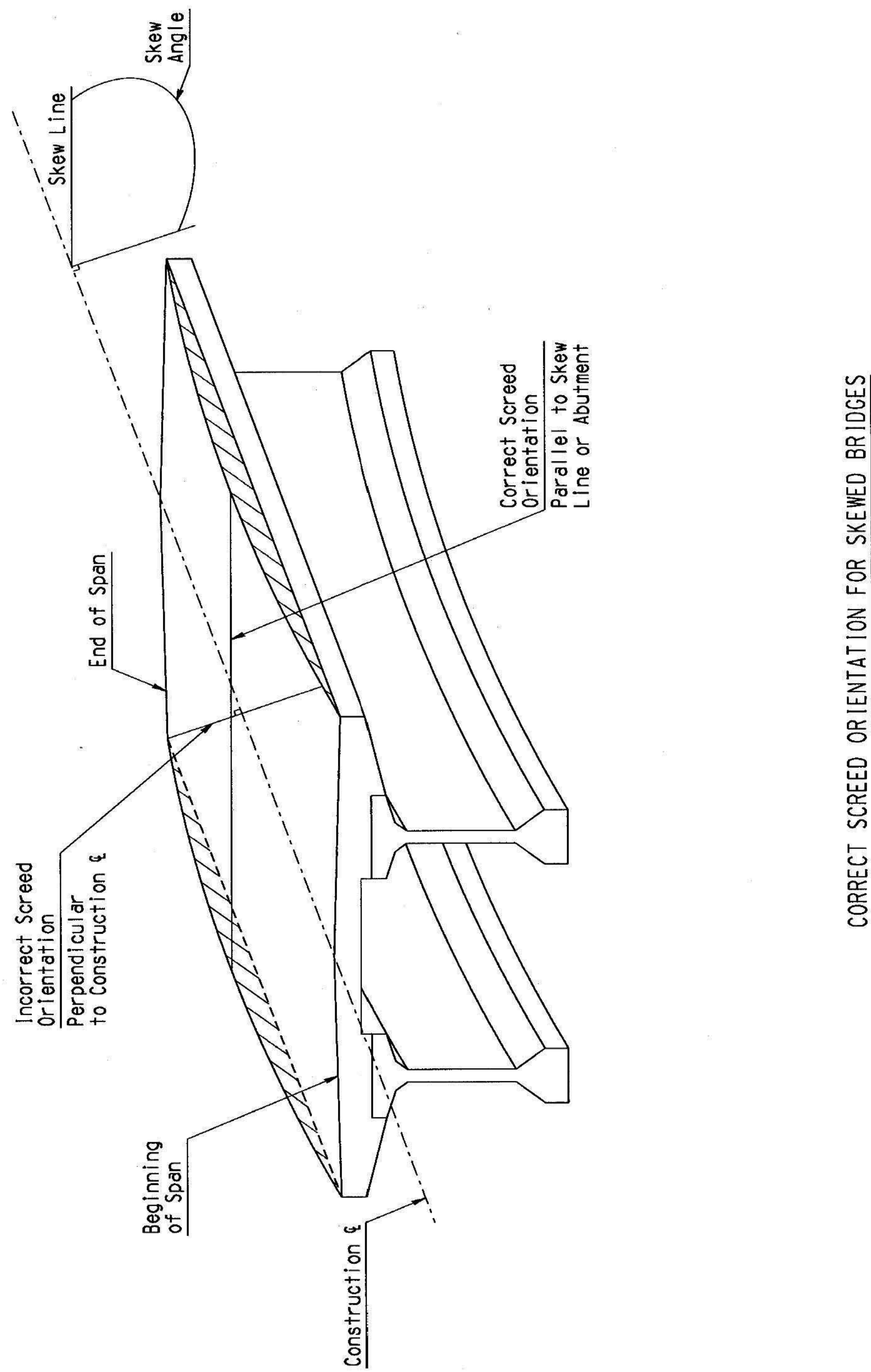


Exhibit 601-3.03-1 Skewed Bridges

Tining on a Skew

The tining of the bridge deck becomes a problem when the deck is poured on the skew angle. Tining the deck transversely to the roadway centerline can lead to uneven tining on skewed bridges. The tining rake crosses each girder at a different point along its span. The rake may start near the low point of an exterior girder, e.g. at a pier, and cross the midpoint of one of the interior girders. This causes uneven contact pressure since the deck is higher at the girder midpoints due to camber.

The solution is to texture the deck at the same skew angle that it was finished. However this is a direct violation of Subsection 601-3.05(D). The Department does waive this provision for skewed bridges when the bridges must be finished at the skew angle. The intent is to get some type of texturing into the deck. The angle of the texture is not as important as its presence.

Rate of Placement and Cold Joints

On small structures, especially short sections of retaining wall and box culverts, the Resident Engineer may waive the minimum pour rate in Subsection 601-3.03(A) to avoid overloading the contractor's formwork.

The Standard Specifications specify minimum pour rates. The pour rates are intended to keep cold joints from forming in a structure. A cold joint is formed when fresh concrete is poured against partially set or hardened concrete. Cold joints can form when there is a long interruption during a concrete pour or when the pour rate is too slow to keep each layer of fresh concrete in contact with a previous layer of concrete that is still fresh. Loads and stresses in the structures can cause the concrete to crack or pull apart at the cold joint.

Cold joints are dependent on the concrete's set time that is affected by temperature, admixtures, and the type of cement and pozzolans used. There is no rule of thumb that says when a cold joint will occur. The inspector and Resident Engineer must carefully examine the concrete after the forms are removed for any visible layering or discoloration. If you suspect a cold joint does exist, say so and reject the structure. The contractor is then obligated to submit a proposal.

At this point the contractor has several options:

1. Core the structure at the cold joint and strength test the cores to see if they will fail at the cold joint.
2. Submit an engineering analysis proving the cold joint is not detrimental to the structure.
3. Repair the cold joint.
4. Remove concrete beyond the cold joint to a place in the structure where a construction joint would be acceptable.

All of these alternatives can be time consuming and costly. Thus it is very important to work with the contractor to minimize the risks of forming cold joints. It is advisable for the inspector not to stop a concrete pour when you suspect a cold joint may be forming. Let the contractor and the Resident Engineer make this call. Usually the burden is placed entirely on the contractor and the Resident Engineer will only interfere when the cold joint and its detriment to the structure are obvious.

Steel Reinforcement Placement

Section 605 is devoted entirely to the requirements of steel reinforcement. It covers material requirements, splicing methods, placement tolerances, and bending requirements. The following is a brief discussion on how reinforcing steel or rebar, as it is commonly called, affects concrete placement.

Reinforced concrete is a composite material consisting of steel and concrete. Composite materials work best when the reinforcement steel is in continuous contact with the concrete matrix and when both are combined in the right proportions. Since the reinforcement and the matrix carry the loads, continuous contact between the two will provide a uniform transfer of the stresses. When there are voids near the reinforcement due to poor concrete placement or consolidation, higher stresses develop in the concrete than would normally be expected. These stresses lead to poor load transfer to the steel and allows premature cracking and water to enter into the void around the steel causing corrosion. Thus it is important for the inspector to verify that there is good consolidation of the concrete around all reinforcing steel. The intent is to have no air voids around any reinforcing steel.

Adequate concrete cover over the reinforcing steel near any surface is needed to prevent steel corrosion. The Project Plans will specify the amount of cover required, which is usually a minimum. Inspectors should be vigilant about ensuring adequate cover over all reinforcing steel.

Concrete itself is a composite material. The fine and coarse aggregates act as the reinforcement while the cement, water, and admixtures act as the matrix. Concrete behaves best when the matrix and reinforcement are in continuous contact with each other and are mixed in the right proportions. Steel reinforcement can interrupt this continuity when the bars are placed too close together. If there is not sufficient room for the coarse aggregate to help fill the space between the bars, there is no longer reinforced concrete, but reinforced mortar. Mortar is more prone to shrinkage and cracking than concrete. To avoid this situation, Subsection 1006-3.01 limits the maximum size aggregate to the least of:

- 2/3 of the clear spacing between reinforcing steel bars or bar bundles
- 1/5 of the narrowest form dimension
- 1/3 the depth of the slab

For example: if 5/8 inch coarse aggregate is used:

- The minimum clear spacing between bars would be 5/8 ÷ 2/3 = 15/16 ~1 inch
- The narrowest form dimension would be 5/8 ÷ 1/5 = 25/8 = 3 1/8 inches
- The minimum slab depth would be 5/8 ÷ 1/3 = 15/8 ~2 inches

Inspectors need to know the size of the coarse aggregate used so they can check for adequate rebar spacing and form size. It is not uncommon in areas where bars are lap spliced to find a spacing problem. Pier caps often have rebar spacing problems especially where the vertical pier steel penetrates into the cap beam.

Rebar spacing and cover problems should be brought to the attention of the contractor and Designer. Both have the responsibility to ensure that the Standard Specifications are followed.

(B) Bridge Deck

The Resident Engineer must hold a pre-pour meeting with the contractor before any series of bridge deck pours. The intent is to have the contractor’s concrete foreperson describe how the deck concrete will be placed, consolidated, finished, textured, and cured.

As a minimum, the following discussion should be covered:

1. The contractor's pour sequence plan which shall include the location of all construction joints by span and station, the width and quantity of concrete to be placed, the scheduled time for each placement, the direction of placement and orientation of the screed, the proposed screed, and the means of setting and controlling screed grades
2. The equipment to be used for vibrating, finishing, floating, tining, misting, and curing
3. Type of materials used for curing
4. Crew experience and assignments
5. Inspection staffing, procedures and timing
6. Rebar placement and scheduling
7. Material sampling, testing, and certification, e.g. concrete, rebar, curing compound, precast mortar blocks, etc.
8. Plant operations, inspections and concrete deliveries

9. On-site and off-site traffic control; traffic under the deck pour should be avoided if possible
10. Safety hazards and protective equipment
11. Ladders and walkways for personnel access
12. Contingencies for plant failures, pump breakdown, screed stoppages and inclement weather, e.g. rain, snow, dry winds, falling temperatures
13. Illumination requirements, if placement is at night

These thirteen points should be used as a basis for developing an agenda for the pre-pour meeting.

Bridge deck pours are difficult and expensive to stop once they get started. The idea behind the pre-pour meeting is to ensure both the contractor’s and the Department’s field personnel have a clear understanding of how the deck will be poured and what inspection procedures will be followed. The time to have discussions about good construction practices and specification enforcement is in a meeting room, not on top of the bridge. Thus it is important for everyone on the contractor’s and ADOT’s team to clearly understand all the details of the pour. The Project Supervisors and inspectors should be free to ask questions so they can fully understand the contractor’s methods. The Resident Engineer should ferret out any hidden agendas on both sides, ask the tough questions nobody wants to ask, and get a commitment from the contractors staff to do what they say they are going to do

Pour Sequence

Bridge superstructures, particularly bridge decks, follow a pour sequence where some portions of the deck or superstructure are poured before others. The pour sequence can be found in the Project Plans. The Project Supervisor must ensure the contractor strictly follows the pour sequence.

The pour sequence is intended to place much of the concrete for the superstructure in the midspan areas before placing concrete over the piers. The placement sequence allows the reinforcing steel over the piers to move as the bridge deflects from the weight of the concrete. If the concrete over the piers were poured first, the rebar would be locked into place as soon as the concrete hardens. When the midspan areas are poured, the concrete over the piers could crack as the concrete tries to restrain the rebar from moving.

Occasionally the contractor would like to alter the pour sequence by using retarders in the concrete. This should be done by a written proposal and included in a new mix design. The use of retarders requires the approval of the Bridge Designer, ADOT Bridge Group, and Materials Group.

Generally bridges built on soffit fill do not have to follow a pour sequence unless required by the Project Plans.

(C) Pumping Concrete

When concrete is pumped, the contractor must have a standby pump in case the primary pump fails. It is not necessary for the standby pump to be at the job site as long as it can be mobilized and placed in operation within 30 minutes of a pump failure.

It is considered good practice on monolithic pours to allow a waiting period from a minimum of two hours, to a maximum of four hours following concrete placement in walls, columns, or piers before permitting fresh concrete to be placed on top of these members. This delay can be modified where wall height is 6 feet or less. The delay is necessary to allow most of the settlement and shrinkage in the earlier placements to occur; thus, decreasing the probability of cracking at the junction of the two placements.

In some cases, the Project Plans will indicate the sequence of placing concrete in a structure. When not shown on the Project Plans, the Resident Engineer should require the concrete to be placed continuously throughout each section of the structure or between indicated joints. The concrete placement rate should be such that no cold joints are formed within monolithic sections.

(D) Vibrating Concrete

The Standard Specifications require all concrete in structures to be vibrated. The purpose is to cause the concrete mix to envelop and bond to the reinforcement, fill voids, and make the structure more waterproof and durable. The concrete vibrator, when properly used, is a good tool for working the concrete under and around closely spaced reinforcement.

Operation of the vibrator requires some skill and considerable physical effort. Workers who are charged with this responsibility should have some experience and instruction in proper methods of vibrating. The vibrator should not be left in any one area of concrete longer than a few seconds. As soon as the surface of the concrete surrounding the vibrator ceases to settle, it should be pulled out slowly and inserted slowly into a new area in accordance with the pattern indicated in the Standard Specifications. Excessive vibration should be avoided as it tends to cause segregation and increases the lateral pressure on the forms.

Subsection 601-3.03(D) allows the contractor to use only approved vibrators for consolidating structural concrete. It is up to the inspector or Project Supervisor to approve or disapprove vibrators. Inspection of vibrators and other placing and finishing equipment should be done at least one day before the pour so the contractor can replace any substandard equipment.

The minimum vibration frequency is 8,000 cycles per minute (130 Hz) in fresh concrete. If the inspector suspects the vibrator is not operating at or above the minimum frequency, measure the vibrator’s frequency with a portable tachometer or a vibrating reed called a Vibra-Tak. ADOT’s regional or central lab should have these instruments. The frequency should be measured with the vibrator operating in and out of the concrete. A significant difference between the vibrator’s measured frequencies in and out of concrete may indicate that the vibrator is in need of repair or there is an inadequate power or air supply.

The contractors should operate vibrators in accordance with the manufacturer’s recommendations. If the inspector suspects that the contractor is not using a vibrator properly, the vibrator can be rejected for not being suitable to the contractor's placement methods. Consult the manufacturer’s recommendations to make this determination.

The depositing of concrete at one point and moving it with the vibrator is not permitted. Concrete should be placed in approximately horizontal layers not more than 24 inches deep. If concrete flow movement is unavoidable, it should be done with shovels rather than vibration. Moving concrete horizontally causes the grout to flow while the rocks settle.

Bridge screeds should be equipped with vibrators. Bidwells and other commercially available screeds can be equipped with external vibrators mounted in front of the rollers. These vibrators must clear the top mat of reinforcing steel and are used to ensure that the riding surface of the deck is properly consolidated for long-term wear.

601-3.04 Joints in Major Structures

(A) Construction Joints

There are basically only two types of joints in any reinforced concrete structure: the construction joint and the expansion joint.

The construction joint is a provisional joint used primarily to terminate a concrete pour at a predetermined location. Some structures are so large that it is not possible or desirable to pour them all at once. The construction joint is intended to provide a temporary means of ending a concrete pour while still providing structural continuity, i.e. adequate load transfer across the joint. The installation of construction joints is generally straightforward. A form serves as a bulkhead where the pour is terminated. Usually rebar will protrude through the form and a key is usually formed on the joint face, see Project Plans. The form is stripped the next day except when a stay-in-place form is used. The joint is then cleaned with either sand or water blasting (if more than eight hours old) and the next pour is continued.

Inspectors need to carefully examine construction joints in structures for:

- The correct location and orientation
- Correct concrete placement procedures. Ensure only the best concrete is used and that it is properly placed and consolidated. Don't use the first concrete out of the chute or pump line.
- Proper cleaning and blasting, don't over blast the joint, this will only loosen the coarse aggregate.
- Smoothness across the joint when placed in a bridge deck or other riding surface. This will require a large amount of straight edging and careful screeding and re-screeding by the contractor.

Expansion Joints

The expansion joint is intended to allow movement between adjacent structures or between different members within a structure. This movement prevents stress build-up due to creep, shrinkage, or temperature changes that would seriously crack the structure.

Expansion joints create a small gap between two structures or structural members (abutment to girders) that allow for movement. There are three important things that the inspector must keep in mind about expansion joints:

1. The joint is in the correct location and runs the full depth and length required by the project plans; the joint must completely separate the two structures or structural elements.
2. The gap is set at the correct width.
3. There are no obstructions or connections between the two structures, e.g. rebar, conduit, utility lines or loose concrete that would interfere with the opening and closing of the joint. Only approved fillers and sealant materials should be used.

Expansion joints are shown on the Project Plans. Expansion joints can be found between abutments and bridge superstructures, between two sections of a long bridge superstructure, between anchor and approach slabs, and between approach slabs and abutments.

Near the surface of an expansion joint, a compressible material, such as a bituminous or cellular plastic filler is placed to prevent rocks, nails, and other incompressible material from entering the joint that would prevent movement. On top of the filler, a joint sealant is placed to prevent water from entering the joint. For expansion joints adjacent to bridge decks, a deck joint assembly is installed and serves as the joint filler and sealant.

Joint Location and Weakened Plane Joints

The Project Plans will show the location of all joints. Construction joints are usually oriented and located in areas where load transfer is uniform or at a minimum. With the Designer's approval, the contractor may add, alter, or relocate construction joints. Section 16 of the Bridge Design Guidelines includes guidelines acceptable to ADOT for locating construction joints.

The weakened plane joint, i.e. concrete is partially sawn to control cracking, is rarely used in reinforced concrete structures. Reinforcement steel acts like a crack stopper so there is no guarantee that the concrete will crack at the weakened plane joint. Expansion joints are used to control cracking.

(B) Deck Joint Assemblies

ADOT most widely uses two types of deck joint assemblies. The compression seal joint, shown in Structure Detail Drawing SD-3.01 and the strip seal joint, Structure Detail Drawing SD 3.02 shown in Exhibit 601-3.04-1. Both are designed to keep out water and prevent debris from falling into the joint.

The contractor must submit shop drawings for all deck joint assemblies in accordance with Subsection 601-3.04(B)(3)(b). The Bridge Designer will review and approve the shop drawings.

The inspector must have these shop drawings on hand when the contractor installs the deck joint assemblies. The shop drawings will describe the method of installation. The inspector should ensure this method is followed. In addition, a temperature correction chart should be included with the drawings. It is very important for the inspector to ensure that the correct gap width for the joint is set prior to pouring the joint. The width is based on the structure temperature (not air temperature) at the time of the pour, which can be read from the chart. Setting the joint at the incorrect gap can create long-term maintenance problems for the Department. A gap that is set too wide can cause the joint material to tear or fall out as the joint expands. A gap that is set too narrow can cause the joint to close, which can severely crack the bridge deck, girders, and diaphragms.

However, unless a more precise method of measuring the temperature of the main superstructure members is used, the setting temperature of the bridge shall be taken as the mean shade air temperature under the structure. This temperature shall be the average over the 24-hour period immediately preceding the setting event for steel bridges and over 48 hours for concrete bridges.

Here are some other inspection checks the inspector can do to ensure the Department gets long-lasting, worry-free deck joints:

- A long-lasting joint is a smooth joint; ensure the steel guard angles on each side of the joint are correctly recessed so that no bump or dip will occur as vehicles pass over the joint. Concrete grinding may be done to improve the smoothness.
- Sample the seal material and have it tested.
- Ensure the existing concrete adjacent to the joint is coated only with an approved adhesive.
- Ensure the contractor achieves good consolidation of the concrete under the guard angles.
- Ensure bolts in the erection angle are loosened after the concrete has set to allow movement.
- Enforce all the provisions of Subsection 601-3.04. They were written to provide the Department with durable, high quality deck joints.

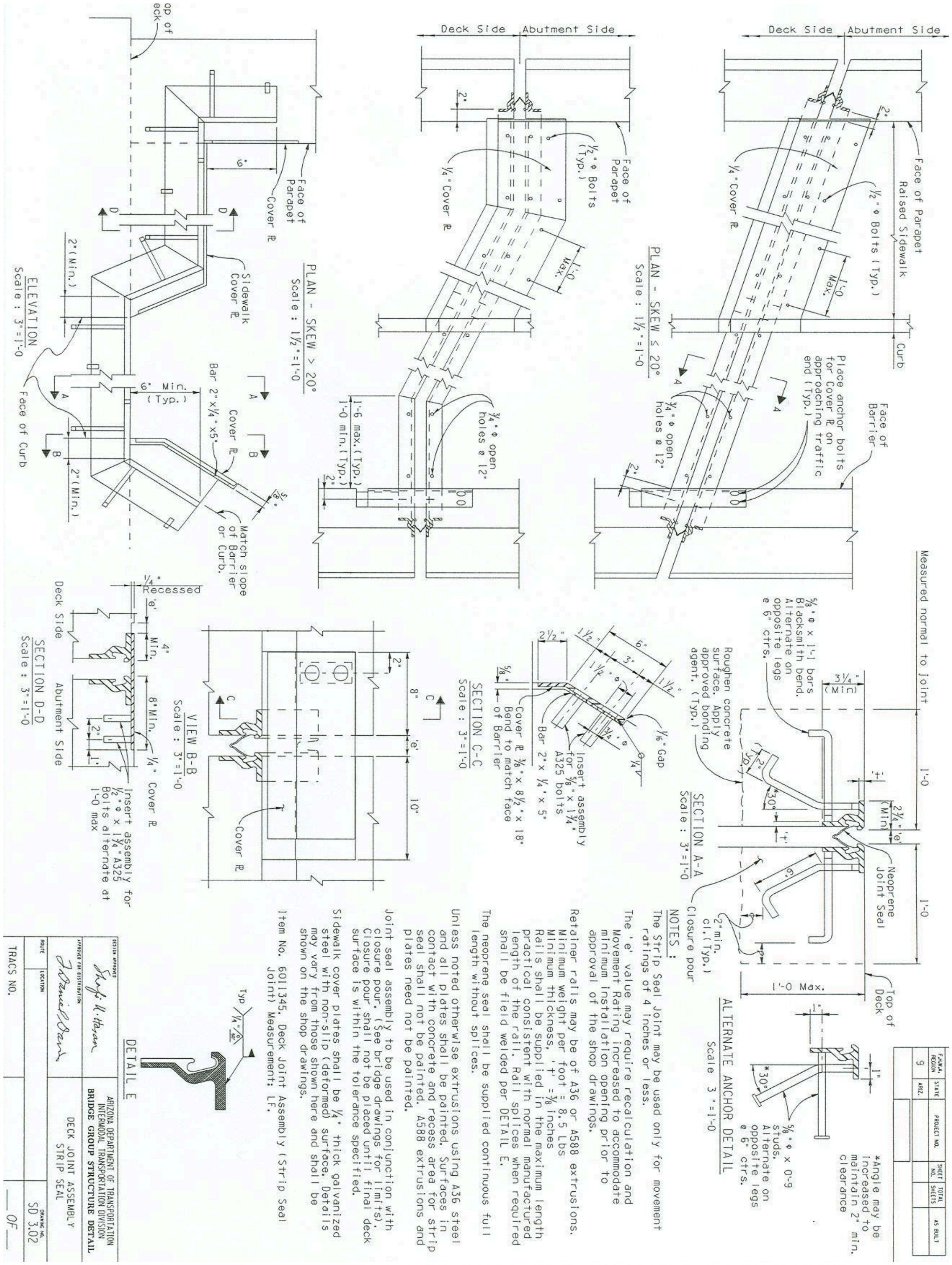


Exhibit 601-3.04-1 Strip Seal Joint Detail

601-3.05 Finishing Concrete

All formed surfaces require a Class I finish, as a minimum. The intent is to provide a concrete surface that is hard, sound, and reasonably impenetrable to moisture. No steel is allowed within 2 inches of the surface. This is to prevent the establishment of a rust channel that could corrode the reinforcement. A Class I finish is just as important below ground as it is above. In fact, the potential for rebar corrosion is much higher underground.

When formed surfaces will remain in view of the traveling public, the contractor must use forms that will provide a pleasing appearance of uniform color and texture. This appearance can be somewhat subjective so the Department has published a Concrete Finish Reference Manual on the ADOTNet Guidelines/Construction and Materials page for the inspector and contractor to use as a guide.

A Class II finish is required when the contractor’s forming system does not produce the pleasing appearance of uniform color and texture required by the Standard Specifications. The intent of Subsection 601-3.05 is for the contractor to produce the proper finish without having to resort to performing a Class II finish. In other words, the contractor cannot use damaged forms or substandard forms and perform a Class II finish after stripping. The Class II finish procedure is merely in the Standard Specifications as a contingency for the unexpected occasion where the formed finish is not pleasing in appearance. It is not a replacement for good concrete forming practices.

If a formed surface does require finishing, Subsection 601-3.05(A) specifies the finishing to begin immediately upon removal of the forms. Immediately does not mean tomorrow or next week. The contractors are often anxious to get their forms down as quickly as possible, but may not want to provide the labor necessary to finish and cure the exposed surfaces immediately after removal.

Resident Engineers have required the contractor to leave forms in place until a satisfactory crew could be assembled to finish and cure the exposed concrete. Mortar adheres to young concrete much better than to older concrete and it is easier to obtain a more uniform color and texture. In the long term, the surface will be more durable and uniform in color and texture if the concrete is finished when it is still relatively young.

Reference ADOT’s Class 2 Concrete Manual for additional information.

(D) Finishing Bridge Deck

One area of bridge deck finishing that inspectors and contractors should always pay close attention to is the deck smoothness at the joints. On precast girder bridges, this is especially important since many construction joints are needed to comply with the required pour sequence, see Subsection 601-3.03 of this manual for further information. Any irregularities disclosed by the straight edging should be corrected immediately. Attention should be given to finishing the gutter lines on bridges particularly on nearly flat grades in order to preserve good longitudinal drainage.

The inspector should allow the contractor to make minor adjustments to the screed grades to obtain the smoothest joint possible while maintaining a deck thickness within allowable tolerances. In some cases, the contractor may need to back up the screed and re-screed the surface to get the required smoothness. A small uniform roll of concrete should be maintained ahead of the screed. This requires constant attention when the screed is in operation. The smoothness of the deck will be governed to a great extent on how smoothly the screed operates.

For bridges longer than 300 feet, using the profilograph might be warranted to locate areas on the surface that are suspected of being too rough. Using the profilograph should be supplemented with the use of a conventional straightedge when any suspected areas are located. The profilograph has two advantages over the straightedge. First it records on paper a scaled profile of the surface. Second this profile can be converted into a Profile Index of inches per mile of roughness. This index figure can then be compared with indices of other bridges and pavements. However the Profile Index is not a requirement bridge decks must meet; only the straight edge requirement applies.

Experience is important in the evaluation of straightedge and profile data. Occasionally high spots are really on grade, but the low areas make the high spots look high. When this condition exists, cutting the area to meet tolerances over the low spots may result in removing too much of the surface and reducing the reinforcing clearance.

Subsection 601-3.03 of this manual describes special finishing and texturing requirements for skewed bridges.

As one last reminder, inspectors should spot check the deck thickness behind the screed. Inserting a piece of thick steel wire or rebar into the fresh concrete can do this. The measurement will ensure that the Department is obtaining the correct deck thickness and can alert everyone to potential problems that can be corrected while the concrete is still being placed.

601-3.06 Curing Concrete

Section 1006-6.01 specifies how all cast-in-place concrete is to be cured. Curing should not be delayed more than one hour after surface texturing or form removal. Any remedial finishing operation should be finished as soon as possible and should not interrupt curing for more than one hour. The bottom line is, contractors need to have sufficient labor available to begin Class I or II finishing and apply curing as soon as the forms are removed,not three hours or three days later.

There are three methods that are acceptable to the Department:

1. The water curing method
2. The curing compound method
3. The form-in-place method

The type of curing method that is used depends on the type of concrete surface:

- For formed surfaces, the contractor has the option of using either water curing, curing compound, or leaving the forms in place.
- For unformed surfaces such as top of walls, or concrete pavements, the contractor has the option of using either water curing or curing compound.
- For bridge decks, the contractor must use both water curing and a curing compound.

Water Curing Method

The curing process is as follows:

1. Apply water to the concrete surface with a water atomizer immediately behind the finishing or texturing operation, see Subsection 1006-6.01[A], first paragraph.
2. Continue to apply water with an atomizer until the concrete has set or a curing medium has been applied then either:
    A. Apply a curing medium, e.g. burlap, Burlene, rugs, carpets, or earth blankets and keep them continuously moist for 7 days.
    B. Continuously spray the deck with water for 7 days.

Curing Compound Method

The materials in many curing compounds separate, requiring the curing compound to be mixed or agitated before use. The Standard Specifications do not require agitation specifically, but the Resident Engineer may require this to maintain the integrity of the curing compound. Inspectors should verify that the curing compound has been agitated properly. Propellers and air agitation have been used. Rolling a barrel on the ground is not acceptable. Thorough mixing should be done at least once daily when curing compound is being used.

When a curing compound is to be applied to an exposed horizontal surface, it should be applied just after any bleed water or other standing water has left the surface. On formed surfaces that require a Class I finish, the curing compound should be applied as soon as possible after removal of the forms. The application should only be delayed long enough to permit any needed patch or repair work. On surfaces that require a Class II finish, it is somewhat of a problem to perform good finishing and the curing simultaneously. Both are important and both need to be performed early.

Forms in Place Method

For this method the contractor leaves the forms on the structure, in the same condition as they were during placement (not loosened) for seven days (see Subsection 1006-6.01[D]).

Curing Bridge Deck

Curing bridge decks requires a combination of wet curing and the application of curing compound. This curing process is more intricate than curing other concrete members.

The generally accepted procedure is to:

1. Finish and texture the bridge deck
2. Immediately spray with curing compound
3. Continuously apply atomized water until curing medium is applied
4. Apply the curing medium within 4 hours of the finishing operation; usually wet burlap or Burlene.
5. Continuing wet curing for seven days

In the past, the Department has allowed step number 3 to be an option for the inspector. The decision to waive this step should be based on weather conditions including: wind speed, relative humidity, temperature and cloud conditions. On very hot and dry days, contractors have been required to begin atomizing before the texture or curing compound can be applied, see subsection 601-3.05[D].

601-3.07 Supporting, Handling, and Transporting Precast Concrete Items

Minor precast structures are defined as precast items such as cattle guards, catch basins, manholes, median barriers, and other small miscellaneous structures. The great majority of minor precast structures are fabricated in Phoenix. Only the fabricators shown in the Special Provisions are approved to supply minor precast structures to ADOT projects.

It is the responsibility of ADOT Materials Group to inspect the fabrication of precast concrete structures and accept or reject the finished product. Precast units are accepted if strength tests indicate at least the required 28 day compressive strength. The compressive strength is determined by use of a rebound hammer and a calibration curve. The curve is established from rebound readings taken on concrete test cylinders fabricated at the precast plant and from the actual compressive strength of the cylinders.

When the Central Laboratory accepts precast units, each unit is stamped to show acceptance. The stamp consists of the letters "ADOT" on the unit by use of a stencil and black ink. The letters are approximately 2 inches high.

When precast units arrive on the project, they shall be accompanied by a Certificate of Compliance and shall include a copy of the approved mix design. The contractor shall certify that sufficient concrete testing has been performed to ensure compliance with the slump and air entraining requirements. If the precast units have been damaged during shipping or there is any reason to question the workmanship, it is the responsibility of the project supervisor or inspector to reject the units or have them repaired satisfactorily.

Installation of precast items should be done in accordance with the manufacturer's recommendations and any installation notes specified in the Project Plans or Special Provisions. Careful assembly is required when gaskets and joint materials are used to obtain a watertight seal between each precast member.

601-3.08 Backfilling

Refer to Subsection 203-5.03(B) of this manual SD5.02, 6.01(4 of 5) & 7.01 (4 of 5) for additional information on structure backfilling.

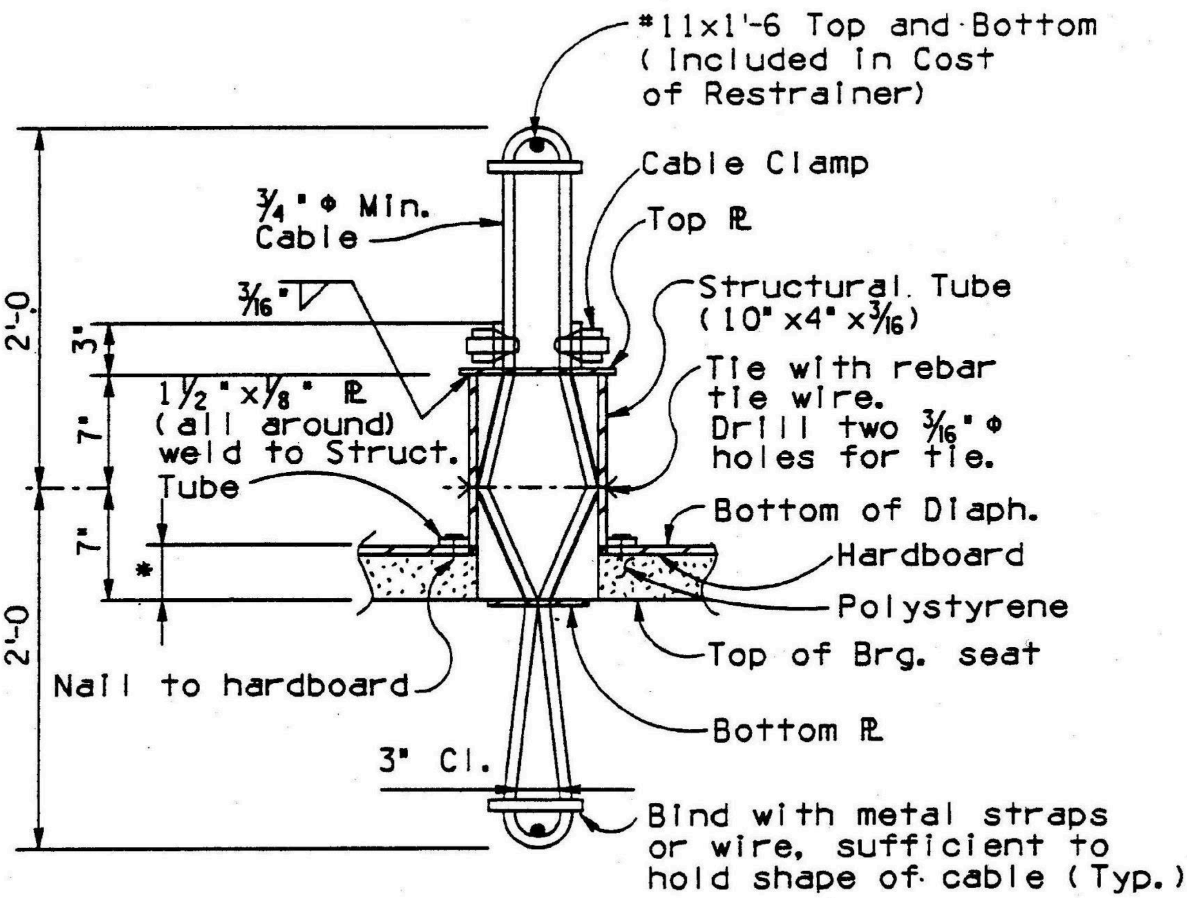
Often the contractor will ask to be allowed to use native material as structure backfill. This is acceptable as long as the material meets all the requirements of Subsection 203-5.03(B)(1). Sometimes the contractor will question why certain structures such as shallow pier footings or catch basins, require structure backfill at all. The Department has several good reasons, which are listed below, why structure backfill should be used to backfill all structures:

1. Structure backfill is a material of known properties and predictable behavior, on which the Designer can rely, that will not adversely affect their structure.
2. Structure backfill does not contain large rocks or boulders that could damage the structure during backfilling.
3. Structure backfill is permeable and does not allow excessive, long-term hydrostatic pressures to build around the structure.
4. Structure backfill has pH and resistivity requirements designed to inhibit the corrosion of reinforcing steel in the structure.
5. Structure backfill can be compacted to a more uniform density than most other native materials; thus, exerts a more uniform lateral load on the structure.

601-3.09 Vertical Restrainers

Vertical restrainers are 4-foot steel cables formed in the shape of a loop. Half of the cable is cast into an abutment or pier while the other half is cast into the diaphragm between the girders. These cables link the bridge superstructure to the substructure. The motions of an earthquake can cause the bridge superstructure to rise off the substructure. If the superstructure rises too high, it can come crashing down on the substructure. The cables are intended to limit the amount the superstructure can raise off the substructure. When vertical restrainers are used, the cables must allow the bridge superstructure to move freely; horizontally at the expansion joints. They must also allow the superstructure to rotate at piers and abutments since the cables are set in place before all loads are placed on the bridge. There are two types of vertical restrainers: One type to be used at expansion joints and another type to be used at piers and abutments where expansion capability is not required. Exhibits 601-3.09-1 and 601-3.09-2 show the two types.

EXPANSION RESTRAINER



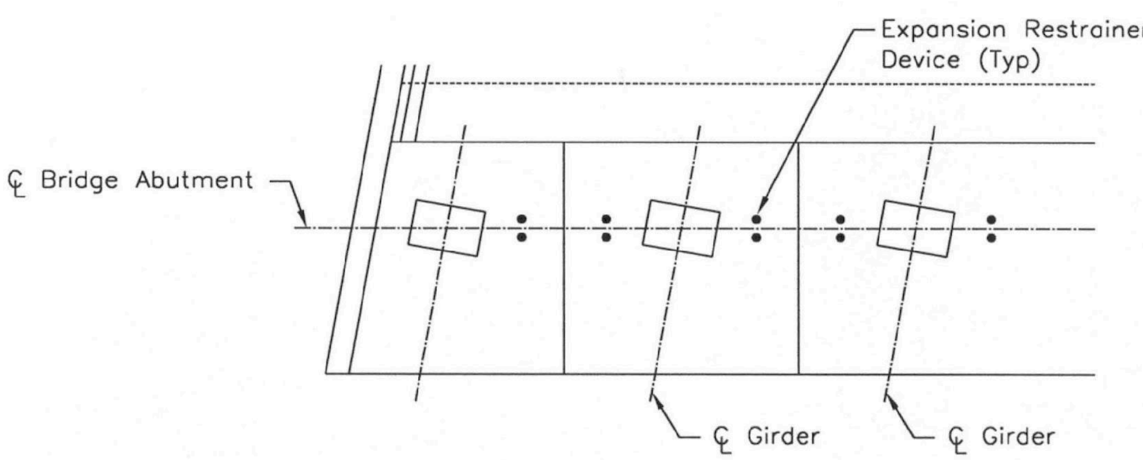
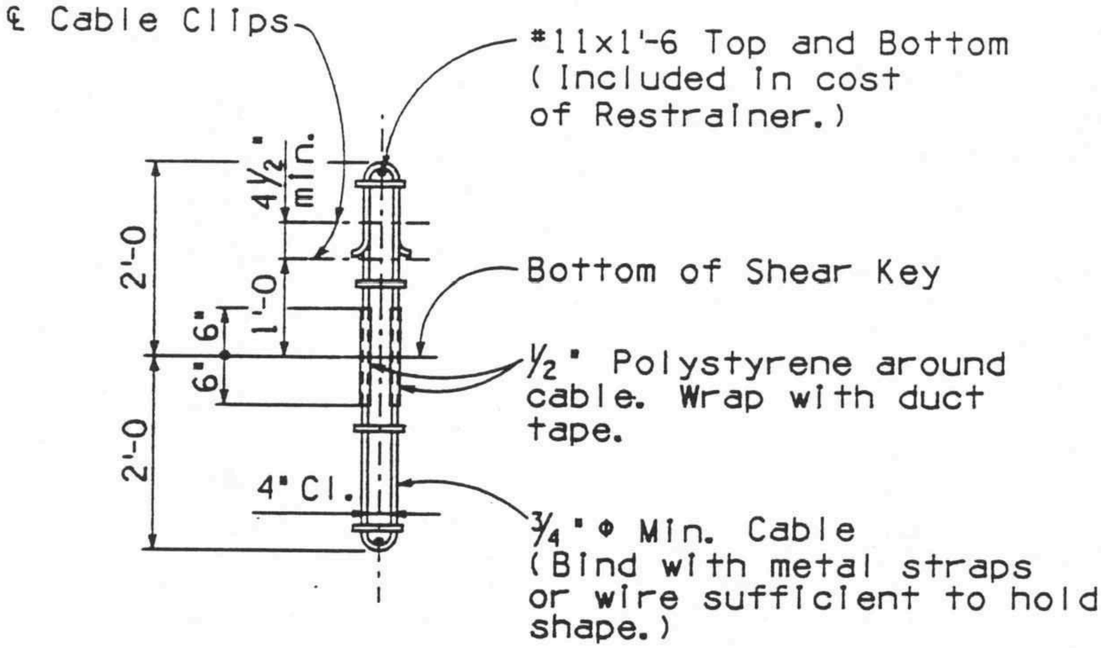


Exhibit 601-3.06-1 Expansion Vertical Restrainers

FIXED RESTRAINER



FIXED RESTRAINER DETAIL

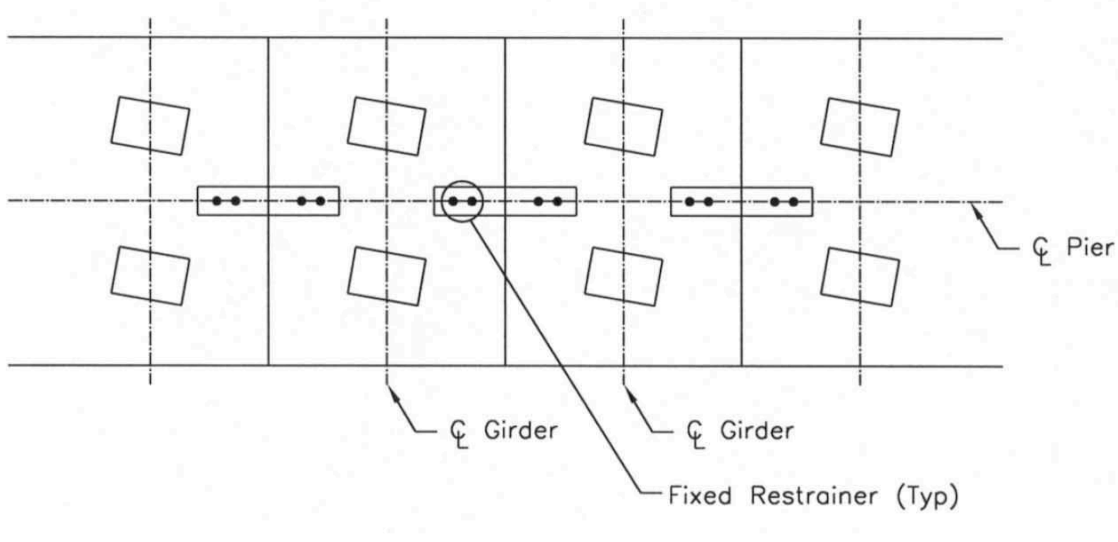


Exhibit 601-3.09-2 Fixed Vertical restrainers

Orientation of the vertical restrainers is crucial to the long-term performance of the bridge. Fixed restrainers are installed with a different orientation than expansion retainers. It is important to review the Project Plans and verify the correct orientation of each restrainer.

Fixed restrainer cables have the face of the loop parallel to the abutment or pier centerline and perpendicular to the girder as shown in Exhibit 601-3.09-2. This allows the cable to bend or fold over as both the girders and diaphragms rotate due to loading of the superstructure. If the cables were turned ninety degrees they could inhibit the rotation of the diaphragm that might result in undesirable cracking of the diaphragm.

Expansion restrainer cables, on the other hand, have the face of the loop perpendicular to the abutment or pier centerline and parallel to the girder as shown in Exhibit 601-3.09-1. This is due to part of the loop being contained inside a hollow steel box. This steel box is cast into the superstructure and performs several important functions. First it spreads the cable loop apart. This is done to allow some vertical movement so that the superstructure can be jacked up slightly from the substructure in order to replace any worn bearing pads. Secondly it provides room for the superstructure to move by expanding and contracting while allowing the cable to freely bend and stretch as the structure moves. The correct alignment of the box is of critical importance. The box prevents the portion of the cable embedded in the substructure from snagging against the sides of the box as the superstructure moves on the bearing pads. The Designer will specify how wide each box will be based on the amount of expansion and contraction they expect at the joint.

Inspectors are required to sample vertical restrainers and have them tested for breaking strength and compliance with other material specifications. The polystyrene and hardboard used to separate portions of the restrainers from the surrounding concrete have material specifications that the inspector should enforce.

Superstructure-Substructure Connections

The superstructure of a bridge consists of the girders, diaphragms, deck, and barrier. The substructure of a bridge consists of the abutments and piers and their foundations. The superstructure carries all loads, e.g. the weight of traffic, force of the wind, and the weight of the superstructure itself between each portion of the substructure's piers and abutments and transmits the loads to the substructure. The substructure, in turn, transmits the loads from the superstructure to the ground.

The best way to visualize the difference between superstructure and substructure is to think of the piers and abutments and everything below them as substructure. Everything above the piers and abutments is superstructure. From a load carrying point of view, the superstructure transmits loads horizontally, or diagonally, in the case of an arch, to the substructure and the substructure transmits the loads vertically to the ground.

It is very important for both the inspector and the Resident Engineer to understand how the superstructure is designed to behave when it comes in contact with the substructure. There are three fundamental ways of connecting the superstructure to the substructure. Although in practice these connections are complicated to build. Understanding how they are supposed to behave, ideally, will help in finding construction errors that could seriously affect the performance of the bridge.

The bridge elevation sheet will show an "E," "F," or "P" where the girders of each span come in contact with either a pier or an abutment.

An "E" on the bridge elevation sheet indicates the superstructure is allowed to expand over the substructure. Bearing pads are placed between the girders and girder seats on the substructure to allow independent movement and rotation of the superstructure. Usually an expansion joint is also placed in this location that forms a physical gap in the superstructure. The important thing to remember is that the superstructure is not physically tied to the substructure. There should be no rebar connecting the girder diaphragm into the pier or abutment. Expansion restrainer cables and perhaps a shear key should be the only things restraining movement of the superstructure. If there is an expansion joint in the superstructure, there should be no rebar or conduit that ties the two portions of the superstructure together. There should be a continuous gap all the way around the diaphragm so the girders can move freely on the bearing pads.

An “F” on the bridge elevation sheet indicates the superstructure is physically tied to the substructure. The superstructure can’t move or rotate without the substructure moving or rotating with it. Rebar from the pier or abutment protrudes into the girder diagram forming a rigid connection between the two structures. Bearing pads are used to distribute the loads evenly across the girder seats rather than allow any differential movement. Fixed restrainer cables and shear keys may be used to help resist seismic loads induced from earthquakes. The Resident Engineer and inspector should verify how the substructure steel is tied to the superstructure steel. Accurate rebar placement and good splicing and tying practices are important so that a highly rigid attachment of the superstructure to the substructure will result.

A “P” on the bridge elevation sheet means the superstructure is attached to the substructure but is allowed to rotate independently like a pinned connection. Some rebar will protrude from the substructure to prevent horizontal movement. Fix cable restrainers are used to prevent excessive vertical movement. Bearing pads are used to allow rotation. The Resident Engineer and inspector should focus their attention on the bearing pads since defective or the wrong bearing pads could inhibit rotation. Rebar placement and positioning of the restrainer cables are other important inspection areas.

Bearing Pads

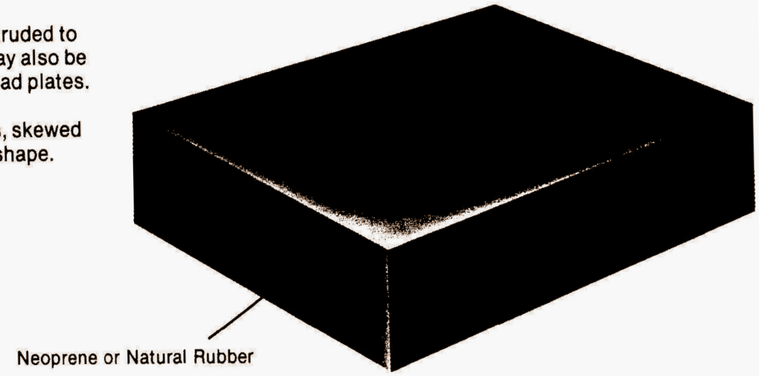
Very little is said about bearing pads in Section 600 of the Standard Specifications. Section 1013 discusses the material requirements. The Project Plans and Special Provisions specify the installation requirements. The Special Provisions may talk about material requirements for bearing pads not covered by Section 1013.

Bearing pads are typically made of Neoprene or natural rubber. The shape and design of the bearing pad depend on the type of movement allowed. Plain bearing pads are essentially rubber blocks or strips placed under the ends of each girder. They allow the girder ends to rotate. When some horizontal movement is needed, laminated bearing pads are used. The more movement needed, the thicker the pad needs to be in order to flex. When a lot of horizontal movement is needed, a Teflon plate or a greased galvanized steel plate is placed on top of the bearing pad. Exhibits 601-3.09-3, 601-3.09-4, and 601-3.09-5 show typical bearing pad details.

Plain Bearing

Plain bearings may be molded, cut, or extruded to any size and thickness. Plain bearings may also be vulcanize-bonded to top and/or bottom load plates.

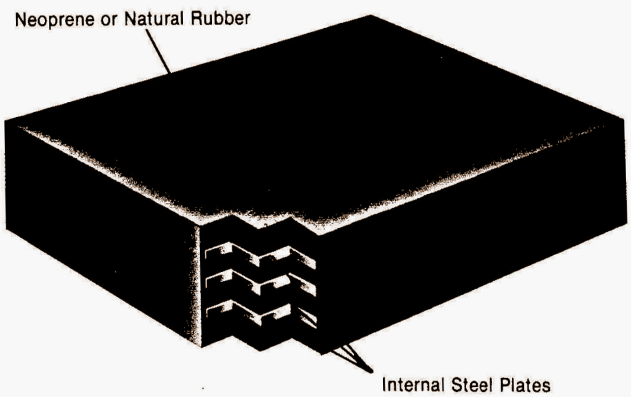
Plain bearings may also have holes, slots, skewed ends, clipped corners, and/or circular in shape.



Laminated Bearing

Laminated bearings may be molded to any shape or size, depending on the design requirements. Internal steel plates may vary in thickness and are vulcanize-bonded during the molding process.

Laminated bearings may also be manufactured with top and/or bottom load plates vulcanize-bonded during the molding process. Cover layer thicknesses may be varied according to specific requirements on the top or bottom of a bearing, or on the edges, for environmental resistance.



Sliding Bearing

A sliding bearing consists of two components. The top component incorporates a steel load plate with a polished stainless steel plate welded to it. The top plate is welded or bolted to the girder during installation.

The bottom component consists of a 1/16″-3/32″ TEFLON® sheet bonded to a stainless steel backing plate, bonded to an elastomeric bearing, bonded to a steel load plate. All bonding is done by vulcanization during the molding process.

Sliding bearings may be guided or free to move and are custom made to individual project requirements for material types, expansion, rotation, etc.

Also available are preformed fabric sliding bearings. All miscellaneous elements, including lead plates, anchor bolts, and side retainers, are available as required.

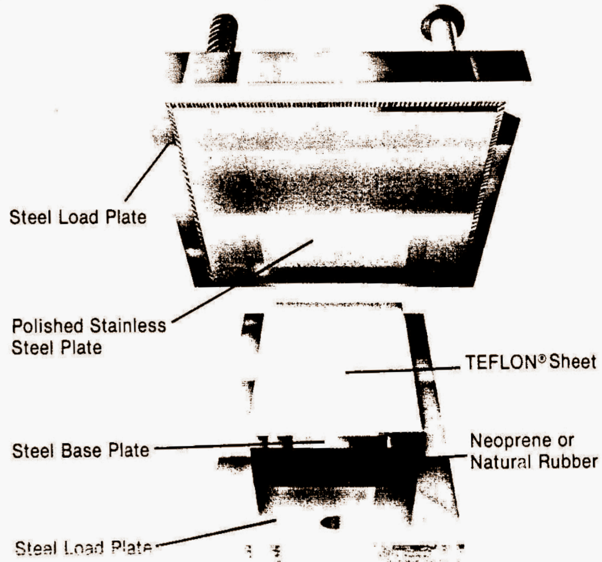
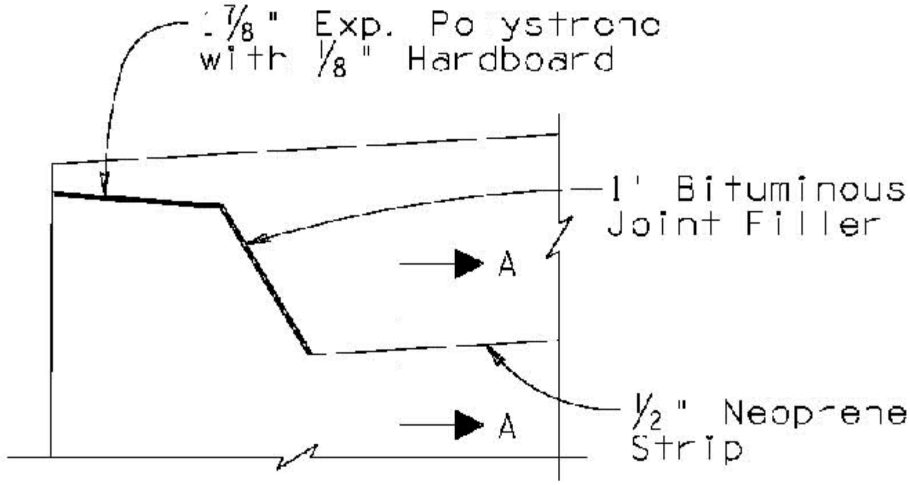
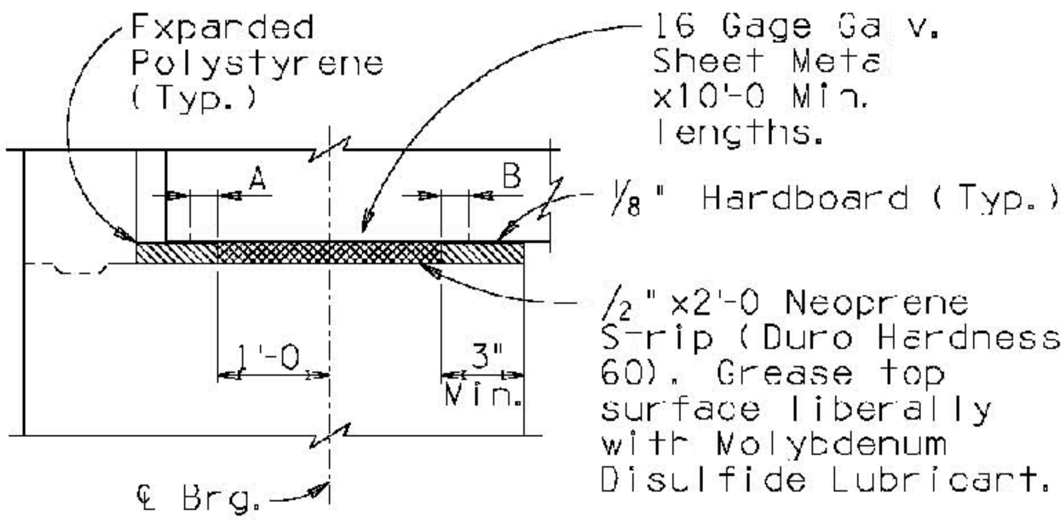


Exhibit 601-3.09-3 Bearing Pads



PARTIAL ELEVATION

No Scale



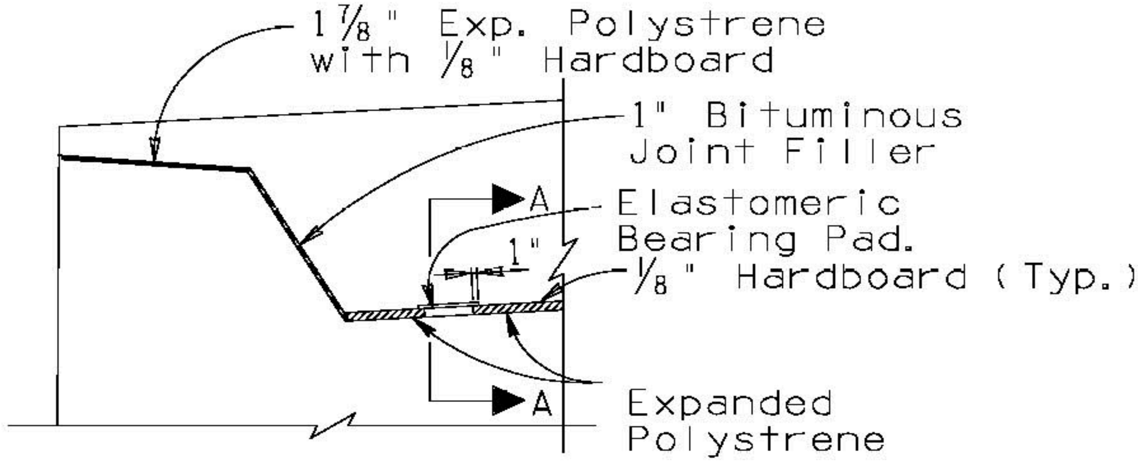
SECTION A-A

No Scale

A = Movement due to temperature fall + rise + prestress shortening (elastic + long term) + 1' Min.

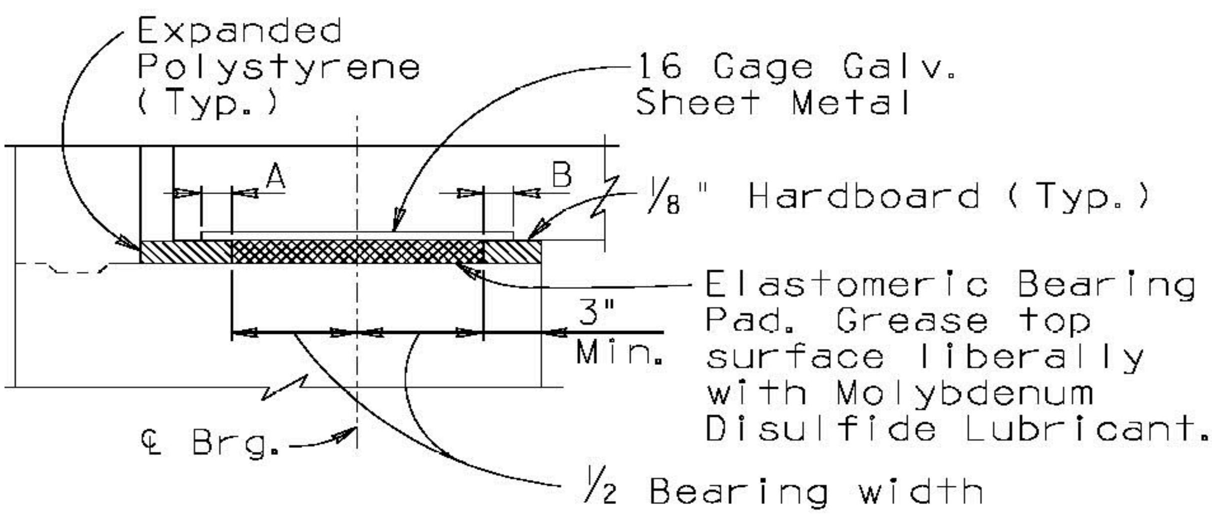
B = Movement due to temperature rise + fall + + 1/2' Min.

Exhibit 601-3.09-4 Neoprene Strip Details



PARTIAL ELEVATION

No Scale



SECTION A-A

No Scale

A = Movement due to temperature fall + prestress shortening (elastic + long term) + 1" Min.

B = Movement due to temperature rise + 1/2" Min.

Exhibit 601-3.09-5 Elastomeric Bearing Pad Details

Bearing pads can only carry so much load before they lose the ability to flex. When a bearing pad is required to carry heavy loads, the Designer may specify pot, disc, or spherical type bearings. These are sophisticated types of bearings that must be pre-approved and tested prior to installation.

The wide variations in bearing designs do not permit a more detailed discussion on bearing types and installation requirements. However the inspector should follow these general rules when inspecting all types of bearing pads:

- Consult the Project Plans and Special Provisions first.
    - Most of the installation and material requirements will probably be found in these two documents. You should clearly understand how the bearings will be placed on the pier or abutment and how they will be connected to the bridge girders.
- Bearing pads must be made of material acceptable to the Department.
    - The Special Provisions or Section 1013 specifies the material properties for bearing pads. Bearing pads have strict material requirements that must be adhered to in order to achieve a long lasting, low maintenance service life. Bearing pads are sampled by the inspector in accordance with the Sampling Guide and sent to ADOT Materials Group for testing.
- Bearing pads need to be level.
    - Bearing pads are intended to be a plane level surface that the girders and bridge superstructure can slide upon. Unlevel bearing pads, especially when the bridge has a superelevated deck, may cause the girders to slide right off the pads to the bridge pier or abutment concrete. This could restrict expansion and contraction of the superstructure that may crack the bridge.
- Bearing pads must be oriented in the right direction.
    - The correct direction is the direction shown in the Project Plans with the markings on a visible face per Subsection 1013-3.01(C). Sometimes this is parallel to the girder line. Other times, they are set in the same direction as the abutment. For bridges with extreme skew the bearing pads are usually aligned in the same direction as the girders, regardless of the angle created between the bearing pads and the abutments or piers. Incorrectly oriented bearing pads can cause the superstructure to slide off the bearing pads just as easily as unlevel pads. Any ambiguity as to how the bearing pad should be oriented should immediately be brought to the attention of the Designer.
- Bearing pads must be set in the correct positions with the correct offsets.
    - The Project Plans will show the exact location and orientation for each bearing pad. The inspector should carefully consider how each pad would be placed, in what position it will be, and whether it will function as intended. Any confusion on how the pads are to be positioned should be clarified with the Project Supervisor or the Bridge Designer.
- The Bearing Seat should be level and finished to elevation with a wood float.
    - If a bearing seat elevation is low, the bearing seat must be built up with an equal strength fine mortar (girder buildup). If the bearing seat elevation is high, the bearing seat must be ground down. The grinding of the bearing seat shall not create a depression which can trap water. The adjusted area shall extend to the edge of the cap to permit drainage. For either situation, a repair proposal must be submitted by the contractor, and approved by the Designer of Record.

On post-tensioned box girder bridges, the galvanized steel plate that is cast into the superstructure will not be centered over the neoprene strip. There will be a slight offset to account for the shrinkage of the superstructure after post-tensioning. The inspector should ensure this offset is built into the bearing assembly. See Section A-A of Exhibit 601-3.09-4. Other types of bearings used for this application should have a similar kind of offset. See Section A-A of Exhibit 601-3.09-5.

Jacking up a bridge superstructure to replace faulty bearing pads is an expensive undertaking. Inspectors must properly inspect, sample, and test bearing pads. The Special Provisions or Section 1013-3 describes the sampling and testing procedures the contractor and the inspector must follow.

601-4 Tests on Finished Structures

601-4.02 Dimensional Tolerances

Section 601-4.02 lists a variety of dimensional tolerances required for each member of a concrete structure. The inspector must verify that each construction tolerance is met by taking the appropriate measurements in the field. For some tolerance measurements, you may need the assistance of a survey crew or special equipment such as a straight edge.

Dimensional tolerances are very important in structural concrete construction because:

- Structural members that are too thin may have inadequate load carrying capacity.
- Members that are out of tolerance in elevation, plumbness, or horizontal alignment can result in high stress concentrations in other members or within the member itself.
- Members that are at the incorrect elevation may require the elevation difference to be corrected in other members that throw them out of dimensional tolerance.
- Members that are too big may add additional loading to the structure unforeseen by the Designer.
- Members with too much dimensional variation may appear unsightly to the traveling public.

For example, a girder seat that is too low may require more deck buildup in order to get the riding surface at the correct grade. A column that is out of plumb can result in severe stress concentrations in the pier cap or footing that may crack these members under normal loading.

Precast members have dimensional tolerances that are very important for the same reasons cited above

601-5 & 6 Method of Measurement & Basis of Payment

Concrete structures are typically measured and paid for on a lump sum basis. Minor precast structures such as catch basins or manholes, are usually paid for on a unit or each basis. Subsection 109.10(A) of the Special Provisions will list major structures or groups of structures that must be paid on the basis of Lump Sum. Major concrete structures such as bridges and box culverts are usually measured and paid separately as one lump sum structure item. Each lump sum structure may have separate bid sub-items for girders, structure backfill, reinforcing steel, vertical restrainers, and other bridge components. These sub-items are intended to provide a means of measuring and paying for a partially completed structure on a monthly basis. The structure is still paid for as a lump sum with the total of the sub-items equaling the lump sum amount. The sub-items help track significant overruns or underruns in quantities that may require adjustments under Subsection 109.10.

When a structure is founded on drilled shafts or piling, separate bid items will be listed for these types of foundation. These bid items are not considered to be part of the lump sum structure amount. The work is paid for separately based on the actual quantities used. The project bidding schedule will show these bid items below the lump sum bid item for the structure.

There are three types of price adjustments allowed to a lump sum structure. The first type is due to strength deficiencies in the structural concrete. This is specified in Subsection 601-6. Subsection 1006-7.06(B) can be used to resolve strength deficiencies. The other two adjustments are due to quantity variations discovered during construction or to adjustments ordered by the Bridge Designer. These are specified in Subsections 109.10 (B) and (C).

Quantity variations during bridge construction are not uncommon. It is recommended that the inspector and the Project Supervisor closely monitor pay quantities.

Some suggestions are:

- Count all vertical restrainers and bearing pads that go into the structure

- Collect tickets from all concrete pours and document the quantities
- Retain the cut sheets for all the reinforcing bar placed
- Note any forming deviations and elevation differences that are consistently on the high or low side of the tolerances specified in Subsection 601-4.02
- Note any excessive form deflections during concrete pours
- Track the amount of rebar and wasted concrete left over after completion of key structural members
- Spot check the dimensions of completed structural members, e.g. walls, decks, slabs, abutments, footings, etc. and compare them with the dimensions shown on the Project Plans.

Subsection 109.10 of this manual further discusses how to handle quantity variations in lump sum structures.

602 PRESTRESSED CONCRETE

602-1 Description

Prestressed concrete construction is specialized work done by experienced crews trained for this type of work. Although the responsibility for prestressing lies with the contractor, it is important that the Resident Engineer and the inspector are familiar with the operation.

Prestressed concrete is different from reinforced concrete in that an initial compression load is applied to the structural member. This prestress is applied by means of steel strands that run through the structural member. Placing an initial compression stress in a structural concrete member allows it to carry greater loads than normally would be achieved by adding more reinforcing steel. The idea is to keep the structural member from experiencing any tension stresses that might crack the concrete. The higher the compression stress induced into the concrete, the more load the member can carry before going into tension and cracking. ADOT uses prestressed concrete for most bridge girders and sometimes for pier caps and deck slabs. Prestressing allows for lighter and stronger concrete members that do not crack easily.

There are two methods for prestressing concrete pre-tensioning and post-tensioning. Precast concrete girders are pretensioned, while cast-in-place box girders are post-tensioned.

Pre-tensioning involves running steel strands along the length of the member to be prestressed. The strands are initially tensioned to a predetermined stress. This causes the strands to stretch. Concrete is then poured all around the strands. Once the concrete has hardened and gained sufficient strength, the ends of the strands are cut. The strands inside the concrete member try to relax and shorten. However there is now concrete bonded to the strands. As the strands shorten, they push the concrete together and induce a compressive stress into the concrete.

Post-tensioning involves running steel ducts through the concrete members. Special anchors are placed at each end of the member. Then concrete is poured around the ducts and the anchors. Steel strands are run through the ducts. Once the concrete is strong enough, the strands are pulled at one end while anchored at the other. Pulling or jacking of the strands causes the ends of the concrete member to push toward each other. This induces compressive stresses along the entire length of the concrete member. After jacking, grout is injected into the ducts then concrete is poured around the ends of the anchors. Once the grout gains strength, the strand is now bonded to the concrete member in a way similar to pre-tensioning.

The results of pre-tensioning and post-tensioning are the same. Compressive stresses are induced into the concrete member. The differences are in the technique used to induce the prestressing.

Prestressed members require the use of additional reinforcing steel. Extra steel is used to control certain types of cracking near the end of a prestressed member.

602-2 Materials

Prestressing Strand

The Department allows two types of prestressing strands. For precast girders, seven-wire, high-tensile 0.5 inch strands are used. For cast-in-place box girders either 0.5 inch or 0.6 inch strands are used with the 0.5 inch strand being the most preferred.

Prestressing strand is more susceptible to corrosion than rebar and should be treated accordingly. After the packaging has been removed from the reels containing the prestressing steel, the reels should be kept off the ground on blocks or timbers and covered with a tarpaulin. The tarpaulins should be wrapped loosely around the reels to permit air circulation and avoid moisture build-ups due to condensation.

The following criteria is a guide for the acceptance or rejection of the prestressing steel strand:

- Steel that has a thin rust film, removable by light rubbing and leaving only light streaks or spots but no pitting, need not be rejected.
- If there is an even coating of rust over the entire reel when it is opened, the reel should be rejected.
- The reel should be rejected if one or more wires in a strand shows extensive rust throughout its length.
- Any section of strand or wire that contains clinging rust, pits, or other faults should be discarded.

Concrete

Good concreting practices in regards to mixing, placing, and curing are a prerequisite to any prestressing operation. Uniformity and consistency of the concrete is especially important. Variations in concrete properties can lead to excessive camber deflection and pronounced long term creep of prestressed concrete members. The inspector should carefully monitor batching and placement procedures and reject all concrete that fails to meet slump or other placement related specifications.

602-3 Construction Requirements

602-3.01 Shop Drawings

Extensive shop drawing submittals are required for all prestressed concrete members. The contractor will submit drawings showing the location of all prestressing strands and detailing any additional hardware needed to secure or anchor the strands to the concrete member.

The shop drawings should include:

- A scaled composite drawing showing strand and hardware locations
- The jacking method and sequence
- The strand type, size, location and number of strands
- A calibration chart for the jack, including a calibration certificate that is no more than two years old
- Elongation and stress calculations
- Details on additional hardware such as plates and bars

Additional requirements for pretensioned concrete members (precast girders) include:

- The location of all harping points and other hold down locations
- The location of all lifting points and lifting hardware details
- The type of finish on the tops of the girders

Additional requirements for post-tensioned concrete members include:

- Anchorage design details including bursting diagrams and stress calculations
- Duct layout details and vent locations
- Post-tensioning sequence
- Grouting procedures
- an approval letter from a recognized authority on post-tensioning systems that conforms to the requirements of subsection 602-3.02.

The Resident Engineer should verify the submittal is complete with all of the required drawings, calculations, and details before sending to the Bridge Designer for review. A PDF copy of all prestressed concrete members must be included with the as-built plans when the project is finalized, refer to Subsection 105.03.

Hardware Installation

The contractor is responsible for furnishing hardware that will withstand the prestressing loads transferred from the strands to the concrete girders. The hardware requirements are shown in the approved post-tensioning shop drawings. The contractor will provide calculations with the shop drawings showing the transfer stresses in the hardware and how the hardware was sized and selected. It is important for the inspector to ensure that all the hardware shown in the shop drawings is incorporated into the girders. Sizes, spacing, and material grades should all be checked carefully.

A transition cone, usually referred to as a trumpet, is placed at the end of the duct at the bearing plate. The size and the length of the trumpet varies with the size of conduit and the jacking system used. The trumpet section is used because the area of the duct is much smaller than the area of the hardware needed to tension and anchor all of the strands in the duct.

The girder webs are usually flared at the ends to accommodate the trumpet sections and to provide enough concrete cover. The amount and length of the flared section will depend on the prestressing system and size of duct used. The alignment between the duct and trumpet section is critical. A smooth connection is required or problems may arise while tensioning or grouting. The joints between the duct and trumpet must be sealed in the same manner as the other duct joints.

Openings for the injection of grout are placed at the bearing plates and are usually connected to the trumpet cone. The connection is generally brazed, watertight, and must be able to withstand the grout pumping pressures. The grout ports and vents must be anchored securely to the forms or rebar to prevent displacement during the concrete pour.

602-3.02 Approval of Prestressing Systems

When precast girders are used, ADOT's Material Group will approve the pre-tensioning system. For cast-in-place box girders, the Bridge Designer will approve the contractor's post-tensioning system.

For post-tensioning, the inspector should have copies of the approved post-tensioning drawings and calculations. It is important for the inspector to verify that the contractor closely adheres to the approved shop drawings. The structural integrity of the entire bridge is dependent on the post-tensioning system. Even the slightest deviation from the approved shop drawings or Project Plans can have serious consequences for the long-term performance of the structure. Daily inspections of post-tensioning hardware such as ducts, bearing plates, trumpets, bolts, and bars, during installation are required. Spacing, location, sizes, and material requirements are key inspection areas. Inspectors should strictly enforce the installation tolerances shown in Subsections 601-4.02 and 602-3.05.

602-3.03 Sampling and Testing

Inspectors are required to sample each reel of pre-stressing strand that arrives on the project site. Steel bars, wires, and couplers should be sampled at the rate shown in the Standard Specifications. Steel plates should be sampled at the rate shown in the Sampling Guide. Testing is usually performed by the Structural Material Testing Section of ADOT's Material Group.

Certificates of Compliance must accompany all pre-stressing materials. All materials are required to have a lot number assigned by the manufacturer that must be referred to on the Certificate of Compliance. The inspector should document where these materials are placed in the structure and should not allow any materials to be used that are not properly tagged and certified.

602-3.05 Duct Installation for Post-Tensioned Structures

Ducts are generally placed after the stirrups are in place in the girder webs and before the side forms have been placed. The utmost care must be exercised in the storage, handling, and transporting of ducts, as they are relatively flimsy compared to other bridge components and damage easily.

Two types of ducts are used in bridge construction. Smooth wall rigid conduit is made from galvanized strip steel held together longitudinally with a continuous resistance weld or a continuous interlocking seam. They are normally furnished in 20-foot lengths with one end of each length enlarged to form a slip type connection. The other type of duct is galvanized ribbed sheet steel with helically wound interlocking seams. It is generally furnished in 40-foot lengths and connected by larger rigid conduit couplers.

All of the joints in the duct, whether they are couplers or interlocking seams, should be taped with durable waterproof tape to prevent the intrusion of mortar while placing concrete. A careful inspection should be made at all joints to verify they are well sealed to prevent problems due to a plugged duct.

The correct positioning of the ducts is most critical at the high and low points of the duct profile and at the points of contra-flexure. The profile between these points should form a smooth parabolic curve. As discussed in Subsection 602-3.02 of this manual, strict adherence to installation tolerances is extremely important. Misaligned ducts can severely affect the amount of prestressing transferred to the bridge structure. Ducts that are installed too low in a girder can cause additional uplift stresses on a post-tensioned bridge that can crack the bridge deck and tops of the girder webs. On the other hand, ducts installed too high can cause a post-tensioned bridge to sag due to a lack of adequate uplift stress.

The horizontal alignment of the ducts is important and should be carefully checked. Ducts that are out of horizontal alignment can cause a wobbling effect on the girder webs when they are post-tensioned. This effect can cause the girder webs to twist out of alignment resulting in severe cracking and even spalling of the web concrete around the ducts.

The ducts should be tied securely; both vertically and horizontally, to the stirrups and other rebar to prevent displacement during the concrete placement operation. Ducts have a tendency to float during concreting causing the joints to open up if the conduit is not properly secured.

Grout vents are usually attached to the ducts by brazing or using metallic structural fasteners. The vents should be mortar tight and taped when necessary to prevent the intrusion of mortar. Grout vents are used to ensure that a steady and continuous flow of grout is being pumped through the duct. Vents must be placed according to the approved shop drawings that are usually within 6 feet of the high point of the duct profile in continuous structures. Grout vents may be placed at the low points of the duct profile. Usually this is not done unless specified because of the difficulty in access due to falsework obstructions. The advantage of using low point vents is to allow water that has collected in the ducts to drain.

Ends of the ducts should be covered after installation to prevent entry of water and debris.

Duct Inspection

After the installation of the ducts, rebar, and forms, a thorough inspection should be made to locate possible duct damage prior to placing concrete. The inspector should be aware of the most common sources of duct damage. Some of the common forms of duct damage are:

- Separation due to dragging the duct
- Punctures due to threading rebar
- Indentation due to dropped rebars
- Indentation due to workmen walking on, or placing equipment or material on the ducts
- Punctures caused by drilling forms for snap ties while buttoning up side forms

Two alternative methods that have been successfully used to locate duct damage prior to concrete placement are described below:

Method No. 1:

- Through visual inspection by the use of angle-mirrors and flashlights.

Method No. 2:

- Check the ducts with compressed air. This method is described as follows:
- While introducing a large volume of air (3 cubic yards per minute) continuously at one end of the tendon, note the dynamic pressure on a gauge at the opposite end. Since the duct is not closed, no specific gauge pressure is required. Large holes or openings in the duct will allow more air to escape than an undamaged duct and will result in a lower dynamic air gauge pressure. It is necessary to compare the noted pressures between similar tendons.
- Any large holes or openings can be located by the disturbance caused by the escaping air, e.g. sound, dust, etc.

After inspection of the ducts, all holes or openings found in the ducts must be repaired prior to concrete placement. The following methods of repairing damaged ducts can be used as a guideline. Holes less than 1/4 inch can be repaired by several wraps of waterproof tape. Holes or openings larger than 1/4 inch should be repaired with a split metal sleeve extended at least 3 inches on each side of the hole. The sleeve should be secured to the duct and be sealed with waterproof tape. Extreme care must be exercised while repairing damaged ducts so there is no further damage.

Duct Protection During Concrete Pours

After a thorough inspection of the ducts, hardware, rebar, and forms, the bottom deck and webs of the bridge can be poured. Problems often occur while pouring the webs and the contractor must exercise extreme care in placing and vibrating the concrete. Generally with the ducts installed, there is not much room in the webs to place and vibrate the concrete. Unless the utmost care is exercised, honeycomb or complete void areas may result. Consolidation of the concrete is especially important around the trumpets since most of the prestressing loads will be transferred to the concrete in this area. Damage to the ducts can occur from wedging the vibrator against the duct. Pencil vibrators are sometimes used and recommended when there is a high risk of getting the vibrator jammed between the reinforcement and the ducts.

All of the web walls must be checked after the forms have been removed. Any honeycomb or void areas must be repaired. Minor imperfections can be repaired by chipping away the defective area and patched in a manner approved by the Resident Engineer. The size of the damaged area will govern the materials used for patching. If the Resident Engineer deems that the integrity of the member has been affected by extensive honeycombing, part or the entire web may have to be removed. The contractor must be careful and not damage the duct while chipping defective concrete.

Duct Blockages

Before closing the bridge cells to construct the top deck, the ducts must be tested again to verify there are no holes in the duct and that the ducts are unblocked. A common way to verify that the ducts are unblocked is to blow an object (a rubber ball is excellent for this purpose), slightly smaller than the inside diameter of the duct, through the duct with compressed air. If the object cannot be blown completely through the duct, the duct has a blockage and the location of the blockage must be determined and corrective measures must be taken to repair the duct. A method of checking the amount or size of blockage is to use smaller diameter balls to see if they can be blown through.

Sometimes blockages can be removed by see-sawing a strand back and forth in the duct. However be careful not to damage or nick the strand while trying to clear the duct. If this method or any other method the contractor uses is not effective then the blockage must be repaired by chipping the girder web before the top deck is poured.

Pressure Testing

Once the inspector is satisfied that all possible blockages have been investigated and repaired, the contractor must demonstrate to the Department that the ducts will not leak. This is done by pressure testing the ducts. Either air or water is pumped into a closed duct until the charging pressure is attained, then the valve is shut-off and the retained pressure is measured after five minutes. The specified charging and retained pressure depends upon whether the duct will be partially, or completely encased by concrete during the pressure test. Ducts that are not completely encased in concrete must have exposed areas sealed with epoxy before pressure testing.

If the performance of the pressure test is unacceptable, the contractor must take some action to find and repair any leaks. If after testing, the duct is still unacceptable, the Resident Engineer has the option of approving the ducts or requiring more repairs.

It should be a very rare occasion when a Resident Engineer approves a post-tensioning duct that fails the pressure test. The Resident Engineer should insist that the contractor make all the necessary repairs to fix any leaks. Once the deck forms are placed and the deck poured, it is much more difficult to access the girder webs to repair any leaking ducts.

If you find a duct that cannot pass the pressure test, some steps you can take are:

- Try switching between the two types of pressure test; water vs. air
- Air test during the very early morning when it is quieter
- Hydrostatic test the duct for several hours; leaking water will eventually reveal the location of the leak
- Use dye in the water to make it easier to trace the leak, be careful about staining exposed concrete

Occasionally the contractor will have made a good faith effort to fix all the leaks but the duct may still fail the pressure test. If this is the case, the advice of Bridge Group and the Bridge Designer should be sought prior to approving the duct.

After all the ducts have been checked for blockages and leaks, the cells can be closed and the top deck can be poured. The strands may be placed in the duct prior to pouring the top deck. However the strands should be protected from rust by using an approved corrosion inhibitor. The better method is to install the strands after all of the concrete has been placed and has developed the required compressive strength for tensioning.

602-3.06 Prestressing

The following terms should provide the inspector with a better understanding of the concept of prestressing:

- Anchorage Device - The hardware assembly at the ends of each post-tensioning duct, used for transferring a post-tensioning force from the strands to the concrete.
- Curvature Friction - The friction resulting from bends or curves in the specified post-tensioning duct profile.
- Effective Prestress - The stress remaining in the concrete due to prestressing after all losses have occurred excluding the effects of dead load and superimposed loads. Effective Prestress equals Jacking Stress minus Loss of Prestress
- Friction (Post-Tensioning) - The surface resistance between the strands and duct in contact during post-tensioning. It includes curvature friction.
- Jacking Force (Pjack) or Jacking Stress - The temporary force exerted by the jack that introduces tension into the strands.
- Loss of Prestress - The reduction in prestressing force resulting from the combined effects of:

  - Elastic shortening of the concrete and rebar due to the jacking force
  - Relaxation of the strands
  - Friction
  - Anchorage losses due to seating of post-tensioning strands and movement of the anchorage device
  - Long term creep and shrinkage of the concrete

- Pre-compressed Zone - That portion of the flexural member's cross section compressed by the post-tensioning force (Pjack)
- Relaxation of Tendon Stress - The time-dependent reduction of stress in the strands at a constant strain.
- Tendon - The post-tensioning duct and the strands and grout within the duct used to impart a prestress to the concrete or each strand in a prestress, precast concrete girder.
- Wobble Friction - Friction caused by the post-tensioning ducts (or the stands in precast girders) that are misaligned, horizontally and vertically, from their intended alignment and profile. This is the primary reason ADOT requires formwork drawings for interior girder webs on post-tensioned bridges.

Prestressing takes place in two increments. The first increment, referred to as the initial pull, is applied to straighten the strands and to eliminate slack. The initial pull is usually between 5 to 10 percent of the initial stress and can be applied either by a hydraulic jack equipped with a pressure gauge or load cell or by a fence stretcher and dynamometer.

Immediately following the initial pull, the contractor must mark both the dead ends of the strands for slippage and the stressing end for elongation measurements. If spliced strands are used, the splices must be marked for slippage.

After the reference marks for elongation and slippage have been placed, the strands can be tensioned and anchored at the required initial stress. The jacking stress must be applied with a hydraulic jack equipped with a pressure gauge or load cell.

At the end of the stressing operation, the elongation must be measured and compared to the theoretical calculated elongations. The calculations must be submitted to the Bridge Designer for approval. In pre-tensioned members, each strand elongation should be recorded. For cast-in-place post-tensioned members, the elongation of the strand group in each tendon should be recorded.

(A) General

Prestressing Equipment

Each jack must be equipped with either a pressure gauge, or a load cell with a digital display that is readable at a distance of 10 feet. Pressure gauges used for measuring the stressing load should have a dial at least 6 inches in diameter, and increments with an accuracy within 2 percent. Gauges must be calibrated by an approved laboratory prior to being used. A certified calibration curve should be furnished by the laboratory for each gauge and jacking device. Gauges should be calibrated for the jacks they are to be used with.

Gauges should read in pounds or be accompanied by a chart from which the dial reading can be quickly converted into pounds. All gauging devices should be recalibrated at least as often as specified. During the post-tensioning, if any gauging system appears to be giving erratic or erroneous results or if the gauge readings and elongation measurements indicate materially different stresses, the jack and gauges should be recalibrated.

Welding

Welding should not be permitted in the vicinity of any prestressing strand, steel, or duct. Spatter from welding can pit the steel wire. Very minor pitting can cause failure of the strand even at a low stress. Damage of this type is extremely difficult to detect so adequate precautions must be taken when welding near any strands.

(B) Pre-tensioning Precast Concrete

In precast girder manufacturing long pre-tensioning beds are generally used allowing several members to be made with one strand. The tension must be the same for each member but when strands are draped, friction develops during stressing at hold-down or hold-up points that may reduce the tension in the members toward the non-jacking end. This stress reduction should be checked by computing the elongation of some convenient lengths, say 20 to 25 feet, which may be measured on a straight section of strand near the non-jacking end. The length should be marked on the strand in two or three locations before stressing. Then, after stressing, the elongations are determined and compared. Corrective measures should be taken if results indicate non-uniformity of tension.

The usual procedure for stressing is to place a small initial stress, about 5% of the total, into the strands before marking them for elongation measurements. This is to take the slack out of the strands, seat the opposite end anchor, and tighten up the bearing surfaces. The initial stress produces some elongation. The manufacturer's recommended modulus of elasticity should be used in all elongation computations. One set of stressing calculations may be used for more than one member, if the members are identical. However the inspector should be satisfied that the stressing setup is the same for which the calculations are based.

The strands should not be tensioned more than 72 hours ahead of placing the concrete.

Metal chairs or small precast concrete blocks, aka dobies, may be used to support the strands and stirrups.

Reinforcement and Anchorage Details

The centerline of bearings or the beam centerline should be marked on the form soffit and used as a reference for spacing of stirrups, drape supports, bearing devices, diaphragm connections, etc. Tack welding of reinforcing steel will not be permitted unless approved in writing by the Resident Engineer. If the contractor requests to tack weld, the proposal should be included with the shop drawings. Details provided in these drawings should include compliance with ASTM A 706 for welding rebar.

Positioning of the reinforcing should be performed carefully to make certain that the correct distance from the forms is maintained. End bulkheads and bearings should be set out far enough to compensate for elastic shortening of the member when tension is released.

The alignment of prestressing anchorages to ducts is critical. As a general rule, the anchorage should be within 2 percent of perpendicular to the centerline of the duct. Larger variations can cause failure of the strands due to shifting of the stressing head toward the centerline of the duct.

Placing Concrete (See Sections 601 and 1006)

The inspector should not permit the placing of concrete in any member until the forms, reinforcing steel, and prestressing strands have been verified for compliance with the Standard Specifications and the approved working drawings. When the forms or the steel are hot, they should be sprayed with water ahead of the placement of concrete.

The consistency of the concrete should be closely controlled through frequent moisture tests of the aggregate and slump tests of the concrete. No more water should be used in the mix than is necessary for good placement. Inconsistent concrete produces large variations in girder camber growth. These variations can result in significant changes for both deck build-up and deck concrete quantities that have not been anticipated by the Designer and reflected in the Project Plans.

Concrete should be deposited in its final position as nearly as possible without resorting to moving the concrete appreciably by use of vibrators. Concrete should be placed in at least two continuous horizontal layers for I or H shaped beams of depths not exceeding 3 feet and at least three such layers for beams of greater depth. The first layer of concrete should completely fill the bottom flange and extend 2 to 4 inches up into the web.

Care should be exercised to see that all parts of the forms are completely filled with concrete. The coarse aggregate should be worked away from the form faces by use of the vibrators and spades. The concrete should be worked under and around the prestressing tendons and the reinforcing bars without moving them. There should be at least one spare vibrator in case of a breakdown.

Unless otherwise specified on the Project Plans, the top surface of I-beams, box beams, and flat slabs must be roughened with a hand tine rake while the concrete is still plastic.

Concrete Tests

Compression tests are important in prestressing because they determine the time of de-tensioning or post-tensioning. They show the ultimate strength of the concrete. This makes it more imperative that the sampling, handling, fabrication, curing, and testing shall be in strict conformance with the Materials Testing Manual.

Field cure the cylinders in the same manner as the members are cured. The cylinders should be placed in areas representing the average curing condition of the member or members that they represent. All other cylinders are to be cured and stored according to standard procedures.

Curing (See Subsection 1006-6.02)

Ordinary moist-curing methods are satisfactory if properly performed. Accelerated curing to increase the production of precast members is often used. However steam curing is the most common method.

Steam curing must be performed properly to accomplish the desired results. However even under the best control, there is a loss in ultimate strength of 5 to 15 percent when compared with good moist-curing. The rate of temperature rise, the average temperature, the maximum temperature, and the rate of drop in temperature must be carefully controlled to keep strength loss to a minimum. The rate of rise in temperature of the air surrounding the concrete member should not exceed 40 °F per hour. Maximum temperature must not exceed 175 °F, and the average temperature must not exceed 160 °F. Effective acceleration in the curing is not accomplished unless the temperature surrounding the member is above 120 °F. The rate of cooling should not exceed 40 °F per hour. Usually 12 to 18 hours at a temperature near 160 °F, will result in the required minimum strength of release of the tendons. Coverings or hoods over the members should be at least 6 inches above the concrete surface to provide circulation, and be secure enough to prevent heat and moisture loss.

Stress Release

The required compressive strength for stressing the concrete, as indicated by cylinder strength tests, must be reached before this operation is permitted to begin. For members cast end-to-end on a pre-tensioning bed, the strands should be cut in a pattern and at selected locations along the bed so as to keep the eccentricity of stress loading and longitudinal movement to a minimum. If some of the strands are draped, they should be cut first then the hold-down apparatus released. The straight strands should be cut last.

If the hold-downs are released first, the beam may camber up and crack due to the end moments. If the straight strands are cut first, the unbalanced pull on the beam might shear off the hold-down bolts with resulting damage to the beam and casting bed.

Inspection

Each member should be inspected carefully for conformance with the requirements of subsection 602-3.08 of the Standard Specifications. The following are among the important features that should be checked:

- Concrete cleaned off of exposed reinforcing bars
- Pacer holes and form tie holes should be repaired
- Tendons should be trimmed at the girder ends
- Any necessary finishing and patching done

The Specifications require the contractor to monitor the camber growth of each girder. This can be done by taking elevation readings with a level along the bottom flange of the girder. Only three shots need to be taken; one at each end of the girder and one at the midspan. If the girder remains undisturbed, only a single elevation reading is needed at midspan. These readings should be done immediately after the girder is removed from the casting bed and again just prior to shipping. The camber growth rate is simply the change in the midspan elevation divided by the elapsed time between the two sets of readings. This information should be given to the Bridge Designer who can check the design assumptions concerning camber growth. Camber growth serves as an early warning to the Designer about potential deck build-up problems before much of the deck formwork is placed.

Beams should be inspected for voids or honeycombs before they are shipped or erected. Small voids or honeycomb on the sides of beams may be repaired and accepted if the repair work is performed and properly cured before any stress is released.

Small voids or honeycomb in the bottom of a beam may be repaired and the beam accepted under the same conditions except when the voids are over or near the bearings. Voids or honeycomb in the bearing areas should be considered probable grounds for rejection of the beam. The Resident Engineer should investigate the defect and request the assistance of the Materials Group and Bridge Group.

Transporting

Transporting and erecting precast, prestressed girders are the responsibility of the contractor. A permit is usually required from ADOT Permits to haul girders on ADOT highways. Municipalities and county governments may require additional permitting.

Various kinds of devices are anchored in the concrete for the purpose of lifting the members. The members should not be lifted in any way other than by use of the lifting devices provided. Members should always rest in an upright position setting on blocks located near the ends—just as they would be sitting when installed in the structure. The inspector should observe the handling of the members but the prime responsibility for proper handling is the contractor's. The inspector should record and report any suspected improper handling or damage to the Resident Engineer.

Girders that fall on to their sides or are completely flipped over are usually severely damaged. This is due to the fact that the weight of the beam offsets the bowing action of the prestressing strands. This bowing action gives the girder its camber. If the beam falls on its side or is flipped over, there is nothing restraining the bowing action of the strands. The girder will arch until it cracks all the concrete around the strands. The strands then become de-bonded causing the girder to lose most of its prestress.

(C) Post-Tensioning Cast-in-Place Concrete

Time and Curing Requirements

Tensioning cannot take place until the required concrete compressive strength has been reached for jacking and seven calendar days have passed since the last deck concrete has been placed. The seven day requirement cannot be waived even if the concrete cylinders meet the strength requirement in less time. The seven days ensure the concrete has matured enough so that it will not be susceptible to excessive long-term creep after post-tensioning. Young concrete can creep excessively when loads are applied too early causing the bridge superstructure to sag with time.

Once these requirements have been met, the stressing operation can be started. Compressed air will generally blow most of the water out of the ducts.

Installing the Strands

The strands may be placed in the duct prior to pouring the top deck, or after completion of concrete curing. The better method is to install the strands after all of the concrete has been placed and has developed the required compressive strength for tensioning. For protection of the steel from corrosion, the Standard Specifications state that the prestressing steel placed after curing is acceptable if it is tensioned and grouted within ten calendar days after placement of the steel in the ducts. Usually this is not a hardship on the contractor because ten days is generally sufficient time to tension and grout tendons. Strands placed prior to curing must be protected from rust by using an approved corrosion inhibitor, and the contractor must demonstrate that strands are free and unbonded in the duct before tensioning. The Resident Engineer should be notified when the contractor runs into these difficulties. The Engineer should obtain advice from the Bridge Group, and the Bridge Designer before allowing the contractor to make any attempt to free a bonded strand. If the contractor fails to meet the corrosion requirement, then it is left to the judgment of the inspector whether to re-inspect the prestressing steel for rust.

There are many methods employed in the installation of the prestressing steel in the ducts. The strands must first be pulled from the reels and cut to the required lengths needed for tensioning. Care must be exercised while laying out the strands to prevent them from collecting foreign material. The strands must be clean when installed in the ducts. Stringing the strands over blocks of wood is one effective way of keeping the strands off the ground and free of dust and dirt. The strands cannot be cut with an acetylene torch. An abrasive bit can be used as long as a clean cut is made to allow the prestressing steel to fit through the hardware being used.

The prestressing steel is installed by first blowing a piece of tie wire, nylon cord, or cable through the duct. This may or may not be adequate to pull all of the strands through the duct. If it is not, a heavier cable capable of pulling all the strands is fed through the duct.

A winch is the most common piece of equipment used in pulling the strands. The required numbers of strands for each tendon are pulled using a Kellem Grip placed over the ends of the strands.

On occasion, the contractor will fail to place the correct number of strands in the duct. If this happens, the contractor must add or take out strands until the correct amount is in the duct. This can be an extremely difficult process.

Split wedges are the most common means used for holding the strand during stressing and for the final anchorage of the strands in the bearing plate after stressing. All of the friction wedges have teeth or small serrations that make small notches on the material being gripped. All wedges and pulling chucks must be kept clean so as not to alter the efficiency of the system.

Post–Tensioning Procedure

The sequence of stressing is shown on either the approved shop drawings or the Project Plans. The sequence of stressing is usually determined by the Designer in order to keep the stresses within a predetermined symmetry about the axes of each member.

The Standard Specifications allow stressing from one end only for simple span bridges. Prestressing continuous structures must be done by jacking at each end of the tendon, unless otherwise specified on the Project Plans. Such stressing need not be done simultaneously even though some contractors may choose to do so.

OSHA Standard 1926.701(c) prohibits anyone from standing behind the hydraulic jack during post-tensioning. Poorly anchored or broken strands can shoot through the jacking head. The area several hundred feet behind the jack should be kept clear of all personnel. If this is not practical, suitable barriers should be erected to protect adjacent work, passing vehicles, and pedestrians.

The inspector should measure and record the jacking forces applied to each tendon. A load cell meter is available at ADOT Materials Group for measuring jacking forces during post-tensioning. An instruction manual comes with the meter to calibrate the meter at the project site. The manufacturer's recommended modulus of elasticity should be used in all elongation computations.

The usual procedure for stressing is to place a small initial stress, about 5 percent of the total, into the strands before marking them for elongation measurements. This small initial stress takes the slack out of the strands, seats the opposite end anchor, and tightens the bearing surfaces. The initial stress does produce some minor elongation.

Uniform tension in all of the strands in a post-tensioned tendon is difficult to achieve because of the varying amounts of friction, length, and the modulus of elasticity between the individual strands. Due to inevitable weaving of strands within a tendon, some of the strands may be stressed close to their yield strength before others. This can occur when the jacking force approaches only 78 percent of the ultimate tensile strength of the prestressing strands. Therefore when jacking force exceeds the 78 percentile, some of the strands in the tendon may be over-stressed. This is the main reason that the Standard Specifications do not permit stressing beyond 78 percent of the minimum ultimate tensile strength of the prestressing steel (see Subsection 602-3.06[A]).

Elongation Measurements

The stress induced in the prestressing strands must be measured both by gauges and by elongation of the tendons. Occasionally there are differences between the measured elongation and the elongation shown in the calibration chart for a given jacking force. This is because strain (elongation) versus stress (gauge reading) differs due to variations in modulus of elasticity in the steel, variation in tightness of twist in the strands, variations in friction between the supports or ducts, or friction and losses in the jack and pumping system.

If the variation is more than 5 percent, the contractor must take corrective action before proceeding, see Subsection 602-3.06[A]. This includes finding the source of the error, which could be an improperly seated jack, incorrect assumptions about the amount of twist in the strands, or using the wrong modulus of elasticity. It may even be necessary to have the jacks and gauges recalibrated.

Regardless of the error, it is up to the contractor to find the source and correct it. The Resident Engineer should be notified when the contractor runs into these difficulties. ADOT's Bridge Project Engineer and the Bridge Designer should only be contacted after the contractor has performed all reasonable checks on the post-tensioning operation and cannot rectify the more than 5 percent variation.

If the difference in indicated stress between the jacking pressure and the pressure computed from the elongation is less than or equal to 5 percent, the lower of the two pressures should be increased to the specified value. This would result in a slightly over-stressed strand that is preferable to an under-stressed strand.

Strand Breakage

Occasionally while stressing strands in a prestressed member, a wire in a strand will break. Generally failure of wires is acceptable provided that not more than 2 percent of the total area of the prestressing steel has failed. If a wire failure occurs after the strand has been anchored at its initial stress and the 2 percent criteria has not been violated, the strand should be acceptable subject to approval of the Bridge Designer. If failure occurs while jacking and before initial stress, a new jacking stress can be computed and the strand tensioned to this calculated stress. If failure occurs and the required jacking force cannot be obtained, that strand should be rejected and replaced.

The ends of the stressed strands should not be cut until just prior to grouting so that the inspector can put reference marks on the strand to note any slippage of strands or failures in the hardware system.

602-3.07 Grouting of Post-Tensioned Members

The purpose of grouting is to have the entire void space within the ducts filled with grout. This protects the tendon from corrosion and continuously bonds the tendon to the girder web.

Just prior to grouting, the strands can be cut and the grout caps installed. The grout injection and ejection pipes should be fitted with positive mechanical shut-off valves. The grout vents should be fitted with shut-off valves. Once this has been done, the tendons are ready to be grouted.

Equipment

The grouting equipment must be capable of continuously mixing and pumping grout that is free of lumps and undispersed cement. The mixing tanks, storage tank, pump, and hoses must be in good working condition to provide a satisfactory grouting job. It is essential that the ducts be free of holes and unblocked to accomplish a good grouting job.

Usually two grout mixers are used. Both discharge into a single storage agitator just prior to pumping. The storage agitator should utilize gravity to feed grout to the pump inlet. This avoids additional air being entrapped in the grout mix if pressurized lines are used. Just before the grout is introduced into the grout pump, a 1/8-inch maximum size screen should be installed to keep any lumps or foreign matter out of the grout mixture. The screen should be easily accessible for inspection and cleaning.

The grout mixers and pump should be driven by separate motors. The pump should have a minimum pumping pressure of 150 psi with a gauge having a full scale reading of 300 psi. Maximum grouting pressure must not exceed 250 psi. The pump must prevent any introduction of oil, air, or other foreign substance into the grout and prevent any loss of grout or water.

Standby equipment capable of flushing out any partially grouted tendons must be available at the job site. The standby equipment must be capable of developing a pumping pressure of at least 250 psi with sufficient volume to flush out the duct. Flushing equipment should have a power source separate from the grouting equipment. Any flushing should be from the ejection end of the tendon. The standby equipment should be inspected prior to grouting to verify it is operational.

Materials and Testing

It is necessary to check the consistency of the grout to verify that the correct proportions of materials have been used and that the grout can be easily pumped and will not take a false set in the duct.

The consistency of the grout must be tested with a flow cone per ARIZ. Test No. 311, prior to being introduced into the tendon. Only one test is required per structure since the grouting is usually completed in one day. If grouting is not completed in one day, a test should be taken at the beginning of each day the contractor is grouting. The flow time, immediately after mixing, should not be less than 11 seconds. The flow time is defined as the time it takes the grout to discharge from the flow cone. The contractor should provide initial set times for the grout at various temperatures. The set time can be of extreme value when dealing with leaky post-tensioning ducts.

Procedure

All vents in the tendon should be open when grouting begins. The flow of the grout should be in one direction only. Any intermediate vents must be closed as soon as a steady flow of grout, without any residual water or entrapped air, is maintained. The grout should be continuously wasted at the outlet until no visible slugs of air or water are ejected. The pumping pressure should then be increased and the inlet valve should be closed. The maximum pressure must not exceed 250 psi, and the minimum pressure after one minute must be at least 75 psi.

Occasionally the anchor blocks do not make a tight seal with the bearing plates. When this happens, grout leaks may occur. To control leaking, the pumping can be stopped momentarily to let the grout seal the leak. If this procedure does not stop the leak, then the tendon must be flushed and re-grouted.

The initial pumping pressure should be small; less than 40 psi, and gradually increase in pressure until the duct is filled. The maximum grouting pressure should not exceed 250 psi. If the grouting pressure exceeds the maximum, the grouting may continue at one of the upstream vents as long as one-way flow has been sustained at that vent. If a one-way flow of grout cannot be maintained, then the grout should be immediately flushed out of the duct.

Leaks

Leaks in the ducts may prevent the contractor from maintaining the required 75 psi pressure for one minute. The pressure will drop off gradually as the contractor tries to hold the pressure. If there is a small leak, the contractor may try to:

- Close the valves at both ends, do not pressurize
- Wait for approximately 30 to 60 minutes; do not let the grout set up in the ducts and check the grout set time and temperature
- Grout the adjacent duct(s) while you are waiting
- Return to the original duct and increase the pressure to 75 psi
- Check for gout flow at the outlet
- Hold pressure at 75 psi for one minute

If the 75 psi pressure cannot be held then:

- Thoroughly flush the ducts and blow the water out with oil-free compressed air
- Immediately refill with fresh grout
- Check for grout flow at the outlet
- Pressure test again

If these procedures fail to seal the leak or if there is a rapid drop in pressure, the contractor has no alternative but to find the leak through air or water testing and physically repair the leak.

Judgment needs to be used when trying to seal leaks through the grouting process. General principles to keep in mind are:

- The grout must always be able to flow through the outlet before pressure testing; this indicates that the grout has not set in the ducts and there are no voids or blockages.
- Leaking between ducts can happen, pressurizing one duct may force grout into an adjacent, yet-to-be grouted duct or into an open, leaky duct you are trying to fix.
- Large cracks and holes cannot be sealed during the grouting process, no matter how hard the contractor tries
- Pressurizing the grout reduces its set time, so does increasing the temperature
- Don’t ever allow the grout to set up in the ducts before passing the pressure test
- When in doubt, flush the grout out

Grouting Curves

A great deal of useful and oftentimes critical information can be obtained by monitoring the grout pressure gauge and analyzing the information, see Exhibit 602-3.07-1. Grout injection time and the length of duct filled with grout are interrelated and are dependent on two constants: the duct void volume and the pumping rate, see the formula in Exhibit 602-3.07-1. During pumping, grout will conform to known principles of hydraulics.

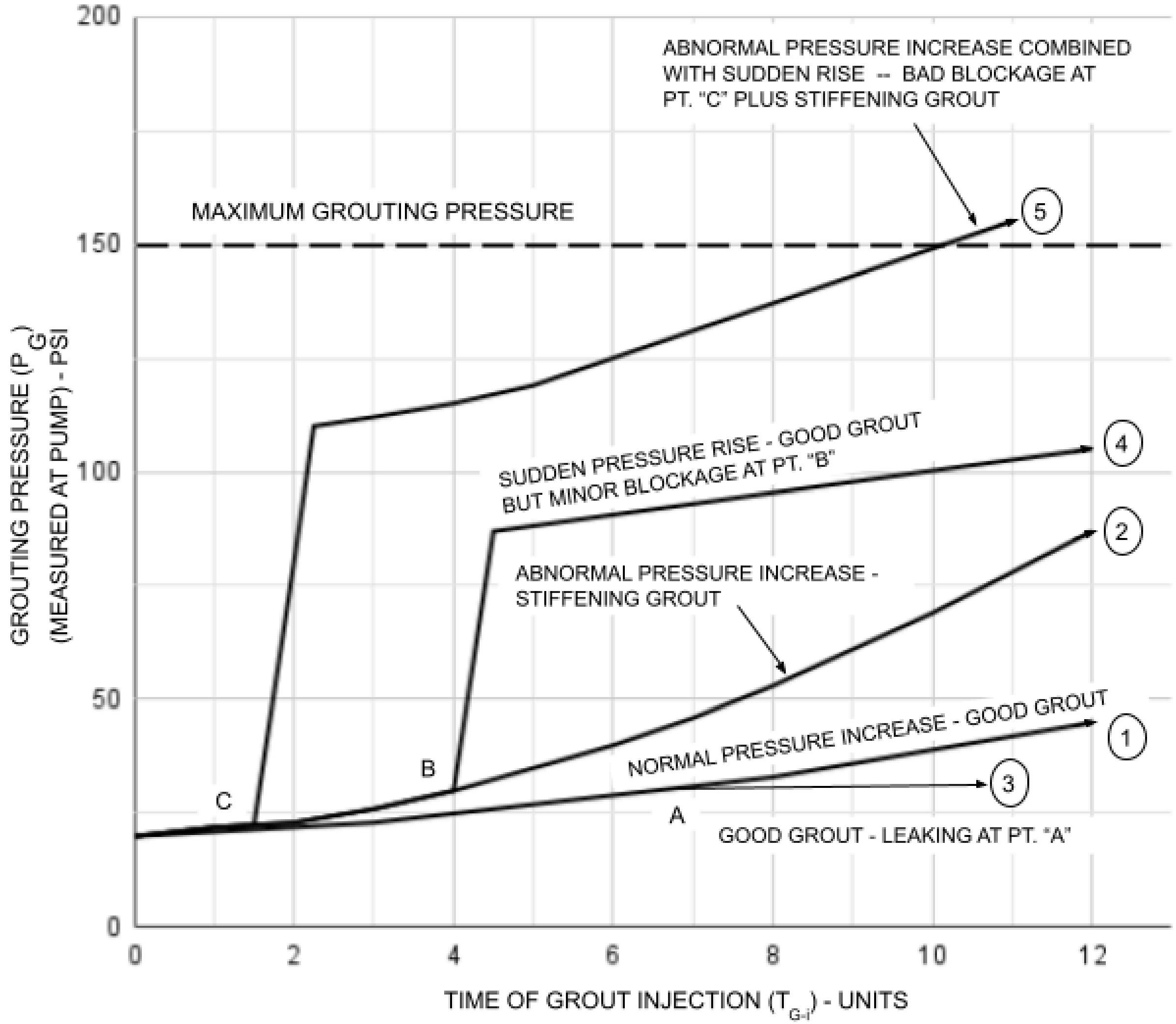
Good grout will exhibit a gradual increase in pumping pressure due to:

- Friction in the duct
- Any head which exists
- Normal stiffening, see Curve 1 in Exhibit 602-3.07-1

A grout that tends to flash-set in the duct will still exhibit a gradually increasing pressure but at a greater rate, see Curve 2. A constant pressure as shown in Curve 3 will indicate a hole in the duct, which allows grout to leak. A minor blockage will be indicated by a sudden jump in pressure followed by a continued gradual increase as shown in Curve 4.

It should be determined whether:

- The entire duct can be filled without exceeding maximum recommended pressure
- Grouting should be transferred to a vent
- Grouting should be discontinued, the duct immediately flushed, and the blockage repaired



NOTE: GROUTED DUCT LENGTH AND GROUT INJECTION TIME HAVE FOLLOWING RELATIONSHIP:

$$T_{G\text{-}i} = \frac{V_V \times L}{C_p} \quad \text{OR} \quad L = \frac{T_{G\text{-}i} \times C_p}{V_V}$$

WHERE:

$T_{G\text{-}i}$ = GROUT INJECTION TIME (MINUTES)

V_V = DUCT VOID VOLUME (FT^3/FT)

C_p = RATE OF GROUT PUMP (FT^3/MINUTE)

L = LENGTH OF DUCT FILLED WITH GROUT (FT)

Exhibit 602-3.07-1 Grout Injection Time Graph

A bad blockage, possibly combined with stiffening grout, would be indicated by a large jump in the pressure curve as shown in Curve 5. As illustrated in Curve 5, there is nothing to be gained by allowing pressure to build up and hoping that a miracle will happen. Grouting should be stopped at a low pressure so the grout can be flushed out easily.

Successful grouting of one or more tendons will establish the normal pressure versus time relationship. Thus, any abnormal conditions existing in other tendons can be detected.

The valves and grout caps shall not be opened or removed until the grout has set. Usually caps and valves can be removed the morning following grouting operations.

602-4 & 5 Method of Measurement & Basis of Payment

Prestressed concrete is considered part of the lump sum structure payment and no separate measurements or payments are made for this work. A sub-item under the lump sum structure item is listed in the bidding schedule for precast girders or for prestressing cast-in-place concrete. The sub-items exist for partial payment purposes only.

603 PILING

603-1 Description

Piles are rarely used for ADOT bridges and other major structures. ADOT does use pilings for temporary bridges for projects. Drilled shafts are usually the preferred foundation. The rocky and cemented soils of Arizona are not conducive to deep pile driving. In addition, slender driven piles are not the preferred foundation by many ADOT Bridge Designers due to the severe scouring that occurs in many of our waterways. However, driven piles do have a place as a deep foundation for some ADOT structures. When soil and scour conditions are favorable, piles are a very economical alternative to drilled shafts.

This section covers only pile driving and inspection at its basic level. The FHWA has excellent manuals on piling that the Resident Engineer and inspector should read in advance of any pile driving operation. The Manual on Design and Construction of Driven Pile Foundations, referenced at the end of this chapter, is particularly informative and helpful.

What are piles?

A pile is a long slender column usually made of steel, reinforced concrete, or wood that is driven into the ground. The pile transmits loads by the frictional resistance developed between the side surface of the pile and the adjacent soil by direct bearing of the pile tip on bedrock, very hard soil or by a combination of the two.

For example, if you drive a stake into the ground deep enough so that it can support your weight when you stand on it, you have a pile. You may only use a 5-pound hammer to drive the stake but the stake can carry much more than the weight of the hammer when a weight (or load) is placed at rest on top of the stake. You may be able to drive the stake further into the ground by jumping up and down on the stake but in reality, the loads placed on piles are static and do not impact the top of the pile, except during earthquakes.

Piles are used when a deep foundation for a structure is needed. Deep foundations are usually required when the soils near the surface are not strong or stable enough to support the weight of and the loads placed on a structure. Piles are also used to support a structure when there is a chance the soil, directly underneath a structure, would become loose or would wash away even though the soil could support the structure. Piles are usually placed in groups. Piling simply refers to a group of piles.

It is useful for the inspector and Resident Engineer to know whether the piles used on the project are friction piles or bearing piles (some piles are a combination of the two) and what soil layers the pile are expected to be driven through. Friction piles rely on the residual friction developed between a driven pile and the adjacent soil to transmit loads from the pile to the soil. The friction is developed along the side surface of the pile. End-bearing piles are designed to transmit the loads carried by the pile to bedrock or hard soil strata. Although there may be friction developed between the pile and the adjacent soil, this friction is not relied upon. It is the layer of rock or hard soil at the pile tip that is expected to carry the loads.

Problems often occur during pile driving, the knowledge of how the piles are intended to function can be very helpful when different solutions are considered. The Project Geotechnical Engineer can provide more information on piling design characteristics and soil conditions intended for the piles.

Test Piling

When test piles are required, the test piles must be driven in the exact location required for piling in the completed structure. The driving must be done in the same manner and utilizing the same equipment as specified for driving the piling for the structure. The test piles must be marked off in 1-foot intervals in order that a complete log may be kept on the driving of the test pile.

This log should record:

- The date the pile was driven
- Location
- Time required for driving
- Information on hammer blows per marked foot of penetration into the ground
- Penetration obtained during the last ten blows

After the test piles are driven, the information should be forwarded to the Geotechnical Engineer for review.

When no test piling is required, the Resident Engineer shall review the driving results of the first two to three piles as to penetration, bearing value, and pile length. Any differences from plan requirements should be reported to the Geotechnical Engineer and the Bridge Designer as soon as possible.

603-2 Materials

Piles can be made of structural steel, pressure treated timber, hollow steel casing, reinforced concrete, or prestressed concrete. The most common type of pile is the steel H-pile. H-piles, like other steel piles, require certificates of analysis showing the test results for yield strength and ultimate strength.

Dimensions for steel H-piles can be found in the Steel Construction Manual referenced at the end of this chapter. In addition to checking the size of the H-pile, the inspector should ensure that the correct grade and yield strength of steel is used. Some piles, especially those designed for end bearing, are limited in load carrying capacity by the yield strength of the steel. Thus it is imperative that the correct grade of steel is used.

Excavation and Embankment Materials

Subsection 203-5.03(A) requires that the contractor excavate down to the top of the piling elevation before driving the pile. Driving a pile and then excavating around the piles is not an acceptable procedure. The risk of the excavating equipment accidentally hitting a pile and loosening or damaging it must be avoided.

When backfill material is used around metal piles, it must meet the structure backfill requirements of Subsection 203-5.03(B)(1). This specification requires, among other things, a resistivity of at least 2,000 ohm-centimeters to prevent corrosion of the metal pile.

In an embankment situation where metal piles are driven through an existing embankment, Subsection 203-10.02 requires the embankment material within 10 feet of the pile to have resistivity and pH value similar to structure backfill. The avoidance of corrosion is the goal here as well. Most long-term corrosion in metal piles comes from fill materials (like structure backfill and embankment) that do not meet the minimum requirements for pH and resistivity. Rarely do undisturbed native soils cause corrosion problems with metal piles even when they have pH and resistivity values outside the required limits for backfill and embankment materials.

Embankment materials within 3 feet of the piling should not contain large rocks or debris that might damage the pile tip or prevent the driving of the pile, see Subsection 203-10.03[A].

603-3 Construction Requirements

Inspection Objectives

There are five basic requirements that the Resident Engineer and inspector should focus on during pile driving. By keeping the following objectives in mind both before and during piling driving, the Resident Engineer and inspector will achieve 99 percent of the requirements for a long-lasting, solid foundation.

1. Pile Location:

- Is each pile in the correct location?

- Are pile groups laid out correctly?
- Is the pile plumb and has the batter been checked?

2. Pile Material:

- Is the pile size correct?
- Is the material type correct?
- Is the material grade correct?

3. Pile Driving Equipment:

- Does the contractor’s pile driving equipment meet the specification requirements with the hammer developing the minimum energy needed to properly drive the pile? Check the equipment manufacturer specifications.

4. Pile Length

- Is each pile driven to the correct length?
- Was the tip elevation or an acceptable bearing value achieved?

5. Pile Bearing Values:

- Does each pile have the minimum required bearing capacity as calculated in Subsection 603-3.08 or by an approved wave equation analysis?

Pile driving contractors measure their productivity based on the number of feet of pile driven each day. Once a pile driving operation begins, contractors are reluctant to stop. As a result, it is strongly suggested that the Resident Engineer hold a pre-activity meeting for pile driving with the contractor so that much of the equipment and materials approvals are acquired long before a single pile is driven. Discussions at the meeting should include:

- The contractor’s pile driving procedure
- Safety and hearing protection requirements
- Measurement and payment procedures
- How bearing values will be determined
- Splicing and welding procedures
- Inspection activities as they impact the contractor’s production
- Potential problem areas during pile driving and possible solutions
- How the Geotechnical Engineer should be involved in resolving pile driving problems
- A streamlined process for resolving piling driving issues as soon as they arise

The idea is to anticipate any problem areas and resolve them before they become issues at the job site.

Meeting ahead of time to fully discuss the expectations and potential problems associated with pile driving is one of the most important activities a Resident Engineer can do to ensure a successful pile driving operation.

603-3.03 Equipment

Pile driving equipment should be thoroughly checked as soon as the contractor delivers it to the job. In checking the contractor's equipment, the inspector and pile driving foreperson should see that:

1. The equipment proposed for use meets the requirements of the job
2. The leads are sturdy, smooth, and straight
3. The hammer falls freely in the leads
4. The blocks in the driving head of the hammer are not badly worn

Inspecting the hammer is very important since it is the most essential piece of equipment of the pile driving operation. The hammer must operate properly so that it delivers its rated energy to the pile. If the hammer does not, then the inspector's estimation of the pile bearing value will be virtually meaningless.

The Performance of Piling Driving Systems: Inspection Manual cited at the end of this chapter contains the forms and lists the procedures necessary for inspecting pile-driving hammers. You will need the contractor's assistance when inspecting the hammer, so it is advisable to schedule this inspection during equipment set-up procedures.

603-3.04 Driving Piles

Embankments

Subsection 603-3.04(A) requires all embankments to be constructed in the area of piling before the contractor drives any pile. For example, the embankment for a bridge approach should be constructed up to the top of the berm, see Standard Drawing B-19.40. The contractor may have to excavate back down to the top of pile elevation in order to drive the piles.

On some projects the contractor may propose to build the embankment to some point at or below the top of pile elevation, drive the piles, and then build the rest of the embankment. This is not the correct procedure because building embankment after pile driving will cause surcharge loading and down drag on the piling. Material placed adjacent to and above the piling will induce lateral and vertical loads not accounted for in the design of the piles.

Driving

Piles should be marked in 1-foot intervals to track the driving depth before being placed in the leads. Care shall be taken to see that each pile is driven in a vertical position except in cases where battered piles are specified. After the pile is placed in position and plumbed, a few strokes of the hammer should be made to settle the pile. The pile should be checked again to see if it is plumb and blocked firmly in the leads before actual driving starts.

Frequently obstructions are encountered which deflect the pile. If the pile becomes seriously out of line it may have to be pulled and re-driven. As a last resort, the pile location can be moved with the approval of the Bridge Designer.

Piles are either driven to:

- A specified tip elevation, regardless of bearing value
- A minimum bearing value, regardless of tip elevation
- A minimum specified tip elevation with a minimum bearing value

The Project Plans will specify which of these conditions the piles must meet. Of course the inspector's job is to determine which of these conditions applies and then ensure that each pile meets the applicable condition.

Another duty of the inspector is to verify that soil conditions are the same as that shown in the Project Plans or the soils report for the project. This can be done by comparing blow counts shown on the boring logs with actual blow counts for the piles at a given tip elevation. The idea is to compare differences in blow counts as the pile advances to identify the soft and hard soils layers shown on the boring logs. If the inspector notices significant differences or inconsistencies in the pile blow counts, when compared to the boring log, then the Geotechnical Engineer should be notified. This verification does not need to be done on every pile, but should be done for at least one pile in each pile group.

If the piling cannot be driven to the minimum bearing or tip elevation shown on the Project Plans, the Resident Engineer should immediately notify the Geotechnical Engineer of the condition and must not allow the contractor to cut off such piling unless authorization to do so is obtained from the Bridge Group. Often a study of all available information may require the contractor to use jetting, drilling equipment, or other methods in order to reach minimum penetration.

Before a driven pile is cut, the Resident Engineer and inspector, along with the piling driving foreperson, should verify that the pile would be cut to the correct top of pile elevation. Piling is usually covered with a concrete pile cap with the pile extending part way into the cap. The inspector should ensure that the pile penetrates into the pile cap for the prescribed length shown in the Project Plans before the pile is cut.

603-3.05 Pile Splices

When piles are to be spliced, the Project Plans will show a splicing detail. Steel H-piles (the most common metal pile) are usually butt spliced with the pile still in the leads. Any welding done on a metal pile must be done by an AWS certified welder.

If a splicing detail is not shown on the Project Plans then Bridge Group should be involved in approving any splicing detail.

Pile driving contractors should order their pile lengths and plan their pile driving sequence in order to minimize the amount of splicing that needs to be done. It is suggested that the Project Supervisor meet with the pile driving contractor before piles are ordered to go over lengths and pile driving sequence with the intent of minimizing cut-off waste and unnecessary splicing.

603-3.06 Pile Cutoff (Waste)

Cut-off waste that remains at the end of a pile driving operation is the property of the Department unless that quantity is deducted from the furnished pile bid item. The cut-off waste may be incorporated into the project elsewhere or salvaged by a Department of Administration (DOA) authorized salvage contractor. The DOA Surplus Property Section can be contacted at (602) 542-5701 for further information. The contractor may purchase the cut-off waste through a supplemental agreement.

603-3.08 Determination of Bearing Values

The inspector, with the assistance of the Resident Engineer, must determine the bearing value for each pile. This must be done as each pile is driven and before the pile is cut. Bearing values are determined by measuring the pile penetration per blow for the last 1 foot of pile driving. Table 603-1, in Subsection 603-3.08 of the Standard Specifications, is used to calculate the bearing value. Penetration readings and blow counts must be carefully recorded in the pile driving records discussed in Subsection 603-4 of this manual.

When a wave equation analysis is used to determine bearing values, the Resident Engineer should consult with the Geotechnical Engineer about acceptable bearing values. The inspector must monitor the contractor's dynamic monitoring equipment for acceptable readings when bearing is reached.

603-4 Method of Measurement

Pile Driving Records

Pile driving records consist of the Pile Record Book and Pile Summary Sheet.

The Pile Record Book is a bound field book that contains a pile location plan, hammer data, a pile driving log for each pile, an inventory record of pile cutoff, and any other information gathered or measured in the field related to pile driving. Exhibit 603-4-1 (a through f) illustrates how a piling book should be organized.

Pile Record Books are part of the project as-built plans and should accompany them when forwarded to ADOT's Project Management Section. Bridge Group uses the Pile Record Book to complete a bearing pile record sheet for their Bridge Management Section. This sheet is used for trouble-shooting future bridge foundation problems.

The Pile Record Summary Sheet is a recap of the piling quantities used for each structure for payment purposes, see blank forms. The inspector prepares the sheet after all pile driving is completed for a structure and should be checked by the Resident Engineer.

EXAMPLE:

PILING RECORD BOOK COVER AND PAGE 1

EXHIBIT NO. A

PROJECT I-8-3 (71)	Project Number
YUMA-CASA GRANDE HWY.	Project Name
PILE RECORD BOOK	Book Title
JOHNSON WASH BRIDGE	Name of Structure
Sta. 1800+	Location
John Doe ~ Resident Engr.	Project Engineer and Title
Date: March, 1983	Date piling items were completed.
BOOK 1 OF 2 BOOKS.	Book Number

Exhibit 603-4-1a Piling Record Book

INDEX and INSPECTOR

Example:

INDEX

LOCATION	PAGE
Abutment #1	3 - 10
Pier #1	11 - 20
Pier #2	21 - 30
Abutment #2	31 - 37
Recapitulation	38
Inventory	39

Inspector:	J. D. Brown
Transitman:	P. O. Blue
Chainman:	A. C. Gray

Exhibit 603-4-1b Piling Record Book

PILE LOCATION, TYPE, PLANS LENGTH

a. Batter Pile are indicated by crossed circle. Show cosine of batter to compute elevations.

EXAMPLE

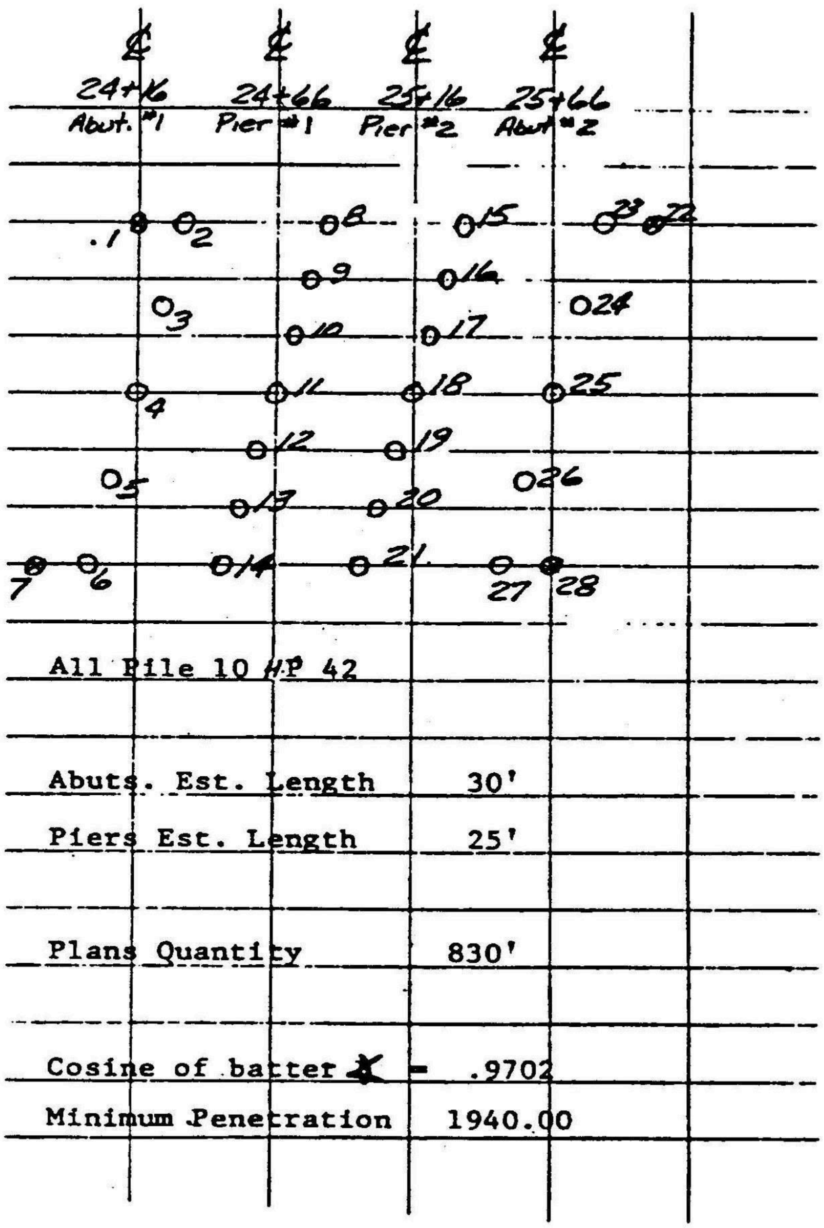


Exhibit 603-4-1c Piling Record Book

HAMMER DATA

a. When loading tests are required, the method of testing shall be as specified in the Special Provisions or Standard Specifications.

b. The Hammer Data to be entered in the field book should be for only the hammer used in driving. Should more than one hammer be used, indicate for which pile each was used.

c. For bearing formulas, see below.

EXAMPLE

HAMMER DATA

Type	-	Single Action
Make	-	Vulcan
Weight of Ram	-	5000#
Stroke	-	3'

Formula = $P = \frac{2\ wh}{S + 0.1}$

Bearing = $\frac{2\ (5000 \times 3)}{S + 0.1}$

P = safe allowable bearing in pounds

W = weight of hammer in pounds

H = fall of hammer in feet

S = average penetration in inches per blow for the last 10 blows

A = effective area of piston in square inches

p = mean effective pressure in psi

E = manufactures energy rating in foot-lbs. per blow

For the Metric Bearing Formulas, See Table 601-3 of the Standard Specifications

Type of Pile	Type of Hammer	Formula
Timber and Steel	Drop	$P = \frac{2WH}{S+1.0}$
Timber, Steel and Metal Shells for Cast-in-Place Concrete	Single-Acting Steam or Air, or Diesel	$P = \frac{2WH}{S+0.1}$
	Double-Acting Steam or Air	$P = \frac{2H(W+Ap)}{S+0.1}$ $P = \frac{2E}{S+0.1}$
Precast Concrete	Single-Acting Steam or Air, or Diesel	$P = \frac{2WH}{S+0.1}$
	Double-Acting Steam or Air	$P = \frac{2H(W+Ap)}{S+0.1}$ $P = \frac{2E}{S+0.1}$

Exhibit 603-4-1d Piling Record Book

EXAMPLE

Piling Book Entries

DATE 2-4-83	PILE NO. 21 (BATTER)				LAST 10
TIME	NO. BLOWS	PEN. IN FEET	NO. BLOWS	PEN. IN FEET	BLOWS
		0	37	24	4 1/4"
			40	25	S: 4.25/10
DRILL			40	26	S= .42
9:25	10	11			
	12	12			Bearing
	11	13			56.9
	10	14			Tons
	11	15			
	12	16			
	15	17			
	14	18			
	16	19			
	21	20			
	22	21			
	27	22			
	30	23			

LENGTH OF PILE BEFORE SPLICE	25.2
LENGTH OF SPLICE - FROM STOCK	2.2
TOTAL LENGTH OF PILE AFTER SPLICE	27.4
TOTAL LENGTH OF PILE BEFORE CUTOFF	27.4
LENGTH OF CUTOFF - TO CONTR	0.7
LENGTH OF PILE IN PLACE	26.7
ELEVATION OF PILE CUTOFF	1029.35
LENGTH OF PILE BELOW CUTOFF	26.34
ELEVATION OF PILE POINT	1003.01

HEAT No. 13697

26.7 Cos ∢ .9864 = 26.34

INSPECTOR: W. F. R.

NOTE: Rubber stamps for formats are available from Field Reports Services

Exhibit 603-4-1e Piling Record Book

CUTOFF INVENTORY

Example
(Theoretical)

(OPTIONAL)

38 (page number)

	CUTOFF INVENTORY				
	From	In Yard	Contr. Use	Waste	Total
Abut #1	Pile #1	2.00	.67		2.67
	2	—	.50		.50
	3	5.50			5.50
	4	4.25			4.25
	5	5.17			5.17
	6	10.00		.33	10.33
	7	1.83			1.83
	8	1.00		.50	1.50
	9	3.17			3.17
	10	6.00	2.80		8.80
	11	3.50		.50	4.00
	12	1.50		.17	1.67
		Total cutoff		-	49.39
		Contr. Use		-	3.97 (not payable)
		Waste	-	-	1.50 (not payable)
		Piling on hand		-	43.92

Exhibit 603-4-1f Piling Record Book

603-4.01 Furnishing Piles

- Measure the quantities delivered to the project site or designated storage area; the quantity should not exceed lengths specified in the Project Plans unless approved by the Resident Engineer.
- Record the lengths in the Pile Record Book.

Cast-in-place pile quantities are equal to the actual driven amount only since any cut-off sections are usually unusable, see Subsection 603-4.01 of the Standard Specifications.

The quantities of furnished pile may be reduced by the inspector due to:

- Pieces wasted through mishandling by the contractor.
- Pieces used by the contractor for convenience or construction aids, e.g. splice plates.
- Pieces used for other structures or for other projects.
- Lengths in excess of those specified unless ordered or approved by the Department in advance.

The length of unused steel piling or metal shells on hand, which are to be purchased by the Department, should be documented in the Pile Record Book and Pile Summary Sheet.

603-4.02 Driving Piles

- Measure the actual length driven in meters and record in the Pile Driving Book.
- Track the number of blows per 1 foot (300 millimeters) and the penetration depth for the last five to twenty blows depending on the hammer type, see Standard Specification Table 603-1.
- Compute bearing values for each pile.
- Record all this information in the Pile Record Book. Include hammer information and any computations.

If pile load testing is performed for the structure, record the results in the Pile Record Book and sign the book.

603-4.03 Splicing Piles

Record the number of splices in the Pile Record Book and pay at the contract unit price. If there is no unit price then refer to Subsection 603-5.04.

The quantity of pile splices may be reduced when splices are made:

- For the contractor’s convenience, e.g. splicing lengths less than those ordered by the Resident Engineer to make a specified length of pile
- To correct the contractor errors in cutoff elevation.

The Department will pay for additional splices when they are used to keep the quantity of unused pile down to a minimum.

604 STEEL STRUCTURES

604-1 Description

The most common steel structures found on ADOT projects are sign structures, sign posts, light and traffic signal poles, handrails, cattle guards, underdrains, and steel piling. Although these are all steel structures, only underdrains, sign structures, poles, and cattle guards refer to Section 604 for additional specification requirements.

Steel bridges are less common on ADOT projects, but do fall under this specification when they are built.

Field inspection of steel structures is a straightforward process when compared to reinforced concrete structures. With reinforced concrete, the structure is built from scratch. The contractor must build forms to shape the structure and very little off-site fabrication is done except when precast members are used. On the other hand, much prefabrication and pre-assembly is done with steel construction. The steel is made and shaped in a steel mill. A steel fabricator cuts, punches, bends, and welds the basic steel shapes from the mill to form each member of the structure. The fabricator may even assemble part of the steel structure in the shop before shipping. By the time the components of the structure arrive on the job site, most of the fabrication work has been done. All that is left for the inspector and Resident Engineer is to oversee the erection and final assembly.

Erection and final assembly inspection basically involves making sure the contractor follows the requirements in the approved shop drawings and the specifications. The shop drawings will show how each part of the structure is to be connected together, which parts are to be used, what specs they must meet, and what order the parts are to be assembled.

Good inspection of steel structure construction involves:

- Ensuring that all the steel and steel parts delivered are the correct type and grade specified, e.g. steel plates and members are usually ASTM A36 steel, high strength bolts are the A325 type. This involves checking the Project Plans, shop drawings, the markings on the steel, and checking the paperwork that accompanies each steel shipment.
- Verifying that each component has the correct dimension as shown on the approved shop drawings or required by the specifications. The sections on standard mill practices and structural shapes in the Manual of Steel Construction are excellent guides, see the references at the end of this chapter.
- Ensuring that the structure is erected and assembled in strict accordance with the procedures described in the approved shop drawings, the Special Provisions and the Standard Specification. When material is delivered to the project an inspector should ensure that no steel components are bent, over-stressed, cut by acetylene torch,
- Holes for connections are punched or drilled, never cut in with an acetylene torch or otherwise altered or slotted in an attempt to expedite the erection procedures; unless such alterations are approved by the Structure Designer or ADOT Bridge Group. This approval should be documented through the project's RFI process. Monitoring the erection process for safety and structural stability is very important.
- Paying close attention to how connections are made in steel construction, connections are defined as the method by which two or more steel members are joined. Connections are either welded, bolted, or pinned. In assembling a steel structure, the inspector must ensure proper connection installation. Most steel structures are designed to fail in the steel members where the steel will yield and warn people of the danger; breakaway posts are the exception. Failures in a connection are highly undesirable. They are usually sudden and without warning. Proper inspection of field connections by the inspector will help to ensure that the structure will behave safely and predictably when placed in service.

These are the overall goals for the inspection of steel structures. The rest of this section describes in more detailed structural steel inspection procedures and the underlying engineering objectives.

604-2 Materials

604-2.01 Structural Steel

ADOT steel structures are made of high-grade carbon steel (usually “A36” steel). This kind of steel is stronger and more ductile than the steel found in more common items such as refrigerators and filing cabinets. A36 steel will yield (stretch) considerably before breaking, warning people that the structure is about to fail.

This type of safety mechanism will only work if the right kind of steel is supplied to the project. The inspector must examine all steel members, plates, bolts, nuts, washers, and other hardware for:

- Shipping documents that accurately identify the quantities, shapes, and type of steel shipped.
- Certificate of Analyses that are complete and descriptive of the materials supplied including grade identification, test results, and the applicable lot number/heat number.
- The appropriate markings which would show the type and grade of steel used, however, not all structural steel is marked.
- Compliance with key dimensional requirements such as thickness, length, width, diameter, and section shape.

Steel structures are most likely to fail if the wrong materials are used. This is why it is important for the inspector to verify that only the proper materials, i.e. correct grade, shape and size, are supplied.

604-2.03 High-Strength Bolts, Nuts and Washers

In this section, high-strength bolts and high-strength bolted connections will be discussed. Bolted connections are the most common type of field connection. Careful inspection of bolted connections will help ensure that they do not become the weakest link in a structure.

The AASHTO guidelines require a bolting inspector to be experienced in structural steel bridge fabrication, erection, and/or inspection, and be directly involved with structural bolting operations. Proof of the aforementioned requirements can be satisfied by providing a certification stating that they have successfully completed an 8 hour training course offered by an organization or an individual recognized by ADOT. The training and certification documentation requirements are outlined in sections 4.1 and 4.2 of the AASHTO Guidelines for the Qualification of Structural Bolting Inspectors.

Identifying and Sampling AASHTO and ASTM bolt types:

A307 and 1554 Grades 36 and 55 bolts are considered medium strength bolts ranging from 60 ksi to 100 ksi tensile strength. These bolt types are used for general purpose applications from holding up light fixtures to cattle guard assemblies. However, 1554 Grade 105 bolts are considered high strength bolts typically used in anchoring heavy structural supports to concrete foundations, columns, highway sign supports, street light poles, and machinery bases.

Bolt designation and tensile strength:

- A307A - 60ksi min
- A307B - 60 ksi min to 100 ksi max
- F1554:
  - Grade 36 - 58 ksi to 80 ksi
  - Grade 55 - 75 ksi to 95 ksi
  - Grade 105 - 125 ksi to 150 ksi

ASTM F3125/F3125M-23 Specification includes bolt designations: A325, A325M, A490, A490M, F1852 and F2280, with Types 1 and 3. These bolt types are heat treated and considered high strength bolts, ranging from 120 ksi to 173 ksi min tensile strength. These bolts are used for structural purpose applications where durability and stability are essential such as construction of bridges, buildings, pressurized pipes and other large structures.

The various bolt designations and types under this specification can be square or heavy hex-head driven type bolts and or tension-control (TC) driven type bolts. Square or hex headed bolts are driven (tightened) by securing the bolthead and driving the nut until the specified torque is achieved. TC bolts are round headed (button) and utilize a spline at the end of the threaded shank to secure and pretention the bolt during installation, the spline is thereby sheared off upon reaching the bolts specified torque requirement. Additionally, TC type bolts require specialized tooling referred to as a shear wrench that must be used during installation. The shear wrench utilizes an inner socket that rotates the spline clockwise and an outer socket that rotates the nut counterclockwise.

Bolt designation and tensile strength:

- A325 - 120 ksi min
- A325M - 120 ksi min
- F1852 - 120 ksi min
- F2280 - 150 ksi min
- A490 - 150 ksi min to 173 ksi max
- A490M - 150 ksi

Blot types include:

- Type 1 - 120 ksi - carbon steel, carbon boron steel, alloy steel, or alloy boron steel with boron addition
- Type 1 - 150 ksi - alloy steel or alloy steel with boron addition
- Type 3 - 120 ksi or 150 ksi weathering steel

ASTM standard F3148-17a(2024) specification covers F3148 bolts, which are a type of TC spline driven high strength bolt used for structural purpose applications where durability and stability is essential such as construction of bridges, buildings, and other large structures. However, unlike most TC type bolts, the F3148 spline does not shear off upon reaching its torque specification. Instead, the F3148 bolts are installed using a torque and angle method, where the spline remains attached to the bolt allowing for more precise tension control and eliminates the need to replace the bolt after the spline shears off. As with the aforementioned TC type bolts this will also require a proprietary specialty power wrench to be used during the installation process.

Bolt designation and tensile strength:

- F3148 - 144 ksi

Bolt types include:

- Type 1 - 144 ksi - carbon steel, carbon boron steel, alloy steel, or alloy boron steel with boron addition
- Type 3 - 144 ksi - weathering steel

With such a wide range of strengths, it is easy to see why it is so important to identify the type of bolt used in a connection. There have been documented cases in which the wrong type of bolt or an inferior counterfeit bolt had been used in a structural connection with devastating results.

The Commentary on Specifications for Structural Joints Using ASTM A325 or A490 Bolts found in the Manual of Steel Construction can provide information on how to identify high-strength bolts, nuts, and washers.

High-strength bolts need to be properly lubricated before being placed in a connection. The lubrication is necessary to limit the amount of friction developed between the bolt, the nut, the threads and the connection plates. Improper lubrication can cause the head of the bolt to be twisted off during torquing if too much friction develops.

Therefore, proper storage of bolts prior to and after being delivered to the project is crucial in protecting the factory-applied lubrication from drying, coagulating, or collecting dust prior to installation. Additionally, proper storage prevents corrosion, maintains mechanical properties, and ensures a bolt can withstand the intended loads in critical applications. Excessive exposure to moisture, dirt, or extreme temperatures can significantly degrade a bolts strength and reliability, potentially leading to structural failure if used in a compromised condition; essentially, proper storage helps to guarantee the bolts structural integrity.

Inspectors should sample bolts, nuts, and washers in accordance with the Sampling Guide and deliver them to Materials Group for testing. Make sure the contractor orders extra hardware so the correct number of samples can be taken without leaving the project short. Samples should be obtained at random, from the delivered stockpile onsite, by the ADOT field inspector. Designated samples provided by the contractor or manufacturer should not be permitted.

Understanding Bolted Connections

A structural connection transfers loads from one structural component to another. Bolted connections consist of plates, bolts, nuts, and washers--they all play a part in transferring loads across the connection.

There are two types of bolted connections. Both look the same, only the function of the bolts changes. The first type is the bearing connection. Loads are transferred across the joint by shear stresses on the bolt and bearing stresses on the plates caused by the bolts. If the loads get too high, either the bolts will shear or the plates will rupture as the bolts tear out of their holes. When bearing-type connections are specified, the bolts only need to be snug tight to keep the bolt properly aligned and secure after installation.

The other type of connection is the slip-critical connection. Loads are transferred by means of friction between the plates and the structural members at the connection. The role of the bolts, nuts, and washers is to provide a clamping force between the connection plates and the structural members to prevent any sliding. This connection is designed to prevent any movement of the plates or bolts during normal loading conditions. Under extreme loading conditions and after slippage has occurred, the connection behaves just like a bearing-type connection. However the idea behind the slip-critical connection is to design the connection so it doesn’t slip. Loads are transferred only through friction. The bearing properties of the connection are used only as an added factor of safety. Connections where the bolts are placed in direct tension by the loads in the members also fall under the slip-critical category since the design and behavior of the connection are similar.

Slip-critical connections are used more often in highway structures than bearing-type connections because they more effectively handle stress reversals, impacts, vibrations and other extreme stress changes. Slip-critical connections are more efficient than bearing connections, as they require fewer bolts in the connection to carry the same load. Bearing connections are more prone to metal fatigue when they are subject to repetitive stress changes.

You can identify the type of bolted connection by checking the Project Plans or the shop drawings to determine how the bolts are to be tightened. If the bolts are specified to be snug tight, the connection is the bearing type. If the bolts are required to be tensioned, the connection is slip-critical.

Snug-Tight Bolts

The inspector must verify that all bolts in a bearing connection are snug tight. Even bolts in a slip-critical connection are to be in a snug-tight condition before tensioning. AASHTO paragraph 11.5.6.4.1 (from Section 11, Steel Structures, the inspector should have a copy) defines snug tight. Section C8 of the Commentary on Specifications for Structural Joints Using ASTM A325 or A490 Bolts in the Manual of Steel Construction is helpful in determining when a bolt is snug tight.

If the bolt length is long enough, snug-tight bolts should contain two nuts with the second following the first (double nutting). If the bolt is not long enough to allow for double nutting, it is common practice to score the exposed threads with a hammer or cold chisel. This prevents the primary nut from loosening after the bolt has been snugged tight.

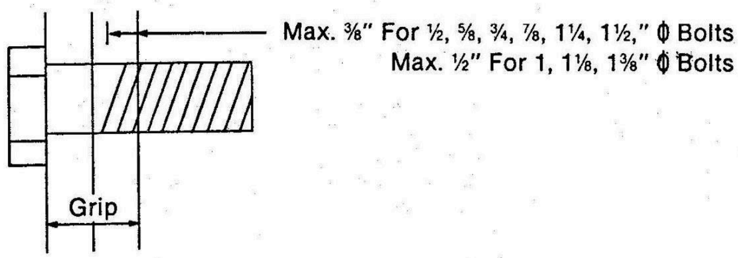
Bolts are always tightened and tensioned from the most rigid (stiffest) part of the connection to free edges. Most rigid is usually defined as the thickest or stiffest part of the connection or the interior of the connection. Check with the Resident Engineer if you are unsure where to start tightening.

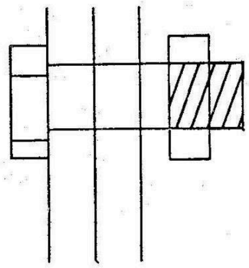
Bolt and Thread Lengths

Bolted connections are much stronger when the threaded portion of the bolt shaft is kept out of the grip, which is defined as the connection plates and the adjoining structural members. For this reason, limits are placed on how far the threads can penetrate into the grip (see Exhibit 604-2.03-3). On the other hand, if the thread is too far out of the grip, the nut may run out of thread before the bolt is properly tightened. Washers can be added to remedy this situation. If washers are used, the bolt length should be increased in 5/32-inch increments for flat washers and 1/4-inch increments for beveled washers. The bolt lengths determined by the above procedure should then be increased to the next greater 1/4-inch increment. These lengths allow for manufacturer's tolerances and will provide an adequate length of bolt protrusion through the nut, see Exhibit 604-2.03-3 for calculating bolt lengths.

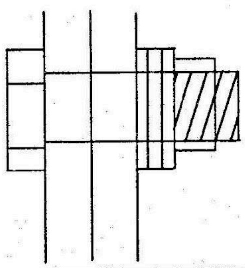
The inspector must check each bolt in a connection to verify these conditions are satisfied. The inspector should also check the bolt length to ensure that at least two threads are exposed after all the washers and the nut or double nuts have been added.

DETERMINING CORRECT BOLT LENGTH





Guard against condition where nut runs out of thread



Add circular washers as needed to prevent stopping run of the nut
There must be enough thread for a full nut

Bolt Size, in Inches	To determine required bolt length add to grip, in inches
½	11/16
⅝	⅞
¾	1
⅞	1⅛
1	1¼
1⅛	1½
1¼	1⅝
1⅜	1¾
1½	1⅞

TO DETERMINE CORRECT BOLT LENGTH

- Use the table to determine the bolt length then take the next ¼ inch increment.
- Check that the thread does not protrude more than the specified amount into the connected members.
- Check that the nut will not run out of thread (use the dimensions in Exhibit B)
- Check that the bolt will protrude from the nut.

Exhibit 604-2.03-3 Determining Correct Bolt Length

Tensioning Bolted Connections

For slip-critical connections, the bolts are tensioned to at least 70 percent of their allowable tensile strength. This provides the clamping force needed to keep the connection plates from sliding. The inspector must closely monitor and document this process. At least 10 percent of the bolts in a connection should be checked by the inspector for proper tensioning. If one bolt fails, the entire connection should be re-tightened and the checking process repeated.

Tightening can be done with a manual torque wrench or a power impact wrench. Over-tightening up to 85 percent of allowable strength is acceptable.

The Project Plans or shop drawings will specify which bolts are to be tensioned. Bolts that are not specified to be tensioned should be snug tight. The inspector should not allow the tensioning of bolts unless specified. For example, anchor bolts embedded in concrete foundations and bolts on breakaway-type base plates are never tensioned.

When tensioning is specified, AASHTO Subsection 11.5.6.4 allows four methods for bolt tensioning. The Bridge Designer may override AASHTO and permit only one or two of the tensioning methods, see the Project Plans for clarification.

1. **Turn-of-Nut Tightening**

   Basically the turn-of-nut method requires the nut to be tightened a certain number of turns after a snug-tight condition is reached in the bolt. The number of turns needed to tension the bolt depends upon the length of the bolt, the slope of the outer faces of the connection plates or structural members, and the type of washers used, see Exhibit 604-2.03-4. AASHTO specifications require the contractor to prove that this method will develop the required tension by testing the bolt and nut assembly in a direct tensioning measuring device such as the Skidmore-Wilhelm Calibrator discussed later in this subsection.

2. **Calibrated Wrench Tightening**

   This method uses a torque wrench to determine the amount of tensioning in a bolt. The method assumes that the amount of tension in a bolt is directly related to the amount of torque it takes to turn the bolt. In practice however, friction can develop between the nut and the bolt greatly increasing the amount of torque needed to achieve a given tension. This friction is dependent on temperature, moisture, and the cleanliness of the bolts. For the last few years this type of tensioning was not allowed by AASHTO. However this method is allowed again but with some stipulations.

   The first stipulation is the requirement for daily calibration of the torque wrench in a direct tension calibrator. The second is the use of only hardened washers. The third stipulation is the protection of the nuts, bolts, and washers from dirt and moisture. This last requirement has probably the greatest effect on consistent tensioning of the bolts by this method. Dirty and even slightly rusty bolts greatly affect the amount of torque needed to develop a given tension in a bolt. This method of tensioning is much more inspection intensive, requiring very careful monitoring and documentation by the inspector.

TURN-OF-NUT TIGHTENING			
	Nut Rotation[1] From Snug Tight Condition		
Bolt Length: Measured from underside of head to extreme end of point	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)	Both faces sloped not mo than 1:20 from normal to bolt axis (bevel washers not used)
Up to and including 4 diameters	⅓ turn	½ turn	⅔ turn
over 4 diameters but not exceedin 8 diameters	½ turn	⅔ turn	⅚ turn
Over 8 diameters but not exceedin 12 diameters[2]	⅔ turn	⅚ turn	1 turn

[1]Nut rotation is relative to the bolt, regardless of the element (nut or bolt) being turned. For bolts installed by ½ tu and less, the tolerance should be ± 30°; for bolts installed be ⅔ turn and more, the tolerance should be ± 45°

[2]No research work has been performed by the Research Council on Riveted and Bolted Structural Joints to establi the turn-of-nut procedure when bolt lengths exceed 12 diameters. Therefore, the required rotation must determined by actual tests in a suitable tension device simulating the actual conditions.

Exhibit 604-2.03-4 Turn-of-Nut Tightening

3. **Installation of Alternate Design Bolts**

   This method is just a variation of the second method. It uses a breakable splined adapter that grips the nuts and breaks off after a certain torque is reached. These fasteners must be properly stored and pre-tested in a direct tension calibrator before use.

4. **Direct Tension Indicator (DTI) Tightening**

   In this method, collapsible washers are used to indicate when a certain tension in the bolts is reached. The washers, which are placed under the head of the bolt, collapse when the bolt achieves a predetermined tension. This method is the most accurate for determining the tension in a bolt. However the washers should still be tested at the job site in a direct tension calibrator to demonstrate that they do collapse at the required tension. It is important for the inspector to ensure that the collapsible washers are installed in accordance with the manufacturer’s recommendations.

The commentary in Manual of Steel Construction and the FHWA publication called High Strength Bolts for Bridges provide more information on tensioning methods and inspection procedures. Their consultation is highly recommended.

Skidmore-Wilhelm Calibrator and Torque Wrenches

The Skidmore-Wilhelm Calibrator directly measures tension in a bolt. It is used to calibrate torque wrenches, verify tension in bolts tightened by the turn-of-nut method, and check the tension developed in a bolt when DTIs or alternate design bolts are used. Exhibit 604-2.03-5 shows the calibrator.

There should be a Skidmore-Wilhelm Calibrator on the project site when high-strength bolts are tensioned. The Phoenix Regional Lab has Skidmore-Wilhelm Calibrators that the field office can borrow. They also have torque wrenches available for use.

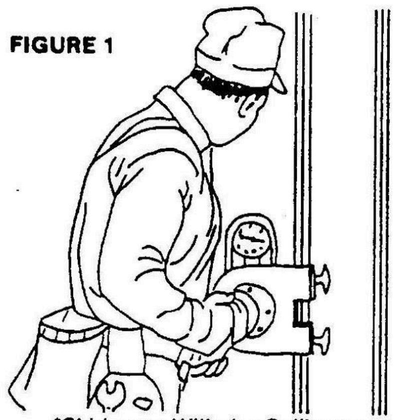
The field office is responsible for verifying that all Skidmore-Wilhelm Calibrators and torque wrenches are properly calibrated before use on the project. The Materials Group Annex (602-712-7741) can calibrate these instruments. It is permissible to use a calibrator or torque wrench supplied by the contractor as long as these devices have been calibrated within the last year by a recognized calibration service; contact the Materials Group Annex for verification of calibration service.

Calibration of Wrenches:

The impact wrenches shall be calibrated at the beginning of each working day and each time a new size or lot of bolts are used or there is a change in wrench connections such as hose, extensions or universal sockets. Three bolts of the same grade, size and condition as those being used shall be placed individually in the calibration device. There shall be a washer under the part turned in tightening each bolt. Figure 1 shows a method of calibrating a wrench.

Calibrate wrench on the job site, Illustrated is the method using a hydraulic tension calibrator* that records on a dial the tension of the bolt.

FIGURE 1



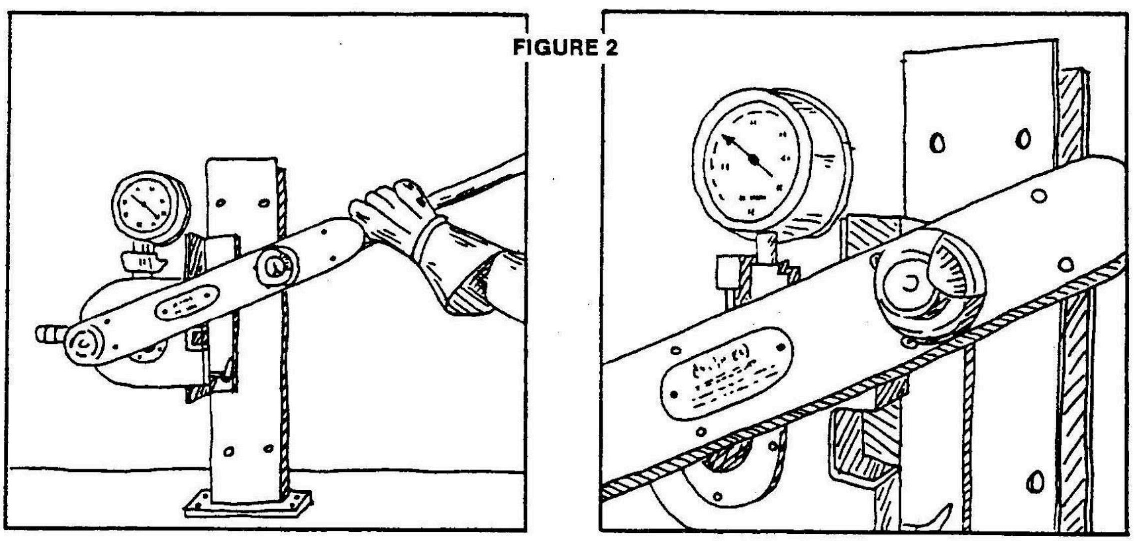
*Skidmore-Wilhelm Calibrator

a. Use same lot of fastener assemblies for testing that will be used on the job.
b. Use same length of hose and socket that will be used on the job.
c. Gage needle should be slightly **above** the required tension. Make enough checks so this reading is consistent. (Figure 3)
d. Change bolts with each check.
e. Replace equipment not reaching proper tension with larger equipment.

Calibration of Inspection Torque Wrench:

Figure 2 shows the operator calibrating a hand-indicator torque wrench. The bolt is brought to the proper tension in the calibrator. The dial on the wrench was set at "zero" and sufficient torque applied to slightly move the nut in the tightening direction. At this point, the wrench dial shows the foot-pounds required to further rotate the nut. This test should be made on at least three bolts of each lot and the torque figures averaged. This average may then be used for inspection of installed bolts of the same lot. The torque wrenches used by inspectors of both the erector and the State should be tested and compared at the same time for purposes of uniformity.

FIGURE 2



Bolt Diameter (inches)	Recommended Bolt Tension For Calibrating Wrenches in Kips		Required Minimum Bolt Tension in Kips		*Equivalent Torque For Minimum Bolt Tension in ft. lbs.	
	A325 Bolts	A490 Bolts	A325	A490	A325	A490
½	13.2	16.5	12	15	100	125
⅝	20.9	26.4	19	24	198	250
¾	30.8	38.5	28	35	350	438
⅞	42.9	53.9	39	49	570	716
1	56.1	70.4	51	64	852	1069
1⅛	61.6	88.0	56	80	1052	1503
1¼	78.1	112.2	71	102	1482	2130

Exhibit 604-2.03-5 Skidmore-Wilhelm Calibration

Documentation

Inspectors assigned to bolt tensioning should document:

- When and where hardware samples were taken for materials testing
- Which bolts or bolt groups were tensioned and the tensioning force that was achieved
- What method was used to achieve the required tension in the bolts, turn-of-nut, DTI’s, etc.
- The order in which the bolts were tensioned; a diagram may be useful in this instance
- Torque readings on all bolts if a torque wrench was used
- Any bolts that were tightened to only a snug-tight condition
- Any re-lubricating of bolts if ordered by the inspector or Resident Engineer
- How often the tensioning method was checked with the Skidmore-Wilhelm and what the results were
- Any corrective actions that were taken to properly assemble the bolted connection, like changing bolts lengths or hole reaming

Complete documentation of how bolted connections were constructed can become crucial if there is a failure of the structure later on. The documentation also shows that the inspector was actively involved in verifying tensioning of bolts and reduces the chance that any serious defects exist in the connection.

604-2.10 Certification of Structural Steel

Certifications for structural steel elements such as plates, steel members, nuts, bolts, and washers require additional information above and beyond what ADOT normally requires on a certification.

Certifications for structural steel are called Certificates of Analysis and require a regular Certificate of Compliance in addition to the following test results:

Structural Steel Shapes and Plates

- Chemical analysis, metallurgical composition
- Charpy V-notch test (CVN) for structural steel subject to tensile loading

High-Strength Bolts, Nuts, Washers

- Rotational capacity test
- Proof load test
- Zinc thickness test; when galvanized bolts are specified

The heat number of the steel covered by the Certificate of Analysis should be shown on the test results and on the Certificate of Compliance. The type and grade of steel must be shown on the Certificate of Compliance.

604-3 Construction Requirements

604-3.01 Shop and Working Drawings

Every steel structure, whether it be a sign structure, light pole, or bridge, requires shop and working drawings showing:

- How each steel member will be fabricated
- How each connection will be made and the details for making those connections
- How the structure will be erected and assembled

The shop drawings are intended to be a complete set of step-by-step fabrication and assembly instructions, not very different from the instructions included in a model airplane kit or furniture assembly box.

Complicated steel structures may include separate erection schemes and temporary shoring drawings, but these documents still fall under the requirements for shop and working drawings.

The steel fabricator is usually the one who prepares all the shop and working drawings for a steel structure.

Shop and Working Drawings Reviews

Like all shop and working drawings, the contractor needs to allow for sufficient review time of the shop drawings before scheduling fabrication, see Subsection 105.03. The Resident Engineer should do an initial review of all shop and working drawings as recommended in Subsection 105.03 of this manual. Then shop drawings should be forwarded to the Designer of the steel structure (either a design consultant or a design team within ADOT) for final review and approval.

Once approved, a copy of all shop and working drawings should be sent to the Bridge Project Manager for Steel Fabrication and Inspection in Bridge Group assigned to oversee the project. The Bridge Project Manager will forward approved drawings to the On Call Structural Steel Fabrication Inspection Consultant, who will oversee the shop fabrication of the steel structure for the Department. A copy should also be given to the inspector.

The fabricator's detailed shop and erection drawings, after approval by the Designer of the steel structure, become a part of the Project Plans and are used in place of the Project Plans insofar as fabrication and erection details are concerned. If the inspector or Resident Engineer finds something in the Project Plans contrary to what is shown in the approved shop and working drawings, the Designer of the steel structure should be called for clarification.

A PDF of the shop drawings must be included with the as-built plans for any bridge structures, refer to Subsection 105.03 Standard Specifications.

604-3.04 Shop Inspection

Subsections 604-3.02 and 604-3.04 require the contractor to make arrangements with the Department for shop inspections of structural steel components. Written notice can take the form of a shop drawing submittal, a letter if the shop drawings are not ready, or a note in the weekly meeting minutes. The key is to give adequate notice at least two months so Shop Inspectors can be scheduled for the work.

Bridge Group is responsible for all shop inspections of steel structures except for steel poles. They use on-call consultants to provide Shop Inspectors at the fabricator’s plant. The RE should coordinate with Bridge Group on scheduling the on-call consultants and ensuring adequate budget. Fabrication of steel components shall not begin until arrangements have been made for shop inspection.

604-3.06 Welding

Most welding on steel structures is done in the shop. ADOT’s Shop Inspectors are certified by AWS to inspect shop welds. It is rare for welding to be done in the field, but when it is, it should comply with the following welding policy.

ADOT Welding Policy

Welding done on any structural steel, rebar, or other metal components on any ADOT structure must be done in accordance with the Bridge Welding Code, see references section. Copies of the Code are available from Bridge Group, Materials Group, and the ADOT Library.

All welding, regardless of where it is done (shop or field) or what components are welded (rebar, steel, or other metals), must be done by an AWS certified welder. This includes temporary steel structures such as falsework and underground shoring.

AWS Certified Welding Inspectors are trained in various detection methods for precisely determining the integrity of a weld, some of these methods may include: A visual inspection and/or the x-raying or ultrasounding of welds. All shop welds must be inspected and approved by an AWS Certified Welding Inspector.

No field welding is to be done without the approval of the Structure Designer and notification has been given to the Bridge Project Manager. Structural pieces that are too long or too short must not be torch cut or spliced in the field just to speed up the erection process. Steel members that do not fit should be sent back to the shop for alteration.

In rare situations a field weld may be necessary or even advantageous for the Department. The contractor must submit copies of current AWS certification for all welders on the project to the Resident Engineer before any field welding begins. Certain field welds may also require a special inspection. In these rare situations, the unit should hire a consultant AWS Certified Welding Inspector through the same process used to hire any other consultant inspector. The unit should acquire the consultant welding inspectors certification(s) to be kept on file in the project folder.

Field welds that would require a AWS Certified Welding Inspector may include:

- Welding on any bridge component; except for very minor bridge elements like sole plates
- Welding on any traffic barrier system such as bridge rail, guardrail, impact attenuation systems, and handrails; barriers such as right-of-fence and other fencing used to restrict access are excluded
- Welding on any structure or structural member in which failure of the weld would risk public safety; such as a sign or mast arm falling on the road. This would include, but is not limited to, overhead sign structure components, light and signal mast arms, and any overhead steel support brackets.
- Welding on any structure or structural member that may carry a structural load, or is critical to the support of the structure or its intended operation.

It is always advantageous and prudent for the Engineer to involve the ADOT Bridge Group prior to making any decision that allows a contractor to make any alterations and subsequent field welding to a structure or its components.

604-3.08 Erection

Site Inspection

Steel erection often involves lifting equipment, safety hazards, traffic control, and a deluge of documentation. For large steel structures such as bridges, the Resident Engineer and the contractor should have a pre-erection meeting to discuss erection procedures, traffic control, crew hours, safety procedures, paperwork, and inspection requirements. Inspectors need to have a copy of the Manual of Steel Construction and Section 11 of the AASHTO Standard Specifications for Bridges to verify steel shapes, connection preparation, and assembly procedures. They should also have a copy of all approved shop and working drawings.

Upon delivery, steel should be inspected for signs of damage and any such damage should be documented and reported to the contractor. All steel members should be tagged or marked by the Shop Inspector to indicate their acceptance by the Shop Inspector. Untagged members should be brought to the attention of the Resident Engineer for further investigation. In general, the Shop Inspector will not tag hardware such as nuts, bolts, and bins since these items are to be inspected and sampled by the inspectors at the project site.

The unloading of the steel must be accomplished by means of equipment and methods that will not damage the members. The steel should be moved by the use of slings and wood blocks to prevent damage to the flanges. Steel members should never be dropped.

Steel should be stored in a well-drained area that is in no danger of being flooded. The members should be handled and transported in an upright position. All beams and girders should be placed in an upright position on wooden blocks. Long members should be supported in a manner that will prevent damage due to excessive deflection. Deep members should be braced to prevent overturning.

The contractor has to provide safe access for the inspectors to do their inspections (see Subsection 105.12). This means that the contractor will have to leave the fall protection equipment in place and provide the necessary access and equipment so that inspectors can properly perform their inspections. ADOT is responsible for supplying inspectors with the appropriate personal protective equipment, while the contractor must provide the fall protection system and any lifting equipment necessary to inspect the work.

Bearings

Before the erection of structural steel begins, the centerline of bearings should be laid out and marked on all substructure units. Bearing areas should be checked to verify that a plane surface will provide uniform contact with the steel at the correct elevation. If the concrete surface that will be in contact with the bearing pad is rough or irregular, it should be ground flat to provide full and uniform bearing.

If a bearing area is low with respect to other areas on the unit or in relation to other units of the structure, shims of the same size as the bearing plate may be needed to adjust the bearing plate elevation. Avoid using a number of thin shims if a single one of the required thicknesses can be made from plates of standard thickness. The shims should be made from the same type of steel as that specified for the bearings. If shims are needed, approval from the Structure Designer and Bridge Group will be required. If shims are to be welded or secured to the bearing plate to prevent slippage of the shim, refer to Section 604-3.06 of this manual.

Assembly

During erection, the inspector should verify that all members are placed in their proper position in the structure by checking match marks or identification marks on the members with the location shown on the erection drawings.

Bearing surfaces and metal surfaces in contact with each other must be free of rust, loose mill scale, dirt, oil, or grease.

Any contact surfaces of beams, girder splices, or main truss connections to be connected by high strength bolts must be free of paint or lacquer. Primer is usually acceptable.

The steel should fit together with very little strain or distortion. If bolt holes are only slightly out of alignment, usually it is possible to bring the pieces into their proper position with drift pins. However if the holes fail to line up properly to the extent that forcing the drift pin through would result in enlargement of the hole or distortion of the metal, the holes may be re-drilled or reamed, but only with the approval of the Designer; this approval should be documented through a projects RFI process.

Any fabrication error that cannot be corrected by a slight amount of drifting, drilling, or reaming is cause for rejection of the material. Heavy sledging of the parts to bring them into alignment or making any cuts or adjustments with a burning torch must not be permitted.

No hole reaming, field bending, or straightening of structural steel members will be done without the approval of the Designer and Bridge Group.

Any heating of steel members to facilitate bending and installation must have the prior approval of Bridge Group. Applications of heat to structural steel must be done under rigidly controlled, predetermined conditions that may require different controls for the various members.

All of the above practices, if not done carefully, will weaken the steel through metal fatigue from excessive bending; net section removal from too much drilling and reaming or re-crystallization from overheating.

The entire structure or as a minimum, an entire unit of continuous spans, should be assembled, drift pinned, bolted, and adjusted to the proper grade and alignment in accordance with the erection drawings before permanent connections are made. If high strength bolts are to be used for the permanent connections, they may also be used for this "fitting up." Splices and field connections must have one-half of the holes filled with bolts and pins before bolting up with high strength bolts.

Elevations on tops of erected bridge girders must be checked and any necessary adjustments made to the slab build-up as noted on the bridge plans.

Connections

Inspectors must pay close attention to how connections are bolted or welded. One of the primary goals of any inspector of a steel structure is to ensure that the connections are not the weakest link in the structure. Subsection 604-2.03 discusses the requirements for bolted connections while Subsection 604-3.06 discusses the requirements of welding. The shop drawings will detail how connections are to be made and what hardware is to be used. Inspectors must take an active role in inspecting all connections and carefully observe and document the contractor's workmanship.

Final Alignment

Due to fabrication tolerances and inaccuracies in laying out the bearing locations, it is sometimes necessary to make slight adjustments in the position of the bearings after the erection is complete. Proper clearance between structural units and the correct opening for expansion devices are required. If the expansion bearings are of the rocker type, the rockers are adjusted according to the prevailing temperature so they will be vertical at the standard temperature shown on the Project Plans; usually 70 °F.

605 STEEL REINFORCEMENT

605-1 Description

Reinforced concrete is a mixture of concrete and steel reinforcement. Concrete is weak in tension and cracks easily when it shrinks or creeps under sustained loading. It is a brittle material. When concrete fails, it breaks suddenly without warning. Steel on the other hand, is 100 times stronger in tension than concrete; concrete is 6 times stiffer and will stretch 17 times more than concrete before failing. Steel reinforcement provides reinforced concrete the tensile strength, stiffness, and ductility needed to make it an efficient, durable, versatile, and safe building material.

For reinforced concrete to work as the Designer intended, the inspector and Resident Engineer must ensure that reinforcing steel placed in a structure is:

- The correct grade and type of steel
- The correct size, shape and length
- Placed in its specified location and spaced properly
- Tied and spliced together properly
- Clean and will get an adequate cover of concrete in all directions
- Placed in the correct quantities

Primary and Secondary Reinforcement

In any reinforced concrete structure, the reinforcing steel can be divided into two categories. Primary reinforcement is the steel in the concrete that helps carry the loads placed on a structure. Without this steel, the structure would certainly collapse. Secondary reinforcement is the steel placed in a structure that enhances the durability and holds the structure together. It provides the resistance to cracking, shrinkage, temperature changes, and impacts necessary for a long service life of the structure. Primary reinforcement can be thought of as the steel that holds up the structure while secondary reinforcement can be thought of as the steel that holds a structure together.

For example, the bottom mat of rebar and the truss bars in a bridge deck are intended to function as primary reinforcement. They resist the tensile stress that is induced by the bending of the deck as vehicles pass over it. If this steel was not there, the concrete could collapse and a vehicle could fall between the girders. On the other hand, the steel in the front face of a cantilever retaining wall functions more for crack and shrinkage control. Its main job is to hold the concrete together. It's the steel on the backfill face of the wall that is the primary reinforcement that helps the structure retain the soil.

It’s important for the Resident Engineer and inspector to become familiar with the primary and secondary steel reinforcement in structure. Not only does this help the inspector visualize how the steel should look, but it helps in getting compliance from the contractor by being able to discuss the reasons for good placement procedures and how each bar in the structure is intended to function. The Designer can help identify which steel is primary and which is secondary reinforcement.

Reinforcing Steel Changes in the Field

The contractor may request changes in how reinforcing steel is specified and designed to facilitate construction.

These changes may include:

- Moving bars
- Bending bar
- Substituting bars for different sizes, grades or types
- Cutting or torching bars
- Welding bars

- Using different splice details or splice locations

All requests; written or oral, that would change the design of the steel reinforcement in a structure must have the approval of the Designer. This includes, but not limited to, the location, size, shape, type, grade, length, or splice location of any bar. As mentioned earlier, steel reinforcement can be divided into primary and secondary reinforcement. Even minor changes in either category can have a profound impact on the behavior and longevity of the structure. This is why it is important to contact the Designer on rebar changes so the impacts can be accurately assessed and accounted for in the design.

The Resident Engineer can deal with changes in how steel is tied, cleaned, supported, stored, and handled with input from Bridge Group and Materials Group, as needed.

605-2 Materials

Steel bars, steel wire, welded wire fabric, and other structural steel shapes used as reinforcement must be certified as conforming to the specifications before being covered with the concrete. In addition to the certification requirements, random samples must be taken by the inspector in accordance with the Materials Testing Manual, Sampling Guide Schedule and the Materials Practice and Procedure Directives Manual. PPD No. 1 is an excellent guide for identifying the type, sizes, and grades of reinforcing steel and discusses the sampling and certification requirements in much detail. Please note that these references will be updated at times; utilize your materials coordinator or the regional materials engineer if you are having difficulties locating references.

One important point about rebar sampling that should be stressed is that precut bars furnished by the supplier as sample bars are not acceptable. Sample bars must be removed from a steel shipment at random when delivered to the project site. The Department now requires only one copy of the certificate of compliance for steel reinforcement.

Steel Type, Grade, and Bar Size Substitutions

It should be noted that as per ADOT Standard Specifications that project supervisors and inspectors have neither the obligation nor authority to authorize alterations, modifications or substitutions contrary to what is stated in the contract documents. The following technical statements should be used as guide for determining the risk to the project and the urgency of escalation should the contractor have begun work utilizing substitutions without prior authorization. The Resident Engineer, having the authority to authorize these changes and alterations, is always advised to confer with the design engineer before approving alterations and allowing the contractor to move forward.

Additionally, all changes in bar size, locations of splicing, types of splicing must be approved by the Designer. Larger bars can cause clearance problems and in some cases may lead to over-reinforcement of a concrete section in violation of AASHTO bridge specifications.

Most reinforcing steel for ADOT structures is specified as Type A615M (billet steel), Grade 420. Occasionally the contractor may want to substitute A706 steel for the A615 type. This kind of substitution is generally acceptable as long as the grade of steel stays the same or is better and there are no changes in bar sizes or lengths. A no-cost minor alteration should be executed with the concurrence of the Structural Designer and Materials Group. Other types of reinforcing steel such as ASTM A616 (rail steel) and A617 (axle steel) are not acceptable substitutes.

The contractor may always furnish Grade 420 steel when Grade 300 is specified. However if the contractor proposes to use Grade 520 steel for Grade 420, the Structural Designer and Bridge Group should be contacted for their approval. Grade 520 steel has a much higher yield strength than Grade 420 and could adversely affect how a structure behaves during a failure.

Welded Wire Fabric (Wire Mesh)

Wire mesh is sometimes specified by a Designer to control shrinkage and cracking in a concrete slab or wall. Information on identifying and placing wire mesh can be found in the CRSI Manual of Standard Practice referenced at the end of this chapter; a copy is available from Bridge Group.

605-3 Construction Requirements

605-3.01 General

Inspectors that regularly inspect reinforcing steel on an ADOT project should have access to a copy of Placing Reinforcing Bars published by the CRSI, see references. The CRSI manual is not something to which we have a subscription, but it is available for purchase on the CRSI website.

Bar Bending Diagrams, Bar Lists, and Cut Sheets

Although bar bending diagrams (aka Cut Sheet) are shown in the Project Plans, it is not a common practice for the Designer to show bar lists in the Project Plans. The contractor needs to submit the bar lists for a structure to the Resident Engineer prior to fabricating the reinforcing steel. The intent is to get the inspector and the Resident Engineer to review these lists before the steel is made and shipped to the project. This proactive approach will help prevent any delays to the project due to bars that have been cut the wrong length, bent the wrong way, or specified as the wrong size. Waiting until the steel arrives on the job to begin checking bar dimensions is a reactionary practice that the Department would like to avoid. The contractors may request approval or review of the bar bend diagrams from the Department. The construction office may also request review from the designer.

Bending, Heating, and Cutting Bars

The contractor may want to field bend bars to simplify reinforcing steel installation or to improve access around a structure. Grade 40 bars smaller than # 8 can be bent out of the way and then re-bent to their final shape.

The contractor can only bend # 8 and larger bars once and any bars made from Grade 60 steel. This means that they cannot be bent then re-bent once they are no longer in the way. The bars cannot be bent temporarily to accommodate other construction activities. Furthermore if the bars have already been bent once in the shop, no further bending is allowed in the field. Bending these bars more than once weakens the steel at the bends due to metal fatigue; similar to what happens every time you bend a paperclip back and forth, the repeated bending action weakens the steel until it breaks. Heating the steel to bend it is not acceptable. The heat, if not strictly controlled and closely monitored, produces a metallurgical (chemical) change of the steel properties. This change is called a notching effect because too much heat will cause a permanent and local weakening of the steel's structure just like a physical notch or cut in the steel.

If #8 bars or larger have to be bent, the designer, in consultation with the contractor and the Resident Engineer should provide the specifications for the bending of the bars, reference section five of the ADOT Bridge Design Guidelines.

Cutting or torching bars because they are a hindrance to steel installation or concrete placement must not be allowed without the approval of both the Structure Designer and the Resident Engineer.

Cutting the bars and then splicing them after they are out of the way is another practice that should not be allowed. The problem with cutting the bars and then splicing them has to do more with the splicing than the cutting of the bar. If the bar has to be spliced, the type of splice and the location of the splice should be discussed with and approved by the Designer before the bar is cut. Many times, contractors want to cut rebar at locations where stresses in the steel are too high or insufficient bar length is available after the cut to fully develop the splice. These are the reasons why the Designer must be involved in any bar cutting decisions.

Rusty, Oily and Dirty Rebar

Actually rust is not detrimental to rebar unless the amount of rust is so excessive that it flakes off the bars or reduces their cross-sectional area significantly. Oil, dirt, and loose mortar are the most detrimental to rebar since all three reduce the adhesion between the steel and the surrounding concrete.

Oil, especially form oil, acts as a bond breaker. When this gets on the bars, the inspector must direct the contractor to remove the oil. A hand-held torch may be used to burn off the oil so long as the rebar is not significantly heated up. Use of chemical or petroleum cleaners should not be allowed without prior authorization. The use of these materials should be addressed in the SWPPP and adherence to current environmental rules and regulations

Loose mortar, dirt, and mud can weaken the bond between the steel and concrete. The steel should be wiped or washed clean of these contaminants. In severe cases, wire brushing may be needed especially on any primary reinforcement. If a small amount of mortar in random locations is tightly bonded to the steel so that vigorous wire brushing cannot easily remove it, the mortar is probably acceptable. However, check with the Project Supervisor or Resident Engineer before approving the steel.

Rebar Cover and Clearance

Reinforcing steel must have adequate concrete cover near any exposed surface. This cover is needed to prevent corrosion of the reinforcing steel due to moisture, atmospheric conditions (like high humidity), and reactive soils.

The Project Plans should clearly indicate the amount of cover required for reinforcing steel. If the Plans do not, the Designer should be contacted. AASHTO and ACI have minimum cover requirements on all reinforcing steel. As a guide, consult Chapter 10 of Placing Reinforcing Bars (see references), which has an excellent section on concrete cover requirements.

Adequate clearance is needed between reinforcing bars so all of the concrete mix can completely surround the bar. When bars are spaced too closely together, two things can happen:

1. An air void can develop between the bars because there is not enough room for the concrete to flow between the bars. This void severely weakens reinforced concrete locally because there is no concrete bonded to the steel. The void also causes stress concentrations in the surrounding concrete because the concrete must transfer additional stresses that the void cannot.
2. The area between the bars is filled only with mortar, and is void of coarse aggregate. The problems with only having mortar between the bars include:
    - A reduced shearing strength in the mortar due to the absence of coarse aggregate
    - Increased stresses in the steel as the mortar tries to shrink around the bars in the absence of coarse aggregate
    - Surrounding areas of weakened concrete that have too much coarse aggregate and not enough mortar

ADOT’s Standard Specifications do not specifically limit the clearance between individual bars. Instead Subsection 1006-3.01 limits the maximum size of coarse aggregate in the concrete mix based on the minimum rebar clearance. In other words, the contractor must adjust the concrete mix design to fit the minimum rebar clearances in the structure. The inspector’s responsibility is to check areas of minimum rebar clearance and verify that the contractor’s concrete mix will meet Subsection 1006-3.01; you'll need to examine the mix design to do this. If the mix does not, either the contractor submits a new mix design or the Designer is contacted about moving bars so the contractor’s mix can adequately coat the bars. See Steel-Reinforcement Placement in subsection 601-3.03 of this manual for a detailed discussion and example of how to calculate the required rebar clearance for a given mix design.

Common locations where rebar congestion is a problem include:

1. Lap splices of longitudinal bars
2. Column and cap beam connections, where the cap beam reinforcing steel crosses the column steel protruding into the cap.

Tolerances for Cutting, Bending, and Placing

As soon as reinforcing steel is delivered to the project, it should be sampled in accordance with the Sampling Guide. The inspector should determine if the bars are of the proper size and length and if the bends and bend dimensions are in accordance with the Project Plans and the tolerances shown herein. After placement of the steel in the structure, a complete final inspection must be made and documented.

In the cutting, bending, and placing of reinforcing steel, it is recognized that it is not reasonable to require all bars to be cut, bent, and placed precisely as shown on the Project Plans. On the other hand, the strength of each member of a structure is dependent upon the cutting, bending, and placing being within reasonable tolerances. Because of these facts, the Department has adopted allowable tolerances that are considered reasonable and practical to meet yet will not significantly reduce the strength of the structural member below the theoretical design strength.

Cutting and Bending Tolerances

The following tolerances are based on industry standards established by the Concrete Reinforcing Steel Institute, refer to Chapter 6 of Placing Reinforcing Bars.

- Cutting to length on straight bars: ±1 inch
- Hooked bars, out-to-out: ±1 inch
- Truss bars, out-to-out: ±1 inch. The height (H) or drop (rise): ± 1/2 inch. Bend down points and bend up points shall be within 2 inches of position indicated on the Project Plans.
- Spirals or circles ties, out-to-out dimension: ±1/2 inch
- Column ties or stirrups, out-to-out dimension: ±1/2 inch

Subsection 105.05 applies to reinforcing steel just like it does to all other construction materials and workmanship. Bars that are consistently too short or consistently bent to the wrong dimensions are cause for rejection. Improper cutting and bending can also result in failure to meet placement tolerances in the forms.

Placement Tolerances (Refer to Subsection 606-3.01)

- Height of bottom bars above forms shall be as indicated on the Project Plans, ±1/4 inch
- Top bars shall have the clearance indicated on the Project Plans, ±1/4 inch
- Clearance from forms on vertical walls, columns, wings, and similar members shall be as indicated on the Project Plans, ±1/4 inch
- Spacing of bars in long runs of slabs or walls may vary up to 2 inches. It is important to note that the proper number of bars is placed.

The effectiveness of the reinforcement and the strength of the structure are dependent upon the reinforcing bars being placed in the concrete in nearly the exact position shown on the Project Plans. If they are not placed as shown, the structure will likely not have the strength that the Designer anticipated. For example, when the depth (H) of all truss bars in a structural concrete member is 1/2 inch less than shown on the Project Plans, the strength of that member is reduced from 15 to 25 percent.

The correct position of the steel, in relation to the tension face of the concrete, is of great importance. If it is too far away from the face, the strength of the member will be adversely affected. If the position is too close, particularly in bridge decks, water and de-icing chemicals penetrate to the steel and cause it to rust. The rusting process causes an expansion in the volume occupied by the steel that will cause spalling of the concrete.

Sometimes cover problems with reinforcing steel are the results of errors in the formwork rather than errors in steel placement. If a cover problem does not seem to be the result of improper rebar installation then check the dimensions of the forms for the correct forming tolerances.

Bar Supports

Adequate support for reinforcing steel must take into account not only the weight of the steel, but the stresses and strains encountered while placing the concrete as well. The Concrete Reinforcing Steel Institute publication, Placing Reinforcing Bars, contains recommended spacing for metal chair supports. Regardless of the recommendations, there must be enough support to keep the reinforcing steel within the placement tolerances and to keep it from deflecting under construction loading (concrete pours and foot traffic usually) until it is covered with concrete.

The supports (chairs) should be inspected for bending, compression, or other deformations to the supports in addition to any indenting of the form material. It may be necessary to use more supports or supports with a broader base to carry the load exerted by the reinforcing steel and the ironworkers. Heavy rebar cages containing large bar sizes are candidates for bar support inspection by the inspector. Wall and column reinforcement should be checked for adequate lateral support to prevent the reinforcement from being pushed against the forms during concrete placement.

The Resident Engineer and inspector should pre-approve all bar supports and bar support methods in advance of any steel placement (preferably when the bar bending diagrams are approved). If precast mortar blocks are used as bar supports, the blocks must have a compressive strength that meets or exceeds the strength of the concrete poured around them. The inspector must take one sample of precast mortar blocks for every 50 placed and send it to the Regional or Central Lab for strength testing.

Reinforcing Steel Inspection

The inspector shall not permit the start of concrete operations on any portion of the structure until he or she has thoroughly checked all of the steel for conformance with the Project Plans and the following:

- number of bars
- spacing
- clearance
- cleanliness
- size
- splices
- tying
- length
- bends
- support

This inspection cannot be made in a few minutes and it cannot be properly made until all of the steel is in place. Therefore the contractor must allow sufficient time for the inspector to make this check when planning the start of concrete placement. The contractor should be made aware of the time necessary for this inspection. If this matter is discussed at the preconstruction conference, the contractor should be informed again just before he or she begins concrete and steel work.

Inspectors doing rebar inspection should have the latest edition of Placing Reinforcing Steel, published by CRSI (see references) available to them.

605-3.02 Splicing and Lapping

Reinforcing steel is often specified in lengths that are too long for the steel to be delivered and placed as a single piece. As a result, two or more pieces are often spliced together at the site to form one long single bar. The following are three methods that ADOT allows to splice rebar.

Lap Splices

Lap splices are formed when two bars are overlapped for a certain length and tied together. The length of the overlap is called the lap length and is specified in the Project Plans. A sufficient lap length is needed to adequately transfer loads between the bars. Lap lengths can be longer than specified, but never shorter. Inadequate lap length can cause severe cracking in the concrete around the lap.

Reinforced concrete is typically its weakest around the lap splices in the primary reinforcement bars. For this reason, lap splices are placed in areas where the stresses in a reinforced concrete section are the lowest. The inspector must ensure that the contractor laps reinforcing steel only in the places specified in the Project Plans and with sufficient lap length. If the contractor wishes to move a lap splice, the Designer must approve the location change. In areas of high bending and tensile stresses, the Department should insist on using continuous bars or either mechanical or welded splices.

Lap splices can present problems with concrete cover and clearance between bars. Lap splices must have adequate concrete cover for corrosion protection just like continuous bars. It is important to ensure that the spacing between the lap splices allows for the adequate flow of concrete around the splice (see Subsection 1006-3.01). Often the lap splices in a group of bars are staggered to reduce congestion at the splice location This also prevents a continuous line of splices that could cause a weak spot in the structure.

Designers and contractors have joint responsibility to ensure that lap splices are workable in terms of spacing and adequate cover. The Designers need to ensure that lap splices will fit within the dimensions of a concrete member. Concrete cover must be adequate and rebar clearance must take into account a reasonable coarse aggregate size. If lap splices do not work, alternatives such as resizing the member, stagger splices, or a different splice detail should be specified. The contractors, on the other hand, have a responsibility to identify congested rebar sections on the Project Plans and adjust their concrete mix design accordingly. They also have a responsibility to place lapped bars well within the allowable placement tolerances when congestion at a lap splice is a problem.

Non-Contact Lap Splices

When a precast member is structurally connected to a cast-in-place concrete member or another precast member, the rebar from both members is lap spliced together to ensure adequate stress transfer across the two members. Sometimes due to the positioning of the precast member or because of placement tolerances in the reinforcing steel, the lapped bars do not end up touching each other at the splice. In other words, there is a gap between the two bars at the lap splice. The Designer must approve any non-contact laps that are not shown on the Project Plans.

When non-contact laps are permitted, the bars must not be spaced too far apart or a zig zag crack in the concrete may develop between the bars. Usually the gap is limited to the lesser of 1/5 the lap length or 6 inches. Non-contact laps are generally permitted in secondary reinforcement and in some minor structures. However they should not be allowed as an alternative to chronically poor workmanship.

Mechanical Couplers

When mechanical couplers are used to splice rebar, the couplers should be submitted to the Department ahead of time for approval. Couplers shown on the ADOT Approved Products List do not need to be pre-tested. Couplers not on the list should be pre-tested by ADOT Materials Group before they are covered with concrete.

For each type of mechanical coupler used, the inspector should have the manufacturer’s recommendations on how to make field splices. It is part of the inspector’s job to verify that the contractor is following the manufacturer’s recommendation for making mechanical splices.

It is also the inspectors responsibility to sample mechanical couplers in accordance with the Subsection 605-3.02 even if the mechanical couplers have been pre-approved. The samples must be taken at random and after the splices have been made. The samples should be sent to the Materials Group for testing. The contractor is not entitled to compensation for providing samples of mechanical splices used for testing or for the cost of repairing the rebar where the samples have been taken, see Subsection 605-4.02 and 605-5.

Welding Rebar and Welded Splices

Most rebar is specified as ASTM A615 steel. There are no strict controls on the chemical composition of the steel as long as the desired mechanical properties are met. Because there are no strict chemical controls, heating this type of steel for welding or cutting purposes can adversely alter the chemical composition of the steel. The steel can become permanently weakened and brittle due to the applied heat. As a result, most construction specifications, including ADOT's, prohibit the welding and torching of A615 rebar. Like a chain, a piece of rebar is only as strong as its weakest link so even minor tack or spot welding is prohibited.

Tack welding is not permitted unless approved in writing by the Engineer. When welding is permitted, ASTM A706 steel must be used and the welding must be performed by an AWS certified welder. Butt-welded splices are the only acceptable welded splices.

The welder should have the correct mill test report (chemical analysis) from the heat in which steel was made. Welding procedures do change to reflect the actual chemical composition of the steel. This test report should be included in the Certificate of Analysis.

No welding should be performed near prestressing strands without protecting the cable from welding splatter. Even the slightest nick or burn mark in the strands is enough to cause failure during tensioning.

Chapter 10 of Placing Reinforcing Bars contains additional information about rebar splices.

Changing the Type of Rebar Splice

For placement reasons, safety reasons, or for other constructability reasons, contractors may want to use mechanical couplers or welded splices in place of lap splices. Subsection 605-3.02 gives the option to the contractor of what type of splice to use as long as the Department approves the splices. The Designer may show only lap splices, but the contractor may need to change the type of splice to make the steel easier or safer to place, lift, and handle.

Just because lap splices are shown, doesn't mean the contractor is limited to this type of splice. The Contractor must choose the appropriate type of splice based on how he or she intends to construct the work. Changing lap splices to mechanical couplers or welded splices should be at no cost to the Department since the Standard Specifications clearly allow the contractor other splicing options. The contractor's selection of a different splicing option is not a changed condition unless the Project Plans or Special Provisions specifically preclude other splicing options.

605-3.03 Epoxy-Coated Reinforcement

When epoxy-coated steel reinforcement is specified, inspectors need to be watchful in how the contractor handles the bars. Scratches, nicks, and other marks are to be kept to a minimum. Don't allow the contractor to mishandle the rebar with the intent of fixing any damage to epoxy coating later. The intent of Subsection 605-3.03 is to avoid mishandling the bars in the first place. Repair procedures should only be allowed for the occasional accident.

For the epoxy coating to prevent rebar corrosion, the entire bar support must be corrosion proof, e.g. chairs, tie wires, and mechanical couplers. It makes no sense to support an epoxy-coated bar on a bare-metal chair. The Resident Engineer and Materials Group must pre-approve all bar supports, couplers, and tie wires for epoxy-coated rebar. The contractor should submit samples and product literature well in advance of any placement work.

Specifications do not allow any metal bar supports or uncoated tie wire for epoxy coated rebar in concrete barrier walls. Non-metallic supports such as plastic, must be used since the steel in a barrier wall is highly susceptible to corrosion.

The CRSI has an excellent inspection guide for epoxy-coated rebar, which is referenced at the end of this chapter.

605-4 & 5 Method of Measurement & Basis of Payment

Most reinforcing steel is paid for as part of a lump sum structure item or is included in the cost of another contract item. Rarely is an ADOT contract setup to measure reinforcing steel on a weight basis. However when there is a quantity dispute or additional work under a lump sum payment provision (605-4.02), the weight basis (605-4.03) is used to measure reinforcing steel to equitably adjust the contract amount.

Even when reinforcing steel is measured on a lump sum basis, the inspector should still collect the cut sheets that accompany each steel shipment and note any quantities used for placements, aids, or left out of the structure. The date and time the steel was placed in the structure should be noted. This process should not be much different than collecting concrete tickets, where the inspector tracks the concrete quantities, placement location, and waste.

Tracking steel quantities as steel is placed is important for heading off quantity disputes. Often these disputes arise because the quantity shipped to the project is different from the quantity shown in the bidding schedule or Project Plans. However inspectors need to keep in mind that there is a yield factor that applies to rebar similar to the yield factor that applies to ready mixed concrete. With rebar, there are end pieces that are not used, bars that are used as placement aids, and waste from rebar cutting. Sometimes even extra bars are sent at the contractor's request to replace damaged bars previously shipped.

Inspectors don't need to document every single bar placed in a structure, but they do need to scrutinize cut sheets and other shipping documents and note any quantity discrepancies as steel is placed.

606 OVERHEAD SIGN STRUCTURES

Sign structures are designed to stand up under severe wind loads. If a sign structure fails, there is a high potential for serious injury and death for any members of the traveling public around the structure when it fails. As a result, overhead sign structures should be treated no differently than if inspecting a bridge or any other major structure.

606-2 Materials

All of ADOT's sign structures are made of structural steel. Section 604 of this manual on steel structures discusses the requirements the contractor must meet for any steel. Section 605 provides more information on reinforcing steel requirements.

The non-shrink grout used under the support anchor plates serves a very important function in the structure. The grout ensures uniform contact pressure between the base plate and the sign foundation. The grouting operation needs to be carefully observed to be sure that the grouting is properly done and conforms to the manufacturer's recommendations. The ADOT Approved Products List specifies which non-shrink grouts are pre-approved for use by the contractor. The manufacturer's recommendations for the placement of the grout supersedes all other requirements. It is therefore the inspector's responsibility to ensure the contractor carefully follows those recommendations to the fullest extent possible.

606-3 Construction Requirements

Much of the construction requirements for sign structures are the same for steel structures. Refer to Subsection 604-3 of this manual for additional information.

Sign structures are fabricated and erected in accordance with approved shop drawings. During shop drawing development, the contractor must obtain as-built elevations of the sign foundations so that the columns are fabricated to the corrected length. The inspector must have a copy of the approved shop drawings to adequately inspect the erection operations. Shop drawings will show any erection procedures that must be followed including splicing methods and connection requirements.

The Resident Engineer, while the final authority in approving any welding to be done in the field,must adhere to ADOT's Welding Policy in Subsection 604-3.06 of this manual and all its requirements when welding on ADOT projects.

Sign bridges and supports should be inspected at the manufacturing plant and should not be delivered to the project until ADOT has accepted them and approved them for delivery. However the inspector should still inspect all the structural elements on the job. If any element differs from the Project Plans, the Designer of the sign structure should be advised. If the Designer needs additional information, they should contact Bridge Group as needed. If the welding appears inadequate, Bridge Group can have an AWS certified welder come to the project site to inspect the welds. All galvanized metal should be examined by the inspector for damage and uniformity. Unacceptable areas should be brought to the Resident Engineer's attention before rejecting the sign structure.

Inspectors should check the height of the sign structure above the roadway to verify the signs and the sign structures meet the minimum height requirements shown on the Project Plans.

606-3.05 Foundations

Foundations for sign structures are treated as drilled shafts and constructed in accordance with Subsection 609-1 through 609-3. Refer to Section 609 of this manual for information on drilled shaft construction. Requirements for concrete work fall under Section 601 and include:

- Concrete placement - Subsections 601-3.03(A), (C) & (D)
- Concrete finishing - Subsections 601-3.05 (A) & (B)

- Concrete curing - Subsections 601-3.06 & 1006-6.01

607 ROADSIDE SIGN SUPPORTS

Breakaway, perforated, and U-channel posts are the 3 main types of sign support. Sign supports are designed to minimize damage and injury during a crash. They may become a safety hazard if not installed properly. Signing and Marking Standard Drawings S-1 through S-11 show where and how the various types are typically installed. Sign locations should be staked as soon as possible in order to allow as much time as possible for fabrication of the sign supports.

Usually sign post lengths are determined by the Department based on the survey information provided by the contractor. The procedure is for the Resident Engineer to collect the survey information on the sign foundations from the contractor's surveyors and forward this information onto the Sign Designer for the project. However to do this, the contractor should have most of the shoulder grading complete before staking. Otherwise errors in sign foundation elevations and signpost lengths can occur.

The Designer determines the appropriate post lengths and returns this information to the Resident Engineer who passes it onto the contractor.

Breakaway Sign Supports

Breakaway signposts can be a tricky item for Resident Engineers. Pay attention to where breakaway signposts are called for in the Project Plans, but pay closer attention to how slopes are built around those locations. Many errors in breakaway sign installations can be traced back to changes in slope work that did not conform to the contractor's staking plan.

Breakaway sign support foundations are set so that the top of the concrete footing is flush with the ground and the top of the slip base is 2 1/2 to 3 inches above the concrete. The tops of concrete footings are sloped or rounded to drain, see Signing and Marking Standard Drawing S-5. It is important that the contractor does not pour breakaway sign foundations until the slopes are nearly complete and final elevation has been established. The sign foundation elevations must be based on the finished slopes; including topsoil plating. Do not regrade the slopes immediately adjacent to the sign foundation to match the sign foundation elevation. This can create a bump or dip in the slopes near the foundation that aggravates any vehicle collision with the sign.

After all topsoil plating and final grading work is finished, check the footings again to be sure that the tops of the footings are clean and that no dirt or debris remains on or around the stub post or slip plate assembly. The posts must be free to move when hit.

Bolts for fuse plates and base mounts are required to be torqued. The amount of torque and the tightening procedure are shown in the Standard Drawings. Subsection 604-2.03 of this manual has additional information on torque wrenches and torquing requirements not covered in the Standard Drawings.

Tightening bolts on breakaway sign bases requires close inspection. If the bases are not tight enough, the sign can walk off the plate under repeated wind loading. If over-tightened, the breakaway feature will not work.

608 SIGN PANELS

The Standard Specifications require all the materials used to make a sign panel to be certified. The materials coordinator or project supervisor should prepare a list of certificates of compliance and analysis required for all sign structures, panels, and supports for the inspector. The list will help ensure that all signing materials comply with the Special Provisions and the Standard Specifications. With sign panel certificates, it is important that each certificate properly identifies the sign materials used on the project and that all items of the panel comply with the appropriate specifications. See the Materials Testing Manual for the proper formatting of Certificates of Compliance.

The Traffic Engineering Group is available for advice and assistance relating to all phases of sign installation and will make a final inspection of the completed work upon the Resident Engineer's request. Seeking their assistance is highly recommended since signing requirements change often and many potential problems are caused by subtle changes that require experience to detect. Although the change may seem minor, it could compromise safety or increase maintenance cost.

When stored out-of-doors, sign panels must be elevated and otherwise protected as needed to prevent soiling of the lower parts of the panels.

Inspection of mounted panels in daylight and at night is necessary to detect variations in color, brightness, or reflectivity over the face of the panels. Panels are rejected if they fail to meet the rigid visibility requirements. Inspection should also ensure that the sheeting on the sign panels are not damaged by installation of bolting and ensure proper sign layout. The Regional Traffic Engineers office (TSMO) can help determine when sign panels fail to meet visibility requirements.

Signs are expensive and designed to last for a long time. They are viewed continuously by the traveling public (our customers) so even minor variations in the specified appearance, color, brightness, and reflectivity should be cause for rejection and alterations.

609 DRILLED SHAFT FOUNDATIONS

609-1 Description

A drilled shaft is a deep circular hole in the ground filled with reinforced concrete. The drilled shaft transfers the weight and loads on a structure to soils and bedrock deep underground. Drilled shaft depths can range from 6 feet for pole foundations to 130 feet for bridge foundations.

A drilled shaft transfers loads to rock and soil by one of the following methods:

- The shaft transmits loads to the ground by the friction developed between the outside vertical surface of the shaft and the adjacent rock or soil. This is called a skin-friction drilled shaft.
- The shaft transmits loads to a layer of bedrock or hard soil that the drilled shaft sits on. The loads are transferred through the bottom of the shaft to the ground, hence the term end-bearing drilled shaft. Skin friction is not relied upon to transmit loads, although it may be present in an end-bearing drilled shaft. End-bearing drilled shafts are occasionally widened at the base to spread out the load. Underreaming to form a bell-shaped shaft tip does this.
- When a drilled shaft is designed to transmit loads by a combination of end-bearing and skin friction, the shaft is designated as a combination end-bearing, skin-friction drilled shaft.

The most common type of drilled shafts is the skin-friction type. End-bearing shafts are not as common because of the additional cost of underreaming to form the bell shape and the need to send an inspector down in the hole to inspect the bottom of the shaft. Combination end-bearing, skin-friction shafts without bells are becoming more common as Foundation Designers get better at predicting end-bearing capacities for soil and rock.

Construction Procedures Are Critical

Unlike driven piles, drilled shafts are more reliant on a multitude of construction procedures any of which could severely reduce the capacity of the shaft if not followed properly. As a result, the inspection of drilled shafts is much more demanding on the inspector than pile driving. Inspectors must have a wider range of skills including soil identification, rebar inspection, concrete testing, and equipment familiarity.

To quote from Drilled Shafts: Construction Procedures and Design Methods (see references), “The most frequent cause of drilled shaft failures are almost always attributed to improper construction procedures”. With this in mind, inspection must play a very active role in drilled shaft construction. Any inspector assigned to a drilled shaft operation must have plenty of prior experience in this type of work. Inspectors who are inexperienced at doing a drilled shaft inspection should not be leading such a critical operation.

609-1.03 Installation Plan

The contractor must submit a detailed installation plan describing the equipment and tools to be used and the methods for constructing the drilled shaft. The amount of detail required should depend upon the anticipated site conditions and the complexity of the drilled shaft operation. An installation plan fulfilling all thirteen points listed in the Standard Specifications should include sketches and equipment information. If drilling slurry is to be used, the plan submitted may be quite large.

The intent of submitting a drilled shaft installation plan is to get the contractor and the Resident Engineer to plan ahead of time on what materials, equipment, and methods will be used to construct the drilled shafts. The Department wants a well thought-out plan that demonstrates the contractor is ready and capable of doing the work. Unlike mistakes in an above ground structure, mistakes buried 33 to 100 feet underground are not easy to detect and repair.

The contractor must be permitted to freely adjust the installation methods as ground conditions warrant. However this need to rapidly adjust the drilling operation does not negate the need for an initial installation plan. The point of the installation plan is to ensure the drilling contractor has adequately prepared for the work. This preparation helps minimize the Department's risk of having to deal with defective shafts because of haphazard and uncoordinated work methods.

The plan gives the Resident Engineer an opportunity to verify that the contractor's work is in conformance with the Project Plans and Specifications and helps avoid those unpleasant surprises during drilling that could lead to a Department-ordered work stoppage or rejection. Of course, the more details the plan gives, the more likely that issues can be resolved ahead of time. Sketchy incomplete Project Plans, submitted just to meet a contract requirement, usually serve as a warning for many problems in the field.

Plan Evaluation

The Resident Engineer is responsible for reviewing and approving the installation plan. The Geotechnical Section of Materials Group or the Consultant Geotechnical Engineer for the project will help review the plan and establish guidelines. They even have sample Project Plans from previous jobs that can help the contractor achieve a complete submittal the first time. However it is the Resident Engineer who must be satisfied that the plan is complete enough and in sufficient detail to allow the contractor to proceed with the work.

If the Resident Engineer has not been involved with a drilled shaft installation before, it will be difficult to evaluate the suitability of the contractor's equipment and installation procedures. The Geotechnical Section can help with this. Keep in mind that the objective of the installation plan is not so much a verification tool for the Department as it should be a planning tool for the contractor. The Resident Engineer's job is to ensure that the contractor has adequately planned the work. If the Resident Engineer can't understand the plan because of vagueness, generalities, and lack of detail, chances are the drilling contractor has no clear idea what is to be done.

Minor details omitted from the plan can be discussed in a pre-activity meeting. Major details such as the type of equipment used, rebar support and spacers, casing procedures for the hole, slump test results and drilling slurry procedures must be shown on the plan.

Pre Activity Meeting

Although it may not be required by the contract, it is highly recommended that the Resident Engineer hold a pre-activity meeting prior to drilling for all but the simplest drilled shafts.

Points to cover at the meeting include:

- The details of the contractor's installation plan, including any clarification required by the Resident Engineer
- Factors that may cause the concrete placement duration to exceed the elapsed time and how those factors can be mitigated
- Contract pay limits and method of measurement
- Inspection requirements, and assistance by the contractor during inspections
- Contingencies for caving, groundwater, utilities, boulders, and other obstructions
- Safety precautions

The goal of the meeting should be that the Resident Engineer and the inspector walk away with a clear understanding of the contractor's installation plan and how the contractor intends to construct the drilled shafts. At the same time, the contractor should have an understanding of how the Department intends to inspect the shafts and how both need to work together so the inspector can effectively do his or her work.

References

Space limitations in this manual prevent the reader from obtaining everything he or she needs to know to properly oversee and inspect drilled shaft construction. However there are three excellent references cited at the end of this chapter that can easily fill in the gaps.

The Drilled Shaft Inspector's Guide is a handy little booklet that every inspector should have when inspecting drilled shafts. It concisely describes the drilled shaft construction processes and the inspector’s basic duties during construction.

Drilled Shafts: Construction Procedures and Design Methods is a comprehensive look at drilled shaft construction. It is definitely the industry bible and the most informative in explaining all the little but important details of drilled shaft construction. Each district office as well as field offices that do a lot of drilled shaft work should have a copy.

Chapter 6 and 9 of the California Foundation Manual are two other excellent sources of information on drilled shaft methods and inspection duties. Unlike the drilled shaft bible, which was written by two college professors, these chapters were written by practicing engineers and construction technicians. The information is concise and the explanations more descriptive. Copies are available from the ADOT library.

As with all references, ADOT’s specifications override any construction specifications mentioned in these publications.

609-2 Materials

609-2.01 Concrete

Drilled shafts are one of the few reinforced concrete structures where the Department will let the contractor get away with pouring soupy looking concrete. Fluidity of the concrete is very important for successful drilled shaft construction. Subsection 609-3.05 will have more to say about concrete properties for drilled shafts but for now it is important to remember that the mix design needs to be reviewed for compliance with Subsection 609-2.01 as well as for the following:

- The slump should be within the 4 to 7 inches for the dry, uncased holes and 7 to 10 inches for all other placements.
- The maximum aggregate size should meet the limits set in the Special Provisions or in Subsections 609-2.01(B) and 1006-3.01.
- Concrete must contain 660 to 750 pounds of cementitious material per cubic yard.
- Any other requirements specified in Section 1006, see Subsection 1006-3 of this manual.

Aggregate size and grading, fluidity, and setting time are the most important characteristics of concrete for drilled shafts. These characteristics as well as strength, mixing uniformity, and segregation potential can be tricky to control in a concrete mix for drilled shafts. If the contractor’s concrete supplier has no well established history on using the proposed mix design, the Resident Engineer must insist on trial batches. Defective concrete in a drilled shaft is incredibly harder to diagnose and repair than concrete in an aboveground structure.

Slump Loss Test

Concrete workability is vital in maintaining the integrity of the drill shaft. Any honeycombing or voids will be detrimental to the final product, so it is vital that the concrete remains in a plastic state throughout the pouring process. In order to ensure this, a slump loss test will need to be taken by the contractor prior to submitting the mix design. These results are to be submitted with the installation plan. This is to help mitigate the potential formation of cold joints within the drilled shaft during the pouring process. Reference the 609 specification for further information on this test.

609-2.02 Reinforcing Steel

The inspection duties associated with drilled shaft reinforcing steel is no different than for reinforcing steel in other reinforced concrete structures. See Subsection 605-2 of this manual for more information.

Some drilling contractors like to tack weld temporary rebar supports and cage stiffeners to the spirals or longitudinal steel. No welding should be done on rebar required by the Project Plans unless A706 steel is used, see Subsection 605-3.02. Any temporary supports and stiffeners should be removed before the cage is lowered completely in the hole.

609-3 Construction Requirements

Understand the Intent of the Drilled Shaft Design

Drilled shafts can be designed to transfer loads through skin friction on the outside walls, end-bearing of the shaft tip, or a combination of the two. The Resident Engineer needs to contact the Foundation Designer and to determine how the drilled shafts are designed and pass this information on to the inspector.

Just as important, the Resident Engineer needs to find out which soil strata are intended to carry the loads from the shaft. Sometimes the soils near the surface are not relied upon to carry any loads and this is important to know if the contractor wants to use permanent casing. Other times, the bearing strata can become damaged during drilling so it’s imperative to know which soils are critical to the success of the drilled shaft.

Review Subsurface Information and the Contract Documents

Before any drilling is done, the Resident Engineer and the inspector together, should review the subsurface information gathered from the geotechnical investigation of the project. It is not necessary to read all the reports from cover to cover. Instead the goals in reviewing these documents should be:

- To become familiar with the soils expected to be encountered including the soil type, the expected depth, and the classification system used to identify the soils.
- Determine if there are any soil characteristics that could give the driller problems such as groundwater, an artesian condition, loose or caving soils, heaving soils, soils containing cobbles and boulders, or manmade features, such as landfill or an old foundation.
- Know any assumptions made by the Foundation Designer and the Geotechnical Engineer on how the contractor is supposed to construct the drilled shafts.

Of course, the Special Provisions, Project Plans, and Standard Specifications should be read. Review of the references cited in Subsection 609-1 of this manual should be required for those not involved in drilled shaft construction for one year or more. The novice inspector should refer to Section 2 of the Workbook for Major Concrete Structures Inspection.

609-3.02 Confirmation Shafts

For projects with unusual soil or groundwater conditions, a confirmation shaft may be designated in the Project Plans or Special Provisions. The intent of this confirmation shaft is to validate the construction methods described in the installation plan. It is important for the contractor to follow his or her own installation plan until changes become necessary.

The inspector should carefully document the work including production times, down times, tools used, and the development of a concrete yield curve for the shaft. Any deviations from the installation plan should be noted.

Revisions to the installation should be required when site conditions are different than those assumed by the plan. The plan should be revised if the contractor's actual methods are significantly different from those described in the plan. The next shaft would then become the confirmation shaft for the revised plan.

609-3.03 Excavation

Before the contractor drills any holes, any embankment that the drilled shafts pass through must be constructed. The Department does not allow any construction joints in drilled shafts near the surface. Drilled shafts are often designed for bending and most of the bending occurs within 10 to 20 feet below the ground surface; the last place the Department wants a construction joint.

Safety First

Before drilling begins, the work area must be blue staked. In addition to searching for underground utility conflicts, the contractor and the Resident Engineer need to look for any overhead conflicts. Plenty of head room is needed when constructing deep-drilled shafts. It is not so much the drill rig that needs the room but the crane for lifting the rebar cage and tremie. Some rebar cages can be up to 100 feet in length. Sometimes it is possible to get the power lines de-energized temporarily while the drilled shafts are being installed. The power company will place markers on the power line to help in judging clearance distances.

When drilling next to an underground utility, it is advisable for the contractor to pothole first and exactly locate the utility. During drilling, caving may expose the utility. If this occurs, the inspector should verify that the utility is well supported, if needed, and that the contractor does not entomb it in concrete when the shaft is poured.

With sandy and sand-gravel-cobble (SGC) type soils, there is the danger of the soil collapsing near the surface as the driller advances the hole. The Resident Engineer should examine the stability of the surface soils. If the Resident Engineer believes the surface soil is too unstable to work on, he or she has the authority under 105.02 to suspend the work until the contractor makes the area around the hole safe. Usually a safety casing can be placed around the hole in order to protect workers. Keep in mind, Subpart P of OSHA does apply to any drilled shaft excavation.

The most obvious safety hazard with drilled shafts is the open hole. Fall protection needs to be provided as required by Subparagraphs 1926.501(b)(7)(ii) and 1926.651(l)(2) of OSHA. Common practice is to keep unattended holes covered with plywood, steel plates, or some other protective covering that comply with Subparagraphs 1926.502 (i), 1926.502 (i)(2) through 1926.502 (i)(4) of the OSHA Standards. Chain link fence is to be placed around any unattended holes in accordance with Subsection 107.08. However, a section of chain link fence should not be used as a hole cover unless it is capable of supporting at least twice the weight of employees, equipment, and materials imposed on the cover at any one time. This safety topic should be discussed and agreed upon in advance at the pre-activity meeting.

Embankments

Other reasons for having embankments built first are identical to the ones that apply to driven piles, see Subsection 603-3.04. There is the down-drag effect caused by material placed immediately around the shaft and there is the surcharge effect caused by material placed above and beside the shaft. On bridge structures the embankment must be built to the top of berm elevation before any shafts are placed, See Standard Drawing SD 5.02.

No boulders or debris should be placed in embankments that contain drilled shafts, see Subsection 203-10.03[A].

Drilling the Hole

Excavated materials removed from drilled shafts, when suitable, are intended to be used in fills and embankments within the project.

The references at the end of this chapter provide more information on the drilling equipment, tools, and methods used by drilling contractors to excavate deep holes. The type of drilling method chosen by the contractor greatly affects the cost of the shaft and the inspection requirements placed on the Department. There are only three basic drilling methods applicable to drilled shafts. The following is a brief description of each method, see the references for more details. These methods will be referred to extensively throughout the rest of this section.

The Dry Method

The dry method is by far the quickest, cheapest, and easiest method of drilled shaft construction. The hole is drilled and remains dry and stable until a rebar cage can be placed and the concrete poured. The contractor will always try to use the dry method even if there is a risk of the shaft walls collapsing.

The Casing Method

Unfortunately not all soils remain stable during drilling, some soils heave, others squeeze, and others just collapse. To overcome this undesirable soil behavior, drillers will place a temporary casing in the hole. The casing is driven into the hole and the auger either drills inside the casing or usually just ahead of it. As the hole advances, the casing is driven further into the hole until either a layer of stable soil or the tip elevation of the shaft is reached. Sometimes drilling slurry is used to keep the hole open beneath the casing until a layer of stable soil is reached. When the shaft concrete is being placed, the contractor will pull the casing while the concrete is still fresh. The fresh concrete should fill in any voids left by the casings and unstable soils.

In some instances, the Department may allow the casing to remain permanently in place above some predetermined elevation.

The Slurry or Wet Method

This is the drilling method of last resort. Sometimes it’s the only method that will work and provide a suitably constructed drilled shaft. The cost is usually double that of the dry method so expect a request for additional compensation from the contractor if he or she has to resort unexpectedly to this method.

The slurry method relies on thick and heavy mineral slurry to keep the surrounding soils from collapsing into the hole. The entire process is slow and subject to intensive inspection. The slurry has to be cleaned and re-circulated into the hole. The slurry head elevation must be carefully maintained even as the auger is removed from the hole to prevent any sudden pressure changes in the hole. The slurry is considered a water pollutant and has to be carefully monitored and disposed of. More on drilling slurry can be found in Subsection 609-3.02 of this manual.

A variation on the slurry method is the wet method of drilling. With this method, the drilling takes place underwater. The water behaves like slurry and stabilizes the hole. Groundwater is usually the source of water used for the hole. Although some contractors add their own water to stabilize dry holes. Subsection 609-3.02 does not apply when water is used as drilling slurry. Some of the basic principles, like letting the sand settle out before concrete placement and not dumping the silty water into an active water course, do apply. The wet method is often preferred over the casing method and definitely over the slurry method if it is capable of stabilizing the hole.

AASHTO designates the wet method to include both drilling slurry and water. However the drilling industry typically makes a distinction between the slurry and wet methods since the operations are significantly different.

When either the wet or slurry methods are used, the contractor is required to provide a temporary surface casing to stabilize the ground around the hole and to prevent material from falling into the hole. This is a contract requirement specified in the AASHTO Standard Specifications for Highway Bridges (Div. 2, Subsection 5.4.5), which applies to drilled shaft construction for bridges.

Identifying Soils

One of the more important jobs of the inspector is to verify that the soil profile shown in project boring logs is the same as encountered during drilling. The second page of the Drilled Shaft Inspection Form (see blank forms) is used by the inspector for recording soils information. The soil type and depth should be recorded on the form as well as any other observations that would help identify the soil. Any groundwater or caving conditions should be reported.

If there are significant deviations in soil types, soil stratum depths, or other ground conditions encountered by the driller when compared to the project boring logs, the Resident Engineer and the Geotechnical Engineer for the project should be notified immediately. Design changes to the drilled shafts may be needed including lengthening the shafts to account for any unexpected soil or rock conditions.

Soil identification should be done for each drilled shaft. However the Resident Engineer should decide how many drilled shafts in a drilled-shaft group need complete soil profile identification.

When rock sockets are involved, the Resident Engineer should contact the Geotechnical Engineer for the project and have him or her identify the rock formation encountered during drilling. Rock identification, including when sound bedrock is reached, can be tricky and should be left to a specialist. In most cases, the Geotechnical Engineer only needs to make one or two visits to the site to train the Resident Engineer and inspector what to look for. Afterward if anything different is encountered, then the Geotechnical Engineer must be notified again. All rock socket depths and elevations must be measured and recorded by the inspector, see Subsection 609-4 & 609-5 of this manual for further information.

Caving Soils

Loose sands, silts, or squeezable clays surrounding the drilled shaft can cause caving in drilled shaft excavation. Infiltrating groundwater can cause the walls of a drilled shaft to collapse.

The contractor has several alternatives when dealing with caving soils:

- Enlarge the hole to reduce the wall curvature and decrease slope angle of the caving soil; too large a hole may cause utility conflict or interfere with an adjacent drilled shaft.
- An approved one sack grout (low cement/sand mix) can be used to fill the drilled shaft in the area of the collapsing soil, after the grout has set, the contractor drills through the grout and continues with the hole; this method requires the prior approval of the Foundation Designer except for light pole and sign foundations.
- Use the wet method of drilling.
- Use the casing method; any permanent casing must be approved by the Department.
- Use the slurry method of drilling , see subsection 609-3.02.

Inspectors must do a good job of documenting any caving conditions encountered during drilling. The depth, type of soil, and groundwater conditions must be identified. In some cases, it may be advisable to sample the soils brought up by the auger and send them to the lab for positive identification. When a drilling contractor encounters caving soils unexpectedly and has to resort to some of the more expensive drilling methods like casing or slurry method, expect a request for additional costs. Good site condition identification and thorough documentation are essential in equitably resolving any caving-soil issues.

Boulders and Other Obstructions

Boulders are difficult but not impossible to remove from a drilled shaft. There are several tools available such as grab buckets, boulder rooters, down-the-hole hammers, and hammergrabs, which can pick up, break, or remove boulders. Boulder rooters work best on the rounded, 12 to 18 inches diameter boulders usually encountered in holes in Arizona. Core barrels can be used when the boulders are prevented from shifting during drilling. More on boulder removal can be found in Drilled Shafts: Construction Procedures and Design Methods cited at the end of this chapter.

Boulder removal using the previously described tools is time consuming and expensive especially when there are many boulders. Usually the contractor will widen the hole so the boulders can ride up through the auger flights. This may be acceptable as long as the widened shaft does not interfere with adjacent shafts or with underground utilities.

Most differing site condition claims for drilled shafts in Arizona involve boulders. ADOT's Geotechnical Section usually size drilled shafts to two times the expected boulder size. This means that the largest boulders cannot be easily removed through the auger flights. For these large rocks the contractor has the option of widening the hole at their expense or using one of the specialized tools such as a grab bucket.

Intervention by the Resident Engineer

When is it appropriate for the Resident Engineer to immediately stop the drilling operations? Some guidelines are:

- The surface soils are likely to cave during drilling and the contractor has not implemented adequate safety precautions such as temporary casing or keeping workers away from the hole.
- The soils are unlikely to cave, but there are workers around the open hole without adequate fall protection.
- Soil caving becomes excessive to the point where an underground cavern is created jeopardizing any adjacent shafts as well as the safety of workers at the surface.
- The contractor is drilling deeper than necessary.
- Drilling slurry does not meet the desired chemical and physical properties.
- The shaft does not meet the specifications with regards to location, plumbness, width, depth, rebar configuration, slurry treatment, etc. and the contractor continues working.
- A differing site condition is encountered which the Resident Engineer needs time to evaluate.

Of course, it is impossible to list all the scenarios that might require the Resident Engineer to halt a drilling operation; however, unsafe acts and any activities that would cause irreparable harm to the integrity of the shaft are the more common reasons for a Department-caused drilling shutdown.

Plumbness

Plumbness of the shaft is usually checked after the hole has been cleaned and before the rebar cage is set. The drilling contractor lowers a cleanout bucket or an auger to the bottom of the hole. The plumbness readings are taken on the Kelly bar with a carpenter's level or a slope inclinometer.

The inspector can calibrate the carpenter's level to show a 1.5 percent variation by setting it vertical then moving it left and right to a predetermined distance and marking the new bubble location each time. The predetermined distance would be 1.5 percent of the length of the level. For example, a 4-foot carpenters level would be moved 3/4 inch out of plumb and the new bubble location marked. A 3/4 inch wedge can be used to place under one end of the level if it is not possible to mark the bubble tube.

On large drilled shaft projects, when more accuracy is needed, the Special Provisions may require the contractor to check plumbness with a slope inclinometer and certify the correctness of the readings. The inspector should verify slope inclinometer readings have been taken and are satisfactory before any rebar cages are set in the hole. It is a good practice for the inspector to witness several of these readings to ensure correct procedures are followed.

In dry holes, the inspector can walk around the sides of the hole and check plumbness with a plumb bob. Usually four readings are taken along the sides of the hole at right angles to each other. Plotting these measurements against the outside diameter of the hole can give a good indication which direction the hole is slanting and how plumb it is.

Location Requirements

Although 609-3.01 allows the location of the shaft to vary by as much as 3 inches, this variation may be excessive when other structural elements connected to the drilled shaft, such as columns, must meet the requirements of Subsection 601-4.02(A). The inspector should carefully review the Project Plans to see what structural elements will be cast on top of the drilled shafts. Any location or tolerance problems in the structure that could be created by mislocated shafts should be brought to the attention of the contractor before drilling begins.

Inspection

Drilled shaft construction is a high production operation involving expensive tools and equipment. Inspection activities should be designed to minimize delays to the contractor while ensuring the intent of the Standard Specifications is met. The best way to achieve these objectives is through cooperation with the drilling contractor. Working together is important because many of the key inspection activities like checking hole depth, hole width, plumbness, and depth of concrete require the contractor to interrupt production while the inspector takes measurements.

The best way to get the contractor to cooperate is by applying the principles of partnering described in Subsection 104.01 to the drilling operation. Here are some tips:

- Have a pre-activity meeting (see Subsection 609-1 of this manual) and bring up important issues such as: correct hole depth, verification of soil or rock conditions, correct positioning of the rebar cage, cleaning the bottom of hole, depth of tremie in concrete, safety around the hole, etc. Solicit the most important issues from the contractor. Then work on resolving all the issues before drilling begins.
- Let the contractor know that some of your inspection activities will interrupt drilling and slow down production; but then work together to minimize these conflicts. Do not start any drilling with issues still unresolved. If issues can't be worked out at the project level to everyone's satisfaction, then escalate to the Resident Engineer or District Engineer.
- Participation by the drilling contractor in the inspection process is a must for successful drilled shaft inspection. Experienced drill rig operators and drilling foreperson can tell the inspector a lot about subsurface conditions and the quality of the drilled hole by the behavior of the drilling tools and equipment. For example, a drill rig operator knows exactly where soils change from loose to dense by the additional engine power needed to advance the drilling tool.

Don't hide behind the Standard Specifications if you can't work out differences over inspection access, escalate issues to the Resident Engineer or District Engineer through the partnering process if necessary.

Roles of the Inspector

As an observer and record keeper, the inspector has several roles:

- To ensure that drilled shafts are built in accordance with the Special Provisions, Projects Plans and Standard Specifications.
- To verify that actual soil and subsurface conditions are the same as those anticipated by the Foundation Designer and alert the Designer to any changes.
- To document production methods and rates for forensic use by the Resident Engineer and Materials Group.

There is a lot of material to review by the inspector including the Project Plans, Special Provisions, soils reports, and inspection manuals, see Subsections 609-1 & 609-3 of this manual. Inspectors should go to any pre-activity meeting so they can fully understand the issues raised between the drilling contractor and the Department. The success any inspector has in filling these roles depends to a large extent on the preparation time allowed by the Resident Engineer.

Inspectors also need time to get all the inspection equipment together, such as weighted tapes, plumb bobs, levels, inspection forms and familiarize themselves with how to use each one for drilled shaft inspection. Inspectors may need to brush up on their soil identification skills.

Another aspect of the preparation is opening the lines of communication with the Foundation Designer and the Project Geotechnical Engineer. Protocols need to be developed when the inspector finds soil conditions different than expected by the Designer or when the drilling contractor encounters an apparent differing site condition. As mentioned previously, drilled shaft production is a high production and expensive operation. Inspectors and the Resident Engineer need to be prepared as soon as the contractor is ready to begin and not gear up after work has commenced.

Drilled Shaft Inspection Report and the Concrete Placement Chart

The Drilled Shaft Inspection Report (see Blank Forms) should be completed by the inspector for each drilled shaft. A blank form is shown at the end of this chapter. It is important to completely fill out the report especially in the area of soil identification and drilling difficulties encountered. For example, if the drilling contractor has trouble advancing the hole because of boulders, this should be noted in the report. Drilling tools with worn cutting teeth or cutting edges that inhibit progress should also be noted.

The report is typically the only historical information the Department has on how the shaft was constructed. As was mentioned previously, construction methods greatly affect the load carrying capabilities of any drilled shaft. The inspector’s report ends up being a very important document in the future if integrity of the shaft ever becomes an issue. More on what observations to include in the report can be found in the Drilled Shaft inspector's Manual.

In addition to completing the Drilled Shaft Inspection Report, any results from integrity testing on the shaft (gamma ray probing or cross-hole sonic logging) should be attached to the report.

When drilled shafts are placed by the slurry method or in the wet method, the significant risk of soil collapse warrants the production of a concrete placement chart for each shaft by the inspector. The volume of concrete placed per yard of shaft depth is measured and plotted against the theoretical volume; 6 foot increments can be used for harder or denser soils that are unlikely to collapse. Exhibit 609-3.03-1 is a Concrete Placement Chart developed in MS Excel that the inspector should use.

The drilling contractor's cooperation is needed when taking these measurements. As a result, it is suggested that the inspector and the drilling foreperson share the responsibility of developing the placement chart.

Concrete Placement Charts are used to show if there has been any necking or enlargement of the shaft due to soil collapse. The charts are a great aid to the Resident Engineer and Geotechnical Engineer if integrity tests indicate a void in the shaft or if no integrity testing was done at all. These charts should also be attached to the Drilled Shaft Inspection Report.

Hole Cleanout

Cleaning out a hole involves removing loose material from the bottom of the shaft just before the cage is set and the shaft poured. Inspectors are responsible for approving the cleanliness of a drilled shaft before the shaft is poured. Mirrors and lights can be used to inspect the bottom of the hole. The bottom should appear flat and uniform. Soundings with a plumb bob often provide helpful information.

When the hole is full of water or slurry, hole cleanliness can be checked by repeatedly lowering a cleanout bucket and removing any accumulation of soils at the bottom of the hole. A change in the elevation at which the bailing tool hits bottom will indicate a build up of sloughed material.

A feeling device should also be used such as a heavy rod or anything heavy with a blunted point to check for a firm, flat bottom. Check the center of the hole, which is usually the cleanest then check the sides of the hole. Lifting and dropping the feeling device should produce the same feel everywhere if the bottom is firm, flat and uniform. If there is any doubt, error on the side of overcleaning the hole. The Resident Engineer can always use a minor alteration for those occasions where the cleaning of the hole becomes excessive.

One other element of hole cleanliness that inspectors should be aware of is the smearing of medium to soft clays on the walls of the excavation. If the contractor is not careful about how these materials are removed, they can adhere to the sides of the excavation and act as a lubricant between the shaft concrete and soils surrounding the shaft. If the inspector suspects that the sides of the shaft have been slickened by auger trimmings then the contractor should ream the hole until the sides are returned to their native condition.

Drilled Shaft Concrete Placement Chart (attach to Drilled Shaft Inspection Report)

TRACS No.: ____________________ Date: ____________________

Structure Name: ____________________

Structure No.: ____________________ Inspector: ____________________

Foundation Location: ____________________ Shaft No.: ____________________

Shaft Diameter: ______ FT

Shaft Depth (Actual): ______ FT

Theoretical volume
CY
CY/FT

NOTE: All linear measurements are in feet (FT), and all volume measurements in cubic yards (CY).

Concrete Ticket Number	Volume Delivered (CY)	Measured Depth (FT)	Depth of Concrete (FT)	Time of Measurement	Volume in Mixer (CY)	Cumulative Volume (CY)	Theoretical Volume (CY)	Difference in Volume (CY)
							Total Overbreak/Underbreak	
								+ = bulging - = necking

Remarks: ____________________

Instructions:

1. Enter drilled shaft measurement in **highlighted** cells only.
2. Auto-calculated cells are in *italics*.
3. Foundation location is defined as the roadway direction and supporting structure (pier/abutment/etc.) that the shaft underlies.
4. Drilled Shaft No.'s are identified on the foundation plan sheets.
5. Depth measurements should be taken every 3' when cave-in potential is high, 6' intervals elsewhere.

Exhibit 609-3.03-1 Drilled Shaft Concrete Placement Chart

Down-the-Hole Inspections

Rarely the Project Plans or Special Provisions may require the inspector to make down-the-hole inspections of the soils or rock at the bottom of a drilled shaft. This is done usually for end-bearing type drilled shafts when underreaming is done. The goal is to positively check the firmness or solidity of the bearing stratum.

Down-the-hole inspections must comply with Subparts S of the Occupational Safety and Health Standards for the Construction Industry. Some of the safety precautions that must be undertaken include casing the hole from top to bottom, lowering the groundwater table in the vicinity of the shaft, pumping fresh air into the shaft, using safety lines, and providing for an observer.

Unsuitable Material

When unsuitable material is encountered, the Resident Engineer should be informed as soon as possible, and will then begin the process of evaluating whether further action needs to be taken. The Resident Engineer should work in concert with the project’s geotechnical engineer and bridge designer to come to the best solution. When the direction is given by the Resident Engineer to the contractor to drill further until suitable materials are reached, the bridge designer will need to confirm whether or not the drilled shafts reinforcing will need to be extended if this is the case, then the Department will be responsible for any additional compensation substantiated by the contractor.

609-3.04 Drilling Slurry

(A) General Requirements

Drilling with slurry is a highly complicated and inspection-intensive process. Drilling slurry should only be used as a last resort. If the contractor has to use drilling slurry, the installation plan submitted by the contractor should discuss in detail the methods, materials, and equipment used to drill with slurry. If slurry drilling is not included in the installation plan, then the plan must be amended in writing.

Mistakes made with drilling slurry can easily ruin a drilled shaft and seriously delay a project. The Department requires at least two full-time inspectors on any drilled shaft operation using drilling slurry. One inspector should inspect the drilled shaft activities that are normally monitored on any drilled shaft operation. The other inspector should be assigned to monitoring and testing the drilling slurry.

It is highly recommended that Chapter 6 of Drilled Shafts: Construction Procedures and Design Methods be reviewed by both the inspector and Resident Engineer before any drilling with slurry begins; Chapter 9 of the California Foundation Manual is also an excellent reference.

Drilling slurry mixtures

Drilling slurry is a mixture of water and finely dispersed clay. The clay is suspended in the water resulting in a heavier and more viscous fluid. Mineral slurries consist of water and either bentonite clay or attapulgite clay. Mineral slurries are difficult to dispose of and considered to be a pollutant.

There has been a trend in the industry to use synthetic or polymer-based drilling slurries. These types of slurry are easier to dispose of and less of an environmental hazard. These types of slurries must be pre-approved by the Geotechnical Section of Materials Group for use on ADOT projects.

How slurry works

Drilling slurry stabilizes a hole in two ways. First the heaviness of the liquid slurry exerts a positive hydrostatic pressure against the walls of the drilled shaft. This pressure keeps the surrounding soil from collapsing into the hole. The density of the slurry can be adjusted to increase or decrease the pressure as needed.

The second way drilling slurry stabilizes a hole is through the building up of a filter cake or mud cake on the walls of the shafts. The positive hydrostatic pressure forces some of the slurry particles into the surface voids of the surrounding soils. The slurry bonds to the soil forming a filter cake. The filter cake stiffens the soil through intergranular cohesion and seals the walls of the shaft. The looser soils have a thicker filter cake and the longer the slurry sits in the shaft the thicker the filter cake buildup is.

Once the hole is stabilized with slurry, drilling can continue. Fine sand and silt will become suspended in the slurry making it thick and very viscous. Periodic de-sanding of the slurry is needed to keep it fluid.

Equipment

During drilling the slurry is circulated between the hole and a slurry tank using pumps or an air lift pipe system. The slurry tank processes the slurry by removing the finer materials not picked up by the drilling tools. This process of de-sanding thins out the slurry by means of centrifugal pumps, screens, or settling tanks. The treatment process lowers the density, viscosity, and sand content of the slurry. Slurry needs to be thick enough to stabilize the hole, but thin enough to be displaced by the fluid concrete when the drilled shaft is poured. The contractor should verify that the slurry meets the specified density, viscosity, and sand content requirements before placing it back in the hole. The pH should also be checked and adjusted.

Drilling tools used with drilling slurry are not that much different than the tools used when the hole is dry. The drilling tools can be inserted and removed from the hole as long as the driller is careful to maintain a constant head of slurry in the hole and remove the tools slow enough to prevent any major caving due to suction.

Tools that do not flow smoothly through and around the drilling slurry can disturb the positive hydrostatic pressure exerted by the slurry against the shaft walls. Rapid pressure changes caused by lifting and lowering the tool can interrupt the pressure distribution. This piston effect can be so severe as to cause suction in the bottom of the hole as the tool is removed. The characteristic sucking sounds coming from the hole are a good indication to the inspector that something (slurry, drilling tool, drilling procedure) needs to be changed in order to reduce the risk of collapsing the hole. All drilling tools used with slurry must be vented to prevent suctioning of the hole.

Handling

During drilling, slurry needs to be cleaned periodically to allow drilling tools to move freely through the slurry without damaging the excavation. The frequency at which the slurry needs to be cleaned is determined by testing the slurry as specified in Subsection 609-3.02.

Excessive filter cake build up is one of the biggest dangers to using drilling slurries. Since skin-friction type shafts rely on the friction developed between soil and concrete, the slickness of the filter cake can severely reduce the capacity of the drilled shaft. Filter cake is not meant to be left in place during concrete placement.

Slurry left standing in a hole can begin to set up. This hardening is temporary until the slurry is agitated again. However the effects on the drilled shaft can be very detrimental. A thick membrane of filter cake will form on the sides of the hole when the slurry is allowed to stand for up to 24 hours. This thick membrane acts as a lubricant and significantly reduces the skin friction of the shaft. The solution to this problem is either, don’t allow the slurry to stand in the hole for more than 4 hours as required by the specifications or enlarge the hole to remove the filter cake at no additional cost to the Department.

The sand and silt removed from the slurry tank must be disposed of carefully. This material contains residual slurry that is still considered a water pollutant. It should not be placed in any hole or fill within the flood plain of a river or wash. The residual slurry can be removed through washing to allow a more convenient disposal of the material. However the wash water must then be disposed of properly.

Drilling slurry is considered a water pollutant and should be either recaptured for reuse or taken to an ADOT approved liquid waste disposal facility.

(B) Slurry Inspection and Testing

The contractor is responsible for sampling and testing the slurry under the observation of the Department. As mentioned previously, an inspector should be assigned to monitor the drilling slurry full time. The inspector should ensure that the contractor is using appropriate sampling and testing procedures for the drilling slurry.

The inspector should check:

- The sampling device to ensure it can obtain a sample of the slurry at any depth in the hole without contaminating the sample, see Drilled Shafts: Construction Procedures and Design Methods for equipment and methods of sampling slurry.
- The contractor’s testing procedures ensure they conform to the prescribed test methods for the testing equipment; written test methods are usually included with the testing equipment or can be obtained from the American Petroleum Institute.
- The contractor’s testing equipment to ensure it is both appropriate for the required test method and properly calibrated.
- The frequency at which the contractor samples and tests to ensure the slurry does not become excessively stiff or sandy.

Sampling procedures are the most important to check. The goal of the inspector should be to ensure that any sample of the slurry is representative of the slurry at the depth the sample was taken.

Slurry samples are tested for density using a mud balance, viscosity using a Marsh funnel, pH using litmus paper, and sand content using an API sand content kit. The specifications set upper and lower limits for density, viscosity, pH and sand content. It’s the inspectors job to ensure the contractor’s slurry stays within the range of values specified. Here’s why:

Density

For density, a lower limit is needed to stabilize the hole and prevent it from caving. On the other hand, slurries with too high a density can become unstable with respect to their ability to suspend solids. These solids could settle out during concrete placement causing voids and other defects.

Viscosity

Viscosity refers to the fluidity of the slurry, the higher the viscosity, the thicker the fluid. Viscosity controls how much sand can be suspended in the slurry. When the viscosity is too low, not enough sand is suspended in the slurry to improve the slurry density and hole stability. In addition, the slurry may be too thin to form a filter cake, which also stabilizes the hole. Too much viscosity allows too much sand to be suspended, which can throw off the allowable density and sand content values of the slurry. It also makes the drilling tools more difficult to remove from the hole without damaging the sides of the excavation.

pH

Slurries that have a pH value outside the specified range may not fully hydrate and develop the expected viscosity. During drilling, changes in pH can cause the slurry particles to lump together (flocculate) and settle out. No more filter cake will form to stabilize the walls of the hole and any suspended sand may begin to settle out as the viscosity decreases.

Sand Content

For sand content, an upper limit is set to prevent any sand from settling out during concrete placement. The upper limit also controls the amount of filter cake or mud cake as it is sometimes called, that can develop from the slurry on the walls of the hole. Too much filter cake reduces the load carrying capacity of skin-friction type drilled shafts.

The inspector should receive a copy of all test reports on drilling slurry and include them with the Drilled Shaft Inspection Report (see blank forms) for that hole.

609-3.05 Integrity Testing

The contractor is required to assist the Department in inspecting completed drilled shaft excavations for the correct depth, plumbness, and diameter. The inspector is free to use the drilling contractor's labor and equipment to make these checks. The contractor must also make the hole safe for the inspection work.

Drilled shafts that are constructed by the wet or slurry method require inspection tubes placed in them as shown in the Project Plans. When PVC tubes are used, it is recommended that the water in the tubes be changed 12 to 18 hours after completion of the concrete pour. Replacing the water with cooler water will help reduce the temperature rise in the shaft that can melt and distort the plastic tubes.

Gamma testing or cross-hole sonic logging performs integrity testing of the shaft. Both methods are to be performed by the contractor with the Department's oversight. A brief description of each method follows including the corresponding responsibilities of the Resident Engineer and the inspector.

Gamma Ray Testing

A radioactive probe is lowered into a dry inspection tube. Gamma ray emissions from the probe measure the density of the concrete directly adjacent to the tube. A counter records the number of radioactive particles reflected back towards the probe. The higher the count, the denser the concrete around the probe.

Counts are to be taken for at least 90 seconds at 3-foot intervals along each inspection tube. The spacing can be increased to 6 feet in areas of the shaft where the risk of soil intrusion is low e.g., inside a permanent casing. However the inspector has the right to request testing at any specific location and at any specific interval within the shaft where defects are suspected.

The counts for each tube are analyzed to determine the mean and the sample standard deviation, see Exhibit 609-3.05-1. Counts below the mean by more than three standard deviations are a good indication of a soil intrusion or poorly consolidated concrete around the inspection tube. When counts this low occur or when wide variations in standard deviations occur in adjacent tubes, the Resident Engineer should send the results to ADOT Geotechnical Section for further analysis.

The key to having meaningful results with the gamma ray probe is to take the measurements consistently. The 2.5 inch PVC tubes will provide the widest variations in reading especially if the tubes are warped due to the hydration heat from the concrete. Consistency is improved when:

- The concrete has had a chance to gain strength and cool to a uniform temperature; wait at least 3 days after the pour if possible.
- The tubes are straight, with no bend and no tight fits.
- The probe is positioned consistently in the tube; always in the center if possible.
- The readings in each shaft are all taken during the same day with the same standard count for the probe.
- A two inch black steel pipe is used for tubing instead of PVC.

Cross-Hole Sonic Logging (CSL)

Unlike gamma ray testing, which measures the density of the concrete within 2 to 4 inches of the inspection tube, cross-hole sonic logging measures the density of concrete between inspection tubes. Ultrasonic pulses are emitted from a probe and measured by a receiver in an adjacent tube. Sound travels faster in denser material and sound waves lose energy as they pass through softer or less dense material. These two characteristics are used to measure the integrity of concrete between each pair of tubes. Not only can the concrete between adjacent tubes be probed, but the concrete in the interior can be evaluated by placing the receiver probe in a tube diametrically opposite from the source probe.

GAMMA RAY TEST RESULTS

PROJECT: **IM-010-C(9), H4321-01C** DRILLED SHAFT: **WB6-9** APPROVED BY: **John Somebody** DATE: **4/1/01**

DEPTH	TUBE 1		TUBE 2		TUBE 3		TUBE 4		TUBE 5		TUBE 6		TUBE 7		TUBE 8	
(feet)	WD	%V	WD	%V	WD	%V	WD	%V	WD	%V	WD	%V	WD	%V	WD	%V
3.0	126.26	17.91	125.18	16.82												
6.0	124.13	17.52	123.42	19.36												
12.0	123.88	17.79	125.66	17.51												
18.0	126.48	18.32	125.38	17.32												
24.0	125.61	19.37	123.75	18.09												
27.0	124.17	17.45	127.19	18.67												
30.0	124.02	17.73	130.54	16.82												
33.0	123.82	18.26	122.04	18.37												
36.0	125.66	17.55	124.83	17.45												
39.0	132.77	17.09	120.64	17.38												
42.0	123.14	19.21	120.81	18.63												
45.0	126.13	16.96	123.22	16.21												
48.0	128.51	17.53	120.4	18.57												
51.0	127.44	17.81	123.28	18.7												
54.0	124.66	18.62	125.49	17.57												
57.0	129.15	17.52	129.93	17.66												
60.0	127.63	16.84	125.66	18.27												
63.0	128.55	16.33	127.83	18.13												
66.0	125.17	17.14	127.75	18.19												
69.0	129.4	18.85	128.08	18.6												
72.0	129.58	18.09	129.96	17.45												
75.0	128.88	17.14	129.55	16.16												
78.0	127.65	18.85	130.23	16.55												
81.0	129.12	18.09	134.14	17.23												
Mean	126.74	17.83	126.04	17.74												
Std. Dev.	2.44	0.77	3.57	0.85												
3xStd.Dev.	7.31	2.30	10.71	2.55												

Exhibit 609-3.05-1 Gamma Ray Test Results

Logging should be conducted at intervals of no less than 4 inches along each tube. Testing should be done with the source and emitter in adjacent tubes and at the same elevation. However the inspector has the right to request testing at any specific location, at any specific interval, and using any source/receiver arrangement within the shaft where defects are suspected.

Steel tubing is preferred over PVC tubing for cross-hole sonic logging, but is not mandatory. PVC tubes can debond from the surrounding concrete rendering the test useless in that part of the shaft. Where this occurs, the contractor will have to provide other means for testing the integrity of that portion of the shaft.

The results of cross-hole sonic logging are difficult to analyze and are beyond the scope of this manual. Test results from cross-hole sonic logging should be sent to the Geotechnical Section for analyses. The Geotechnical Section can also provide field guidance to the Resident Engineer and inspector as to what good test results should look like and when suspect results should be forwarded for review.

Coring

In the event that CSL or GGL testing cannot sufficiently provide enough information to determine the cause of the drilled shaft's anomaly further event investigation may be needed. In all cases where this is necessary the contractor shall submit an investigation plan to determine the cause of the anomaly. These investigations can range from hand digging in more shallow cases, but may need to be investigated via coring if mechanical or hand digging means will not sufficiently allow for proper investigation. Further information regarding coring can be found in the 609 standard specification.

609-3.06 Reinforcing Steel

Section 605 of this manual provides additional information on inspecting reinforcing steel that is applicable to this Subsection.

Rebar Cages

The Project Plans will show the reinforcing steel details for each group of drilled shafts. Shop drawings for the rebar cages should be produced in accordance with Subsection 605-3.01 and sent to the inspector for review. The inspector should compare the shop drawings and any bar lists with the Project Plans. Any changes in how bars are spliced or how longitudinal bars are terminated at the top or bottom of the cage should be brought to the attention of the Resident Engineer and the Structural Designer. Hooks on spiral or hoop bars should be checked to ensure a tremie or pump tube can move freely through the center of the rebar cage without getting caught on any protruding steel.

The shop drawings should be approved by the Resident Engineer before any rebar cages are fabricated. Fabrication is usually done at the project site close to the holes. The cages are built on the ground giving the inspector ample opportunity to observe the fabrication process. Rebar cages need to be checked for:

- Bar sizes and grades
- Proper bar spacing and bar lengths
- Adequate bar clearances
- Proper lap lengths for hoops, spirals, and straight bars; overall length and width
- Stiffness and stability for lifting
- Proper placement and securing of inspection tubes; when used

For safety or constructability reasons, the contractor may want to substitute welded splices or mechanical couplers for the lap splices shown in the Project Plans. These substitutions are permissible as long as they conform to Subsection 605-3.02. Any substitution should be at no cost to the Department. See Subsection 605-3.02 of this manual for a further discussion.

When mechanical splices are used, the inspector must use the manufacturer's instructions as a guide to inspecting the splicing operation.

When the cages are lifted, it is important for the inspector to look for any twisting or distortions that may have bent bars. High stress concentrations can develop in a drilled shaft when distorted cages are used. The inspector should closely examine the rebar cage as it is lowered into the hole. If the inspector notices significant bending or distortion of the bars that affects bar straightness, spiral pitch, bar spacing, or cage shape and diameter, the cage should be lifted from the hole and the bent bars replaced.

Drilled shafts can usually be deepened by up to 2 feet without having to extend the rebar cage; refer to the Project Plans.

Centering Devices

To construct a long lasting and durable drilled shaft, the rebar cage must be completely surrounded by an adequate cover of concrete; 3 inches is usually the minimum. Centering devices are used to keep the rebar cage properly aligned in the hole until the concrete is placed. Concrete rings and plastic wheels that clip onto the spiral or hoop reinforcing are the best type of centering device. As long as they can turn freely as the cage is lowered into the hole, they will minimize the amount of loose material that falls into the hole if the cage hits the side of the excavation. The wheels should have a maximum horizontal spacing of 90 degrees with the maximum vertical spacing between 10 to 15 feet depending on the stiffness of the rebar cage.

The steel hair-clip type of centering device is also acceptable as long as the steel is epoxy coated in accordance with Subsection 1003-5 and placed in accordance with Subsection 605-3.03. The epoxy coating is needed to prevent the establishment of a corrosion channel from the surrounding soil to the rebar cage. Certificates of Compliance for the epoxy coating are required.

Dobie blocks are not acceptable as centering devices except for shallow sign foundations and light foundations. When they come in contact with the sides of the excavation, the blocks often move out of position while knocking too much loose material into the excavation.

Cage Stiffeners

Rebar cages are built horizontally on the ground then lifted vertically for lowering into the hole. The cages themselves are long, slender, and flimsy. The process of lifting a cage to a vertical position can severely distort and bend portions of the rebar cage. To prevent this, contractors will place temporary stiffeners inside the rebar cage. Sometimes they are tied to the outside of the cage. Regardless of where they are placed, stiffeners shall be removed as the cage is lowered into the hole. Stiffeners can interfere with concrete placement especially when the concrete is allowed to free fall. Outside stiffeners can provide a corrosion channel from the ground to the rebar cage.

No tack welding of stiffeners to the rebar cage should be done unless the rebar cage is made of weldable reinforcing steel (ASTM A706 type).

Modifications Due to Overdrilling

If the contractor drills past the designed tip elevation of the drilled shaft and does not encounter any unsuitable material, then any additional remediation will be the responsibility of the contractor. If the contractor drills past the design tip elevation and unsuitable material is encountered, the previously mentioned steps for dealing with unsuitable material will need to be followed, and the contractor should be compensated for the additional work and materials per the contract.

609-3.07 Concrete Placement

(A) General

In Subsection 609-2.01 of this manual, it was stressed that drilled shaft concrete needs to be fluid. The more fluid the concrete, without risking segregation and strength loss, the better. Fluid concrete in the drilled shafts has the advantages of:

- Completely coating reinforcing steel without the need for vibration.
- Being able to fill any surface voids along the walls of the excavation.
- Exerting an enormous hydrostatic pressure against the walls of the excavation.

With some shafts as deep as 130 feet, it is extremely difficult to get a concrete vibrator deep enough to sufficiently vibrate the concrete around the rebar cage. Fluid concrete eliminates this problem, and this is governed by the slump loss test that the contractor must perform for drilled shaft concrete mixes. Regarding the maximum pour duration, the inspector should verify that the concrete placement duration does not exceed the elapsed time specified. If the concrete placement duration exceeds the elapsed time, the Resident Engineer shall be promptly notified and the placement of the drilled shaft shall continue to completion. Appropriate measures shall be taken to rectify the situation, if needed. The Resident Engineer may determine the need for further action or remedial work.

For skin-friction type drilled shafts, an irregular surface between the walls of the excavation and the concrete is highly desirable. Fluid concrete will fill in any voids along the walls of the excavation no matter how irregular. The resulting irregular surface will enhance the skin friction abilities of the shaft.

Perhaps the most important advantage of highly fluid concrete is the hydrostatic pressure it exerts against the walls of the excavation. The resulting hydrostatic pressure does several things.

First it pushes the concrete against the walls of the excavation. Not only does this help fill any surface voids, but it also compacts the surface materials. In other words, the drilled shaft concrete is pressure fitted against the sides of the excavation.

Second, the hydrostatic pressure removes any loosely held material along the walls of the excavation above the concrete surface. There is a squeezing action going on as the concrete rises. The fluid and dense concrete loosens any lighter material held above. The material falls on top of the concrete and floats there until the pour is completed. This is an important phenomenon that should not be ignored by the inspector. When drilling slurry is used, a filter cake is formed on the walls of the excavation. This cake is muddy and slippery. The fluid concrete removes this coating of filter cake eliminating any unexpected loss in skin friction due to the drilling slurry. The pressure also prevents any of the drilling slurry from mixing in with the fresh concrete.

Thus a very fluid concrete that doesn't segregate and has a long setting time is ideal for drilled shafts. Inspectors can ensure fluidity is maintained by taking many slump tests and regularly checking mixing time on the concrete tickets. When carefully controlled, adding water or a plasticizer to improve the slump is an acceptable field practice for drilled shafts.

(B) Placement in Dry Excavations

Having a clean hole is most important. The inspector must approve the cleanliness of the hole before any steel is placed or concrete poured. During concreting, the shaft needs to be inspected at frequent intervals to be sure that there is no caving of the walls and significant contamination of the concrete.

The best time to pour a drilled shaft is immediately after the hole is cleaned and accepted by the inspector. The rebar cage should be promptly set and the concrete poured immediately after that. This rapid sequence of events minimizes the chances of debris falling into the hole and contaminating the shaft.

In a dry hole the concrete can be placed by a concrete pump or using the chutes from the mixer trucks. There is no limit on the amount of free fall as long as the concrete does not hit anything, like the rebar cage, on the way down or scour the bottom or sides of the shaft. Any cage stiffeners or supports should be removed before pouring.

As the concrete rises to the top of the hole, loose materials such as sand, silt, and filter cake will ride on the surface. This material mixes with the top meter of concrete. The pour needs to be continued and the excess concrete spilled until the inspector observes fresh concrete that is relatively uncontaminated. There is no additional compensation to the contractor when extra concrete has to be added to the hole in order to expel contaminated concrete already placed.

Regardless of how fluid the concrete looks, the top 10 feet of concrete poured in a dry hole and the top 5 feet poured in a wet hole needs to be vibrated, but only after all water, slurry, and contaminated material has been removed. These areas are the most likely to have voids around the steel since they do not benefit from any hydrostatic pressure exerted from concrete above.

(C) Placement under Slurry or Water

When concrete is placed in water or slurry, the concrete needs to be placed the same day as the excavation is completed. This reduces the risk of a major soil collapse if the hole is left open too long.

When placing concrete in the water- or slurry-filled shaft, a tremie is used to deliver the concrete to the bottom of the shaft. The tremie cannot be made of aluminum since aluminum reacts adversely with fresh concrete.

The purpose of the tremie is to keep the fluid concrete from mixing with the water or slurry in the hole and to deliver the concrete to the bottom of the shaft in an uncontaminated state. A valve, sealable cap, or plug is placed in the tremie tube to prevent water or slurry from entering.

The keys to successful concrete placement with a tremie include:

- The initial placement of the tremie at the bottom of the tube should be in the range of 2 to 12 inches from the bottom of the hole.
- There should be a quick, uninterrupted, initial flow of concrete that buries the tip of the tremie in at least 5 feet of fresh concrete.
- There should always be a head of concrete in the tremie tube itself of at least 4 feet higher than the surface of the slurry or water.
- The concrete must have a slump of at least 7 inches with no segregation and no cement balls.
- Lifting the tremie as the concrete rises prevents segregation, but be especially careful to monitor the depth of the concrete versus the depth of the tremie so that there is never any chance that the end of the tremie will pull out of the fresh concrete.

Strict adherence to these practices will prevent the concrete from mixing with the water or slurry in the hole, the primary objective of pouring with a tremie.

If everything works properly, the concrete cleans the slurry off the reinforcing as it rises up the shaft. The top layer of concrete catches any slough or filter cake from the sides of the shaft. The pumping continues after the concrete reaches the top of the shaft until all the contaminated concrete has been ejected.

When pumping off the ejected slurry, especially when the top of the shaft has been widened appreciably, care must be taken to not allow the water to flow fast enough to wash cement and fines from the concrete.

609-3.08 Casing Removal

Temporary Casing

Temporary casing functions as a means for keeping a hole opened while it is excavated and filled with concrete. It can also be used as a means for stabilizing ground around the excavation to reduce the amount of overbreak (extra concrete) or as a safety barrier for people working in and around the excavation. Temporary casing is usually made of smooth rolled steel plates.

Permanent casing reduces the skin friction developed between the shaft and the surrounding soil to zero. This is why temporary casing needs to be removed and any casing left by the contractor needs the prior approval of the Foundation Designer. If there is a loss in drilled shaft capacity due to casing left in the hole, the contractor is responsible for placing additional drilled shafts and altering the substructure as necessary to meet the load carrying requirements of the foundation.

Drilling contractors and the Department do not like to leave temporary casings in a completed drilled shaft. Drilling contractors have to buy a replacement casing and the Department then has to determine whether the temporary casing reduces skin friction around the shaft sufficiently enough to warrant remedial actions.

In order to encourage a win-win outcome with temporary casing, inspectors should examine temporary casing for any characteristics that would cause them to get stuck in the hole. This could include accumulations of mud or dried concrete, imperfections on the casing surface, too much rust, or anything that detracts from the smooth, clean appearance that a temporary casing should have.

Sometimes temporary casing is telescoped. This means a large surface casing is above a smaller subsurface casing which may be above a deeper and smaller temporary casing. There is usually overlap between these casings, sometimes to 6 feet in length. The material in the overlap between the casings is usually loose soil or slurry. When the shaft concrete is poured, the smaller casing needs to get pulled before the concrete reaches the top of that casing. If this is not done, concrete will spill over and fall into the gap between the smaller and larger casing. The concrete then mixes with the loose soil or slurry between the two casings, forming a permanent zone of weakness in the shaft. This can render the shaft defective.

Casing Removal

- When removing casing during a concrete pour, the inspector needs to keep four points in mind:
- There must be at least 5 feet of concrete head in the tremie pipe above the surface of the concrete as the casing is being removed; except near the top of the shaft.
- The concrete surface must always be at least 5 feet above the bottom of the casing as the casing is being removed.
- The slump of the concrete must be at least 4 inches.
- The casing should be slowly removed from the hole to prevent an upward movement of the concrete and the rebar cage.

The first two points ensure that there is at least 10 feet of concrete head pressure at the bottom of the casing. Head pressure is needed to keep soil, water, or slurry from mixing with the concrete that discharges from the bottom of the casing as the casing is pulled.

When deep casing is used (30 feet or more), the hydrostatic pressure exerted by water or slurry in the excavation can be substantial. The 10 feet of concrete head required by the Standard Specifications may be insufficient to offset the pressure exerted by the water or slurry. The minimum head requirements as the casing is pulled should be increased by the Resident Engineer based on the following formula:

Minimum Total Concrete Head (feet) =

$$\frac{4 \times \text{total slurry or water head outside of casing (feet)} \times \text{density of water or slurry (lb/cf)}}{\text{Density of concrete (lb/cf)}}$$

or,

Minimum Total Concrete Head (meters) =

$$\frac{1.2 \times \text{total slurry or water head outside of casing (m)} \times \text{density of water or slurry (kg/m}^3\text{)}}{\text{Density of concrete (kg/m}^3\text{)}}$$

The concrete head and water or slurry head are both measured from the bottom of the casing.

Slump is another important concrete property that must be closely monitored when a casing is pulled. If the contractor waits too long to pull the casing and the concrete begins to lose slump, three things can happen:

1. The concrete sets up enough such that the casing cannot be removed.
2. The concrete sets and comes up with the casing; usually lifting and twisting the rebar cage out of position.
3. The concrete cannot expand sufficiently enough to fill the voids and exert a positive pressure against the walls of the excavation.

Any one of these is potentially devastating to the integrity of the drilled shaft. Inspectors must keep a close eye on slump and set time for the concrete that is already down in the hole. The contractor can use super-plasticizers and retarders when the concrete is batched to provide more flexibility on when the casing needs to be removed.

Even when there is sufficient concrete head in the casing and the slump is okay, the contractor must still be careful in how the casing is removed. Problems with casing removal have produced the largest number and worst type of drilled shaft defects. The inspector should closely monitor casing removal for any upward movement or racking of the rebar cage. A level with a target placed on the cage can be used to measure movement. However this can only be done before and after removal of the casing.

Monitoring rebar cage movement during actual casing removal is extremely difficult. The inspector can monitor the position of the crane jib holding the cage for some signs of cage movement. However the best thing for the inspector to do is ensure that good casing removal techniques such as slow withdrawal, vibration assistance, casing tapping are used. Casing removal is a topic that must be thoroughly discussed at any drilled shaft pre-activity meeting and should be included in the contractor's installation plan.

609-4 & 5 Method of Measurement & Basis of Payment

Drilled shafts are not usually part of a lump sum structure, but paid separately on a linear foot basis for the actual length placed. Drilled shafts may be extended up to 2 feet without having to lengthen the rebar cage.

When drilled shafts are shortened and the contractor has to cut the rebar cage, the Department will purchase the wasted rebar from the contractor under the provisions of Subsection 109.04. Labor and equipment used for assembling that portion of the wasted rebar cage can also be included. The rebar becomes the property of the Department and should be disposed of in accordance with Subsection 603-3.04 of this manual.

Drilled Shaft Over Excavation Payment

For contractor payments associated with Engineer directed over excavation of drilled shafts, reference Exhibit 609-4&5-1

Rock Sockets

Under Subsection 609-3.01 Soil Identification, establishes the procedure for determining when bedrock has been reached for rock socket purposes. The following attempts to more narrowly define the top of rock socket elevation for payment purposes.

Rock sockets, when specified and paid for separately, are measured from the top of bedrock elevation to the bottom of the shaft. The question that invariably arises on each project is, where exactly does the bedrock begin? When highly fissured or decomposed rock many meters deep lies on top of bedrock, the boundary can become obscured.

In Subsection 609-6.01 of this manual, the Geotechnical Engineer for the project makes the initial determination in the field when suitable bedrock is reached. The Resident Engineer or the inspector then makes subsequent determinations and contact the Geotechnical Engineer only when there are bedrock identification problems. For payment purposes, the Department considers the top of the rock socket to be the elevation at which suitable bedrock is reached. This means regardless of the difficulty the drilling contractor has in reaching suitable bedrock, the separate measurement for rock sockets does not begin until a suitable rock has been reached.

Here is a procedure the inspectors should use for determining the elevation at which the rock socket begins:

1. As the contractor advances the hole, fractured and decomposed rock will begin showing up on the auger flights. When the auger trimmings contain predominantly rock fractured by the auger; 80% or more, then this is a good indication that the top of the rock socket has been reached. If the rock is hard, a rock auger may be needed to fracture the rock. Rock fractured by drilling tools will have sharp edges and fractured faces that look fresh. Decomposed rock will have rounded edges with dull fractured faces. The inspector should observe a corresponding increase in both engine noise and amount of down pressure (crowd) applied to the auger.
2. When the inspector is convinced based on the auger trimmings that the rock formation is suitable to begin the rock socket, the inspector should measure and record the depth of the hole. The Inspector can adjust the elevation upward if the auger has clearly penetrated into suitable rock before the depth measurement is made.
3. From this point on, drilling begins for payment under the rock socket item. The inspector should measure and record the bottom of rock socket elevation, then check the rock socket length to ensure it meets the minimum shown on the Project Plans.

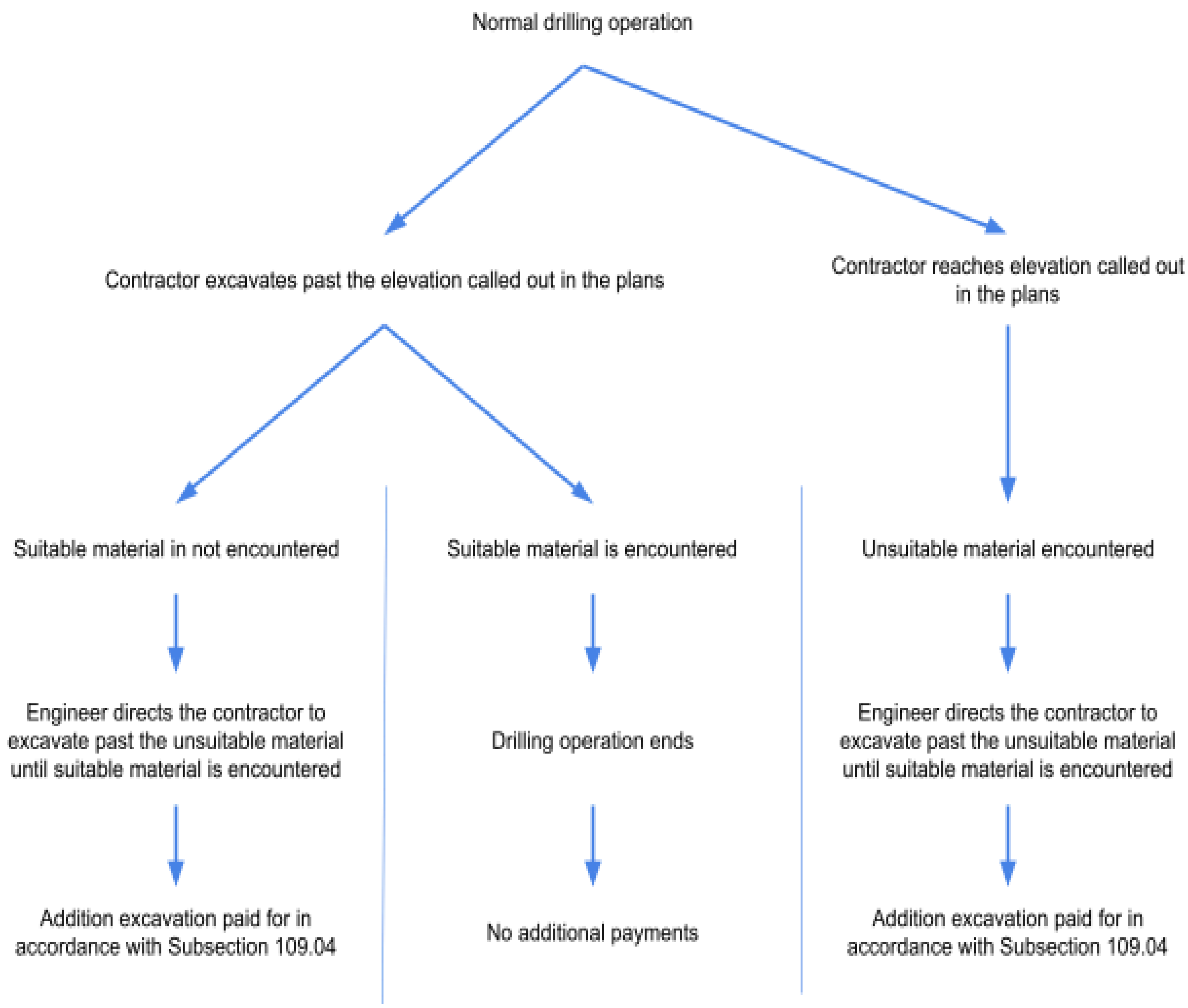


Exhibit 609-4&5-1 Drilled Shaft Over Excavation

610 PAINTING

Structures are painted to improve their visual appearance. Paint that chips and peels in a year or two detracts from the visual appearance of a structure. Of course, this defeats the purpose of painting in the first place. The intent of this section is to give the inspector the basic knowledge of what constitutes a good, long-lasting paint job.

Painting Concrete

Concrete paint is a surface treatment. Water-based acrylic paints are used to color a concrete surface. Concrete stain, on the other hand, penetrates into the surface of the concrete. Concrete stains cannot be used in Arizona because of the solvent emissions that occur when the stain dries. However, from a maintenance standpoint, stains are preferable over paint because they are less likely to peel and chip after prolonged exposure.

Inspectors can ensure a good paint job by adhering to a few fundamental practices of painting:

- ADOT specifies high quality paint; inspectors should ensure through sampling and proper paperwork that materials used meet or exceed the Standard Specifications.
- Focus on surface preparation; paint adhesion is as much a function of how well the surface is prepared as the quality of the paint, careful inspection of the prepared surface is important.
- Follow the manufacturer's recommendations closely, this includes humidity, temperature, and wind requirements.
- Apply in thin, even coats; two thin coats are better than one thick coat.

Application

The contractor must develop an Application Plan for painting concrete surfaces in accordance with the manufacturer's written recommendations.

The Plan must include:

- Rate of application
- Number of necessary coats; minimum of 2
- Ambient air temperature
- Application equipment
- Qualification of workers
- Safety and damage protection
- Proposed surface preparation

The contractor and Resident Engineer or inspector should discuss which concrete surfaces require paint. Several factors such as type of bridge, posted speed, view from vehicular and pedestrian traffic must be considered. Project Plans may have specific requirements in addition to the general requirements contained in Subsection 610-3.05(B) of the Standard Specifications.

Materials

One thing the Resident Engineer or the inspector needs to do before the paint is ordered is to ensure the contractor knows the right color type. Sometimes the Special Provisions give the contractor a color option or leave the color type unspecified. Either way, an agreement between the Department and the contractor should be reached on the color type before the paint is ordered.

Paint for concrete must be pre-approved by ADOT Materials Group before use. ADOT's Approved Products List contains all pre-approved paint and stains. Pre-approved paints still need to be sampled and tested before application. This is best done when the preliminary or final sample test sections are coated. The inspector samples the paint at the project site and sends a sample to the Materials Group's Structural Materials Testing Section for testing.

Inspectors should carefully note the lot number on the sample ticket to ensure it is the same as:

- On the sample container drum
- On the Certificate of Compliance
- On any paint containers shipped to the project site in the future

Any paint that arrives on the project that does not have the same lot number as paint previously sampled and tested should be sampled and sent to Materials Group.

Surface Preparation

The greatest impact the inspector can have on getting a good paint job is the attention paid to surface preparation. The Department requires all painted concrete surfaces to be sandblasted prior to application. The cleaned surface should have a roughened textured appearance consistent with the surrounding concrete surface. Any additional preparation of the surface washing or rinsing in accordance with the manufacturer's recommendations then follows. Concrete surfaces must be thoroughly dry and free of dust at the time paint is applied. The inspector must have a copy of the recommendations and Application Plan during the preparation process.

The inspector should recognize what constitutes good surface preparation. Consult with the paint manufacturer's representative if you are unsure of what an acceptably prepared surface should look like.

Protection

Before painting begins, talk to the painting subcontractor about the safety precautions that need to be taken around the paint. Safety Data Sheets (SDS) should be available to you and the painters at the project site. Personal protective equipment such as goggles, face shields, and a respirator mask may be needed for some paints. Stains that contain solvents need to be used in a well-ventilated area, see product SDS.

Also discuss with the contractor how adjacent areas will be protected from paint spray and splashes. When painting near traffic, a means of protecting passing vehicles from airborne paint will be required.

Test Panels

The contractor must provide a preliminary test panel of concrete with the paint already applied. This sample can be part of the actual surface to be painted as long as any unacceptable paint can be easily removed without marring or disfiguring the surface.

Once the preliminary test panels have been approved, a final test panel on the actual surface should be done. Be careful where you locate the test panels. Use an area that is the least visible to the public. That way if the surface appearance cannot be properly restored, any uncorrectable mistakes won't be as noticeable.

The Resident Engineer is free to streamline this process if the painting subcontractor has recent experience (last 6 months) using the identical paint on another ADOT project. For example, the Resident Engineer could omit the preliminary test panel and go right to the final test panel.

The Resident Engineer and any other project stakeholder concerned about the color should inspect test panels. This would include any local officials, Bridge Designers, or landscape architects associated with the project

Sampling and Testing

Paint must be sampled in accordance with the Sampling Guide. At least one peeling and flaking test must be done per project.

The product must be approved before it is applied to any permanent surface.

Peeling and flaking testing must be done on all test panels after any required observation period. The Structures Materials Testing Section of Materials Group has the proper equipment to perform peeling and flaking testing. The field offices can either borrow the equipment or have a technician from Materials Group perform the test.

Painting Steel

Painting of structural steel serves two purposes. The primary function of paint application is to prolong the life of the metal by means of a continuous film or coating which will mechanically seal the surface against corrosion. The secondary function is to produce and maintain a pleasing appearance.

Material

The materials used in painting must conform to Specification 1002 and either be listed on ADOT's Approved Products List or pre-approved by Materials Group. Manufacturer's certificates of analysis shall be furnished as required by the Standard Specifications and samples shall be taken in accordance with the Special Provisions or the Sampling Guide Schedule.

Inspection

Steel is normally cleaned of all dirt, grease, rust, and mill scale by profile blasting in the fabricator's shop. Then a coat of primer paint is promptly applied. The primer will serve as a rust inhibitor but is easily scarred during handling, transporting, and erecting the steel. After the steel has been erected, the areas where the prime coat has been damaged or is otherwise defective should be cleaned and given another coat of primer.

After all the necessary spot priming has been done and the primer has dried, the intermediate (first) field coat of paint may be applied. Before painting in the field, the surfaces must be dry. Morning dew and high humidity conditions are to be avoided when painting. Wind will not only result in dirt and other undesirable material being blown onto fresh paint but coverage may be uneven or paint may be blown onto surfaces that are not intended to be painted.

Care should be exercised by the painters in order for paint to not be accidentally applied or blown onto passing vehicles or parts of the structure not to be painted. It may be necessary to apply paint by brush on some areas of the steel.

It is not possible to get a good durable paint film that will protect and preserve the metal and also provide an attractive structure unless a thorough job of cleaning and preparation has been done. Imperfections, such as runs or sags in the shop coat, cannot be covered up with the field coats so it is imperative that the inspector insist on proper cleaning and correction of defects prior to the application of the first field coat.

In applying paint with a spray gun, the gun should be held perpendicular to the surface and the trigger released at the end of each stroke. All runs or sags should be brushed out immediately.

The Standard Specifications require each coat, including the shop primer coat, intermediate (first) field coat, and top (second) field coat to have a minimum thickness of 2.0 mils. The inspector should check areas such as the edges of beams, bolt heads, and the like for compliance with this specification, as these are the areas where the paint film is likely to be thinnest. These checks should be documented.

An instrument for measuring paint thickness (micrometer) may be obtained from the Materials Group's Structural Materials Testing Section. The Society for Protective Coatings (SSPC) has developed a specification (SSPC-PA 2) that ADOT uses for measuring paint thickness with a micrometer. A copy of this specification is available from Materials Group.

Some inspection points for painting steel include:

- Are the necessary personal protective equipment and safety devices available and being properly used?
- If paint had not received prior approval, have samples been obtained by the project personnel, submitted to Materials Group, and approved by Materials Group prior to use?
- Has the paint been formulated and mixed in accordance with Section 1002 and the manufacturer's recommendations?
- Has the surface to be painted been thoroughly cleaned of rust, loose mill scale, dirt, oil, or grease and all foreign substances?
- Is the metal dry and free of frost; are atmospheric conditions satisfactory?
- Is the temperature above 40° F at time of application?
- Are proper precautions taken to protect both vehicular and pedestrian traffic from spotting?
- Is paint being applied in a smooth and uniform manner so that no excess paint will collect at any point?
- After paint is applied, are there runs or thin areas? If runs occur, are they sanded out and the area repainted?
- Has the paint thickness been checked with a micrometer?

701 MAINTENANCE AND PROTECTION OF TRAFFIC

701-1 Description

One of ADOT's primary goals for any construction project is the safe and efficient handling of traffic through and around construction zones with as little inconvenience and delay as possible. The constant watchfulness by the Resident Engineer (RE) and all inspection personnel is necessary to accomplish this goal. The highest concern should always be the safety of the public, workers, and Inspectors. The convenience of the Contractor is never to be placed above safety when planning or approving traffic control. Safety to the general public, mitigation of economic loss as a result of delays, and good public relations are the benefits of diligent, intelligent traffic handling.

Often a traffic control plan will appear in the Project Plans. The Inspector must evaluate the traffic plan based on the conditions found at the work site. The Inspector or Resident Engineer can have the plan reviewed by the Regional Traffic Engineer when a second opinion is needed. During the project, the contractor's and ADOT's traffic control representatives shall have a current copy of the approved traffic control plan.

Usually traffic handling needs will depend on the way the Contractor chooses to construct the project. As a result, it may be necessary to plan the traffic control to fit the construction sequencing. The Contractor and ADOT's field staff can use their ingenuity to reduce traffic control clutter, confusion, and cost. An example of this may be to use painted traffic control delineation rather than vertical panels.

MUTCD references in this section refer to the adopted editions of both the Manual on Uniform Traffic Control Devices (MUTCD) and the Arizona Supplement to the Manual on Uniform Traffic Control Devices.

Detours

In a construction zone that carries considerable traffic, it is often preferable to provide a route which will take the traffic around the construction zone. When detours are practical but no detour plans are included, or when the detour plans provided must be modified, it may be necessary for the Contractor and the Resident Engineer to take the initiative to design the detour. If the Contractor is proposing a detour as part of his traffic control, the complete design of the detour would be the Contractor's responsibility. It is usually necessary to obtain local government approval when city streets are used for detours.

It is desirable that both ends of the detour are visible to approaching motorists. Transitions should not be in close proximity to horizontal or vertical curves, structures, or any obstruction which would interfere with the motorist's view of the transition. One ideal situation is to locate entering transitions on far sides of sag vertical curves so that the complete detour is visible (like a huge map) to the motorists. Detour plans call for a great deal of thought, planning, and on-the ground investigation. Plans for detours should be drawn to include the applicable standards and submitted for the approval of the Regional Traffic Engineer. Add that detours shall be constructed (if needed) in accordance with chapter 2 etc.

Speed Limits

The District Engineer has the authority to change the legal speed limits in construction work zones. Speed limits should be reduced only to the minimum amount necessary and in 10 mile per hour increments, to ensure safe conditions for drivers and workers. Traffic passing through a construction work zone is not a legitimate reason in itself for reducing speeds. Furthermore, speed limits should not be reduced when no hazards or work activities are present.

Flagging

Both the Resident Engineer and the Contractor should be aware that flagging for haul vehicles is set up to reduce the hazard to street traffic caused by crossing vehicles. Although the street traffic is better protected from haul traffic when the street traffic is stopped, there is an inherent risk of motor vehicle accidents when frequently stopping traffic. As a result, the flaggers must be instructed not to stop street traffic for any non-haul vehicles. Non-haul vehicles can cross during the first available gap. Fewer traffic breaks mean a safer cross haul operation. Street traffic stopped for an equipment crossing is more vulnerable to an accident if they have not been warned. Proper warning is of benefit to both the street traffic and the Contractor. No traffic should be stopped until approved warning signs are in place, and warning signs must be removed if no hauling/crossing is in progress. Certifications are needed for the civilian flaggers and must be verified on the American Traffic Safety Services Association (ATSSA) website.

Traffic Control Documentation

The courts have made it clear that liability will follow if written standards and requirements for traffic control are not followed faithfully. This not only means that the placement of traffic control devices must be correct, but also that the size, physical condition, cleanliness, and every other requirement must be met.

Good records of traffic control facilities will include:

- Dates and times of day that inspections are made
- Statement of conditions found
- Complete listing of type, size, and location of devices
- Orders to the Contractor to make changes or corrections
- Time and date that devices are removed or modified
- Photographs
- Comments explaining any variations from standard procedures

Additionally, it is a good practice to videotape the project traffic control following the initial setup and periodically thereafter. Remember, although traffic control is the responsibility of the Contractor, the State may also incur liability due to its action or inaction. Photographs of accidents are all too often of the accident vehicles themselves. ADOT personnel must develop the habit of photographing all the approaches to the accident site, photographing the signs and conditions on the approaches, and photographing a view backwards along the vehicle paths. As with all photographic and video documentation, the photographs and videos must be logged, referred to in the diary, and filed with the project records. Inspectors must document facts, comments, and observations of the accident, but must be careful not to express individual opinions.

Inspection Guidelines for Traffic Control

- Have traffic control representatives been appointed by the Contractor and the State?
- Is traffic being controlled in accordance with the specifications, special provisions, the ADOT Temporary Traffic Control Design Guidelines and the MUTCD? Are all local regulations being followed?
- Are flaggers properly outfitted with hard hats and either international orange shirts or vests during daylight hours? Are reflective vests and illumination utilized during poor light?
- Are flaggers properly equipped and trained in conformance to the ADOT Temporary Traffic Control Design Guidelines and the MUTCD?
- If traffic delay has caused a long line of waiting vehicles, are two flaggers being used for each direction of traffic movement (one at the head and one at the tail)?
- Is traffic being stopped for haul vehicles only?
- Are flaggers informing the public of the reason for the delay and instructing them to stay in line and not pass the vehicle ahead while within the controlled traffic section?
- Are pilot cars being used when required?
- Are the necessary signs being used, and do they conform to the requirements of the ADOT Temporary Traffic Control Design Guidelines and the MUTCD?
- Are devices being maintained in a clean and legible condition?
- Are signs being installed only when needed and promptly removed or covered when the traffic control setup is taken down?

- When any type of closure or detour of the traveled way has been made, has all conflicting signing and striping that might mislead the traveling public been covered or obliterated?
- Are there any rough spots, loose material, or surprise hazards in the detour or construction zone that should be repaired or more adequately signed?
- Is the Contractor making repairs and checks on their own initiative? Are they ignoring needed work until informed that it must be done? (Document this.)
- If a detour is not paved, is adequate dust palliative being applied for the safety and convenience of the motorists? Is it adequate to prevent a nuisance to residents or a hazard to crops in the area?

701-2 Materials (Equipment, Workers, Devices, and Facilities)

701-2.01(B)(1) Safety

The Specifications require the contractor to have reports which verify that certain devices meet a specified criteria. Copies of such reports shall be kept in project files and accessible to the project supervisor and inspectors, payment can be withheld for items that do not have required documentation.

701-2.02 Flashing Arrow Panels

The MUTCD refers to a number of performance values for arrow displays or flashing arrow panels that are not easily verifiable in the field. To document such things as candlepower, dimming range, beam spread, etc.; the Inspector can find this information in the manufacturer's literature which can be obtained from the Contractor. Arrow-boards are not to be used as substitutes for signs, barricades, or other devices, but rather as supplemental devices. Arrow boards should be in good condition, have reliable components, and must not leak lubricants or fuel, both of which are hazardous and detrimental to the pavement. The Contractor will be required to repair any damage caused by the equipment. Diesel generators on arrow-boards are preferred over gasoline generators because diesel generators have a lesser risk of explosion or fire from an impact to the fuel tank.

701-3 Construction Requirements

701-3.01 General

The specifications require that the Contractor provide an employee qualified to implement, monitor, and modify the traffic control plans associated with the project. This employee's name and the means to contact him in the event of an emergency shall be provided to the Resident Engineer at the Preconstruction Conference.

The Resident Engineer should designate a Department employee who will be responsible to monitor the traffic control and ensure that traffic is handled safely and efficiently.

The Standard Specifications allow the Resident Engineer to either suspend the work or have traffic control measures performed by others, at the Contractor's expense, in case of serious or willful disregard for the safety of the public or construction personnel. The Resident Engineer should allow the Contractor every opportunity to take corrective measures prior to taking such action. If it becomes necessary for the Resident Engineer to take action, the actions should be discussed in advance with the District Engineer unless public safety is seriously at risk.

701-3.02 Maintenance and Protection of Traffic

Inspectors and Field Engineers must make sure that the traffic control is maintained in the original condition. Items such as dirty barricades and lights must be cleaned. Flags that have faded from their "International Orange" color must be replaced. Obscured striping must be exposed. Dirt and stones on the roadway must be removed. A good guide for inspection is the ATSSA Quality Standards for Work Zone Traffic Control Devices.

Traffic control features must be installed in strict conformance with the MUTCD and the ADOT Temporary Traffic Control Design Guidelines to enhance safety through consistency and to reduce the risk of liability for both the

Contractor and the State. Given the increase in litigation involved with traffic control, all parties must realize that hasty, undocumented changes of traffic control will increase the legal liability for everyone. Major modifications to the traffic control plans should be reviewed and approved by the Designer prior to implementation. Changes must never be made by personnel not trained in traffic control planning and implementation.

Should a local agency be involved with the project, the Resident Engineer is advised to meet with that local agency to get their interpretation, coordination, and approval for traffic control.

701-3.03 Temporary Concrete Barrier

Construction and installation drawings for concrete barriers are shown in the Project Plans or Standard Drawings. A review of the placement location should be made to ensure the barrier placement allows for drainage.

In order to function as designed, the barrier run must be a reasonably rigid structure. Barrier sections can be "stretched" after pinning to take up any slack in the pin connection. The foundation must be solid and uniform. The flare at the end of the barrier runs must not be installed on top of a curb and gutter. The curb and gutter must be removed to ensure that errant vehicles will not be launched over or into the barrier.

In some cases where a barrier is placed close to a vertical drop-off, it may be desirable to place steel pins at the backside of the barrier to prevent movement when impacted.

Some barrier sections have holes for pins. If pins are driven through the holes on the front face, the pins must not protrude above the front face of the barrier. The barrier sections must have uniform bearing on firm material to function properly. Styrofoam sheets are usually placed under the ends of barrier sections to provide uniform contact pressure when barriers are set on hard surfaces such as pavements.

All previously used barriers should be carefully inspected for badly chipped or cracked areas. Any badly damaged sections should be rejected. Delineation must be placed at proper intervals along the barrier. The barrier must meet the requirements of Signing and Marking Standard Drawing C-3.

End treatments for temporary concrete barriers are either impact attenuation or flared end. The criteria for selecting an end treatment is based on using an end treatment that will give the best protection for the least cost under the given conditions. The first criteria for use of an end treatment should be safety, not convenience or cost.

701-3.04 Temporary Impact Attenuation Devices

Two types of attenuation devices are commonly used by ADOT, an energy absorbing terminal and sand barrels crash cushion.

The energy absorbing terminal is more complicated than sand barrels but is more compact, and can be used where it is important to save space.

The Inspector should obtain a copy of the assembly diagrams and instructions for the installation inspection. The Inspector should see that the replacement parts package is properly stored in a convenient location; the package contains all the necessary parts; and any parts used are replaced in the package. The Standard Specifications require that a complete replacement package be on the project at all times whenever an energy absorbing terminal is being used.

Repair or replacement of an energy absorbing terminal should begin immediately after the damage occurs. When damage occurs at night or during severe weather, the repair or replacement should not be delayed longer than the next day. The Resident Engineer must use some judgment to decide whether a damaged attenuator needs only extra warning signs until normal Contractor personnel are available, or whether to call the Contractor and reimburse him or her premium overtime for immediate repair.

In either case, an attempt must be made to retrieve the money spent to repair the device. Following completion of the repairs, the costs should be calculated by the Resident Engineer and all related documentation forwarded to Risk Management for insurance recovery.

Energy absorbing terminal devices are anchored to the road surface by bolting them to a concrete slab or by pins when placed on asphaltic concrete. Whichever method of anchoring the device is used, the manufacturer's recommendations are to be followed exactly. Never permit improper installation of safety devices. Escalate the issue to the District level if necessary. If the devices are not installed properly, the facts are to be documented and the Contractor must be notified in writing.

Although the installation of sand barrels is not complicated, it is still important that erection instructions are followed carefully, and materials used to fill the barrels are in compliance with subsection 702-2.03. The foundation must be uniform, the correct interior parts must be used, and barrels containing the right amount of dry sand at each location are to be placed in the specified geometric pattern. If sand barrels are installed above 3,000 ft elevation, the sand shall be thoroughly mixed with a minimum of 5% (by weight) rock salt. All of the above precautions need to be rechecked carefully during repair of damaged installations. Barrel material should either be pre-certified by the Structural Materials Testing Section or the material must be sampled and tested. If rock salt is to be used, a sample of both the sand and the sand-rock salt mixture are required.

Sand barrels should not be installed and forgotten. They are subject to vandalism, so they should be checked periodically.

701-3.05 Temporary Pavement Markings (Application)

The most commonly used temporary pavement markings are raised markers, paint, and reflective tape. Unless the surveying is done by ADOT, the Contractor is to perform the basic layout.

Control points must be set at a frequency and accuracy that encourages the striping to be placed with uniform, eye-pleasing alignment (normally accomplished in 50-foot intervals). There are no placement tolerances for temporary marking, but this should not be used as an excuse for accepting poor workmanship. It is important for the Inspector to meet with the Contractor's representatives to agree on placement tolerances before any striping work is started.

The first option for temporary pavement marking should be paint since it is less expensive than tape or raised pavement markers. When applying paint as a temporary pavement marking, it should be applied as if it were permanent. Ensure that the correct width, thickness, and bead content are achieved. See Section 708 for requirements of Temporary Pavement Markings paint.

When striping with plastic tape, it is sometimes possible to correct the alignment by pulling it up and replacing it, provided that this is done before it has become firmly stuck. The activator used to enhance the adhesive properties in cool weather may help to restore stickiness to the adhesive when the tape has been pulled up.

Delineators and markers used for temporary traffic control may be reused as permanent devices if they are undamaged or if slight damage is adequately repaired. There is no obligation on the part of ADOT to allow the reuse of pavement-marking materials that are not in first-class condition.

Temporary Pavement Marking Procedures

The ADOT Temporary Traffic Control Design Guidelines describes ADOT’s policy on temporary striping and temporary pavement markings as they apply to construction work. The Department does require some type of pavement markings to be in place before any section of roadway is opened to traffic. Traffic should not be allowed to run on unmarked pavement.

Permanent pavement markings should be placed as soon as possible. Temporary pavement marking should only be used when weather conditions, scheduling conflicts, or unfinished construction prohibit the placement of the permanent pavement markings.

Use Type II (Temporary-Removal) preformed pavement markings if eventual removal is required. Use Type III (Temporary-Nonremovable) preformed pavement markings, and/or temporary marking paint when removal of markings is not required. For example; Type III preformed pavement markings could be placed on the lower AC lift surfaces, then Type II placed on top of the ACFC, or chip seal surface. The Type II temporary markings would be removed just prior to application of permanent markings.

A 4-foot centerline stripe placed at 40-foot intervals must be used for intermediate lifts of overlays. Temporary pavement markers placed in accordance with Standard Signing and Marking Drawing M-20 should be used for temporary pavement markings on chip seal projects. On freeways and interstate highways only temporary painted stripes should be used to delineate lane lines and centerlines. For severe curves, a 2-foot stripe placed at 20-foot intervals should be used.

Temporary pavement markings should be used for delineation instead of barricades when the duration will exceed five days, or the lane width is less than 12-feet.

701-3.06 Obliteration of Existing Pavement Markings

Removal of pavement marking can be done by any means that will not leave an illusion that the pavement marker is still there. Sandblasting or wet blasting are two acceptable methods. Painting or flushing with asphalt will leave a shiny surface that looks like a paint stripe under adverse conditions (usually at times when it is most important that obliteration is complete) and is not an acceptable method.

Areas where pavement markings have been removed should be checked at night and during wet weather to verify that the removal is effective under these conditions.

Removal of lead-based markings is hazardous, and must be done in compliance with 29 CFR for Lead Exposure in Construction. The contractor must submit a lead exposure plan prior to obliterating lead-based markings.

701-3.07 Truck Mounted Attenuator

The purpose of a truck-mounted attenuator (TMA) is to decelerate the impacting vehicle at a rate which prevents serious injury to the vehicle occupants. Each type of TMA has specific vehicle weight requirements in which it will operate in an acceptable manner. The Inspector should check to verify that the truck on which the TMA is mounted is the appropriate weight for the application. The TMA should be positioned a sufficient distance ahead of the workers or equipment to allow for the appropriate vehicle roll ahead (distance the vehicle will move during impact). For stationary operations the TMA should be down and locked, wheels locked, parking brake set, and wheels turned away from the work site and traffic. The vehicle on which the TMA is mounted should not be allowed to be used as a utility vehicle, but dedicated to the purpose of work zone safety.

701-3.08 Changeable Message Board

The benefit of changeable message boards (CMB) is the flexibility to display a variety of messages to fit the needs of the situation. CMBs are called portable changeable message signs (PCMS) in the MUTCD. The CMB typically consists of the following components: the message panel, control system, and the power source. The CMB should be clearly visible and legible from a distance of at least 800-feet under both day and night conditions.

The primary purpose of the CMB is to alert drivers to unexpected traffic and routing situations.

Typical applications include the following:

- Speed of traffic is expected to drop substantially

- Significant delays are expected
- There are alignment changes
- Provide advance warning of roadway closures

The CMB is not to be used as a stand-alone item of traffic control, but rather as a supplement to enhance the existing traffic control. The CMB should be offset at least 8-feet from the nearest traffic lane. When positioned on the highway, the changeable message board trailer shall be delineated with a minimum of 10 Type II barricades or vertical panels with Type C steady burn lights at a spacing of 10 to 20 feet, or as shown on the approved traffic control plan. Turn the message board away from traffic when not in use.

The format of the message is extremely important. No more than two message displays should be used within any message cycle. Each message should convey a single thought and should be as brief as possible. The flash rate should allow the entire message cycle to be read at least twice at the posted speed limit. Messages should be approved by the Regional Traffic Engineer when long duration setups are anticipated.

The acceptable type of CMB and message should be discussed during the pre-construction conference. The contractor must use a CMB on the Department's Approved Products List, or provide Certification of Compliance. See the Standard Specifications for a list of requirements.

701-3.13 Flagging Services

The Department recognizes three types of flaggers: civilian, local law enforcement with vehicle, and Department of Public Safety (DPS) with vehicle. All flaggers serve a similar purpose, to move traffic safely and expeditiously through or around work zones while protecting on site workers and equipment. When the project traffic control plans require the use of a flagger, the Resident Engineer will determine what type of flagger will be used. In the event that an officer and vehicle are required, either a DPS officer or an off-duty local Officer will be used, depending upon what jurisdiction the roadway falls under. DPS officers are preferred on interstates and urban freeways and shall be contacted for right of first refusal before utilizing local law enforcement officers.

Travel time up to 1 hour is allowed for Officer flagging. Anything over that will require preapproval from the State Construction Engineer.

Procurement of civilian, local law enforcement, and DPS flaggers is the responsibility of the Contractor.

701-4 Method of Measurement

The contractor will be reimbursed for Traffic Control by one of three ways depending upon how the "Elements of Work" are measured and paid. The inspector must read the project Special Provisions to determine which way is appropriate. The most common way is to require the contractor to bid every traffic control element of work. Item 7010005 is used for lump sum traffic control, see Special Provisions for elements included in the lump sum and what is paid for as listed below.

There are two basic methods for measuring traffic control: "Elements of Work". Some Elements of Work are measured once "Complete-in-Place" after installation and other elements are measured "In-Use" on a periodic basis. Except for Temporary Concrete Barrier and Temporary Impact Attenuators, no measurement for payment is made for relocating Elements of Work. The unit of measure for an In-Use Element will always have a periodic time dimension. For example: "Each-Day" is a common In-Use unit of measure.

701-4.03 Payment Exceptions

It is the intent of the Standard Specifications to reimburse the Contractor for maintenance and protection of traffic, provided that the traffic control plan and required devices are properly maintained and monitored. If the Contractor fails to properly implement the traffic control plan and maintain the required traffic devices, payment may be withheld until such time as deficiencies are corrected. Notification of such action must be in writing.

No payment will be made for traffic control serving a commercial pit or batch plant. Since these commercial operations serve other customers as well as ADOT, an equitable distribution for shared traffic control cost cannot be consistently made.

Hauling vehicles should not use median turnarounds within 1 mile of a traffic interchange (TI). The Contractor must be encouraged to make maximum use of the TI structure. Existing median turnarounds may be used in other areas, but new median crossings will not be constructed.

If the Contractor fails to work in a diligent manner and is ineffective in his or her use of traffic control devices, the Resident Engineer may determine not to reimburse the Contractor for these elements until proper progress is being made. The Contractor must be notified in writing of any such action.

The Contractor will not be reimbursed for elements of work if work is suspended as a result of the Contractor's fault, or upon expiration of contract time. It is the intent of this subsection that no payment will be made for traffic control during periods of liquidated damages.

Regardless of the circumstances for not reimbursing the Contractor for work elements, the Contractor is responsible for maintaining all traffic control devices in proper functioning condition at all times. Therefore, the Resident Engineer should continue monitoring the project during these times.

702 ATTENUATION DEVICES

Permanent installations of energy absorbing terminals are usually placed on a reinforced concrete pad. Unless otherwise specified on the project plans, the paved pad must be 4-inch thick utility concrete or asphalt. The type of bolt and anchorage called for in the installation instructions must be used as specified since the effectiveness of the attenuator depends on the anchorage being strong enough to withstand the design impact stresses. The inspector should verify the attenuation device is on the Department's current Approved Products or obtain approval from ADOT Traffic Group.

Alignment and slope of the attenuator are important for reasons of aesthetics and for the proper functioning of the unit. When permanent attenuators are constructed with salvaged material, or material that was obtained from a replacement package, all parts should be carefully examined for damage and compatibility with the existing attenuator parts. Field modifications of parts are not to be made unless they are approved by ADOT Traffic Group and the attenuator manufacturer.

The Standard Drawings give the dimensions, weights, and layout criteria for typical sand barrel installations. These layouts are to be used unless the Project Plans contain a separate detail for a given location.

The angles and weights shown in the drawings for the installation of sand barrels are not to be changed. The details shown in the drawings have been developed through calculations and testing to provide maximum protection for the design vehicle within a reasonable range of speeds. Any change in layout criteria may seriously affect the performance of the sand barrel array. As an aid to maintenance, it is helpful to paint the outline of each barrel and its sand weight on the concrete base. The placement of temporary sand barrels on pallets should not be allowed unless the manufacturer specifically approves this.

Inspectors are reminded that when sand barrel crash cushions are installed at elevations above 3,000 feet, a minimum of 5 percent rock salt (by weight) shall be thoroughly mixed with the sand.

Barrels which have been filled with sand and rock salt prior to delivery to the project require pre-certification. The Structural Materials Testing Section will mark the pre-certified barrels in stencil with a production lot number and a referenced ADOT test report. The project should confirm the test results are in compliance with specification requirements. If not stenciled, or markings are not legible, material must be sampled and tested for compliance.

703 DELINEATORS AND MARKERS

Posts are to be checked to maintain good alignment, proper orientation, and correct height. Do not allow driving that will damage the top of the post. When placed in hard or rocky ground it may be necessary to pre-drill a hole to the required depth. Cutting of posts because driving is difficult should never be allowed.

Faceplates are installed after the post is driven. Driving posts with the faceplate attached may cause the mounting bolts to shear. Sometimes the bolts do not shear completely and may not break off until after the project is accepted. Then ADOT maintenance has to remount the faceplate.

Guidelines for Inspecting Delineators and Object Markers:

- Do the following materials conform to the Project Plans and specifications and are material certifications available for those items requiring them?
  - Reflective Sheeting
  - Prismatic Reflectors
  - Metal Posts and Plates
  - Hardware
  - Paint
- Are steel posts driven with a driving head when soil conditions permit?
- Are posts plumb and properly aligned?
- Does the installation conform to the applicable Roadway Construction Standards?
- Are items that were inspected at the manufacturer's plant properly stamped

704 THERMOPLASTIC PAVEMENT MARKINGS

The materials used in thermoplastic may cause allergic reactions in some people, so it is recommended that persons working with or around thermoplastic material carefully monitor themselves and others for such reactions. Material Safety Data Sheets (MSDS) should be available from the Contractor describing the hazards of working around thermoplastic materials.

Spilled material and containers are to be cleaned up and disposed of quickly and correctly. The containers will have recommended disposal instructions printed on them if disposal is necessary.

Alignment of stripes should be checked, and any corrections in the application method should be made at the very beginning of the striping operation. Thermoplastic markings will be there a long time so they need to be placed correctly the first time.

Surface preparation is critically important for long-lasting thermoplastic markings. On concrete pavements, the areas to be marked need to be thoroughly cleaned (usually by water blasting or sandblasting) and free of all curing compounds (which acts like a bond breaker). Any oil or fuel spills on the pavement need to be removed before thermoplastics are placed. A primer-sealer must be applied to Portland cement concrete and existing asphaltic concrete surfaces before application of the thermoplastic material.

Additional items to be checked during thermoplastic striping include:

- Is the material on the current Approved Products List?
- Does the Certificate of Compliance conform to subsection 106.05, along with precertification test results from ADOT central lab?
- Check the expiration date; shelf life is less than one year.
- Is the application equipment within specification?
- Is the material temperature within the specified range when applied?
- Ensure the road surface temperature and wind chill factor stay above minimum.
- Is the pavement clean and dry?
- Is the material bonding to the pavement?
- Are the thickness and widths of the stripes per plan?
- Stripes are not to be applied over pavement joints.
- Is the correct amount of glass beads mixed into the molten material and firmly embedded to the thermoplastic surface?
- All white and yellow pavement marking materials shall have the prescribed minimum retro reflectance values when measured by the Department, as described in Subsection 704-3.02(G), within 30 days of application, but no sooner than three days after application to the roadway surface.

704-3.03 (B) Retro Reflectance Testing

The testing of thermoplastic markings for retro reflectance requires a technician to walk on the road in the direction of traffic, traffic control measures should be employed to ensure the safety of the technician and any other personnel involved in the testing operation, the use of law enforcement is recommended and encouraged when testing. Calibration of the LTL-X Delta retroreflectometer or similar device is done according to the manufacturer's requirements annually. It’s a good idea to have at least two technicians trained in each district to use this device. The ADOT Construction Group can assist by providing training if schedule permits. Retroreflectometer devices are housed in the ADOT Materials Group ANNEX and usage should be coordinated through the Material ANNEX Supervisor. A nighttime visual inspection should be conducted to identify any questionable areas and should be included in the testing area.

Additional points to keep in mind while testing for retro reflectance:

- Testing is performed every 0.2 miles, with the average of four readings taken at each location.

- The four readings are taken randomly within a 10 foot section and the average of the four readings is the result for the location.
- If the average of the readings does not meet the required retro reflectance values, a second test of four readings will be performed 50 feet forward from the failing test, the higher average test results of the two are used for that location.
- On roadways where yellow stripes separate opposing traffic, testing is done in both directions, two locations per 0.2 miles, one in each direction for each line.
- Lines less than 0.2 miles must be tested. A single test of four readings can be taken at the approximate midpoint of each line, if the average of these readings does not meet the required retro reflectance values, a second test of four readings has to be performed at the approximate halfway point between the midpoint and end of the line.
- Transverse markings, symbols or legends are not tested.

704-4 Method of Measurement

Gaps in dashed lines are deducted from the total length of striping. Double lines are measured as two individual lines. Striping that is wider or less than 4-inch must be converted to equivalent 4-inch striping in accordance with the Standard Specification.

$$\frac{\text{Plan Width of Striping (inches) x Linear Feet}}{\text{4 (inches)}}$$

Each legend and symbol is measured separately. A legend is defined as a complete letter grouping such as “RR”, “SCHOOL”, and “XING”. For example: “SCHOOL” “XING” are measured as two separate legends.

705 PREFORMED PLASTIC PAVEMENT MARKING

Preformed markings have a retro-reflective film coating on a backing that is coated with an adhesive capable of adhering to the roadway surface. Preformed pavement marking tape, arrows and legends come in four basic types depending upon use; Type I (Permanent), Type II (Temporary - Removable), Type III (Temporary - Nonremovable) and Type IV (Permanent). Type III (Temporary - Nonremovable) has a metal foil backing which makes it easy to identify. Type III should only be used for temporary markings on pavement surfaces that will be removed, or covered by additional paving during completion of the project. Type II (Temporary - Removable) is more expensive than Type III, but it can be removed manually. Type II can be used for temporary markings on final pavement surfaces. Type I (Permanent) looks similar to Type II. Type I is used for final markings in locations of high wear such as stop bars. Type IV is high durability and used in severe wear conditions with high traffic volumes. Certificates of Compliance are required for all types in accordance with subsection 106.05.

Preformed markings are factory or field cut to the specified shape and are applied with an adhesive. The adhesive may be pre-coated or applied separately. No matter how the adhesive is applied, it must allow the marking to be moved around before the final pressure is applied to seal it in place.

The pavement must be non-bleeding, clean, warm, and dry. The manufacturer's recommendations are to be followed and a copy of the recommendations should be included in the project file.

Temperature records and comments on how the pavement was cleaned and its condition at the time of application are to be included in the Inspector's diary.

706 RAISED PAVEMENT MARKERS

There are many different types of raised pavement markers. Most projects will use more than one type of marker in approximately the same location. The inspector must verify the correct type of marker is being installed at the correct location as shown on the plans. Inexperienced inspectors will find Signing and Marking Standard Drawing M-19 (sheets 1 through 3 of 9) very helpful when trying to identify the various types of markers. Certificates of Compliance are required for raised pavement markers. Raised markers are applied using the type of adhesive specified in the Project Plans, Special Provisions, or Standard Specifications. Standard Specifications require a hot-melt bituminous adhesive from an approved manufacturer. The inspector should verify the adhesive manufacturer is on the Department's current Approved Products List.

The surface to which the adhesive is applied must be dry, free of dirt, paint, curing compound, and any other deleterious materials which would adversely affect bonding of the marker to the surface. Loose layers of pavement must be corrected prior to application of adhesive. The method of cleaning detrimental material from the surface is subject to the approval of the Resident Engineer. The Resident Engineer and Inspector should ensure the cleaning method includes sweeping and high pressure air spray. On Portland cement concrete and old asphaltic concrete pavements, cleaning shall be accomplished by sandblasting followed by sweeping and air blowing. Clean, newly placed asphaltic concrete does not require sandblasting unless substantial contamination is evident.

706-3 Construction Requirements:

Adhesive must be applied uniformly and in accordance with directions from the manufacturer. This will include removing excess adhesive from the pavement and the markers themselves, and protecting the markers from impact until properly set.

Temperature, humidity, and surface moisture are important elements which should be monitored by project personnel. If these elements begin affecting the proper placement of the markers and do not meet the requirements of the manufacturer, it may be necessary to suspend work.

Inspection of raised or recessed pavement markers during installation should include verification of correct orientation. After several hundred markers are placed in a shift it can be easy for the installer to get a few backwards. A quick drive through the project can easily expose these markers to get them corrected.

707 TUBULAR MARKER (FLEXIBLE)

707-1 Description

Tubular Markers (Flexible) are most often utilized to provide warning or delineation of roadside hazards, including median curb islands and changes in roadway features. As the name suggests, these devices are meant to be flexible, so as to be able to take the impact of a vehicle in the event the driver misses corner entry.

707-3 Construction Requirements

With the preceding in mind, the Inspection team and contractor should be mindful to follow the installation details and make sure that the devices are indeed flexible if impacted by a passing vehicle. Tubular markers are most often surface-mounted to the roadway or median. The most common installation methods include bituminous material or post-installed concrete anchors. Installation details can be found in the Traffic Signing & Marking Standard Drawings, found on the ADOT Traffic Group webpage. Additionally, the manufacturer's recommendations shall be followed.

Layout and spacing details are covered under Standard Detail M-26. It is also important to follow the layout details for the tubular markers, making sure to adhere to the proper spacing requirements. While the Regional Traffic Engineer should be consulted by the design team during project development, the Resident Engineer should reach out to their RTE to confirm the marker layout and make any necessary adjustments that may be required.

708 WATERBORNE PAVEMENT MARKINGS

Waterborne pavement markings are typically the initial striping of all pavement remediation projects and are therefore quite important to the final striping configuration and aesthetic of a project. Section 925-3.01 provides the details regarding survey requirements for striping and the inspector should become familiar with what the final roadway will look like. This information is usually found in the project plans, however certain projects will rely on the contractor's striping as-built survey data to recreate the original layout.

Waterborne pavement markings are divided into 2 classifications - Type I (Standard), and Type II (High-build). Both classes can also be further divided into fast-dry or rapid-dry.

Type I (Standard) is used for long line and short line striping including symbols and legends and typically is used for the following:

- For temporary traffic control.
- At the end of a work shift if the roadway is to be opened to traffic.
- As a primer on the final lift or layer of pavement 30 days prior to the application of the durable pavement marking materials. This is a use case example. This does not mean that Waterborne Pavement Markings must cure for 30 days prior to final pavement markings.
- During construction on pavement that will not be resurfaced.

Type II (High-build) is also used for long line and short line striping including symbols and legends and is used for the following:

- For temporary traffic control.
- Needs to be in place and serviceable for at least 180 days.
- Used between two construction seasons.

Rapid-dry paint shall dry to a no-track condition in 60 seconds or less, fast-dry paint shall dry to a no-track condition in five minutes or less.

All waterborne pavement marking paint shall be on the Approved Product List, shall be precertified from the Central Lab, and shall have a Certificate of Compliance conforming to Subsection 106.05.

709 DUAL COMPONENT PAVEMENT MARKINGS

The importance of roadway striping can not be overemphasized. The final striping of any project on a new surface is what the public will see day or night, rain or shine, and needs to be clean and consistent.

It is very important prior to the start of striping operations that the locations for the final striping are laid out by survey. This will help ensure that striping lines and symbols are neat and clean and in the locations they need to be.

At least 2 weeks prior to application, a pre-activity meeting should be held with the contractor, contractor's surveyors, pavement marking subcontractor, and the Engineer to discuss survey control and layout for the striping. Survey control will be provided for the pavement marking subcontractor.

Survey points are to be set by instrument at intervals not greater than 50 feet for each traffic lane, at the beginning and ending of each yellow stripe, and at the beginning and ending of gores and tapers.

On projects with No Passing Zones, it is very important that the contractor coordinate the survey layout with ADOT's No Passing Zone Crew (phone number on project plans) at least 14 days before placement of pavement markings.

In most cases, the permanent paint striping will be placed in the final location of the dual component epoxy. However, if there is an error in the layout of the permanent striping, the best time to catch and correct it is prior to the placement of the dual component stripe.

Dual component pavement markings shall not be applied to new asphaltic concrete pavements, or bituminous treated surfaces, for a minimum of 30 days after the pavement has been placed.

On the day the dual component striping is to begin, the road surface shall be cleaned of all dirt, dust, grease, oil or other detrimental material by the contractor prior to application.

The roadway surface shall be dry with no surface dampness.

Surface temperatures at the time of application shall be 40 degrees F and rising. Air temperature and wind chill shall not be lower than 35 degrees F. It is best to discuss the weather forecast during the pre-activity meeting should concerns about low temperatures manifest themselves.

When striping on PCCP (Portland Cement Concrete Pavement): Any curing compound present is removed by means of a high-pressure water jet or sandblasting at least one inch beyond the width, followed by sweeping and high-pressure air spray.

Prior to the start of application of the dual component stripe, it is necessary to follow steps 1 through 4 of Section 709-3.02(F)(1) in the ADOT Standard Specifications to ensure that the striping equipment is properly calibrated.

The width of the striping is in accordance with the striping plan. (When plan stripe width is six (6) inches, actual width is 6 to 6 ½ inches; when plan stripe width is 8 inches, width is 8 to 9 inches; when plan stripe width is over 8 inches, width is plan width ± ONE inch).

For striping placed on AC, dual component markings shall be .025 ± 0.002 inches thick. Dual Components placed on PCCP shall be .020 ± 0.002 inches thick.

Glass beads are an important ingredient of dual component epoxy and it is necessary for ADOT to ensure that the glass bead delivery equipment is properly calibrated. This calibration is done daily prior to the start of epoxy striping. Section 709-3.02(F)(2) of the Standard Specifications has the steps needed to ensure equipment calibration is done properly.

Dual Component Pavement Markings: Contractor has provided documentation to the Engineer to verify that the driver and operator of the application truck are fully trained and experienced in the application of the dual component marking system.

Dual component pavement markings, whether longitudinal or transverse are measured by the linear foot along the centerline and are based on the 4-inch equivalent stripe and calculated from the formula below:

$$\frac{\text{Plans Width of Striping (inches) x Linear Feet}}{\text{4 (inches)}}$$

Symbols and legends will be considered as a unit for purposes of measurement and payment.

Following completion of all dual component striping ADOT shall perform retroreflectivity testing. Each district has retroreflectivity testing equipment assigned to it, however, it may be required that advanced scheduling of this equipment be performed so that testing is completed within the time specified by the contract special provisions.

Testing shall be performed not later than 30 days, but no sooner than 3 days after striping is completed. Copies of the test results will be provided to the contractor.

Dual component striping that does not meet the minimum retroreflectivity as defined by the special provisions shall be re-striped and retested. In some cases it may not be practical to retest with a retroreflectometer. In such instances, the Department may perform visual nighttime inspections and if the re-striping appears as bright as the surrounding stripe, then the Engineer can accept the reapplication.

710 SMART WORK ZONE SYSTEMS

710-1 Description

One of ADOT's primary goals for any construction project is the safe and efficient handling of traffic through and around construction zones with as little inconvenience and delay as possible. The constant watchfulness by the Resident Engineer (RE) and all inspection personnel is necessary to accomplish this goal. The highest concern should always be the safety of the public, workers, and Inspectors. In the current environment of increasingly digital and virtually connected workspaces, traffic control has entered into this technological field with the development of Intelligent Transportation System (ITS) or Smart Work Zones (SWZ). In the simplest of terms, Smart Work Zones consist of data collection and data analysis which then delivers fully automated traffic information to all concerned motorists about real-time downstream traffic conditions. Smart Work Zones can be as small as two to five devices or scaled up to as large as the project may need. SWZs typically consist of four features:

1. **Detection and surveillance equipment** - Collects speeding and queuing data and video near the work zone and sends data to the central processing system.
2. **Central processing system** - Analyzes, processes and stores the data.
    - Received from the SWZ devices deployed and third-party subsystems.
    - The central processing system also pushes messages to the public through message signs.
3. **Dissemination outlets** on and off the road that interpret real-time information about work-zone conditions available to the public and governmental agencies.
4. **Auxiliary equipment** that provides communications, safety protocols, geolocation, power supply, portable trailers, and static traffic control devices required to achieve a fully functional SWZ system.
    - Auxiliary equipment is considered included.
    - Various miscellaneous components to the SWZ devices and systems required for a functioning system are also included.

710-1.01 Abbreviations

AFADs	Automated Flagger Assistance Devices
AVL	Automated Vehicle Locator
CCTV	Closed-Circuit Television
CMB	Changeable Message Board
CoA	Certificate of Analysis
CoC	Certificate of Compliance
CSA	Communications Site Assessment
DAS	Digital Alert System
DMS	Dynamic Message Sign
DLMS	Dynamic Lane Merge Subsystem
FMS	Freeway Management System
GPS	Global Positioning System
GPSLS	Global Positioning System Location Sensor

GUI	Graphical User Interface
IDS	Impact Detection System
O&M	Operations and Maintenance
OMP	Operations Maintenance Plan
PDA	Power Distribution Assembly
POC	Point of Contact
PTS	Portable Traffic Signal
PTZ	Pan, Tilt, and Zoom
QWS	Queue Warning Subsystem
SAB	Smart Arrow Board
SCP	System Configuration Plan
SFS	Speed Feedback Sign, a.k.a. Speed Feedback Board
SWZ	Smart Work Zone
TCP	Traffic Control Plan
TDC	Traffic Data Collection
TDCS	Traffic Data Collection Subsystem
TEES	Truck Entry/Exit Subsystem
TMA	Truck-Mounted Attenuator
TMCS	Traffic Monitoring Camera Subsystem
TOC	Traffic Operations Center
TOM	Transportation Operational Monitoring
TOM-POC	Transportation Operational Monitoring – Point of Contact
TPRS	Temporary Portable Rumble Strips
TTS	Travel Time Subsystem
VPDL	Vehicle Presence Detector Location
VSDL	Vehicle Speed Detector Location
VSL	Variable Speed Limit
VSLS	Variable Speed Limit Sign

WZDx	Work Zone Data Exchange

710-1.02 Definitions

SWZ System:

The SWZ system is a broad range of portable communications-based information and electronic technologies placed in and around work zones to enhance transportation and improve safety and mobility. The real-time information and automation provided by the SWZ system is used by contractors and transportation agencies to alter traffic control strategies, provide traveler information to better inform motorists of upcoming traffic conditions, allow motorists the opportunity to alter their travel routes, and/or modify the travel behavior within work zones. The SWZ system consists of one or multiple SWZ subsystems that operate together.

SWZ Area:

The SWZ area is the area where SWZ field devices are deployed near, within, and/or around the project and work zone limits.

Active Work Space:

The active work space is the area that is anticipated to have the largest concentration of field personnel within the work zone during a specific day or construction shift. The personnel working in active work space are exposed to the dangers of an errant vehicle.

Work Zone:

The work zone is the entire area in which traffic control devices, which includes static signs and SWZ field devices are implemented. This includes the area approaching and the active work space.

Traffic Data Collection Subsystem (TDCS):

The TDCS is a component of the SWZ system that is capable of detecting, processing, and disseminating real-time traffic information such as vehicle speeds, traffic volumes, and travel time/delay within and in advance of the work zone for use by other SWZ subsystems, third-party traveler information systems, and/or to archive work zone traffic conditions. This subsystem could also include the use of third-party data, solely, or in combination with site specific gathered data.

Vehicle Speed Detector Location (VSDL):

A VSDL functions like the TDCS, but only collects vehicle speed data for use by other SWZ subsystems, third-party traveler information systems, and/or to archive work zone traffic conditions.

Vehicle Presence Detector Location (VPDL):

A VPDL functions like the TDCS but only collects vehicle presence data for use by other SWZ subsystems, third-party traveler information systems, and/or to archive work zone traffic conditions.

Queue Warning Subsystem (QWS):

The QWS is a component of the SWZ system that uses the real-time TDCS information to determine traffic queue lengths. The QWS warns approaching travelers of slowed or stopped traffic conditions through warning messages displayed on SWZ CMBs. When a queue begins to form, the QWS automates the display of warning messages on the associated SWZ CMB displays located in advance of the anticipated queue areas. The QWS also alerts field personnel and remote SWZ system operators of the real-time queue conditions.

Hybrid Queue Management Subsystem:

A subsystem that performs both queue warning and dynamic lane merge functions at the same time.

Dynamic Lane Merge Subsystem (DLMS):

The DLMS is a component of the SWZ system that uses the real-time TDCS information and SWZ CMBs, in advance of a lane closure, to instruct approaching travelers when to merge. When traffic volumes are high or a potential queue condition is detected by the DLMS, the DLMS automates the display of messages that instruct drivers to merge later. When traffic volumes are low and a potential queue condition is not detected in advance of the lane closure, the DLMS automates the display of messages that instruct drivers to merge earlier.

Travel Time Subsystem (TTS):

The TTS is a component of the SWZ system that uses the real-time TDCS information and SWZ CMBs, in advance of the work zone, to determine the approximate travel time between the SWZ CMB location and another fixed point as shown on the project plans, or at the end of the work zone. The TTS automates the display of messages on each CMB to inform the drivers of the associated travel time (at predetermined locations) through the work zone. In addition, the TTS can be configured to compare real-time TDCS information to historical travel time information to estimate the approximate travel delay that a driver can expect, when traveling through the work zone.

Traffic Monitoring Camera Subsystem (TMCS):

The TMCS is a component of the SWZ system that uses closed-circuit television (CCTV) cameras to provide real-time video streams that are monitored on-site by field personnel using a mobile display device and/or remotely by the Engineer, TOC operators, and the District to view real-time roadway traffic conditions within the work zone.

Variable Speed Limit (VSL) Subsystem:

The VSL subsystem is a component of the SWZ system that uses TDCS real-time traffic information and VSLS to dynamically reduce or increase regulatory speed limits in the work zone. Regulatory speed limits are dynamically reduced in the active work space. Regulatory speed limits are dynamically increased within the same area of the work zone when the construction personnel are not present.

Truck Entry/Exit Subsystem (TEES):

The TEES is a component of the SWZ system that uses the real-time TDCS information to determine the entry of construction vehicles to the roadway from the work area and warns approaching travelers of slow-moving vehicles ahead. The TEES may warn drivers by displaying a message on a SWZ CMB or by illuminating flashing warning lights attached to a static sign. Once the construction vehicle has entered the roadway and a predetermined amount of time has passed, the TEES no longer displays the warning message until it detects another construction vehicle entering the roadway from the work area. The TEES also alerts the field personnel and remote SWZ system operators when the system is activated.

Digital Alert System (DAS):

The DAS is a component of the SWZ system that collects digital alerts from AVL devices deployed, within DLMS, IDS, QWS, TEES, TTS, VSL, and subsystems, and distributes the digital alerts to third-party navigation systems, e.g. Waze, Apple Maps,Google Maps and connected in-car safety alert systems, e.g. Jeep, Dodge, RAM, Chrysler, Alfa Romeo. The DAS software platform can receive, store, analyze, send, and display real-time location information of construction vehicles and SWZ field devices to alert the traveling public of the work zone location along with related work zone activities, e.g. lane closure, traffic queuing and delay.

Automated Vehicle Locator (AVL):

The AVL is a component of the SWZ system that tracks the location of active vehicles, e.g. portable impact attenuators and active SWZ devices, e.g. arrow boards marking the start of a lane closure. The AVL sends this location date, along with the type of vehicle or device, to the DAS for processing and distribution to third parties.

Impact Detection System (IDS):

The IDS is a component of the SWZ system that uses electronic devices that monitor for impact when attached to guardrails, work zone attenuators, permanently installed crash cushions, cable barriers, truck mounted attenuators, end terminals, or other critical safety roadway assets. The electronic devices deployed in the project area incorporate both impact sensors and communications technology to send impact alerts to a remote system server that processes the alerts and notifies personnel, via smartphone text message or email, when a protection device is struck by a vehicle.

Transportation Operational Monitoring (TOM):

The TOM program requires a designated TOM-POC responsible for analyzing data being received from the SWZ devices to measure, identify, and report on operational issues due to MOT lane restrictions, capacity modifications, road closures, and detours. The TOM-POC coordinates with the project stakeholder, e.g. ADOT, MOT team, Public Information team, and regional stakeholders responsible for traffic operations along detour routes on arterial roadways, to implement congestion mitigation strategies within the work zone and along detour routes and to respond to operational inquiries.

Smart Temporary Portable Rumble Strips (TPRS):

The TPRS alerts distracted drivers in work zones and other changing road conditions. The Smart TPRS is a component of the SWZ system that includes a TPRS assembly with an integrated GPS location device and communications device used to push the GPS location data and type of device, e.g. Smart TPRS, to the SWZ system.

Automated Flagger Assistance Devices (AFADs) Subsystem:

The AFADs is a portable flagging station that removes the traditional human flagger from the road while providing motorists with clear guidance through a TTC zone.

SWZ System Software:

The SWZ system software is a software platform that can receive, store, analyze, send, and display real-time information from the TDCS, QWS, DLMS, TTS, TMCS, TEES and VSL subsystem field devices, Department furnished data from roadway sensors, or other third-party sources. The SWZ system software provides the required automation, GUI, user device applications, and system reports required to operate and maintain each respective SWZ subsystem deployed within the SWZ area.

710-2 Materials (Equipment, Workers, Devices and Facilities):

710-2.01 General Requirements

As with any traffic control deployed onto a construction project, an approved TCP has to be submitted by the contractor for review and approval by the Engineer. SWZs are no exception and have a much higher degree of documentation required for acceptance.

These include:

- CoC for all devices planned to be used, must conform to Subsection 106.05.
- SWZ Technician Credentials, proof of technicians qualifications to deploy and maintain chosen devices.

- CSA proof that the chosen communications will work in the area.
- SCP shows where devices will be placed, operational logic used for each subsystem, what alerts are generated and where they are sent.
- SWZ Systems and OMP describe how the system will be maintained, adjusted or repaired.
- SWZ Software User Training Outline and Schedule, contractor provided training for field and Department staff.
- SWZ Software User Access Privileges and Alert Messages, coordinated details between the contractor and the Department defining user access levels to the system and who will receive alerts generated by the system.
- SWZ System Data Reports examples of the system generated reports to be sent weekly to the Department.
- Subsystem Acceptance Testing Procedures logs for all devices to be used in their planned locations.
- CoA for all devices planned to be used, must conform to Subsection 106.05.

Once a submitted TCP has been approved for use, the Inspector should have a copy of all of the above records and verify in the field for their accuracy and document these details and the location of in-use devices in their Daily Dairy.

An item that will be very insightful for the Engineer and field inspection staff is to make full use of the contractor provided training. What was deployed last year may not be what will need inspection this year.

710-2.10 Data Submittal

The SWZ system software shall record all alerts related to any loss of communications, instances of low power, and loss of power for the project duration.

The SWZ system software vendor shall also record the following data before final project acceptance:

- All real-time traffic information received by the SWZ system software from all TDC locations deployed in the SWZ area and received by third-party sources, and all real-time traffic information generated by the SWZ system software within every one-minute time interval.
- All messages posted on all SWZ CMB assemblies deployed in the SWZ area.
- All speed limits on all VSLS assemblies deployed in the SWZ area.
- All geolocation data associated with these devices and the required device data.
- A date and time stamp that the data pertains to each data set.

This data shall be submitted electronically to the Engineer in a format compatible with the Work Zone Data Exchange Common Core Data Specification version available at the time of the project’s bid opening date.

710-4 Method of Measurement / Basis of Payment

SWZ system will be measured on a lump sum basis for a fully functional complete in place system. Individual items will be paid under their respective bid items. The inspector will need to review each project's Special Provisions to determine the correct method of payment and be aware that some items are paid through the weekly MPT report, while others are paid daily on the items tab in the Daily Diary.

730 GENERAL REQUIREMENTS FOR TRAFFIC SIGNAL AND HIGHWAY LIGHTING SYSTEMS

Traffic signals, highway lighting, and highway electrical systems are integral parts of roadway design and construction. Attention to electrical inspection and quality control can eliminate costly corrective measures and frequent maintenance costs after completion of the work. Once the hardware and equipment have been installed, many of the installation details will not be visible. The only evidence of incorrect procedures may be decreased reliability during the operation of the system. It is extremely important that the Resident Engineer has trained and skilled Electrical Inspectors assigned to inspect the electrical portions of the contract.

Regional Traffic Signal/Lighting outside of Central District may provide the Electrical Inspector for the project. Within the Central District the VISION Field Office may provide this inspector. A consultant may also be used through the temp-tech contract. This Inspector will act as a technical advisor to the Resident Engineer during the phase of the project that deals with traffic signals, highway lighting, and electrical devices. The Inspector will report directly to the Resident Engineer unless other lines of responsibility have been prescribed by the Resident Engineer. When an Electrical Inspector is assigned to a construction project, he or she will be primarily responsible for the inspection of electrical systems to ensure compliance with the contract documents, codes, and regulations governing the installation and operation of electrical systems.

The Electrical Inspector's work begins as soon as the final construction plans are received. A copy of the Project Plans should be forwarded to the Electrical Inspector for the project, who should carefully review the Project Plans and inform the Resident Engineer of any discrepancies or omissions that are evident. Such a thorough review can avoid costly change orders or potential claims. During construction, the Electrical Inspector will check certifications, perform all inspections related to electrical items, and submit the proper documentation on all electrical pay items as directed by the Resident Engineer.

Traffic Signal Activation and Final Cleanup

Before the Inspector can recommend activating and accepting any traffic signals or other electrical work, he or she should be satisfied that all required work is completed. The following inspection guidelines should be reviewed in order to provide the Inspector with an accurate appraisal of the work performed:

- Were signal circuits tested with 120-volt power applied to each signal wire at the pull box and in front of the control cabinet by the Contractor in the presence of the Inspector?
- Has the Inspector coordinated the activation date with the Electrical Inspection Supervisor, Traffic Group, who in turn will schedule the Department or local agency's technician to connect the field wire inside the control cabinet and set up the timing of the controller and activation?
- Is the roadway striping and signing done or coordinated with the District for the same day of activation?
- Has the Contractor arranged for traffic control for the day of the activation?
- Does the Contractor have sufficient personnel and equipment for the activation?
- Were stop signs removed after the signal was activated?
- Are signal heads aimed for proper alignment?
- Is all grouting completed?
- Is all touch-up painting completed?
- Was all patching or replacement of AC or PCC completed?
- Did the Contractor clean up and remove all construction rubbish and equipment from the highway right-of-way?
- Was existing landscaping and grading restored to the original or an acceptable condition?
- Were all final measurements and quantities recorded and submitted to the Resident Engineer?
- Were as-built plans completed and submitted?
- Was salvaged equipment dismantled and stockpiled or delivered?
- Was any salvage equipment that was damaged or destroyed by the Contractor replaced?
- If the Department or local agency loaned equipment or material to the Contractor, was it returned?

- Did the Contractor furnish and deliver to the project office all manufacturer's warranties and guarantees?

730-4 Equipment List and Drawings

The specifications require that the Contractor submit a complete project material for approval to the Engineer electronically by the pre-construction conference. In addition to the electronic submission, the Engineer may request up to three hard copies. This list shall contain all required information listed in the Project Plans and Special Provisions and shall be reviewed and approved prior to ordering materials. The Contractor should be notified of the review time requirements and the possibility that it may be necessary for some items to be resubmitted.

Shop drawings for signal and lighting equipment are required and must be submitted for review and approval before ordering this equipment. These shop drawings must include all pertinent information related to providing a fully functional system. Such information may include photometric data sheets, optical details, and wiring diagrams.

730-7 Installation of Decals

The specification requires that the contractor shall furnish and install a maintenance unit number decal approximately 42 inches above the base-plate displayed on the traffic-side of the device at a 45 degree angle to the direction of travel, or as approved by the Engineer.

731 STRUCTURAL SUPPORTS AND FOUNDATIONS FOR TRAFFIC SIGNAL AND HIGHWAY LIGHTING

To ensure traffic signal and lighting systems perform as designed and provide the required life as expected, it is very important that project personnel closely monitor the installation of foundations and structural supports.

The Inspector should be familiar with those specifications that apply to proper excavation, placement of concrete, and backfill requirements when applicable. The Inspector must ensure that all excavations and construction of foundations are coordinated in order to minimize the time of open trenches or excavations. Those excavations that are open and not complete must be covered and properly barricaded to protect the workers and the public.

Construction and Inspection Requirements

The following guidelines are intended to assist the Inspector in providing a complete and thorough inspection of foundations and supports on the project:

Foundations

Locations for foundations will generally be laid out by station numbers, offsets, and elevations by the Contractor's survey crew.

- Check consistency of survey layout and plans. If in doubt, have the survey crew recheck.
- Are locations of underground utilities blue staked?
- Have overhead utilities, high voltage electric lines, and overhangs been checked for clearance?
- If a pole foundation cannot be installed at the location designated due to obstructions, they may be moved as directed by the Resident Engineer. If a foundation location is moved, it is critical to verify that the mast arm length specified will still meet the placement criteria.
- Check sides and bottoms of augured holes for firm and stable soil conditions.
- Did it require a deeper foundation for unstable soil and/or steeper slope?
- Are foundation holes the proper size?
- Was any irrigation conduit rerouted on foundations? (rule of thumb 4').
- Are forms and templates securely braced?
- Check anchor bolts and conduit stubs for proper size, alignment, position, and height projections.
- Is there a 25-foot coil of #4 AWG copper ground wire placed at the bottom of the pole foundation hole and a 1-inch sleeve for a 5/8-inch by 10-foot ground rod in the cabinet foundation?
- Make sure that utilities like water, sewer, and telephone lines are not encased in foundation holes.
- Check steel wire cages for sizes and dimensions.
- When placing steel wire cages, spot check spacing and elevation for clearance compliance.
- Check steel wire cages for loose rust and scale.
- Have all certificates been received and submitted to the project field office for anchor bolts and steel wire cages?
- Has the concrete design mix, source, and curing compound been approved?
- Does the Contractor have a vibrator and tremie at the project site?
- Was the poured concrete vibrated regularly by the Contractor in presence of the inspector?
- Have the sides and bottom of the foundation hole been thoroughly moistened prior to placing concrete?
- Check to see that surface finish on concrete is as specified.
- Make certain on all types of cabinet foundations that there are two 2-inch conduit stubs for future use. The conduit should be stubbed out and capped 2 feet past the edge of foundation and noted on the as-built plans.
- Was there a PCC pad poured in front of all cabinets in unpaved areas?
- Have batch tickets for each load been received and submitted to the project office along with the required quantities report?

- Was a ground resistance test performed and recorded in the presence of the Electrical Inspector on each foundation ground.
- Was the result of the ground resistance test 25 ohms or less?
- Have all changes been noted on the as-built plans?

Pole and Mast Arm Installation

All pole foundations must cure for three days prior to pole installation except for the Type J, K, Q, and R pole foundations (which must cure for seven days).

- Were poles and mast arms inspected upon delivery to the job site for conformity with the approved material list and shop drawings?
- Were certificates of compliance furnished upon delivery?
- Was the galvanized finish damaged in shipment, if applicable?
- Check coloring of galvanizing for uniformity if applicable.
- Check to see if a metal information tag is permanently affixed by the manufacturer to all poles and mast arms at the time of delivery to the job site.
- Upon delivery and prior to installation, inspection is needed for the inside of the pole for metal overrun (sharp edges from manufacturing process).
- Before poles are erected, make sure that there are no high voltage overhead electric lines any closer than 10 feet. If closer, has the Contractor made arrangements with the servicing utility company to de-energize or rubber-over to protect the workers from injury from the conflicting power lines?
- Were high strength bolts A325 used to connect the mast arm to pole?
- Were poles plumbed to the vertical with all mast arms, signal heads, and/or luminaries installed?
- Has the non-shrink, non-metallic grout used between pole base and foundation been approved?
- Check the block out area between pole base and foundation for complete grout fill.
- Make sure, for slip-away foundation base plates, that conduit entering into the plate is 1 inch below top of the plate.
- Check clearance of anchor bolts on slip-away foundation base plates. Is it 1/8 inch below the top of the plate?
- Did the measurement of the anchor bolt threads meet the 1'' (Typ) from the top of the anchor bolt nut to the end of the threads?
- Was there a 28 gauge galvanized steel keeper plate installed on slip-away poles between the slip plates?
- Were high strength connecting bolts on slip-away bases torqued to 208 ft•lb. in the presence of an Inspector?

732 ELECTRICAL UNDERGROUND MATERIAL

The Project Plans and specifications will specify the type of materials to be used and the location of conduit runs, junction boxes, and stations and offsets of pull boxes. The locations may be changed by the Resident Engineer to avoid conflicts with utilities and other underground obstructions. These changes must be documented and shown on the as-built plans.

The Inspector on the project must verify that the Contractor complies with any applicable national codes and contract requirements when installing conduit, conductors, pull boxes, and other related work. The specifications provide specific requirements that must be met for all work and materials provided.

The following procedure is a guide which should be followed by the Inspector to assure proper compliance with contract documents. The initial requirement of the contract is to blue stake any areas to be excavated prior to excavating. The Contractor must update the blue staking as required because the markings are valid for only fifteen working days.

Construction and Inspection Requirements

Conduit Installation:

- Has the Inspector sent samples of all sizes of conduit to ADOT Materials Group for testing prior to installation?
- Check to see if PVC conduit has the UL approval stamp, the manufacturer's name, trade size, schedule 40, and 90 degree temperature rating imprinted on each 10-foot length of conduit.
- Was the conduit inspected for cracks, gouches, elongation and sunburn before installation?
- Is conduit embedded in concrete structures securely tied to reinforcing steel every 12 inches?
- Check expansion fittings. Are they installed properly where conduit crossed expansion joints in the structure?
- Open trench installation of conduit should be checked for straight line, grade level, and depths.
- Is back-fill material clean and granular type, and compacted in accordance with the specifications?
- If trenches remain open overnight, a minimum of 6 inches of back-fill material should be used as a protective cover to eliminate the contraction of conduit. Backfill material shall be removed if final inspection has not been made.
- Is warning tape installed in open trenches at a depth of 6 to 8 inches above the highest conduit?
- Make sure trenches left open overnight are properly barricaded.
- See that no open trenching across an existing roadway is performed without written authorization from the Resident Engineer.
- For conduit that is designated as "future use," check to see that a #8 bare bond wire is installed and that the conduit is properly capped, plugged or sealed with conduit putty.
- Make certain that the Contractor has cut a 3-inch "Y" into the face of the curb directly over the conduit located under the curb line.
- Has the Contractor blown out, with compressed air and mandrel all existing conduits incorporated into the new system?
- When conduits enter pull boxes, are they located near the sides and 2 to 4 inches above the bottom of the pull box while sloping towards the direction of the conduit run?
- Check conduit ends in pull boxes and foundation. Do not allow the Contractor to pull the conductor until all end bells are installed on conduit ends.
- Are jacking (boring) and drilling pits no closer than 2 feet from the edge of the travel pavement and barricaded?
- Has the Contractor documented and properly noted all conduit changes on the as-built plans?
- Has the Inspector recorded all quantities on the proper forms and submitted them in a timely manner?

Electrical Conductors, Splicing, and Tagging:

Wire and cable for traffic signals, highway lighting, and other electrical systems shall be UL listed copper and rated for 600 volt operation.

- Were conduit bell ends installed on all conduit ends before wire was pulled?
- Did the Contractor clean out all of the conduit runs with a mandrel and compressed air before conductors were pulled?
- Was the UL label affixed to each reel, coil, or container of wire or cable delivered to the job site?
- Check to see if wire has distinctive and permanent markings showing the manufacturer's name or trademark, insulation type, size, UL and voltage rating.
- Double check plans conductor schedule for the number of conductors, size, and color-coding for each conduit run.
- Was an approved pulling lubricant used?
- Make sure wire is not dragged along the pavement or earth to avoid damage to the insulation.
- Is there a minimum of 36 inches of slack wire from the conduit end bell in the pull boxes?
- Were the detector lead-in cables pulled continuously and not spliced from the detector pull box to the control cabinet?
- Were cabinets, pedestals, poles and conduit and cable sheaths wear bonded to form a continuous grounded system?
- Were separate signal circuit wires installed to each mast arm mounted signal head from the pull box?
- Were all conductors tagged to identify their circuit number and function?
- Was tag identification correlated with the conductor schedule shown on the Project Plans?
- Was each signal wire tagged in pull boxes, in the terminal compartment of mounting assemblies, and in the control cabinet?
- Were signal conductors phase grouped together and tied in the pull box?
- Check roadway lighting conductors for circuit number tagging in pull boxes and service cabinets.
- Were in-line nonlocking type fuse connectors installed in the pull box for luminaries?
- Check fuse fault current rating and amperage rating.
- Was wire splicing done only in pull boxes, terminal compartments, and cabinets?
- Did the insulation of the splices consist of two layers of electrical rubber tape, four layers of plastic electrical tape, and two layers of friction tape?
- Were the tape splices covered with three coats of approved liquid waterproof splicing compound?
- Did the insulation tapes were securely applied over the bare wire splice area and back onto the original insulation a minimum of 1 inch?
- Check loop wire soldering splices.
- Check to see if heat shrink encapsulating fit caps were used to weatherproof the soldered loop splice.
- When the conductor schedule calls out for a green insulated copper bond wire, check to see if the insulation was removed from the bond wire in the pull box at the point where the wire leaves the end bell of the conduit?

Precast Reinforced Concrete Pull Box Installation:

- Check the size of pull boxes specified on the Project Plans.
- Ensure that the pull-box lid has proper ADOT legend.
- Reject chipped or cracked pull boxes, extensions, and covers.
- Check rock sump for depth and size of aggregate and backfill material.
- Was 30-pound felt paper used between aggregate and backfill material?
- Are pull boxes set at grade elevation and level with curb or sidewalk? In cut and fill areas, are the pull boxes at the same level as the slope?
- Check pull boxes installed in concrete areas for expansion joint material around the pull box.
- Check pull boxes installed to be free of debris.
- Are there four concrete blocks set under the pull box?

- Were any pull boxes relocated and as-built due to utility conflicts?

733 SIGNAL INDICATIONS AND MOUNTING ASSEMBLIES

Equipment compatibility is very important. All equipment at an intersection is required to be from the same manufacturer and of the same material. Maintenance or replacement costs are minimized by this requirement.

The Special Provisions or Project Plans will provide details and description of acceptable equipment and materials to be used on the project. It is important that the required shop drawings and materials list comply with the contract documents and show the specified material to be furnished.

Installation Procedures:

- Check the signal hardware package when it is delivered to the project site for conformity with the approved materials list, Standard Drawings, and project specifications.
- Do the traffic signal faces meet the optical requirements?
- Has the accuracy of pole layout for mounting assemblies been checked for correct orientation against the pole schedule and the Standard Drawings?
- Were the mounting bolts properly sized, galvanized steel bolts, 13-UNC with one flat washer and one lock washer?
- Check pipe nipple lengths on mounting assemblies.
- Were elevator plumbizers and pole plates checked to verify they were made of bronze?
- Check for double nutting on the through bolt for elevator plumbizers.
- Are all mounting assemblies plumbed and securely assembled?
- Are the arrow signal face lenses made of glass?
- Are the tunnel visors at least 11 inches in length?
- Check back plate dimensions.
- Were the correct wattage and type signal lamps installed?
- Check back plate for no open gap between elevator plumbizer and signal face section.
- When fiber optic turn-arrows are installed, check the post and side mounts to verify the individual lens holders are mounted perpendicular to the signal face. On mast arm mounts, they should have a 10-degree down angle.
- Were new not-in-service signal heads covered with burlap?
- Did the contractor level and square the traffic signal heads?
- Do the traffic signal heads align with the respective traveling lane?

734 TRAFFIC CONTROLLER ASSEMBLY

The traffic control assembly which includes the controller unit, auxiliary equipment, controller cabinet, foundation, conduit, anchor bolts, and clearance pad must conform to the requirements of the Project Plans and specifications. The unit must be fully inspected and accepted by the Electrical Inspector before incorporation into the project. The Contractor's material proposal shall include all required documentation related to the controller assembly. The specifications provide a list of the required documentation.

All traffic signal controller units require testing and pre-approval by the Department. The Contractor must deliver a complete controller assembly to the Department for testing. In the event the project falls under a local government jurisdiction, the unit should be delivered to that local government's traffic operations facility for their testing and approval.

734-2 Materials

734-2.03 Control Cabinets

The traffic control cabinets listed in the Project Plans and in the specifications are used to house pretimed and actuated signal controller assemblies. This includes intersection and auxiliary control cabinets. Housings must be NEMA approved, Type 3, weather resistant, and properly painted to meet specification requirements. The cabinets should be manufactured to meet the specific requirements of the plan details or specifications including the standard security measures. The specifications provide a list of individual components that should be considered as part of the cabinets and the Inspector should be satisfied that these are being furnished complete-in-place.

734-3 Construction Requirements

It is the responsibility of the Inspector to ensure that the Contractor installs all equipment according to the Project Plans, Special Provisions, and the Standard Specifications. This includes the correct wiring of all equipment, labeling of wiring, furnishing wiring diagrams, signal phase layout, and any other incidental work called for in the contract documents.

On construction projects involving intergovernmental agreements, the Inspector may have to coordinate his efforts with representatives of the local jurisdiction and obtain their approval prior to accepting any portion of the work as being complete.

Construction and Inspection Requirements:

- Were signal control cabinets and equipment delivered to the Department ADOT Traffic Operations) or local government agency's facility for testing approval?
- Was a 5/8-inch by 10-foot ground rod installed through the 1-inch sleeve in the foundation before the cabinet was set?
- Was the bottom of the cabinet sealed between the cabinet and foundation with a good quality caulk?
- Was the photocell oriented to the north?
- Service load center cabinets and service entrance equipment will be checked by the Electrical Inspector to verify:
  - Were all cabinets checked for conformity with the approved shop drawing and/or Standard Drawing?
  - Were all components in a 240/480 volt circuit rated for 600 volt operation and all other components rated for 250 volt operation?
  - Did the inspector submit the letter in-lieu of electrical clearance to the Electrical Utility Company for APS, SRP or GRIC? For other power companies was the green tag inspection completed?
  - Did the Contractor consult with the utility company to establish and install the proper amperage interruption capacity breaker?

- Was the meter socket approved by the utility company?
- Did the Contractor and Inspector meet with the utility company in the field to verify the exact location of the service run?
- Were all live electrical components protected by a dead-front panel?
- Were all circuit breakers labeled for the correct circuit number?
- Is there a wiring diagram placed in the cabinet?
- Did the Inspector approve all equipment and wiring before the Contractor contacted the utility company for hook-up?
- Was a ground resistance test performed and recorded in the presence of the Electrical Inspector on each ground rod at the service entrance equipment before being energized?
- Was the ground resistance test reading 25 ohms or less?
- If the ground resistance test reading was over 25 ohms, were additional ground rods installed and retested to achieve proper grounding below 25 ohms?
- After the electrical service was energized, was a voltage and amperage reading taken on each circuit?
- Were padlocks furnished and installed? Have plans been made for key transfer?

735 DETECTORS

Detectors should be installed as shown in the Project Plans. There are several different types of loops covered in this specification; signal loops for detection, preformed loop detectors, traffic data loops, WIM and pedestrian detectors. It may be necessary for the Resident Engineer to layout the exact locations of these detectors when the Project Plans are in conflict with existing detectors. It is important that the Resident Engineer contact the Designers if such a conflict is evident. The Electrical Inspector should bring any potential conflict to the attention of the Resident Engineer as soon as possible. Although the Inspector should make recommendations, no action should be taken until directed by the Resident Engineer.

Following installation of loop detectors, the Inspector should be satisfied that all required testing has been completed and the system is fully functional before accepting the work.

Loop Detector Installation:

- Check Project Plans for location, size, and type of loop detectors required.
- Make sure that loop detectors are installed in PCCP or Asphalt on new roadway construction.
    - Make sure loop detectors are properly located with respect to centering in each traffic lane and distance into the stop bar area (usually 6 feet if not specified).
    - Check the number of wire turns.
    - Was a 3/8'' High Temp Backer Rod installed continuous on top of the last installed loop wire?
    - Did the contractor twist the home run wire pairs 3 twists per foot?
    - Was the insulation resistance to ground test at least 50 megohms before and after the saw cut sealant was installed, and was it tested in your presence?
    - Did the Contractor perform and document a continuity test?
    - Were loop detector wires identified as to phase number, direction, and lane, with wire marking tags?
- Saw cutting loop detectors in asphaltic concrete or PCCP:
    - On new construction with multiple lifts of asphaltic concrete, make sure loop detectors are installed prior to the final lift being placed.
    - If a manhole or water valve cover is located where loop detectors are to be installed, the loop detector must be modified. Contact the project traffic Designer for a design change.
    - Are corner holes drilled first?
    - Is the saw cutting straight?
    - Check saw cut depth every 3 feet.
    - Were the saw cuts blown out with compressed air and dried before installing conductors? Check for small rocks and other debris.
    - Has the loop detector wire been approved?
    - Check the number of wire turns.
    - Were hold down tabs installed every 2 feet?
    - Was the approved sealant furnished and applied?
    - Was the insulation resistance to ground test at least 50 megohms before and after the saw cut sealant was installed, and was it tested in your presence?
    - Did the Contractor perform and document a continuity test?
    - Check sealant for voids.
    - Make certain that the Contractor has cut a 3-inch "Y" into the face of the curb directly over the loop detector conduit stub-out located under the curb.
    - Were loop detector wires identified as to phase number, direction, and lane, with permanent wire marking tags?
    - When loop detectors are to be installed on existing roadways under traffic conditions, does the Contractor have an approved traffic control plan?
    - The trap length will need to be tested and calibrated. The trap length is set with a test vehicle and adjustments in the controller.

- Were there any loops locations changed from the original plans and were they added to the as-builts?
- Was a loop detector accuracy verification form filled out?

A copy of the contractor’s preliminary test results shall be furnished by the Engineer to the Data Section of the Transportation Planning Division (206 S. 17th Ave., MD 070R, Phoenix, AZ 85007) to allow for final TPD-Data testing and input of the detector into the state highway log. Prompt notification will allow for final inspection by TPD-Data Section prior to retention release. Look at the other type of loops. See the Construction Manual Forms tab on the ADOT website for “Detection Loop for Traffic Counter or ATR” form.

Refer to T.S. 6-1 through 6-8 of the ADOT 2012 Standard Drawings for Traffic Signals and Lighting on specific details of the type C, SA and SB traffic counter systems.

Refer to T.S. 7-1 through 7-5 of the ADOT 2012 Standard Drawings for Traffic Signals and Lighting on specific details of the Traffic Signal vehicle detection loops including preformed loops installed under PCCP.

736 HIGHWAY LIGHTING

Highway lighting materials including luminaires, lamps, fixtures, and all other components listed in the specifications should be inspected to make sure that they are in compliance with the Project Plans and specifications. The Inspector should be fully involved in the installation of the poles and any adjustment of the luminaires in order to assure proper initial installation.

In the event the construction involves an existing system, the system must remain fully functional at night for the duration of construction unless otherwise stated in the Project Plans.

Installation:

Highway Lighting luminaires are Light Emitting Diodes (LED) used for roadway lighting. These are horizontally mounted, vertically mounted, and high-mast mounted. The following guidelines should be followed by the Inspectors monitoring this work:

- Did the certificate of compliance meet the luminaire housing, electrical, optical, and LED performance requirements?
- Check all luminaries delivered to the job site from the approved materials list.
- Check lamp socket position for the correct light distribution as specified for any horizontally mounted luminaires.
- When vertically mounted luminaires are used, check for correct tilt angle setting as specified on the Project Plans?
- Are the up-light shields installed?
- Is the lamp wattage checked?
- Were sign lighting luminaires checked for internal fusing, (internal fuses must be removed and located in an adjacent pull box) and correct fuse amperage rating?
- Were external up-light shields installed on sign lighting luminaires?
- Were Certificates of Compliance furnished for the shield?
- Were horizontally mounted luminaires leveled to the horizontal, and are all mounting bolts tightened?
- Were vertically mounted luminaires plumbed to the vertical before the tilt angle was set, and are all mounting bolts tightened?
- Were decals installed in roadway lighting clearly visible from the ground showing the lamp wattage in LED?
- Were all lighting luminaires energized for the 100-hour test?

800 GENERAL

Roadside Development covers:

- 801- Landscape Excavation
- 802- Landscape Grading
- 803- Landscape Plating Materials
- 804- Topsoil
- 805- Seeding
- 806- Trees, Shrubs and Plants
- 807- Landscaping Establishment
- 808- Water Distribution
- 809- Sewerage Systems
- 810- Erosion Control and Pollution Prevention

ADOT requires that Roadside Development must be under the direction of a Registered Landscape Architect, currently in good standing with the Arizona State Board of Technical Registration.

The requirement is covered under Arizona Revised Statute 32-142, Public Works that states: “Drawings, plans, specifications and estimates for public works of the State or a public subdivision thereof involving architecture, engineering, assaying, geology, landscape architecture, or land surveying shall be prepared by or under the direction of and the construction of such works shall be executed under the direct supervision of a qualified registrant within the category involved.”

Landscape Architecture is a technical profession in a distinct category of its own, different from Civil Engineering. ADOT’s Professional Landscape Architects (PLA) carry a technical registration and must be licensed through the Arizona State Board of Technical Registration. ADOT Construction Bulletin 11-06 for Roadside Development / Landscape Inspection and Acceptance covers the relationship between the RE and the PLA responsibilities relative to landscape construction activities. Additionally, the Central District Landscape Office Resource Guide and Statewide Landscape Architect Resource Guide were developed to help field offices to know when and how to utilize the PLA’s provided by ADOT.

ADOT furnishes state registered Professional Landscape Architect (PLA) services for construction in two different ways:

Central District has a landscape construction field office supervised by an PLA. This office normally handles the projects specifically covering those areas specific to Roadside Development scope of work and will assist other Central District field offices on projects with ancillary landscape work.

PLA services are furnished to other Units and Districts by the Construction Group Statewide Landscape Architect. A typical division of responsibilities is for the PLA to serve as the technical resident expert on a project, while the Resident Engineer (RE) supervising the project field office serves as the administrative resident. This approach requires close communications between the RE and the PLA. To accomplish the objectives, the PLA must be involved from the beginning of the project. The Statewide Landscape Architect initiates involvement at an early stage through review of the pre-award plans, as well as advising and inspecting during the construction phase.

Landscaping excavation and grading may necessarily be under the purview of an Engineer when incidental to other work, but those elements of work are important to accommodate future landscaping. For example, asphalt pavement, concrete, rocks or other deleterious materials should not be placed near the ground surface because their placement may inhibit construction of future plantings, irrigation systems or decorative rock

Incidental items such as curbs, sidewalks, slope paving, and drainage are covered elsewhere. When the plans include such things as buildings and water distribution systems, the Specifications will be found in the Special Provisions.

Progress Schedule

If the plans or Special Provisions require a landscape schedule, then it should show the order and/or sequence in which the contractor proposes to perform the work for landscaping. It should show the beginning and completion dates for the several prominent features of the work provided in the contract. In the case of plant material, the contractor shall supply the Resident Engineer with written verification, within 30 calendar days after the pre-construction conference, that they have located and reserved all the plant material that is necessary to complete the job as specified.

The schedule must include the weed control plan, called the Noxious Species Control Plan (NSCP), nursery inspection, the anticipated plantings per day, and areas to be worked concurrently. The underground irrigation, electrical, or other work within the planting areas must be completed and controlled through the irrigation controller before planting can begin.

The correct timing for herbicides, fertilizing, mulching, pruning, and all other phases must be specified in relationship of one event to another.

ADOT Landscape Architect Resource Guide

This section is intended to supplement Construction Bulletin 11-06 in assisting the construction field offices and provide guidance to Resident Engineers and Project Supervisors on how to utilize the Construction Professional Landscape Architects (PLA) on their projects. This also applies to all permit offices and their projects within the State of Arizona. Items listed below are typical items found on ADOT, Statewide Permit and LPA projects. It describes what part of the item applies to the PLA and how the administering field office should utilize the PLA in their approval and inspection of those items.

ADOT Landscape Architects

ADOT has four groups in which you will find a Landscape Architect. These four offices are involved with almost all projects, throughout the project's life cycle.

1. Roadside Development, Chief Landscape Architect
    - The Roadside Development Section provides landscape architectural and environmental technical design direction and expertise during project planning and design.

2. Central District Construction, Landscape Architect
    - The Central District Landscape Architect(s) through the Landscape Construction Field Office administers their own construction projects while also providing assistance and oversight to all Central District field offices whose projects have landscape elements during construction.

3. Construction Group, Statewide Landscape Architect
    - The Statewide Landscape Architect(s) work under the State Construction Engineer to provide oversight, quality control and assistance with all landscape elements during design and construction for all Districts in the State outside of the Central District.

4. Central District Maintenance, Landscape Architect
    - The Central District Maintenance Landscape Architect(s), or duly appointed landscape representative(s) oversees all maintenance of landscaping within the Central District.

Preconstruction

During design development (by Stage III design review) if the project has landscape, irrigation, seeding, aesthetics or noxious and invasive weed control, be sure to include both the regional maintenance and construction PLA's in the review process to ensure no issues with those items will arise during construction. The PLA's will provide technical review and comments for the landscape, irrigation, seeding, aesthetics, and weed control items of work.

This process also includes permitted projects that are being developed outside of ADOT for projects within the ADOT Right of Way.

The Construction PLA should be invited to the partnering and preconstruction meeting where the following responsibilities may be addressed.

Construction

During construction, it is the responsibility of the administering office to collect all required submittals and distribute them to the appropriate reviewer. Sampling and testing of materials will also be done by the administering field office with inspections of the work generally being the responsibility of that field office; unless otherwise noted below. Items of work or tasks requiring the participation of the Construction PLA or Landscape Construction office have been outlined below. The regional Construction PLAs are available as the technical registrant advisor for landscape, irrigation, seeding, aesthetics, and noxious and invasive weed control to Resident Engineers statewide. If any coordination with Roadside Development is needed during construction, the Landscape Construction Field Office PLA will coordinate on behalf of the Resident Engineer.

- **201 - Removal of Trees, Item 2010020**
  Applies to the removal of trees as part of the clear and grubbing operations.
  - The Construction Field Office is responsible for general inspection of the item requirements.
  - The Landscape Construction Field Office is responsible for assisting in identifying and flagging trees to be removed or protected in place.
  - Allow the PLA a minimum of one week notice before an inspection is needed.

- **202 - Remove and Salvage, Items 2020053 - 2020060**
  Applies to projects with salvage and nursery plans. Existing plant material would be salvaged, boxed and placed in a temporary nursery until planted on site.
  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance. Inspecting the salvage operation to insure compliance with the approved salvage and nursery plan.
  - The Landscape Construction Field Office PLA will review and approve the salvage and nursery plan. If needed and available, the PLA can assist in inspection of removals and temporary nursery inspections.
  - Allow the PLA a minimum of one week to review and provide comments on the salvage and nursery plan. Advanced notice of inspections are helpful when scheduling the PLA and if available, providing an inspector to assist with the inspection.

- **500's - Drainage**
  Applies to Rock Mulch and Rip Rap incidental to the work required for the construction of drainage facilities. Typically will reference the 810 Standard Specification.
  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance. Conduct the installation, inspection, and the completion of any required Quantlists.
  - The Landscape Construction Field Office is responsible for the review and approval of the color and gradation on all landscaping rock products being placed on the project.
  - Allow the PLA a minimum of five business days to review color and visual gradation once the samples have been provided or material is delivered to the project site.

- **601 - Structures (rustications)**
  Applies to wall aesthetics and rustications for structures such as sound and retaining walls, bridge piers, abutments, etc.

- The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance. Shop drawings should also be sent to the designer for approval.
- The Landscape Construction Field Office is responsible for reviewing shop drawings, approving formliners, mockups, and final finished products. If needed, the Landscape Construction Field Office will coordinate with Roadside Development on behalf of the Resident Engineer.
- In most cases the PLA's review of formliners and mockups can be done as soon as the mockup is ready; provided the PLA is kept informed of dates. Advanced notice of inspections are helpful when scheduling the PLA for inspection of final finishes.

- **610 & 1002 - Painting**
  Applies to paint for structures and aesthetic treatments. Paint colors and type should be per the specified colors called out in the project documents.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance. Conduct the installation, inspection, and the completion of any required Quantlists.
  - The Landscape Construction Field Office is responsible for the review and approval of paint drawdowns, mockup samples, and final finished products. If needed, the Landscape Construction Field Office will coordinate with Roadside Development on behalf of the Resident Engineer.
  - Allow the PLA a minimum of three business days to review paint drawdowns. In most cases the PLA's review of painted mockups can be done as soon as the mockup is ready; provided the PLA is kept informed of dates

- **801 - Landscape Excavation, Items 8010051 - 8010052**
  Rarely used item for removal of existing landscape, typically turf.

- **802 - Landscape Grading, Items 8020001 - 8020011**
  Applies to the final fine grading of any slopes or grades that will receive decomposed granite (DG), plantings, seeding or landform graphics prior to acceptance. Construction and conformance to the project plans, i.e. built per the specs and details, is the responsibility of the administering civil construction office. The Construction PLA should be consulted on the final acceptance of grades and slopes

  - The Construction Field Office is responsible for grades being constructed in conformance of the lines, dimensions and cross sections shown in the project plans.
  - The Landscape Construction Field Office is responsible for the review and approval of the final fine grading prior to installation of decomposed granite, rock mulch, plantings, seeding or landform graphics.
  - In most cases, review of the fine grading can be done once the site is ready; provided the PLA is kept informed of dates. Advanced notice of inspections are helpful when scheduling the PLA and if available, providing an inspector to assist with the inspection.

- **803 - Landscape Plating Materials, Items 8030001 - 8030150**
  Applies to all plating treatments including soil backfills, decomposed granite and rock mulch.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance.
  - The Construction Field Office is responsible for conducting the installation inspection, sampling, and testing.
  - The Landscape Construction Field Office is responsible for the review and approval of product color and visual gradation samples prior to installation. If needed, the Landscape Construction Field Office will coordinate with Roadside Development on behalf of the Resident Engineer.
  - Allow the PLA a minimum of three business days to review color and visual gradation once the samples have been provided or material is delivered to the project site.

- **804 - Topsoil, Items 8040001 - 8040321**
  Applies to projects with topsoil specifications for ground amendment to planting areas. The contractor will most likely be required to submit a topsoil plan for review and approval by the Department.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance.
  - The Construction Field Office is responsible for conducting the installation inspection, sampling, and testing.
  - The Landscape Construction Field Office is responsible for the review and approval of the proposed topsoil plan.
  - Allow the PLA a minimum of one week to review and provide comments on the topsoil plan.

- **805 - Seeding, Items 8050003 - 8050151**
  Applies to the placement and maintenance of seeding for the purposes of erosion control in final stabilization and as an element of the landscape.

  - All seeding submittals should be reviewed by the construction PLA who will then start a seeding submittal review form on behalf of the administering field office. The construction PLA will see the submittal process through the final approval of all required submittals. PLA will work with the Engineer to review seeding areas.
  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance.
  - The Construction Field Office will conduct the installation inspection and the completion of any required Quantlists.
  - The Landscape Construction Field Office is responsible for the review and approval of all seeding submittals along with holding the seeding pre-activity meeting. If necessary and available, the PLA will assist in the seeding installation and inspection along with conducting the 45 day maintenance inspections.
  - Allow the PLA a minimum of one week to review and provide comments on the first seeding material submittal and three business days for all subsequent material submittal reviews. Provide the PLA a minimum of one month notice prior to seeding operations. This allows for the scheduling of a seeding pre-activity meeting, weed inspection, and the pre-treatment of the seeding areas, e.g. fine grading, weed and rock removal.

- **806 - Trees, Shrubs & Plants, Items 8060001 - 8063003**
  Applies to the selection, placement, construction requirements and care of planting materials from nursery stock and collected/local stock.

  - The PLA will assist in plant layout, nursery inspection, maintenance of existing landscape during construction and installation.
  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance.
  - The Construction Field Office will conduct the installation inspection and the completion of any required Quantlists.
  - The Landscape Construction Field Office is responsible for the review and approval of all material submittals for soil amendments, staking, and plants. The PLA will conduct an on-site nursery inspection and approve selected plant stock. The PLA will approve plant layout and if needed, assist in the installation inspection.
  - Allow the PLA a minimum of one week to review and provide comments on material submittals and a minimum of three business days for all subsequent material submittal reviews. Allow the PLA a minimum of one week notice for all plant layout inspections and a two week minimum notice for all nursery inspections.

- **807 - Landscape Establishment, Items 8070001 - 8070106**
  Applies to the maintenance required to care for the planted stock and irrigation as well as keeping the project free from weeds, grasses and construction debris.

  - The Landscape Construction office will assist the administering office with the Phase II Landscape Establishment portion of their project. All ADOT projects will be inspected by the Landscape Construction office. Local Public Agency (LPA) projects may or may not inspect their own landscape during establishment.
  - The Construction Field Office will coordinate with the prime contractor and make payments for the items.
  - Landscape Construction field offices should be involved in the creation of the final punch list before substantial completion is given. This is to add any landscape related items prior to the beginning of the landscape establishment phase. The Landscape Construction field office will conduct a pre-activity meeting to communicate the Departments requirements and expectations prior to the landscape establishment phase. The Landscape Construction field office will conduct the Phase II inspections and report findings to the administering office.
  - Allow the PLA a minimum of two weeks notice prior to the acceptance of phase I landscape, this allows the PLA time to schedule and prepare the pre-activity meeting prior to phase II. Notifying the PLA prior to creating the final punch list allows the PLA time to collaborate with the field unit, schedule a landscape inspection, and submit their findings to the field unit.

- **808 - Water Distribution, Items 8080001 - 8087006**
  Applies to all temporary and permanent irrigation systems.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance. Irrigation submittals should be sent to the irrigation designer for approval.
  - The Construction Field Office will conduct the installation inspection and the completion of any required Quantlists.
  - If needed and available, the Landscape Construction Field Office is responsible for the installation inspection and assistance along with technical advisory on any modifications to the specifications or project plans.
  - Advanced notice of inspections are helpful when scheduling the PLA and if available, providing an inspector to assist with the inspection.

- **810 - Erosion Control & Pollution Prevention, Items 8101001 - 8102000**
  Applies to all rock mulch, rip rap or granite products being used for permanent erosion protection.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance.
  - The Construction Field Office will conduct the installation inspection and complete any required Quantlists.
  - The Landscape Construction Field Office is responsible for the review and approval of the color and gradation on all landscaping rock products being placed on the project. Field units should consult the PLA or District Environmental Coordinator (DEC) for questions and guidance regarding erosion and sediment control.
  - Allow the PLA a minimum of three business days to review color and visual gradation once the samples have been provided or material is delivered to the project site.

- **924 - Noxious Weeds, Items 9240181 - 9240182**
  Applies to the Noxious and Invasive weed specification. Weed control is a Federal, State and Local regulatory requirement.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance. Inspection and payment for the herbicide and/ or manual/mechanical items. Inspecting for new or existing weed growth within the project limits throughout the life of the project and reporting any findings to the contractor and the ADOT PLA.
  - The Landscape Construction Field Office is responsible for the review and approval of the NSCP. The PLA will inspect the project before ground disturbance and identify the areas in need of treatment. The PLA will hold the NSCP pre-activity on site with the contractor and spray sub-contractor. The PLA will periodically inspect projects throughout construction for new noxious and invasive weed growth.
  - Allow the PLA a minimum of one week to review and provide comments on the first NSCP submittal and allow three business days for all subsequent NSCP submittal reviews. Because weed control must be done prior to any ground disturbance, including contractor mobilization and the herbicide treatments requires up to fourteen days to work, the NSCP should be reviewed a minimum of four weeks prior to any disturbance and if possible, the pre-activity meeting should be held three weeks prior to that.

- **924 - Landform Graphics**
  Applies to the selection of graphic artists, layout, and construction of landform graphics.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance.
  - The Construction Field Office will conduct the installation inspection and the completion of any required Quantlists.
  - The Landscape Construction Field Office is responsible for the review and approval of the qualifications of the graphic artist, layout of graphics, and the installation of the drainage features in the graphics.
  - Allow the PLA a minimum of one week to review and provide comments on landform graphic artists and materials. Allow the PLA a minimum of one week notice prior to any layout and inspections of the graphics. Advanced notice of drainage feature inspections are helpful when scheduling the PLA and if available, providing an inspector to assist with the inspection.

- **924 - Irrigation Enclosure**
  Applies to the enclosures that all ADOT irrigation controllers and master irrigation assemblies are in. May be simple chain link fencing or more elaborate concrete, CMU or steel structural enclosures.

  - The Construction Field Office is responsible for collecting all submittals and certifications and forwarding them to the PLA for review and acceptance. Shop drawings should also be sent to the designer for approval.
  - The Landscape Construction Field Office is responsible for the review of shop drawings, the review and approval of materials, mockups, and when required any final finished products. If needed, the Landscape Construction Field Office will coordinate with Roadside Development on behalf of the Resident Engineer.
  - Allow the PLA a minimum of one week to review and provide comments on material submittals. In most cases the PLA’s review of formliners and mockups can be done as soon as the mockup is ready; provided the PLA is kept informed of dates. Advanced notice of inspections are helpful when scheduling the PLA for inspection of final finishes.

801 LANDSCAPE EXCAVATION

Work necessary to reshape the ground and to remove material unsuitable for planting is performed as landscape excavation. The excavated areas are often backfilled or plated with imported material.

The inspector should ensure that the work performed is carried to the staked limits. Irregular areas may be difficult to stake using conventional methods and adjustments may be necessary.

Over or under excavated areas are to be corrected before the placement of topsoil, rock mulches, decorative rock, seeding, landform graphics or landscape borrow is permitted.

The depth of topsoil, rock mulches, or landscape borrow is critical for plant growth so the outcome of the entire landscaping project may depend on the performance of this initial work.

Some details that usually need to be checked during this operation are:

- Only legal loads are to be allowed; however, some projects have roadways requiring less than legal loads on large trucks.
- It may be necessary to cover loads or take other measures to prevent spillage caused by slumping and sliding or wind. In Maricopa and Pima County it is required by law to cover loads. In other areas it is a good practice to reduce dust.
- When the contractor has their own disposal area, they must furnish the Resident Engineer with evidence that they have a Use Permit and also that the owner is satisfied with the condition of the disposal site after the contractor is finished with it.
- When the Department furnishes disposal areas, the Resident Engineer will designate where material may be placed and will specify how the area is to be cleaned up and reshaped.
- Maintenance access should be considered in areas being worked for forming and grading on the project. If the plans do not specifically show maintenance access roads in the grading plans, consider providing for access to difficult areas in the project limits.

802 LANDSCAPE GRADING

The grading of the areas outside of planting beds, rock mulch, lawns, or other special treatment zones is performed under this item of work.

The grading work will be performed whether or not payment is specified. It is intended that the entire area will be finished to a uniform appearance by smoothing and shaping and giving it a final raking. All objectionable rock larger than 2 inches in diameter, or debris that is turned up or loose on the surface, must be removed. Any irregularities in the grade will become prominently visible once final surfacing is placed, especially in landform graphics whose metal edging will emphasize changes in the grade. Close attention must be made to ensuring all maximum allowable slope percentages are adhered to prevent any sloughing or erosion of the final plated surface material.

The final finishing and raking should be timed with the completion of all the other landscaping so that the weather or other agents will not cause rutting, sloughing, erosion, or any other kinds of deterioration.

It is important that the record shows a complete description of the area being requested for payment.

803 LANDSCAPE PLATING MATERIALS

Roadside areas that will be planted usually receive a plating material. The plating material may be landscape borrow, decomposed granite, granite mulch, or rock mulch. The area on which the borrow is placed may be the original ground surface or areas shaped and prepared under landscape excavation or landscape grading.

Whether or not the ground was excavated or graded, it shall be cleared of all objectionable material, as described in the Standard Specifications or Special Provisions, before borrow is placed.

If the contractor has delays between excavating, grading, or placing borrow, they may be faced with a considerable amount of weed cleanup or fill repair. The contractor should be encouraged to schedule construction operations to minimize new weed growth and erosion in previously prepared areas. If the project includes it, the Noxious Species Control Plan (NSCP) should outline the contractors plan for the control of noxious and invasive weed species. Weeds not listed as noxious and invasive on the State or Federal lists shall be cleared by chemical or manual removals prior to any plating material being placed.Only a licensed spray technician through the State of Arizona can apply chemical herbicide in the right-of-way. If a reasonable schedule cannot be met, the contractor should be notified of the consequences in writing.

The borrow may be obtained from within the project limits or from special sources away from the project, but, wherever it comes from, it must be tested and must meet all requirements of Specification 804 for topsoil.

Compaction requirements will be found in the Special Provisions.

Landscape borrow may be specified for use to repair erosion damage prior to placement of rock mulch, decomposed granite, or granite mulch in landscaped areas. It is important to fill and compact the borrow areas in a uniform manner to lessen the possibility of future erosion.

Decomposed granite or granite mulch will not be placed until the required landscape irrigation system and planting operations have been completed within the area. If the contractor chooses to place decomposed granite or granite mulch after they have planted, special attention should be made to ensure the planted material is not damaged in the placement process.

Non-woven filter fabric under rock mulch shall be completely covered and not visible.If the details show it, filter fabric edges shall be toed into the adjacent slope to prevent water from undermining the fabric and eroding the rock mulch or riprap swale. If not shown in the detail, it should be suggested to the contractor as good practice to prevent the undermining Planting in rock mulch shall be kept to a minimum in the desert. All rock mulch swales should appear natural and follow the drainage flow line. Check elevations of all aprons to ensure they are low enough to catch the flow.

The use of pre-emergent or soil-active herbicides within landscape plating materials requires prior approval. All materials and products used for weed control shall be submitted to the project office for review and approval. These should be reviewed by the RLA assigned to assist with the project. The contractor, as required in the contract, will document all applications of herbicide using the ADOT Herbicide and Pesticide Application Log or approved equivalent and a copy of this documentation will be given to the Resident Engineer. The inspector will obtain this documentation the day of application. Water shall be applied to all areas receiving a pre-emergent herbicide application as required by the manufacturer’s product label. This water may be supplemented by rainfall as determined by the Resident Engineer within the period required by the manufacturer’s label. Inspectors should utilize the contractor’s record for the purpose of documenting application details and note the observation in their Daily Diary. Close attention should be made by the inspector to the process of placing plating materials. The special provisions will outline a specific sequence of grading, applying herbicide, plating and maintenance.

804 TOPSOIL

Sources may or may not be designated. When sources are furnished by the contractor, prior to hauling any topsoil to the project site, the contractor shall submit a written soil analysis prepared by a laboratory, for approval by the Resident Engineer. The Resident Engineer should send the analysis to Roadside Development through the RLA assigned to assist the project for review and approval.

Requirements to be met and attested to in the soil analysis are:

- Soil shall be fertile.
- Soil shall be friable or easily crumbled.
- Soil shall be from well-drained arable land.
- Soil shall be from land that has been producing healthy vegetation.
- Soil shall be non-toxic.
- Soil shall be reasonably free from subsoil, refuse, roots, heavy clay, clods, noxious weed seeds, phytotoxic materials, coarse sand, rocks over 2 inches in diameter, sticks, brush, litter, and other deleterious matter.
- The characteristics of the soil shall meet the requirements of the Standard Specifications.
- Topsoil that has pH values that are too high can be amended with soil sulfur and/or gypsum as recommended by an accredited soil laboratory and approved by the Resident Engineer.

Soil obtained from more than 4 feet deep should not be considered as topsoil even if it complies with the grading, pH, soluble salts, and plasticity index requirements. Topsoil usually is no deeper than 3 to 4 feet. Anything below that usually has calcium carbonate chunks, poor structure, and does not have soil bacteria and microbes necessary to facilitate good plant growth.

Sometimes onsite material is designated to be stockpiled and placed at the top of new embankments, check Section 203 of the project Special Provisions for this requirement.

Certificates of Analysis shall be submitted to the Resident Engineer for each source of topsoil proposed for use. The Resident Engineer's approval shall be obtained prior to delivery of the topsoil from the source to the project.

The Resident Engineer at the job site gives final approval of the material after testing in accordance with the Standard Specifications. Six random samples shall be taken after final placement of each 20,000 cubic yard lot delivered to the site.

Sub-grade material shall be scarified to a depth of 6 inches prior to placement of topsoil. Placement shall be uniform and any compacted areas are to be broken up by cultivation.

805 SEEDING

Certificates of Analysis conforming to Specification 106.05 are needed for all material used in seeding.

Commercial materials are required to be labeled showing all the included ingredients. The inspector must have a clear understanding with the sub-contractor as to the areas to be seeded and which method will be used in each area. Do not allow operations during windy weather. Raking, harrowing, disking, and loosening of the soil as specified are very important.

Read the Specification carefully and see that the procedures are followed faithfully. The procedures are the result of many years of experience and are known to give the best possible results.

A review of slope soil types is quite important. Erosion problems can lead to unsightly slopes and cause maintenance problems. In some cases, this creates a safety hazard and water pollution if not properly handled. If erodible soils are on or near the surface of slopes, consideration must be given to reducing erosion through seeding.

805-2 Materials

805-2.02 Seed

Seed is specified by using genus, species, and sometimes variety. When a variety is specified, no other variety is acceptable unless approved by the Landscape Architect, who would consider delivery times, complications, plant characteristics, cost, etc. An example would be Agropyron trichophorum (Luna). If Agrophyron trichophorum were specified, any variety of Agrophyron trichophorum would be acceptable. If Agrophyron trichophorum (Luna) were specified, only the variety Luna would be acceptable.

The Specifications will designate the type of seed and the rate of application in terms of Pure Live Seed (PLS) pounds or ounces per acre. Pure Live Seed is just that, all the seed that has a live germ in it. It is the total germination rate and hard dormant seed. Purity is described as the amount of the weight (mass) that is actually seed and is given in percent: 95% purity indicates for each pound of weight (mass) you have only 95% seed, the rest being trash or dead seed.

To determine how much pure live seed you have in a given weight (mass), you multiply the purity by the total of the germination and the hard (dormant) seed. If you have ten pounds of seed with 50% germination, 5% hard seed, and a purity of 60%, you would have 3.3 pounds of pure live seed.

This can be shown as follows:

purit	(germination + hard seed	(PLS)
.60	(.50 + .05)	.33

For each 10 pounds of seed from the sack, the PLS equals: .33 x 10 = 3.3 pounds of PLS

Each seed container will be labeled as required by Arizona and Federal Laws.

The labels will indicate, among other things, percent purity or pure seed, percent hard or dormant seed, if there is no hard or dormant seed the term may not even be listed, and the percent germination.

Two examples of how this information may be listed are shown below:

A		B	
Pure Seed	98.00	Purity	98.25
Other Crop	0.30	Crop	0.67

Inert	1.65	Inert	1.06
Weeds	0.05	Weeds	0.02
Noxious Weeds	0	Noxious Weeds	0
Germination	88.00	Germination	85.00
Hard Seed	0	Dormant Seed	1.00

Note: The values in the above table are in percent. In order to make calculations, convert the percent values to decimal proportions by dividing each by 100. For example, 98.00 (%) = 0.98.

The adjusted rates of application are computed by the PLS formula as follows using the examples shown above:

A: PLS = (0.88 + 0) x 0.98 = 0.86

B: PLS = (0.85 + .01) x 0.9825 = 0.84

The adjusted rate of application of seed is then calculated by dividing the specified rate of application by the PLS percent.

If the specified application rate is 12 pounds per acre, then using the appropriate percent from the above calculations:

A: 12/0.86 = 13.95 lbs. per acre B: 12/0.84 = 14.28 lbs. per acre

We now have an adjusted rate of application that will provide 12 pounds of pure live seed per acre.

805-2.03 Mulch

(A) Wood Cellulose Fibers

Wood fiber is usually used for Class I seeding and straw is usually specified for Class II seeding.

Wood cellulose fibers made from virgin wood is specified to prevent the use of shredded newspaper or other paper products. Ink, glues, and other impurities used in paper manufacturing can be detrimental to plant growth.

(B) Straw

Straw shall be certified, free of restricted or noxious weed seed, and from the current season's crop to preclude the use of dry brittle mulch that does not crimp properly. The Resident Engineer will select a minimum of one bale of straw from each shipment, and open the bale to check for dry brittle straw and take samples of any uncommon seed in the straw. The object of the crimping is to provide vertical stubble to help hold the loose stems from blowing away.

It is more desirable to have mulch crimped but if the soil is too rocky or the land is too steep for good crimping, the alternative is to tack the mulch.

805-3 Construction Requirements

The seeding operation typically is a six step process. These steps are:

1. Initial 6”-12” tillage of the soil to break the surface which may be native cut slope soil or compacted fill slopes. This creates a growing medium for seeds to germinate and grow from.
2. Application of the soil amendments which generally includes a fertilizer and a soil sulfur.
3. A second tillage to a depth of 4” to incorporate the soil amendments into the growing medium.
4. Application of the seed mix as specified in the special provisions.

5. Application of the final coverage of the seed bed which may be straw, hydro mulch or combination of the two. This protects the newly planted seed from the elements such as sun/heat, wind and rain.
6. A 45 day maintenance period to ensure the seed bed has not been damaged by other incidental construction activities or from the elements.

Recommended inspection steps are as follows:

1. Check that all seeding materials have been approved and delivered to the jobsite. Verify all materials delivered to the job site are in fact the approved material in the correct packaging and weights.
2. Measure the total acreage requiring seeding on the project. Start with plan areas, then field check for any adjustments required. Convert slope areas and adjust seeding material quantities as required in the special provisions.
3. Check all seed delivered to the project for the correct species/genus/variety, correct weight per package and from the correct supplier. Review the seed tags for all certification requirements. If the tag doesn’t include the final pure live seed content, species/genus/variety or suppliers name, the seed should be rejected and taken off of the project.
4. The first critical step in the seeding process is the initial tillage of the seed bed. The specifications will guide you on the required depths based on cut/fill slopes. It is critical that the contractor meet the required depths no matter how difficult or hard the soil may be. The contractor is required to furnish the equipment capable of reaching the required tillage depth. Think of this as farming. Farmers do not place seed on top of unbroken soil.The seed would just dry up in the sun or blow away. Farmers will till and turn their fields to a depth of one foot or greater to get the best conditions for seed germination and growth.
5. Observe the correct rates of soil amendments are placed in the seeding areasOnce complete, the amendments will be incorporated into the soil to a minimum 4 inches in depth.
6. Observe weighing and verify weights when batched. Use the ADOT Seeding Rate/Batch Mix form to verify the correct batch mixes are being used. This should be submitted to the Department from the contractor prior to beginning the seeding operations. The form provides a guideline for the mix design calculations and inspection information.
7. The seed mix design in the special provisions will provide the required PLS rate for each acre of coverage. Each batch mix will cover a maximum area of the seeding base off of the seeding mix design in the special provisions. The seeding area should be sectioned off appropriately, so the inspector can verify the seed distribution aligns with the design requirements.
8. The ADOT Seeding Application Inspection Report should be utilized to track the seeding operations and activity.

ARIZONA DEPARTMENT OF TRANSPORTATION

SECTION 805 - CLASS II SEEDING

Seeding Rate/Batch Mix

TRACS Number		Date	
Beginning Milepost		Bid Project Acres	
Ending Milepost		Seeded Acres	
Seed Mix (H1,H2,H3,H4)		Method (Hydro or Drill)	
ADOT Representative		Contractor Representative	

Pure Live Seed (PLS) Calculation					**Adjusted Application Rate**	
$\left(\left(\frac{\%\ \text{Germinatio}}{100}\right)+\left(\frac{\%\ \text{Hard Seed}}{100}\right)\right) X \frac{\%\ \text{Pure Seed}}{100} = \text{PLS}$					**SAR÷PLS=AAR** Pounds Per Acre	
Seed Type Common Name (spec)	% Germination *(on tag)*	% Hard or Dormant Seed *(on tag)*	% Pure Seed Percentage *(on tag)*	Decimal - Pure Live Seed (**PLS**)	Specified Application Rate (**SAR**) *from Special Provisions*	Adjusted Application Rate (**AAR**)
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	*0.00%*	*0.00%*		*0.00*	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
	0.00%	0.00%	0.00%		0.00	
					TOTAL	0.00

TRACS Number		Date	
Beginning Milepost		Bid Project Acres	
Ending Milepost		Seeded Acres	
Seed Mix (H1,H2,H3,H4)		Method (Hydro or Drill)	
ADOT Representative		Contractor Representative	

Slope Adjustment Calculation

Plan Area x Adjustment Factor = Slope Area

	Plan Area (acres)	Slope	Adjustment Factor	Slope Area (acres)
1		Flat	1.00	0.00
2		3:1	1.05	0.00
3		2.5:1	1.08	0.00
4		2:1	1.12	0.00
5		1.5:1	1.20	0.00
6		1:1	1.41	0.00
			Total	0.00

Total Batch Mix Calculations

Slope Area x (Seed + Tacking Agent + Wood Fiber) = Total Batch Mix

	Slope Area (acres)	Total Seed Weight (AAR)	Tacking Agent (40lbs./acre)	Wood Fiber (200 lbs/acre)	Total Batch Mix
1	0.00	0.00	40	200	0.00
2	0.00	0.00	40	200	0.00
3	0.00	0.00	40	200	0.00
4	0.00	0.00	40	200	0.00
5	0.00	0.00	40	200	0.00
6	0.00	0.00	40	200	0.00

Total Hydraulically Applied Straw Mulch and Tacking Agent

Area x Tacking Agent *and* Area x Hydraulically Applied Straw Mulch

Slope (H:V)	Slope Area (Acres)	Tacking Agent (Pounds per acre)	Total Tacking Agent (Pounds)	Hydraulically Applied Straw Mulch (Pounds per acre)	Total Hydraulically Applied Straw Mulch (Pounds)
Flat to 6:1	0.00	150		2,000	
From greater than 6:1 to 3:1	0.00	150		2,500	
Greater than 3:1	0.00	200		3,000	
Erosive Soil Slopes or Highly Erosive Areas*		250		3,500	
*As determined by Engineer		Total	0.00	Total	0.00

Exhibit 805.03-1 ADOT Seeding Rate/Batch Mix Form

805-3.01 General

Many problems can be prevented in the initial stages of construction if the contractor will protect the roadway as the work progresses. Elimination of low spots, grading of slopes, and direction of drainage water can all reduce damages. Poor construction practices can, in the long run, cost the contractor additional money to correct the damage. The Construction Landscape Architect is available to assist the ADOT construction personnel in changing erosion control or seeding requirements.

The permanent protection of earth fill and cut slopes should be accomplished as soon as possible. When provided in the contract, topsoil should be evenly placed on the slopes at the specified depth for areas to be seeded. The topsoil shall then be compacted per specifications, taking care to have the topsoil penetrate and bond with the soil it is covering. The purpose for this is to penetrate the topsoil layer, bonding it to the underlying material and to lessen the possibility of losing the topsoil by erosion.

Seed and fertilizer are to be uniformly applied on the slopes at the rate and mixture specified in the contract. Application shall be by an approved hydro-seeder, blowing equipment, properly equipped helicopters, or power drawn drills or seeders. Where areas are inaccessible for this equipment, approved hand seeding will be permitted.

All seed mixtures shall be mixed under the direction of the Landscape Architect through the Resident Engineer and observed by the inspector on site who will document the batch mix on the ADOT Seeding Application Inspection Report.

The Resident Engineer and contractor will measure the areas to be seeded and fertilized as soon as they can be determined, and inform the inspector of the anticipated acreage. The contractor will use this information to order the proper amount of materials for the project and to determine the correct application rate of the seed and fertilizer. During the seeding and fertilizing operation, the inspector shall see that the material is placed at a uniform rate and compare the amount of seed and fertilizer applied with the area covered to verify that the proper rate of application is being placed.

Inspectors can reach out to the ADOT Roadside Development office or the Construction Landscape Architect regarding the fillable calculation sheet, which was developed to assist the inspector in documenting the contractor’s application and verifying the calculations of the seed mix and weight per load.

The seed shall be applied in a separate application after fertilizing. Straw mulch must be uniformly applied to the seeded areas within 24 hours after seeding. Checks are also necessary to determine that the mulch is applied uniformly and at the required rate. In areas that cannot be reached by a mulch spreader, hand methods resulting in uniform application may be used. The straw shall be crimped or tacked within 24 hours after being placed.

Crimping the straw mulch is the preferred method for anchoring straw mulch, and must be performed immediately behind the straw application. In some areas, it may be specified for the contractor to anchor the mulch with a tacking agent. The Standard Specifications and Special Provisions are quite complete in the method of anchoring mulch.

In order to control the possible erosion resulting from fast run-off on steep slopes, excelsior matting may be used for temporary erosion control. It also has its use on flatter slopes (less than 3:1) where erodible soils are encountered. The purpose for using matting is to provide a quick temporary protection until the seed has grown enough to be permanent protection for the soil, but the matting cannot be expected to cope with water other than precipitation. Drainage from above or beyond the raw slope should be controlled by ditching or drains. The inspector is charged with being alert to this potential problem and making every effort to ensure that drainage is diverted from the slope.

There is usually no seeding date specified in the Special Provisions for Class II and III. It is felt that it is better to plant as soon as possible--before the soil crusts. A variety of different seeds is used to further the chances of success. Both cool and warm season germinating grass varieties, as well as shrub and flower seed, is used.

806 TREES, SHRUBS, AND PLANTS

806-1 Description

Trained and experienced personnel should perform inspection of all roadside plantings, under direction of the Construction Landscape Architect. Recognizing that this is not always possible, this section is written to serve as a guide for project personnel. It is not intended as a substitute for professional assistance when available. When questions concerning adequacy of planting stock and procedures are encountered, or when differences of opinion concerning the acceptance or rejection of plants occur and the answers are not readily found in this section, the inspector should request the assistance of the Construction Landscape Architect. In cases where insect damage and diseases are suspected, the services of an entomologist or plant pathologist may be required.

The highway right-of-way is largely a disturbed environment, lacking in natural soil profiles and subject to unusual run-off, abnormal air turbulence, pollutants, temperature variations, and other extremes. In this environment the designer is faced with providing appropriate highway vegetation.

Functional plantings serve to improve traffic guidance, reduce headlight glare, provide safety features, reduce pollution, provide view and wind screening, control erosion, act as a sound barrier, and contribute to improved aesthetic values. The interest and variety created by imaginative planting design are important aesthetic values. Plantings can also be used to create a smooth transition from rigid geometric cross section and structural forms to nearby natural vegetation and landforms.

Of concern is the survival of plants under the conditions imposed by the design and the environmental conditions of the site. The best conceived and designed planting may not produce the desired results if the quality of plants and the planting procedures fail to meet the specifications. It is important to follow the plans, specification and details as these were developed by ADOT specifically for landscapes along the public highways and freeways.

Arizona Revised Statutes 32-142, Public Works', requires that “Drawings, Plans, Specifications, and estimates for public works of the State or a public subdivision thereof involving architecture, engineering, assaying, geology, landscape architecture, or land surveying shall be prepared by or under the direction of and the construction of such works shall be executed under the direct supervision of a qualified registrant within the category involved". Therefore, before commencing any work, there should be a meeting with the Resident Engineer, the Construction Landscape Architect, and the inspectors. The agenda for the meeting scheduled by the Resident Engineer should include, but not be limited to, the following:

- The basic concept of what is to be achieved with each individual area and the project as a whole.; revegetation, open forest, screening, focal attention, and all other aspects to be discussed must be understood if the ultimate concept of design is to be accomplished.
- The growing characteristics, weaknesses, and strong points of each plant should be discussed especially as they relate to the environment over which the inspector has some control, e.g. drainage, exposure, etc. Modifications of the plans should be discussed with the Construction Landscape Architect.
- Discuss possible maintenance problems with maintenance personnel. Modifications that were unexpected during design may need to be implemented. At the initial layout stage, maintenance personnel should be consulted on any unforeseen conflicts in the planting design. Any modifications to the plans should be coordinated with the Construction Landscape Architect to ensure that the design concept is maintained.

806-2 Materials

Certificate of Compliance is required for all contractor furnished materials. Materials on landscaping projects include many items besides plant material, e.g. planting media, pesticides, fertilizer, mulch, staking and guying material, irrigation/electrical material; pipe, pumps, sprinklers, backflow control devices, valves, etc., drainage, surfacing, and more. The appropriate section of this manual covers the inspection and testing of the more common highway construction material encountered.

Plant Material: Sampling of plant materials must be done with judgment. Look the entire lot over, carefully noting the general size differential, coloring, the sturdiness, the shapes, leaf dropping on evergreens, condition of bare root, bare root drying, denseness of bare root hair and fibrous root system, firmness of the ball for B&B, general size of balls, root development, wrapping method, evidence of handling methods, and all items of emphasis pointed out in the Plans and Specifications. This should be completed by a trained person knowledgeable in the horticultural industry, i.e. a nursery expert or a Landscape Architect.

Planting Media: Various additives are used to improve the root growing environment of that soil that exists on the site, e.g. shredded bark, sand, gravel, sawdust, peat,compost, etc. The additives may be either used singularly or in combination with the existing soil. A homogeneous blend of the materials specified is a must and can be checked by lab analyses if necessary.

Pesticides: Pesticides should be applied with caution, by a licensed applicator. The label should be checked for the proper material and timing of application. The label also indicates if the material is registered for use on a particular type of plant material. Appropriate pesticide application records will be completed and distributed by the Resident Engineer to the designated recipients on each contract where a pesticide is used.

Fertilizers/sulfurs/other conditioners: Fertilizers should be applied in accordance with the specifications. The formula should be cross checked with the specifications and the label on the bag or container. When water-soluble nitrogen fertilizers are used, particularly in lawn areas, adequate moisture is needed to prevent fertilizer burning. Close attention should be paid to the requirements specified in the project specials as they can change from project to project.

Drainage: Drainage materials include gravel backfill, culvert piping, French drains, etc. These drainage items should be checked as to function and compliance with the Standard Specifications and details.

806-2.01 Nursery Stock

An inspection of planting stock should be made at the nursery or other approved source to ensure the quality of planting stock. Someone with horticultural expertise representing the Department should accomplish the inspection such as the Construction Landscape Architect.

The size and quality of planting stock cannot be rigidly standardized because of varying growing conditions. Judgment should be exercised and allowances made for reasonable variation in growth and appearance.

All planting stock should be of the genus, species, variety, and sizes specified and shall conform to the Contract Specifications for the particular species, or variety, regarding straightness of trunk, branching structure, proportion, health, and size of material.

Individual plants should be measured to determine conformance with contract. If a particular detail or measurement has not been specified, consult with the Construction Landscape Architect for requirements.

Inspection at the nursery or other source of supply should include:

- Check the general condition of the plant in the block from which the stock is to be taken for:
    - Uniformity of Leaf Coloration. Plants that exhibit yellowing or discoloration could indicate poor drainage, fertilizer deficiency, herbicide damage, insect damage, or disease, and may not meet specifications.
    - Bud Development. During dormant periods of the growth cycle plants should have buds that are firm, moist and uniformly spaced. A slight cut may be made into the bark to determine that the cambium (growing layer just beneath the bark) is moist and green.

    - Uniformity of Growth. The plants in any given block should exhibit uniform vigor and health. Plants that do not conform may not be acceptable.
    - Spacing of Plants in the Row. Vigorous growing, well rounded, fully developed plants will transplant well. Quality nursery stock should be grown with sufficient spacing to permit good development of the individual plant. Plants grown too close together may be extremely high headed.
    - Presence of Weeds. An overgrown, weed-infested nursery block indicates lack of care and the plants growing in it may be in a poor state of vigor because of the weed competition. Weeds should not be growing in containers.
- Check individual plants for freedom of defects such as:
    - Decay. On trees, look for spots of decayed tissue on the trunk and branches.
    - Sun Scald or Sunburn. The destruction of tissue caused by the sun rays striking a plant on the south or southwest side. This may result in the death of cambium tissue and bark, exposing the plant to secondary insect and/or disease infestation.
    - Abrasions of the Bark. Abrasions severe enough to damage the cambium tissue may be sufficient for rejection.
    - Girdling Roots. Roots that grow around another root or a stem, thus tending to strangle the plant.
    - Improper Pruning. Stubs resulting from improper pruning, which have died back, are an excellent point of entry for disease organisms. All cuts should be flush with the trunk or supporting branch. When a cut is made to encourage branching, it should be made back to a bud.
    - Frost Cracks. Long vertical splits in the bark and/or wood may occur on the south and southwest sides of young and thin barked trees. Such cracks may become invaded by canker or decay producing fungi and bacteria.
    - Signs of Injury. Dead leaves, dry buds, dieback of twigs and branches blackened sapwood and sunken, discolored patches of bark (sun scald) on the trunk or limbs.
    - Root Ball. Roots should be all through the container so the root ball stays together during planting.
- Check individual plants for freedom from plant diseases and pests such as:
    - Diseases. These will appear in a variety of forms such as abnormal growth of the collar, leaves, twigs, fruits, discoloration of leaves and bark, unusual discharges of sap through the bark, etc. Any plant showing evidence of disease should be rejected.
    - Insects. Look for insect eggs, spider webs or evidence of damage from insect feeding on leaves, twigs, buds, or other plant parts. Examine the trunks of trees for borer holes that appear as tunnels drilled into the bark and inward into the wood of the trunk. Trees with evidence of borers or other insect damage should be rejected.
- Check individual plants for proper habit of growth as follows:
    - If a particular habit, e.g. single stem, multiple stem, etc., has been specified, be sure to obtain plants that conform to this requirement.
    - If no particular growth habit has been specified, consulting with the ADOT RLA is recommended.
    - Shade and flowering trees should have top growth symmetrically balanced. Shade trees should have a single leader. The balancing should be well developed and characteristic of the species.
    - Evergreen trees should be full foliage plants with uniform density. Sheared plants, such as pines sheared for Christmas trees, should be avoided unless specified.
    - Shrubs should be well branched in a manner characteristic of the species. The current American Standard for Nursery Stock under ANSI Z60.1, is an excellent guide for determining the proper number of branches for certain size shrubs.
- Check all container grown plants to determine that they meet the requirements outlined in 1 through 4, above. In addition, a random sampling of plants should be removed from their containers to determine that the root system is healthy. Plants that are found to be pot bound and plants that have insufficiently developed root systems to hold the soil together when removed from the container should be rejected. Healthy roots should be able to hold the soil mass together yet not be crowded around the outside perimeter of the container.

- Planting stock that is based on the above criteria may be tagged with seals placed on all plants or representative samples at the nursery. This will assist in future inspection of these plants when delivered on the job site. Seals placed on planting stock for later identification do not imply acceptance on the construction site.

806-3 Construction Requirements

806-3.02 Excavation

The layout of landscape features should clearly show where exact dimensions are required and where some variances will be permitted. Accurate location of all buildings, roads, walks, paved areas, and features such as sculptures, walls, pools, etc., must be accomplished. Landscape beds, trees, and indigenous features must be laid out to mold the landscape design to the existing topography and available area. Some variances are generally allowed in the bed area and tree locations of the proposed plan to fit the particular situation; however, coordination with the various other civil roadway plans and with the Construction Landscape Architect is advised.

Trees must be adjusted for minimum clearance to roadways and allowances must be made for maintenance mowing; especially when the tree is fully grown. One must ensure that placement of trees is not over existing utilities or drains or that tall growing trees are not placed under overhead utility lines or that any planting will block signage or other critical objects within the right-of-way. Shrubs and groundcover beds are often intended for un-mowable areas. The outline must be adjusted to fulfill the intent and the edge should create a flowing outline that is aesthetically pleasing. It is important that sufficient stakes are used to clearly outline the planting areas.

The inspector should check and approve the stakeout of all planting areas and planting hole locations prior to excavation. Minor relocation of planting areas and holes can be done at this time to avoid utility lines, rock outcrops, drainage ditches, or impervious or wet soil conditions. If minor relocation of plantings are not possible, the inspector should contact the Construction Landscape Architect to adjust the design requirements.

The inspector should observe excavation of planting pits to determine if they will drain, i.e. not hold water. Test pit drainage in accordance with the specifications if the contractor has a difficult time excavating, or the ground looks impervious.

806-3.03 Shipping and Handling Plants

Inspection of stock at the construction site is to ensure that the plants are from an approved source, are in a healthy and undamaged condition, conform to sizes, quantities, and standards called for in the specifications.

This inspection should consider the condition of the plant and the use of proper handling procedures prior to delivery at the construction site. Inspection at the construction site should include the following checks:

- Each shipment of plants should be free of weeds, disease and insect pests, and meet all applicable State and Federal certification requirements. All necessary quarantine or State nursery inspection certificates should accompany each shipment.
- A representative sample of all plants should be legibly tagged with the correct botanical name, common name, and size to agree with the specifications and plant list. Bare root plants should be shipped in bundles with each bundle properly tagged.
- Planting stock which has not been inspected at the source should be inspected as appropriate, in accordance with items 1 through 6 of Inspection at the Nursery, found in this manual. This should be done as the material is being unloaded, or immediately thereafter, so that plants which are unacceptable can be set aside for removal from the project site.
- Where root formation is irregular, measurement of the spread of bare root plants should be the average, considering all sides of the plant, rather than the maximum root spread. The inspector may allow moderate deviations from exact measurements in the case of plants that normally have irregular root systems.

- Large root stubs on nursery grown balled or bare root stock should be considered evidence of lack of proper care and root pruning, and sufficient grounds for rejection of such plants. Root stubs frequently characterize collected stock and precautions should be taken to ensure that root systems are adequate.
- Damage to plant material caused by improper operation of mechanical diggers may be sufficient cause for rejection at the construction site. Plants dug with equipment leaving a cone shaped ball should be carefully checked to make sure that an excessive portion of the feeder roots have not been cut away.
- Bare-rooted plants should have adequate live, damp, fibrous roots, free of rot and mold. Earth balls should be unbroken and of specified size.
- Precautions should be taken to prevent the drying of root systems in all shipments of plants to ensure arrival in good condition. During transport, plants must have been protected by a covering such as canvas or plastic sheeting. Bare root plants should have been protected by moist burlap, sawdust, plastic, etc. Under no conditions should the root system have been allowed to dry out. All plants must exhibit normal thrift and vigor.
- Plants damaged in transit, or not conforming to the specifications, should be rejected. All rejected plants should be removed from the site immediately. However, these plants may be suitable for other jobs so take care and do not damage any rejected plants. Be careful that any system of identifying these plants does not ruin them for resale to other buyers.
- Plants should be transported in a protected manner such as an enclosed shipping truck or covered with a tarp or similar to avoid any wind blown damage to the plants during transit.

Following completion of inspection, all plants accepted should be carefully stored and maintained until planted.

All plants not planted on the day of arrival at the site should be placed in a temporary nursery, and handled as follows:

- Outside storage should be shaded and protected from the wind.
- Bare root or balled plants stored on the project should be heeled-in to protect them from drying out at all times by covering the bare root or balls with moist sawdust, wood chips, shredded bark, peat moss, or other approved mulching material. Plants, including those in containers, should be kept in a moist condition until planted.
- Plants kept in the temporary nursery for longer than three days should be well maintained at all times and sufficiently watered to maintain health and vigor.

806-3.04 Planting

(A) General

The inspector should determine that planting operations at the construction site are properly completed in conformance with contract Plans and Specifications and good horticultural practices. The planting operation should not begin until the irrigation system has been completed, tested and fully operational to supply water to plants.

The inspector and contractor should jointly review and become familiar with all plan sheets, quantities, details, specifications, and other provisions of the contract. At this time, questions or interpretations can be answered or problems resolved through discussion with the Construction Landscape Architect, Horticulturist, or other authorized persons.

All materials that have specification requirements shall have an approval of source prior to incorporation or use on the project. Additionally, samples of these materials will be required to verify adherence to the specifications.

Prior to installation of plant materials, the following preparations should be completed according to the requirements of the Plans and Specifications:

- If specified, planting should be performed only during the specified seasons.
- If the soil is dry, irrigate the planting bed as specified before planting.

- Check for the correct depth of the root collar, which is at grade.
- Bare root plants should have roots spread out carefully before planting.
- Ball and burlap plants should have twine removed and burlap removed or rolled back and buried below grade.
- Place approved backfill material around plant roots or plant balls, being careful not to damage the ball or the fine root system of bare rooted plants. Backfill that is frozen or wet should not be used.
- Eliminate air pockets in the backfill by filling, tamping, and watering as required by the specifications. It is generally advisable to water the plants thoroughly before the backfilling of the pit is completed. Container plants should be moist at the time of planting. If backfill material settles after wetting and rootball sinks, the plant should be removed and raised to the correct height
- When the above operations have been completed, if specified, a berm of soil should be placed around the perimeter of the pit to form a basin or saucer to facilitate watering and retention of rain or irrigation water.
- Biodegradable pots should have sides scored and top edge broken down below finish grade.
- Container grown plants shall have metal or plastic containers removed carefully prior to planting. Metal containers shall be cut at least twice with a sharp can cutter before removal. Plants that have root balls that fall apart shall be rejected.
- Weed control around planting holes or entire bed area as called for by the Contract Specifications. The inspector should check to be sure that weed root systems have been killed. The interior color of dead or dying roots is usually tan or brown, whereas healthy roots are usually white. If the root systems are alive, planting should be delayed until they can be killed. Details of the application should be documented on the ADOT herbicide log. The contractor shall keep a record of all applications, types of herbicide used such as pre- or post-emergent, rates and methods of application, and the dates and locations of such applications on forms supplied by the Engineer, and the inspector should reference their observation in their Daily Diary.
- Excavation of planting holes, pockets, or beds should be to the required size and depth and spaced as shown on plans.
- Extra work may be required to deepen or move any planting pit that does not drain properly. Payment will be made under a Supplemental Agreement or if necessary Force Account Item.
- Preparation and stockpiling of backfill mixture as called for by Contract Specifications.
- The planting holes are to be excavated minimally to the sizes in the planting details. In mixed planting areas, trees are usually planted first followed by the larger shrubs, low shrubs and finally planted with ground cover plants. The planting pits for trees and large shrubs may be dug well ahead of time, provided that the holes are backfilled with an approved soil or soil mix within a day or two after digging. The Soil Amendment form should be completed by the inspector and referenced in their Daily Diary. Before backfilling, especially in drilled holes, the sides and bottoms must be scratched and loosened to break all glazing. This promotes moisture transfer between different soils; existing and backfill. Holes that are staked in solid rock or other impervious material shall be moved or omitted.

(B) Nursery Stock

Planting pits must be pre-wetted before planting nursery stock. Two to four days before planting, the pits must be irrigated for at least twelve hours. Care must be taken to avoid damaging plants during movement from the storage area to the planting site.

Plants should be protected against drying and handled carefully to avoid cracking or breaking the earth ball. Bare root plants should be puddled when removed from the heeling in bed to protect the roots from drying. Plants should be protected against freezing or drying by a covering of burlap, tarpaulin, or mulching material during transportation from the heeling in bed to the planting site. Should damage occur, or be found at this time, the plants should be rejected and removed from the site.

In order to ensure against reuse of discarded plants, seals should be removed at the trunk or stems above the root crowns and marked with a small spot of paint or dye. Since discarded plants are the property of the contractor, they should not be marked or mistreated in such a way as to make them unfit for other uses.

806-3.05 Pruning and Staking

All plants should be staked and pruned, as specified, in accordance with accepted horticultural practice.

- Stakes should be driven solidly into the ground outside the planting pit and guying installed to prevent excessive movement of the plant until the root system is firmly established in the new planting location.
- Deciduous plants should be pruned during planting to restore a balance between the root and top growth. Tops should be pruned to compensate for the partial loss of roots when the plant was removed from the nursery, in a manner that will retain the characteristic shape of the plant. The larger pruning wounds and those made with a pruning saw should be finished smoothly with a pruning knife. See Sunset Western Garden Book, The Editors of Sunset, 2012.
- Generally, all deciduous trees should be pruned by removing no more than 1/3 of their former branch structure. Broken or damaged branches, plus competing leaders, should be removed.
- Trees may be pruned before planting to save time and trouble. At this time, hand clippers can be used to cut closer than can be done with pole pruners; usually used for trees in an upright position. Pruning may be done under inspector's supervision prior to planting.
- All broken, torn, or damaged roots should be pruned, leaving a clean cut surface to help prevent rot and disease.
- Deciduous shrubs should be pruned to approximately 1/2 their former branch structure.
- Coniferous and broadleaf evergreens normally should not be pruned except for broken, crossed or forked branches, unless otherwise specified or directed.
- Broadleaf evergreen trees should have 1/2 of the length of long branches pruned to help prevent future wind damage. No entire length of any branch should be removed unless directed by the Landscape Architect.

Watering all plants as needed completes the planting operation. Weather and soil conditions dictate the need for watering. Over-watering is as harmful as under-watering. Adequate watering is more critical during the first few weeks following transplanting. Do not allow plants to stress from lack of water.

806-5 Basis of Payment

Payment for trees, shrubs and ground cover plants is to be made as specified in the contract. Upon completion of the planting operation, the inspector verifies the quantity of plants and the contractor is paid on that monthly estimate based on the inspector's count. The contractor warrants any failures of plant materials during the Plant Establishment Period and replacement will occur at that time.

ARIZONA DEPARTMENT OF TRANSPORTATION

SOIL AMENDMENT INSPECTION

PROJECT:

Highway: ________ Location: ______________________________ TRACS: ____________ Date: ________

1. Have all the correct amendments (compost, fertilizers, soil conditioner, etc.), that were submitted and approved by ADOT, been delivered to the jobsite, with all the delivered quantities verified? ☐ Yes ☐ No

   If no, give brief explanation and/or corrective action taken:

   ____

   ____

   ____

   ____

2. What type of plants are the amendments for?

   a) Cactus ____________

   b) Palm Tree ____________

   c) Tree/Shrub/Groundcover ____________

3. List the ratio (%) of site soil to soil conditioner, amendments for each type of plant listed above for the project according to specifications:

   a) ______________________

   b) ______________________

   c) ______________________

4. List the products, amendments and quantities of each mixed with the soil conditioner:

   a) soil conditioner product name/type, and/or supplier:

   ______________________________________ qty. ________

   b) amendments/fertilizer product name/type:

   ______________________________________ qty. ________

   ______________________________________ qty. ________

   ______________________________________ qty. ________

   ______________________________________ qty. ________

   ______________________________________ qty. ________

   ______________________________________ qty. ________

   c) other: ________________________________ qty. ________

5. Were the amendments inspected prior to mixing with the soil conditioner? ☐ Yes ☐ No

6. List the quantity of soil conditioner with amendments for each type and size of plant pit:

1 gallon tree/shrub	____________	cu. yds.	5 gallon tree/shrub	____________	cu. yds.
15 gallon tree/shrub	____________	cu. yds.	24" box tree/shrub	____________	cu. yds.
36" box tree/shrub	____________	cu. yds.	Palm tree (if applicable)	____________	cu. yds.
___" box tree/shrub	____________	cu. yds.	Cactus/other (if applicable)	____________	cu. yds.

______________________________ ______________________________

Contractor's Representative ADOT Inspector

807 LANDSCAPING ESTABLISHMENT

807-1 Description

Landscaping establishment is all work necessary to care for the plants, including operation of the irrigation system. This work also includes weed control, erosion repair and the removal of trash and debris from the project limits.

The specifications state "all other contract work" must be completed before the establishment period will begin. Typically this will begin after substantial completion has been granted for Phase I Construction. There may be occasions when establishment may begin before all other work is completed. If such items of work as placing delineators, minor paving or other work that would not likely encroach on landscaped areas are being done, the establishment period could begin. The Construction Landscape Architect should be consulted if considering starting the landscaping establishment period prior to substantial completion or having all other contract work completed.

The completion of planting in any given area may precede the start of landscaping establishment by considerable time. It is not recommended to start multiple Landscaping Establishment periods based on individual areas of landscaping being completed early before the project as a whole is complete. Landscaping Establishment should only be started once the entire landscaping portion of the project is complete and substantial completion has been granted. Prior to the landscaping establishment being started, the area should be inspected to make sure that all plants are in place and healthy and the irrigation system is connected and working properly.

807-3 Construction Requirements

After planting stock has been properly selected and delivered to the planting site in a vigorous and thriving condition, planted in accordance with good horticultural practices, survival and normal growth depend, to a large degree, upon appropriate care during the establishment period.

Ideally, the landscaping establishment period should encompass the time required for the planting stock to become acclimated to the growing conditions at the planting site. The Project Specifications should clearly indicate the length of the landscaping establishment period, which may vary from one area of the state to another, depending on the local conditions, climate, and the type of plant materials utilized.

A well-rounded program of horticultural practices used during the landscaping establishment period may include watering, adjusting emitter locations, fertilizing, pruning, insect, disease, weed control, and replacement of unsatisfactory plants in accordance with the Specifications.

Per the Standard Specification, the Contactor and ADOT shall conduct monthly inspections of the project every 30 days during the Landscaping Establishment. These inspections should be coordinated with the ADOT Construction Landscape Architect whenever possible. The Construction Landscape Architect or representative of that office will conduct the inspections on behalf of the Construction Field Office administering the project when possible and provide a written inspection report back to the Engineer of the inspection findings. When the Construction Landscape Architect is unable to perform the inspections, the Engineer shall conduct the inspections in accordance with the specifications.

The following inspection guidelines include critical items that should be observed and documented every 30 days during the landscaping establishment:

- Plants must be kept in the proper position as appropriate for the species. Plants may require repositioning as a result of settlement, wind action, vandalism, etc. Care should be exercised in straightening to minimize disturbance to the root mass and should include replacing topsoil as required.
- Stakes should be firmly embedded; redriving may be necessary. Stakes should not be allowed to rub the tree.
- Guy wires must be adjusted to allow some movement. Adjustments may be necessary to keep the tree straight (not too tight) to prevent a large amount of swaying and prevent damage by rubbing.

- Protective wrapping on trunks or stems should be secure.
- Vehicular, fire, or damage due to vandalism should be noted and corrective action taken.
- Note damage caused by animals, e.g. deer, rodents, javelina, and seek advice from the Environmental Planning Group (EPG) on control measures. Damaged material should be replaced as necessary.
- Report infestations of insects and disease to the contractor or other appropriate professional for recommendations on corrective action.
- Inspect for broken branches or sucker growth and have them removed by pruning.
- Where discoloration or foliage occurs, especially in evergreen material, advice on corrective measures should be sought.
- Dead and severely damaged plants should be removed immediately and replaced within 21 calendar days.
- Inspect for settlement of soil or soil mix and replace to required grade, repositioning the plant if necessary.
- Inspect berms and water basins constructed for the purpose of retaining water to ensure that they are functioning properly; repair and rebuild as necessary.
- Inspect the project for any erosion and make note of it in the inspection for repair.
- See that project areas are weeded, mowed, or sprayed as specified. Use the Herbicide Application Log to record application details and reference in the inspector's Daily Diary. All areas of the project shall be kept weed free. This encompasses the entire project, R.O.W to R.O.W, project beginning limits to project end limits.The cost for weed control during landscaping establishment is inclusive in the cost of the landscaping establishment payment. No additional payment will be made for weed control during landscaping establishment.
- If planting projects require the use of fertilizers, the specifications should be followed.
- Qualified personnel, utilizing the best horticultural practices and tools, should perform pruning at the appropriate time.
- A pre-final inspection should occur approximately 21 days prior to the end of the landscaping establishment period. The contractor should correct any deficiencies within 10 days.

A final inspection at the end of the landscaping establishment period will be made to determine if all plants are growing in a healthy manner. There should be no problems at this time if the plants were well maintained during the course of the establishment period. The Resident Engineer or a representative, the Construction Landscape Architect, a maintenance representative, the inspector and contractor should attend this final walk through. If the project is a local public agency project or if any portion of the landscaped project is within a local municipality which will then be maintained by that municipality, a local representative should also be invited to the final inspection.

807-3.03 Irrigation System Establishment

The irrigation system testing that is done during the landscaping establishment inspection, involves walking the project and checking the remote control valves (RCV) and pressure regulating valves (PR) with a pressure gauge. The pressure gauge at the backflow prevention unit should be read and recorded with the other readings. Changes in pressure should be investigated. The backflow unit shall be tested yearly by a qualified representative. Inspect filters and flush end caps, if necessary. For irrigation systems capable of reading flow rates, these flows should be documented month to month to identify any unseen leaks or faulty valves. The establishment period for the irrigation system coincides with the landscaping establishment.

The monthly inspections of the landscape and the irrigation system t are typically done simultaneously. During the regular monthly inspections, be aware of eroded areas or unusual wet spots. Check the wetting pattern around each plant. Expect numerous cuts, cracks and dislodged emitter hoses during the landscape maintenance period..

Sprinkler irrigation systems most often fail when mowers hit the raised head. The damage is usually so severe that replacement is required. Check all heads for water delivery, spray arc, and droplet size. Deviations from their normal performance will require servicing of the sprinkler head. Has the head been driven over? Is it sunk into the ground? Check the flow path through the nozzle. Is it obstructed? Check the pressure. Is it operating at the correct pounds per square inch? Look for bent or broken parts. Repair or replace as necessary. Is the watering pattern hitting road surfaces or walks? Make the proper adjustments.

The contractor may also be required to conduct a training and orientation session for State and/or local LPA personnel covering the operation, adjustment, and maintenance of the irrigation system. The Resident Engineer shall arrange to have the maintenance, or local government personnel who will be involved with the irrigation system attend this orientation session. The record drawings shall be available so they can be reviewed and all features explained. One copy of the record drawings shall be made available to the maintenance personnel when completed, along with parts lists and service manuals for all equipment.

GLOSSARY OF LANDSCAPE TERMINOLOGY

Acid/Alkaline Soil
pH is a measure of hydrogen ions in the soil. Various plants respond differently to pH variations. The pH scale ranges from 0-14. pH of 7 means a neutral soil. pH below 7 is acidic soil. pH above 7 is alkaline soil or basic soil. Generally, plants are selected for a particular area without a need to change pH of soil. When a pH change is desired, a soil test is taken, analyzed and the pH is changed appropriately upon recommendations from a landscape architect, soil scientist, landscape specialist or horticulturist.

Balled and Burlaped (B&B)
Plants are prepared for transplanting by digging them so that the soils immediately around the roots remain undisturbed. The ball of earth and root is then bound in burlap or similar mesh fabrics. An acceptable B&B root ball should contain 90 percent (visual estimate of volume) of the earth material held together with the root system when removed from the burlap.

Bare Root (BR)
Most deciduous plants are dug when dormant. The roots are cleared, pruned and usually stored in moist material. Deciduous bare root plant materials must be pruned or thinned to about 1/3 of its limb area to balance the loss of root area due to digging and root pruning. The shock of transplanting can be compensated by thinning, not just tip removal, using care not to change configuration of the plant. Roots must remain moist and not be allowed to dry out.

Botanical Name
The botanical name is the plant name, written in Latin, that is used universally. The common name is the name used in a local area, and is not necessarily the same name used in other areas. The correct botanical name is usually found in Standardized Plant Names, available from the District Landscape Specialist. The botanical name usually consists of two names, genus and species, but may include additional names.

GENUS	1st word
SPECIES	2nd word
VARIETY	3rd word (if appropriate)
FORM	4th word (if appropriate)

Example - Juniperus chinensis “Pfitzeriana Glauca”

Branch
An offshoot from a trunk or main stem. It could be also called a bough or a portion of a main stem.

Caliper
The diameter of the trunk of a deciduous tree is measured 6 inches above ground level, up to 4 inches caliper size. If greater caliper than 4 inches, it is measured at 12 inches above ground level.

Cambium Layer
The layer of actively dividing cells between the outer bark and the inner wood of woody plants.

Candle
The new growth at the terminal end of a twig on coniferous evergreens.

Cane
A primary stem which starts from the base of a shrub or at a point not higher than 1/4 the height of the plant. A cane generally only refers to growth on particular plant material, such as roses, etc.

Conifer
Conifers are plants that bear seeds in a cone, usually evergreen, with needles or scales in lieu of broad leaves. Examples of conifers include pine, spruce, fir, and giant arborvitae.

Container Grown
Plants grown and delivered to the job site in cans or other containers. The containers are manufactured in nominal sizes with a capacity of about 3/4 stated size, i.e. a gallon container has about a 3 quart capacity. Container grown plant material can be planted anytime of the year and should not be allowed to dry out while in the container. Usually, plants grown in containers are in a very free draining soil mixture made up of nutrient free components. Container grown plants have a tendency to dry out and decline in vigor when not under the care of the nurseryman. Container grown material should have a firm root ball that will hold 90% (visual estimate of volume) of the ball material when removed from the container. Good container grown materials will hold virtually all of the soil in the root zone when a good growing medium is used. Some root growth should be visible in the outer edges of the ball. Excessive roots at the bottom of the ball indicate lack of proper root pruning at the time of canning. Excessive roots at the side or bottom of the container could indicate a root bound condition.

Deciduous
Plants that shed all their leaves at the end of the growing season and remain leafless during the winter or dormant period.

Evergreen
Plants that maintain green foliage throughout the year. Some leaves may be shed, however, the terminal foliage will remain on the plant.

Fertilizer
Any natural or artificial material added to the soil or directly to the leaves to supply one or more of the plant nutrients. Generally, a complete fertilizer refers to a fertilizer that contains Nitrogen, Phosphorous, and Potassium (NPK). Indications on a container are usually numerical 10-8-6 or 20-10-5, etc. These numbers indicate the percentage of actual nutrient elements available, e.g. 10% Nitrogen, 8% Phosphorous and 6% Potassium (10-8-6). Other minor nutrients are sometimes added to NP&K such as Magnesium, Manganese, Boron, Iron, Zinc, Calcium, Sulfur, etc. The nitrogen in a fertilizer can be readily available or slow release (controlled availability) depending upon how water soluble it is. The slow release nitrogen (high percentage of water insoluble nitrogen) will allow the nitrogen to be available to plants over a long period of time. The readily available 100% water soluble fertilizer can leach away with heavy rains or damage the plant by the high concentrations of nutrients. Additional nitrogen and other elements are often necessary for plant growth when mulches are used. The decaying activity of the mulch ties up the plant nutrients and is thus unavailable for plant growth.

Form
A plant subdivision of botanical variety, usually the fourth word in the botanical name. It distinguishes some minor characteristics such as dwarf, columnar, or white flower.

Friable
A granular soil, easily crumbled by cultivation.

Genus
A plant family is divided into groups of one or more related plants called genera; plural of genus. The first word in a plant’s botanical name is the name of the genus to which the plant belongs, e.g. Pinus Contorta, Pinus ponderosa, and pinus Densiflora.

Granite Mulch
Larger sized hard grained granite. Able to hold larger gradation and less weathered than decomposed granite. For use on roadway slopes for decorating plating material, where decomposed granite would erode off the slopes.

Hardy (Hardiness)
Hardiness usually refers to a plant's tolerance to cold temperatures, however, it could be tolerance to heat, drought, abundance of moisture, etc. as it relates to survival.

Heeling In
A method of temporary storage by covering plant roots with sawdust, mulch or a mixture of other materials capable of good moisture retention, to keep the roots from drying out.

Herbicide
A herbicide is a pesticide chemically formulated to control or destroy weeds. Herbicides are broken down into main groups:

- Post-Emergence Herbicide is a plant killing material that acts on the active growing surface of a plant after the plant has emerged from the soil. It is usually most effective during the rapid growth of the plant.
- Pre-Emergence Herbicide is a plant killing herbicide that acts on the seeds, bulbs, tubers, stolens, etc., as they sprout (before-emergence).

Humus
Decomposed or partly decomposed organic matter in the soil. Humus is generally found on the upper surfaces of the soil. Humus frequently imparts a dark color to the soil. It is beneficial because of its nutrient and moisture storage capacity.

Horticultural Variety (Cultivar)
A plant variety or cultivar originating as a result of controlled fertilization, selective breeding of progeny, or hybridization. Such plants are given a variety name which is added to the rest of the plant name and usually set off by single quotation marks or all capitals, e.g. Gleditsia Triacanthos Inermis 'MORAINE'.

Inoculated Seed
Seeds of the legume family, i.e. clover, have been treated with nitrogen-fixing bacteria to enable them to make use of nitrogen from the soil atmosphere.

Leader
The main stem or trunk that forms the apex of a tree. If the leader is missing, another leader will try to establish itself. Often several leaders take off and a multi-set tree results from the point.

Liners
Liners are small plants such as seedlings, plants from cuttings; unfinished nursery stock or whips usually under 3 feet in height. These plants are usually lined out in nursery rows or planted using reforestation methods.

Mulch
Mulch is any loose material placed over soil, usually to retain moisture, reduce or prevent weed growth, insulate soil or improve the general appearance of the plant bed. Additional fertilizer is usually necessary in order to offset the loss of plant nutrients used by the microorganisms that break down the mulch.

Perlite
Lightweight, granular material made out of an expanded volcanic material and used in a growing medium or soil amendment. This material allows for a more aerated growing medium, with good drainage.

Pesticide
A pesticide is any substance or mixture or substances intended to control insects, rodents, fungi, weeds or other forms of plants or animal life that are considered to be pests.

Pinching Back (Heading Back)
Pinching back or heading back is a process of pruning a branch back to a bud or side branch. This process encourages the plant to branch out, resulting in a bushier plant.

Plant Classification
Plants are universally known by their Latinized botanical name. Generally only two names are used, (Genus and Species). However, varieties or cultivars may break down the species into small subgroups. Pinus mugho is an example of a varietal breakdown of Pinus (genera), mugho (species), mugho (variety).

Puddling
Puddling is a process used to settle the soil with water to eliminate air pockets during the planting process.

Root Ball
Ball of earth encompassing the roots of a plant. Generally, the root ball will have a good portion made up of root networks. A manufactured root ball is one where the root system is not adequate to hold the soil in place. Manufactured root balls should not be accepted, since the root system is not developed sufficiently.

Root Bound (Pot Bound)
The condition of a potted or container plant whose roots have become densely matted and most often encircle the outer edges of the container. Generally, this condition is a result of holding the plant in the container for too long a period. Root bound plants should be rejected.

Root Collar (Plant Crown)
Root Collar is the line of junction between the root of the plant and its stem, also known as the plant crown.

Root Pruning
Cutting back and trimming the outer edges of the roots with a sharp tool to encourage a better, more fibrous root system. This is done periodically at the nursery. It should not be done at the project site before planting.

Species
A genus may include one or a great number of species. Each species is a particular kind of plant, e.g. Pinus Ponderosa, Pinus Contorta, Pinus Mugho. The second word in a plant's botanical name designates the species, distinguishing it from other plants in the same genus, i.e. plants with the same first name. Species in the same genera share many common features, but differ in one or more characteristics.

Soil Mixture
A mixture of growing medium such as sand, sawdust, perlite, vermiculite, peat, and bark dust which is used to grow plant materials. The soil mixture usually contains two or more items and may be combined with the native topsoil.

Stem
The main upward growing axis of a plant. The main stalk or trunk of a tree, shrub or other plant. The main body of the above ground part of a plant.

Sucker
Any unwanted shoots. A side shoot from the roots of a plant. A side growth arising from an axillary bud.

Systemic
A substance (hormone, insecticide, herbicide, etc.) that, when absorbed and translocated, makes the plant poisonous to certain pests and diseases. In the case of an herbicide, it can move into the root system and kill the root system.

Thinning
Thinning is the removal of some of the plants in a row or area, or trees in a stand, to open up or avoid crowding of plant or material. Thinning also involves the removal of branches, buds, flowers or fruits for superior results with a single plant.

Tolerant
A plant that is capable of withstanding unfavorable growing conditions, e.g. cold, heat, moisture, drought, etc.

Tube Container
A tube container is a deep narrow container either single or in blocks used to produce deep root systems or unfinished nursery stock. A deep root system has advantages for establishment of plants where soil moisture is limited.

Vermiculite
A lightweight expanded mica product often used as a rooting medium for plants or as a soil amendment.

Watering In (puddling)
The procedure of watering the backfill and planting hole during the planting procedure. The purpose is to eliminate air pockets and voids around the roots, not to irrigate.

Whip
A young tree that has not started to branch.

808 WATER DISTRIBUTION

808-1 Description

An efficient irrigation system depends upon proper design, successful installation and maintenance accompanied by careful and thorough inspections.

Irrigation has been defined as "the controlled application of water to soil for the purpose of supplying the moisture essential for plant growth". An irrigation system applies the right amount of water to a specific area or plant so that it can be utilized by the plant material with little or no water loss.

Irrigation systems are designed to produce optimum soil moisture levels and encourage maximum plant growth. The use of irrigation in ADOT is to sustain landscape life over a period of time. The application rates of irrigation systems are designed to provide the maximum moisture requirements for plants. Properly designed and installed irrigation systems distribute water uniformly over the intended planting area at a predetermined precipitation rate.

A variety of factors influence the efficiency of a system's operation and must be taken into consideration during the design stage. Carefully inspect the installation of all irrigation systems to ensure that the system not only follows the design intent, but also fully conforms to the Special Provisions, Project Plans, Standard Specifications, and the manufacturer's requirements and recommendations.

The Department installs two types of systems, emitter and bubbler. The water conservation regulations and State laws have eliminated turf sprinkler systems in desert areas. Low pressure and less water consumptive emitter and bubbler systems are being established as the standard.

Additional methods of watering include temporary and flood irrigation systems. Truck watering systems are temporary systems used to irrigate plant materials on roadways without accessible water lines. Flood irrigation is used where water is available and supplied by the city. There is usually an agreement in place to authorize this method.

Emitter systems apply water at low pressure and flow rates to avoid ponding, puddling or runoff and are designed in a variety of configurations. The rigid pipe system, installed by ADOT consists of Polyvinyl Chloride (PVC) pipe laterals with flexible polyethylene supply and flexible distribution lines. It is important to examine the irrigation plans carefully, since they vary from project to project.

With bubblers, the laterals are PVC while risers are flexible PVC or swing joints. Bubbler heads could have a manually adjustable flow rate or are the non-adjustable pressure compensating type. Integration of bubblers and emitters on a common valve circuit is not recommended because emitters irrigate in gallons per hour (GPH) while bubblers/sprinklers irrigate in gallons per minute (GPM). Run times for bubblers and sprinklers vary, so even though they are both measured in GPM, it is not advisable that they water on the same system.

Additional components found in irrigation systems may include water meters, backflow prevention devices, manual and automatic valves, controllers, pressure regulators, check valves, flush caps, sleeves, drain valves, air/vacuum release valves, isolation valves, piping, ball valves, etc.

808-2 Materials

808-2.01 Components

A. Backflow Prevention

Backflow is the unwanted reverse flow of liquids or solids in piping systems. Backflow is the result of either back pressure or back-siphonage. Irrigation systems are a potential source of pollution to a potable system. Backflow prevention is the process of separating the potable water from the irrigation system. By installing a backflow preventer, the possibility of contamination to the potable water system is greatly reduced.

Some jurisdictions require backflow preventers with reclaimed water. Locations in freeze zones may require insulation and seasonal draining. Requirements will vary from area to area.

Backflow prevention for an ADOT system is supplied using a Reduced Pressure Assembly (RPA). This assembly consists of two independently operating check valves. There is an automatic operating pressure differential relief valve located between the two valves.

Reduced Pressure Assembly

An RPA is designed to protect against backflow, back-siphonage and backpressure. It is utilized where there is a high risk for hazard and is a standard for commercial irrigation installations. The unit must be installed 12 inches above ground and is not required to be higher than outlet devices downstream of the unit. The single unit is installed upstream of all valves and is designed to release water through the relief valve.

Upon installation of the backflow prevention unit and prior to the contractor using any water from the cities' supply, the device shall be tested by an authorized and city approved tester.

The backflow component shall be tested before acceptance of phase I and phase II, and following any repairs or service to the device.

Backflow prevention units should be tested whenever they are taken out of service and returned at a later date, e.g. removing the unit during winter months to prevent freezing. If a backflow prevention device requires repair or replacement, re-testing is always required prior to putting the unit back into service.

Certified Testers will use the RPA manufacturer installed test cocks to examine the device for proper operation.

Pressure Vacuum Breaker

A pressure vacuum breaker (PVB) is designed to protect against backflow and back-siphonage. It is installed on the mainline leading to the control valves. The PVB contains a single body that houses a single loaded check valve and a loaded air-opening valve. The air valve opens for ventilation whenever the pressure within the body approaches atmospheric. The valves are designed to be under continuous pressure and must be installed 12 inches above any distribution of water downstream of the device.

A single PVB must be installed on the mainline leading to the control valve.

Atmospheric Vacuum Breaker

The atmospheric vacuum breaker (AVB) is designed to prevent back-siphon age only. It is installed directly after a remote control or gate valve and is not meant to be under continuous pressure. This type of back-siphonage prevention is rarely found on ADOT projects. However, it may be encountered on retrofit projects.

This device has no shut off, gate valve or remote control valve downstream of the instrument. It must be installed above ground and must be 6 inches higher than the tallest sprinkler head controlled by any of the valves.

In a sloped yard, it is installed at the top of the slope, with a pipe running to it from a water source and then down to the emitters or sprinklers.

B. Controllers

Controllers are manufactured and designed to automate an irrigation system. The system is activated by setting the current day, time and year. The controller needs to establish an irrigation schedule, program the time of day, the number of watering times per week, and the length of time each valve operates. This timetable constitutes a program.

Programs run independent of one another. For example, one program may require daily watering, while another program irrigates every third day, and yet another waters once every ten to fourteen days. The use of automatic control to maintain an efficient watering program is a requirement for systems where water conservation is desirable or necessary.

Controllers come in a variety of configurations from electro-mechanical to complete computer units. The controller commonly used in the Phoenix and Tucson metro area by ADOT is the Motorola Irrinet (MIR-5000i) or Scorpio (MIR-5000s). The controllers are connected through radio transmission to a central satellite system that monitors the irrigation system, see System Overview of MIR 5000i on Exhibit 808-2.01-1.

While both the Irrinet and Scorpio units can be utilized as stand alone controllers, only the Irrinet is capable of communicating with the central satellite system. Scorpio controllers communicate with Irrinet, which in turn passes the information to the central system. It is necessary for the Irrinet and Scorpio to be within the line of sight or one another to enable them to communicate.

Other controllers are solar, battery or electrically powered. Solar and battery operated controllers have different latching solenoids and are attached to a variety of manufacturer remote control valves. Inspectors will have to consult the manufacturer’s specifications for each type of controller.

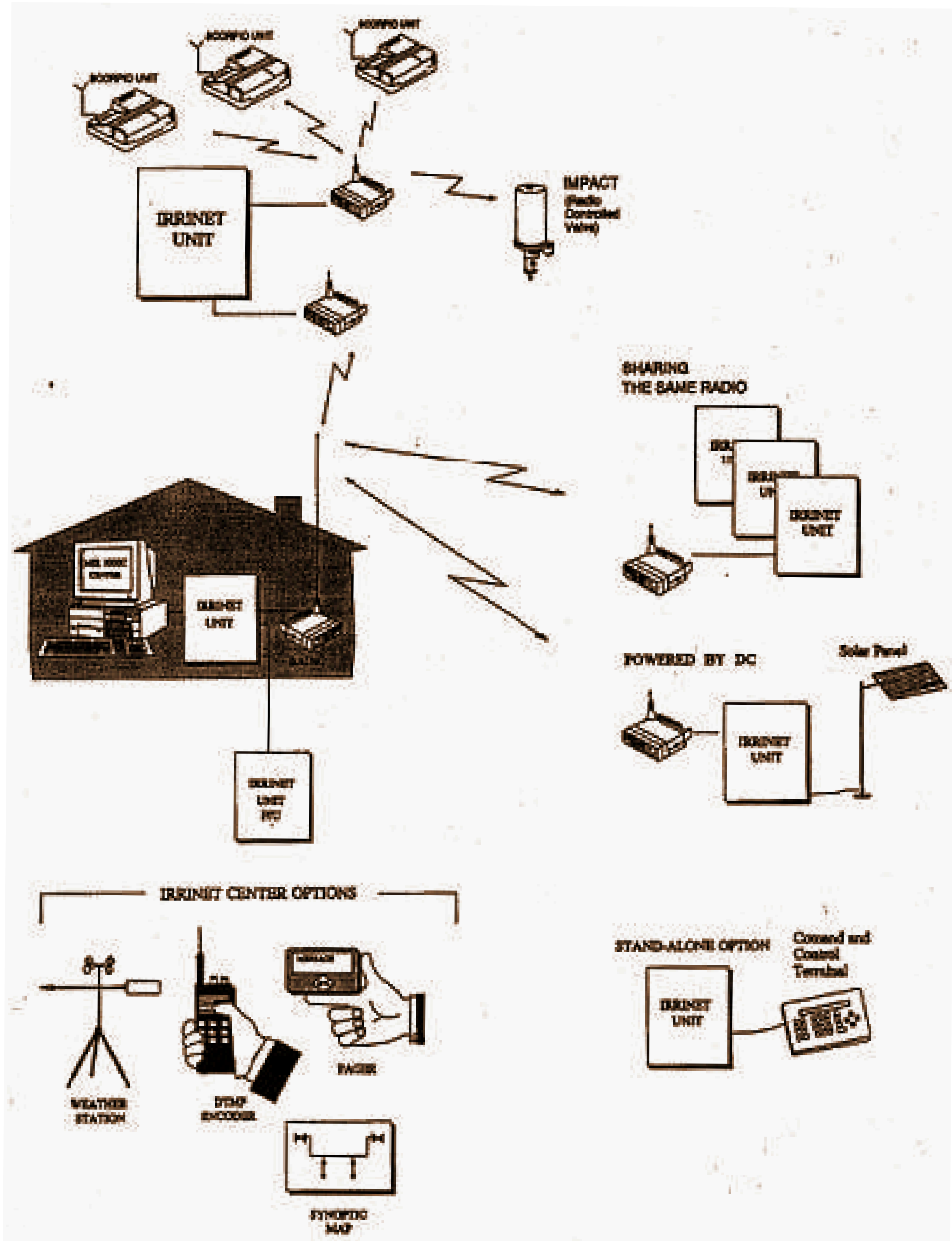


Exhibit 808-2.01-1. System Overview of MIR5000i Motorola Irrinet

C. Filters

Filters sift water entering the irrigation system by removing small foreign particles that could clog the irrigation system. The openings in emitters are small and can plug easily. Once clogged, the emitters will not deliver water to the intended plant material, potentially causing the plant material to die.Filters strain water according to the mesh size of the screen.

ADOT installations require the filter/strainer to be installed after the backflow device. However, some municipalities have the filter installed before the backflow preventer, while others install the filter downstream of each control valve.

Filter screens are rated by ‘mesh’. The term ‘mesh’ applies to woven wire cloth and is used primarily for very fine straining. An example: 100 mesh means 100 vertical and 100 horizontal strands of wire to the square inch, resulting in 10,000 openings of .0055 square inches.

Mesh typically comes in the following sizes:

Mesh	Openings per Sq. in.
20	0.033
30	0.023
40	0.0165
50	0.0117
60	0.0098
80	0.0078
100	0.0055
140	.0041
200	.0029

The inspector must read the Special Provisions to determine which type of mesh has been specified. The inspector must visually check the filter to verify that the mesh is as specified. Filtration product labeling will vary between manufacturers. Inspectors are required to review the manufacturer product literature contained in the contractor submittals to ensure that the correct filter is installed.

D. Emitters

Emitters are instruments that regulate the amount of water the plant material receives. They are located downstream of the control valve and pressure regulator, and are connected to the lateral irrigation pipe.

Emitters are configured as single, multi-outlet, or in-line units. A multi-outlet emitter has six to twelve outlets on a single device. In-line emitters are manufactured inside of polyethylene tubing. Their watering and spacing requirements will vary based on the designer specifications.

Emitters are also available with pressure compensation. A pressure compensating emitter has the same output regardless of the inlet pressure. For example, a 1 GPH pressure compensating emitter will discharge 1 GPH, whether the inlet pressure is 30 psi or 50 psi.

The amount of water released through each outlet is measured in GPH. Normal settings for emitters are 0.5 GPH, 1.0 GPH and 2.0 GPH. Manufacturer's color code emitters according to the out-put. Inspectors will have to check the project plans emitter schedule and read the product literature to ensure that the correct gallonage is being installed.

F. Flow Sensors and Monitors

Flow sensors track and monitor the amount of water used by an irrigation system. Sensors can detect and shut down the system in the event a valve does not turn off as programmed or if an irrigation line breaks. Flow sensors are located downstream of the backflow preventer and upstream of the control valves.

The flow sensor is an inline component with an impeller that comes in contact with the water. As the impeller rotates, it sends a signal out to a monitor that is calibrated to the pipe size and number of gallons or cubic feet per pulse.

Installation according to manufacturer’s recommendations is always advised. The general rule is that there be a minimum of 10 pipe size diameters of straight pipe upstream from the first flow sensor and 5 pipe size diameters of straight pipe downstream. This helps prevent turbulence in the water, which could cause the device to malfunction.

A monitor is used to condition the signal from the sensor to a pulse which the controller reads as 1 or 10 gallons of water. The controller compares this flow quantity to the pre-set norms. An alarm is sent if the actual flow is outside of the norm by a given percentage. The central computer is then updated by radio.

G. Pressure Regulators

The pressure regulator is designed to convert the inlet water pressure to a lower outlet pressure. Depending upon the system, the pressure regulator can be located downstream of the backflow preventer or at each control valve.

Adjustable Pressure Regulator

Pressure regulators are available as adjustable or pre-set. An adjustable pressure regulator is constructed of brass or PVC. The unit comes from the factory at a pre-set psi and can be adjusted higher or lower. The valves inlet pressure rating will vary by manufacturer from 150 to 400 psi with an outlet pressure from 25 to 75 psi.

Pre-Set Pressure Regulator

The pre-set pressure regulator is constructed of plastic. Pre-set pressure regulators come in a wide range of operating pressures. Depending on the manufacturer, the system can have a range of 80 to 120 PSI inlet pressure and an outlet pressure that is set from 15 to 50 PSI. The flow of the regulator could be as low as .320 GPH, or increase to 22 GPM (1320 GPH).

H. Valves

Valves are available in a variety of styles. The common factor is the ability to allow water to flow.

- Master Valves control the entire irrigation system and are located downstream of the backflow preventer. It is an automated valve that responds to commands issued by the controller. The master valve will allow the system to flow or shut down the entire system.
- Remote Control Valves (RCV) are similar to master valves because they react to commands issued by the controller. The difference is that they control only one portion of the system. An irrigation system can be composed of any number of remote control valves. The controller opens one RCV after another, for a programmed duration, until an entire area has been irrigated. Motorola controllers are capable of opening multiple valves on one program.
    - The controller sends a 24-volt signal to the magnetic solenoid located on the RCV. When the signal is sent, the magnet energizes and lifts the plunger up off of its seat, allowing water to bleed off of the top of the diaphragm. This action allows the RCV to open. The RCV remains open as long as the signal is received from the controller. When the signal stops the plunger in the solenoid drops, effectively stopping the water flow and forces the RCV to close.

- The remote control valves are equipped with a flow control valve and two manual bleed valves. The flow control valve limits the amount of travel the diaphragm has inside of the valve. This will in turn limit the flow.
- The manual bleed opens the valve without using the controller. One manual bleed allows water to bleed from the top of the diaphragm to the atmosphere. The internal valve bleeds down through the valve into the pipe. This prevents the valve box from being filled with water.
- The manual valve directed to the atmosphere should be used to operate the RCV. Upon its initial opening, debris will be flushed from the system helping to avoid a clogged solenoid.
- This step should be followed the first time the RCV is operated. After the initial opening, the internal valve may be used.

- Pressure Release Valves are used on mainline pipes to release water when the pressure in the mainline exceeds a set value. They are used to prevent a buildup of excessive surge pressure when a line is filling up or when a valve closes too quickly.
- Isolation Valves are either gate or ball valves. Both valves are used to stop the flow of water to specific parts of the irrigation system. The ball valve requires a quarter of a turn to completely shut down while a gate valve needs to be turned several times before shutdown is accomplished.
  - To prevent water hammer in the system, exercise caution when operating ball valves by opening and closing them slowly.
  - Isolation valves are used on separate parts of the system. If a leak occurs in one section of the system, it can be shut down while the rest of the system remains operational.
  - Isolation valves are designed to be either fully open or fully closed. They are installed upstream of the remote control valve. If the remote control valve requires repair or replacement, a single RCV may be shut down rather than the whole system.
  - The manufacturer installs ball valves on the inlet and outlet of the RPA. The valves are used to shut the device down as well as for testing the device to ensure that it is operating properly.
- Check valves are in-line valves that prevent the reverse flow in a piping system. The following configurations are available:
  - Spring loaded
  - Adjustable spring loaded
  - Swing or flapper
  - Check valves are installed to prevent low head drainage in a turf irrigation system. Check valves are often built into the base of a turf rotor and will check up to 15 feet of elevation change. In case of an elevation change, this prevents water from draining from the head.
- Blow-off valves are ball or gate valves placed at the end of a mainline. The valves are opened up on occasion to allow a flushing of an irrigation system. The system is flushed to prevent contaminants from plugging up the system.
- Quick coupler valves provide supplemental water at various locations around a site. They are installed directly on the mainline and are under constant pressure. The valves are operated using keys that screw inside of the coupler. When attached, the coupler forces the valve open and allows water to flow. The keys have a sprinkler head or a hose adapter attached to distribute water where needed.
- Schrader valves are used to measure the psi pressure in a system. It is the same equipment used to measure air pressure in vehicles tires.

I. Bubblers

Bubblers, like emitters, regulate the amount of water plant materials receive and are measured in gallons per minute. Bubblers are available in two configurations, adjustable or pressure compensating. Adjustable bubblers have variable operating ranges from being closed to 5 gallons per minute. Pressure compensating bubblers have an operating range of .25 to 2 gallons per minute. The outlet pressure remains the same regardless of the inlet pressure.

J. Pipe Types

PVC is offered in a variety of sizes. Selection depends upon the amount of pressure the system will be operating under. The following types are commonly used at ADOT:

Schedule 80

Nominal Pipe Size in inches	Outside Diameter	Inside Diameter	Min. Wall Thickness	Max Working Pressure (PSI)
½	.840	.546	.147	850
¾	1.05	.742	.154	690
1	1.315	.957	.179	630
1 ¼	1.6660	1.278	.191	520
1 ½	1.9	1.5	.2	470
2	2.375	1.939	.218	400
2 ½	2.875	2.323	.276	420
3	3.5	2.9	.3	370
4	4.5	3.826	.337	320
6	6.625	5.761	.432	280

Schedule 40

Nominal Pipe Size in inches	Outside Diameter	Inside Diameter	Min. Wall Thickness	Max Working Pressure (PSI)
½	.840	.622	.109	600
¾	1.05	.824	.113	480
1	1.315	1.049	.133	450
1 ¼	1.6660	1.38	.140	370
1 ½	1.9	1.61	.145	330
2	2.375	2.0679	.154	280
2 ½	2.875	2.469	.203	300
3	3.5	3.068	.216	260
4	4.5	4.026	.237	220
6	6.625	6.065	.280	180

Class 200

Nominal Pipe Size in inches	Outside Diameter	Inside Diameter	Min. Wall Thickness	Max Working Pressure (PSI)
¾	1.05	.930	.060	200
1	1.315	1.189	.063	200
1 ¼	1.6660	1.502	.079	200
1 ½	1.9	1.72	.090	200
2	2.375	2.149	.113	200
2 ½	2.875	2.601	.137	200
3	3.5	3.166	.167	200
4	4.5	4.072	.214	200
6	6.625	5.993	.316	200

½ inch PVC pipe is not manufactured in Class 200. However, it is available in Class 315.

PVC can be either bell end or ring-tite. Bell end pipe is welded together with solvent. Ring-tite uses a rubber gasket to seal against leakage. Ring-tite pipe has a groove built into the bell end of the pipe. The installed gasket forms a tight seal against the male end of the pipe.

The range of pressure rating for plastic pipe materials is referred to as the Standard Dimension Ratio (SDR). SDR is the ratio of pipe diameter to the minimum wall thickness. It is used to classify the pressure class of plastic pipe. SDR rated pipe of the same pipe materials and at standard temperature will have the same pressure rating for all pipe diameters. For example, Class 200 PVC pipe has an SDR rating of 21.

K. Lateral End Cap

This end cap is used to manually flush the emitter laterals. The end cap is constructed using Schedule 40 fittings, one socket slip by ¾ inch male hose thread (MHT) and a female hose thread (FHT) cap. The riser from the lateral to the end cap is Schedule 80/Schedule 40 flexible PVC. Lateral lines are installed with a flush cap at the end of each line. This allows for build-up removal.

808-3 Construction Requirements

Thorough inspections carefully conducted during construction help ensure the proper installation of irrigation systems. To be adequately prepared to inspect the installation it would be beneficial for the inspector to be knowledgeable in at least one facet of irrigation design, installation, and/or maintenance.

Exhibit 808-3.1 illustrates typical landscape symbols utilized on irrigation plans.

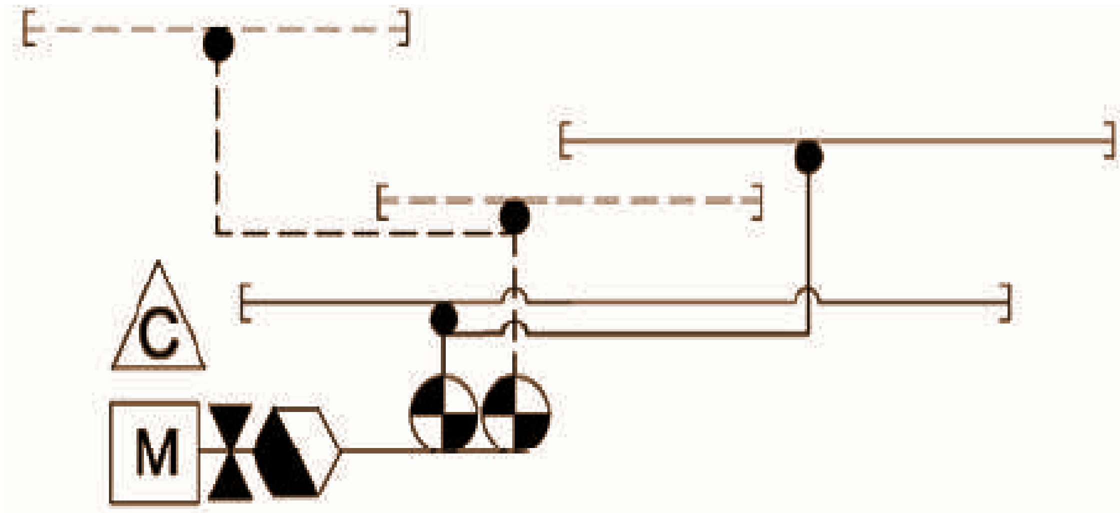
If this is not possible, the inspectors should familiarize themselves with the sections of the Standard Specifications, contract documents and bid schedule that pertain to inspection of irrigation systems before attempting the necessary inspections. In addition, it is advisable for the inspector to obtain additional advice and/or assistance from department representatives having expertise in these specialty areas. If in the Central District, construction field offices can reach out to Landscape Construction Field Office for assistance with inspection. Rural Districts can reach out to the Construction Group for assistance. Both the Central District Landscape Construction Field Office and the Construction group have Professional Landscape Architects (PLA) on staff which can assist in this field.

An initial inspection shall be conducted on all irrigation system components, as they are delivered to the project site, to determine acceptance or rejection. The inspector must check the components against the approved submittal list. If at any time, until final acceptance, components are damaged, defective, or not formally approved for use on the project, shall be rejected and removed from the project site. Irrigation submittals indicating acceptance or rejection of components shall be properly documented and maintained by the inspector at all times.

Irrigation systems have similar components. However, layouts will vary based on the individual project site. All systems, temporary or permanent, begin at the water source. Most systems will go from the water source to a water meter, from the water meter to the backflow prevention device, from the backflow prevention device to a control valve, and from the control valve to emitters.

The irrigation controller is often located adjacent to the backflow prevention device. The final destination will depend on the location of the electrical power source. There may be other components included in an irrigation system. The items can include flow sensors, fertilizer injectors, pressure regulators, filters, coupling, check and isolation valves.

Irrigation components and their locations are represented by landscape symbols in the irrigation plans.



Irrigation Symbols

IRRIGATION LEGEND

SYM	MANUFACTURER	MODEL	DESCRIP.
C	MOTOROLA	IRRnet	IRRIGATION CONTROLLER
M	BY OTHERS		METER
	NIBCO	T-555-Y	BALL VALVE
	FEBCO	825YA	BACKFLOW PREVENTION ASSEMBLY
	RAINBIRD	PEB SERIES	REMOTE CONTROL VALVE
	HENCRICKSON	DG 5025	PRESSURE REGULATOR RISER
N/S	BOWSMITH	ML06	.6 GPH MULTI-OUTLET EMITTER
N/S	BOWSMITH	SL206	.6 GPH SINGLE OUTLET EMITTER
	SPEARS	M-66-P/AP-100	END CAP
	MAINLINE	SCHEDULE 40	
	TREE SUBMAIN	1" CLASS 200	
	SHRUB SUBMAIN	1" CLASS 200	
	TREE LATERAL	3/4" CLASS 200	PVC SLEEVE
	SHRUB LATERAL	3/4" CLASS 200	
		SCH. 40 PVC	PVC SLEEVE

Exhibit 808-3-1 Symbols Legend

The inspector must verify that the proper municipality has been advised that a tap will be made into their infrastructure. The inspector shall keep a diary of contact information for each tap. A city representative must be present for each tap. If a municipality conducts its own tap, that information should be documented in the inspector's diary.

The inspector must verify that the contractor has contacted Blue Stake prior to any excavation. Blue Stake was established as a one call notification and prevention service to avoid damage to underground facilities. Blue Stake marks all utilities and underground facilities for the contractor.

When the project has been Blue Staked, the contractor is responsible for laying the system out on grade. The layout must show the locations and routing of the irrigation backflow prevention assemblies, mainline, isolation valves, sub-main, emitter laterals, remote control valves, pressure regulators, end caps, etc. The ADOT inspector shall approve the system prior to installation.

The layout should take into consideration all conflicts with staked utilities and avoid conflicts whenever possible. Layout is performed at no additional cost. Planting pits, beds and turf areas shall be laid out, approved and prepared prior to staking the irrigation system. If adjustments to the system are required, the contractor must provide a system that will leave no dry areas or un-watered plants.

The irrigation system routing will be determined after the plant locations have been approved. This will eliminate any conflicts between irrigation piping and planting pits. The minimum distance allowed between the edge of the plant pit and piping is 12 inches or as specified in the Standard Specification, Special Provisions or the project plans. The supply tubing lengths indicated on the project plans will determine the maximum distance.

In emitter systems, laterals should run between or adjacent to rows of plants. Emitter supply tubing connects the lateral line to an emitter that is placed near the plant pit or in an area of multiple plants. To assure proper water supply, unless otherwise noted, the maximum length of the supply tubing for a single port emitter is 25 feet. The maximum length of the supply tubing for a multi-port emitter is 20 feet.

Distribution tubing is usually placed in shallow trenches with the delivery end above grade at the planting pit. Tubing left exposed to direct sunlight can prematurely break or crack. Additional distribution tubing will make the final delivery of the water to the plant. Unless otherwise noted, the maximum length of any distribution tubing, after the emitter, is 12 feet or as detailed on the plans. Longer tubing lengths may cause a loss in pressure.

The contractor shall furnish to the Resident Engineer, prior to installation, all installation instructions as published by the plastic pipe and fitting manufacturers. Prior to the install, the inspector shall review and become familiar with the installation instructions. Installation of PVC piping and fittings shall be in accordance with the manufacturer's published instructions and the project construction documents or as directed by the Resident Engineer.

The emitter lateral end cap assembly shall be installed at the locations indicated on the project plans and in accordance with the requirements as stated in the Special Provisions. A lateral pipe should always end at a flushing end cap.

The contractor shall furnish and install T-posts, or other posts approved by the Resident Engineer, as ADOT end cap markers. The markers are used only on end caps 30 feet behind the travel lane edge. The markers must be driven at least 24 inches into the ground, with a height at 30 inches above the ground level.

The inspector shall tabulate all quantities of in-place irrigation system materials and components prior to backfilling. In addition, all information supplied by the contractor to produce the as-built plans in regard to component quantities, sizes and locations shall be verified by the inspector prior to backfilling.

The inspector should know which items are to be compensated for under the contract. The Special Provisions detail what is to be paid for and what is considered incidental to the cost of an item under each item number. An example is the end caps. Their cost is included in the cost of the irrigation pipe. A statement in the Special Provision may read “No measurement or payment will be made for the emitter lateral end cap assemblies. The cost for these items is included in the cost paid under this item”.

808-3.01 Materials and Equipment

Prior to beginning work on a project, the contractor shall submit a list of materials and equipment for approval. A partial listing of materials/components requiring review and approval is shown on Exhibit 808-3.01-1. The list is submitted at the pre-construction conference and includes the manufacturer, model numbers and product specifications. Copies of all documents must be submitted for distribution to departments within ADOT and to the irrigation designer for review and approval. Only material that has been submitted and approved may be stored or used on the project. Once construction begins, it is the inspectors responsibility to ensure that the contractor is installing approved equipment and materials.

All components intended for use in an irrigation system must receive approval from the Designer or Resident Engineer. ADOT Inspectors are responsible for verifying that the correct equipment is received and installed by the contractors. At each delivery inspectors shall verify that items used on the project are outlined on the submittals.

Approval of items is based upon information supplied by the contractor within a predetermined period of time as indicated in the Special Provisions. All components of the irrigation system shall be listed and identified by the corresponding bid item. Information must be included to identify each item listed. The following items should be highlighted to help the inspector identify that the correct materials have been delivered:

- Sizes
- Specifications
- Manufacturer name
- Instructions
- Model number
- Design data
- Options

Copies of the catalog cut sheets of all listed items shall accompany the contractor’s submittals. The designer will either approve or reject the items. A questionable item shall not be installed on the project without approval. Re-submittal is necessary until approval is granted. One copy of the submittal will be retained as an office file copy and one copy will be distributed to the designer. The remaining copies will be distributed by ADOT as needed.

It is the contractor’s responsibility to obtain and submit samples required for preliminary evaluation to the Resident Engineer, if necessary. The items will be submitted to the appropriate testing facility.

This partial list of materials along with any additional components of the irrigation system and equipment must be reviewed and approved prior to installation.

- Backflow Preventer
- Backflow Preventer Enclosure
- Enclosure Lock and Key
- Flow Monitor
- Master Valve
- Remote Control Valve
- Pressure Release Valve
- Isolation Valve
- Pressure Regulator
- Emitters
- Control Wire
- Bedding Sand
- Backfill material
- Copper Pipe & Fittings
- PVC Pipe & Fittings
- Steel Pipe & Fittings
- Solvent Cement
- Primer/Cleaner
- Fertilizer Injector
- Insulation and Metal Jacketing
- Pressure Gauge Assembly
- Nipples
- PVC Couplings
- Valve Boxes
- Isolation Valve Key
- Check Valve
- Blow Off Valve
- Quick Coupler
- Irrigation Controller
- Controller Enclosure
- Irrigation Controller Enclosure
- Filters (Mesh Size)
- Fertilizer Injector
- Antenna & Tower
- Bubbler Heads
- Circuit Breaker & Enclosure
- Conductor
- Conduit & Fittings
- Ground Rod & Clamp
- Hose Bib
- Pipe Insulation
- Pressure Gauge
- Pull Box
- Schrader Valve
- Swing Joint
- Emitter Supply & Distribution Tubing
- Wire Connectors

Exhibit 808-3.01-1. Partial Materials List

The Material Checklist, provided by the Materials Group, identifies which items require testing.

The contractor is required to submit to the inspector all maintenance manuals, warranties, guaranties and operation manuals from all equipment prior to acceptance of the project.

808-3.03 General Requirements

Trenches should be excavated to a required depth and be relatively smooth to provide support along the entire length of pipe to be installed. The inspector should do a visual inspection of the trench to ensure that a smooth surface is present. The trench shall have no deflections or sudden turns unless a fitting is planned to make a change in direction. The bottom of the trench must be free from large or sharp rocks, roots or any foreign material that would prevent proper bedding of pipe or other facilities.

Depths and separation of piping must be as shown on the plans. Trench width may vary with the number of pipes in the trench and soil type. There should be a minimum of 2 inches provided between pipe and trench wall or between pipes. Pipe that is not properly bedded or that has any hard material resting adjacent to the pipe can cause the pipe to weaken. Water flowing through the pipe will create vibrations causing the pipe to rub against the hard materials.

The bedding and cover shall be of sand, and to the dimensions specified on the project plans. Gradation shall be as specified in the Standard Specifications, Subsection 808-3.04.

The inspector should clear off the trench sides and lay a straight edge across the channel. The following measurements should be taken:

- Trench bottom
- Top of bedding
- Top of pipe
- Top of cover material

The measurements are used to confirm that minimum standards are being met.

Backfill material is used to fill the trenches after the bedding and cover materials have been placed. The backfill material should be excavated material that is free from all large or sharp rocks, and any foreign material 2 inches in diameter or greater. All material should have a smooth rounded surface to prevent PVC punctures.

All trenches excavated for the irrigation systems shall be backfilled within five working days from the day of initial excavation. Barricades shall be placed by excavated ditches located within 30 feet of the traveled way in a manner acceptable to the Resident Engineer. Open ditches beyond 30 feet from the traveled way shall be delineated and protected in a manner acceptable to the Resident Engineer.

The inspector shall be responsible for taking a four-foot section of pipe for every 5000 feet installed. The pipe is used for testing and keeping track of pipe installed on the project. The pipe will have the stationing and the area that it was taken from written directly on it.

Pipe should be stored in an area without direct sunlight and with adequate ventilation to prevent overheating. Plastic pipe and fittings should be stored in a way that prevents damage by crushing or piercing. PVC pipe should be free of cracks and not be discolored in any way. PVC pipe darkened by the sun must be rejected.

Any portion of the pipe that is bent, dented, grooved or damaged, in any way, should be cut out of the section and discarded. The pipe should be square cut and free from all burrs before installation.

PVC piping for water or irrigation systems is joined by solvent welding or with ring-tite fittings. Assembly of pipe fitting shall be in accordance with manufacturer’s instructions and project documents. Careful inspection and enforcement of assembly procedures are essential.

Solvent welding is a technique used to glue or bond PVC pipe and fittings together. Shake or stir the cement before using. Note: If the cement has a jelly-like consistency, it should be discarded. A ¾ inch dauber should be used on smaller diameter pipes. For larger pipes, increase the size of the dauber to accommodate the pipe.

The pipe fittings should be cleaned and primed using a solvent or primer. Remove all dirt, oil, moisture and gloss from the surface of the pipe. Note: Primer is used to soften both pipe and fittings prior to the application of cement.

Apply a coat of primer to begin softening the pipe and fittings. Primer should only be applied to the male and female ends that will come in contact with one another. While the primer is still wet, use the appropriate sized applicator to quickly and evenly coat the cement to the pipe and fitting. Note: Best results are achieved when the cement is flowed on the pipe surface- not thinly brushed.

Working quickly, insert the pipe into the fittings until it stops. Give the pipe a ¼ turn to help evenly distribute the cement. The cement on both the pipe and fittings must be fluid at this time or a failure may occur later.

To help prevent the tapered fittings from pushing away from the pipe, apply pressure to the pipe and fitting for 15 seconds to 3 minutes. Larger pipes may require assistance to help push the pipe together. The cement should appear to wet the surfaces of the pipe and fitting when assembled.

Remove excess cement with a dry rag to help prevent the pipe from weakening. A wet bead of cement on the outside of the fitting indicates that a sufficient amount of cement has been used and that the cement was fluid when assembled.

When working with bell end pipe, make sure excess cement does not puddle in the end of the socket. The excess cement can weaken the pipe causing leaks or breaks to form in the sidewalls of thin schedule and bell end pipes.

Follow the manufacturer's recommendations for solvent welding procedures. The set joint must be treated carefully during the initial curing time, and not distributed. For convenience, pipes are usually assembled above ground and then lowered into the prepared trench.

If the pipe is assembled above ground, the inspector needs to be sure the solvent cement joints have had enough time to set before the pipe is moved or tested. The following tables are the estimates for Average Initial Set Times.

The information can be located at IPS Weld-On website.

Average Initial Set Time

Temperature Range	Pipe Size ½" to 1 ¼"	Pipe Size 1 ½" to 2"	Pipe Size 2 ½" to 8"
60° - 100°	2 minutes	5 minutes	30 minutes
40° - 60°	5 minutes	10 minutes	2 hours

Note: Initial set schedule is the necessary time to allow before the joint can be carefully handled. In damp or humid weather allow 50% more set time.

There are a variety of pipe solvent/cements available. The application will vary depending on the type of pipe being used. The inspector should be familiar with the types of cement used for each type of pipe. The manufacturer's cut sheets will provide guidelines.

At the end of each day, the pipe ends should be capped to prevent unwanted debris or animals from entering. Prior to backfilling, snake the pipes from side to side in the trench to prevent expansion failures. Walk the length of the pipe and record the installed footage in the daily diary.

Wrap all threaded joints with Teflon tape or a manufacturer's recommended sealant/lubricant compatible with the part being installed. This will prevent water from leaking around the threads.

Electrical control wires between the automatic controller and the automatic control valves shall be bundled together at 10-foot intervals in the trench. The wires shall be placed either adjacent to or beneath the irrigation mainline to protect against possible damage from future excavation.

Sufficient wire slack shall be maintained to eliminate wire stressing or breakage. Variations in moisture content or extreme seasonal temperature fluctuations cause the expansion or contraction of wire and/or earth. Wire shall be provided with a 36 inch loop at all changes in directions and on both sides of sleeve crossings. Wire shall be wrapped around a ¾ inch PVC pipe 10 times at all splices.

Wire color code shall be white for common, red for trees, green for shrubs or ground cover and blue for other components, as designated. The plans will have a wire schedule to show the minimum wire gauge to be installed on the project. Wire sizes shall be a minimum of 14 gauge and as specified in the project plans.

The inspector shall do a visual inspection to verify that the wire being installed is in accordance with the project plans and Special Provisions. The wire size and type will be continuously written on the jacketing of the wire.

Electrical splices shall be permitted only in valve and junction boxes, or at the control equipment. No direct burial splices shall be allowed. The types of electrical splices allowed in ADOT irrigation projects shall be as specified or approved for use by the Resident Engineer. The inspector will need to investigate what has been submitted and approved by the Resident Engineer and read the installation procedures for that style of connector.

The mainline should be installed up to the ball valve in front of the remote control valve. The flushing ball valves should be opened. The contractor should close them, as water starts to flow from the ball valve, starting at the closest source and moving towards the end of the line. Test the mainline and then install the remote control valves and sub-main lines.

The sub-main should be installed up to, but not including, the pressure regulators. As water begins to flow from the regulator riser, it should be capped, starting with the closest emitter to the source, moving towards the end of the sub-main. Test with ball valves closed. After testing, remove the caps and install the pressure regulators and laterals.

The lateral pipe should be installed up to, but not including, the emission device. The process begins by flushing the lateral with the supply tubing open. As water begins to flow from the tubing, it folds over and becomes kinked or closed. A retainer, installed on the end working closest to the source, forces all of the debris out the end of the line. Test and install the emitters.

Install thrust blocks and partially backfill, leaving all joints and fittings exposed, prior to testing the pipe. Under no circumstances will air be acceptable as a testing medium.

The inspector is responsible for collecting a copy of the Backflow Prevention Unit (BPU) report after the testing has been completed. A copy is placed in the project files after being reviewed by a supervisor. A copy is also made available for the appropriate municipal representative, if requested. It is recommended that the inspector keep a copy on site for their records to identify project information, e.g. BPU type, model, address, locations, serial numbers, sizes and owners/purveyor, for BPU water meters.

The contractor’s certified tester should always check a BPU assembly that appears to be leaking.

The contractor should not be allowed to use water from a source without first having an approved backflow prevention device installed and tested. BPU units installed on ADOT and/or city irrigation systems must be installed according to municipal regulations or Maricopa Association of Governments (MAG) standards.

The inspector should check for leaking sweat joints on the copper fittings, threaded pipe connections, minimum clearance of 12 inches above grade, and placement in close proximity to the water meter requirements according to the standards.

All irrigation system components and piping shall be tested for acceptance. All emitter lateral lines shall be tested at the operating flow pressure. Document the testing on the form and reference in the inspector’s Daily Diary.

The inspector should check all isolation valves in the section being tested to ensure that they are all open. All remote control valves should be assembled and installed prior to testing.

The pipe shall be pumped up to the pressure called for in the Special Provisions or Standard Specifications. The gauge should be monitored for the first 15 to 30 minutes to see if the pressure holds. If the pressure begins to drop, the inspector should walk the tested portion of pipe looking for visual signs of leaks. If the pressure holds, the inspector should stay at the test site for the duration of the test to verify results.

If leaks are discovered, they must be repaired. The contractor is then required to retest that portion of pipe. The test should be administered until it passes. Air trapped in the pipe can cause the pressure test to fail. It is important to remove all of the air out of the lines before testing. Not being able to locate leaks does not excuse the inability to pass the pressure test. The contractor is responsible for passing the test. It is unacceptable to pump the pressure higher than the required pressure in the contract documents so that the specified pressure is reached after the duration.

All portions of the mainline shall be partially backfilled, leaving all fittings exposed and thoroughly flushed of all foreign material prior to installation of any remote control valves or irrigation devices. All portions of the sub-main shall be backfilled and thoroughly flushed of all foreign material prior to installation of any pressure regulators or irrigation devices. Laterals should also be flushed before any emission devices are installed.

After the system has been installed and is operational, the blow out filters and flush end caps should be opened. Allow the system to run for 2 to 3 minute intervals for flushing, during both construction and landscape establishment.

The flushing of valves, piping and other components shall be performed in accordance with the Special Provisions. The minimum velocity of 4 feet per second flushing, must be verified by a meter at the point of connection or, in some cases, at the flow meter by the backflow assembly.

In the following tables, please note that the gallons per minute (GPM) at the meter will read differently for different velocity and pipe sizes.

Flow in GPM for Schedule 40 PVC

Velocity Ft/s	½”	¾”	1”	1 ¼”	1 ½”	2”	2 ½”	3”	4”
1	0.9	1.6	2.6	4.5	6.2	10.3	14.6	22.7	39.1
2	1.8	3.2	5.2	9.1	12.4	20.5	29.3	45.3	78.3
3	2.7	4.7	7.8	13.6	18.6	30.8	43.9	68.0	117.4
4	3.5	6.3	10.4	18.1	24.8	41.0	58.5	90.6	156.5
5	4.4	7.9	13.0	22.6	30.9	51.3	73.2	113.3	195.6

Flow in GPM for SDR21 Class 200 PVC

Velocity Ft/s	½”	¾”	1”	1 ¼”	1 ½”	2”	2 ½”	3”	4”
1	1.2	2.0	3.3	5.4	7.1	11.1	16.3	24.2	40.1
2	2.4	4.1	6.7	10.8	14.1	22.2	32.6	48.5	80.1
3	3.6	6.1	10.0	16.1	21.2	33.3	48.9	72.7	120.2
4	4.7	8.1	13.4	21.5	28.3	44.4	65.2	96.9	160.3
5	5.9	10.1	16.7	26.9	35.4	55.5	81.5	121.1	200.4

½ inch PVC pipe is not manufactured in Class 200. However, it is available in Class 315.

After flushing the system, all irrigation devices shall be assembled and installed. They will require settings at the proper elevations according to the Project Plans. Final adjustments, after the finish grade is established, must be inspected. A visual inspection of the clearance of both horizontal and vertical items installed in valve boxes should be performed.

Bubbler and sprinkler devices are assembled using threaded PVC connections. The tubing used is either polyethylene supply or vinyl distribution tubing. Polyethylene tubing connects from the PVC to the emitter. Vinyl distribution tubing connects from the emitter to the emission point at the base of the plant or as shown on the plan details. The tubing is flexible and must be handled with care.

Supply tubing should be used to center the emitter in the group of plants it will be serving. With trees, bring the emitter to within 5 feet of the base of the tree or as detailed on the Project Plans.

The emitter systems distribution tubes are held in place with hose stakes. It is important that they are placed as shown on the Project Plans. Their placement around the plant determines the wetting pattern. Emission points work together to push salt away from the root zone and supply the plant with fresh water. In sloped conditions, the emitter and emission points shall be placed on the uphill side of the plant because gravity will pull the water downhill. When a plant requires more than one emission point, one point will be placed at the root ball. The remaining shall be distributed around the plant as detailed on the Project Plans.

Future emission points shall be placed and plugged at radius distance as detailed and approved by the Landscape Architect. All emission points shall be installed at time of construction and opened (unplugged) during the landscaping establishment period as required. During landscaping establishment the root ball emission point will be adjusted as directed by the Resident Engineer.

The number of outlets each individual plant receives will be indicated on the project plans in an Emitter Schedule. The Emitter Schedule is a table that identifies the emitter type, placement, outlet GPH, recommended run hours and number of tubes open at construction and maturity.

Emitter Schedule Defined

Emitter Placement	Coordinates with another detail outlining where the distribution outlets will be placed around the plant material.
Emitter Type	Identifies whether the emitter will be a single or multi-outlet unit.
Tubes / Emitters at Construction	Number of tubes opened at the beginning of construction.
Tubes / Emitters at Establishment	Number of tubes opened during landscape establishment
Outlet GPH	Nominal gallons per hour each emission point will produce
Peak Run Hours	Hours the designer believes the plant material will need in a worst case scenario. The hours shown in the schedule are for reference only. *Note: The ultimate decision on how much water the plant material receives is up to the contractor.*
Peak Daily Gallons	Amount of water applied to each type of plant material at the peak run hours applied. This is equal to the following: Tubes open x outlet GPH x runs hrs = Daily gallons 4 x .6 x 5 = 12
Peak Daily Applied Inches	Inches applied during each watering cycle
Plant Names	Name of the plant material to be watered.

Exhibit 808-3.03-1. Emitter Schedule Defined

Emitter Schedule

	EMITTER PLACEMENT (See detail)	EMITTER TYPE M=Multi S=Single	TUBES/ EMITTERS @ CONSTRUCTION	TUBES/ EMITTERS @ ESTABLISHMENT	OUTLET GPH	PEAK RUN HOURS	PEAK DAILY GALS	PEAK DAILY APPL'D INCH SYMBOL	PLANT NAMES
Trees	C	M	4	4	0.6	5	12	0.04	SWEET ACADIA
Trees	A	M	10	10	0.6	5	30	0.07	BLUE PALO VERDE
Trees	A	M	10	10	0.6	5	30	0.07	LITTLE LEAF PALO VERDE
Trees	A	M	10	10	0.6	5	30	0.07	MEXICAN REDBUD
Trees	A	M	10	10	0.6	5	30	0.10	DESERT IRONWOOD
Trees	C	M	4	4	0.6	5	12	0.06	TEXAS EBONY
Trees	A	M	10	10	1.0	5	50	0.08	HONEY MESQUITE
Trees	A	M	10	10	1.0	5	50	0.08	ARIZONA MESQUITE
Trees	C	M	4	4	0.6	5	12	0.11	CHASTE TREE
Trees	C	M	4	4	0.6	5	12	0.11	ARIZONA YELLOW BELL
Trees	C	M	6	6	1.0	5	30	0.10	DATE PALM
Trees	C	M	6	6	1.0	5	30	0.15	WASHINGTON FAN PALM
Shrubs	B	M	3	3	0.6	1	1.8	0.05	BARBARA KARST
Shrubs	B	M	5	5	0.6	1	3.0	0.10	RED BIRD OF PARADISE
Shrubs	B	M	5	5	0.6	1	3.0	0.10	LITTLE LEAF CORDIA
Shrubs	E	M	1	1	0.6	1	0.6	0.03	DESERT SPOON
Shrubs	E	M	1	1	0.6	1	0.6	0.01	OCOTILLO
Shrubs	E	M	1	1	0.6	1	0.6	0.05	RED YUCCA
Shrubs	B	M	2	2	0.6	1	1.2	0.15	DESERT RUELLIA
Shrubs	B	M	2	2	0.6	1	1.2	0.04	JOJOBA
Shrubs	E	M	1	1	0.6	1	0.6	0.05	SIERRA GOLD
Shrubs	E	M	1	1	0.6	1	0.6	0.03	TRAILING INDIGO BUSH
Shrubs	E	M	1	1	0.6	1	0.6	0.14	DESERT MARIGOLD

Not all emitter schedules are identical but information contained in the schedule should be consistent from one to another.

Bubbler systems are utilized on level ground and rely on a basin or contained bed area that is flooded when the valve is opened. Construction of the finish grade elevation is critical to ensure adequate dispersal and containment of the applied water. With poorly constructed basins, water may spill into the roadways. They can also create erosion rills when installed on any kind of slope.

Careful attention should be given to the basin construction, especially where decomposed granite is applied over the finish grade. Do not allow the granite to be spread until the basins or swales are inspected and approved. The wetting pattern and salt leaching capabilities are as critical as they are for emitter systems.

The Electrical Inspector is responsible for the inspection of power and source connections to the controller. The Landscape Inspector is primarily responsible for the inspection layout, location and the controller components. The controller cabinet layout and location, relative to other irrigation components, must be approved prior to installation of the concrete slab. The contractor should give the inspector a 24-hour notice so that inspections can be done for the following:

- Quantity, size and location of conduit sweeps, sleeves
- Concrete pad dimensions and thickness, reinforcements, turndowns
- Setting controller cabinet
- NEMA supports (National Electrical Manufacturers Association)
- Adjacent grade relative to the pad
- Mixed design
- Coloring to differentiate between the common, spare, tree and shrub wires
- Concrete curing compound
- Ground rods

The wires should be bundled and routed through the cabinet in a clean, organized manner resembling the project details.

The inspector is responsible for obtaining from the contractor, a wire diagram or schematic of all controller components. A copy should be added to as-builts and kept inside the controller cabinet for reference prior to the close of construction.

The inspector is responsible for obtaining a copy of the irrigation controller program schedule from the contractor. A copy is provided to the supervisor for placement in the file. The program or schedule is compared against the project plans and is used for calculating water usage reports.

The ADOT controller, when it is a Motorola, communicates via radio. The correct type and quantity of radios should be checked by the inspector. Communication should be verified in the field between controllers (Field IRRinet Units) and their sub-satellite controllers (Scorpio Units), if applicable, and the home base (Central Command Center). The inspector is responsible for the coordination and assignment of the correct radio ID addresses with the ADOT supervisor and the contractor.

The inspector is also responsible for monitoring the radio communication periodically during construction and establishment. The radio address must be programmed into the controller using an approved address supplied by ADOT. The radio communication controller program can be verified at the Central Command Center computer located either at district maintenance or district construction offices (Phoenix and Tucson districts only). The controller should be programmed in flow.

The irrigation system controller must operate all the automatic or remote control valves (RCV) electronically according to the programmed instructions. Instructions are input by a field programmer. The inspector should verify accurate operation by having the contractor run the program from the controller and verify that each remote control valve opens and closes accordingly.

The verification of the operation of the controller is recorded on the Irrigation System Pressure Testing Report. If no pressure is recorded, or the remote control valve does not turn on, the contractor must resolve the deficiency before the inspector accepts the work. Once the repair has been made, the inspection procedure is repeated.

The inspector should verify that the master valves open and close according to the program for each valve grouping. The inspector should follow an ADOT supplied inspection punch list for the controller items that include:

- Flow monitoring system
- Microphone is included
- Spare wires color/quantity
- Connection to terminal board
- GFCI receptacle is included
- Proper grounding
- Pressure switch set
- Master valve connection

Unless otherwise specified, all irrigation systems within the designated controller area shall be completed, tested, approved and properly backfilled before landscaping can begin.

The system should be set to pre-water the plant pits prior to planting. In +100° F temperatures and dry soil, it is not uncommon for newly planted specimens to wilt and expire in a few hours.

The operation of the system and the amount of water needed by each plant will vary. There are no set watering times, although guidelines exist to help the designer calculate the daily demand for plants in a landscape project. The information is based on mature plant size, type, evapotranspiration (ET), irrigation efficiency, and soil type. The information available in the field is by direct observations of the plant and soil. If plants are wilting, water is needed. Check by probing the soil. Generally grasses and flowers need watering to a minimum depth of 12 inches, shrubs to 2 feet and trees to 3 feet or more.

Freeze protection must be provided as specified in the project documents. Either a three-way valve with compressed air fitting for blowing water out of the lines or automatic drain valves, placed at the low point of each lateral pipe, must be used. The type of drain and installation shall be as specified and detailed in the project documents.

To keep the system in good working condition during landscaping establishment, the gate valves should be opened and closed to ensure proper operation. Filter and end caps should be checked and flushed. Pressure and flows should be verified, see the monthly irrigation inspection form.

Serving Utility

Water Source

Irrigation water can be supplied through a number of sources. It can be delivered from a temporary water storage tank, from city water or from a private water supplier. The water source for any project will be identified within the Project Plans and Special Provisions. A project located within an urban or rural setting will have irrigation water supplied from an underground water mainline of various sizes. Projects located outside of an urban setting will have water delivered by a water truck to above ground temporary water storage tanks.

When the water source is a city or private water purveyor, a water meter is installed so that the amount of water used on a project can be determined and the appropriate billings processed. Water provided at the water source and through the water meter is generally used only for planting, landscaping establishment, irrigation line flushing, and irrigation equipment testing. The water provided through the water meter must not be used for office equipment, construction yard, water-settling trenches, watering in pre-emergent herbicide, rock or granite mulch or other construction related tasks.

The contractor shall be responsible for contacting a representative of the water department, requesting the water service and arranging for installation. Before any water can be used from any source, the inspector must ensure that the local water provider has inspected and accepted the connection to the infrastructure. This should be documented in the inspector's diary.

The contractor shall work with the city and inspectors on the exact location of the water meter. All coordination, meetings, permits and miscellaneous work related to establishing the exact location(s) for the water meter(s) shall be completed by the contractor.

The cost and work performed by the contractor for the installation of the water meters shall be at no cost to the department. The cost will be considered as included in the item providing water service or related items. The contractor will be reimbursed for any work performed by the city. Upon billing, the contractor shall pay the city for the cost of water service installation and will be reimbursed for the exact amount paid to the city. This may vary according to intergovernmental agreements. No supplemental markup will be allowed. The work for providing water service will be paid for as stated in the Special Provisions.

The contractor should contact the city for water meter installation before the pre-construction conference. Actual dates of installation shall be set at the Pre-construction Conference. The contractor shall coordinate with the city regarding any water services work completed under the roadway contract.

The water meters must be placed in ADOT's and the city's name in the Phoenix area. In areas outside of Phoenix, the water will be placed under that city's name. Usually city supplied water is paid through a municipality.

The contractor should measure the static water pressure on site at each point of connection as soon as practical and report to the inspector. This is done to ensure that the pressure is the same or higher than the design pressure shown on the plans. If the pressure is too low, contact the supervisor or designer to determine if modifications are necessary.

The inspector should be aware of the water purveyor supplying the project with reclaimed water. When reclaimed water is supplied to a project it is necessary to work a specific set of rules.

The inspector must ensure that the contractor prepares worker education and safety guidelines detailing the risks associated with and working with reclaimed water.

The contractor shall be responsible for keeping all reclaimed water out of contact with the general public. At no time shall the reclaimed water be allowed to escape onto the roadway or into any drainage systems.

Color identification shall be purple and shall be integral with the valve box and pipe manufacturing process. All valve boxes, lids, remote control valves, and PVC piping shall have the color purple for identification of a non-potable system. Any PVC pipe shall meet the provisions for identification as set forth by the Arizona State Department of Environmental Quality for the use of Reclaimed Water

The contractor shall comply with all laws, from all appropriate jurisdictions, that pertain to the construction, operation, and maintenance of reclaimed water distribution systems during construction and during the establishment period.

The irrigation system will be operated to avoid ponding or puddling. To minimize ponding or runoff, the reclaimed water shall be applied at a rate that does not exceed the infiltration rate of the soil.

Signs reading "CAUTION: RECLAIMED WATER, DO NOT DRINK" shall be prominently displayed on the roadway and at all entrances to the roadway. It is particularly important to place the caution signs around any above ground irrigation equipment. The purpose and intent of properly notifying the public is to ensure that the reclaimed water is not misused.

All reclaimed water system facilities shall be identified by the color code and marking system specified by the Maricopa Association of Governments, revisions 1998 through 2003 (MAG Section 616), to differentiate it from the potable water system.

There shall be no connection between the potable water supply and any piping containing reclaimed water.

People working in and about the reuse site shall be informed that reclaimed water is being used and shall take appropriate safety precautions.

Reclaimed water irrigation systems are subject to restrictions in construction that contractors shall make themselves aware of. The contractor will comply with all Municipal, County, and State codes regarding construction of the reclaimed water irrigation distribution systems. Special attention must be paid to worker safety, hygiene, training and the required separation distances between any reclaimed water line and any potable water line.

The contractor will not be paid extra for installing this irrigation water distribution system in complete compliance with the rules and restrictions of Local, Municipal, County, or State, in place at the time of the construction.

Electrical Source

The local electrical company usually provides an electrical source for the irrigation system. The project designer will have completed coordination and identification of the electrical source during the development of the construction documents.

The contractor shall work with the utility company and inspector on the exact location of the electrical point of connection(s) (POC). All coordination, meetings, permits, and miscellaneous work related to establishing the exact locations for the point of connections, shall be completed by the Contractor. The costs and work performed by the contractor for the installation of the electrical service(s) shall be paid for as stated in the Special Provisions.

The amount and type of work requiring completion by the contractor will be detailed on the project plans as stated in the Special Provisions.

The inspector shall be responsible for contacting an ADOT electrical inspector and confirming that a clearance letter has been received. The letter must state that the installation of all electrical items conforms to the local utility company requirements. After all permits and fees have been paid according to the Special Provisions, the utility company will install the electrical meter and make the final electrical connection. Electrical services need to be placed in ADOT's name

808-4 Method of Measurement

Items should be measured or counted as called out on the cost estimate. The choices for irrigation measurement are lump sum (L. SUM), each (EACH), or linear foot (L.FT.).

Measurements for each include emitters, pressure regulators, control valves and controllers, while pipe and tubing is measured by the linear foot. It is important for inspectors to read and understand the Special Provisions. This will help identify items that require measuring. In most instances the distribution and supply tubing are considered part of the emitter cost.

The inspector will consider measuring the pipe while the pressure test is being conducted. The trenches should be walked to look for leaks and can be measured by the wheel at the same time.

While the Method of Measurement in the Special Provisions explains how the individual items are to be paid, the Description, Materials and Construction Requirements sections explain what is involved in the individual pay item.

GLOSSARY OF WATER DISTRIBUTION TECHNOLOGY

Air Release Valve
A device used to expel air in the piping system.

Anti-Siphon Device
A device used to assure positive protection against back-siphonage of impure water into main supply in the event that pressure loss causes vacuum conditions.

Application Rate
The rate (inches or gallons) at which water is applied to the turf or landscape. In sprinkler irrigation, refers to the amount of water applied to a given area in one hour, usually measured in inches/hour.

Approved Backflow Prevention Device
A device, method or type of construction that has been approved by an appropriate regulatory agency that will prevent backflow into the potable water system.

Arc
The degrees of coverage of a sprinkler from one side of the throw to the other. A 90-degree arc would be a quarter of a circle coverage. Likewise a 180-degree arc would be identified as a half circle coverage.

As-Built-Plan
A complete plan of an installed irrigation system that designates the valve, sprinkler, controller locations, routing of pipe and control wire. The plan includes all changes to the original design necessitated during the systems installation.

Atmospheric Vacuum Breaker
A mechanical device consisting of a check valve in a supply line, where the valve member opens to the atmosphere when the pressure in the line drops to atmospheric levels or below. An atmospheric vacuum breaker is designed to prevent back-siphon age only. It is not effective against back-flow due to backpressure and should be installed only on the downstream of the control valve.

Automatic Control Valve
A valve in an irrigation system that is activated by an automatic controller through the use of electrical control wire. Also referred to as a remote control valve.

Automatic System
An irrigation system that will irrigate in accordance to a preset program.

Available Water
The amount of water which is held in the plant root zone between field capacity and the wilting point.

Backflow
The reversal of flow or a mixture of water and other undesirable substances into the distribution piping of the potable water system. There are two types of backflow, backpressure and back-siphonage.

Backflow Preventer
A mechanical device that prevents the reverse flow of any foreign liquid gas or substance from a non-potable system into a potable water system.

- Vacuum Breaker
  - Atmospheric Vacuum Breaker
  - Combination Atmospheric Vacuum Breaker and Control Valve
  - Pressure Vacuum Breaker
  - Hose Connection Vacuum Breaker
- Double Check Valve Assembly

- Reduced Pressure Backflow Preventer

The choice of backflow preventer to be used will depend on the degree of hazard and the particular piping arrangement involved.

Backpressure

Any condition that could cause the non-potable water system piping pressure to be greater than that of the potable water system. This allows the non-potable water to be pushed back into the potable water system, most likely caused by gravity due to elevation changes or booster pumps.

Back-siphonage
A form of backflow due to a negative pressure within a potable water system. This is most likely caused by a fire engine connecting to a fire hydrant and pumping water to put out a fire or supply line breaks.

Booster
A pump that has a pressurized suction and is designed to raise the existing pressure of the water in the irrigation main line to a desired level.

Bug Screen or Cap
A device placed at the end of the emitter distribution tubing or emitter head to prevent dirt and insects from entering and plugging the line.

Check Valve
A valve that permits water to flow in only one direction.

Circuit
A group of irrigation devices controlled by one valve.

Combination Atmospheric Vacuum Breaker
A device that combines in one body an AVB and a tightly closing shut-off valve located upstream of the vacuum breaker portion.

Controller
A mechanical or electronic timing device and enclosure. The enclosure shall be capable of automatically actuating automatic remote control valves or other devices on a preset program.

Coverage
A General term, referring to the manner in which water is applied to the spacing between sprinklers.

Cross Connection
A connection between the pipe transporting potable water and the pipe that is transporting non-potable water creates a point in which a polluting substance may come in contact with the potable water.

Distributing Tubing
A flexible plastic tube, polyethylene or vinyl connected to the emitter for the purpose of delivering water to the plant at a specified location.

Double Check Valve Assembly
Generally refers to a type of backflow preventer that is composed of two inline positive seating check valves. The DC assembly also includes two approved shut-off valves and test cocks.

Drain Valve
An automatic or manual valve located at a low point in the irrigation system, which allows the system or portions thereof to be drained during winterization of the system.

Electric Valve
An automatic valve is usually controlled by 24 to 30 volt current. These are connected with wire to the controlling device or circuit.

Emitter
A precise metering device capable of very low flow rates for the slow application of water and nutrients directly to the plant material. Emitters are generally installed adjacent to the plant material to be watered. Additional water application points may be located, as required by project documents, by using distribution tubes from the emitter.

Evapotranspiration
The transfer of water from soil to the atmosphere. It is the total amount of soil water lost by transpiration through plants and by evaporation from the soil surface.

Fertilizer Injector
A mechanical device for the proportional injection of nutrients or chemicals into the irrigation system. The injection device shall be electrically or water operated and adjustable to the injection rates.

Filter
A mechanical device for the removal of harmful materials that would plug orifices or nozzles of irrigation equipment. The filter shall consist of a body or vessel containing a porous filter element with openings compatible with filtration requirements of the irrigation equipment.

Flow Control Valve
A valve that regulates the flow rate of water without drastically altering the pressure.

Flow Switch
A device placed in a piping system to monitor water flows. May be used to start or stop pumps or other devices as required by system design.

Friction Loss
The loss of pressure caused by water flowing in a pipe system. Pressure loss is due to turbulence produced by water flow against the inside wall of the pipe. Friction loss is a function of the pipe inside diameter, wall surface roughness and the velocity of the water flow.

Gravity Flow
Flow of water in a pipe on a descending path.

Ground Water
Water found below the surface and usually considered not to include the water flowing in underground streams.

Gypsum
A widely distributed mineral consisting of hydrous calcium sulfate that is used as a soil amendment to counteract alkali conditions.

Head of Feet
A measure of pressure in feet of water. Equivalent to .43 psi per foot of water depth or 1 psi per 2.1 foot of vertical rise.

Head-to-Head Spacing
The placing of sprinklers such that a sprinkler radius of throw causes water to hit adjacent sprinkler heads. Also known as 100% coverage and head-to-head coverage.

Hose Connection Vacuum Breaker
A device consisting of a positive seating check valve and an atmospheric vent that is biased to a normally open position. The device is designed specifically for use on hose threaded outlets.

Impact Drive
A method of providing rotational movement to a sprinkler through the use of a weighted or spring loaded arm. The arm is being pushed away from the sprinkler by the water stream and returning impact with the sprinkler body to force a movement.

Infiltration Rate
The rate at which the soil will take in water, measured in inches per hour.

Irrigation Frequency
The amount of time that can be allowed between irrigation cycles to avoid runoff.

Lateral
The low-pressure piping downstream of the control valve where the water delivery devices are located. Laterals may be flexible or rigid plastic material as required by project documents.

Leaching
The removal of harmful soluble salts from the plant root zone by an extra heavy application of water; the undesirable salts are carried by gravitational water to a point below or out of the root zone.

Loop
A piping network that allows more than one path for water to flow from the supply to the point(s) of demand.

Mainline
A large pipe that is sized to carry the water for the irrigation system. Mainline is the piping between the supply point of the backflow device and the control valve and is under pressure at all times, unless drained during the winter or turned off by the master valve.

Manual System
A system in which control valves are opened manually rather than by automatic controls.

Master Valve
A valve located at the supply point of the mainline that opens or closes by commands from the controller.

Moisture Control
An automatic feature on the control equipment that will control the programmed cycles based on the moisture content of the soil in the area of the moisture sensor.

Moisture Sensor
A device that senses the moisture content of the soil at a predetermined depth. The device may be equipped with a gauge for visual observation or may be capable of automatically controlling the irrigation cycle(s).

Normally Closed Valve
An automatic valve that allows no water to flow unless externally activated by remote forces.

Normally Opened Valve
An automatic valve that allows water to flow unless externally activated by remote forces.

Operating Pressure
The pressure that allows a system of irrigation devices to operate. Operating pressure is static pressure less pressure losses. Usually indicated at the base or nozzle of the irrigation device.

Orifices
Openings in pipe, tubing and nozzles.

Overlap
The coincidence of coverage by more than one sprinkler in a common area. The amount of overlap is expressed as a percentage of the radiuses or spacing of the sprinklers.

Peak Consumptive Use
The average daily rate at which moisture is used during the growing season, when evapotranspiration is at the highest level. Peak consumptive use may be expressed in inches of water per day.

Peak Moisture Demand
The amount of moisture required by a plant during its peak maximum growth, which usually occurs during the time when temperatures are at a maximum and evaporation is generally at their highest levels.

Percolation

The downward movement of water through soil.

Permeability

The quality of soil that permits water and air to be moved through it.

Pollution
The presence of a foreign substance that creates, or may create, a danger to the health and well being of the general public.

Polyethylene Pipe
A black flexible pipe or tubing commonly used in emitter systems. Polyethylene pipe is manufactured with controlled inside and outside dimensions.

Polyvinyl Chloride PVC Pipe
Unplasticized polyvinyl chloride pipe. A semi-rigid plastic in general use in irrigation systems that is available in a variety of thicknesses and pressure ratings. PVC pipe is manufactured with controlled inside and outside dimensions.

Potable Water
Water that is safe for drinking, cooking or personal use.

Precipitation Rate
The rate at which sprinklers apply water to the landscape. Usually figured for a pattern at a given spacing. The precipitation rate is expressed in inches/hour.

Pressure Regulator
A device that regulates the available pressure to a preset maximum. May be used to protect the piping system from excessive pressures or for reducing operating pressures to individual or circuited irrigation devices.

Pressure Relief Valve
A valve that will open when the pressure exceeds a preset limit (to relieve and reduce the pressure).

Pressure Vacuum Breaker
A device contained within a single body, consisting of a single loaded check valve and a loaded air-opening valve, that opens to admit air whenever the pressure within the body of the device approaches atmospheric pressure. The body of the device shall be equipped with two (2) tight closing shut-off valves and test cocks for appropriate testing. The unit is designed to prevent back-siphonage only and is not effective against backflow due to backpressure. Pressure vacuum breakers shall be installed a minimum of 12 inches above the highest water in the system.

Primer
A chemical used to soften the surfaces of PVC and CPVC pipe and fittings that are necessary for the proper solvent welding of the materials.

Programming
The act of devising and applying to the controllers a plan or procedure for irrigating landscaping material. A program consists of a day to water, a start and watering time, quantity (flow) and what control valves should irrigate.

Pump Start Circuit
The features on some automatic controllers allow a connection to be made through a relay with the pump starter so that the starter will be energized when the watering cycle begins.

Quick Coupling System
An irrigation system that uses quick coupling valves and coupling keys. The valves are permanently installed, while the keys and attachments are manually moved from valve to valve.

Rain Shutdown Sensor
A mechanism that will stop or delay the watering program when a preset amount of rain falls.

Rate of Application
The rate that water is applied to the ground by the sprinklers within a pattern, sometimes referred to as the precipitation rate.

Reclaimed Water
Wastewater that has been treated and brought to a level of water quality that makes it suitable for further beneficial use. It is used for turf and landscape irrigation, recharge, and suitable for some industrial uses such as cooling towers.

Reduced Pressure Backflow Preventer
A device consisting of two (2) positive seating check valves and an automatic operating pressure differential relief valve, integrally located between the two check valves. It is installed as a unit between two tightly closing shut-off valves, and fitted with properly located test cocks. This device is effective against backflow caused by backpressure and back-siphonage and is used to protect the water system from substances which are hazardous to health (high hazard).

Remote Control Valve
An automatic valve that is activated by an automatic controller or manual remote control unit through use of hydraulic or electric control lines.

Repeat Cycle
The programming of an automatic controller to repeat an irrigation cycle automatically for those controller stations is set.

Riser
Usually refers to a length of pipe affixed to a lateral line, or sub-main for the purpose of supporting a valve, emitter, bubbler, or a sprinkler head.

Run-Off
Water that is not absorbed by the soil to which it is applied. Run-off occurs when water is applied at too great a rate, when there is a severe slope or the application rate exceeds the infiltration rate.

Sand Filter
A device installed in a pipeline to remove sand or silt from water by allowing it to settle out of the flowing stream.

Sleeve
Conduit where water pipe or electrical wire is run through. This provides for added protection and ease in replacing piping or wire when running under paved areas.

Slip Fittings
A fitting that is solvent welded on PVC or ABS pipe.

Soil Compaction
The compression of soil particles that may cause the intake rate of a particular soil to be reduced.

Soil-Moisture Tension
The measure of force that allows water to be held in the soil by adhesion and cohesion. It is expressed in terms of atmospheres against the forces exerted by a plant’s root system and evaporative processes.

Solvent
A material that causes a chemical fusing of PVC pipe and fittings so that a permanent bond can be accomplished between the pipe and fittings. Each type of PVC pipe may require different solvent/cements. Refer to the Special Provisions.

Solvent Welding
The act of chemically fusing pipe and fittings together using solvent cement/primer.

Spacing
The distance between irrigation heads.

Sprinkler
A hydraulically operated mechanical device that discharges water through a nozzle(s) or an orifice.

Static Pressure
The pressure (pounds per square inch) in a closed system, without any water movement.

Stop-a-Matic-Valve
A spring loaded check valve used beneath a sprinkler to prevent low head drainage of circuit piping through the sprinkler heads. The check valve feature may also be built into the sprinkler device.

Supply Tubing
A polyethylene or PVC tube used to supply water from an emitter lateral to the emitter. Supply tubing size varies with the emitter manufacturer, the size being specified on the project document.

Surge
An energy wave in pipe lines caused by sudden opening or closing of valves.

Swing Joint
A threaded or “O” ring fitted connection of pipe and fittings between the mainline or lateral piping and irrigation device that allows movement to be taken up in the flexible joint, rather than as sheer force on the pipe. Also used to raise or lower irrigation devices to a final grade without plumbing changes.

Tapped Coupling
An asbestos, cement, or metal coupling that has a tapped outlet on the side.

Tensiometers
Devices for measuring the moisture content of the soil, on the principle that a partial vacuum is created in a closed tube when water moves out through a porous ceramic tip to the surrounding soil; the tension causing the movement of water is measured on a vacuumed gauge.

Tension
Energy used in moving moisture from a soil or exerted soil particles to hold moisture; the higher the moisture content of a soil, the lower the tension and vice versa.

Thrust Block
A concrete support poured adjacent to pipe fittings and valves where surging is expected. It holds the pipe in place and prevents movement that could damage connections. Thrust blocks are normally placed between the fittings and undisturbed soil at the side of a trench.

Transportation
A process in which the plant moves water from the soil throughout the plant to the leaves and transpires moisture to the atmosphere.

Underspaced
An unusual situation where heads are spaced closer than they need to be for efficient operation of the system.

Uniformity of Application
A general term designating how uniform the application of the sprinkler is over the area it is covering.

Vacuum Breaker
A type of backflow prevention device that prevents the reverse flow of water from a potentially contaminated source to the potable water supply, by allowing air to the entire supply line -- interrupting the vacuum or siphon condition

Vacuum Pump
A type of pump used to move fluids at a low pressure, or to prime larger pumps; operates on the principle of reducing pressure in the direction of the desired movement.

Valve-in-Head
Indicates the automatic control valve, electric or hydraulic, is an integral part of the sprinkler assembly.

Vinyl Tubing
A flexible pipe used for emitter distribution tubing. It has less potential to coil when exposed to the sun than polyethylene pipe. Vinyl tubing is preferred when laid in place on the surface of the ground.

Water Hammer
A shock wave created by a fast closing valve. Also referred to as a surge pressure.

Water Pressure
Pressure where water exerts is measured in pounds per square inch or in head of feet.

Water Ram
A shock wave is set up by introducing water under high pressure into an air filled pipe.

809 SEWERAGE SYSTEM

809-1 Description

The Sewage system includes all the structures and procedures required for collecting, treating, and disposing of sewage. The Arizona Department of Environmental Quality must approve all sewerage system design and grant approval to construct the sewerage system. The Standard Specification Section 809 has been developed for the design and construction of rest area sewerage systems.

Layout

The location of the sewerage system components shall be staked out before start of construction. These components may include: manholes, septic tanks, clean outs, diverter valves, inspection ports, disposal trenches, evapotranspiration beds, and evaporation ponds.

809-2 Materials

All components intended for use in a sewerage system must receive approval from the Resident Engineer prior to their incorporation into the project.

Approval of items is determined from information supplied by the contractor within the specified time period as indicated in the Special Provisions. All components of the sewerage system shall be listed and identified by their corresponding bid item number where applicable. Sufficient information must be included to positively identify each item listed. Each item shall be identified by size, catalog number and the name of the manufacturer.

809-3 Construction Requirements

809-3.01 General

Copies of catalog cuts of all items listed shall accompany the contractor's submittals. Copies of submittals shall be retained in the construction file and provided to Roadside Development Services for their review. Roadside Development Services will either approve or reject the items. The Resident Engineer should exercise caution when advising the contractor as to how to revise a rejected submittal. As with all contractor submittals, questionable items and materials are not to be installed on a project; therefore, the contractor’s submittals shall be revised until acceptable by the Department.

If samples are requested for preliminary evaluation, it will be the contractor's responsibility to obtain and submit the designated items to the Resident Engineer for testing by the appropriate testing facility. Unless destructive testing is required, all items will be returned to the contractor upon completion of testing, at which time approved items may be incorporated into the project.

All system components shall be installed in accordance with the Project Plans and documents, using methods or techniques recommended by the respective component manufacturers. Careful inspection and enforcement of assembly procedures are essential.

The sewerage system shall be set at the proper elevations according to the Project Plans. Final adjustments after the finish grade is established must be expected.

The testing of the sewerage system shall conform to the requirements of the Special Provisions and the manufacturer's recommendations. Unless otherwise specified, all sewerage systems shall be completed, tested and approved before the backfilling operation is done.

As-Built Plans & System Orientation

Accurate as-built plans are a valuable and necessary aid in designing and constructing future projects for the area, and for maintenance and repair of the sewerage system. Therefore, it is imperative that these as-built plans show the true location, size, and quantity of components installed.

The contractor is responsible for supplying working drawings, corrected shop drawings, schematic circuit diagrams, or the drawings necessary for the Resident Engineer to prepare corrected plans to show the work as constructed. To ensure accuracy of this information requires that the contractor or his field representative record each change as it is completed. In addition, the inspector shall inspect and verify this information prior to the commencement of backfilling. Upon completion, all working drawings and pertinent information shall be submitted to the Resident Engineer for approval and use in preparing the as-built plans.

GLOSSARY OF SEWAGE SYSTEM TERMINOLOGY

Clean out
A surface access to a sewer line or disposal field line to provide for cleaning of the sewer line or for treating the disposal field.

Disposal field
A system of disposal trenches, disposal pits or evapotranspiration beds.

Disposal pit
A covered pit with an approximate diameter of 3 feet, filled with clean coarse aggregate and a perforated pipe to allow the wastewater effluent to seep into the surrounding soil.

Disposal trench
An individual subsurface sewage disposal system component of a covered excavation made within soil or fill material to contain filter material in which a single distribution lateral has been placed for the disposal of septic tank effluent.

Diverter valve
A valve used to direct wastewater effluent into alternate sections of the disposal field.

Effluent filter
A cylindrical device installed on the outlet baffle of a septic tank assists in the removal of solids from wastewater before it enters into a drain field. Effluent filters are a crucial element in the wastewater system as they prevent larger particles (solids) from clogging up the drain field.

Evaporation pond
A reservoir used for holding and treating wastewater and/or wastewater effluent through bacterial action on the solids and the evaporation of the liquid into the atmosphere.

Evapotranspiration bed
A covered bed filled with mainly clean, fine sand and a series of perforated pipes to allow the wastewater effluent to seep into the bed, and then through capillary action to rise up through the bed and be evaporated into the atmosphere.

Inspection port
A vertical pipe placed in a disposal field to monitor the operation and performance of the disposal system.

Pond aerator
A floating mechanical aerator is used on the surface of the pond to mix and to introduce additional oxygen into the wastewater to enhance bacterial action and increase the evaporation rate.

Septic tank
A water-tight, covered receptacle designed and constructed to receive the discharge of sewage from a building sewer, separate solids from the liquid, digest organic matter and store digested solids through a period of detention, and allow the clarified liquids to discharge for final disposal.

810 EROSION CONTROL AND POLLUTION PREVENTION

810-1 Description

Erosion and sediment control and pollution prevention control measures include all the materials and work necessary to maintain compliance with the Arizona Department of Environmental Quality Construction General Permit and ADOT's Stormwater Management Plan. The necessary components of erosion control and pollution prevention include the contract plans & specifications, the project specific Storm Water Pollution Prevention Plan (SWPPP), Section 104.09 of the Special Provisions, the ADOT Erosion and Pollution Control for Highway Design and Construction Manual, and the ADOT Post-Construction Best Management Practices for Water Quality Manual.

The SWPPP describes provisions contained in the AZPDES Construction General Permit (CGP) that must be implemented by the contractor to comply with the CGP. The SWPPP should be submitted using the current ADOT template found on the ADOT website or in a format approved by the Engineer prior to submission. The ADOT template also includes an inspection form that meets all ADOT and ADEQ requirements. To be considered qualified to conduct inspections, the ADOT Inspector and a representative of the contractor must have completed the Erosion Control Coordinator inspection course through Arizona Associated General Contractors. The SWPPP can be a daunting task to review. If assistance is needed in reviewing the submitted SWPPP seek assistance from the Construction Landscape Architect or the District Environmental Coordinator.

ADOT personnel involved in the construction and maintenance of pollution and erosion controls as required in project plans & specifications, the CGP and SWPPP should be familiar with all ADOT erosion and prevention control policies, as explained in Section 104.09 of the Special Provisions, the ADOT Erosion and Pollution Control for Highway Design and Construction Manual and the ADOT Post-Construction Best Management Practices for Water Quality Manual found on the ADOT website. The proper application, installation, maintenance and removal of all pollution and erosion control tools are described in detail through these manuals in addition to the project plans & special provisions along with the Standard Specifications for Road and Bridge Construction.

Erosion prevention and protection is commonly missed or during design. It can be difficult for Designers to know exactly where every possible location for erosion may happen. As a result, once construction begins it may become apparent in many areas that some measure of erosion protection should be installed to prevent future maintenance problems. If an area with concentrated flows of water appears to be unprotected from erosion, seek guidance from the RE or RLA. Examples of areas prone to erosion include any location where water collects and concentrates into a single flow, channels, ditches, slopes steeper than 6:1, toe of slopes or where hard structure surfaces meet unprotected soil.

810-4 & 810-5 Measurement and Payment

Measurement and payment for Erosion Control and Pollution Payment will be made in accordance with the project plans and specifications along with the ADOT Standard Specifications for Road and Bridge Construction.

The development of the SWPPP and use of materials and work to install, maintain, repair, replace and dispose of material shall be paid for in accordance with the requirements of Section 104.09 (D) and Section 810.

This will include regular site inspections to ensure that Stormwater Control Measures are functioning properly, inspection forms being filed within 7 calendar days of completing the inspection, and follow-up actions based on results of the inspection being completed within 4 calendar days or before an anticipated storm event if one is forecasted before the 4 day deadline. Make sure to be in compliance with any updated requirements of the CGP concerning inspection requirements.

901 MOBILIZATION

Mobilization is a contract item established to compensate the contractor for move-in costs and certain other startup costs incurred as the project work begins. The item is set up so that partial payments are made as the work progresses.

There are four milestones that trigger mobilization partial payments:

1. The preconstruction conference/partnering workshop.
2. The point when there is a significant amount of equipment on the project site.
3. When 5% of the contract is completed excluding stored material payments.
4. When 10% of the contract is completed excluding stored material payments.

There are caps in the Specifications for how much the mobilization bid amount can be. If the contract is $5,000,000 or less the contractor can put up to 12% of the contract value and if the project is more than $5,000,000 it is 10%. If the contractor exceeds these caps the excess mobilization will be paid upon completion of the project.

Typical payments are broken into 25% increments of the total lump sum for most projects but there are projects that may have the 3% or 2.5% rule outlined in Table 901-1.

The first milestone is not reached until the preconstruction conference has been held and all the documentation required by Subsection 108.03 has been submitted complete enough for review. The table in Subsection 108.03 of this manual lists all the submittals required at the preconstruction conference, including those specifically required by 108.03. The Special Provisions may have additional submittal requirements under 108.03. A satisfactory submittal should be one that can be reviewed by the Department without being sent back to the contractor for incompleteness. For example, a generic safety plan that doesn't address some of the specific project safety hazards would be unsatisfactory and could be used as a basis for withholding the first mobilization partial payment.

The Department considers the preconstruction submittal documents part of the contractor's preparatory work paid for under mobilization. Thus, to get paid for mobilization, complete documents need to be submitted.

The second milestone occurs when a significant amount of equipment has been mobilized to the project site. What constitutes significant is left up to the interpretation of the Resident Engineer. However, to be consistent statewide the Resident Engineer should take into consideration the size of the project and how much equipment will be needed initially to complete the first 5 percent of the contract work. Setting up a trailer, installing fences and signs for the contractor's yard does not qualify for this mobilization milestone. Nor does parking a single piece of equipment, like a frontend loader, to be used much later in the project qualify.

The third milestone is reached when 5 percent of the project work has been completed in terms of dollars paid to the contractor. The 5 percent includes the two previous mobilization partial payments.

There is some confusion as to when the 5 percent should be paid, in the month that it is reached or in the following month. The 5 percent milestone is triggered when the work is completed in the field, not when the field office prepares the monthly estimate. The milestone can be reached at any time during the month and is not necessarily the end of the month. For example, if 10,000 cubic yards is needed to trigger the 5 percent mobilization payment, and this point is reached halfway through a given month, then the 5 percent mobilization would be paid on the estimate prepared at the end of that month (the next estimate after the 5 percent is reached). The "next estimate" provision was placed in the Standard Specifications to prevent the contractor from requesting a supplemental estimate (see Subsection 109.06 of this manual) every time a mobilization milestone was reached

The same reasoning applies to the fourth and final mobilization partial payment, when 10 percent of the work is complete.

Although not explicitly stated in the Standard Specifications, the mobilization milestones must be paid in order: the second payment cannot be made before the first. The numbering of the milestones implies an order that should be followed. A contractor that has submitted incomplete documents required by Subsection 108.03 cannot receive the first or any subsequent mobilization partial payments until complete documents are submitted.

The mobilization pay item should not change due to changes in other work items or due to altered quantities.

902 CHAIN LINK FENCE

Fencing with secured access gates should be installed on a project as soon as possible. Although fences may restrict the contractor's access to parts of the site, they do protect the public from the safety hazards associated with highway construction, refer to Subsection 107.08. Permanent fencing is preferred over temporary fencing because permanent fencing is usually more secure.

Fence lines are to be staked so that the fence posts are 6 inches from the right-of-way line, unless otherwise specified on the plans.

When building a new fence requires removal of an existing fence or erection of temporary fences, the inspector and the contractor are to work with the property owner to accomplish the changes with the least disruption and inconvenience.

902-2 Materials

Two materials options are permitted for fence material: zinc-coated, galvanized, or aluminum coated steel; however, only one kind of material will be allowed on each project. This material requirement is due to the corrosive reaction caused by interaction of dissimilar metals.

Zinc-coated metals have a dull-to-very dull (almost greenish gold) appearance when the zinc coating has the proper thickness. A shiny surface is a good indicator that the coating may be too thin. If this is the case, the inspector should take a sample before the material is installed and have the sample sent to the Structural Material Testing Section of the Materials Group for a coating thickness check. Additional sampling methods are to be carried out per Arizona Test Method ARIZ109.

902-3 Construction Requirements

When a chain link fence is installed over irregular ground, it may be necessary to do a considerable amount of grading along the fence line to obtain the uniform, bottom-of-fence line clearance specified in the standard drawings.

Rock or hard ground makes installation of fence posts difficult, hindering either the post driving or hole excavation. It may be necessary to increase inspection to assure that posts are anchored to the proper depth and diameter.

When Class B or utility concrete is used to anchor fence posts, the contractor will have to wait several days before stretching the fence fabric. The concrete needs to develop adequate strength and stiffness to resist the bending forces developed in the posts when the fence fabric is stretched and tensioned. If the contractor is in a hurry and with the approval of the Resident Engineer, Class S concrete with high early strength cement can be used which may allow fabric stretching and tensioning the day following fence post installation.

Guidelines For Inspecting Chain Link Fence:

- Do the materials conform to the plans and specifications, (refer to Standard Drawings C-12.20 1 through 3), and are the materials certifications available for those items requiring them?
- Are the pole foundations free of debris and the correct diameter and depth as specified on the plans?
- For pole foundations, is the approved type of concrete being used?
- Are the fence posts the correct type, e.g. wall thickness, diameter and length as specified on the plans?
- Are the posts spaced at 10 feet or less intervals?
- Have intermediate posts assemblies been installed for continuous fencing distances greater than 500 feet?
- Have gate post assemblies been placed at the prescribed locations shown on the project plans?
- Has the concrete used in foundations cured at least 72 hours before the fabric is stretched? Unless high-early strength concrete was used, then allow for a 24 hour minimum cure time.
- Is the wire fabric of proper height and gauge as specified on the plans? (Type 1 and Type 2)

- If the fence height is under 60 inches, the fabric should have the knuckled selvage ends at the top along with twisted and barbed selvage ends installed at the bottom, unless otherwise specified on the plans.
- If the fencing height is 60 inches or greater, the fabric should have twisted and barbed selvage ends at the top and the bottom.
- Are the truss rods and truss tighteners of the proper diameter and thickness as specified on the plans?
- Are the stretcher bars and stretcher bar bands of the proper diameter and thickness as specified on the plans?
- Are the fence post wire ties of proper gauge as specified on the plans?
- Are the strain wire, hog rings of proper gauge as specified on the plans?
- Are the strain wires of proper gauge as specified on the plans?
- Is the strain wire and bottom of the mesh fabric at the correct height above the finished grade? Remember to include additional height for unplaced decomposed granite.
- Does the fence line follow the contour of the finished grade?
- Has the chain link fabric been installed on the correct side of the posts? (Away from mainline traffic)
- Has the fabric been stretched taut (without deforming) and securely fastened to the posts as well as the top and bottom strain wires at the specified design intervals?
- Are all nuts and bolts facing the correct direction (toward mainline traffic) and tightened to the designed specifications?

Fence materials that are thicker or have thicker coatings than required are usually acceptable to the Department. Unless there is an appearance problem with the fence, the Resident Engineer can approve the thicker materials by a no-cost minor alteration.

903 WIRE FENCE

Before fence construction starts on a project, the inspector and Resident Engineer should study the plans diligently. Special attention should be given to right-of-way lines, access control lines, location of gates, cattle guards, flood gates, and angle points in order that the contractor may be given complete, accurate information necessary to begin fence construction without delay or interruption. The inspector should know what type of fencing materials and hardware are specified. For example, is barbed wire or barbless wire specified? If game fencing is specified, is the bottom wire barbless? Are any special details required for environmental mitigation?

When constructing or reconstructing fencing, the contractor shall be held strictly responsible for any and all damage to private property during or as a result of their operations. This includes losses and accidents caused by such things as loose livestock.

903-2 Materials

The inspector must be sure that all fence materials have been certified, tested, and approved. Project samples must be taken as outlined in the Materials Testing Manual as soon as materials are delivered to the project.

903-3 Construction Requirements

Close inspection during construction is necessary to see that posts are driven to the proper depth and spacing shown in the Standard Drawings. This is especially important where post driving is difficult. After all required line, intermediate, and corner posts assemblies have been placed, the wire should be stretched taut and securely fastened to each post. Post concrete should cure 72 hours minimum before any fence wire is stretched and tied. After the required strands of wire have been properly placed, the guy wires, sag weights, and other details should be completed as required.

Avoid construction of fencing in washes or along bank edges where erosion may destroy the usefulness of the fence. Wing fences at box culverts need not be an extension of the wing line. The alignment of the wing fence can be adjusted away from the channel to keep as much of the fence as possible out of the drainage area. These adjustments will often result in the need to increase the length of the flood gates. Probably the most important consideration is that the gate/end post assemblies are located well away from areas subject to erosion.

The installation of the gates, hinges, and latches should allow them to operate freely. They should open to the full opening size in the direction indicated. The upper post hanger of Type I line fence gates shall be installed so that the gate cannot be lifted and removed.

Carefully check horizontal and vertical angle points to determine whether corner posts or diagonal tension wires are needed.

The clearance between the bottom wire and the ground must be checked since extra posts, sag weights, or special treatment may be needed.

Sag weights shall be prefabricated 100 pound concrete blocks. This is sometimes necessary to prevent line posts from being pulled out of the ground upon tensioning of the barbed wire or woven wire fabric.

It should be noted that flood gates are to be constructed to the same requirements specified for barbed wire construction, except that the concrete sag weights shall weigh 35 pounds.

Unusual ground conditions should be looked at to determine whether a modification of the standard fence treatment is called for, or if perhaps some fence can be eliminated.

Inspection Guidelines For Wire Fence And Gates:

1. Do the following materials conform to the plans and specifications, and are material certifications available for those items requiring them: (Reference Section 902 of this manual under Materials and Installation Guidelines)

    - Barbed/woven wire zinc or aluminum coated and of the same type for the entire project
    - Gates, along with gate hardware?
    - Posts; intermediate and all post assemblies?
    - Fasteners, latches, hinges/hangers, and any additional hardware?

2. Have adequate measures been taken to protect livestock while building or rebuilding fencing?

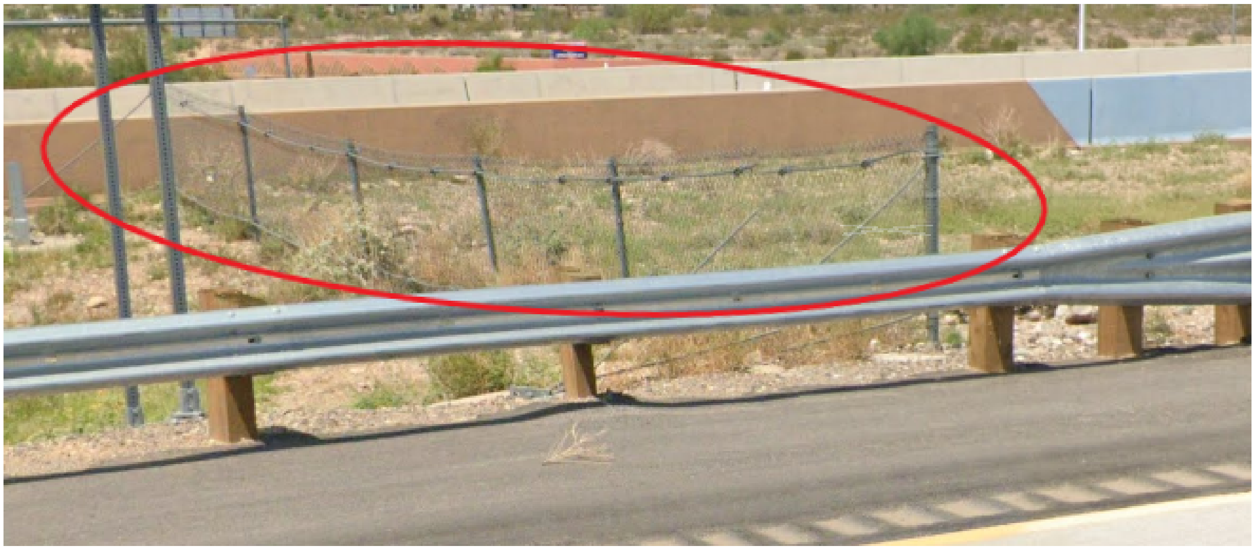
3. Has the fence line been cleared or graded in accordance with the project plans and specifications?

4. For installation procedures reference Project Drawings, Standard Drawings C-12.10 Sheets 1 - 5 and the manufacturers recommended installation procedures.

    - Are posts of the proper length and have they been driven/set to the proper depth, are posts spaced correctly, are the posts plumb, and does the fence have the correct alignment with the ROW?
    - Has the wire been stretched taut; not over stretched or sagging, and fastened to each post? Was the wire stretched on the outside of posts around curved areas? Is there only one wire splice per panel?
    - Is the vertical spacing between wire strands correct and have stays been installed at the desired intervals?
    - For Type I gates, is the upper post hanger installed so the gate cannot be removed?
    - Is the concrete (bag mix) used for footings and foundations on the APL or has it been approved?
    - Is the concrete being mixed properly, Per ADOT and manufacturer recommendations.
    - Have the Intermediate post assemblies and corner posts assemblies been installed at all required locations?
    - Has fencing been properly tied into the structures?
    - For low lying watershed areas such as washes or creeks, have the posts been installed and if applicable weighted to plan specifications?

904 CHAIN LINK CABLE BARRIER

Chain-link cable barrier is a safety device, typically installed in the roadway median in between bridge abutments.



904-3 Construction Requirements

It should be noted that the concrete anchor blocks must be flush with the ground so that they do not catch on a vehicle passing over them. At the same time, they must be well-drained so that water doesn't collect where it can corrode the hardware or soften the ground around the block.

The distance from the barrier to the top of the slope must be as specified on the plans. If the distance is too short, the barrier will not stop a vehicle before it drops off the slope.

All the fittings must be accurately placed and torqued as specified.

As with all safety devices, it is legally imperative that the barriers are built strictly according to the plans.

905 GUARDRAIL

The Project Plans will specify the locations, type, and quantity of guardrail to be installed, removed or reconstructed. Installation will be in accordance with the appropriate standard drawings and special details and manufacturer's approved drawings. Installation of guardrail has evolved into a relatively complex procedure. The standards and manufacturer's drawings for guardrail are being constantly updated to improve the design and facilitate maintenance. It is imperative that construction personnel are aware of the latest guardrail standards and manufacturer's drawings. In order to assure installation in accordance with the correct drawings, the pre-activity meetings are required. This is discussed in more detail at the end of this section. Occasionally, a supplemental agreement to address revisions to the system after the contract has been awarded may be necessary. This can be conveyed to the contractor at the pre-activity meeting.

When the contractor is given the option of selecting an end treatment, the type of device to be used should be submitted at the pre-activity meeting. If this is not possible, the type must be submitted before the contractor orders delivery of guardrail materials to the site. This will provide the lead time necessary for the Resident Engineer to determine the final location for end treatments, which in turn affects the length of need, the total guardrail length and the quantity of material ordered. In the event of major changes in guardrail locations, the roadway designer should be consulted for placement criteria and standards.

Proprietary items, such as guardrail end treatments, change as design modifications are introduced. The supplier of a proprietary item is required to submit the changes to the ADOT New Product Committee. Changes which are approved are on file with the Standards Engineer in the Roadway Design Section. Installation guidelines shall also be furnished with the units so that the contractor and inspectors can confirm that the installed end treatment meets the NCHRP 350 and manufacturer's requirements.

When staking post locations be sure to locate all drainage structures so that where possible the post location can be adjusted to eliminate any conflicts or the need for an anchoring device. Guardrail layout staking generally consists of marks on the pavement to locate the longitudinal position of the post together with the offset distance to the post. The offsets at flared end sections can be obtained from the Plans Detail Layout Sheets. Stakes or markings for guardrail control are generally adequate if set at 50-foot intervals for tangent sections and 25-foot intervals on curves.

Wood posts are to be inspected in accordance with section 1012 of the ADOT Standard Specifications before they are placed in pre-punched, or pre-drilled holes and driven the final 10-inches to grade. Steel guardrail posts may be driven full depth, or placed in manually or mechanically dug holes and driven the final 10-inches to grade. When posts are placed in manually or mechanically dug holes, the space around posts must be backfilled with moist soils placed in compacted lifts as approved by the RE. Excessive driving effort, in some cases will cause damage to the post and which may be cause for rejection of the post. When posts are set in position, each post must be plumb, true to alignment and grade, and surrounded by well compacted ground. In paved areas, the displaced material from post driving will often cause the pavement to bulge upward or crack an adjacent curb. If either of these occurs, the contractor is required to use other methods that will not damage existing pavements or structures and to repair any damage that has been caused by post installation.

On occasion the contractor may encounter rock that prevents the driving of posts to the full depth for W-beam guardrail. Requests for changes should be submitted to the RE through the project RFI process. Approval for any changes to end treatments must be obtained from the manufacturer.

When posts are set in concrete at the top of the concrete leave-out, material (normally 1-sack grout) adjacent to the posts should be finished in accordance with the plans or manufacturer's drawings. For asphalt pavement the space around the posts is backfilled with moist soils, compacted in lifts and topped with 3" of compacted bituminous material to match roadway cross slope.

Blocks are to be toe-nailed to the post with two galvanized sixteen-penny nails. The tops of the post and block are designed to be flush; a maximum of 1/2-inch difference in the elevation of the top of the post and block is permitted.

The rail should be inspected for any damage that may have occurred to the rail itself or to the galvanizing due to rough handling. A Certificate of Compliance is required for all rail and should be furnished before construction starts. All guardrail fasteners also require a Certificate of Compliance and one sample of each item.

Rail elements should be assembled to present a smooth, continuous appearance with the top of the rail being in near perfect alignment horizontally and vertically with the roadway. There should be no noticeable sags or humps. Rail laps must be oriented in the direction of traffic to the closest lane.

The reflector tabs for guardrail are thin and pliable, so they can be bent over the head of the bolt. The tabs are bent to keep them from falling off when the bolt loosens due to the drying and shrinking of the posts and blocks. The reflective material is high intensity reflective type sheeting. See the Standard Specifications for post spacing and color requirements.

Projects with an average elevation over 4000 feet require flexible markers in addition to reflector tabs. Sheet 2 of the plans should show average project elevation. See section 905 of the ADOT Standard Specifications for height, attachment hardware, post spacing, and color requirements.

The end treatments (a.k.a. terminals) for guardrail are numerous and each has specific construction requirements. Therefore it is important that construction personnel carefully review and adhere to all the construction details in the Project Plans, Standard Drawings, Standard Specifications, Special Provisions, Manufacturer's Drawings and, Manufacturer's Installation Manual associated with end treatments. Delineation of guardrail posts must be done in accordance with Table 905-1 of the Special Provisions. See the Special Provisions and Standard Specifications for post locations and type of barrier marker required.

When existing guardrail elements are to be reused, it is important to permanently mark any damaged or otherwise unsuitable elements before construction begins. This can be accomplished with the use of a high visibility marker paint; to prevent the deficient material from being incorporated into the final product. Reconstruction of guardrail shall meet the same requirements as construction of new guardrail. Existing guardrail designated on the Project Plans to be reconstructed should be carefully removed from the old location, and reused materials should be inspected with care. Sharp kinks or enlarged bolt holes are reasons for the rejection of rail elements. Posts that are severely cracked, rotted or splintered are to be rejected, see requirements of Task Force 13, Guide to Standardized Roadside Hardware. The Special Provisions or the plans may require all reconstructed posts to be replaced with new posts, if the Resident Engineer requested it during the project planning, or design phases.

It should be noted that the Standard Specifications prohibit the use of a cutting torch for the making of new bolt holes. Heating guardrail weakens the metal around the bolt hole so that the bolt head may pull out under the force of impact. The only acceptable methods of making bolt holes in the field are drilling or punching; if a punching method is used, the inspector should ensure that the process is not deforming the rail section in any way.

Prior to acceptance, each section of guardrail should be inspected utilizing the appropriate quantified checklist for the specific type of guardrail installed.

Inspection Guidelines For Guardrail:

- Schedule the pre-activity meeting sufficiently in advance of ordering the materials to resolve all issues; a minimum of 20 days in advance is recommended. Attendees should include the superintendent, the subcontractor(s), the foreman installing the devices, the RE, the Project Supervisor and any inspectors who will be working on the installations.

- A suggested agenda for the pre-activity meeting for Roadside Safety Devices is shown in Exhibit 905-1. The RE should assign discussion roles and times.
- It is understood the contractor will bring the manufacturer’s installation requirements to the meeting, including the manufacturer’s drawings approved by ADOT. When a newer end treatment system has been approved the RE should encourage the contractor to install the current approved system. ADOT personnel will bring the current Quantlists.
- The most recent manufacturer’s approved drawings can be found on the Roadway Design web page.
- Current versions of ADOT Inspection Quantlists for Guardrail End Sections can be accessed using the Construction software application. Additional Quantlist access instructions may be found in Subsection 105.12 of this manual.

ROADSIDE SAFETY DEVICES

PRE-ACTIVITY MEETING AGENDA

1. **Introduction of participants**
2. **Review Special Provisions**
3. **Discuss Barrier Summary Sheets; Roadway Engineering Memorandum, dated 6-27-2002**
4. **Review Plans Layout Sheet:**
    - Dimensions of widening
    - Foreslope rate
    - Borrow source; if needed
    - Bituminous material; source and type
5. **Discuss schedule and sequencing:**
    - Blue staking
    - Surveying layout
    - Borrow for pad construction
    - Potential drainage conflicts, e.g. created by widening
    - Units to be installed before or after paving
    - Compaction around posts
    - Removal of existing rail and unit completion in same day
    - Traffic control
6. **Review traffic standards and specifications for delineation**
7. **Review manufacturer’s approved drawings & other standards**
8. **Review the manufacturer’s installation requirements, e.g. manuals and instructions**
9. **Review the ADOT checklists**
10. **Discuss governing order of requirements, authority and escalation practices**

Exhibit 905-1 Suggested Pre-activity Agenda for Roadside Safety Devices

906 CATTLE GUARDS

The Project Plans will specify the location and type of cattle guards to be constructed. Each cattle guard must be constructed in conformance with the appropriate Standard Drawings or any special details included in the plans. The item itself consists of furnishing all materials and constructing new cattle guards or reconstructing existing cattle guards as noted on the plans.

Completed cattle guards must be well-drained to prevent ponding of water in the structure. Cattle guards should be carefully constructed to the specified grade and cross slope, with special care being taken to achieve a bump free, smooth riding installation. Errors in the elevation of the cattle guard or the approach grade that cause a bump for traffic must be corrected.

Inspection Guidelines For Cattle Guards:

- Do the materials conform to the plans and specifications (Refer to Standard Drawings C-11.10 (1 through 4), and C-11-20.
- Are all steel parts primed in accordance with Section 1002?
- Are all materials certifications available for those items requiring them?
- If the unit is precast, is the roadway longitudinal grade no greater than 6 percent and does the Certificate of Compliance match the unit and is the unit identified as an ADOT cattle guard?
- Has the exposed ground surface been adequately prepared and compacted to receive a precast unit?
- Does the rebar conform to Sections 1003 and 1004?
- Does the grade and cross slope conform to the surface of the finished pavement and is the unit at the correct elevation as shown on the plans?
- Is the approved type of concrete being used per Section 1006?
- Prior to pouring concrete, is the excavation free of debris and the correct dimension and depth as specified on the plans?
- Has the concrete been finished and cured in accordance with the specifications?
- Does the backfill material conform to Section 203-5 and has the backfill material been compacted to at least 95% of maximum density?
- No rocking is observed between the grille unit tread assembly and the steel angle bearing surfaces and no gap greater than 1/32 inch exists between any pair of bearing surfaces, when a unit or assembly is not under load, spiked, welded or otherwise held in place.
- Have all nuts and bolts securing the grille unit been installed, torqued or tightened to the designed specifications?

907 DAMPPROOFING AND WATERPROOFING CONCRETE SURFACES

There is a tendency to be careless with dampproofing and waterproofing because the surfaces will be buried and it is assumed that appearance is not important. Appearance is important because creases, spotty sealant coverage, loose ends, uneven appearance and other visual blemishes may indicate defects and potentially reduce the service life of the water proofing material thereby no longer protecting the structure from moisture.

Among the most important things to watch for are a dry surface before treatment and a smooth coverage of the waterproofing coating. A dry surface, besides increasing the adhesion of the product, reduces the possibility of vapor buildup under the coating which can cause a rupture and compromise the water seal. Surface depressions and high spots in the waterproofing are to be avoided because they create weak areas that can be easily broken during backfilling or settlement. If the surface being treated becomes wet from rain or for any other reason, it must be dried completely before allowing the work to proceed. The contractor must strictly adhere to manufacturer installation instructions.

Where primer is specified, the primer must be applied uniformly and completely over the surface. When a thickness of dampproofing coating is specified. The inspection records should show that the thickness was measured including the results.

Treatment of joints, with or without fabric, should be watched closely as they are often the weakest part of the treatment.

Application rates of sealant are to be checked and recorded.

As a final precaution, don't destroy the usefulness of the treatment by allowing careless backfilling methods that will tear, punch holes, or scrape off the fabric and sealant.

908 CONCRETE CURBS, GUTTERS, SIDEWALKS, AND DRIVEWAYS

Curb and gutter serves two purposes, providing a conveyance for storm water and as a means of channeling traffic. Vertical curb may also serve as a barrier to low speed traffic. The type of curb shown on the plans should not be changed without consulting the designer.

Curb and gutter serves to convey stormwater to inlets, catch basins, storm sewers, and ditches. Paved streets with curbs sometimes serve as storm water channels. Both proper design and construction are required for the curb and gutter to function properly. Poor construction may result in areas which pond water, resulting in a potential safety hazard. Areas where this frequently occurs are at grade intersections especially in radii and valley gutters.

Curbs serve as a means of channeling traffic at intersections, ramps, traffic islands and medians, and delineating the limits of the traveled way to prevent the encroachment of motor vehicles onto sidewalks, medians, and refuge areas. Curbs also serve as an effective means to control driveway entrances. It is always good practice to consult with the property owner before final location of the depressed curb driveways. Minor adjustments to the size and locations of driveways to suit the property owner are acceptable as long as safety standards and local ordinances are not violated.

It is very important for the engineer to study the drainage conditions on any project where curbs will control or have an effect on drainage. This study should be made prior to the start of any grading work, as it may be necessary to make minor alterations in grades or minor changes in elevations of inlets to catch basins, culverts, etc., in order to assure efficient drainage. The engineer and surveyor are cautioned that two particularly troublesome areas are drainage through turnouts and areas where the curb is on the high side of super-elevated portions of the roadway. The areas behind and between curbs and right-of-way line should be checked to assure drainage flows to a drain structure.

Finished appearance is of great importance in the construction of curbs, gutters, sidewalks and driveways as they are seen by motorists and pedestrians. Good alignment, grade, and finish are essential. Clean, straight forms, in good condition, are necessary to achieve a quality product. Flexible radius forms should be used on curves. Forms should be properly staked and braced.

The operations of mixing, placing, and consolidating the concrete should be coordinated with the finishing operations so that the pour operation does not get too far ahead of the finishers. The use of too much water while finishing, e.g. sprinkling or spraying additional water on the surface, may make for a good initial appearance, but in a few years, traffic and run-off will wear away the thin, weak layer of paste on the surface that now has an excessive water-cement ratio. This is often difficult for the inspector to enforce due to poor past enforcement, but it must be done. In areas where freeze-thaw is of concern, such surfaces will delaminate within only one or two winters.

The inspector should not accept concrete that has been retempered or concrete that has been in the mixer longer than the time allowed by the specifications unless the use of a hydration stabilizing admixture has been approved and is included in the mix design. Since the specifications do not require vibrating concrete used in curbs and gutters, spading along the forms is necessary in order to work the coarse aggregate away from the faces, thus avoiding honeycombing.

Curing should follow closely behind the finishing operations, in accordance with the specifications. The application must be uniform and without discontinuities.

Concrete placed during cold weather including near-freezing temperatures should be properly covered and insulated to prevent fresh concrete from freezing. Even if freezing temperatures are not expected, evaporation can continue to lower the temperature of the concrete resulting in frozen concrete.

Areas of curb that are low must be augmented with fresh concrete, not paste or grout. Under no circumstances are these materials to be poured on the curb and gutter surfaces as an added layer for finishing purposes.

The top, front face, and flow line of curb shall be tested with a straightedge during the finishing operations. Documentation of the fact that such testing has been done will be made in the inspector's diary. The stationing of the section tested, the date and the results should all be included in such documentation. Each such entry is to be signed by the inspector. The contractor is required to take whatever corrective measures are necessary to produce curb and gutter that will completely conform to the specifications.

Scoring of sidewalks to create weakened planes and control cracking should be in accordance with standard drawings. Expansion joint material should meet the specifications and should be placed in accordance with the standard drawing. Special attention should be given to the scoring not only in sidewalk, but also curb and gutter. Good joints are important. It should be noted that Standard Drawing C-5.20 requires a broomed finish on sidewalks.

It is crucial that the construction of sidewalk ramps conform to the Standard Drawings. The inspector should pay particular attention to slope requirements guaranteeing that the ramp is navigable by a disabled individual. Locations which tend to be problematic are intersections in which signal poles, traffic signals, or fire hydrants are located immediately behind the sidewalk, potentially preventing the sidewalk ramp from maintaining the desired slope. Ramp grades must conform to the American Disabilities Act (ADA) requirements. If the ramp cannot be built as shown on the plans then contact the designer.

Reconstruction of driveways are often constructed with accelerated or high early strength concrete mixtures. These mixtures are very susceptible to excessive drying due to the increased heat of hydration that occurs during curing. These mixtures are also susceptible to shrinkage cracking due to increased cement/paste content. Therefore, for large driveways or any slabs that may be placed, it is imperative to consider the need for control joints, and both proper finishing and curing is essential for the longevity of the concrete.

Inspection Guidelines For Concrete Curb, Gutter, And Sidewalk:

- Has all soft or unsuitable subgrade material been removed and replaced to a depth of at least six inches below subgrade?
- Has the subgrade material been thoroughly compacted and tested to 95 percent at a depth of six inches before placing concrete?
- Have the subgrade and forms been watered ahead of placing concrete?
- When Portland Cement Concrete Pavement (PCCP) is to be constructed adjacent to the curb and/or gutter, has the pavement been placed prior to the construction of the curb and/or gutter?
- When the curb and gutter are adjacent to asphalt concrete pavement, does the curb and gutter have 2-inch contraction/expansion joints placed every 15 feet?
- Are the fixed forms of good appearance, shape, strength, rigidity, smoothness of surface and set to the depth equal to the full face height of the curb and/or to the full depth of the sidewalk?
- Have the forms been set to the correct dimension, grade, slope, ADA compliance, and adequately staked as to prevent movement during concrete placement.
- Does the slope of the gutter match the cross slope of the roadway?
- Have contraction/expansion joints been constructed every 60 feet and at all radius points, driveways and structures?
- When the curb and gutter are adjacent to PCCP do the joints match the PCCP joints?
- Are control joints properly formed and do sidewalk joints match with the adjacent curb at the required intervals per the plans or Standard Drawing C-05.20?
- Is the correct concrete mix being used in accordance with Section 1006.
- Has concrete been properly consolidated, and has finishing mortar been worked to the surface of the sidewalk?
- Did the finishers refrain from sprinkling/spraying additional water on the surface of the fresh concrete?
- Has the concrete surface of sidewalks been struck off with a float, troweled smooth, and then given a final fine brush finish?

- Have any electrical or irrigation sleeves running under the curb and gutter been identified and marked with an “S” on the top of the curb and the locations noted in your diary?
- Has the top surface, front face, and flow line of the curb and gutter been straight edged and the results documented in your diary?
- Has the sidewalk slope and surface tolerances been checked with a straight edge and documented in your diary?
- Has the all exposed concrete surfaces, including the front and back faces of curb and gutter, been properly cured in accordance with Section 1006-6.01?
- Has the exposed surface of fresh concrete been protected from freezing during cold weather?
- Does the finished product give a good appearance?

909 SURVEY MONUMENTS

A section line monument that has been disturbed by construction activities shall be re-established by the contractor, following the procedures in the Manual of Surveying Instructions, U.S. Department of the Interior, Bureau of Land Management. Applicable statutes and standards set forth in Minimum Standards for Land Surveying in Arizona, Arizona State Board of Technical Registration, shall also be followed. Monuments re-established shall be recorded in the Office of the County Recorder, and a copy of the Corner Recordation documentation shall be submitted to the Resident Engineer within five working days of recordation.

The contractor is responsible for locating and properly referencing the locations of the monuments so that the monument can be constructed with reasonable accuracy. Contract survey crews, as part of the verification process, shall locate and make ties to all located Section Line monuments and roadway monuments in the vicinity of the proposed work.

Frames and covers shall be cast iron and shall conform to the requirements of Subsection 1004-6 for Gray Iron Castings. The Department will furnish the brass caps for the survey monuments.

Normally excavation for the monuments will be made at the location and to the depths designated. When locations are changed, the as-built plans and the field books must show all the necessary details of the new location and a note explaining the reason for the change in location included. The monument will then be set as shown on the standard drawings, and the earth tamped into place.

910 CONCRETE BARRIERS

Three methods of constructing barriers are allowed under the specifications:

1. Cast-in-place by slip form or extrusion
2. Cast-in-place by fixed form
3. Precast

The most common method where large quantities are involved is the slip form system. Shorter runs of barrier are commonly cast in place utilizing fixed forms or are precast sections.

Whichever method is used, the final appearance will be influenced by the foundation. The inspector will need to exert the greatest part of their effort towards getting the contractor to prepare the foundation for the barrier or the grade the slip-form will ride on so that smooth horizontal and vertical lines will result.

The placing of concrete barriers on new bridges may not precede the release of falsework. Concrete barriers and barrier transitions to be constructed on bridges can only be constructed by fixed form, cast-in-place methods.

If at all possible, the Engineer should inspect work that has been done by the equipment to be used. By inspecting previous work any shortcomings can be discussed with the contractor and corrective measures agreed on. There have been problems in the past with vertical cracking of slip-formed barrier. In some cases the problem was never completely eliminated but the condition has been eased by attention to the rate of travel, maintenance of the proper concrete level when feeding the machine, properly operating vibrators, proper cure, and fine tuning the concrete mix.

The alignment of the barrier is very important and project personnel should be familiar with the tolerance requirements of the specifications. If difficulties are experienced by the contractor in providing an acceptable product, then the Engineer should take steps to correct the problem or stop work until the contractor can provide a product within the allowable tolerances. Barrier that has an unsatisfactory alignment which cannot be corrected to the satisfaction of the Engineer should be removed.

Cast-in-place forms are usually made of metal and need to be inspected for dents, bends, or any other defects that would be detrimental to the appearance of the finished barrier. Precast barrier sections will probably be inspected at the supplier's plant. As with any precast item, it is good practice for the Engineer to inspect finished work at the plant early in the production run. If the jobsite inspection shows cause for rejection, this can be resolved with the least disruption and expense to all parties if done before installation. The fact that precast barriers were inspected and accepted at the plant does not mean they must be accepted on the job if they are defective.

Joint sealant is used in all three types of barrier but the time of application and sealing procedure varies so it is important that the inspector is aware of the provisions for the particular type of barrier and the particular project.

911 RIGHT-OF-WAY MARKERS

Right-of-way markers consist of the furnishing by the contractor of all materials, except the brass caps, and installing right-of-way markers and reference markers in conformance with the Plans, applicable statutes, and procedures per the statutes and standards set forth in Minimum Standards for Land Surveying in Arizona, Arizona State Board of Technical Registration, shall also be followed.

Considerable care should be taken in setting right-of-way markers and survey monuments, as they become permanent control points for future survey work.

Right-of-way markers are set in cast-in-place concrete. The Department will furnish the brass caps for the markers and after completion of the monument the contractor will establish the survey point on the marker.

The reference markers are painted, lettered, and installed as shown on the plans or as directed.

Normally, the Engineer will furnish the contractor with a list of required information to be painted on the reference markers. The stations should be determined and established by the contractor as soon as possible.

The same precautions mentioned in Section 909 for survey monuments should be observed when staking for right-of-way monuments.

912 SHOTCRETE

Shotcrete is a pneumatically placed concrete mix that is also commonly called gunite. Shotcrete is a very useful and versatile method of paving flat slabs, vertical walls, and the entire gamut of slopes and shapes between. It is especially suited for constructing warped surfaces around structures. It has been used to construct inlets and outlets to culverts for the purpose of improving the efficiency of the structures. It may also be used successfully to preserve and protect or to enhance the appearance of a concrete wall or other structure providing the concrete is firm and reasonably sound. Construction costs, particularly on curved surfaces, are reduced because complex forms are not normally required. The equipment used is mobile and therefore usable in areas where it might be difficult to operate other types of equipment.

912-3 Construction Requirements

Slopes that are to receive shotcrete are best constructed by overbuilding the fill material to allow for compaction past the limits of the slope grading, then trimmed back to the desired grade. The exposed surface must be kept moist to reduce sloughing during construction operations.

The subgrade must be finished accurately to aid in maintaining uniformity in thickness. The subgrade must be kept damp but not overly saturated in order to avoid the moisture being drawn out of the shotcrete. The areas upon which shotcrete is to be placed are to be checked to see that they have been properly graded and compacted and that joints, wire mesh, side forms, and weep holes have been provided where required.

Welded wire fabric is usually specified for reinforcement. It will be designated in the following manner, 6 x 6 - W1.4 x W1.4, which means a 6-inch longitudinal by 6-inch transverse wire spacing using wires having a nominal diameter of 0.134-inch and a cross-sectional area of 0.014 in^2.

Specifications for wire fabric are to be found in AASHTO M55.

Wire mesh reinforcement (a.k.a. mat) must be held in its planned location prior to the shotcrete placement, proper positioning and securing of the wire mesh is critical. The mat should be adequately supported and secured to prevent appreciable and permanent deflection under the impact of the mortar during placement. Degradable or moisture transferring materials such as lumber or steel chairs should not be used in elevating and securing the mat, it is preferable to utilize plastic rebar chairs or concrete dobies. Too often contractors will attempt to skip this process by not supporting the mat and simply pulling the wire mesh up through the fresh mortar, This method should not be permitted, too often the mesh remains on the subgrade, in which the reinforcement is ineffective and is subject to rusting.

The success of shotcrete construction depends on having proper equipment, a satisfactory mix, and an experienced operator on the nozzle. An experienced nozzleman can get the best results with the least amount of rebound and filling in of low areas. Uniform pressures are necessary at the mixing tank, on the waterline and at the nozzle. Leaky lines or too long a nozzle line can have adverse effects on the pressure system. Where feasible, the equipment should be moved along the work rather than to use long hoses.

Rebound material may not be reused. The thickness shall be checked frequently. The placing of gauging wires aids in obtaining a uniform thickness and true surface.

Precaution is necessary to see that shotcrete is never subjected to hydrostatic pressure on the underside or backside. Paved slopes should have a cut-off wall at the top so that surface water can be diverted away from the paved slope where feasible. Weep holes, properly placed and spaced, with the proper filter material, are helpful in avoiding failure from hydrostatic pressure.

912-3.06 Quality Control Testing

All materials used to manufacture shotcrete shall be sampled and tested as prescribed for use in concrete.

The specification gives detailed requirements for making shotcrete test specimens. It is important to note that the test method calls for coring a test panel. The test panel is made by shooting the shotcrete onto a flat surface, then trimming the edges back to make the correct sized panel. Cylinders are not used with shotcrete.

912-3.09 Curing

Curing has been neglected in some cases because it was thought that curing was not necessary since the shotcrete does not carry a load and does not need strength. Curing is necessary for the prevention of cracks and to assure a hard, weatherproof surface.

Curing should be performed by one or more of the methods prescribed in the specifications. If the liquid membrane method is used, the inspector should assure himself that the required amount of material is being used. Due to the normally rough surface texture of shotcrete, it will be necessary to apply the cure from multiple angles and use a heavier application of curing material than that prescribed by the specifications in order to obtain complete coverage of the rough textured surface.

Due to the tendency of the compound to leave extra material on the side of the irregularities opposite the nozzle of the applicator, the second application should be applied from the opposite direction from the first application where feasible.

912-6 Records

The inspector should record the square yards of area covered with shotcrete within their diary each day with the following information; mix design code, type of equipment, length and size of hose, pressures, being utilized. Additional information such as operational problems affecting the quality of the work, any shutdowns, reasons for shutdowns, such as breakdown of equipment, lack of material, insufficient grade, or other reasons should also be noted.

The record must also show that the shotcrete being used meets the applicable specifications. A mix design is to be furnished by the contractor and verification is needed that the designed mix is being produced.

Temperature records are to be kept, especially when temperatures are close to the specification limits. Whenever air temperatures reach 50 degrees F, it is necessary to be alert to the possible need for a shut down of the work and/or protective action.

A record of the application rate of curing material should be documented in the inspectors diary.

913 BANK PROTECTION

The area designed to receive bank protection should be studied to see that the design is proper and adequate to meet field conditions. One area of scrutiny should be the direction of flow. Water should be directed toward the center of the streambed in order to avoid losses of property or structures downstream. Do not hesitate to recommend extension or modification of the riprap if there is doubt concerning the adequacy of the plans design.

Riprap will be one of the types specified on the plan, and described in Specification 913 and in the standard drawings. Often the size of riprap is designated as D50, which means the effective size of rock would be where the line crosses 50% on the grain size distribution curve. In other words, D50 is the median size of rock in a mix where 50% of the material, by weight, is finer particles. The purpose of riprap is to prevent erosion, so considerable care should be taken for proper placement of each section.

While riprap is designed and built to perform a very important function, the Resident Engineer should not lose sight of the need to make each installation pleasing to the eye. The cross section should be uniform and the lines and grades should be in reasonably close conformity with the standard drawings.

The Construction Standard Drawing, C-17.10, C-17.15 and C-17.20, depicts 9 different types of rail bank protection. Types 1 through 6 are all similar in design. The major difference is the length and spacing of the rails. Types 4, 5 and 6 are specifically designed to protect banks at bridge abutments.

When constructing types 1 through 6, rails should be driven as specified in the standard drawings. Wire mesh should be securely fastened to the rails, placed in the trenches and laid on the slopes. The wire mesh must entirely enclose the rock backfill. The rock backfill should then be placed so as not to disturb or displace the mesh or rails. The completed rock fill should be to the lines and grades specified and should be pleasing in appearance.

Type 7 and 8 are similar in design and are usually used for directing flow of water to a bridge. Type 9 is used to cause deceleration of the stream and deposition of aggregate particles principally behind the bank protection.

It should be noted, riprap and bank protection designs provide for the rock, etc., to be placed below the stream level. This portion of the design is crucial since most failures in riprap occur as a result of storm water undercutting the rock protection which leads to eventual collapse.

Special care should be exercised to construct all types of protection at the proper stream elevation. Inspections downstream should be made for possible problems which could later contribute to scour or silting conditions. If problems are evident, a check with the Drainage Design Services is advisable before plans grades are changed.

The specifications say the rock shall be sound and durable which leaves a broad area subject to personal interpretation. It is advisable to have the District and, if needed, the Materials Section inspect rock sources proposed by the contractor. This inspection should be arranged for as soon as possible so that any testing or prospecting will not cause undue delay or expense.

It is important to maintain a uniform grading of dumped rock riprap. The uniform grading is necessary to assure proper filling of the voids in the riprap. Properly filled voids will lend stability by keying the mass and to protect the underlying filter material.

It is also important that filter fabric be installed properly. Holes in the fabric will permit fine particles in the bank to erode and pass through the riprap. The protected structure can fail as the bank erodes away even if the riprap remains intact. A layer of bedding material is required to protect the fabric when the maximum rock size is greater than 18 inches.

The specifications call for two 5 ton samples of the graded rock to be used in judging the acceptability of gradation for dumped riprap and slope mattresses; 500 lbs is required for riprap that is to be grouted, wire tied, placed in gabions, or as rail bank protection. Frequent reference to the sample rock pile will help to maintain uniform grading. Uniformity of grading is especially important in untied or ungrouted riprap. These types of riprap need good distribution of the coarse and fine rocks to provide interlock and keying which gives the riprap enough rigidity to resist erosion.

The specifications also require the specific gravity of the rock used for riprap to be at least 2.4, therefore riprap should be sampled and tested. This is important to ensure the riprap satisfies design assumptions to provide adequate protection. If necessary, the contractor must break down and provide material sized between 3 inches and the No. 4 sieve for the Department to perform such testing.

For grouted riprap, the specification states that retempering will not be permitted. Retempering is defined as adding water to grout to restore workability. Although referred to as grout, the grout used for riprap must be a very durable material and meet the requirements in 913-2.01(D).

The use of sacked concrete or soil-cement also includes important requirements to ensure performance; equally important for all bank protection is making sure the contractor complies with all installation and any other construction requirements.

915 TEMPORARY SILT FENCE

The temporary silt fence should be installed in accordance with the SWPPP plans and Special Provisions after being reviewed by the Resident Engineer with the inspectors. The inspector should know the type of materials used when constructing a temporary silt fence. Some silt fence geotextile fabric will deteriorate when exposed to ultraviolet light. The standard specifications and or the manufacturer recommendations should explain requirements for storage and handling of the geotextile fabric used in the silt fence.

Close inspection is required to ensure that construction requirements are met. The geotextile fabric at the bottom of the fence must be buried to an appropriate depth in accordance with the plans and specifications. The appropriate depth will keep flow from passing underneath the fence. The posts, wire supports, and fabric post attachments must be in accordance with the plans or special provisions. Any geotextile fabric that is flawed such as a hole, rip, etc. will be rejected by the inspector.

Guidelines For Inspecting Temporary Silt Fence:

- Do the materials conform to the plans and specifications, and are the materials certifications available for those items requiring them?
- Is the geotextile at the bottom of the fence buried to the correct depth?
- Are posts spaced at the proper intervals and have the posts been driven to the proper depth?
- Is the geotextile fabric fastened with the proper attachments and in the proper locations?
- Is the wire support used, and placed properly?
- Will the temporary silt fence be able to handle the expected stress from sediment loading?
- Once installed, the silt fencing should be inspected following every rain event; no matter how small, and during the scheduled SWPPP inspections.

916 EMBANKMENT CURB

The embankment curb is constructed of concrete, as shown on the plans and the standard drawings. Its purpose is to contain and direct the run-off water from the pavement surface so that it may be removed from the roadway at selected locations by means of spillways or down-drains.

Every effort should be made to place embankment curb to true lines and grades without humps and sags and to produce a mixture which will require little or no hand finishing.

The most common method of concrete embankment curb construction is by use of the slip form. Curbs however, may be constructed by the use of conventional forms.

The concrete specifications have been modified to fit the special conditions found in embankment curb construction. Standard Specification 916 contains the detailed requirements for concrete used in embankment curb.

Some curb extrusion machines cause trouble with slumping, tearing, irregularities, or other unacceptable results. Usually the machine can be adjusted or modified, or the concrete mix can be adjusted, but sometimes it may be necessary to discontinue use of the machine if it can not construct the curb according to the specifications.

917 EMBANKMENT SPILLWAYS, DOWN-DRAINS, INLETS, AND OUTLETS

Spillways or down-drains for carrying the water collected by the curb from the roadway surface will be constructed at the locations shown on the plans or as directed and in accordance with the Standard Drawings (C-04.10 through C-04.50) and the Standard Specifications. These types of down-drains must be practically waterproof to prevent erosion of the fill. Consequently, if there is any suspicion that it is not waterproof, a test should be made by pouring water through the inlet to test for leakage. If leakage occurs, the point or points of leakage should be patched with hot-poured, or cold-application joint sealant (Subsection 1011-4) as directed by the Resident Engineer.

It is important that drains are carefully located to assure there will be no standing water on the roadway. Standing water can be a traffic hazard or may damage the roadway by seeping into the base and subgrade.

922 UTILITY CONCRETE FOR MISCELLANEOUS CONSTRUCTION

Utility concrete is used when high strength is not needed and small quantities are used at one time so that elaborate testing and inspection are not justified.

Specifications for materials are the same as for other types of concrete found in Section 1006. The minimum cement content is 470 pounds per cubic yard. The discussion on concrete in Section 1006 should be read for guidance in judging whether the contractor's materials and methods will be satisfactory. Section 1006 should not be considered to be setting out requirements but only as a guide to assist in recognizing areas where problems may develop.

If approved by the Engineer, the contractor may substitute commercially available sacks of redi-mix concrete, suitable for the intended purpose. Should such substitution be approved, the cement specified herein and the requirements of Subsection 922-2 shall not apply.

Although minimal inspection is required, it is necessary to look at the contractor's batching and mixing equipment and procedures. If the contractor's methods are not acceptable, a written notification is required. The Resident Engineer will need to use firmness and ingenuity in dealing with the contractor under the concept of recognized practice.

The contractor has to furnish an acceptable product and choose the slump range and aggregate size. However, the Resident Engineer is required to review and approve the proposed mix prior to its incorporation into the work.

Although the contractor chooses the aggregate size, the grading must conform to AASHTO M43. Mixing can be done manually at the job site as well as plant or truck mixing as long as the Resident Engineer approves. A great amount of leeway also exists in the method used to proportion the materials; again, only the Resident Engineer's approval is needed.

When reviewing the contractor's mix proposal, a rule of thumb guide for aggregate having a fineness modulus of from 2.60 to 2.90; is when 1 to 1-1/2 inch aggregate is used, the fine aggregate should be 40% to 45% of the combined fine and coarse aggregates. The total water needed to provide a 3 inch slump will be about 7 gallons per sack of cement.

925 CONSTRUCTION SURVEYING AND LAYOUT

Contractor Survey

On those projects that are so designated, the contractor will be responsible for providing construction surveying. This will require competent personnel to perform survey calculations and necessary field documentation such as field books, cross section books, and earthwork quantities. The Resident Engineer should insure that this work is performed under the direction of a Registered Professional Engineer/Surveyor employed by the contractor.

The Department will provide either traverse or control points for establishing an accurate construction centerline and will establish benchmarks adjacent to this line for the proper layout of the work as described herein. Control points will be located on centerline at the beginning and ending of the project, and at all points of curve (P.C.), points of tangent (P.T.), tangents to spiral (T.S.), spirals to tangent (S.T.), and angle points. On long tangents, additional points will be provided for continuity of line.

Traverse points, when provided, will be as follows:

For horizontal control, the Department will run a traverse from which construction centerlines can be established. The control points, delineated by iron pins, marks in concrete, or similar devices, will be located to minimize the likelihood of their destruction during construction activities. Coordinates of these points and/or ties to construction centerline will be provided.

For vertical control, the Department will establish benchmarks the entire length of the project at horizontal intervals not to exceed 2,500 feet.

These control points will be properly referenced and their location documented for future reference. The contractor should then be provided with this information and physically shown their locations. At this time, the contractor should be made aware that it is their responsibility to preserve these points for the duration of the project.

Copies of recorded Results of Survey, Record of Survey, Corner Records, documents, maps and plans shall be submitted to the Engineer within ten working days after recordation at the Office of the County Recorder. Copies of all field notes, computation sheets and calculations that relate to the boundary surveys shall also be submitted to the Engineer within this time frame.

Before beginning any construction, the contractor must submit an outline detailing all survey activities for the project and the sequencing of these events. Section 1150.00, contractor Construction Surveying, of this Construction Manual should have been used by the contractor in preparing the outline. The Resident Engineer should thoroughly review this plan to ensure that it is realistic, provides the scope of work that is required, and can be monitored by project personnel.

When the survey plan is approved, the contractor should then check the accuracy of the control work established by the Department, to their satisfaction.

Once construction begins, the Resident Engineer should assign a survey supervisor to monitor the activities and documentation of the contractor's survey personnel. Conflicts can easily be resolved if there is cooperation between the contractor and ADOT personnel in this area. The monitor should not actively get too involved with this work, but should be aware of the various survey activities and be available for consultation if the contractor requests it. The monitor should also be checking for suspected problem areas or deficiencies in the operations. If there are serious survey problems and inconsistencies, the Resident Engineer should be made aware of them, and actions taken to correct them. Serious problems may require restaking at the contractor's expense.

Survey Control for Pavement Marking

It is important that pavement markings be accurately laid out prior to their application on the roadway.

At the start of the project, when the contractor submits the schedule of payment for the lump sum Construction Surveying and Layout item, the R.E. should ensure that survey control and layout for final striping is included. If the schedule fails to include a reasonable percentage for this item, the R.E. should reject the schedule and require the contractor to resubmit a corrected version for approval. The intent is to ensure that the contractor has planned for the necessary resources to complete the final striping requirements for the project.

A minimum of two weeks prior to any paving activities, the contractor, the contractor's survey and pavement marking subcontractors, a representative from Regional Signing and Striping and the Resident Engineer will hold a pre-activity meeting in accordance with the project special provisions, to discuss the survey control for the applications of all temporary and permanent striping. At the meeting the contractor shall provide a written pavement marking layout plan, including provisions for survey control for the final pavement markings, that is satisfactory to the Engineer. The plan must meet the minimum requirements for survey control and layout of the temporary and permanent striping as defined in Standard Specification 925-3.01.

The plan shall include timeframes that ensure layout is completed in a timely manner. It is the intent that the contractor's survey and pavement marking subcontractors concur with the provisions of the written pavement marking plan. When applicable, the plan shall also include the contractor requirement to coordinate the survey layout of projects with no-passing zones with the ADOT No Passing Zone Crew. This contact (phone number provided on the project plans) should be made at least five working days before placement of the applicable pavement marking.

The liability for the proper layout and placement of the striping is clearly the contractor's. If done incorrectly, the Engineer has the authority to require that it be redone correctly at no additional cost to the Department.

926 - 927 ENGINEER'S FIELD OFFICE AND FIELD LABORATORY

When the plans or special provisions require it, the contractor may be responsible for furnishing adequate facilities for the Resident Engineer to use as a construction field office and a field laboratory. The Standard Specifications or Special Provisions will contain a list of what services and facilities are included in this requirement.

The Resident Engineer will designate the location of the field offices and the contractor will provide and maintain all utilities necessary to make this office fully functional prior to commencing any work activities.

The Resident Engineer should ensure that all required permits are obtained by the contractor and that provisions have been made to keep the facilities fully functional for the duration of construction activities.

928 GROUND-IN RUMBLE STRIP

Rumble strips are indentations in the surface of a pavement which serve the purpose of alerting a driver that they are leaving or drifting away from the designated driving lane. They are usually placed on both the inside and outside shoulders of rural high speed divided highways and on the shoulders and centerline of rural undivided highways.

The Traffic Guidelines and Processes (TGP) Sub-section 480 Continuous Longitudinal Rumble Strips provides the guidelines for the installation locations and exceptions. Traffic Standard Drawing M-22 contains information on the dimension and tolerances for the rumble strips.

The plans should identify the specific rumble strip locations and exceptions. There is careful consideration during design with respect to proximity of current and future urban areas, residences, shoulder widths, bicycle accommodations, pavement conditions, intersections, driveways, etc. Rumble strips are not placed on structures, approach slabs, or weigh-in-motion slabs. If the locations and exceptions are not clear on the plans or if field conditions warrant a change to the rumble strip locations, contact Traffic Engineering Group for review and approval prior to installation.

It is important that inspectors who are assigned to this portion of the work assure that the equipment used to construct the strips is adequate and conforms to the specifications. Rumble strips shall be constructed by milling or grinding; indentations formed by a roller on newly paved asphalt are not acceptable. This equipment should be equipped with an approved guide easily visible by the operator. The right type of equipment allows the contractor the capability of providing the required alignment and uniformity.

929 GEOSYNTHETIC REINFORCED SOIL (GRS) RETAINING SYSTEMS & MECHANICALLY STABILIZED EARTH (MSE) WALLS

Geosynthetic or geogrid reinforced retaining systems may be included in the project where conventional retaining structures, e.g. retaining walls, abutments, would typically be constructed, and GRS is often utilized for Accelerated Bridge Construction (ABC). Although GRS & MSE walls have several features that are very similar such as the geogrid;, wall facing blocks, and pins, connecting subsequent courses of wall facing and to secure geogrid, there are several differences between GRS and MSE wall construction. Inspectors should also be careful to not assume the process of installation of geogrid for GRS and MSE walls is the same as that for reinforcement of roadway, GRS and MSE walls are structural whereas roadway geogrids are purely geotechnical; the products themselves, the design process, and the installation are NOT the same and treating GRS and MSE wall construction the same as geogrid-reinforced road construction may result in instability in the form of excessive vertical and lateral displacements. Likewise, geogrid for structural applications may not be appropriate for use as roadway geogrid.

Both GRS and MSE walls include reinforcing geogrid specifically designed to control and stabilize slope failure mechanisms that would otherwise result in failure of the structure. GRS systems require closely spaced layers of geogrid, while MSE systems use metallic grids of welded wire or other straps spaced much farther apart than GRS. In both instances, the geogrid is designed (strength, length, and vertical spacing) based on slope stability analysis to intercept the potential failure planes associated with the retaining system. The primary difference between these two systems is that MSE walls may be constructed of backfill material that is not a manufactured product, could perhaps even be natural soil of reasonable quality, and typically always includes a drainage system to prevent the occurrence of hydrostatic pressure due to saturated soils, however, GRS construction utilizes highly engineered, manufactured (crushed) aggregate that is free draining, the quality of which must be tightly controlled during production and construction.

MSE walls are designed based on the specific mechanical properties of the backfill material anticipated or required to be used for construction; each MSE wall is different, has a different design, and different requirements. Therefore, it is vital that the materials used to build the MSE wall meet the requirements for all properties specified without exception. The backfill material used for MSE walls will be sampled and tested in accordance with the project special provisions.

For GRS, the design is general in nature, but also relies on the materials used to build the structure meeting the requirements specified without exception. The design is not specific to a particular aggregate material, however, the aggregate must be manufactured to meet the requirements specified to ensure the structure performs as intended. Because the engineered reinforced aggregate backfill material does not lend itself to density testing the compaction of the aggregate is specified by the method specification.

Geogrid for GRS and MSE walls is accepted based on certificate. There is no category for this type of geogrid on the Department's Approved Products List (APL). Rather, such geogrids may be specified by product name and manufacturer as part of the system designed for the project in the special provisions. The special provisions may reference a specific type or category of product or provide material properties which the selected product must meet. The specific product to be used must have been evaluated by the National Transportation Product Evaluation Program (NTPEP), and the associated data for which must appear in NTPEP's online Datamine. All required information must be on hand and the product confirmed adequate prior to installation. Sampling is typically not required unless stated in the project special provisions, or the quality of the material is suspect or appears defective.

Geogrid Manufacturer handling and installation instructions must be strictly adhered to which may include limiting exposure to sunlight as well as how the geogrid may be lifted, moved, and placed.

There are many different types of MSE retaining wall systems. Review the installation instructions and specifications for the specific wall system being installed. Many systems have specific requirements for shims and spacers, wedges, batter, leveling pads, panel alignment, panel storage, reinforcement storage, filter fabric and joints, copings, compaction equipment near the wall, protecting the wall from stormwater damage during installation, etc.

After becoming familiar with the requirements in the project's special provisions, the key construction/installation steps which the inspector should observe to ensure correctness include:

- Preparation of a sound, level, and adequately compacted base or cast in place concrete leveling pad upon which the first course of wall facing will be installed, any deviations will become more pronounced as subsequent courses of block are placed.
- Preparation of a flat, level, moisture conditioned and compacted ground surface upon which geogrid reinforcement and structural aggregate will be installed.
- Where drains are required, drains must be completely wrapped in filter fabric prior to placement of any required drainage rock and/or backfill material.
- PVC should be stored and handled in accordance with the manufacturer's recommendations, to minimize ultraviolet deterioration from sunlight.
- Separation filter fabric, when required, must be installed between any drainage rock and other soils/backfill materials to prevent infiltration of soil into the drainage system.
- Verifying geogrid, block pins, and wall facing blocks are of the correct type; not sourced from multiple types or production lots not covered by the certifications.
- Placement of geogrid is such that the geogrid is kept taught at all times; the material must engage tension against the block pins and from structural aggregate / backfill as the material is placed.
- Structural aggregate backfill material MUST be placed beginning at the back of the wall facing and then by working away from the wall; not at end of geogrid and then pushed toward the wall face. Placing in the incorrect direction will induce slack in the geogrid, preventing it from engaging and mitigating slope failure stresses as intended.
- Compaction of the reinforced structural aggregate must adhere very strictly to the method specified including compaction equipment and compaction patterns. The stability of the system depends on the reinforced aggregate being adequately compacted with the proper equipment. Each lift must be confirmed to have been compacted per design standards.
- For MSE walls, lab proctors should be obtained when controlling compaction of backfill material. Do not use one-point field proctors for compaction control but only as intended when confirming consistency of backfill material.
- Block placement must retain the required vertical alignment. Plumbness of split-faced block should be checked on the back of the block; not the rough face of the block. Any corrections necessary must be made prior to the installation of subsequent courses.

1000 CONTROL OF MATERIAL

Logging of Tests

Project personnel will keep and maintain materials testing logs or reports for all testing results. Either “paper” or “computer” logs may be kept as desired by the project. Copies of materials testing logs are sent to the Regional Lab and/or the Central Lab only upon request.

The service life of a project is dependent not only upon the care used in construction, but also on the quality control and kind of materials incorporated. It is necessary that only materials which comply with the specifications be used. The Materials Policy & Procedures Directives, Materials Testing Manual, AASHTO and ASTM Standard Methods of Sampling and Testing, Construction Manual, and Construction Bulletins provide the procedures necessary for the sampling and testing of material. The project personnel must continually watch to see that no inferior materials are used. They must see that samples are taken in accordance with the Sampling Guide Schedule, by the required procedures, and that these samples are tested and reported promptly.

Prompt testing and prompt reporting to all concerned (including the contractor) are a vital part of our system of quality control. The following guidelines are established in order to provide an acceptable system of reporting project material test results.

Each construction unit will implement one of the two systems as below outlined, with no substitutions or exceptions. The systems will be either Manual Materials Logs or Computer Material Logs.

Project Materials Coordinators (PMC) should provide the inspectors with a list of Proctors, approved concrete mix designs, and approved asphalt mix designs for use in the field. Inspectors should not have to look up the info on their own (sometimes they may not be able to).

Manual Materials Logs

1. Materials test cards or work cards listed below will be used:

    - 44-1000 - One Point Proctor Density (Field Office)
    - 44-1001 - Field Density/Moisture of Soils by the Nuclear Method (Field Office)
    - 44-1002 - Method A or Alternate Method D Proctor Density (Field Office & Lab)
    - 44-1003 - Method C or Method D Proctor Density (Lab)
    - 44-9338 - Asphalt Test Data (Lab)
    - 44-9347 - Sand Cone Density (Field Office)
    - 44-9348 - Volumeter Density (Field Office)
    - 44-9352 - Asphaltic Concrete Tabulation (Lab)
    - 44-9372 - Asphaltic Concrete Tabulation - Furnace (English) (Lab)
    - 44-9374 - PG Binder Test Data (Lab)
    - 44-9379 - RAP Material Tabulation - Ignition Furnace (Lab)
    - 44-9337 - Concrete Test Report - PEN V was developed to automatically assign concrete samples with the next available number in FAST once approved in PEN. This was developed to ensure the Department doesn’t have duplicate numbers or skipped numbers. The inspector makes the sample, enters the info in PEN, then turns in the card and uploads to PEN (the inspector does not need to number the card). The PMC approves the PEN concrete sample and FAST automatically assigns the sample with the next available number based on PSI strength for that project. The PMC goes into FAST to retrieve the sample number and puts it on the test card and concrete cylinder samples. When the cylinders are delivered to the Lab, they are already numbered and in FAST. This process was intended to move away from manually numbering samples.

2. The required information will be transferred from the work cards to the appropriate log form listed below:

    - 44-3904 - Materials Certification Log

- 44-3917 - Proctor and Density Log is available in FAST and shows all info entered in PEN for the test once approved. There is no need to manually track the density tests. The PMC should approve density tests in PEN, and FAST tracks all of the information numbering every test based on classification. This report can be printed.

- 44-4404 - Concrete Log was used to track cylinders made on a project and enter the break data after 28 days. FAST now provides this information. FAST has a printable Density Log and Concrete Log for every TRACS number. The Department no longer requires manual Logs for this.

  Additions and/or updates can be made intermittently to any of the above listed forms.

3. Materials will be sampled as outlined in the Sampling Guide Schedule of the ADOT Materials Quality Assurance Program (Appendix C) or the project Special Provisions. Project test results will be typed or printed in black. Lines will be left blank immediately below the results of each split sample for the purpose of recording corresponding Regional and Central lab results as soon as they are received at the project.

4. For those who wish to record statistical information such as running averages, averages in data, standard deviation, coefficient variation, of individual screens, or other information, may do so on these forms. Averages may be accumulated down the sheet and recorded by leaving blank the number of lines needed. This type of information may also be recorded in the concrete log in spaces not utilized.

Computer Materials Reports (Logs)

1. The same test or work cards as listed for manual material logs will be used.

2. Information from the test or work cards will be entered into the computer when completed, which will make all testing information performed by the project lab available by computer to the project.

3. An up-to-date computer report may be maintained at the project lab or office. When computer reports, commonly called material logs, are used, the necessary information may be obtained two ways, by either looking at the computer screen directly or by printing out a materials report.

4. Materials will be sampled as outlined in the *Sampling Guide of the Materials Testing Manua*l or the project Special Provisions.

Whichever of the two systems is utilized, it is essential that all calculations of test results be correct. When manual materials logs are used, it is essential that the individual performing each test, sign and date each test or work card. Each card should, in turn, be checked and initialed by a supervisor before the results are recorded in the materials log. If a computer report is used, the name of the person performing the test should be recorded in the computer next to the test results.

Logs or computer reports should show all acceptance and test results performed by the project, regional, and central lab. Tests such as informational, etc., will be left to the individual project or District discretion as to whether the information will be included in the log or report. The approximate total quantity of material required should also be shown in the log heading.

Logging of Concrete Test Results

It has been customary to log all tests on concrete after the laboratory reports covering strength have been received. It is suggested all tests on concrete, except strength, be logged as soon as possible after making the tests, then log the strength tests after receipt of the laboratory report showing the strength results. It is believed that earlier logging of all tests, except strength, will serve to alert the Engineer and others concerned with the project to the need of any corrective action with respect to the slump, air content, temperature, yield, and etc.

Logging of Density Test Results

The location and results of density tests shall be logged in the proctor and density log.

1001 MATERIAL SOURCES

The Standard Specifications provide definitions for two types of materials sources specified in the contracts. Sources may be Department-Furnished, or contractor-Furnished. The contractor-furnished sources include commercial operations.

A Materials Source Environmental Analysis (EA) is required for every and all types of material sources. ADOT Materials Group has a list of commercial materials sources known by the Department to have approved environmental analysis. Department-furnished sources should be on the list. All approved sources are assigned a commercial materials number, or CM#; this number must be used when referencing/identifying any material by its source. The contractor must provide an acceptable environmental analysis for contractor-furnished sources. The contractor can either choose a source from ADOT's approved list, or provide an environmental analysis in accordance with the requirements of Subsection 104.12 of the Standard Specifications.

1001-2 General

Section 1001 covers the requirements and restrictions when working a materials source. The Engineer and the inspectors are expected to be familiar with the section and to properly document that the source is worked in accordance with the requirements and restrictions.

The provisions of the OSHA, State Mining Laws, the Arizona Native Plant Law, and Pollution Control Laws relating to exhaust emissions, burning, stream pollution, and dust control are to be complied with. If the contractor does not appear to be complying with these laws they should be notified and the situation should be documented in the project record. ADOT does not enforce these laws but there is an obligation to promote an awareness on the part of the contractor that they must comply with the law.

If the nature of the material or the method of processing changes, so that an unacceptable product may result, the Engineer is to notify the contractor. Changing conditions are to be documented along with any action or inaction on the part of the contractor towards correcting the condition.

Whenever the material source shows evidence of material varying in the vertical plane, the approval of the source should include a requirement to work a full face in order to get the maximum blending of the different materials. Almost all sources, including quarries, have enough variability that justify a full-face method of working. Sources having variability in the horizontal dimension may require blending of material from various areas before final processing.

Even though a source is the contractor's responsibility, the Engineer will need to monitor the operation so he can alert the contractor to any processing problems that could result in a lowering of the quality of the final product. There have been occasions when contractors have refused access to materials sources to ADOT personnel under the pretext that ADOT had no right to be concerned until the final product was tested. The Engineer should not accept such a position on the part of the contractor. If necessary, the assistance of the District and Central offices should be enlisted in getting access to the contractor's operations.

In crushing and screening operations, wet and dry materials usually require different handling methods to produce the same results. The mixing or selection of wet and dry material has to be watched closely to prevent broad and erratic variations in the final product.

1001-2.01 Material Sources in Floodplains:

Any development of a material source that is determined to be in a flood plain must meet the requirements of the appropriate local, state, and federal agencies, including as applicable, the U.S. Army Corps of Engineers, Section 404 of the Clean Water Act, ADEQ or Tribal 401 Water Quality Certification, and the National or Arizona Pollutant Discharge Elimination System (NPDES/AZPDES).

If the contractor wishes to procure a material source within a floodplain, the contractor or material supplier shall submit a Floodplain Use Permit application to the appropriate floodplain management agency. The contractor shall submit to the Department documentation that the Floodplain Use Permit for the material source was approved and signed by the appropriate agency's Floodplain Administrator. The contractor or material supplier shall comply with all the requirements of the Floodplain Use Permit, including renewal of the Permit as needed or required.

The Department will require an engineering report if the material source is situated in the 100 year floodplain of any stream or watercourse, and located within one mile upstream and two miles downstream of any highway structure or surfaced roadway crossing. The engineering report shall be prepared by a professional engineer with expertise in hydrology, hydraulics, river mechanics, and fluvial geomorphology. The engineering report shall address the effects of the potential for structural damages following a 100 year flood event.

All other permits required to obtain a material source shall be furnished to the Department upon request.

Surplus material from agency administered flood control management projects may be used as borrow material only if the contractor submits written evidence to the Engineer that the flood control agency project was fully designed and funded.

Material sources in floodplains located on Native American Tribal Lands will be considered for use on an individual analysis. The analysis shall include a review of applicable land use plans, floodplain management plans, environmental plans, applicable laws and regulations pertaining to Native American Tribal Lands, and an engineering analysis of the effects on any highway facility or structure. The contractor shall obtain from the Bureau of Indian Affairs (BIA) and the Native American Tribal Council all permits, licenses, and approvals for the Department to review.

Department-Furnished Sources

An information packet may be available with Department furnished sources. The Engineer should be familiar with the information packet which contains information on the type of material, ownership, and other pertinent matters.

One print of each material pit established for the project showing its serial number and location with reference to township and section, shall be received by the Hazardous Materials Team within the Environmental Planning Group and the Resident Engineer at the beginning of the project. The Resident Engineer is required to keep all pit information up-to-date as construction proceeds.

It is important to monitor the contractor's operations in the source to be sure they are using the material as intended and not operating wastefully. When a Department-furnished source is exhausted early, the Department may have to pay moving and development costs. A complete record should be kept of the pit operation so that it can be readily determined and verified that a source has been exhausted after being worked in a reasonable manner.

An accurate and indisputable record shall be kept on the amount and type of material removed from each individual ownership. This will save the Department many legal difficulties relating to overpayment, underpayment, no payment, or exceeding the limits of the area covered by the license.

It is very important that all pits from which any type of material is taken (including borrow pits) be accurately described as to location and serial number, and that the type and quantity of material from each pit be detailed separately with the final estimate. The name of the owner of each parcel of land from which materials are taken shall be shown.

Material from a Department furnished source is to be used only for the purposes stated in the contract. A supplemental agreement is necessary for any change in usage. The owner's approval for a change of use is to be obtained by the contractor. The Department has the right to deny a change in use of material when the pit is to be preserved for future use or other valid reasons.

Special care shall be taken when there is more than one owner in one pit area. Before removing any material, the Resident Engineer shall make certain that the property lines between owners are mutually satisfactory. Agreement as to property lines should be attested to by the owners, in writing, after inspection at the pit site where feasible. It is not the Resident Engineer's responsibility to reestablish corners or lines for property owners.

Pits on State Land

Some projects require the procurement of material pits on State Land Department properties. This agency has issued specific requirements which must be strictly adhered to for removal of materials from State Land Mineral Material Leases.

The following procedures will apply to materials removed from all State Land Department Pits:

Preliminary Report

Within twenty days of the notice of award of a contract which requires the use of State Land Pits, Field Reports shall report to the State Land Department, through the Hazardous Materials Team within Environmental Planning Group, the following information:

1. Project number and general location
2. Name of contractor
3. State Pit serial number and State Mineral Materials Pit Lease number
4. As nearly as possible, the date the contractor proposes to enter upon the leased
5. Land (verified at time of preconstruction conference)
6. The time allotted to the project or anticipated completion date
7. The approximate release date (this date will normally fall after completion of project)
8. The approximate amount and types of materials anticipated to be removed from each State Land Pit

As soon as possible after the preconstruction conference, the Resident Engineer shall relay to Field Reports the information necessary to report items 4 and 7 above.

Pit Re-cap Documentation

The Resident Engineer will, within 24 hours after the contractor has completed removal of materials from a State Land Department Pit, estimate quantities of each type of material removed from the State Land source. A reasonably accurate estimate will also be made of all stockpiles (aggregate base, mineral aggregate, cover material, etc.) remaining in the pit. The Resident Engineer shall also estimate the quantities in reject piles for which there will be no royalty accounting. A memo confirming information shall be sent to Field Reports. A final verification of quantities and recapitulation of all material pits is required with all final estimates. Field Reports will submit the following recapitulation through the Hazardous Materials Team within Environmental Planning Group to the State Land Department within 60 days after notice of project completion:

- Project number and general location
- Contractor
- State Pit serial number
- State Land Mineral Materials Pit Lease number
- Type of material removed
- Quantity of materials removed
- Royalty rates on materials removed
- Total royalties due, including a 3% administrative charge. (Total royalties due is equal to the material royalties multiplied by 1.03)

State Land Department Inspection

Inspection of State Land Pit sites and quantity documentation records may be made at any time by an authorized agent of the State Land Department. The Resident Engineer shall cooperate and assist in any such inspection.

Pits on Native Nations

Occasionally, projects will require the procurement of material pits on Indian lands. This procurement is accomplished by the Hazardous Materials Team within the Environmental Planning Group through contact with the United States Department of the Interior, Bureau of Indian Affairs and the particular Indian Agency involved.

Upon receipt of the Notice of Procurement of Material Pits on Indian lands, it is recommended that the same basic steps as outlined above be followed by the Resident Engineer, with special emphasis on the fact that care shall be taken when there is more than one owner in one pit area. Because these pits will often have designated allotments covering different entities, it is recommended that the Resident Engineer contact the Superintendent of the Indian Agency and work with him to determine suitable methods of proportioning quantities to the various allotments. This will also serve to inform the Resident Engineer of any other conditions which may be peculiar to the particular Indian Agency.

The office of Environmental Planning will receive and maintain a list of sacred sites designated by the Navajo Nation and may have additional sites from other Native American Nations. These sites will be incorporated into the highway construction contract documents and referenced to their location. Although the FHWA has informed us that we cannot prevent the use of any particular material source, we will stipulate in the contract that the contractor must be aware that the site is sacred. The contractor must be in compliance with all historical and environmental laws and regulations, which may serve to limit or prevent the use of materials from a designated site.

1001-2.04 Royalty Charges

It is the Engineer's responsibility to see that the contractor has paid all royalty charges before final payment is made on the contract.

Material pits furnished by the Department on some projects will require payment of a royalty charge, while on other projects, the pit or pits will be furnished free of royalty charges. The Resident Engineer shall review the Standard Specifications and Special Provisions to ascertain whether the pits for the project involve royalty charges, and shall be guided accordingly. In any event, a Pit Recap Sheet shall be made and submitted with the final estimate (Exhibit 1001-2.04-1).

No payment by the contractor to the State Land Department shall be made until final billing is forwarded by Field Reports to the contractor. The contractor shall make checks payable to the State Land Department and mail as follows:

Attention: Field Reports Section
Arizona Department of Transportation
Project Delivery & Operations
206 South 17th Avenue, Mail Drop 133A
Phoenix, Arizona 85007

Other Situations Involving Royalties

The information below is a general outline on how other pit situations are handled:

State-leased pits may or may not be set up in the Special Provisions.

1. If they are, the royalty rate is specified within the contract.
2. If they are not:
    - The contractor asks to use a pit.
    - The Resident Engineer checks with the Hazardous Materials Team within the Environmental Planning Group and Environmental Planning to get approval and royalty rate.
    - A copy of the pit license is picked up by the contractor from the Hazardous Materials Team within the Environmental Planning Group. The contractor then checks over and clears the license and

any other pertinent information with the Hazardous Materials Team within the Environmental Planning Group. When this is done, the contractor will give the letter to the Resident Engineer.
- The Resident Engineer then distributes a letter to the Hazardous Materials Team within the Environmental Planning Group informing them of the contractor’s use of the pit.

In either case, a Pit Recapitulation is sent to Field Reports even if the pit is not used. Field Reports verifies any quantities and sends one copy to the contractor. Field Reports also sends one copy to the FHWA with the project final. The FHWA sends the Pit Recap royalty final to the contractor and requests verification of payment. Upon receipt of the contractor's verification of payment, the FHWA releases funds.

1001-2.05 Performance Bonds

The contractor is required to furnish a performance bond when using sources under the jurisdiction of the State Land Department or the Bureau of Land Management. Note that a fully executed copy of the bond is to be furnished to the Engineer together with evidence that a fully executed copy has been sent to the agency having jurisdiction before any work is started in the source.

ARIZONA DEPARTMENT OF TRANSPORTATION

OFFICE MEMO

July 1, 2001

TO: **DEE BOOKS**

Field Reports, 133A

FROM: **KEN DORIGHT**

Project Supervisor, X999

RE: **MS 1111; REVISED**

As part of ADOT Project TEA-87-C(1)P, H9999-01C; Red Ridge-FS Boundary, the following aggregate quantities have been removed from above-referenced material source.

SECTION 416

Asphaltic concrete produced; to date (Item No. 4160003)		33,213 tons
Less:		
	Mineral Admixture (Item No. 4160031)	312 tons
	Asphaltic Binder (Item No. 4040282)	1,661 tons
	Blend Sand (from pit MS1026)	10,964 tons
	Subtotal Deductions	-12,937 tons
Aggregate used for Section 416		20,276 tons

SECTION 414

Asphaltic concrete produced; to date (Item No. 4140040)		4,326 tons
Less:		
	Mineral Admixture (Item 4140044)	39 tons
	Asphaltic Rubber Material (4140042)	389 tons
	Subtotal Deductions	-428 tons
Aggregate used for Section 414		3,898 tons

Total aggregate used to date: **24,174 tons**

Exhibit 1001-2.04-1. Pit Recap Sheet

1001-3 Proposed Source

A letter approving the source is required for contractor-furnished sources. The Bridge Group must be contacted prior to approval of a material source located within the specified upstream or downstream distances from any drainage structure.

When materials sources are contractor-furnished, the contractor is responsible for sampling and testing to determine whether there is enough material available to complete the work within the specifications, for preparing an environmental analysis, for complying with the Arizona Native Plant Law, and for securing rights and access to the material. Evidence must be furnished to the Engineer that the contractor has fulfilled these requirements.

The same requirements for changes in usage, royalty payments, and meeting environmental stipulations apply to contractor-furnished sources as applied to Department-furnished sources. The contractor is required to furnish evidence to the Engineer that they have fulfilled their commitment to the owner. Acceptable evidence is a letter from the owner stating that all agreements have been fulfilled, including payment, and that the contractor is released from any further obligation.

The contractor’s complete environmental analysis should be in accordance with Standard and Specifications 104.12 for all material sources. The Resident Engineer should assure that the contractor has complied with state historical preservation rules.

Contractor Leased Pit

The following procedures are followed if the contractor wishes to lease a materials pit from a private party:

1. The Resident Engineer verifies the landowner's permission and any conditions (such as royalties and clean-up). The contractor should provide a copy of the agreement.
2. The Engineer writes a Pit Approval letter to the contractor (copy to Field Reports).
3. The Engineer completes the Pit Recap and then sends a copy to the Hazardous Materials Team within the Environmental Planning Group and informs the contractor of final quantities.
4. Before finalizing the project, the Engineer requests a copy of the pit-owner's release of the contractor. Upon receipt of the pit-owner's release, the Engineer can finalize the project.

Commercial Operations

A letter approving the source is required for commercial materials sources. The Bridge Group must be contacted prior to approval of a material source located within the specified upstream or downstream distances from any drainage structure.

Commercial operations are to meet the requirements in Subsection 1001-2.01, Definitions, of the Standard Specifications.

Specifically, proof of the following shall be submitted to the Resident Engineer:

- Owner or Producer has been located on site for at least preceding 12 months.
- Owner or Producer has been routinely engaged during regular business hours in processing and selling of materials.
- The Owner or Producer shall have a retail sales tax license.

Specifications require the contractor to furnish documentation verifying the above requirements are being met.

1001-4 Special Access

The contractor may make a request to the Engineer to approve special access to a controlled access highway if special access is not shown on the project plans.

When access is not being utilized, gates shall be closed and locked. Upon completion of all operations, the area within the right-of-way that has been disturbed shall be restored to the condition existing prior to the contractor's operations

1001-5 Operations at Source

The contractor shall notify the Engineer in advance of operations at the source. Notice shall be given before and after clearing and grubbing, and before and after cleaning up. Before beginning stripping, the contractor shall clear and grub the source as necessary to prevent the contamination of materials to be used in the work.

Burning will be permitted only after the contractor has obtained a permit from the ADEQ, and from any other Federal, State, County or City Agency that may be involved. This is generally applicable for counties outside of Maricopa County.

Materials shall be removed from the source in a workmanlike manner and, when required, in accordance with the contractor’s project-specific Plan of Operation and Restoration.

1001-6 Fences and Cattle Guards

The livestock operator or owner shall be contacted prior to the beginning of any operations and effective measures shall be taken and means provided by the contractor to restrict the livestock to the land where it is being kept.

The contractor shall furnish all materials and construct temporary fencing, gates and cattle guards as may be necessary to restrict the livestock as specified.

Existing fences that are to remain in place and which have been damaged by the contractor's operations shall be replaced or restored by the contractor at no additional cost to the Department

1001-7 Cleaning Up

Cleanup of a source should not be taken lightly as it will have a lasting impact on the owner which can drastically affect ADOT's future relations.

The Engineer should always require a final inspection and letter of acceptance by an agent of the public agency involved and have the contractor furnish a clearance letter from private owners.

1002 PAINT

The inspector should be able to recognize the various paint categories since mixing and storage requirements vary. The Standard Specifications group paint into the following categories: Three-Paint Coating System, Zinc Rich Primer, Inorganic Zinc-Rich Primer, Alkyd Primer, Direct-to-Metal (DTM) Combination Primer and Finish Paint, and Acrylic Emulsion Paints. Three-paint coating systems are considered as one unit and include a primer (paint number 1), intermediate coat (paint number 2) and topcoat (paint number 3). Zinc rich primer shall be a solvent based , one-part, epoxy ester, zinc-rich coating used as a primer to repair galvanized metal surfaces. Alkyd primer is solvent based designed for ferrous metal surfaces where rust is an issue and precludes the use of water based primer. Direct-to-Metal is a water-based acrylic paint primer or primer & finish. Acrylic emulsion paint is a waterborne (latex) universal coating system similar to exterior house paint.

Certificates of Compliance are required for each lot or batch of paint. The Certificate of Compliance should be received before paint is applied. Random samples of any lot or batch may be taken at any time. The Engineer should confirm that the contractor and paint supplier have made arrangements for paint testing. Samples of paint may be tested at the Phoenix Central laboratory before any paint is delivered to the project, or may be obtained in the field or from the fabricator and submitted to Materials Group for testing.

Only paints and paint systems approved in accordance with Subsection 1002-3 and shown on the Department's Approved Products List will be allowed for use. The contractor needs to submit to the Engineer a Certificate of Compliance for each lot or batch of paint supplied in accordance with Subsection 106.05.

After testing, the containers of approved paint will have appropriate tags or labels attached identifying them as tested and approved. Additional samples will be taken at the project site as the paint is used.

The Standard Specifications require each label to clearly show the exact title of the paint, the Federal specification number (when applicable), the name and address of the manufacturer, the date of paint manufacture, and the lot or batch number.

Established suppliers of paint within the State are familiar with testing and approval routines; therefore, very few problems arise in dealing with these suppliers. Suppliers from out-of-state or those who have not dealt with ADOT may experience problems initially. The Engineer and the contractor need to cooperate in order to minimize possible problems with paint testing and approval.

1003 REINFORCING STEEL

Certificates of Compliance are required for reinforcing steel. The Certificate of Compliance for reinforcing steel should be received before payment is made. If the project requires epoxy coated bars then the epoxy resin must be on the Department's Approved Products List (APL). The inspector must ensure that any damage to the epoxy coating is repaired in accordance with the Standard Specifications.

Additional information on reinforcing bars and their dimensions can be found in Chapter 5, Section 605-2. Minimum frequency for sampling reinforcing steel - samples are required for No. 7 and above. For No. 6 and below, samples can be taken at the Engineer's discretion.

The same general procedures are followed for wire mesh and smooth bars used as reinforcement except that there are no markings on the metal.

The "W" size designation of wire mesh refers to the area of the individual wire in hundredths of a square inch. W5 wire has an area of 0.050 square inches as shown in the following table (Exhibit 1003-1).

The Standard Specification allows substitution of Grade 60 reinforcing bars for Grade 40 in certain cases. When the substitution is permitted, the authorization is to be in writing.

NOMINAL SIZE NUMBER	NOMINAL DIAMETER (in.)	AREA (square in.)
W 31	0.628	0.310
W 30	0.618	0.300
W 28	0.597	0.280
W 26	0.575	0.260
W 24	0.553	0.240
W 22	0.529	0.220
W 20	0.505	0.200
W 18	0.479	0.180
W 16	0.451	0.160
W 14	0.422	0.140
W 12	0.391	0.120
W 10	0.357	0.100
W 8	0.319	0.080
W 7	0.299	0.070
W 6	0.276	0.060
W 5.5	0.265	0.055
W 5	0.252	0.050
W 4.5	0.239	0.045
W 4	0.226	0.040
W 3.5	0.211	0.035
W 3	0.195	0.030
W 2.5	0.178	0.025
W 2	0.160	0.020
W 1.5	0.138	0.015
W 1.2	0.124	0.012
W 1	0.113	0.010
W 0.5	0.080	0.005

Exhibit 1003-1. Welded Wire Fabric Dimensions

1004 STRUCTURAL METALS

Most structural metals are accepted on the basis of certificates of compliance and certificates of analysis.

The metal fabricator is generally the party responsible for forwarding to the contractor (or supplier) the required mill certifications covering the base metal and any treatment prior to fabrication.

The number of certifications required depends on how many processes/companies the metal passed through before being delivered as the final product.

Each material item is to be considered separately to determine what certifications are needed. Ensure certifications meet the requirements of 106.05 including Build America, Buy America Act (BABAA) requirements.

As a minimum, all structural metals are certified in accordance with the following:

1. The manufacture of the base metal will include a chemical analysis of the metal, a statement that it was manufactured according to a given specification (ASTM, AASHTO, etc.), and a description of the pieces represented by the certificate.

    - A heat number or heat lot is an ID number stamped on a steel product to prove it meets industry quality standards. These numbers are used to identify production runs for quality control purposes. The heat lot serves as a certification of quality. Each heat lot comes with a Mill Certificate, outlining where the raw materials were melted from and what the chemical and physical properties of that particular metal.

    - The manufacturer's certification also assures the individual pieces were made to comply with the specification in regard to allowable variations in dimensions and finish.

2. Any coating or special treatment such as galvanizing or heat treatment must be certified. The coating or treatment may be done by the manufacturer, an intermediate processor, or the final fabricator. Whoever performs the work is the one who must certify it.

3. The fabricator who produces the final product certifies that the materials used are the same as the materials represented by the certifications in #1 and #2 above and that the fabrication process complied with the Standard Specifications. The Standard Specifications cited in the contract are to be referred to individually. A generalized statement such as "meets ADOT requirements" is not acceptable.

    - The certification covers all of the fabrication process including bending, machining, welding, heating, painting, etc.

    - The fabricator is responsible for securing all of the certifications from the manufacturers and processors and relating them to the material he has fabricated.

Structural elements are sometimes inspected at the fabrication plant by the Bridge Group, other agencies, or consultants. A copy of the inspection report must be in the project file before structural elements are accepted. Additional discussion of steel structures is found in Section 604.

1005 BITUMINOUS MATERIALS FOR SURFACING

1005-2 Sampling of Bituminous Material

Sampling and testing of bituminous materials are covered in the Standard Specifications, the Materials Testing Manual, and the Policy and Procedures Directives Manual. Everyone involved in sampling, testing and inspection of bituminous materials is required to be familiar with the written procedures and guidelines.

It is important that everyone understands that the contractor is the one who takes the sample of hot asphalt cement while being witnessed by the Engineer. The Engineer will choose the location, the time and the number of samples to be taken by the contractor. The Engineer will also determine whether the facilities and methods for sampling are satisfactory for obtaining accurate samples and are safe.

For materials using crumb rubber asphalt (CRA) such as ARAC or AR-ACFC, it is now common for the asphalt supplier to blend the granulated crumb rubber and virgin asphalt cement at the terminal in agitated tanker trucks. Therefore, the materials for such, the granulated crumb rubber and virgin asphalt cement, may need to be sampled at the terminal rather than at the hot plant since this process no longer includes a blend plant and these materials are not shipped to the production site separately. This will require coordination and scheduling in advance for projects administered by construction units in outlying districts located far from asphalt supply terminals. Also note that the reaction period time and temperature should be monitored, and the contractor is responsible for performing rotational viscometer tests at the hot plant, also witnessed by the Engineer, prior to using the blended CRA.

1005-3 Bituminous Material Requirements

See Specifications for information on Performance Grade (PG) Asphalt Binder, Terminal Blend Rubberized Binder, Polymer Modified Asphalt Binder, Emulsified Asphalts, Emulsified Recycling Agents, and other bituminous requirements.

1006 PORTLAND CEMENT CONCRETE

1006-1 General Requirements

This specification deals with Portland cement concrete. Included are component materials, design, mixing, transporting, and curing, as covered in the Standard Specifications. Placing and finishing concrete are covered by Specifications 401 and 601. Utility concrete is covered by Specification 922.

Refer to the Standard Specifications and Materials Group Policy & Procedures Directives Manual for additional information on Portland cement concrete inspection guidelines.

Good consistency control of concrete is of primary importance. It should be noted that other factors being equal, an increase in the water cement ratio of 0.4 gallon per sack of cement will result in an increase in slump of approximately 1 inch thereby causing a potential loss in compressive strength of about 100 pounds per square inch. Over-watered concrete also increases segregation and shrinkage. This is not to say that concrete having a very low slump should always be used. Good judgment must be exercised.

The Concrete Inspector should be aware of the factors which affect the slump of a concrete mix.

The following are some of those factors:

- Variations in water content have a very pronounced effect on the slump. A change of 1% in the amount of free moisture in the fine, or 3% in the coarse aggregate can change the slump by about 1/2 inch.
- A change of 1% in the amount of entrained air may alter the slump by approximately 1/2 inch. An increase in air causes an increase in slump.
- A fineness modulus of the sand is important because of its effect on the water demand of the mix. The finer the sand, the lower the fineness modulus, the more water required for a given slump. The fineness modulus of sand is obtained by adding the cumulative percentages retained on the following standard sieves: 4, 8, 16, 30, 50, and 100, the total is then divided by 100.

Under these specifications, duties such as checking the stockpiles for moisture and adjustment of the mix are the contractor's responsibility.

For simplicity, the inspection duties to be performed by ADOT personnel are separated into two categories: plant and site inspection.

Documentation of inspection is necessary and will be made as follows:

- The number of random checks to be made is at the discretion of the individual Resident Engineer or Project Supervisor. The number of random checks needed to document the acceptability of the aggregates will vary. In areas where testing has indicated a uniform product that meets specifications and which has been properly stockpiled to minimize segregation, the sampling guide minimum will probably be sufficient. In cases where testing has shown the material to be borderline or the stockpiles show segregation or excess moisture, extensive sampling may be required.
- Frequent visits should be made to observe plant operations during the time material is being batched for the project. Although ADOT does not control the batching and mixing, it is important that project personnel assure all plant procedures are meeting standards. If problems are found they must be discussed and resolved with all parties involved. The contractor should be advised in writing the first time a discrepancy occurs.

When inspecting the plant some of the things to look for are:

- Inspect/check the aggregates to see that there is no intermingling of aggregates from one stockpile or bin to another of a different gradation. Inspect for foreign material and contamination. If any of these conditions occur, you should stop production until the condition is corrected.
- Inspect the aggregates for moisture content and inform the contractor of your findings Concrete aggregate should be maintained in a saturated condition; this is especially important when chemical

admixtures are used. Although we do not control the mix, every expedient shall be used to obtain and preserve uniform moisture content in the aggregates.

- Inspect the aggregate for cleanliness to ensure these have been maintained in the same condition as when sampled for acceptance testing. There should be no adhesions of dust or presence of other deleterious materials.
- Inspect the cement storage. Inspect for caked cement that may be due to long storage time.
- Inspect additive dispensing equipment. Agitation of these materials is not required by the Standard Specifications; however, it is believed to be necessary in all cases to assure that the original quality of the material is maintained. Agitation should be accomplished by the use of an air jet extending to the bottom of the container.
- If concrete is being mixed in truck mixers, determine that mixers are in good condition and display an approved inspection sticker.
- Verify that the mix designs submitted by the contractor and approved by the Department is the correct design for the concrete strength (f'c) being used.
- Check the batch ticket for correct information. The copy of the contractor's or supplier's invoice (delivery ticket) provided for each load of concrete will be acceptable. Documentation of inspections will be made on the applicable invoice. It will not be necessary for ADOT Inspectors to fill out the concrete test report form for each load of concrete supplied. The minimum information to be shown on each invoice shall be the date, time batched, truck identification number, name or identification of the batch plant, name of the contractor, name and location of the project, volume of the concrete, the number of revolutions the concrete has been mixed, the batch weights, mix design code number, the percent free moisture in the coarse and fine aggregates, the water withheld during batching, and any water added to the mix at the site. When samples for strength tests are taken, the concrete test report form will be completed by the ADOT Inspector and will accompany the cylinders to be tested.
- Check the time cement is added to the batch to assure that the proper time has been recorded on the ticket. (90 minutes is the maximum time allowed for agitated discharge). Time begins when cement first comes into contact with water or aggregate. If additional time is necessary, this should be approved by the Regional Materials Engineer, likely with the inclusion of hydration stabilizing admixture.
- Make sure the revolution counter has been zeroed before mixing. Check mixing time and revolutions at the plant. Document these on the delivery ticket, initial it, and return it to the driver.
- All plant inspections and verifications must be well documented. All information, referring to a particular batch should be recorded and initialed on that batch ticket.
- Any water added to a batch after the batching procedure will be measured and documented (See placement site inspection requirements). Measurement using a clean, calibrated sight glass is acceptable.

Non-Agitated Concrete

Non-agitated concrete is often used for PCCP. In the instance that non-agitated concrete is used, it’s important to note that 45 minutes, as opposed to the standard 90 minutes, is the maximum time allowed for non-agitated concrete to be discharged. An example of this would be when a dedicated batch plant is built on-site or near a project requiring large amounts of concrete. The contractor may choose to do this for economy of scale and to shorten the haul route. If standard concrete trucks with agitation aren’t available or not chosen to be used by the contractor, either end dumps or articulated dump trucks (rock trucks) can be used to transport the concrete. It is critical that the trucks are kept clean, same as would be done for a standard concrete truck. When concrete is poured out of the end dumps, the concrete should have dimples in it and not flow out onto the grade, i.e. very low slump usually 1”-1.5”.

It is important that the complete plant operation be observed for addition of water other than in the batching operation. This is important to assure the maximum water/cement ratio is not exceeded.

The previously cited guidelines do not require full time inspection at the batch plant but it is advisable to have an inspector watch the operation during the first day's production and on all-important major placements.

No concrete should be placed except in the presence of the Concrete Inspector.

Some of the duties of this inspector are as follows:

- Check the batch ticket to see if the correct concrete has been delivered. (See Standard Specifications)
- Observe the discharge of all concrete for acceptability (slump, air, segregation, etc.). If concrete slump is too low, it may have additional water incorporated, followed by additional mixing. Care should be exercised to be sure the problem of low slump is caused by low water. There may be other reasons for a low slump that water will only make worse. For example: sand too fine, or inadequate mixing.
- Document any additional water added, mixing revolutions, temperature of concrete, and discharge times on the delivery ticket. The contractor should not be permitted to move concrete down the chute with a vibrator since this segregates the concrete as it flows.
- Document time each load is completed discharging.
- Document where each load of concrete is placed, and how much of the load is placed there.
- Take slump, air, and cylinder tests as specifications require, or as required to assure compliance of the concrete.

1006-2 Materials

1006-2.01 Hydraulic Cement

The contractor is required to state the type and sources of cement when he submits his mix design.

Refer to the Materials Policy and Procedures Directive Manual (PPD No. 13) for certification and acceptance of hydraulic cements and fly ash.

1006-2.02 Water

The contractor should identify the source when he or she submits his or her mix design. If the water is from a potable supply obtained from a public utility, no testing is required, however a memo stating this should be submitted to Materials Group. Water obtained from any other source shall be sampled and tested.

1006-2.03 Aggregate

(A) General Requirements

The production of aggregates meeting the specification requirements is the contractor's responsibility but this does not mean that the Engineer may divorce himself from all involvement in this phase of the work. There are numerous aggregate quality requirements that are not part of the acceptance testing performed during construction, but are performed annually by the supplier (see Table 1006-1). These tests were previously performed by the Department during bi-annual “pit checks.” Pit checks are no longer performed by the Department, but the requirement for documentation confirming conformance to the specifications remains. These documents should be on file (maintained by Materials Group), but if not on file, the contractor will need to provide these documents for the source materials prior to use in concrete incorporated into the project.

During aggregate production, the Engineer will periodically observe the production methods, the sampling and testing, and stockpiling and handling to determine whether the methods used will result in acceptable products. If the Engineer finds any shortcomings or problems he should discuss these with the contractor and document the details. The Engineer will not do production control testing; quality control is entirely the contractor's responsibility.

Aggregates must be inspected during production to make certain that they do not become segregated through improper handling or stockpiling practices, and that they do not become contaminated. Allowing equipment with steel tracks to operate on stockpiles will tend to break edges of coarse aggregate. This material filters down through the voids and may cause the lower portions of the coarse aggregate stockpile to be out of grading specifications due to the self-contamination.

Uniformity of moisture contents is essential in the production of a concrete mix of uniform consistency. It is necessary to have saturated aggregate and uniform consistency, particularly in bridge decks, to avoid shrinkage and finishing problems. In slip form concrete pavement, it avoids edge slumping, shrinkage of the concrete, and finishing problems. Aggregate which comes directly from washing plants should remain in the stockpile long enough so that no free drainage is visible when the aggregate is transported to the mixer. Aggregate proposed for use in concrete pavement should not vary in moisture content more than 3% in any one work shift if good slump control is to be maintained.

An excess of moisture may collect in the bottom of a sand stockpile. The bottom 1 foot of a stockpile cannot be used, unless the aggregates are stockpiled on a paved surface. If the contractor elects to reclaim the bottom of a stockpile, he will be required to do sufficient testing to be sure that the material conforms to the Standard Specifications; this may require much more testing than is needed when producing the aggregate originally.

Batch plants are typically equipped with moisture probes for estimating the moisture content in the aggregate and the control system may automatically adjust the batch water quantity (relative to saturated aggregate conditions). However, such moisture probes should not be solely relied upon for adjusting the amount of batch water. The contractor or supplier must sample the aggregate to confirm moisture content at appropriate intervals governed by existing conditions. If the moisture is known to be variable or if some event or production change affects the moisture, more frequent sampling may be called for. A reasonable frequency is one or two per day, if visual observation indicates little or no change.

1006-2.04 Admixtures

(A) General Requirements

The contractor has the option of using admixtures for adjusting time of set, adding air, or for reducing water in the mix. If the admixtures have not been used with the aggregates or in the quantities proposed, the contractor will have to test the admixtures using the proposed aggregates to determine the proper amounts to be used. Combining admixtures can result in undesirable effects that cannot be known without testing. Admixtures which may be included in the mix must be on the approved mix design.

The mechanical dispensing devices used for admixtures must be accurate to within narrow limits so they need to be carefully checked to see that they operate properly. Some admixtures are used at rates as low as 2 or 3 fluid ounces per 100 pounds of cement, therefore, it can be seen that the dispensing equipment needs to be accurate. Accuracy checks are made by actual measurement of the material as it is dispensed.

Admixtures may be used prior to testing provided an acceptable Certificate of Compliance has been received and is on file with the Materials Group. Refer to the sampling guide and the Standard Specifications. Most commonly used chemical admixtures are on the Department’s Approved Products List (APL).

(B) Air Entraining Admixtures

The contractor must add air entrainment when it is called for, but the air content shall not exceed 7% and temperature must be documented. If above the 3,000 foot elevation, concrete must have a minimum of 4% entrained air to protect against freeze-thaw induced damage.

1006-3 Design of Mixtures

1006-3.01 Design Criteria

Even though the following discussion is based on ADOT design procedures, the principles apply equally to designs by a contractor or a private laboratory. ADOT design procedures are covered in greater detail in the Material Testing Manual.

1006-3.02 Design Procedures

Approval of Portland cement concrete mix designs is described in the Standard Specifications.

Checking the mix design is essentially the responsibility of the Regional Laboratory; however, it is important that the project personnel are able to check mix designs and evaluate mix adjustments based on the design procedures. The Concrete Inspector should be able to perform the design calculations and to understand the relationships between the various design criteria.

Upon receipt of a concrete mix design submittal, the materials coordinator should confirm that all required information was included in the submittal prior to forwarding to the Regional Materials Engineer for review and approval (see section 1006-3.02 (A),(B) &(C)).

After the Regional Laboratory has checked the mix design, if sufficient compressive strength mix history is not available, a trial mix or test batch will be required to confirm slump and compressive strength, and entrained air if necessary. A test batch may also be produced to check the mix design against actual field conditions.

If it is found that the "test batch" does not give the correct slump and checking has shown that the water in the aggregates has been accurately accounted for and corrected in the field mix, then it may be necessary to change the amount of water or water reducing admixture dosage being used to obtain the specified slump.

Changes must remain within the specifications, mix design limits, and admixture manufacturer recommended ranges. If greater changes are needed, a new mix design will be required.

Water may not be increased beyond the water/cement ratio shown on the approved design. Once at the design water/cement ratio, only water reducing admixtures may be used to further adjust mix consistency (slump). Limited decreases in water are generally beneficial for mixes with typical water/cement ratios (should not be done for those with low water/cement ratios), but if the decrease is substantial, the mix design should be checked.

1006-4 Concrete Production

1006-4.01 General Requirements

Portland cement concrete is strength specified and there are penalties against the contractor if his product does not meet the strength requirements. Proper sampling, molding and curing of test cylinders is of the utmost importance. The specified procedures are to be followed without variation.

The anticipated strength is used by the designer to determine the strength characteristics of the structure. If the 28-day strength is below that specified or if the contractor's 7-day strength indicates that the 28-day strength may be lower than the anticipated strength, then an immediate study should be made to see if there is any deficiency in the materials, proportioning, or procedure. Low strength is usually an indication that something is not being done as it should be done and is an immediate signal for investigation. The District Office should be notified whenever low strength is detected. No adjustments for low strength should be made without District Office and Regional Lab approval.

The yield, as determined by form measurement, will normally be short from 3% to 5%. The reasons for this normal loss may be attributed to such things as spillage, loss of moisture and the fact that a mixer truck cannot be completely discharged. Also, when concrete is placed in the forms, expansion of the forms accounts for part of the loss. The mix will not be adjusted to correct for actual yield variations based on form volumes.

Remember that the discussion in this section is only a guide for the Resident Engineer to enable him to judge whether the contractor is controlling the mix using acceptable practices. The Resident Engineer is not to order any of the adjustments discussed in this section; control of the mix is wholly the contractor's responsibility. If acceptable procedures are not followed, the contractor should be notified and the conditions documented.

1006-4.02 Proportioning

There will probably be minor adjustments needed due to one or more of the following causes:

- Moisture content of aggregate being used.

- Variation in air content.
- Variation in slump.

All the variations can be corrected by field adjustments. However, judgment is needed to determine when to consult with the Regional Materials Engineer before allowing the contractor to make adjustments. Major adjustments may require the contractor to submit a new mix design (see 1006-3.03(A)(1))

The mix design is designed on the basis of an absolute volume of 27.00 +/- 0.05 cubic feet and aggregates in the saturated surface dry (SSD) condition.

All equipment should be inspected to assure that all scales, dials, metering devices, etc. are graduated within allowable tolerances and accurate as outlined in the specifications.

(B) Water

It is extremely important that the amount of water being used in the mix be known at all times; therefore, the water tank or water meter should be the first piece of equipment to be calibrated. This can be done by drawing off water and measuring or weighing the amount for different settings of the gauge or meter. Water valves should be inspected to make certain there are no leaks into the mix.

(C) Aggregates

The amount of mixing water will probably have to be adjusted to allow for the moisture content variations as the stockpiles are used. It is preferable that stockpiles are kept in a saturated surface dry (SSD) condition to minimize adjusting mixing water. The contractor should make moisture determinations at least daily or as often as conditions require.

Scales for weighing cement and aggregate should be inspected for condition of working parts and knife edges. Hoppers should be inspected to make certain that there is no possibility of leakage and that each hopper empties completely. Make certain that the cement hopper is equipped with one or more suitable vibrators as required by the Standard Specifications.

Batching scales must be checked and certified by the Weights and Measures Services Division (WMSD) before any production begins. Certified 50 pound weights furnished by the contractor or supplier should be available at all times for checking these scales. To check scales using these weights, use the WMSD approved procedure. If the scales are not accurate within the limits of the specifications, they should not be used until repaired or adjusted. The scales should be balanced several times each shift and should be retested when deemed necessary by the Engineer

(D) Admixtures

It should be noted that the Standard Specifications require that any admixture added shall be added by means of mechanical dispensing equipment. The inspector should examine and test the dispensing equipment to see that it functions properly and that the amount of admixture can be accurately measured and also that the amount of admixture used can be readily adjusted.

The mix design will show the amount of air entraining agent estimated to be required to give the specified air content. It must be realized, however, that the effectiveness of air entraining agents may be changed by the effectiveness of the mixing of the concrete. The mixing action of the particular mixer employed may have an effect on the amount of air entrained. The amount of air entrained by a large batch mixer or a transit mixer might be much greater or less than the amount obtained by a somewhat smaller mixer.

The amount of air entrained is also variable with the temperature of the mix. The effectiveness of the air-entraining agent is ordinarily decreased with higher temperatures or increased with lower temperatures. It can be seen that the amount of air entraining agent required in the field might be entirely different from the originally recommended amount.

After one or two tests have been made to determine the amount of air entrained, it will often be found necessary to increase or decrease the amount of air entraining agent used on future batches. After the correct amount is once determined, the same amount will usually continue to be satisfactory unless there is considerable temperature change or some other variation which might affect the results.

If it is noted during construction that a high or a low air content has been obtained, one or two check tests should be made immediately. If these check tests confirm the original result then adjustments should be made in the amount of air entraining agent used. Air meters sometimes get out of adjustment; to assure that results are correct, the air meter should be calibrated prior to each day's use.

There is one other factor which sometimes affects the quantity of air entraining agents required. Some of these agents have a tendency to settle or separate in the drum. Agitation of these materials is not required by the Standard Specifications, however, it is believed to be necessary in all cases to assure that the original quality of the material is maintained. The Engineer should therefore require such agitation at least once daily when the material is being used.

1006-4.03 Mixing

(A) General Requirements

Because the contractor is responsible for the concrete does not mean that the Resident Engineer is unable to reject material that is obviously improperly batched. Likewise, if batching equipment is malfunctioning, the Engineer has the authority to refuse the product. All information regarding improper batching or malfunctions of equipment must be carefully documented by the Engineer.

In order to assure that the contractor will be able to control concrete production, the Resident Engineer will have to inspect the batching and mixing equipment for proper operation including checking the weighing devices in actual operation.

Checking will begin with the stockpiled aggregates to see that the stockpiles do not become segregated and that intermingling of stockpiles does not occur. Adequate bulkheads or pile separation will prevent mixing as the piles are built and when material is removed. Spillover in batching bins is fairly common when the bins are loaded with an end loader. It is not unusual to find good stockpile control but poor control in the bins. While the Engineer cannot direct changes in the contractor's operation, they do have the authority to refuse to accept material that is produced when the equipment is not functioning properly. Whenever material is rejected because of faulty processing, it is important to be sure of what the mechanical problem is, what the effect on the final product is, and to carefully document all the details. It goes without saying that every effort should be made to induce the contractor to operate efficiently without getting into the position of having to reject the material being produced.

Alternatively, the supplier may participate in either or both the National Ready Mix Concrete Association (NRMCA) or Arizona Rock Products Association (ARPA) concrete production facility certification programs. Evidence of such certification in lieu of ADOT’s inspection must be submitted by the contractor prior to the concrete being incorporated into the project.

(B) Mixing in a Stationary Mixer

After the field mix has been determined by the contractor, the weights of each size of aggregate, cement, water, air entraining agent, and admixtures, if any, are usually given to the operator for posting on the scales. Any subsequent change in the weights due to a change in the proportions or a change in the free moisture content, should be posted, by the contractor, on the scale and copies provided to the operator. Each change should be noted in the inspector's records, with each one being dated including the time.

It is often useful to prepare a chart showing batch weight adjustments for changes in aggregate moisture content. The inspector can make a quick check of the changes needed to be made by the contractor to allow for variations in the moisture content.

Batching plants can be classified into three categories: manual, semi-automatic, and automatic. All three types are permitted under the Standard Specifications. The operator controls all the functions necessary to complete the weighing and dumping on the manual plant. This type of plant is subject to human error in every operation so it should be inspected carefully by the inspector. A semiautomatic plant is governed by controls that are actuated in a certain sequence to complete the batching cycle. An automatic plant has the complete batching cycle set in motion by a control button, which may be located remotely from the plant. Automatic plants are seldom encountered except at commercial concrete plants and large paving plants.

Dial scales or a load cell providing a digital printed readout is required for weighing all hydraulic cement.

(C) Mixing in Truck Mixers

A large percentage of the concrete placed in structures is mixed by truck mixers. This equipment is not usually permitted for mixing concrete for pavement principally because it cannot quickly discharge the low slump concrete which is required for pavement (Tilt-up type mixers are an exception). Truck mixers usually are satisfactory for structural concrete but require constant inspection of the operation. Instead of having one mixer and one operator to control, as in central mixed concrete, there may be a dozen or more truck mixers and operators, on a large job, where concrete is being mixed by truck mixers. Each truck mixer should be inspected occasionally for hardened concrete, worn blades, and water leaks. The inspector must see that no mixer is loaded beyond its mixing capacity as indicated on the manufacturer's plate attached to the mixer. Weighing trucks before and after charging is an excellent check on the accuracy of the plant.

Where feasible, and when the equipment is adaptable, the sequence of weighing and discharging the aggregates, cement, and water from the batch plant should be such that a small amount of water enters the mixer in advance of the other ingredients then followed by a blended "ribbon" of all the other ingredients, together with the remainder of the required water. Extensive research has proven conclusively that the "ribbon" method of charging a mixer contributes greatly to the uniformity of the concrete within any given batch. The transit mixers should be periodically inspected to confirm that the drums are free of water before being charged

The Standard Specifications require that each batch shall be mixed for not less than 70 and no more than 100 revolutions, at mixing speed, except that the maximum may be increased upon approval of the Engineer. Any revolutions made beyond the 100 specified as maximum are required to be at agitation speed.

Specification 1006-4.03(A) permits mixing at the plant site or at the delivery site. This specification has been interpreted to mean that mixing may also be performed while the truck mixer is enroute between the plant and the delivery site. Remember the maximum time limit for mixing to begin.

If it is necessary to add water to the mix at the site, it is required that the mixer shall be turned a minimum of 30 revolutions at mixing speed before the concrete may be discharged. The amount of water added, and the additional mixing time (or revolutions) shall be recorded on the concrete delivery ticket and, where appropriate, on the test report. This additional mixing may be in excess of the maximum revolutions previously specified. Remember that if samples are taken, they should be taken after all the water has been added.

Regardless of the type of mixer, the mixer drum should be inspected for worn blades or hardened concrete, rate of rotation, and mixing time. Each mixer is required to have a nameplate attached showing capacity and recommended speed of operation.

If truck mixers are used they are to be inspected at least annually, and the inspection will be documented per the Standard Specifications. Similar to concrete production facilities, suppliers may participate in the NRMCA or ARPA concrete truck mixer certification programs annually and provide evidence of such certification to the Department. However, at any time a truck mixer is observed to be deficient, it should be removed from the project until deficiencies are corrected and reinspected.

1006-6 Curing Concrete

Curing practices can significantly detract from, or enhance the long-term durability of concrete. Inspectors and Concrete Finishers usually don't pay close attention to curing practices and to concrete while it cures, but they should. Research has shown that the service life of concrete slabs, decks, pavements and walls is increased when proper curing procedures are followed. Given the high cost of replacing existing highway pavements and structures, the extra amount of time and effort spent on properly curing concrete can result in substantial cost savings over time.

Wet curing for 7 days is the most preferred method of curing (10 days for bridge decks and 14 days for high performance or silica fume concrete). Most contractors prefer to use liquid membrane curing since it is much less labor intensive. However, if given a choice, wet curing is preferred over curing membrane since the added water will promote hydration.

Both water curing and the liquid membrane forming method must be used for bridge decks. Historically, wet burlap was the typical practice for water curing, however more modern products are available and have been developed specifically for water curing that are easily applied and ensure ample water remains available during the entire duration of the wet curing process. These water curing products, without question, facilitate more complete curing and result in a much more durable concrete, and are the preferred medium for water curing.

It is vital that the wet curing process occur uninterrupted and curing membranes be applied thoroughly and remain undamaged for the required curing duration (number of curing days). A curing day is one during which the concrete temperature remains above 40 degrees F for the entire 24-hr period, or the ambient temperature in the shade remains above 50 degrees F for a minimum of 19 hrs. Refer to section 1006-5.03 for Cold Weather Concreting requirements and section 1006-5.02 for Hot Weather Concreting requirements. It may be necessary to embed temperature sensors throughout the structure, especially for bridge decks, to ensure adequate curing temperature is maintained.

1006-7 Acceptance Sampling and Testing

1006-7.02 Sampling and Testing of Concrete

In all cases, a diligent effort should be made to keep the consistency of the concrete within the range of slump and/or air as specified. However, when an occasional batch of concrete is found to have a slump or air content in excess of the maximum specified, corrective action must be taken.

Field tests will be made in accordance with the requirements of ASTM C143 on the concrete as it is discharged to determine the consistency in slump. One additional slump test will be made on a concrete batch that has failed to fall within the required slump range on the first test, unless the contractor elects to make adjustments in the slump. If adjustments are made, the concrete batch will be tested twice after such adjustments. In either case, the average of the two tests for that batch shall be within the required slump range and no single test shall be less or greater than the required range by more than one inch. Concrete that does not conform to the above consistency requirements should be rejected.

High slump concrete which has been placed prior to obtaining slump test results is subject to adjustment in price or removal based on the 28-day compressive strength obtained. An additional set of cylinders should be made to represent the load or portion of a load of high slump concrete placed. The location of the concrete in the structure and the quantity represented by the extra cylinders must be recorded.

Proper fabrication, handling, and curing of the cylinders are extremely important. All personnel responsible for any of the tasks relating to cylinders should be thoroughly familiar with the field procedures associated with the tests listed in Table 1006-9.

The relationship between the contractor's and ADOT's testing programs should be discussed at the preconstruction conference and just prior to the beginning of concrete work. The Engineer should request that if the contractor finds any fault with the ADOT sampling and testing procedures, he will be notified immediately. The contractor should also be clearly informed that he will be promptly notified in writing of any shortcomings in their procedures.

It should be apparent that ADOT project personnel doing testing must perform the tests in exact conformity with the prescribed test method. All inspectors performing concrete testing must be observed annually by the Independent Assurance Sampling technician or Regional Laboratory. The testing technique should be observed frequently and referee tests should be made often enough to assure that proper procedures are being followed.

Compressive strength is not the only measure of the quality of concrete. The compressive strength test does not measure actual field strength of concrete. Field curing procedures (Subsection 1006-6) are different from the test cylinder curing procedure. Field conditions, such as ambient temperature and relative humidity can vary, but test cylinders should be cured in a controlled environment.

Failure to meet the specified mix design criteria such as slump, air, mixing time, segregation, incorrect batching, unloading time, etc., may be sufficient reason for rejection regardless of any claim by the contractor that the concrete is acceptable because it will meet the strength requirement.

Sampling of fresh concrete mix for testing purposes, fabricating cylinders, or beams shall be in accordance with the Materials Testing Manual (Series 300 ASTM C172).

Some contractors and suppliers are doing independent concrete testing and are being observed by ADOT personnel. If the contractor performs the test they should be observed and documented noting whether test procedures conform to ADOT procedures. For example, early age compressive strength testing is the responsibility of the contractor unless ADOT requests for the contractor to accelerate their schedule for reasons beneficial to the Department.

1006-7.03 Acceptance Criteria

Concrete acceptance test results and verifications shall be evaluated for acceptance using the criteria established in this section.

The batch time is defined as the time at which cementitious material is combined with water or aggregate. Discharge from the truck mixer or truck agitator shall be completed within 90 minutes from batching. The Engineer may allow concrete placement to continue in excess of the 90 minutes if the concrete is of such slump, workability, and/or temperature that it can be placed without the addition of water to the batch. Additional discharge time shall also be allowed provided a hydration stabilizing admixture is shown on the approved mix design and has been included in the batch, subject to the following:

- The concrete remains of sufficient slump and workability to facilitate adequate consolidation during placement.
- The hydration stabilizing admixture conforms to the requirements of subsection 1006-2.04 of the specifications and retards hydration by a hydration stabilizing mechanism.
- The dosage rate is identified in the approved mix design, and the additional amount of batch to discharge time exceeding the 90 minute limit has been requested by the contractor for approval by the Engineer and acknowledged on the mix design by the Engineer.
- If during placement, the dosage range is identified in the approved mix design and the application-specific dosage and additional time has been requested by the contractor and approved by the Engineer.

The temperature of the concrete mixture immediately before placement shall not be less than 50 degrees F nor greater than 90 degrees F. The Engineer may allow concrete placement to continue in excess of the maximum temperature if the concrete is of such slump or workability that it can be placed without the addition of water to the batch. The Engineer may also approve concrete mixtures with a temperature less than 50 degrees F or greater than 90 degrees F if otherwise specified or pre-approved by a mix design that accounts for the temperature deviation. Otherwise, concrete that fails to conform to this temperature requirement will be rejected prior to placement.

For Air Entrainment Requirements refer to Table 1006-10 of the Specifications. Concrete placed above 3,000 ft. elevation must have sufficient air content to protect against freeze-thaw induced damage. For batches determined to have low air content, the supplier may add additional air entraining admixture at the project site, and thoroughly mix the concrete at mixing speed, to correct deficiencies in air content. This may be performed only once and acceptable air content must be confirmed by subsequent acceptance testing. If air content is initially high, the contractor may continue placement at their own risk and the concrete may be accepted only upon acceptance cylinders having attained adequate 28-day compressive strength.

Concrete that appears stiff or is of insufficient slump (workability) for the items being placed should be rejected. If the slump fails to meet the minimum stated on the mix design, the inspector may allow placement and the Engineer may accept the material upon adequate 28-day compressive strength test results, provided placement and adequate consolidation is observed and documented by the inspector, and upon removal of forms, no voids, honeycombing, or other evidence of insufficient consolidation is apparent. If slump exceeds the range stated on the mix design, in order to accept the concrete, cylinders must meet 28-day strength requirements, and the inspector must observe and document that no segregation (separation of the coarse aggregate from the paste) occurred during placement or consolidation of the concrete.

Insufficient or excessive air content, or issues with temperature or mix consistency (slump), should be reported to the contractor immediately to allow them to discuss with their supplier and make adjustments for subsequent batches as appropriate.

Excessive variability in slump and or air content is an indication of dry aggregate stockpiles. Provided batching is occurring as expected and quantities on the delivery ticket match the approved mix design, inspect the aggregate stockpiles for both adequate and consistent moisture content (saturated conditions are ideal). If concrete aggregate is dry or only slightly moist, it will absorb both mixed water and chemical admixtures which will adversely affect the properties of the freshly mixed concrete. Some specialty concrete produced with lightweight and highly absorptive aggregate require the aggregate to be presoaked (completely submerged in water) for 24 hrs or more prior to batching.

For Class S and Class B Concrete compressive strength acceptance, use the Table from section 1006-4.03(B)(2) of the Specifications - Adjustment in Contract Unit Price for Compressive Strength of Class S and Class B Concrete.

If concrete fails to meet compressive strength, depending on the class, application, and required strength, the concrete may be in reject and subject to removal. If subject to removal, the contractor has the option to core the concrete to confirm if adequate strength has been attained within the structure. This should be done in consultation with both Bridge Group and Materials Group, and typically must be performed within 45 days of placement.

Special considerations are required for handling, transporting, conditioning, and testing of core specimens. Be sure to confirm that the proposed methods for obtaining the cores are consistent with the requirements. Notify the lab that will be receiving and testing the core specimens so that they may provide guidance and make necessary preparations to receive the cores. Due to a required minimum conditioning period, the day of the week during which the cores are obtained matters; consult with the lab.

In some instances, the concrete may be subject to a reduction in unit price, but not be in reject, or may be in reject but of adequate strength to remain in the structure (as determined by Bridge Group). In such an instance, the contractor may not elect to core the concrete in question. The contractor may only request to core the structure when the compressive strength of the acceptance cylinders is found to be inadequate by Bridge Group and would otherwise result in removal of the concrete/structure in question.

It is preferred to avoid coring the structure when possible. If cores are obtained, core test results replace the 28-day compressive strength for determination of payment. If hold cylinders are available, these may be broken at 56 days to confirm adequate strength, however, the 28-day compressive strength is used for determination of any reduction in bid item price unless the hold cylinders were broken in lieu of obtaining cores. Note that there is a maximum reduction in price of $150 per cubic yard of concrete that may be applied. Also note that cores of properly placed and adequately consolidated concrete typically break at a higher strength than do properly fabricated cylinders.

1006-7.04 Sampling Frequency for Cast-In-Place Concrete

The inspector should refer to Section 1006-7.04 of the Standard Specifications and the Acceptance Sampling Guide for Portland Cement Concrete prior to testing and sampling concrete. Field tests vary for the class of concrete and the amount of concrete being placed. In any case, the inspector and contractor’s personnel should coordinate and agree to a consistent sampling location and procedure in order to avoid as many discrepancies and arguments as possible.

1007 RETROREFLECTIVE SHEETING

The material specified in this section is used on signs and markers and is intended to provide good visibility during day and night. The sheeting must be on the Department's Approved Products List (APL). The current APL is available on the Internet from the Research Center, through its Product Evaluation Program (PEP) program. Certifications and test reports furnished by the contractor should be submitted to Traffic Design for review and acceptance (refer to Section 608 of the Standard Specification).

The Engineer must conduct inspections of the sheeting in the field to verify that:

- The correct type of sheeting is used
- It adheres properly to the support
- Colors, reflectivity are uniform, and meet reflectivity requirements
- It is free of dirt, scratches, and other unacceptable conditions

When sheets from different production runs are used on the same panel, there may be an obvious difference in color or reflectivity that is not acceptable. All surfaces of panels to be covered with retroreflective sheeting shall be prepared in accordance with the recommendations of the sheeting manufacturer (refer to Section 608 of the Standard Specification).

Bubbles and loose corners or edges are not acceptable.

All sheeting shall be applied on flexible delineators in the factory by the manufacturer. Field application of reflective sheeting on flexible delineator assemblies should not be allowed unless approved by the Engineer. If the sheeting has been damaged in any way, the damaged flexible delineator post shall not be installed, and the contractor will need to provide and install a new undamaged device at no additional cost to the Department.

1008 PRISMATIC REFLECTORS

This section covers the material requirements for reflectors used on delineators, reference markers, object markers, snow markers, and milepost markers, letters, symbols, etc. on signs.

When used in arrays, such as for letters or numbers on a sign, all the reflectors are to be from the same manufacturer. Reflectors from different sources that vary in brightness or color and do not present a uniform appearance are not acceptable. The use of reflectors in delineators and markers is discussed in Standard Specification Section 703.

The devices should exhibit good workmanship and shall be free of burns, discoloration, cracks, or other objectionable marks which would affect appearance or serviceability.

The prismatic reflectors in button-copy signs should be attached to the frame of the letter.

Certificates of Compliance conforming to the requirements of Subsection 106.05 of the specifications shall be submitted for approval. Additionally, the contractor shall provide detailed manufacturer's information, specifications and application guidelines.

Samples of each device shall be supplied for testing if requested by the Engineer. The Engineer and contractor shall field verify the locations, necessary lengths and quantities prior to materials being ordered. Item lengths and quantities shall be adjusted as necessary.

<u>1009 ASPHALT RUBBER MATERIAL</u>

1009-2 Materials

Certificates of Compliance are required. The inspector should verify that the certificate confirms the rubber is a crumb rubber derived from materials listed in the Standard Specifications and no waste products were generated during processing.

1009-2.02 Asphalt-Rubber Proportions

Asphalt rubber shall contain a minimum of 20% ground rubber by weight of the asphalt cement. The inspector should check the proportions to ensure the required amount of rubber material is being incorporated into the asphalt-rubber mixture and is documented by the contractor.

1009-3 Construction Requirements

1009-3.01 Mixing of Asphalt-Rubber

The temperature of the asphalt cement shall be between 350 °F and 400 °F at the addition of rubber. The inspector should review Section 1009-3 of the Standard Specifications for other requirements regarding mixing of asphalt-rubber. The inspector should also check the contractor's operation for compliance and that all information can be determined by temperature measuring devices on the storage and mixing tanks.

Prior to production, the inspector should review the contractor's proposed form for recording all the information that is required in Section 1009-3 of the Standard Specifications to ensure that all the information is included. Each batch of asphalt-rubber material should be produced so that all the requirements may be determined by the contractor's documentation. The contractor's documentation should show all the requirements needed for each batch of asphalt-rubber.

1009-3.02 Handling of Asphalt-Rubber

Once the asphalt-rubber has been mixed, the contractor's documentation should contain information that each batch of asphalt-rubber material is handled in accordance with Section 1009-3 of the Standard Specifications. Temperatures should be spot checked during the shift by the inspector.

1010 DRAINAGE PIPE

Certificates of Compliance (COC) for culvert pipe materials need to be carefully compared with the requirements of the Standard Specifications. Each type of culvert material may be covered by several Standard Specifications each of which must be cited in the certificates. Chapter 5 contains additional information on pipe culvert and storm drains.

An exhibit of the different gauges may be seen in Section 1325 of this Manual.

General types of pipe include: Metal Corrugated Pipe, Spiral Rib Metal Pipe, Concrete-Lined Corrugated Metal Pipe, Thermoplastic Pipe, Slotted, etc.

Thermoplastic Pipe includes CHDPPP, HDPE, PVC, etc. Thermoplastics often include polyvinyl chloride (PVC), polyethylene (PE), and polystyrene (PS). An inspection will be done for the thermoplastic pipe 30 days after installation before placing pavement. Pipes can be checked for deflection using a mandrel or laser to verify the pipe size. Pipe inspection shall be performed in the safest manner possible, i.e. no manual inspection for pipes 24” or less in diameter. Pipes 30” or greater inches may be entered following OSHA requirements, and deflection levels may be measured directly.

Reinforced Concrete Pipe (RCP) should be ADOT stamped on the side of the pipe prior to delivery. If it is not, then follow the steps below prior to rejecting the pipe off site.

- ADOT Materials Group, Structural Materials Section, must receive a call from the pipe manufacturer to inspect the RCP ahead of time. It's common practice to have ADOT inspect/stamp prior to shipment.
- ADOT Structural Materials Section must observe load testing (D-Load) in order to verify pipes met AASHTO M 242 for load strength/cracking - 1 test per 100 joints per size and per class needed. Also dimension tolerances are verified at the time of casting.
  - Per 1010-6, Reinforced concrete pipe (circular) shall conform to the requirements of AASHTO M 242 for the D-load specified.
  - Reinforced concrete pipe (circular) shall conform to the requirements of AASHTO M 170 for the class of pipe specified.
- For each pipe installed, the pipe must correlate to the approval date range listed for the tested pipe’s representative lot.
- Certificate of Compliance (COC) needs to show class, type, quantity of which the cert is good for. "Per contract plans" for quantity is not specific enough.

Tracer wire, will be required for non-metallic pipe such as corrugated high density polyethylene plastic pipe (HDPE), steel reinforced high density thermoplastic ribbed pipe, corrugated polypropylene plastic pipe (PP), vitrified clay pipe (VCP), and for polyvinyl chloride pipe (PVC) 2 inches in diameter and larger. Tracer wire will be required where the metallic component is encased within the pipe, such as reinforced concrete pipe (RCP), rubber gasket reinforced concrete pipe (RGRCP), and steel cylinder concrete pipe which is to be placed in the trench with the corrugated high density polyethylene plastic pipe, steel reinforced high density thermoplastic ribbed pipe, or corrugated polypropylene plastic pipe as an aid in location after burial, shall conform to the following requirements;

Tracer wire shall be solid copper wire, American Wire Gauge (AWG) No. 12 or larger. Tracer wire shall be coated with a minimum 30 mil polyethylene jacket designed specifically for buried use. Tracer wire shall conform to the specifications of the NEC, UL, and other applicable industry standards. Splices as required to promote continuity shall utilize sealed water tight connections.

1011 JOINT MATERIALS

The items included under this section are rubber waterstops, PVC waterstops, joint sealant (hot poured), joint sealant (cold application), bridge deck joint seals (neoprene), preformed expansion joint filler, bituminous joint filler, non-bituminous joint filler, cellular plastic joint filler, and silicone joint sealant.

Certificates of Compliance are required for all joint materials. Each type of joint material will have installation procedures recommended by the manufacturer which are to be carefully followed. A copy of the recommended procedures furnished by the contractor are to be included in the project records along with a statement that the material was installed as recommended by the manufacturer. Compare the certification with the specification requirements to be sure that the certification is complete. Also refer to the Sampling Guide Schedule in the *Materials Testing Manual (Series 100 ARIZ 110)* for instructions.

The specification for Bridge Deck Joint Seals (compression & strip seals) requires that one piece of the material shall be furnished 18 inches longer than needed. The extra material is cut off for a test sample.

1012 GUARDRAIL MATERIALS

The AASHTO - AGC - ARTBA "Guide to Standardized Highway Barrier Rail Hardware" is available on the ADOT website under Barrier Design Information. Additionally refer to MASH barrier design.

Reflector tabs made by stamping from galvanized metal sheets is acceptable. The ungalvanized edge is not considered detrimental to the nonstructural tabs.

Post and block inspection for appearance and physical characteristics is a project responsibility.

Rail elements including bolts, nuts, and washers, shall be galvanized after fabrication, with fabrication to include forming, cutting, shearing, punching, drilling, bending, welding, and riveting.

1013 BEARING PADS

The Standard Specifications, Section 1013, describe several different types of bearing pads including but not limited to elastomeric, preformed fabric, etc. It is important to note the type called for in the plans and to read the appropriate Special Provisions and Standard Specifications. All types must be sampled on varying schedules, and all require manufacturer's certification. ADOT will select the pads to be tested at random - the sample shall consist of at least one bearing from each size and material batch lot. The Contractor is responsible for assuring that the pads are tested by a lab approved by ADOT, and provide the results to the Engineer

Bearing pads should be visually inspected for workmanship and conformance to design tolerances. They should be free of damage from weather, handling or other hazards. At the time of installation, they should be clean and free of contaminants.

Installation at the proper position and orientation are critical. A copy of the bearing layout is to be provided to the Engineer. Bearing surface must be clean and free of all loose materials before placing the bearing pad. Pads must be set only on concrete surfaces which have been properly prepared in accordance with the Standard Specifications

Section 601 discusses the construction requirements. Very little is said about bearing pads in Section 600 of the Standard Specifications. The Project Plans and Special Provisions specify the installation requirements. The Special Provisions may talk about material requirements for bearing pads not covered by Section 1013.

1014 GEOSYNTHETICS

Section 1014 of the Standard Specifications describes several different types of geosynthetics and their uses. It is important that each be used for the specific purpose specified.

Certificates of Compliance are required before the material is incorporated into the work. Materials should be sampled and submitted for testing to the regional laboratory. All materials should be visually inspected to see that they were shipped and handled in accordance with manufacturers' instructions and that care has been exercised to prevent damage. Materials should be free from tears and other obvious defects.

Materials should be installed in accordance with specifications and with the manufacturers' recommendations. Care should be taken to ensure proper overlaps, when appropriate, and anchors or staples should be installed properly. Wrinkles should normally be avoided. Geosynthetics must be installed over properly prepared surfaces. Most materials can be damaged by heavy equipment running directly on the fabric, and should be backfilled with care.

If material has not been pre-approved, a Certificate of Analysis is required and one sample (if requested by the Engineer) for every 10 rolls per lot. (Minimum of one sample per lot.) Samples shall not be taken within 5 feet from either end of the roll, and shall be at least 6 feet long by the full width of the roll.

1015 EPOXY RESIN ADHESIVES

1015-1 General Requirements

While most epoxy resin adhesives utilized by contractors on projects can be found on the ADOT Approved Products List (APL), there are instances in which non-APL materials can be substituted. These materials need to be approved by the Resident Engineer prior to use on the project, and need to be accompanied by all the required documentation listed in the specifications. This review should be done with input from the applicable ADOT design section or the consultant design engineer.

All adhesives shall be made up of two components that, when mixed per the manufacturer's requirements, react with each other to produce the adhesive's properties. The Inspector should make sure that the product's packaging is not damaged, that it is stored properly, and that the material has not expired prior to its use, all things which will compromise the adhesive's efficacy. Any material compromised in any of these fashions cannot be utilized.

1015-2 Anchoring Adhesives - Steel to Concrete

Structural Application

When used in a structural application, epoxy resin adhesives not only need to meet the chemical properties of the project's specifications, but they also need to be rated to meet the strength requirements of the project's design. These strength requirements should be outlined in either the project's plans or specifications.

It is important that the contractor submit the product's testing data produced by the International Code Council Evaluation Service (ICC-ES) for the Resident Engineer's approval and not just the product's marketing brochure. These reports are easily accessible online and provide independently-verified testing data for the products in question.

APPROVED PRODUCTS LIST

The Approved Products List (APL) is a list of products that are used in the construction and maintenance of the State's highway system. The APL process begins by manufacturers submitting products for testing. Once the products are tested, the Product Evaluation Committee decides whether they are suitable for highway use. When a product has been approved it is added to the APL.

The APL does not eliminate field testing requirements that are specified in the Standard Specifications, the Materials Group Policy and Procedures Manual, or the Special Provisions for each project. If a Contractor submits a product that is not on the APL, then it is left to the discretion of the Engineer to show that the product is of equivalent value before use. 1101 GENERAL INSTRUCTIONS

The intent of this chapter is to present a series of guidelines and staking methods which will assist field personnel in construction surveying.

Additional information should be sought in the ADOT Engineering Survey Services Manual for Field Surveys. The Manual will explain how and when different survey methods and instruments should be used. All transits, theodolites, etc., will be referred to as instruments in this Manual since they are thoroughly discussed in the Engineering Survey Services Manual for Field Surveys. The Manual also illustrates field book notation and how electronic data files should be handled.

The methods for note preparation and staking procedures outlined in this chapter are presented only as acceptable methods of doing the work. The method selected for each phase of the construction survey must be determined by the Resident Engineer and the contractor in conjunction with the Surveyor as each project may vary considerably in requirements.

Construction survey work should start before construction operations begin in order to avoid delay in the contractor's operations. It is very important that the Resident Engineer and their staff acquaint themselves with the contractor's staking plan and give the contractor formal approval before any staking begins. The contractor's staking plan should be referenced throughout the project to assure that the contractor is following this plan.

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1102 CHECKING OF PLANS

As soon as approved construction plans are available, and before any staking is started, these plans should be checked by the Survey Supervisor or Office Supervisor as directed by the Resident Engineer.

The following checklist is included to assist the checking procedures:

- Geometrics:
  - All parts of the plans pertaining to control such as curve data, both horizontal and vertical, must be checked.
- Roadway plan and profile sheets:
  - Location of all existing utilities
  - Correct stationing for all crossroads, etc.
- Structural sheets:
  - Check elevations from finish grade to bottom of footings on all major structures
- Drainage plans:
  - Catch basin locations and elevations
  - Storm drain conflicts with sewer or irrigation lines
  - Pipe location and slopes
- Signing and lighting sheets
- Pavement Marking and traffic signal sheets
- Right-of-way plans
- Standard Drawings and Notes on plans
- Special Provisions

1103 FIELD BOOKS

1103-1 General

The preparation of field books and recording of field measurements are important parts of the survey operation. Keep in mind, these notes may serve as an official source document and basis of payment to the contractor.

All field notes shall be recorded in standard field notebooks unless an electronic data collector is used. Never use loose-leaf books or pads for permanent records. Neatness and clarity are of utmost importance in the preparation of field notes. When preparing notes, provide sufficient detail and information to enable those who are not familiar with the project to easily understand what has been documented. Too much detail is far better than too little. Never crowd survey notes; paper is relatively cheaper than rework if your notes are not legible.

Errors made in recording field notes should never be erased. Draw a line through the erroneous figures and place the corrected figures directly above. When necessary to make revisions in notes, the abandoned notes should not be destroyed but crossed out and reference made as to the book number and pages where revisions appear. When corrections are made, the individual making these should date and initial each change.

Each book should have pages numbered only at the top of the right hand sheet and the contents indexed on the first page. The date, weather conditions, and survey crew personnel shall be shown at the beginning of each day's notes. The person in charge of making the survey or recording the measurements shall sign the All construction records shall be plainly marked for identification with the contents, route, project number, stations, name of engineer, and year. They shall be turned into project records when complete.

Survey data may also be collected using an electronic data collector. When survey data is collected electronically, it should be turned into the Transportation Engineer Team Leader on the digital copies. It may also be appropriate to send a copy to CADD/Mapping. Refer to ADOT Engineering Survey Services Manual for Field Surveys for additional information.

1103-2 Transit Book

Before staking is started, and after checking of plans and control points, a transit book shall be prepared. A well-prepared transit book is a valuable tool to the staking party.

Avoid confusing information by crowding notes. Leave sufficient room so that the survey party may record other pertinent information. An accepted method of listing information in the transit book is as follows.

From the plans, obtain the engineering station at the beginning of the project. This station number shall be inserted in the first column on a line near the bottom of the third or fourth left hand page from the front of the field notebook. Next, list the stationing up the page consecutively from the beginning station on about every fourth or fifth line. Then enter the station of all transit points shown on the plans, such as point on tangent (P.O.T.), point at intersection (P.I.), point of curvature (P.C.), point of tangency (P.T.), or in the event of spiral curves; tangent to spiral (T.S.), spiral to curve (S.C.), curve to spiral (C.S.), spiral to tangent (S.T.), and alignment equations at the proper place in the book according to station number. After all stationing and control points are in the book, enter all basic information pertaining to the main curve and spirals on the left hand page, opposite the P.I. station of the main curve. The right hand page shall be used to diagram any reference ties opposite the appropriate station of the left hand page. The centerline station of any structure, right-of-way marker or other tie should be indicated in the book in order that these points may be established as the line is being run. Compute all curve deflections and notes just to the right of the station to which they apply. The first chord of the curve or spiral shall be the distance from the P.C. or T.S. station to the first even station or plus 50 feet station. Curves shall be computed using chords with a maximum of 50 feet in length. Any curve greater than 6 degrees shall be run with 25 foot chords or shall be run using 50 foot chords with the necessary chord correction applied. These corrections may be obtained from most survey texts.

1103-3 Grade Book

The grade book is prepared in order that the survey party may readily provide the contractor with the necessary construction grades to properly construct to the requirements of the plans.

This book shall contain all computed and checked grades necessary to provide elevations for cross sectioning, staking of structures, blue topping, and any other elevations necessary to complete the project. Centerline ground elevations should also be shown.

Grade elevations should be computed along the roadway centerline at a maximum of 50 foot intervals and recorded in the grade book. Grades should also be computed and recorded at intermediate stations necessary to facilitate the staking of structures and at other breaks necessary

in cross-sectioning.

The type of design relative to your project can be readily obtained from the typical sections shown on the project plans. All points of change in transverse crown, slope or super-elevation, as indicated on the typical sections, should be recorded in the grade book.

Extensive checking of vertical alignment, including vertical curves, should be done before the grade book is prepared.

Begin at the top of page three at the left hand side, with the station of the first grade break back at the beginning of the project and enter all stations and plus 50 foot stations down the page, leaving one space between each entry. In the column just right of the stationing enter the vertical curve data, such as length of curve, percent of grade, beginning and end of curve and indicate P.I. of vertical curve. In the third column enter the tangent grade elevation as computed from the plans.

The fourth column is reserved for the computations of the vertical curve corrections for each station in the curve. Column five will contain finished grade elevation which is the tangent grade plus or minus the vertical curve correction. Column six will indicate the subgrade elevation. This elevation is the finished grade elevation minus thickness of base and surfacing material. Base and surfacing material thickness changes may also be noted in this column.

The right hand side of the book shall contain rate of superelevation as indicated on plans, beginning and end of transitions or super-elevations, rate of crown or slope and any other information necessary in staking a project.

1104 ALIGNMENT CHECK AND REFERENCE POINTS

All centerline control points set by Department location survey crews should be located and properly referenced in order that they may be re-established at any time during construction. A proper method of referencing these points is indicated on Exhibit 1107-1, Reference of Control Points.

As centerline control points are being established and referenced, the construction survey centerline should be staked. Stakes shall be driven on the centerline, with the station marked on the side facing the initial station of the survey. On tangents, stakes shall be placed on even stations and plus 50 foot stations. On curves it may be advisable at times to stake at 25 foot intervals. The beginning of curve (PC), end of curve (PT) and all station equations shall be staked as well.

1105 PRESERVATION OF MONUMENTS AND MARKERS

1105-1 General

Horizontal and vertical survey controls have been placed at numerous locations throughout the State by several Federal agencies. These controls are survey monuments in the form of a concrete monument or an iron pipe with a brass cap. These agencies are: The Bureau of Reclamation, Army Map Services, Corps of Engineers, Forest Service, U.S. General Land Office, Geological Survey, and the Coast and Geodetic Survey; markers of the last three being those most frequently encountered federal markers. There are also survey markers set by state, county, city and other local jurisdictions and by utility companies and professional land surveyors in the private sector. These could be brass caps, iron pipes, steel bars, rebar or just a railroad spike or large nail.

Every effort must be made to recover, protect, and preserve all such monuments, whenever and wherever found. Federal and State laws provide penalties for the negligent disturbance of all such markers and monuments. As provided in ARS 33-103 such penalties may also include the cost of surveying to reestablish the monument or marker and as a result can become very expensive.

Location crews, as a part of their preliminary engineering activity, will have located and made ties to all monuments which they were able to locate in the vicinity of the proposed work. In the case of U.S. Geological Survey or U.S. Coast and Geodetic Survey monuments, the Chief Surveyor for Construction will have made arrangements for their relocation. This relocation will be accomplished by the Federal agency involved and/or Photogrammetry and Mapping Services prior to the beginning of any construction activities. These crews make diligent efforts to locate all in-place monuments but occasionally one may be overlooked. Refer to subsections 1105-2 and 1105-3 of this Manual in the event that construction crews locate a monument within the highway right-of-way or in an area where construction activities may disturb the monument and it has not been previously referenced.

1105-2 Monuments, Except U.S.G.S. or U.S. Coast & Geodetic Survey

If the marker is outside the proposed roadway prism, reference and erect suitable protective devices and flags to insure against disturbance during construction activities. Should it be disturbed, reset in the original position upon completion of the project.

If it is outside the proposed paved area but within the roadway prism, establish witness corners which will enable relocation of the marker position at any future time. These points shall be iron pins approximately 18 inches in length, embedded in concrete. By use of an instrument, set up over the original marker, locate two witness corners on a straight line passing through the original marker. Locate the other two corners similarly on another straight line turned 90 degrees off the first line. Three points shall be set at a location where they will not be disturbed during construction activities. An accurate measurement from the monument to each witness corner must be made and the distance to each recorded as a permanent project record. Send a complete diagram of the referenced monument to ADOT's Engineering Survey Section. The monument and its references shall be tied to the survey centerline stationing of the roadway.

If the original monument is within the proposed paved area, it shall be preserved with a Standard Drawing C-21.10 Survey Monument and Cover. If the original corner is one established by the U.S. Land Office, the following procedure shall be used: If a stone, encase in concrete, leaving the top exposed, drilling a small hole in the stone to mark the true point. If an iron pipe with a brass cap, imbed a portion of the pipe in concrete, letting the original brass cap substitute for the one indicated in Standard Drawing C-21.10. The brass cap shall be oriented to read from south to north.

1105-3 Monuments, U.S. Geological Survey and U.S. Coast & Geodetic Survey

In the event such a monument has been overlooked every effort must be made to protect it in its original location. Immediate notice of location of the monument must be sent to the ADOT Chief Surveyor for Construction, giving a detailed description of the marker. Enclose an impression of the marker obtained by holding a sheet of paper tightly over the face of the disk and running a soft lead pencil across the area until the imprint is transferred. The Chief Surveyor for Construction will make the prompt reply as to the action which must be taken.

1106 CHECK LEVELS AND BENCHMARKS

Check levels must be run to verify the elevations of the bench marks shown on the plans. Check levels shall begin at the nearest original benchmark just outside the beginning station of the project. Bear in mind that all benchmarks are turning points, and it is important that the level person turns through each bench as they are being checked. It is equally important that the rod person is provided with a peg book to check with the level person throughout the procedure of the work.

At the time check levels are being run, establish all necessary construction benchmarks. See Exhibit 1107-2 for a typical example of check levels. The benchmarks, set on the location survey, establish the vertical control of the construction projects.

The plans show all location benchmarks, but they are too far apart and not established at strategic places for construction work.

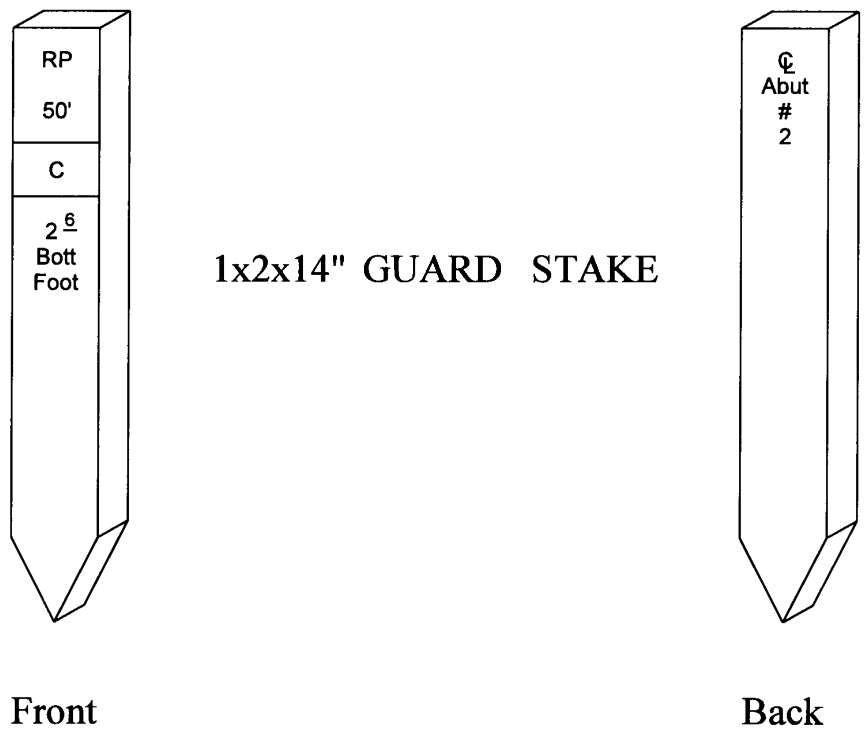
The following are a few established practices that can be performed at the time check levels are run that will expedite the staking of a project:

- Establish a benchmark at each end of a large structure; one bench mark at the high ground elevation and one at the low ground elevation of the structure. One bench is sufficient for a small structure.
- Establish benchmarks at frequent intervals and convenient locations for checking during cross-sectioning and setting of blue tops. As a general rule, a maximum of 500 feet between bench marks should be observed.
- In rough terrain, establish benchmarks at points of change from cut to fill and vice-versa or at high points of fill.
- Establish new guard stakes at all old benchmarks and all newly established benchmarks. The back face of the guard stake will be marked with the abbreviation "B.M." and the B.M. number. The inside face will bear the actual elevation of the benchmark. The guard shall be driven over the bench mark at a slant with the inside face of the guard facing the iron pipe.
- In placing new benchmarks, a sound, firm ground location should be sought and a 5/8 in. X 18 in. or 24in. iron pin driven into the ground allowing approximately 2 inches to protrude. See Exhibit 1107-3 for marking of B.M. stakes.

1107 CONSTRUCTION STAKES

Throughout the work, the Surveyor should see that survey stakes are always provided far enough ahead to enable the contractor to plan his work. The location and message transmitted by these stakes shall be recorded so that the stakes may be easily replaced if destroyed.

Use a permanent marker to mark all stakes. All writing on stakes shall be large enough for easy reading. Stakes shall be driven firmly into the ground.



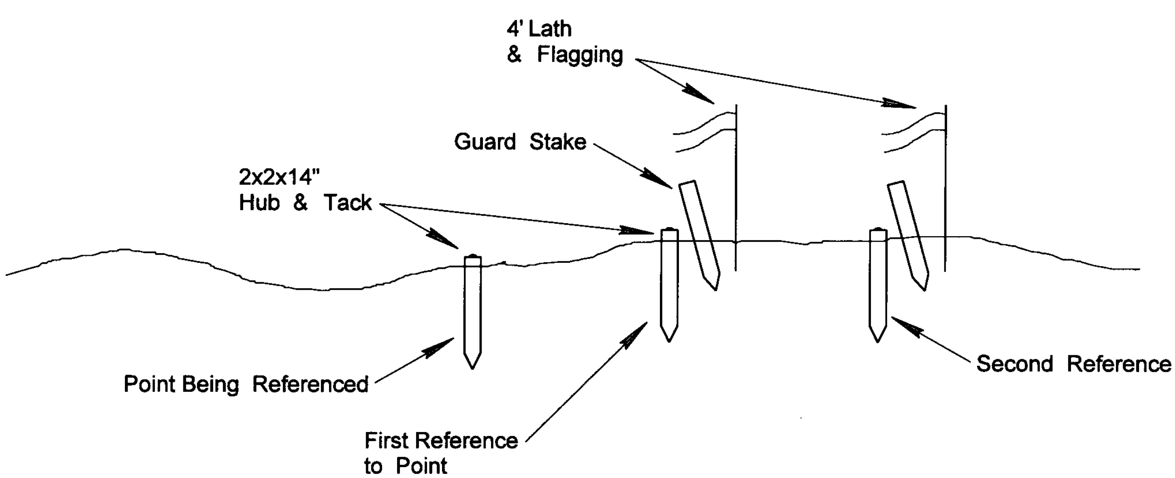
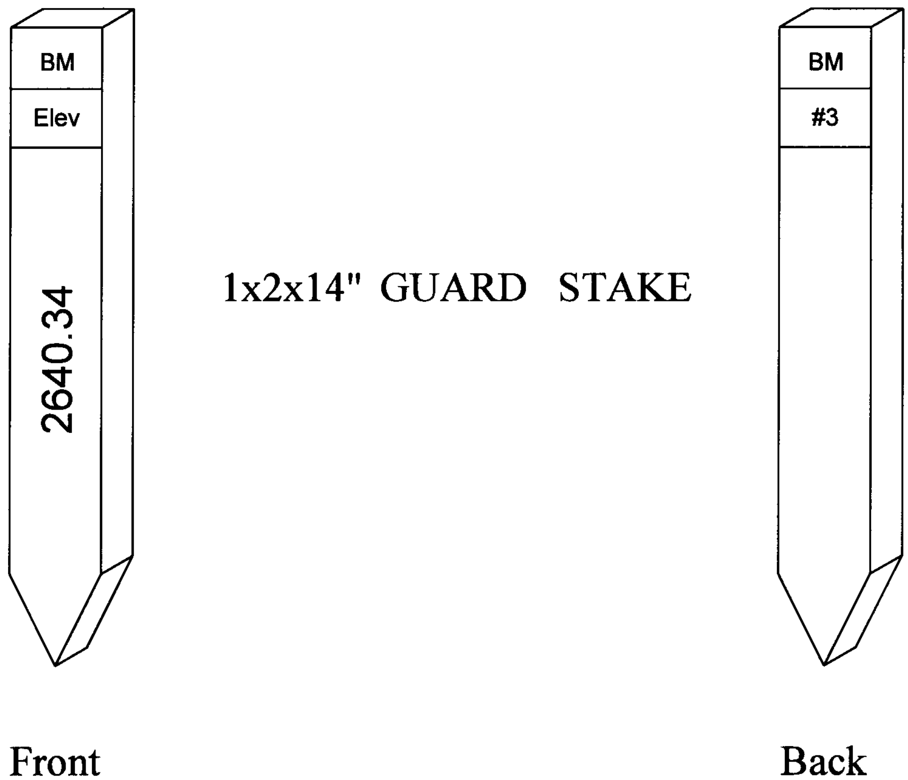


Exhibit 11071. References of Control Points

LOC	BS (+)	HI	FS (-)	ELEV	
BM #1	4.72	951.44		946.72	USGS BM Brass Cap in Conc 125' Lt Sta 127+50
TP	3.75	44.58	10.61	940.83	
TP	2.18	38.03	8.73	935.85	
BM #2	5.26	35.92	7.37	930.66	5/8" Iron Pin & Guard 100' Lt Sta 132+00
TP	4.61	32.56	7.97	927.95	
TP	0.21	21.64	11.13	921.43	
BM #3	9.20	20.49	10.35	911.29	5/8" Iron Pin & Guard 100' Lt Sta 137+00
TP	11.67	29.87	2.29	918.20	
TP	12.01	40.53	1.35	928.52	
BM #4			0.39	940.14	5/8" Iron Pin & Guard 100' Lt Sta 142.00
Σ (+)	53.61	Σ (+)	60.19 -53.61	946.72 -940.14	
		Diff	=6.58 ✓	=6.58 ✓	

Date 1-15-83

Exhibit 11072. Check Level Book



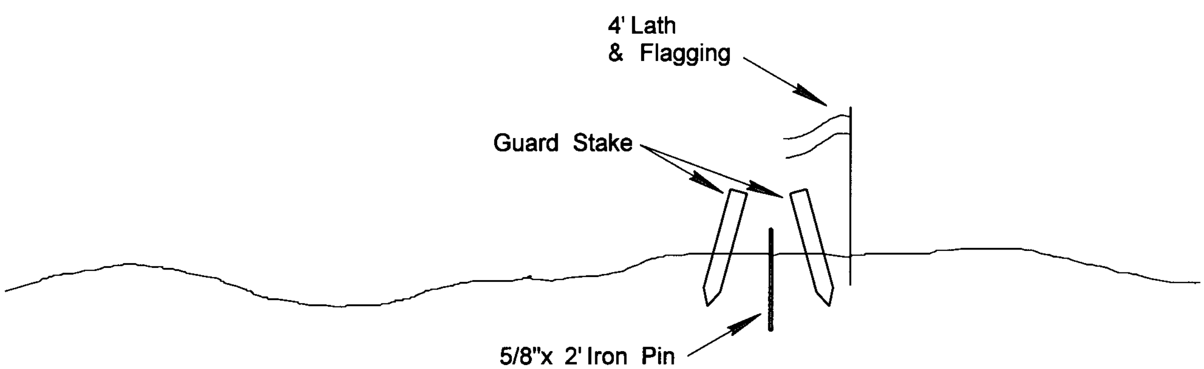


Exhibit 11073. Benchmark Stakes

1108 STAKING STRUCTURES

1108-1 General

Considerable preliminary paper layout work and computing can be performed in the construction field office before ground layout of structures is started. The extent of the preliminary work will depend on the complexity of the structure.

Generally speaking, there are three distinct types of structures which will require staking. They are pipe culverts, concrete box culverts, and large bridge type structures. The following subsections are guides which may be used in the layout of these structures.

1108-2 Pipe Culverts

A study of the normal flow of the drainage should be made before staking is done. It is always possible that the normal drainage pattern may have changed between the time of design and construction which may require a change in the location of pipe culverts.

If possible, all pipes should be staked with length and alignment and verified prior to the contractor placing his order for the pipe.

In staking pipe culverts, in order to attain proper placement of the pipe, it is often necessary that the roadway sections adjacent to the pipe be slope-staked. If this practice is employed, no error should occur in length or proper placement of the pipe. In the event that the slope staking cannot be done, the distance that the pipe should extend each side of centerline may be determined by plotting the pipe and the road, the cross-section at the structure location, and scaling the distance from centerline to each end of the pipe.

The centerline station through which the centerline of the culvert pipe will pass is located and marked with a stake or guinea. Set the instrument on this point, take a sight tangent to the centerline and turn the required angle for the centerline of the pipe. Along the line thus established, measure off the culvert lengths right and left of centerline and place a hub at each end of the pipe location.

After the two ends of the pipe are established, references to these points are set. If there is an inlet or outlet channel, or both, the pipe should be referenced to the sides. If no channel excavation is necessary, it is possible to reference straight out from the ends. With an elevation from the nearest benchmark, determine the elevation of the top of each reference hub, and compute the cut or fill from it to the flow line point at each end of the pipe. Behind each reference hub, set a guard stake on which has been marked the hub's identity, the offset distance, and amount of cut or fill from the reference hub to the flow line point.

Take necessary notes and make structural excavation diagrams in order to compute structural excavation. If drainage excavation is required, the inlet and outlet channels should be slope staked at the time the pipe is staked, see Exhibit 1108-2-1.

When elevations are provided to the contractor for setting of pipe, or for any points on any structure, the level notes should record the bench mark elevation. The level circuit notes should always show closure on the same, or another, B.M. The purpose obviously is to reduce the chance of error.

In addition to pipe culverts, long horizontal pipe runs will also be staked for construction. These runs may go from manhole to manhole or to catch basins. These grades must be checked using manhole or catch basin inverts as the control and figuring the grade in between the structures. Pipe should be staked on an appropriate offset line at no greater than 50 foot intervals. Where flow is critical, such as in sanitary sewer installations, then pipe should be staked with a cut to flow line of pipe every 25 feet. A guard lath should be provided indicating cut to flow line, offset to the centerline of the pipe and station.

1108-3 Concrete Boxes and Bridge Culverts

The size and type of box culvert to be staked will be designated on the plans. Particular attention must be given to the type of wing walls called for on the plans.

Since concrete culvert stakes are used for more precise measurements than in the case with pipe culverts, the layout points are marked with hubs and tacks. Wingwalls are staked according to the standard drawing or special details designated in the plans.

Basically, the same method is used in staking box culverts as for pipe culverts. Additionally, stakes must be set to locate the intersection of the barrel and the back face of the wing and the end of the wing. Reference control lines for each wing wall and wing to barrel intersection point should be set using two tacked hubs appropriate distances outside of the construction area from the end of the wing, 15 to 25 feet are usually satisfactory. All tacked hubs shall be referenced as to the fill or cut to the bottom of the footing elevation.

Guard stakes shall be well marked. Box culverts should be checked for necessary revisions to meet drainage requirements, see Exhibit 1108-3-1.

1108-4 Large Structures (Bridges)

Prior to commencing the actual field layout of a major structure, considerable preliminary work is necessary. The first step should be a complete check of all distances and elevations shown on the plans. Likewise, all survey instruments should be checked and any necessary adjustments made.

It is always sound engineering practice to be certain that elevations given for bottom of footings and other elevations shown on the construction plans are computed correctly from finished grade down or from bottom of footing to finished grade.

After determining that the plans are correct, it is good practice to make a rough paper layout of how you intend to stake and reference the structure at the construction site. Exhibit 1108-4-1 will illustrate one acceptable method of laying out and referencing a structure of this type. Remember that all centerlines and bearing lines must be staked and referenced so that a minimum of time and effort are necessary in replacing any disturbed control lines as construction progresses.

After staking of the structure has been completed, a thorough check of all measurements, angles, and elevations should be made to make certain that no errors exist. This checking should, if possible, be done by a different party than the one which performed the original staking. Checking should be by a different method if practical to do so.

An example of using two methods of staking the centerline of piers, bents, or abutments are:

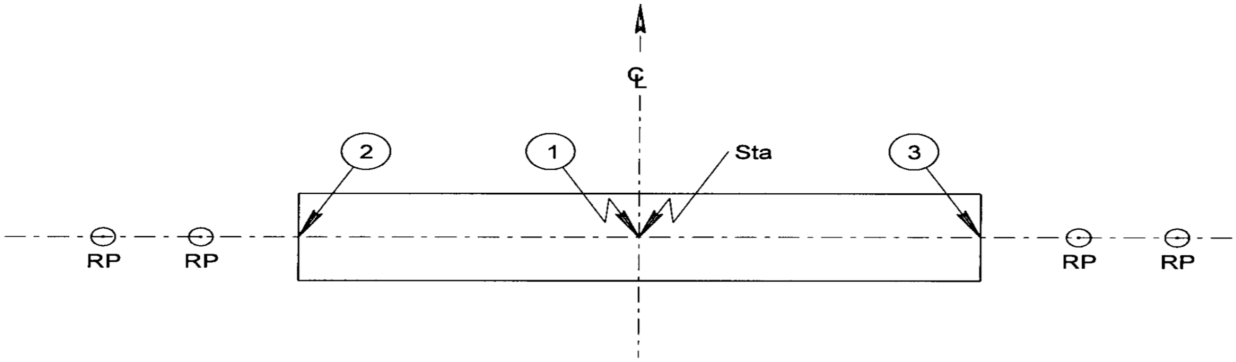
1. Stake the original layout using the dimensions between the substructure units as shown on the bridge sheets of the plans.
2. Compute the station distances for the centerline of each substructure unit and locate them by stationing. Always make certain that the staking is correct, never take anything for granted when staking a bridge.

If doubt arises, consult the plans and double check. Verify the staking carefully and be certain that all distances, angles and elevations are correct, then go over the structure layout in detail with the contractor to make sure he or she knows the purpose and location of each stake. Sufficient RP's shall be provided for such items as caissons so that drilling and cage placement may be checked throughout the installation process.

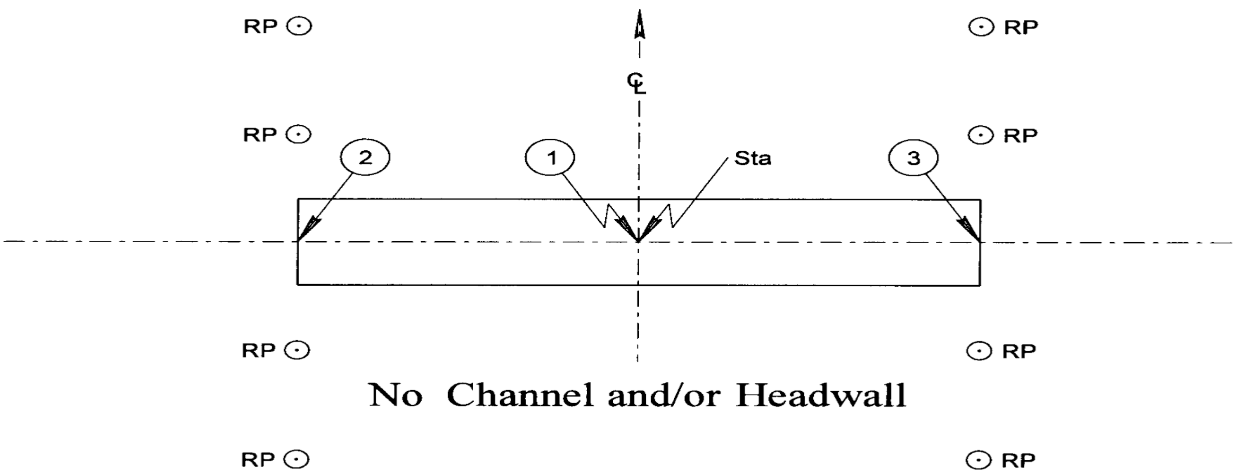
1108-5 Structures On Curves

Extreme care must be exercised in staking structures on curves. A very thorough study of the plans should be made before staking begins. In all cases, a layout of the structure should be made on paper. In some cases, it is also advisable to make an actual layout of the structure on level ground where measurements, staking, and checking of chords, angles, etc., are facilitated.

After being completely satisfied as to the controls needed and all measurements, angles, and elevations have been checked, and double checked, you are better able to proceed with an accurate layout of the structure. Layout staking of bridge structures must be checked by another method such as with rectangular coordinates which can indicate whether all the angles and distances close and provide diagonal dimensions.



No Channel or Headwall



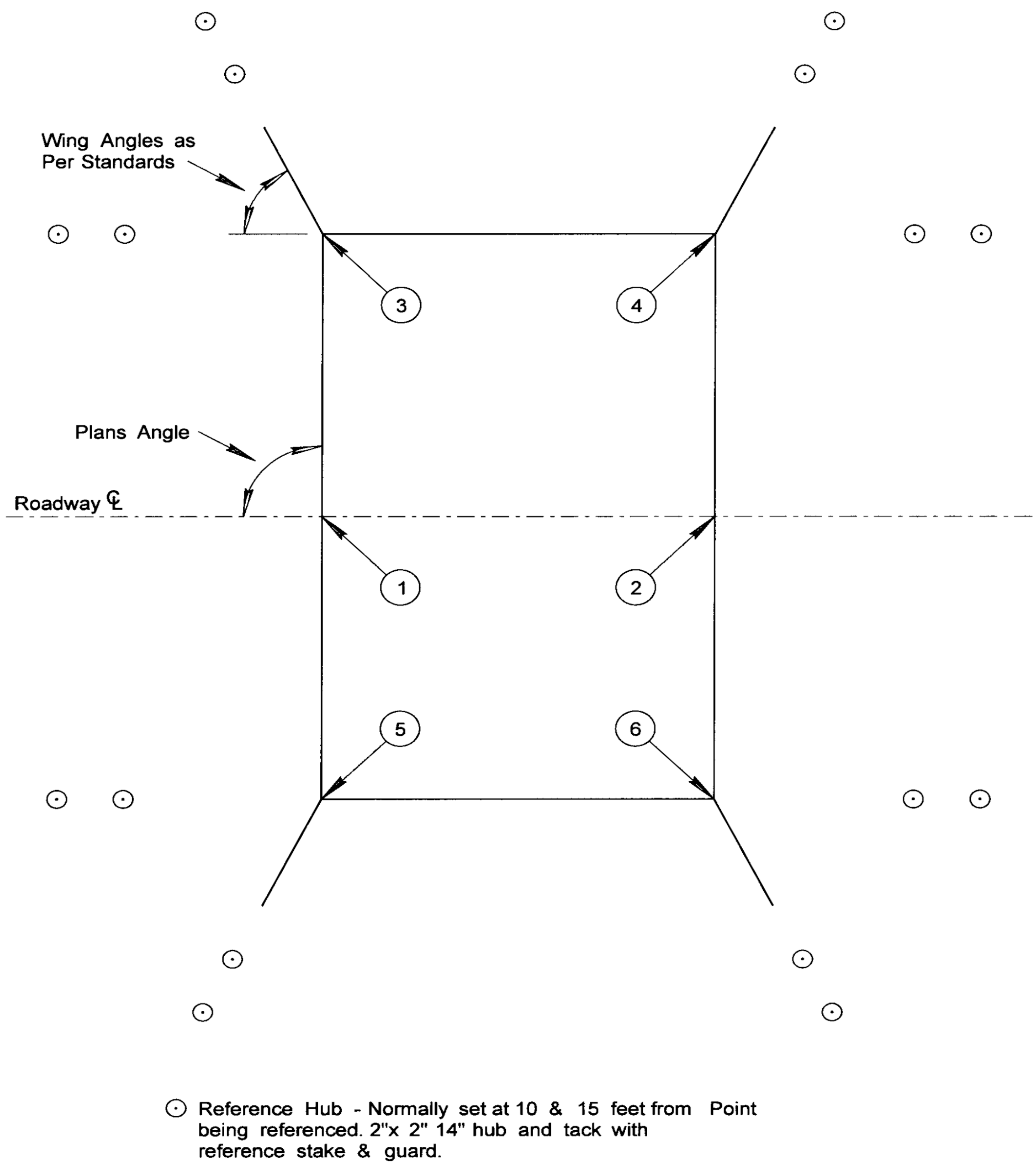
No Channel and/or Headwall

⊙ RP - Hub & Tack with Guard Stake & Lath

Directions:

1. Establish station location at point where survey centerline and centerline of pipe intersect (point 1). Mark this point with stake and tack or nail.
2. Occupy point 1 with an instrument and backsight or foresight to control point on centerline. Clamp vernier and turn the angle that the pipeline forms with the centerline of the roadway. Chain Distances right and left of centerline as per plans or modified pipe lengths and set stake and tack at both ends of pipe; points 2 and 3. If a pipe has no channel or headwall, references may be set to ends of pipe on this same line.
3. If the pipe has a channel and/or headwall the following reference procedure should be used: Occupy point 2 and sight point 3. Clamp vernier and turn 90 degrees. Set reference points with hub and tack at 10 feet and 25 feet. After these references are set, re-sight point 3, turn 90 degrees to the opposite side and set similar references.
4. Move the instrument to point 3 and repeat the procedure using point 2 as a backsight.

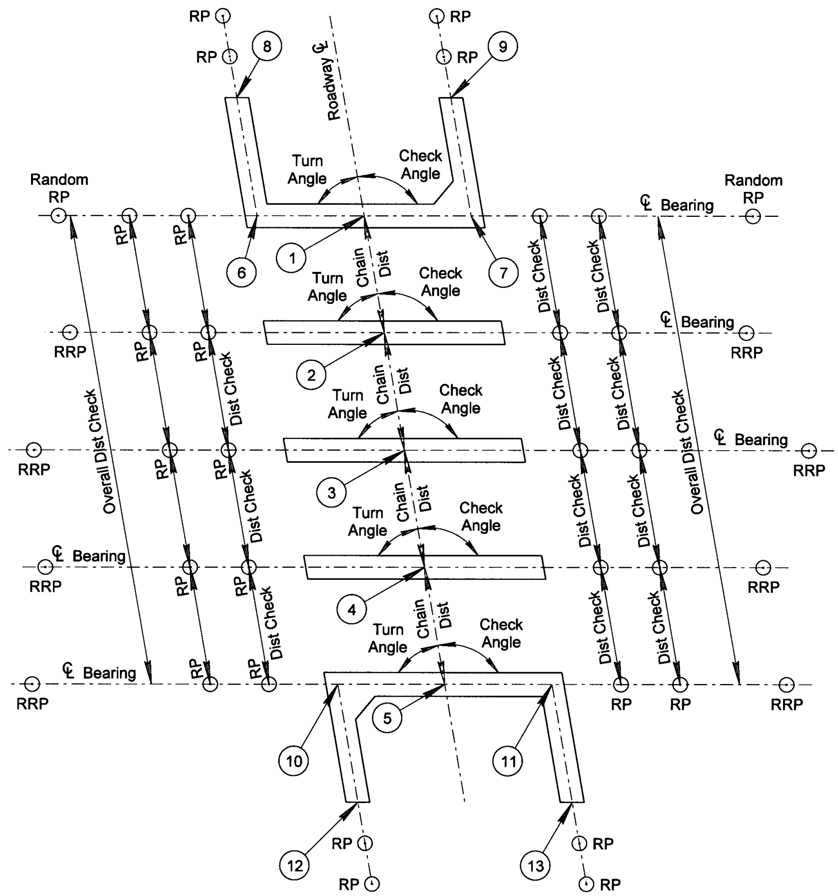
Exhibit 1108-2-1. C.M.P. OR Pipe Culvert Staking Layout



Directions:

1. Locate by stationing the point at which barrel line intersects with roadway centerline (1). Mark this point with 1in. X 2 in. X 14 in. stake and tack.
2. From this point, establish other barrel line intersection (2) and set stake and tack.
3. Set transit over point (1), sight back to centerline control point and turn plans angle. Chain off required distance and establish points (3) and (5) with stake and tack.
4. Follow the same procedure occupying point (2) and establishing points (4) and (6).
5. Having established points (3), (4), (5), and (6), the transit is moved to point (3) or (4) and the unoccupied point (3) or (4) is sighted upon and the vernier locked. Indicated references are then set to points (3) and (4). This procedure will be repeated with points (5) and (6).
6. Assume above occupancy was at point (3). After setting references required, the wing angle as indicated on the plans shall be turned and the end of the wing will be established with stake and tack and referenced with hub and tack. This procedure will be repeated occupying points (4), (5), and (6).
7. A quick measurement check of the layout should be made to make certain that structure is properly staked.

Exhibit 1108-3-1. Concrete Box Culvert Layout



Directions:

1. Complete careful check of plans for dimensions and grades.
2. Establish point (1) by stationing. Occupy this point with transit. Sight transit on centerline control point and clamp vernier. From this, setup chain in and establish intersections of survey centerline and centerline of piers and other abutment; points 2, 3, 4, and 5. These points should be set with 1 in. x 2 in. x 14 in. stake with tack. Carefully check the chained distance obtained from the plans each time. These distances must be to the nearest 0.01 foot.
3. After centerline intersection points of each abutment and each pier have been established, the centerline of each of these substructure units must be located and referenced. While occupying point (1), sight transit on point (5), or a chosen centerline control point, and turn angle as indicated by the plans. After turning angle measure and set stake and tack for each end of abutment points (6) and (7). Turn back to the original sight point (5) or control point and turn check angle; difference between 180 degrees and plans angle. If this does not hit the tack set for each of the abutments, repeat the procedure until points can be hit by turning either angle. After being satisfied that line is good, set 2 in. X 2 in. X 14 in. hub and tack references to each end of abutment.
4. After setting and referencing points (6) and (7), they must be occupied and the end of each wing set and referenced. The same procedure is used, checking angles and distances each time.
5. Continue ahead occupying points (2), (3), (4), and (5) repeating the same procedure.
6. After completion of the staking layout, a check should be made. First, check the distance between reference points to the centerline of piers and abutments. These reference distances should not vary more than one one-hundredth from the chained distance at centerline. Next, chain the overall distances on each side of the structure layout. This should be within one to two one-hundredths of plans length of the structure.
7. All reference points must have guard stake and flagged lath.
8. The caisson layout will have RPs in both directions so the contractor can set a rebar cage with string lines.

Exhibit 1108-4-1. Large Structure Layout

1109 SLOPE STAKES

1109-1 General

Slope stakes may be placed prior to the contractor clearing the ground in cases of open, grassy prairie, or cultivated land, where a minimum of clearing is required; otherwise, clearing and grubbing limits should be established and the roadway prism should be cleared prior to setting of slope stakes, or as specified in the special provisions. Exhibit 1109-1-1 demonstrates commonly found slope staking placement codes.

1109-2 Roadway Cross Sections

Cross sections are taken and slope stakes are set for two primary purposes:

1. The sections recorded in a field book serve as a quantity pay document for work performed by the contractor.
2. The slope stakes outline the cut or fill limits and the slopes to be built for the contractor.

Cross sectioning and slope staking are usually performed at the same time. Usual practice is to cross section and stake at all full and 50 foot stations and at all breaks in topography within the roadway section that will affect the calculation of the volumes of excavations and embankments. In desert or reasonable flat terrain, slope stakes, and cross sections may be spaced at 100 foot intervals. (See Exhibit 1109-2-1 for cross section computations).

Slope stakes need not always be set at every cross section, however, all the information needed for calculating quantities must be indicated in the notebook.The beginning and end of each cut/fill section must be staked.

Measurements shall be from the centerline and shall be noted in the field book for computations. (See Exhibit 1109-2-2, Roadway Cross Section Book.) In setting slope stakes, the rod is read to the nearest 0.01 feet and horizontal distances measured to the survey centerlines are also recorded to the nearest 0.01 feet. In heavy work on steep hillsides, special care shall be taken in reading the rod and in setting slope stakes at right angles to the centerline and also in properly measuring the horizontal distances from the survey centerline to the point where rod readings are taken and where slope stakes are set.

The use of hand levels and the Rhode's Arc should generally be limited to determining elevations of inaccessible locations because elevations taken by this method are not as accurate as elevations read with the engineer's level. In rough terrain, parallel profile levels outside of the slope stake lines may be used to check hand level work. It is recommended that electronic instruments are used for this application to increase accuracy.

1109-3 Cross Sections in Cuts

The centerline stake will be marked with the station facing the beginning of the project. The opposite side of the centerline stake shall be marked with the vertical cut which is the vertical distance from the original ground at this point to the construction grade. This cut will be the difference between the centerline profile elevation and the plan's subgrade elevation. All significant breaks in the ground surface and all breaks in the construction grade template are to be recorded in the cross section field notes. A slope stake shall be set where the cut slope intersects the existing ground surface. (This is known as the catch point.) The slope stake will be marked on the back side with the appropriate stationing. The inside of the slope stake will bear the letter "C" indicating that a cut is to be made, the amount of cut to be made at that particular point, the horizontal distance from the centerline to the slope stake, and the slope ratio.

During the excavation operation, the life of a slope stake is short due to equipment operation.

A reference to each slope stake in a cut section should be set as follows:

- Guinea - A small stake driven flush with the ground surface.

- A guinea shall be driven flush with the ground, outside the slope rounding area, and preferably at an even horizontal distance from the slope stake; a 10 foot offset is usually adequate, if not, additional increments of 10 feet are suggested.
- A guard stake shall be driven behind the guinea. The back side of the guard stake shall show the station of the section. The front side shall show the cut at the slope stake and the horizontal distance from the slope stake to the reference.

Slope rounding shall be staked to conform to the roadway standards when slope rounding is required, see Exhibits 1109-3-1 and 1109-3-2.

1109-4 Cross Sections in Fills

Rod readings and horizontal distances should be recorded at all significant breaks in the ground line in fills and in cut sections. In most cases, it is not necessary to offset the fill slope stake except where the fill will catch on a traveled roadway. In this event, a guinea should be driven flush with the ground at the point where the toe of the fill intersects with the natural ground (catch point). The slope stake shall be placed back of the guinea and out of the traveled way at right angles to the centerline. The marking shall show the stationing of the section on the back of the stake; the front face shall show the letter "F" to indicate fill, with the amount of the fill from the guinea to the grade, the horizontal distance from centerline to the guinea and the ratio of the fill slope to be constructed.

A slope stake marked 0.0 should be driven at the shoulder grade point on entering a cut from a fill or vice versa. The standard size slope stake is 1 in. X 2 in. X 14 in.

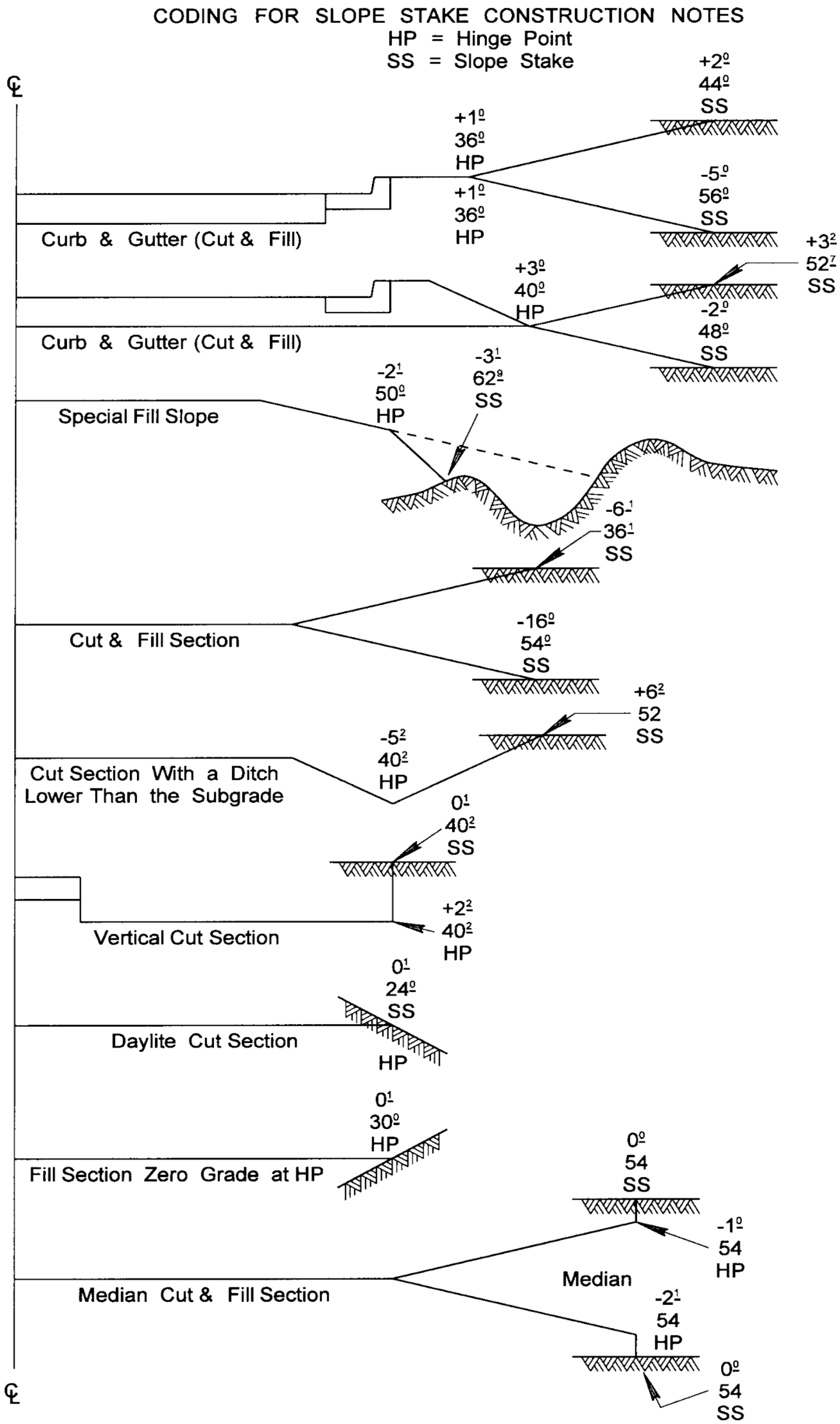
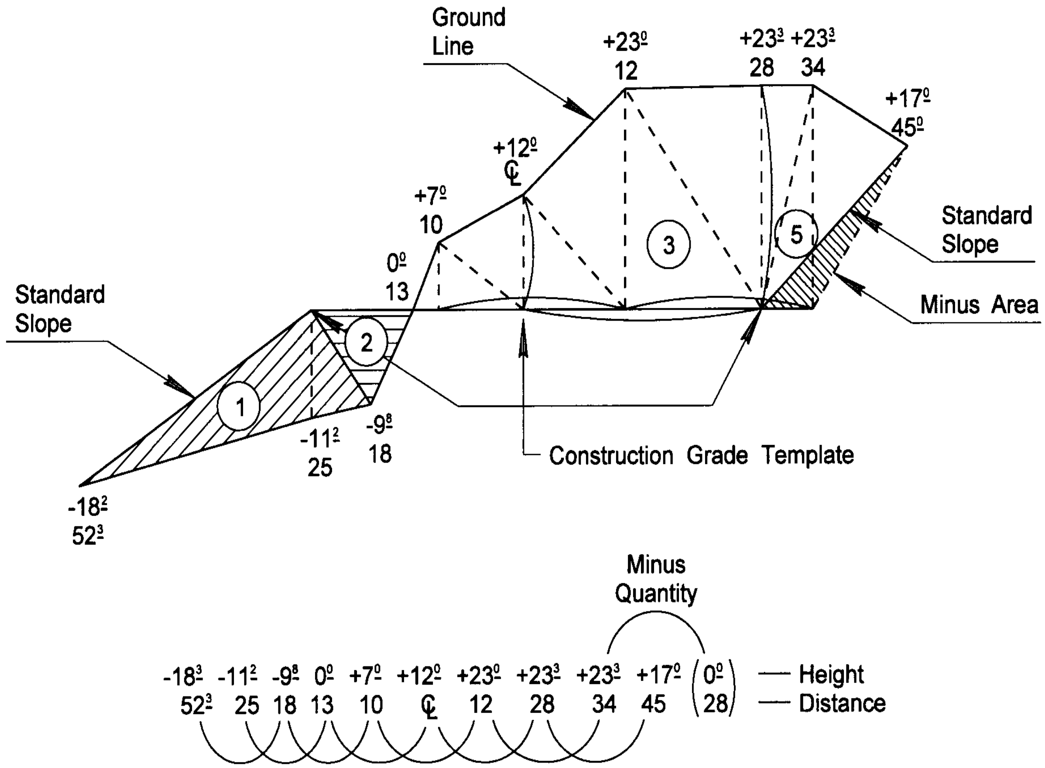


Exhibit 1109-1-1. Slope Staking Coding & Placement



EMBANKMENT

$\underbrace{34.3 \times 11.7}_{1} + \underbrace{12.0 \times 9.8}_{2} = 518.91$ (Double Area)

EXCAVATON

$\underbrace{13.0 \times 7.0} + \underbrace{22.0 \times 12.0}_{4} + \underbrace{28.0 \times 23.0}_{3} + \underset{5}{22.0 \times 23.3} + \underbrace{17.0 \times 23.3} - 6.0 \times 17.0 = 1805.70$ (Double Area)

Exhibit 1109-2-1. Cross Section Computations

												GR	EL
88+50	+88^{0} 106^{0} RS	+70^{4} 83^{8} SS 3/4:1	+32^{8} 31^{0} HP	+31^{3} 23^{5}	+19^{6}	+5^{1} 29^{5}	+2^{6} 37^{0} HP	+2^{0} 38^{5} SS 3/4:1	+5^{4} 53^{0} RS	4199 04		3967.48	87.08
											4002 15		
89+00	+79^{4} 101^{6} RS	+68^{2} 82^{2} SS 3/4:1	+41^{1} 31^{0} HP	+23^{9} 23^{5}	+19^{7}	+6^{3} 29^{5}	+1^{8} 37^{0} HP	+1^{0} 37^{8} SS 3/4:1	+6^{0} 49^{0} RS	4445 61		3969.34	89.04
											4295 92		

Exhibit 1109-2-2. Roadway Cross Section Book

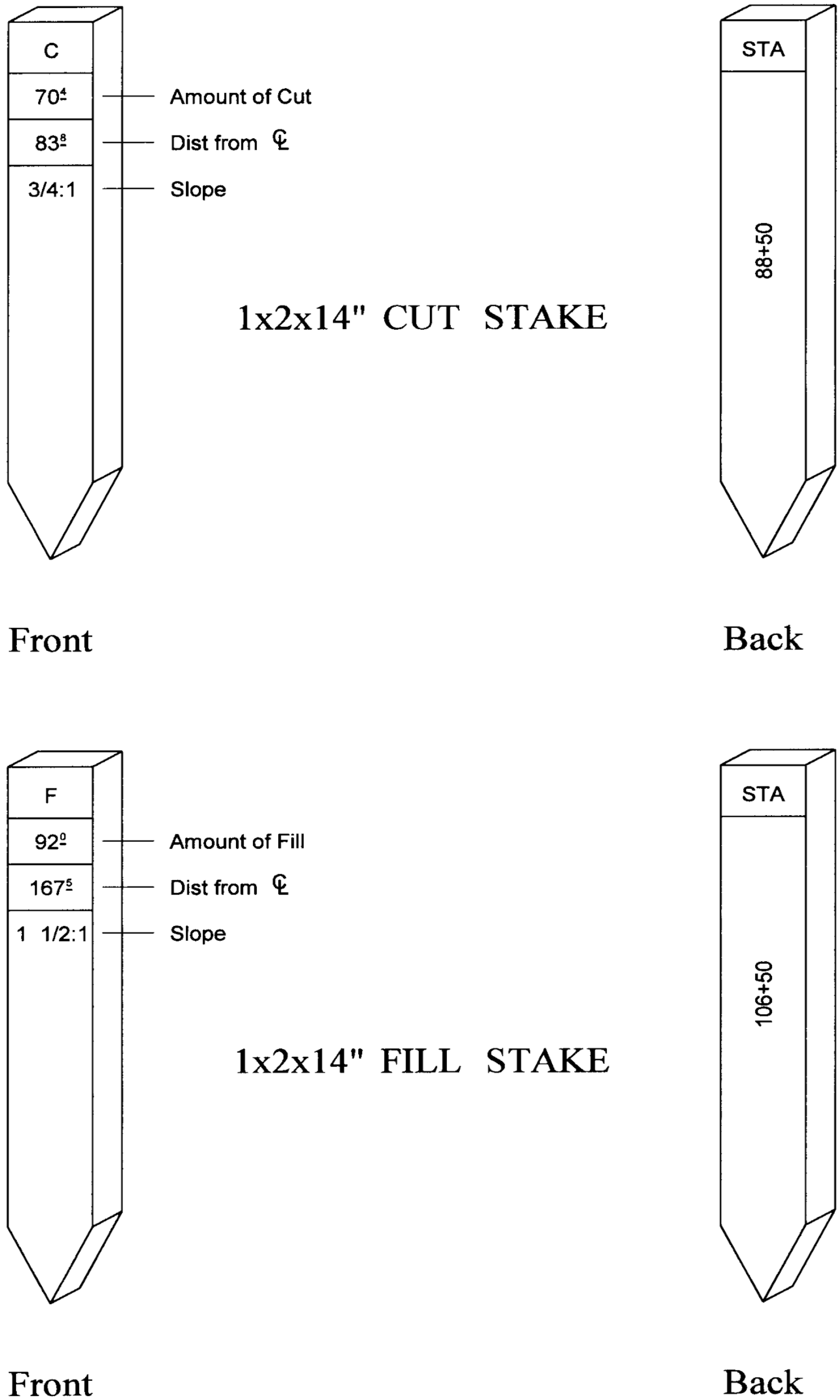


Exhibit 1109-3-1. Marking of Slope Stakes

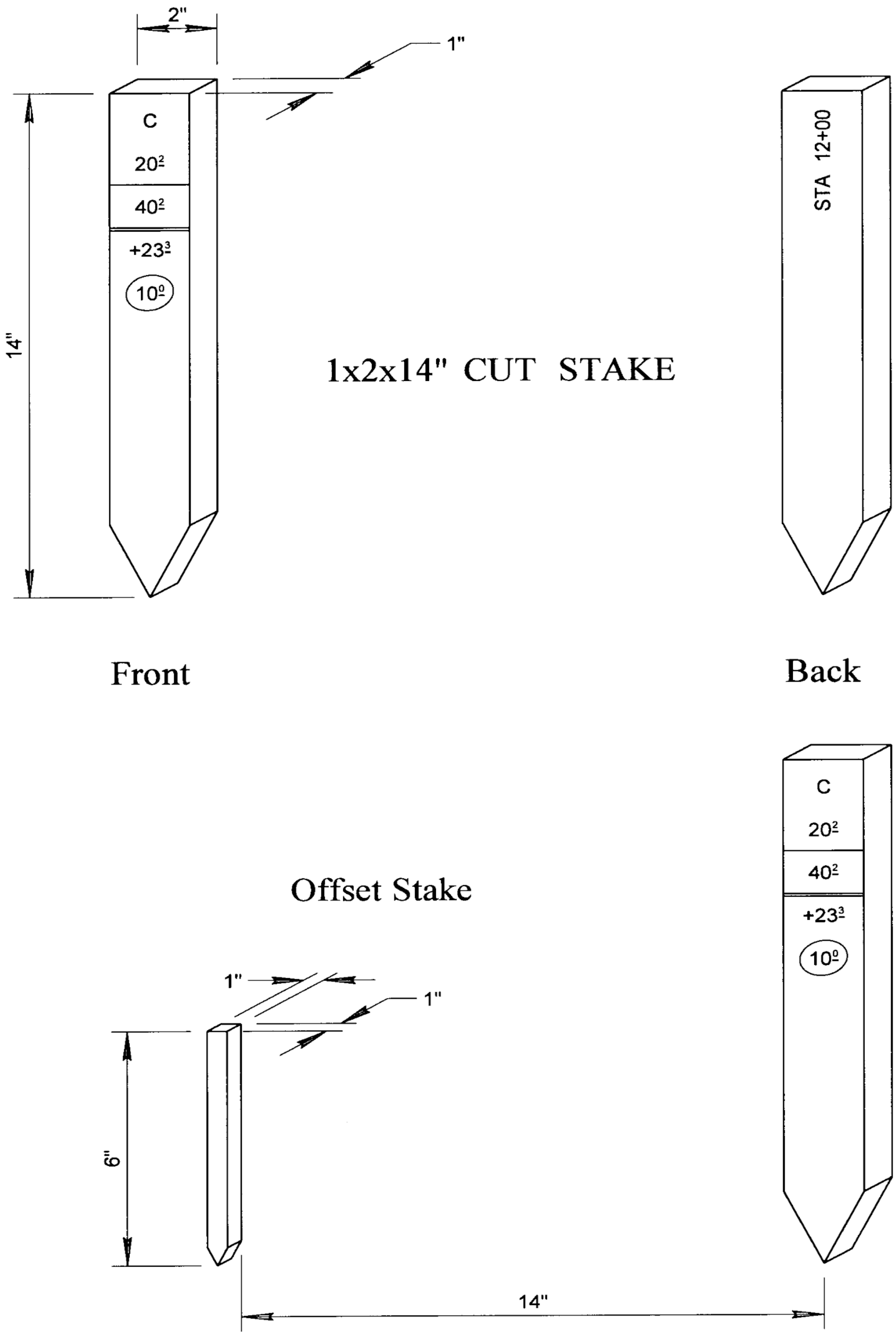


Exhibit 1109-3-2. Slope Stake Offset Alternate

1110 DRAINAGE STAKES

Ditches, dikes, crown ditches, crown dikes, and drainage channels shall be staked to a gradient and alignment which will cause the minimum of erosion and which will conform to the Roadway Construction Standards for the item.

Drainage channels shall be slope staked to conform to dimensions and slopes as shown on the plans. The method of staking shall be the same as that used in staking the roadway section.

A drainage excavation book shall be prepared in the same manner as the cross section book for the purpose of computing drainage excavation quantities. The top of each page shall indicate the location, size and length of each ditch or channel. Use a page to sketch the channel in order to indicate a tie to the centerline of the roadway and position of ditch in relation to the roadway.

Care must be taken when staking drainage excavation at the inlet and outlet ends of structures to make certain that the normal flow of water is not restricted.

Crown dikes, crown ditches, and grader ditches must be staked as soon as slope rounding of cuts has been performed so that the contractor can promptly construct such facilities, thus protecting the slope rounding and cut slopes from erosion. All ditches specified to be measured by the linear foot will be recorded in a prepared miscellaneous book showing type, location and length.

1111 MATERIAL PITS

When the contract specifies that the contractor will supply his own material source, ADOT personnel will not survey or stake the pit.

ADOT personnel will not furnish the contractor any survey services, except those services called for in the specifications or in this manual.

Some basic rules should be followed in the staking of ADOT furnished material pits regardless of the basis of payment. First, the right-of-way limits of the pit should be determined and marked. A sketch of the pit area should be made in the pit book and definite survey ties made between test hole locations and roadway stationing or between test hole locations and a section line in case the road is at a remote distance. If the pit is divided into more than one area, or ownership, each area or ownership shall be marked off, measurements should be taken for each area, and each area plotted in the pit book, see Exhibit 1111-1.

A baseline, well outside the working limits of the pit, should be established on 50 foot stationing. Parallel baselines on opposite sides of the pit are recommended in order to keep sections across the pit area at right angles to baseline. Baselines should be well referenced since equipment working the pit may be expected to operate both inside and outside the pit limits, often disturbing reference stakes located close to the pit area. Distances of 150 feet or more for references should be used.

In most cases the item of stripping pits is paid on a cubic yard basis. In this event, it is necessary to cross section the pit area before and after the stripping operation. The final cross section notes of the stripping item would serve as the original sections for pit measurements.

In staking pits, where the material is to be paid for on a cubic yard basis, the following procedure should be followed. After the baseline has been established and referenced, and assumed elevations or actual elevations have been taken on all hubs along the baseline, the entire pit area is cross sectioned at right angles to the baseline and the notes should be recorded in a field book. Level notes should show level turns and closures. Make certain that cross sections are taken so as to cover the entire area where material is to be removed and such areas marked on the ground so the contractor and the inspector will know which area has been cross sectioned. No material should ever be removed from a pit area on a cubic yard payment basis until cross sections have been taken. Level circuit notes shall be retained with the cross section noted as part of the records of measurement and as a means of perfecting the record in case of a discrepancy or a controversy. After completion of the removal of material from the pit area and smoothing up of the area, final cross sections are taken from the baseline, using the same assumed or actual elevations. Volumes are then computed for the original and final sections, using the average end area method, with the difference between the two representing the volume of material actually removed from the pit area.

Where the pit area is subject to flood conditions during the rainy season, the area shall be re-measured at intervals or immediately after depleting each area. Do not wait until the project is completed before remeasuring.

While the staking method recommended herein is acceptable, the method to be used shall be determined by the Engineer. One important fact to remember, however, is to use the same method of measurement on both the original and final sections.

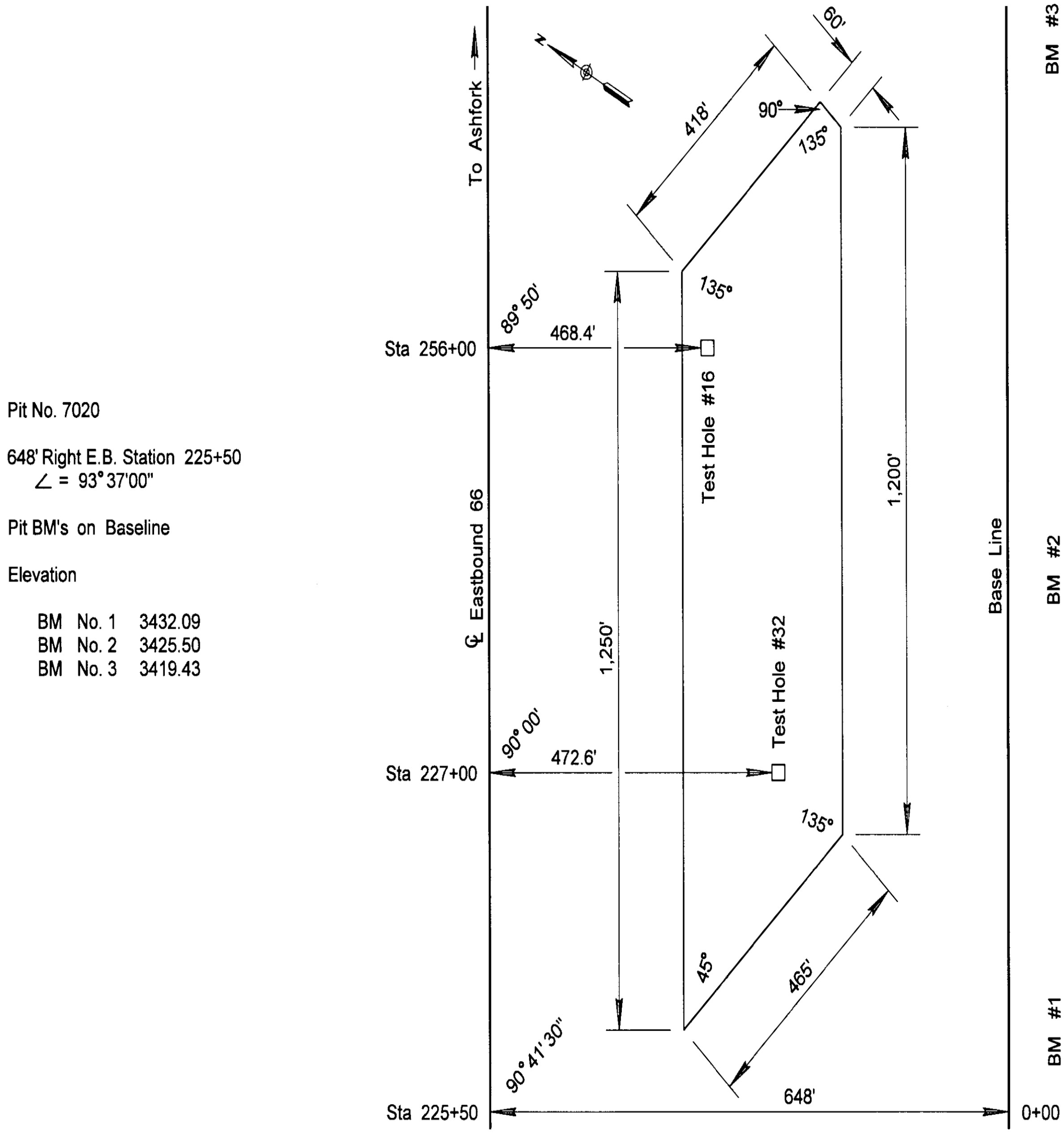


Exhibit 1111-1. Material Pit Diagram

1112 MISCELLANEOUS CONSTRUCTION STAKES

1112-1 Right-of-Way Fence

Line fence shall be staked as indicated on the plans and the Roadway Construction Standards. The staking shall indicate the line of the fence and the location of strain posts, end posts, corner braces, and gate panels.

Right-of-way lines and property boundaries should always be set by a Registered Land Surveyor.

Since right-of-way stakes are usually set as references to the centerline, they are usually sufficient for the line of the fence. The fence line should be staked at intervals not to exceed 200 feet depending upon the terrain, except on curves where the stakes should be set on 25 foot or 50 foot stations, and at every break point. To run offset lines to a centerline curve, use the table entitled "length of circular arcs for radius of one degree", as found in most route survey books.

In lieu of this table, the following formula may be used:

$$L = (R \pm O)\, C / R$$

Where:

R = radius of centerline curve.
O = offset distance from centerline to right-of-way line.
C = chord length on centerline.
L = chord length arrived at for the offset line.

Proceed to run the offset line by using the stationing of the centerline and the deflections as computed for the centerline.

In order to prevent the probability of constructing the fence outside of the right-of-way at any point, the standards require the fence to be located 6 inches inside of the right-of-way. Measurement and payment shall be made in accordance with the standard specifications and special provisions.

1112-2 Cattle Guards

Cattle guards shall be staked and constructed to conform to the finished grade of the roadway and as indicated by the plans and standards drawings. When necessary, provide outlets at the ends for drainage.

1112-3 Guardrail

The staking of guardrail must follow closely the appropriate roadway construction standard. Special attention should be given to the flares and end treatments.

Offset nails for guard rail control are generally adequate if set at 50 foot centers on tangent sections or 25 foot centers on sharp radius curves. Each post of a flared end section should have an offset reference. The terminal pavement for the end terminal should be laid out according to the C-standards.

1112-4 Bank Protection

All bank protection shall be staked soon after the channel changes and structures are built so that proper ties between the structures and the bank protection may be made early for protection of the roadway and structures.

1113 GRADE STAKES (BLUE TOPS)

The first use of grade stakes will normally be to determine that required excavation for drainage structures has been achieved. Following this, as each section of roadway subgrade is brought to approximate grade, it shall be "blue topped" and the surface finished to conform to the grade established. It is recommended that "Blue tops' are placed at all stations and plus 50 foot stations. “Blue tops” frequency can be adjusted to exceed the 50 foot interval at the discretion of the RE if the contractor has proven to meet the accuracy outlined below. They are always placed on centerline and at right angles to the centerline on each shoulder. Very often it is necessary to set additional stakes between the centerline and the shoulder grade stakes due to the greater width of the roadway as for interstate construction.

All grades for "blue tops" shall be computed to the nearest 0.01 feet, the Height of Instrument (H.I.) levels and Bench Marks (B.M.) shall be carried to the nearest 0.01 feet, and the "blue tops" shall be driven until they are within nearest 0.01 feet of the required grade. In moving ahead during the "blue topping" operation, it is always good practice to check back on the last row of stakes driven as a double check on the new H.I. and grade calculations. No writing is placed on the "blue top" stakes. "Blueing" the top of the stake indicates the desired grade at that point. It is standard practice to place a quarter lath at each "blue top" driven to serve as a guard stake to the "blue top". The guard lath placed at the centerline "blue top" should show the station designation. It is very important that these stations be shown for several reasons, e.g. continuity of the surveying operation through cross checks, the ability of the level person to always know where he is, and the ability for those working on the project to keep track of locations for work and quantities. Often the first "blue top" stakes set for the rough subgrade will be partially or totally destroyed by grading equipment, and will have to be reset. When resetting these grade stakes, it is possible that those which are still in place are not correct due to having been disturbed, therefore, they should be checked for grade as they are encountered. Stakes less than 8 inches in length should not be used as blue tops since lesser length is subject to disturbance by equipment and can result in erroneous elevations after the grade has been worked.

"Blue tops" shall be set for each course of surfacing material, e.g. the top of select material, top of aggregate base, etc.

On completion of the grading and draining, the survey crew shall check all references to the centerline and see that the locations, distances and angles are properly shown in the field notebook and on the "as-built" plans. All permanent bench marks shall be checked for elevation and all brass or aluminum caps marked with the proper elevation and recorded in the proper field book and on the as-built plans.

1114 REMEASUREMENT

1114-1 General

Ditches and dikes that are measured by the linear foot shall be remeasured by the survey crew after they are completed and these measurements and locations recorded on the as-built plans.

Numerous other items require remeasurement and documentation such as: line fence and gates, cattle guards, curb and gutter, embankment curb, guide posts, bank protection, right-of-way markers, catch basins, and guardrail.

1114-2 Slides

If slides have occurred in cut sections, the Resident Engineer shall make a determination as to whether such slides are payable under Specification 203. If found to be payable, the volume of the original space which the slide occupied shall be measured and computed in cubic yards by the average end area method and included in the quantity of roadway excavation for payment at the price bid for roadway excavation.

Likewise, any excavation made below grade, if made by the direction of the Engineer, shall be similarly measured and included in the quantities of roadway excavation.

1114-3 Overbreakage

Overbreakage is not measured or paid for. The Surveyor must become familiar with that portion of Section 203, which deals with the measurement and payment for the item Roadway Excavation, originating outside of the neat lines of cut slopes as a result of necessary blasting operations. This section and detail shall be followed in the measurement and payment of this item. The term "overbreakage" is not used in the Standard Specifications.

1115 COMPUTATIONS

1115-1 General

The project field office is given the responsibility of computing the construction survey notes. Since the pay quantities of the contract are determined from the calculations based on the construction survey notes, the project office should be furnished with the necessary equipment and staffed with qualified personnel to facilitate an early determination of pay quantities.

All construction notes and electronic data should be left in the field office on completion of a notebook or when a notebook is not in use in the field. Notes requiring explanation should not exist; should an occasion arise where an explanation of notes or diagrams becomes necessary, the Party Chief and the Office Supervisor will collaborate in making necessary explanations in the book. This work should be performed in the field at the site of the work in order to preclude uncertainty of the facts involved.

Cross-section books consisting of notes on roadway excavation, slides, drainage excavation or channel excavation, borrow pits, and any other items that require measurement by the average end area method shall be computed and checked by the field office, and then submitted to Construction Operations for verification of quantities.

Computations may also be done by a CADD/Mapping technician if an electronic data collector is used.

1115-2 Average End Area

The volume of material removed between two stations along the roadway is determined by the average end area method. The crisscross or loop method of computing cross sections is relatively simple, providing care is exercised in observing five simple rules, as follows:

1. Check the section for grade points (0.0 sections) between cut and fill.
2. Note all ground line breaks between the shoulder point and catch point.
3. Be careful to place the end area quantities in the proper column provided for cut or fill.
4. Show whether the end areas are double-end areas or single-end areas. The area is always a double end area unless the quantity is divided by two before recording the result shown on the calculator.
5. Make certain that all points necessary for proper computation are indicated in the cross section notes, e.g. hinge points, slope stake, etc.

In computing quantities from areas obtained by the double-end area method the following formula applies:

Volume (cubic yards) =

$$\frac{1}{2} \times \frac{(A' + A'')}{2} \times \frac{L}{27} = L\,\frac{(A' + A'')}{108}$$

In which A' and A" equal double areas of end sections.

1115-3 Overhaul

The specifications require that the contractor shall place roadway excavation, structural excavation, drainage excavation, or other material as required. The cost of hauling and placing this material is included in the contract price for the item involved. Although there normally is no pay item for overhaul, it is sometimes necessary to calculate the haul for special studies or as a part of a claim analysis.

Overhaul is generally computed using the cubic-yard-mile.

When the Engineer desires to arrive at the number of cubic-yard-miles of overhaul actually performed by the contractor, it is necessary to construct a mass diagram of the area in question.

1115-4 Mass Diagram

Volumes may be calculated as shown below or done by CADD/Mapping if an electronic data collector is used on a project.

The plans provide the contractor with the theoretical overhaul and balance points. The actual balance points and cross-hauled quantities will vary to fit the contractor's method of operation. This requires the Engineer to keep accurate records of all field balance points and of the materials placed between the balance points.

The mass diagram is constructed in units that extend between the actual field balance points, as reported by the inspector, with the shrinkage or swell of the excavated material considered uniform. The horizontal scale or abscissa represents stations along the centerline, and is usually plotted to a scale of 1 inch = 100 feet . The vertical scale or ordinate represents the algebraic sum of the excavation and embankment from some selected station to any station in question and is called the solidity line. The scale shall be determined from the maximum ordinates on the particular projects. It may be 500, 1000, or 2000 cubic yards or more to 1 inch.

A curve is drawn connecting the points plotted and is called the mass diagram. Reading from left to right, all ascending lines indicate amount and location of excavation, all descending lines indicate amount and location of embankment.

Instead of starting with the origin as zero, it is better to start with an ordinary figure of say 300,000 so as to keep from having to change from plus to minus, or vice versa, when crossing the datum line. The initial abscissa shall be the beginning station of the project or station of the nearest balance point back of the point where overhaul is questionable.

As the quantities involved in the mass diagram are computed, they shall be tabulated opposite their corresponding stations. The columns will show roadway excavation, drainage excavation, or over-breakage; if used in the roadway, ground compaction, embankment, embankment equivalent to excavation, and finally solidity. The ordinate which contains the algebraic accumulated sums of all quantities used in constructing the mass diagram. The initial solidity of 300,000 is the horizontal datum line and should always be of such value that the accumulated solidity value is above zero.

Since excavation usually swells or shrinks, making more or less embankment, it is necessary to adjust the measured embankment quantities to make them correspond to the excavation quantities. To make this correction, first obtain the total net quantity of excavation (considered positive or plus) that went into the roadway, including borrow, over-breakage, drainage, etc., and then obtain the total ground compaction and embankment (negative or minus) quantity. Next, divide the total plus quantities by the total minus quantities to obtain a factor that when multiplied by the measured embankment quantities, gives the corresponding Embankment Equivalent to Excavation. Each measured embankment quantity per station or plus 50 foot station shall be multiplied by the factor in order to compute the solidity at all stations.

As a check, the total Embankment Equivalent to Excavation should equal the total measured excavation quantity contained in the tabulated list. Since the total embankment times the factor equals the total excavation, the desired quantity, i.e. solidity, may then be obtained by progressive addition: excavation (positive) and embankment equivalent to excavation (negative).

It is obvious from the method of computation of the solidity that a cut will be represented by a rising line or increasing quantity, and a fill by a falling line or a decreasing quantity. When the curve is above the datum line, it indicates that material must be hauled ahead or to the right, when below the line, material must be hauled back or to the left. The loops which convex upward indicate that the haul from cut to fill is to be in one direction, to the right in this case, while loops concave upward indicate a reverse direction for haul. The maxima and minima of these curves are opposite the 0.0 or grade points on the profile, the changes from cut to fill, or vice versa, see Exhibit 1115-4-1.

In general, the mass diagram is composed of balanced loops obtained by drawing horizontal lines across the diagram as shown in Exhibit 1115-4-1. Every loop of the diagram is composed of two equal parts, one of cut and the other of fill. The excavation and the embankment are in balance where the diagram crosses any horizontal line, as at Station 1474+50 to the point where it returns to that line as at Station 1494+33, in the example. The loops above and below this line are balanced sections that may be considered apart from the rest of the diagram.

It is usually impossible to balance successive loops within the same datum line for an entire project, especially where imported borrow quantities are required, see Exhibit 1115-4-1.

At times, it will be necessary to show several balanced sections within the field balance points, Stations 1474+50, 1494+33, and 1501+00, as shown in the loops above the datum plane between Stations 1474+50, and 1494+33. These field balance points will be used for computing the swell and shrinkage factors that will be applied to the embankment.

The horizontal lines are drawn through the loops so as to attain as near as possible a straight line on the mass curve between the horizontal lines. The difference in solidity of any two adjacent horizontal lines is the actual quantity of excavated and embankment material between the stationing of the two lines.

In determining where to place these horizontal lines, keep in mind that the excavation shall be placed into the nearest fill. This requires drawing the horizontal line through the loops so that the roadway cut will be placed into an adjacent fill section, keeping in mind that cross haul shall be avoided except where a poor quality of material must be hauled and placed in the bottom of a large fill not adjacent to the poor material.

The most economical distribution of material demands that in making a fill, the material should be obtained from the following sources:

- from the nearest cut,
- from a cut such that the cost of haul shall not exceed the cost of excavating the material, and
- from a nearby borrow pit.

The cubic-yard-mile overhaul is only that quantity hauled beyond the 1500 feet free haul limit.

The only quantities to be considered when computing the cubic yard mile haul are those quantities between the datum line and the line representing the free haul limits. The line representing the 1500' free haul may be determined graphically by first obtaining the approximate stationing of the extreme ends; compute the exact location by applying ratio and proportion to the rate of change per foot and the solidity of the near stations which are 1500 feet apart as determined graphically.

In Exhibit 1115-4-1, the first horizontal line drawn across the large loop is the 1500 foot line crossing the loop at Station 1475+76.7 and at Station 1490+76.7. These stations were determined as directed in the above paragraph. The next horizontal line to be drawn crosses the loop at Station 1475+40.3 and at Station 1492+00. This line is drawn in order to obtain, as near as possible, a straight line on the mass curve between the horizontal lines. The difference between the ordinate represented by the datum line and the ordinate between Stations 1475+40 and 1492+00 is the quantity of material to be hauled as indicated in the example of computations below.

The horizontal line between Stations 1476+50 and 1488+47.5 is drawn to show three balanced sections within the large balanced loop. These small loops were drawn to indicate the most economical distribution of the material within the free haul limits. At times it will be necessary to show several balanced sections within a large loop and the sections may consist of one or more loops in excess of the 1500 foot free haul limits.

The vertical distance between the horizontal lines represents embankment if on a falling line, or excavation if on a rising line. Since imported borrow appears only in calculating the swell or shrinkage factor, the quantity

$$\frac{(1490 + 76.7 - 1475 + 76.7}{2} + \frac{(1492 + 00 - 1475 + 40.3\ )}{2} = \frac{1500 + 1659.7}{2} = 1579.85$$

represented by the borrow will always be represented by an excess embankment quantity, depressing the diagram, as indicated on Exhibit 1115-4-1, between Stations 1494+44 and 1497+12.1. Waste material appears only as excavation in the computations and has the opposite effect.

At Station 1497+12.1, a new datum line is used, as all the embankment above this line has been taken care of by imported borrow. The same condition will exist where waste material is used in the mass except that the datum line will be above the original datum line. There may be several datum lines to consider, depending on the type and quantities of materials in a project. It is usually impossible to balance successive loops with the same datum line as shown in Exhibit 1115-4-1.

The method of computing hauls varies but the method most commonly used is as follows:

The cubic-yard-mile overhaul is the product of the vertical dimension (number of cubic yards between the horizontal lines) starting at the 1500 foot line, and the average length of haul – 1500 foot free haul, divided by 5280 feet.

The number of cubic yards between the horizontal lines equals

300,964.2 - 300,789.3 = 174.9 Cubic Yards.

The average length of haul =

$$\frac{(1579.85 - 1500)}{5280} \times 174.9 = 2.6 \text{ C.Y. Mile Overhaul}$$

This brief outline is for a mass diagram of a completed project. Preliminary diagrams are used in computing quantities for estimates prior to construction by using assumed swell and shrinkage in constructing the mass diagram and computing the haul.

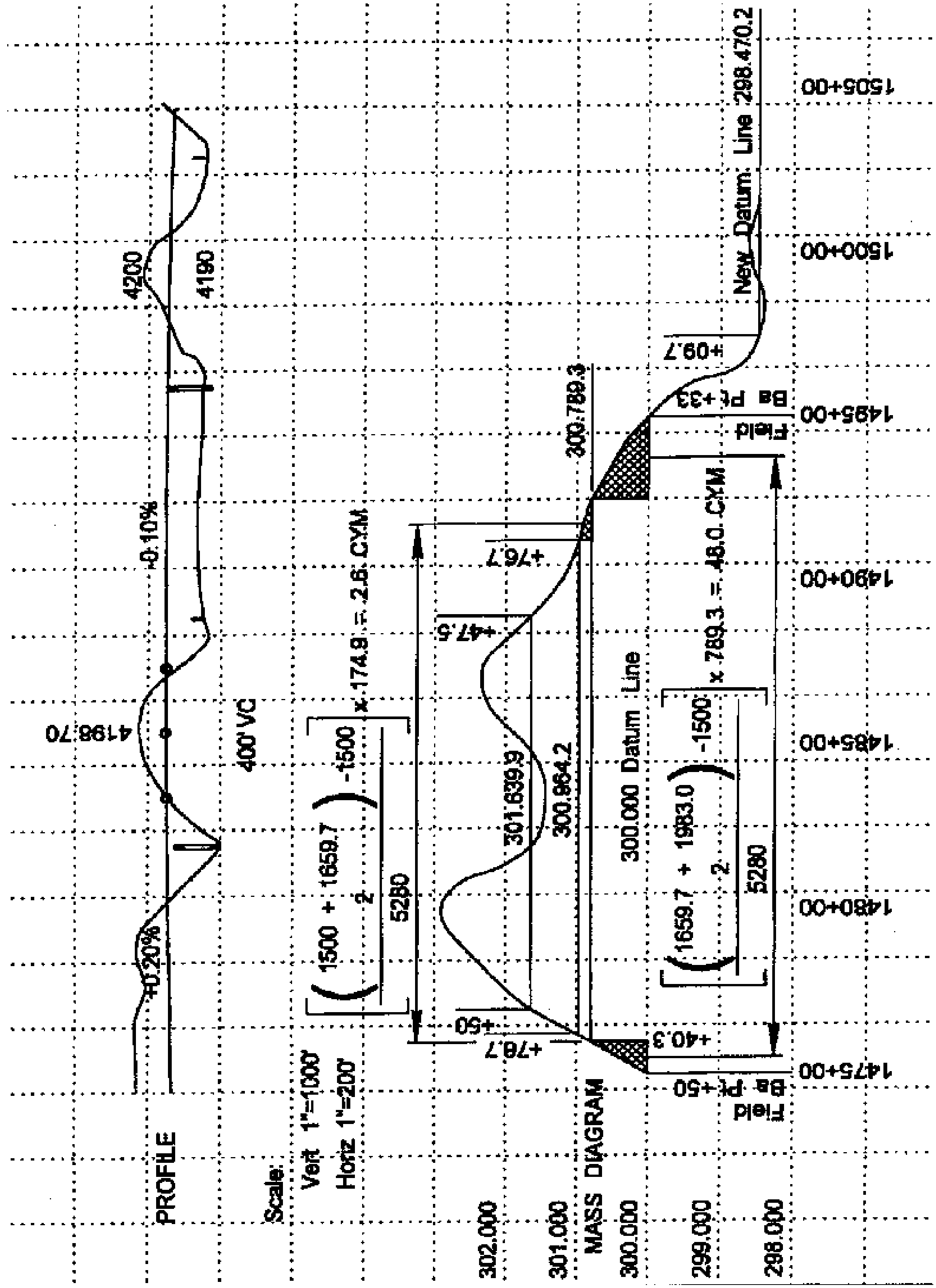


Exhibit 1115-4-1. Mass Diagram

1116 SURVEY TASK LIST

Specification	Work Item	Activity Description	Inspector Verification	Survey Crew Verification	Survey Crew Frequency
201	Clearing & Grubbing	Check staking limits w/ right-angle prism and 100 foot chain	X		Beginning of job
202	Remove Structures & Obstructions	Measurements & records	X		Prior to removals
203 - 204	Earthwork	**Review plans; check contractor's survey staking:**			
		check catch points		X	500 foot maximum
		check 90 degree		X	500 foot maximum
		angles		X	500 foot maximum
		check slope stakes		X	500 foot maximum
		check alignment		X	500 foot maximum
		Spot -check slopes w/hand level	X		As needed, 500 foot maximum
		Check each progressive lift depth	X		As needed, 500 foot maximum
205	Subgrades, Subbases, and Bases	Check contractor bluetop survey staking		X	200 foot average
		Stringline all bluetops	X		All
301 - 304	Subgrades, Subbases, and Bases	Subgrade only - check contractor survey control bluetops.		X	200 foot average
		Subbases & bases: check bluetops		X	By request only

301 - 304 Continued	Subgrades, Subbases, and Bases	Stringline each lift of subgrades, subbases, and bases	X		All
305	Lean Concrete Base	Check horizontal & vertical alignment of wire staking		X	200 foot maximum
		Check hub & tack control with plumbline & stringline	X		100 foot intervals
401	Portland Cement Concrete Pavement	Check horizontal & vertical alignment of wire staking		X	200 foot maximum
		Check hub & tack control with plumbline & stringline	X		100 foot intervals
402	PCCP Repairs	Measure, locate, record work.	X		As required
406 - 408	Asphaltic Concrete Classes	Check depths & offsets, stationing, and straight-edging.	X		100 foot intervals
501 - 502	Pipes, Culverts, and Drains	Check Contractor's survey cut stakes - vertical & horizontal control	X		Short runs - both ends
		Use appropriate survey instruments		X	All large sizes, long runs; others by request only
		Check pipe excavation and backfill using hand level, watch grade checker.	X		Check each advance
503 - 505	Catch Basins, Standpipes, Manholes	Check position - alignment & elevations		X	Check only upon request
		Verify conformance with design	X		Field verify each location
601	Concrete Structures - Bridges	Forms/soffit/falsework - verify edge of deck horizontal and vertical control; Check offsets, grades, screeds from control	X	X	Check all items, every structure
		Abutments & piers - check location & elevation of foundations prior to major pours		X	Check every structure

601 Continued	Concrete Structures - Walls & Misc	Bearing pads - check initial placement and control points, prepare as-builts		X	Verify layout at beginning of job only, and by request thereafter
		Check bearing pads prior to concreting	X		Subsequent construction
		Bid-Well: provide fill marks for Inspector to check Bid-Well initial setup		X	Verify layout at beginning of job and by request thereafter
		Continue progress checks: depths, joint locations, etc.	X		Subsequent construction
		Check Contractor's initial staking, check footings placement & elevations, etc.		X	Verify layout at beginning of job and by request thereafter.
		Check locations & grades - check all wall forms and miscellaneous structures for plumbness and alignment.	X		Check all items
603 & 609	Pilings & Drilled Shaft Foundations	Check Contractor's survey control hubs, check elevations and horizontal placement. Check lines and grades.	X	X	Initially all structures, then subsequent random checks
604	Steel Structures	Forms/soffit/falsework: verify edge of deck horizontal and vertical control		X	Check every structure.
		Check offsets, grades, screeds from control.	X		Check all items.
		Abutments - initial location & elevation.		X	Check every structure
		Bearing pads: check initial placement and control points, prepare as-builts		X	Verify layout at beginning of job and by request thereafter
		Check bearing pads prior to concreting	X		Subsequent construction
		Bid-Well - provide fill marks for Inspector to check Bid-Well initial setup		X	Verify layout at beginning of job and by request thereafter
		Continue progress checks - depths, joint locations, etc.	X		Subsequent construction

606 to 608	Sign Structures & Support	Check installation layouts, foundation elevations, and slopes.		X	Verify layout at beginning of job and by request thereafter.
		Check lines and grades.	X		All major units.
801 to 804	Landscape Earthwork	Check Contractor survey control bluetops. Inspect final grading & depth of soil.	X	X	By request only. All.
808 & 809	Water Distribution & Sewer System	Check Contractor's survey cut stakes: vertical and horizontal control. Use appropriate survey instruments.	X	X	Short runs - both ends. All large sizes, long runs; others by request only.
		Check pipe excavation and backfill using hand level, watch grade checker.	X		Check each advance.
902 & 903	Fences	Check layout work & measure for payment.	X		Prior to and when complete.
905	Guardrail	Check Contractor's layouts.		X	By request only.
		Check layout and placement.	X		Subsequent construction.
908	Curb & Gutter	Check alignment & grade control points.	X	X	Only if C & G is placed prior to paving; otherwise checked by Inspectors.
909	Survey Monuments	Check Contractor's survey on permanent section corne replacements & similar.		X	Verify all key monuments.
910	Concrete Barriers	Check placement and dimensions.	X		All critical points.
911	Right-of-Way Markers	Check placement.		X	Verify all markers.
914	Sound Barrier Walls	Check Contractor's initial staking, check footings placement & elevations, etc.		X	Verify layout at beginning of job and by request thereafter.
		Check locations, grades, and plumbness.	X		Check all structures.

925	Construction Surveying and Layout	Inspections and random checks as detailed above per instructions of the Engineer (per the Specification).	X	As directed.

GENERAL CONSTRUCTION-RELATED SURVEY ACTIVITIES

- Preliminary Design Reviews: geometrics, alignment, terrain, obstructions, constructability.
- Coordinate w/ADOT Photogrammetry on flights and mapping requests.
- Maintain right-of-way records.
- Review and check temporary construction easements.
- Support review and approval of permit requests.

1150 CONTRACTOR CONSTRUCTION SURVEYING

1150-1 General Instructions

The preceding chapters apply to surveys by either contractor or ADOT personnel. It is the intent of this section to present a series of additional guidelines and staking methods for contractor construction surveying, see specification 925.

Additional information should be sought in the ADOT *Engineering Survey Services Manual for Field Surveys*. The manual will explain how and when different survey methods and instruments should be used. All transits, theodolites, etc., will be referred to as instruments in this manual since they are thoroughly discussed in the *Engineering Survey Services Manual for Field Surveys*. The manual also illustrates field book notation and how electronic data files should be handled.

The methods for note preparation and staking procedures outlined in this manual are presented as acceptable methods of doing the work. The method selected for each phase of the construction survey shall be determined by the surveyor as each project may vary considerably in requirements.

The Department will provide control points for establishing an accurate construction centerline and will establish benchmarks adjacent to this line for the proper layout of the work as described herein. Control points will be located in accordance with Standard Specification 925, Construction Surveying and Layout. Some complex projects may require more benchmarks.

Control points set by the Department will be identified in the field to the Surveyor and any diagrams available will be provided. The Department will provide the contractor with field books or data files containing the control point data at the preconstruction conference. If a control point cannot be established at the outset due to right-of-way restrictions, the Department will establish that point at the earliest possible time when right of entry to the area is obtained. At the earliest possible time, the contractor shall furnish as many large and small sets of construction plans to the Surveyor as needed. The contractor shall also provide his proposed schedule of work sequence to the Surveyor.

Prior to beginning any survey operations, the Surveyor shall furnish to the Engineer, for his approval, a written outline detailing the method of staking, marking of stakes, grade control for various courses of materials, referencing, structure control, and any other procedures and controls necessary for survey completion. A part of this outline shall also include a schedule which will show the sequencing of the survey and layout work, throughout the course of the contract, listing a percentage of completion for each month. The method of staking and marking of stakes should be reviewed in the field with the contractor and the inspector, making certain that all parties understand the staking methods and marking.

It may be advantageous to supply the contractor with diagrams indicating staking procedures. This could also be helpful in case the individual that originally was in charge of staking, for one reason or another, is not available. Copies of staking layouts should be kept in the project files. This would be especially helpful in difficult or unusual staking situations.

1150-2 Study and Checking of Plans

Before any staking is started, the plans shall be thoroughly reviewed and cross-checked relevant to the juxtaposition of current project items, past projects, and adjacent projects. Also the field control points shall be carefully checked by the Surveyor. All parts of the plans pertaining to control such as curve data, both horizontal and vertical, shall be checked. All major structures shall be checked as to plans elevations from finish grade to bottom of footings. The Surveyor will verify the accuracy of the control points established by the Department and will also check for correlation between these points and the plans.

If errors are discovered during the plans checking or the verification process, or if control points do not agree with the geometrics shown in the plans, the contractor shall promptly notify the Engineer in writing, and explain the problem in detail. The Engineer will advise the contractor within 5 working days of any corrective actions which may be deemed necessary.

Directed changes to the work shall be reimbursed under subsection 925-5 of the Standard Specifications and additional contract time may be considered for any delays.

A careful check of plans and control points may prevent costly errors and delay in progress.

The preparation of field books and recording of field measurements are an important part of the survey operation. Keep in mind that these notes will serve as an official document.

All field notes shall be recorded in standard field notebooks which will be furnished by the Department unless an electronic data collector is used. Never use loose-leaf books or pads for permanent records. All field notebooks submitted to ADOT become a permanent record. Electronic files shall be compatible with Department software.

Neatness and clarity are of uppermost importance in the preparation of field notes. When preparing notes, provide sufficient detail that they may be readily interpreted by those who are not familiar with the project. Too much detail is far better than too little. Never crowd survey notes; paper is relatively cheap compared to the cost of rework if your notes are not legible.

Errors made in the recording of the field notes will not be erased. Draw a line through the erroneous figures and place the corrected figures directly above. When necessary to make revisions in notes, the abandoned notes shall not be destroyed but shall be crossed out and reference made as to the book number and pages where revisions appear. When corrections are made the individual making these should date and initial each change.

Each book should have pages numbered only at the top of the right hand sheet and the contents indexed on the first pages. The date, weather conditions, and party personnel shall be shown at the beginning of each day's notes. The person in charge of making the survey or recording the measurements shall affix his or her signature at the end of each day's notes and on each page containing the results of a measured item.

Construction survey field notes in the form of electronic stakeout reports, stakeout listings with actual staked positions noted, or other suitable forms, will be filed with the Resident Engineer upon completion of each survey

All construction records shall be plainly marked for identification with the contents, route, project number, stations, name of Surveyor, and year.

All project records shall be delivered to ADOT (electronically preferred) upon completion of the work where they will become permanent project records.

Survey data may also be collected using an electronic data collector. When survey data is collected electronically it shall be submitted to the Resident Engineer in electronic format with a copy that is sent to Record Drawings. Ensure that electronic files are compatible with Department software. Refer to ADOT *Engineering Survey Services Manual for Field Surveys* for additional information.

1150-3 Staking Structures

Refer to subsection 1108 of this Manual for culvert and bridge structure staking requirements.

1150-4 Slope Stakes

Slope stakes may be placed prior to the contractor clearing the ground in cases of open, grassy prairie, or cultivated land, where a minimum of clearing is required; otherwise, a clearing line should be established and the roadway prism should be cleared prior to setting of slope stakes, or as specified in the special provisions, see Exhibits 1109-4-1, 1109-4-4, and 1109-4-5.

The slope stakes outline the cut or fill limits and the slopes to be built for the contractor. Usual practice is to stake at all full and 50 foot stations and at all breaks in topography within the roadway section.

Measurements shall be from the centerline of the survey and shall be noted in the field book. In setting slope stakes the rod is read to the nearest 0.1 feet and horizontal distances measured with a metallic tape (if required) at right angles to the survey centerline also recorded to the nearest 0.01 feet. In heavy work on steep hillsides, special care shall be taken in reading the rod and in setting slope stakes at right angles to the centerline and also in properly measuring the horizontal distances from the survey centerline to the point where rod readings are taken and where slope stakes are set.

The use of hand levels and the Rhodes Arc should generally be limited to determining elevations of inaccessible locations because elevations taken by this method are not as accurate as elevations read with an engineer's level. In rough terrain, parallel profile levels outside of the slope stake lines may be used to check hand level work. It is recommended that electronic instruments are used for this application to increase accuracy.

A slope stake shall be set where the cut slope intersects the existing ground surface, this is known as the catch point. The slope stake will be marked on the back side with the appropriate stationing. The inside of the slope stake will bear the letter "C" (indicating that a cut is to be made), the amount of cut to be made at that particular point, the horizontal distance from the centerline to the slope stake, the ratio of slope, and the shoulder distance or hinge point distance.

During the excavation operation, the life of a slope stake is of short duration due to equipment operation. Therefore, a reference to each slope stake in a cut section should be set as follows:

- A guinea shall be driven flush with the ground, outside the slope rounding area, and preferably at an even horizontal distance from the slope stake; a 10 foot offset is usually adequate, if not, additional increments of 10 feet are suggested.
- A guard stake shall be driven behind the guinea. (A guinea is a small stake driven flush with the ground surface.) The back side of the guard stake shall show the station of the section. The front side shall show the cut at the slope stake and the horizontal distance from the slope stake to the reference.

Slope rounding shall be staked to conform to the roadway standards when slope rounding is required.

In most cases, it is not necessary to offset the fill slope stake except where the fill will catch on a traveled roadway. In this event a guinea should be driven flush with the ground at the point where the toe of the fill intersects with the natural ground (catch point). The slope stake shall be placed back of the guinea and out of the traveled way at right angles to the centerline. The marking shall show the stationing of the section on the back of the stake; the front face shall show the letter "F" (to indicate fill) with the amount of the fill from the guinea to the grade, shoulder point, the horizontal distance from centerline to the guinea and the ratio of the fill slope to be constructed.

A slope stake marked 0.0 should be driven at the shoulder grade point on entering a cut from a fill or vice-versa.

The standard size slope stake is 1in. X 2 in. X 14 in.

1150-5 Drainage Stakes

Drainage staking shall conform to Subsection 1110 of this Manual, except preparation of a drainage excavation book is optional.

1150-6 Miscellaneous Construction Stakes

Refer to Subsection 1112 of this Manual for miscellaneous construction staking requirements.

1150-7 Grade Stakes (Blue Tops)

Refer to Subsection 1113 of this Manual for grade stake requirements.

Automated Machine Guidance (AMG)

AMG is the computerized guidance of construction equipment to follow the line and grade of the engineered design. Guidance is either by direct control of the machinery or through visual and/or audible signals to the operator. Operation is based on digital input from satellite positioning systems, and typically produces an increased level of precision, speed, and accuracy.

AMG Controlled Work

For work being controlled by a 3D Model, see requirements of the special provision. Which include the following:

- A Narrative outlining any changes made to the Agency prepared 3D Engineered Models in the creation of the 3D Construction Models.
- A copy of the 3D Construction Models that will be used by the contractor's equipment for machine guidance or verification, that include and represent the Agency prepared 3D Engineered Models with changes identified in the Narrative. Provide files in LandXML format or as directed.
- A written AMG work plan as required.

AMG - In lieu of setting stakes

The contractor may use AMG if:

- The contractor Informs and gains approval from the Engineer prior to the use of AMG on a project.
- The contractor submits a plan in writing addressing the use of AMG on the project.
    - The plan shall be submitted 10 days prior to the Pre-Construction meeting or 21 days prior to use of AMG.
    - The plan shall include but not be limited to the following items:
        - A narrative outlining the overall AMG plan, including:
            - Processes and procedures used with AMG equipment.
            - Survey control procedures; verification and augmentation.
            - Machine positioning technology method, e.g. GNSS, total station, laser, etc.
            - Data validation and data conversion process.
        - A list of bid items that will be constructed with the AMG procedure for constructing each type of construction material.
        - All construction equipment being used.
        - Personnel being used and their experience using AMG.
        - List of Survey equipment, GNSS, and sensors being used with each piece of equipment.
        - A procedure for collecting Grade Verification points on each type of material.
        - Identify the Registered Professional Land Surveyor in charge of the survey activities.
        - Demonstrate capabilities, accuracy, and reliability of the intended AMG procedure if required by the Engineer.
        - Perform any supplemental staking as directed by the Engineer.

Note:

- Special care should be taken around areas where the GPS could lose signal, e.g. under overpasses. Additional attention should be paid to these areas and should be double checked with surveys. This should be discussed with the contractor in the preactivity meeting.
- It is recommended that the contractor lay a 500 foot test strip to confirm the accuracy and eliminate any potential issues during paving operations. However, the Engineer should refer to the project special provisions for AMG test strip requirements prior to requiring the contractor to do so. This should also be discussed in advance with the contractor during the preactivity meeting.

1151 GLOBAL POSITION SYSTEM (GPS) AS-BUILT OF PROJECT

During construction of the project, as-built information shall be collected for the purpose of documenting the final installation of the contract bid items. This includes, but is not limited to, all final locations of structures, utilities, manholes, valves, storm drains, catch basins, curb and gutter, pavement, sign structures, light poles, pull boxes, FMS facilities, traffic signals, attenuation devices, barrier runs, and any other appurtenances that are included in the final as-built plan.

The electron data file shall be submitted to the Resident Engineer for the purpose of plotting the information prior to final acceptance. The file shall be compatible with Department CAD and GIS software. GIS file formats and feature codes will be obtained from the Department. The data shall include line and point features, as well as sufficient digital photo links to assure that the GPS information will accurately describe or explain the feature that has been captured. An example is a sign structure that shows up as a point/line feature across the roadway. A digital photo should be linked to the data feature showing the actual sigh placard on the structure. Likewise, a link should be provided to the data containing scanned-in shop drawings or manufacturer cut sheets for specialty features such as parapet fence, and specialty structures.

The as-built locations of project items, including elevations shall be tied to the project datum. It may be necessary to include latitude, longitude of project items.

Precision of locations shall be equal to the precision used to stake the project item.

1200 GENERAL

This chapter provides guidelines for preparing Department records and reports during the administration of a typical highway construction project. It is intended to clarify and supplement the information provided in the standard specifications and the special provisions for each project.

It is required that a digital file index be kept at all field offices, this is done in the District or Unit Google Drive.

Each District has a specific template for setting up project files in their Google Drive. Please contact your assigned Unit for specific information.

As a part of the file set up the final folder is also to be created. Please go to the Field Reports Resource Center Site through the intranet to download the latest checklist that includes the folder template.

1201 CPE REPORTS

1201-1 General

The Construction Progress Estimates (CPE) computer program provides automated office logs for each project administered by the ORG. Supplemental agreements, contract item quantities, and time charges are entered into the CPE project records. The CPE program adjusts the contract total as required, calculates accumulated project costs, and tracks contract time.

The program provides several different kinds of reports to help the Resident Engineer monitor the progress of the project. The Resident Engineer should become familiar with the CPE program and its reporting capabilities.

For details on operating the CPE program, refer to the training that is also offered by Technical Training, Course TCH 3041. Self-enrollment is available on ADOTNET ADOT Learning and Development Resources

1201-2 Change Order/Letter of Agreement Report

This report displays the approval date, affected items, and cost impact of Change Orders and Letter of Agreements generated.

See below Exhibit 1201-2 Change Order / Letter of Agreement Report for an example.

Change Order / Letter of Agreement Report

TRACS #: F011601C 04/11/2024 12:11 pm

Project: 303-A-(227)T Page 1 of 3

Note: ** indicates that the total includes an SA adjustment

C.O. No. 1 **Description: Earthwork Quantity Changes** **Date Approved: 03/25/2021**

Section	Item	Type	Description	Cost Adj.	Quantity	Unit Cost	Amount
1	2030301		ROADWAY EXCAVATION		15,010.00	11.50	172,615.00
1	2030904		BORROW (IN PLACE)		-11,190.00	16.00	-179,040.00
						Total Change Order =	**$ -6,425.00**

L.A. No. 1 **Description: Subsurface changed condition at barrier foundations** **Date Approved: 07/30/2021**

Section	Item	Type	Description	Cost Adj.	Quantity	Unit Cost	Amount
1	9240101		MISCELLANEOUS WORK (RESIDENT ENGINEER US		0.00	1.00	
	Subitem: 1		Subsurface Changed Condition	.00	7,808.560		7,808.56
						Total Letter of Agreement =	**$ 7,808.56**

C.O. No. 2 **Description: Jomax Signals** **Date Approved: 09/13/2021**

Section	Item	Type	Description	Cost Adj.	Quantity	Unit Cost	Amount
1	7320050		ELECTRICAL CONDUIT (2") (PVC)		110.00	8.50	935.00
1	7320420		PULL BOX (NO. 7)		-9.00	865.00	-7,785.00
1	7320421		PULL BOX (NO. 7) (WITH EXTENSION)		9.00	915.00	8,235.00
1	7330330		TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE IV		-4.00	505.00	-2,020.00
1	7330360		TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE VI		-4.00	498.00	-1,992.00
1	7330400		TRAFFIC SIGNAL MOUNTING ASSEMBLY (TYPE XI		16.00	252.06	4,032.96
						Total Change Order =	**$ 1,405.96**

C.O. No. 2 **Description: Jomax Signals** **Date Approved: 09/13/2021**

1201-3 Duplicate Payment Check Report

This feature was added so the Field Office could check and determine whether CPE duplicated any payments and make corrections as necessary. There was a period of time when the CPE program was duplicating payments during the import process from PEN.

This report should be periodically checked throughout the project construction phase and at the time of project finalization to ensure duplicate payments did not occur to any item during construction.

The CPE program sometimes flags an entry as "duplicate" because an inspector did not have enough information shown in the description field, i.e. station, milepost, etc. to identify what/where payment was for.

Unless you check quantity payments made after importing from PEN, you would not be aware that the program was duplicating any payments.

See Exhibit 1201-3 Duplicate Payment Report for an example.

Duplicate Payment Report

TRACS #: H617801C

04/11/2024 01:29 pm
Page 1 of 1

Section	Item	Subitem	Install Date	Quantity	Inspector	Comments	Count
1	7310551	363C	10/09/2008	1.00	117 - James Smi	STA 28+22.0, 62.0' RT	2
1	7310652	37921	09/08/2008	-1.00	109 - James Smi	919+00, 80' RT	2
1	7310652	38089	09/08/2008	-1.00	109 - James Smi	STA 1048+40.00, 80.0 L	2
1	7310652	38111	09/08/2008	1.00	109 - James Smi	STA 53+15, 94 RT	2
1	7310652	38112	09/08/2008	1.00	109 - James Smi	STA 67+62, 85' LT	2
1	7320500	373	09/24/2008	120.00	116 - James Smi	STA 1025+00 TO 1038+00	2
1	7320500	37949	09/24/2008	20.00	116 - James Smi	58+40, 52' LT	2
1	7320500	3795	09/24/2008	20.00	116 - James Smi	9+90, 40' LT	2
1	7320500	38051	09/24/2008	20.00	116 - James Smi	62+00, 28' LT	2
1	7320500	38052	09/24/2008	20.00	116 - James Smi	64+30, 28' LT	2

1201-4 Final Balance Report

The Final Balance Report analyzes quantity over-runs and under-runs for every item. Reasons for overruns can be entered in this report. Pay items with a difference of 25% or greater will appear. An explanation is necessary for overruns of 200% and greater. This report is required as part of the backup documentation needed when finalizing a project. The Final Balance report is submitted with the project final and is reviewed and signed by the State Construction Engineer.

See below Exhibit 1201-4 Final Balance Report for an example

Arizona Department of Transportation

Final Balance on Contract Work

Project: F011601C 303-A-(227)T
Description: HAPPY VALLEY PKWY TO LAKE PLEA
Contractor: Sunland Asphalt & Construction Inc.
Engineer: Sara Howard

Date: 04/11/2024
Org: 4676
Date Completed: 02/25/2022

Section 1 FA 03

Item No.	Description	Unit	Plans Qty	Revised Qty	Accum Qty	Difference	Unit Price	Plus	Minus	CO/LA
1080300	SUBCONTRACTOR EARLY START SANCTION	L.SUM	0.00	0.00	-1,000.00	-1,000.00	1.00	0.00	-1,000.00	
1090001	DIESEL FUEL PRICE ADJUSTMENT	L.SUM	0.00	0.00	125,067.38	125,067.38	1.00	125,067.38	0.00	
1090011	ASPHALTIC CONCRETE PAVEMENT QUALITY LOTS	L.SUM	0.00	0.00	-6,897.97	-6,897.97	1.00	0.00	-6,897.97	
1090020	PORTLAND CEMENT CONCRETE PAVEMENT SMOOTH	L.SUM	0.00	0.00	14,067.56	14,067.56	1.00	14,067.56	0.00	
1090021	PORTLAND CEMENT CONCRETE PAVEMENT THICKNE	L.SUM	0.00	0.00	40,110.87	40,110.87	1.00	40,110.87	0.00	
1090022	PORTLAND CEMENT CONCRETE PAVEMENT STRENG	L.SUM	0.00	0.00	43,753.27	43,753.27	1.00	43,753.27	0.00	
1090030	PAYROLL SUBMITTAL RETENTION	L.SUM	0.00	0.00	0.00	0.00	1.00	0.00	0.00	
2020021	REMOVAL OF CONCRETE CURB AND GUTTER	L.FT.	14.00	14.00	14.00	0.00	35.00	0.00	0.00	
2020029	REMOVAL OF ASPHALTIC CONCRETE PAVEMENT	SQ.YD.	9,208.00	9,208.00	9,205.56	-2.44	2.25	0.00	-5.48	
2020048	REMOVAL OF STRUCTURE (CATCH BASIN, MANHOL	EACH	3.00	3.00	3.00	0.00	500.00	0.00	0.00	
2020053	REMOVE (SIGNS, FOUNDATIONS, AND POSTS)) **5 sign removals were not shown on the project plans. One sign changed from a relocate to a remove and**	EACH	9.00	9.00	15.00	6.00	61.00	366.00	0.00	
2020054	REMOVE (GUARD RAIL END TERMINAL))	EACH	12.00	12.00	12.00	0.00	250.00	0.00	0.00	
2020058	REMOVE AND SALVAGE (TEMPORARY CONCRETE E	L.FT.	400.00	400.00	400.00	0.00	5.00	0.00	0.00	
2020071	REMOVE GUARD RAIL	L.FT.	150.00	150.00	137.50	-12.50	4.00	0.00	-50.00	
2020081	REMOVE BITUMINOUS PAVEMENT (MILLING) (1") **Changed the limits of milled area to improve the quality of the mainline rideability.**	SQ.YD.	520.00	520.00	3,364.44	2,844.44	7.00	19,911.08	0.00	
2020101	REMOVE FENCE	L.FT.	797.00	797.00	754.00	-43.00	1.65	0.00	-70.95	
2020162	REMOVE (SLOPE PAVING))	SQ.YD.	408.00	408.00	406.74	-1.26	18.00	0.00	-22.68	
2030301	ROADWAY EXCAVATION **CO #1**	CU.YD.	35,144.00	50,154.00	50,154.00	15,010.00	11.50	172,614.97	0.00	1
2030904	BORROW (IN PLACE)	CU.YD.	79,997.00	68,807.00	68,807.00	-11,190.00	16.00	0.00	-179,040.00	1
3030022	AGGREGATE BASE, CLASS 2	CU.YD.	16,089.00	16,089.00	15,952.49	-136.51	38.00	0.00	-5,187.38	
4010009	PORTLAND CEMENT CONCRETE PAVEMENT (9")	SQ.YD.	22,136.00	22,136.00	21,779.03	-356.97	60.00	0.00	-21,418.20	
4010010	PORTLAND CEMENT CONCRETE PAVEMENT (10")	SQ.YD.	21,912.00	21,912.00	21,974.24	62.24	63.00	3,921.12	0.00	
4040000	BITUMINOUS PRICE ADJUSTMENT	L.SUM	0.00	0.00	8,088.68	8,088.68	1.00	8,088.68	0.00	

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1201-5 Force Account Reports

The Force Account Report shows the amount paid and the percent complete for the specified Supplemental Agreement type force accounts. To obtain a Pay/Line Item type Force Account Report, select the appropriate project and section, and then select the appropriate Pay/Line Item number. You can obtain the same report by selecting “Item/Subitem Report” from the Reports drop down menu on the menu bar.

See below Exhibit 1201-5 Force Account Report for an example.

Force Account Report - Includes Transactions

04/11/2024 12:10 pm

TRACS #: F011501C **Project:** 017-A-NFA

Page 1 of 1

No.	Description	Original Amt	Revised Amt	Accum Amt	Percentage
Section:	1				
000001	PCCP spall, crack, and joint repair	75,000.00	75,000.00	22,876.80	30.50 %

List of Transactions

Date	Amount Paid	Inspector	Comments
04/13/21	3,267.68	E. Morgan	Detail #1 05/30/2020
03/18/22	2,191.18	E. Morgan	Detail #2 02/11/2021 - 02/12/2021
03/18/22	7,696.22	E. Morgan	Detail #3 02/20/2021
04/08/22	139.18	E. Morgan	Detail #4 08/30/2021
04/08/22	9,582.54	E. Morgan	Detail #5 09/21/2021 - 09/22/2021
Total Paid =	$22,876.80		

No.	Description	Original Amt	Revised Amt	Accum Amt	Percentage
000002	Relocate DMS conduits and APS power feed	22,000.00	22,000.00	11,123.72	50.56 %

List of Transactions

Date	Amount Paid	Inspector	Comments
12/03/21	4,349.80	E. Morgan	Detail #2 02/16/2021 - 02/17/2021
12/03/21	507.12	E. Morgan	Detail #3 02/26/2021
12/14/21	1,489.80	E. Morgan	Detail #4 03/01/2021
01/04/22	4,777.00	E. Morgan	FA #2 Detail #1 02/11/2021-20/12/2021
Total Paid =	$11,123.72		

1201-6 Incentive Report

The Incentive Report shows the number of entries made after the estimate cutoff date giving the Transmittal Amount, Cutoff Amount and Date, Percent and Count of Entries Past Cutoff Date.

See below Exhibit 1201-6 Incentive Report for an example.

Arizona Department of Transportation
Division of Highways
Incentive Report

Page: 1
Date: 04/11/2024

Org:	4676		Contract Amount:	$ 70,057,597.22
Tracs No:	F042401C		Date Started:	09/12/2022
Federal No.:	303-A-NFA	Estimate No. 18	Date Completed:	01/25/2024
Description:	51st Ave and 43rd Ave Interch	Month: January 2024	Engineer:	Sara Howard
Contractor:	FISHER SAND & GRAVEL CO.		Percent Complete:	99
Phase 01 days:	392		Percent Time Used:	100

Transmittal Amount: 10,590.09 Cutoff Amount: 0.00 Cutoff Date: 01/02/2024 Percent: 100.00 Count of entries past cutoff date: 8

Item Number	Inspector	Comments
1090001	30 Agnieszka Kasnikowski	Diesel Fuel Price Adjustment for 12/2023
7370430	199 Martin LLerenas	Paying out for placement 3kVAXFMR at STA 2043+84 210'Lt , sheet 447, T-0
7370430	199 Martin LLerenas	Paying out for placement 3kVAXFMR at STA 2051+65 240'Rt sheet 439, T-08
7370430	199 Martin LLerenas	Paying out for placement 3kVAXFMR at STA 2104+38 250'Lt, Sheet 447, T-0
9250102	70 Troy Polvorosa	Additional survey requested at the South Channel
9250102	70 Troy Polvorosa	Additional survey requested at the Upper Buchanan Wash for LOMR
9250106	70 Troy Polvorosa	Additional survey requested at the South Channel
9250106	70 Troy Polvorosa	Additional survey requested at the Upper Buchanan Wash for LOMR

1201-7 Item/Subitem Reports

The Item/Subitem Report is a basic status report for a single item or a range of items. It includes the plans quantity, the revised quantity, the accumulated quantity, accumulated amount, the percent complete, history of partial payments, status of subitems including accumulated quantity, percent complete of each subitem and a list of transactions for the specified subitems. Each listed transaction shows the date, the quantity posted, the inspector's name, diary number and any comments entered when the quantity was posted. This report is valuable in catching duplicate payments or missed payments on a specific item.

This report can be used to verify quantities such as the rounding requirement in 608 sign panels to the nearest 0.10 square foot. This report can be used to verify that the total of 608 sign panels are rounded to the nearest square foot once all work has been completed.

See below Exhibit 1201-7 Item/Subitem Report.

Item/SubItem Report - Includes Transactions

TRACS: F012301C — Sara Howard ,
Project: 101-B-(210)T — **Resident Engineer**
Contractor: FNF CONSTRUCTION, INC. — **Org #** 4676

101 Pima Princess Dr-Shea Blvd

Section: 01 FA 03 Roadway

Item No	Description	Unit	Unit Cost	Change Orders
2020121	**REMOVE (72" STORM DRAIN PIPE))**	**L.FT.**	**$60.00**	

Plans Qty: 781.000 Rev Qty 781.00 Rev Amount $ 46,860.00
PPCode: 0 Accum Qty 781.00 Accum Amount $ 46,860.00 = 100.00 %

Item No.: 2020121

Subitem	Description	Cost Adjustment	Adj. Unit Price	Revised Qty	Accum Qty
D-01.17A	SR101 Sta 2299+17 Lt	$0.00	$0.00	212.00	212.00

Date	Quantity	Qty Subtotal	Inspector	Comments
02/14/2024	180.00		16 Patrick Schuerman	-Removal of 180 Lf of existing pipe Sta. 2299+65 Lt to Sta. 2301+45 D-01.17A
02/15/2024	32.00		17 Patrick Schuerman	-Removal of 32 LF of existing pipe Sta. 2301+45 to Sta. 2301+80 D-01.17A
	Total =	**212.00**		

Subitem Total: **212.00** **212.00**

1201-8 Monthly Estimate

At the beginning of each month, the field office produces a contractor's pay estimate for each active project. The Monthly Estimate is the most important report the office produces because it calculates the amount of payment the contractor receives.

The Monthly Estimate is a report of each item's accumulated quantity to date multiplied by the unit bid price and calculates the total compensation due the contractor for work completed. Shown on the cover recap sheet (aka. the recapitulation sheet) of the monthly estimate is total monies earned to date minus total monies earned from prior months. The difference in the two amounts is the total monies due the contractor for the current month.

The monthly estimate report is sent to the contractor via DocuSign for signature each month.

See below Exhibit 1201-8 Monthly Estimate Report for an example.

ADOT

Arizona Department of Transportation
Division of Highways
Agreement Estimate & Transmittal Sheet
(Money Summary of Progress & Final Payment Report)

Page: 1
Date: 04/11/2024

Org: 4676
Tracs No: F012301C
Federal No.: 101-B-(210)T
Description: 101 Pima Princess Dr-Shea Blvd
Contractor: FNF CONSTRUCTION, INC.
Phase 01 days: 700

Estimate No. 5
Month: April 2024

Contract Amount: $ 108,141,707.00
Date Started: 01/19/2024
Date Completed:
Engineer: Sara Howard
Percent Complete: 13
Percent Time Used: 11

Section		Rdway & Small Str	Str Over 20 FT	Total	Force Account	Total	Notations
1 FA	03	13,535,756.99		13,535,756.99		13,535,756.99	Roadway
2 FA	13	0.00		0.00		0.00	STRUCTURE
3 FA	42	0.00		0.00		0.00	TRAINING
4 FA	03	6,795.35		6,795.35		6,795.35	CITY OF SCOTTSDALE WORK
5 NFA		0.00		0.00		0.00	CITY OF SCOTTSDALE STRUCTURE PAINTING (NOT PA

Summary of Federal Aid Construction

Accum	13,542,552.34	0.00	13,542,552.34	0.00	13,542,552.34
Previous	13,288,038.09	0.00	13,288,038.09	0.00	13,288,038.09
Current	254,514.25	0.00	254,514.25	0.00	254,514.25

Summary of Non-Federal Aid Construction

Accum	0.00	0.00	0.00	0.00	0.00
Previous	0.00	0.00	0.00	0.00	0.00
Current	0.00	0.00	0.00	0.00	0.00

Grand Total Construction

Accum	13,542,552.34	0.00	13,542,552.34	0.00	13,542,552.34
Previous	13,288,038.09	0.00	13,288,038.09	0.00	13,288,038.09
Current	254,514.25	0.00	254,514.25	0.00	254,514.25

Remarks:

1201-9 Stored Monthly Estimate

All estimates paid to date are found in the Stored Monthly Estimate reports. An estimate becomes a Stored Estimate once it has been saved, and sent to Contract Payables for payment. Notice in the exhibit below, the date in the upper right corner is shown as "Run Date". This is the date the report was saved by the Field Office.

Note: The "Accumulated Total" amount should match the next monthly estimate "Previous Total".

See below Exhibit 1201-9 Stored Monthly Estimate Report for an example.

ADOT

Arizona Department of Transportation

Division of Highways

Agreement Estimate & Transmittal Sheet

(Money Summary of Progress & Final Payment Report)

Page: 1 of 41

Run Date: 5/7/2024 3:53:34 PM

Org:	4676	Contract Amount:	$108,141,707.00
Tracs No:	F012301C	Date Started:	1/19/2024
Federal No:	101-B-(210)T	Date Completed:	
Description:	101 Pima Princess Dr-Shea Blvd	Engineer:	Sara Howard
Contractor:	FNF CONSTRUCTION, INC.	Percent Complete:	15
Phase 01 days:	700	Percent Time Used:	15

Estimate No. 5

Month: April 2024

Section	Rdwy Sm Str	Str Over 20 Ft	Total	Force Acct	Total	Notations
1 FA 03	15,757,097.43		15,757,097.43		15,757,097.43	Roadway
2 FA 13	245,204.75		245,204.75		245,204.75	STRUCTURE
3 FA 42	583.50		583.50		583.50	TRAINING
4 FA 03	57,030.01		57,030.01		57,030.01	CITY OF SCOTTSDALE WORK
5 NFA	0.00		0.00		0.00	CITY OF SCOTTSDALE STRUCTURE PAINTING (NOT PARTICIPATED BY

Summary of Federal Aid Construction

Accumulated	16,059,915.69	0.00	16,059,915.69	0.00	16,059,915.69
Previous	13,288,038.09	0.00	13,288,038.09	0.00	13,288,038.09
Current	2,771,877.60	0.00	2,771,877.60	0.00	2,771,877.60

Summary of Non-Federal Aid Construction

Accumulated	0.00	0.00	0.00	0.00	0.00
Previous	0.00	0.00	0.00	0.00	0.00
Current	0.00	0.00	0.00	0.00	0.00

Grand Total Construction

Accumulated	16,059,915.69	0.00	16,059,915.69	0.00	16,059,915.69
Previous	13,288,038.09	0.00	13,288,038.09	0.00	13,288,038.09
Current	2,771,877.60	0.00	2,771,877.60	0.00	2,771,877.60

Remarks:

Date Resident Engineer Date Contractor Date Field Reports

1201-10 Overrun Line Item Report

The Overrun Line Item Report separates the cost for major and minor items.

See below Exhibit 1201-10 Overrun Line item Report for an example.

OVERRUN LINE ITEMS

TRACS # F011701C **Fed Project #** 073-A-(206)T **Location** W OF RIM TANK - W OF CANYON DA

Section A: Major Items

Item #	Item Description	Unit	Unit Price	Revised Quantity	Revised Amount	Actual Quantity	Actual Amount	% Comp	> 125% Comp	Quantity Overrun > 125% Comp	Dollars Overrun > 125% Comp
4040160	COVER MATERIAL (SPECIAL) (PRECOATED)	CU.YD.	$110.00	789	$86,790.00	1,336	$146,991.90	169 %	44 %	347	$38,170.00
										Major Line Items' Overrun Cost:	**$38,170.00**

Section B: Minor Items

Item #	Item Description	Unit	Unit Price	Revised Quantity	Revised Amount	Actual Quantity	Actual Amount	% Comp	> 100% Comp	Quantity Overrun > 100% Comp	Dollars Overrun > 100% Comp
2020019	REMOVAL OF EMBANKMENT CURB	L.FT.	$2.34	176	$411.84	266	$622.44	151 %	51 %	90	$210.60
2030113	SHOULDER BUILD-UP (COMPACTION)	HOUR	$99.00	4	$396.00	10	$990.00	250 %	150 %	6	$594.00
4040111	BITUMINOUS TACK COAT	TON	$468.00	30	$14,040.00	46	$14,953.52	153 %	53 %	15	$7,020.00
4040116	APPLY BITUMINOUS TACK COAT	HOUR	$146.00	60	$8,760.00	92	$13,432.00	153 %	53 %	32	$4,672.00
4160031	MINERAL ADMIXTURE	TON	$90.00	140	$12,600.00	152	$13,717.80	109 %	9 %	12	$1,080.00
7015069	TEMPORARY PAVEMENT MARKERS (CHIP SEAL)	EACH	$1.00	698	$698.00	1,847	$1,847.00	265 %	165 %	1149	$1,149.00
7016030	BARRICADE (TYPE 1, TYPE 2, VERT.PANEL, TUBULAR MARKER)	EACH-DAY	$0.23	2,665	$612.95	3,343	$768.89	125 %	25 %	678	$155.94
7016033	PORTABLE SIGN STAND (SPRING TYPE)	EACH-DAY	$0.64	540	$345.60	872	$558.08	161 %	61 %	332	$212.48
7016035	WARNING LIGHT (TYPE A)	EACH-DAY	$0.18	278	$50.04	4,491	$808.38	1615 %	1515 %	4213	$758.34
7016051	TEMPORARY SIGN (LESS THAN 10 S.F.)	EACH-DAY	$0.41	438	$179.58	1,256	$514.96	287 %	187 %	818	$335.38
7016067	CHANGEABLE MESSAGE BOARD (CONTRACTOR FURNISHED)	EACH-DAY	$47.00	130	$6,110.00	254	$11,938.00	195 %	95 %	124	$5,828.00
7016080	FLAGGING SERVICES (DPS)	HOUR	$65.26	200	$13,052.00	740	$48,259.77	370 %	270 %	539	$35,175.14
7080202	WATERBORNE-TYPE I PAVEMENT MARKING (PAINTED) (YELLOW)	L.FT.	$0.15	49,942	$7,491.30	98,598	$14,789.70	197 %	97 %	48656	$7,298.40
8050003	SEEDING (CLASS II)	ACRE	$5,500.00	1	$5,500.00	3	$16,500.00	300 %	200 %	2	$11,000.00
8101014	EROSION CONTROL (WATTLES)(20")	L.FT.	$5.00	521	$2,605.00	640	$3,200.00	123 %	23 %	119	$595.00
9130001	RIPRAP (DUMPED)	CU.YD.	$104.00	21	$2,184.00	44	$4,563.52	210 %	110 %	22	$2,288.00

1201-11 Partial Payment Report

This report is beneficial to the Office staff when closing out a project, as it allows you to see what items still have inventory remaining that need to be depleted from the CPE program before proceeding with the project final.

See below Exhibit 1201-11 Partial Payment Report for an example.

Partial Payment Report

TRACS:	F012301C		Sara Howard ,
Project:	101-B-(210)T		**Resident Engineer**
Contractor:	FNF CONSTRUCTION, INC.	**Org #**	4676

101 Pima Princess Dr-Shea Blvd

Section: 01 FA 03 Roadway

Item No	Description	Unit	Unit Cost	Plans Qty	Accum Qty
6060078	FOUNDATION FOR BRIDGE SIGN STRUCTUI	EACH	20,000.00	2.00	0.64

Install Date	PPcode	Rate	Quantity	Inventory	Partial Qty	Installed
02/29/2024	1	31.82	2.00	2.00	0.64	0.00
		Totals:	**2.00**	**2.00**	**0.64**	**0.00**

Item No	Description	Unit	Unit Cost	Plans Qty	Accum Qty
6060080	FOUNDATION FOR BRIDGE SIGN STRUCTUI	EACH	20,000.00	3.00	1.43

Install Date	PPcode	Rate	Quantity	Inventory	Partial Qty	Installed
02/29/2024	1	21.55	3.00	2.00	0.43	1.00
		Totals:	**3.00**	**2.00**	**0.43**	**1.00**

Item No	Description	Unit	Unit Cost	Plans Qty	Accum Qty
6060151	SIGN STRUCTURE (BARRIER SIGN STRUCT	EACH	4,000.00	8.00	3.21

Install Date	PPcode	Rate	Quantity	Inventory	Partial Qty	Installed
03/28/2024	1	40.08	8.00	8.00	3.21	0.00
		Totals:	**8.00**	**8.00**	**3.21**	**0.00**

Item No	Description	Unit	Unit Cost	Plans Qty	Accum Qty
6060255	FOUNDATION FOR CANTILEVER SIGN STRU	EACH	20,000.00	6.00	3.86

Install Date	PPcode	Rate	Quantity	Inventory	Partial Qty	Installed
02/29/2024	1	28.85	6.00	3.00	0.87	3.00
		Totals:	**6.00**	**3.00**	**0.87**	**3.00**

Item No	Description	Unit	Unit Cost	Plans Qty	Accum Qty
6060256	FOUNDATION FOR CANTILEVER SIGN STRU	EACH	20,000.00	12.00	6.59

Install Date	PPcode	Rate	Quantity	Inventory	Partial Qty	Installed
02/29/2024	1	32.29	12.00	8.00	2.58	4.00
		Totals:	**12.00**	**8.00**	**2.58**	**4.00**

1201-12 Structure Report

The Resident Engineer and Project Supervisor may choose to establish CPE Structures on a project. Structures are groups of related items linked together for reporting purposes. Structures, in this sense, have nothing to do with payment or with Lump Sum Structures; the term "structure" is used here to indicate a way of organizing information.

When a CPE Structure is established in the CPE program, related items that are part of a larger unit are linked together for reporting purposes. Using a large roadway sign as an example, the office can create a Structure by establishing common subitems in the items for Foundations, Vertical Supports, Cantilevers, Posts and Sign Panels. Then, by producing a Structure Report for that Structure, the inspector can monitor the progress of each roadway sign.

The extra effort required to establish Structures at the beginning of the project often pays off in the increased quality of reporting and the reduction of errors.

See below Exhibit 1201-12 Structure Report for an example.

Structure Report - Includes Transactions 04/11/2024 12:02 pm

TRACS #: F011601C

Project: 303-A-(227)T Page 1 of 29

Section: 1 **FHWA Code** FA 03 **Description:** Roadway

Structure No: 125+86 **Description:** T-01.46

Item Nbr	Description	Revised Qty	Accum Qty
6060059	BRIDGE SIGN STRUCTURE (TAPERED TUBE, SINGLE BEAM, 85'1" TO 100')	1.00	1.00

List of Transactions

Date	Quantity	Inspector	Comments
12/17/2021	1.00	235 Franklin Pathrose	Sign #C125+86, Lt Sta:125+86 on Jomax WB Tapered tube Installed on 12/17/21
Total =	**1.00**		

Item Nbr	Description	Revised Qty	Accum Qty
6060074	FOUNDATION FOR BRIDGE SIGN STRUCTURE (TAPERED TUBE)	2.00	2.00

List of Transactions

Date	Quantity	Inspector	Comments
10/21/2021	2.00	195 Franklin Pathrose	Sta: 125+86 on Jomax WB Concrete placed and foundation completed on 10/21/21
Total =	**2.00**		

Structure No: C114+25 **Description:** T-01.46

Item Nbr	Description	Revised Qty	Accum Qty
6060059	BRIDGE SIGN STRUCTURE (TAPERED TUBE, SINGLE BEAM, 85'1" TO 100')	1.00	1.00

List of Transactions

Date	Quantity	Inspector	Comments
12/17/2021	1.00	235 Franklin Pathrose	Sign #C114+25, Rt Sta:114+25 on Jomax EB Tapered tube Installed on 12/16/21
Total =	**1.00**		

1201-13 Transaction Detail Log

The Transaction Detail Log provides an overview of the entire project. It can include all details and transactions for a project or include only those details you specify. You can include one or more of the following:

- Project/Section Summary
- Section/Item Report, with or without Force Accounts
- Time Report
- Structure Report
- Subitems with Transactions, Partial Payments, and, optionally, Change Orders
- Subitems without Transactions, with or without Change Orders

A complete Transaction Detail Log is required as part of the backup documentation when Finalizing a project (refer to the Final Estimate Checklist).

See below Exhibit 1201-13 Transaction Detail Report

Transaction Detail Report (Project / Section Summary)

TRACS: F011601C
Project: 303-A-(227)T
Contractor: Sunland Asphalt & Construction Inc.

Sara Howard,
Resident Engineer
Unit # : 4676

Contract Days:	385	**Plans Amount:**	$ 20,326,911.29
Revised Contract Days:	450	**Revised Amount:**	$ 20,411,030.62
Accumulated Days	450	**Accum Amount:**	$ 20,323,013.10
Percent Time Used	100 %	**Force Account:**	$ .00

Date Started: 12/03/2020
Date Complete: 02/25/2022

Procedural Change Orders:

4	409 Asphaltic Concrete PG Oil Change
6	Time Extension - Extruded Aluminum Material Shortage
9	Time Extension - APS Redesign

Section		Plans Amount	Revised Amount	Accum Amount	Force Account
01	Roadway	$ 11,844,733.18	$ 11,885,242.88	$ 11,793,473.16	$ 0.00
02	City of Peoria - 1/3 of cost of 9240144 is	$ 310,842.21	$ 352,437.85	$ 342,019.05	$ 0.00
03	Southwest Gas	$ 12,000.00	$ 12,000.00	$ 9,200.00	$ 0.00
04	BEARDSLEY CANAL OP NB, STR #20	$ 2,274,278.50	$ 2,274,278.50	$ 2,274,278.50	$ 0.00
05	BEARDSLEY CANAL OP SB, STR #20	$ 2,435,086.50	$ 2,435,086.50	$ 2,435,086.50	$ 0.00
06	JOMAX PKWY TI OP NB, STR #20171	$ 1,714,985.80	$ 1,714,985.80	$ 1,714,985.80	$ 0.00
07	JOMAX PKWY TI OP SB, STR #20172	$ 1,727,785.10	$ 1,727,785.10	$ 1,727,785.10	$ 0.00
08	Training	$ 7,200.00	$ 7,200.00	$ 24,171.00	$ 0.00
09	Non Federal Aid	$ .00	$ 2,013.99	$ 2,013.99	$ 0.00
		$ 20,326,911.29	**$ 20,411,030.62**	**$ 20,323,013.10**	**$ 0.00**

1202 NOTICE OF START AND COMPLETION OF PROJECT

The Start Memo details the beginning of the contractor's work on the project. This date shall coincide with the Prime Start Date on the Contract Card and can be on, before, or after the Contract Time has begun. The Start Memo is a signal to be on the lookout for the first certified payroll within a week. The Prime Start Date shall be noted on the Weekly Time Report. The field office initiates the Docusign template for the Start and Completion Memo. At a minimum Field Reports, District, BECO, Project Management, applicable Maintenance groups and Partnering shall be notified. This is to be initiated for both the start and the completion of the project. See Exhibit 1202-1 Start and Substantial Completion Memo.

The Completion Memo details the end of the contractor's work. This date shall coincide with the Substantial Completion Date on the Contract Card and is the last day charged for Contract Time. The Resident Engineer writes a Substantial Completion letter and submits it to the contractor. See Exhibit 1202-2 Substantial Completion Letter.

ADOT
Infrastructure Delivery and Operations

MEMORANDUM

TO: DISTRIBUTION LIST

FROM: IRENE OCHOA

DATE: ______________________________

SUBJECT: PROJECT STATUS REPORT

RE: START MEMO/SUBSTANTIAL COMPLETION MEMO

PLEASE BE ADVISED THAT THIS OFFICE WAS NOTIFIED BY:

______________________________ ______________________________

NAME TITLE

THAT CONSTRUCTION ON ______________ ______________ ______________

TRACS NO PROJECT NO UNIT

TYPE OF CONSTRUCTION ______________________________

CONTRACTOR ______________________________

DATE WORK STARTED ______________________________

DATE WORK COMPLETED ______________________________

Exhibit 1202-1 Start and Substantial Completion Memo

ADOT

Infrastructure Delivery and Operations

Katie Hobbs, Governor
Jennifer Toth, Director
Greg Byres, Deputy Director for Transportation/State Engineer
Steve Boschen, Division Director

ADOT Black Canyon Field Office
2501 W. Georgia Ave.
Phoenix, AZ 85017

June 19, 2024

Norman Bessler
Senior Project Manager
Fisher Sand & Gravel DBA Southwest Asphalt Paving
1302 W. Drivers Way
Tempe, AZ 85284

Project: 017 MA 208 F015501C/017-A-NFA
PHOENIX-CORDES JUNCTION HIGHWAY (I-17)/PEORIA AVE TO GREENWAY RD

Subject: ADOT Letter 021 - Substantial Completion

Dear Mr. Bessler:

This letter shall serve to confirm that the above-referenced project was considered substantially complete on June 19, 2024, in accordance with Section 105.19 of the ADOT Standard Specifications Road and Bridge Construction, 2008.

Substantial completion does not imply final acceptance. It does not relieve Fisher Sand & Gravel DBA Southwest Asphalt Paving of the obligation to complete any remaining work and to maintain and repair the work until final acceptance is documented. Final acceptance will be documented at a later date in accordance with subsection 105.20(B) of the ADOT Standard Specifications for Road and Bridge Construction, 2008.

The Department would like to express its appreciation for the positive effort which was made on this project under the Partnering Charter's original conditions.

Sincerely,

Jimmy Naujokaitis

Jimmy Naujokaitis
Senior Resident Engineer

cc: Kirk Kiser, ADOT Assistant District Engineer – Construction
Gabe Vindiola, ADOT Project Supervisor
Roxanne Lopez, ADOT Office Manager
Hector Roman, ADOT Materials Coordinator
Derek Boland, ADOT Project Manager
Mohamed Elomeri, ADOT Assistant District Engineer – Maintenance
ADOT Field Reports

ARIZONA DEPARTMENT OF TRANSPORTATION
1801 W. Jefferson St., Suite 120, MD 102M | Phoenix, AZ 85007 | azdot.gov

Exhibit 1202-2 Substantial Completion Letter

1203 SUSPENSION OF WORK

Section 105.02 of the Standard Specifications gives the Resident Engineer the authority to suspend the work in whole or in part, and lists conditions which might justify a suspension. Section 108.08 of this manual should be referenced prior to issuing any Stop Work Order.

The Resident Engineer may use a Stop Work Order to suspend the work, either partially or fully, see Exhibit 1203-1 Stop Work Order. The Stop Work Order should be specific as to which items of work are being suspended. Stop Work Orders are numbered sequentially, beginning with Number 1. Any subsequent Stop Work Orders related to the same time period shall bear the same number, using a letter suffix; e.g. 1-A, 1-B, and so on, to indicate that the Stop Work Orders are simultaneous. Stop Work Orders have serious consequences and should be utilized only when absolutely necessary as delays to the Contractor’s operations are potentially very costly. If the contractor requests a Stop Work order, they should request it in writing with the reason and backup document.

Work on a project may be partially resumed, with the consent of the RE, without the RE having to issue a Partial Resume Work Order, see Exhibit 1203-2 Resume Work Order. Resume Work Orders are issued when the work is 100% resumed.

The Resident Engineer shall keep a copy of all Stop Work Orders in the project file for documentation purposes and a copy must be sent to Field Reports.

ARIZONA DEPARTMENT OF TRANSPORTATION

STOP WORK ORDER

Project TRACS : ____________________ Order No.: ____________

Project Name: ____________________ Date Effective: ____________

Contractor Name: ____________________ Time of Day: ____________

Full Stoppage of Work ☐ Partial Stoppage of Work ☐

Contract Time Charges to be Stopped ☐ Contract Time Charges to Continue ☐

Reason: ____

<u>Notes:</u>
Check all boxes that apply to this order.
For partial work stoppages, list item numbers affected.

____
Resident Engineer

Exhibit 1203-1 Stop Work Order

ARIZONA DEPARTMENT OF TRANSPORTATION

RESUME WORK ORDER

Project TRACS: ______________________ Order No.: ______________

Project Name: ______________________ Date Effective: ______________

Contractor Name: ______________________ Time of Day: ______________

Full Resumption of Work ☐ Partial Resumption of Work ☐

Resumption of Contract Time (if applicable) ☐

Reason: ____

Notes:

Check all boxes that apply to this order.

Reference the stop work order(s) that this order is rescinding.

____

Resident Engineer

Exhibit 1203-2 Resume Work Order

1204 WEEKLY TIME REPORTS

1204-1 General

Weekly Time Reports provide an accounting of contract time used and contract time remaining. The Field Office generates Weekly Time Reports using the CPE computer program (See Exhibit 1204-1 Weekly Time Report – Working Days) and (Exhibit 1204-2 Weekly Time Reports – Calendar Days) and (Exhibit 1204-3 Weekly Time Report (Fixed Date)). The office staff verifies the number of days being charged with the Resident Engineer; typically only on working day contracts, then enters this information into FAST CPE to generate the report.

The codes shown in the exhibits shall be used by the Field Office. When using a code other than 1 or 0 a remark must be made. Code “X” should be used prior to contract time starting or after substantial completion. Code “S” should be used for full Stop Work orders until the resume work date, this date will be a day charged.

The original Weekly Time Report is signed by the Resident Engineer and sent to the contractor to ensure that there is agreement regarding the contract time charges. The contractor has one week after receiving the report to protest the time charges.

Each phase of the project will have their own time reports. The Field Office adds the additional phases after the project is awarded including Phase II Landscape Establishment.

Contract time is charged on the official contract start date as noted in the Award Letter. If this is changed through a procedural change order, the contract time needs to be noted as “X” in CPE starting on the date noted in the Award Letter until time officially starts per the change order and a comment needs to be entered on the first time report.

If the contractor starts work prior to the date noted in the Award Letter then the contract time needs to be noted as “X” in CPE starting on the date noted in the Award Letter until time officially starts per the change order and a comment needs to be entered on the first time report.

"Zero" time reports are produced when there is no time charged during a given week, except in the case of extended periods of time such as seasonal shutdowns. A seasonal shutdown is noted in the remarks section of the last Weekly Time Report, and the numbering sequence is continued when the reports are resumed. A stop work order and resume work order must be submitted to Field Reports. When the project is accepted as substantially complete, construction time charges stop. The first and last Weekly Time Reports are submitted to Field Reports as part of the project final submittal.

Remarks to be added on weekly time reports:

- If contractor does not begin working on the date shown on the Award letter, add note “Contract time begins”
- Contractor started working on XX/XX/XXXX
- Name the holiday
- If Special Provisions call out periods of time for no work and time is not being charged
- Stop work order date and Resume Work order dates
- Seeding time that starts the 45 days and when it stops
  - The seeding maintenance period must be completed prior to final acceptance but can start after substantial completion. This is to be tracked in CPE with a “X” but weekly time reports are not required to be sent to the contractor.
- Substantial completion on XX/XX/XXXX

1204-2 Working Day Contracts

Contractors are normally charged five days per week (Mon. through Fri.) this is a 24 Hr period starting at midnight and ending at midnight. Any Saturday, Sunday, or State recognized holiday on which the contractor has been approved to work will also be counted as a working day.

Working days on which weather conditions do not permit work on the project to proceed, as determined by the Engineer, will not be charged.

Since weather days are not charged, the contract time is automatically extended for weather without requiring a formal time extension. The Weekly Time Report also eliminates the need for weather-related Stop and Resume Work Orders, except for long periods of interruption in the work such as winter shutdowns, which still require a Stop and Resume Work Order with a copy sent to Field Reports.

1204-3 Calendar Day Contracts

A calendar day contract specifies the number of calendar days allowed for the work. Every calendar day; including weekends, holidays, and inclement weather, is charged on the Weekly Time Report, whether the contractor works or not, unless the Resident Engineer has suspended work by a Stop Work Order.

1204-4 Fixed Calendar Date Contracts

A Fixed Date contract specifies the contract completion date. This date shall be the date on which all work on the project is required to be substantially completed. Time is charged similar to a calendar day contract to include weekends and holidays. If this date needs to change a time extension needs to be completed to add a new fixed end date. A service ticket will also have to be done by the Field Office to have this changed in the Contract Card.

DocuSign Envelope ID: 10F188DC-6AB5-4A8E-BD8C-C934A2076054

Arizona Department of Transportation

Weekly Time Report

03/04/24 07:27:07 am

Tracs Number:	T028301C	**Report Number:**	1
Project Number:	PE0-0-(227)T	**Org:**	4679
Project Description:	Stadium Trail-73rd Ave to 83rd	**Contract Began on:**	08/23/2023
Contractor:	MERIDIAN ENGINEERING COMPANY	**Schedule:**	Working Days

Gentlemen:

Under the terms of this project it is specified that the work must be completed within 190 working days.

During the week beginning 08/19/2023 this project has been charged with 3 days as shown below:

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
1	08/19/23	0	0	X	X	1	1	1	3

Remarks: Per Award Letter Contract time starts 8/23/23.

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**		
Contract Days	190		
Extended Days	0		
Subtotal Days	190		
Previous Days	0		
This Week	3		
Days Used to Date	3	=	2 %
Remaining Days	187	=	98 %

Exhibit 1204-1 Weekly Time Report (Working Days) with X's prior to Contract Time Commencing

04/12/24 09:21:42 am

Arizona Department of Transportation
Weekly Time Report

Tracs Number:	F014101C	**Report Number:**	29
Project Number:	060-B(225)T	**Org:**	4676
Project Description:	Bethany Home Rd & Northern Ave	**Contract Began on:**	12/18/2019
Contractor:	COMBS CONSTRUCTION COMPANY, INC.	**Schedule:**	Working Days

Gentlemen:

Under the terms of this project it is specified that the work must be completed within 160 working days.

During the week beginning 06/27/2020 this project has been charged with 4 days as shown below:

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
29	06/27/20	0	0	1	1	1	1	H	4

Remarks: INDEPENDENCE DAY

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**		
Contract Days	160		
Extended Days	0		
Subtotal Days	160		
Previous Days	128		
This Week	4		
Days Used to Date	132	=	83 %
Remaining Days	28	=	18 %

Resident Engineer

Exhibit 1204-1 Weekly Time Report (Working Days) with Holiday

04/12/24 09:32:55 am

Arizona Department of Transportation
Weekly Time Report

Tracs Number:	F014101C	**Report Number:**	13
Project Number:	060-B(225)T	**Org:**	4676
Project Description:	Bethany Home Rd & Northern Ave	**Contract Began on:**	12/18/2019
Contractor:	COMBS CONSTRUCTION COMPANY, INC.	**Schedule:**	Working Days

Gentlemen:

Under the terms of this project it is specified that the work must be completed within 160 working days.

During the week beginning 03/07/2020 this project has been charged with 2 days as shown below:

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
13	03/07/20	0	0	1	1	W	W	W	2

Remarks:

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**		
Contract Days	160		
Extended Days	0		
Subtotal Days	160		
Previous Days	52		
This Week	2		
Days Used to Date	54	=	34 %
Remaining Days	106	=	66 %

Resident Engineer

Exhibit 1204-1 Weekly Time Report (Working Days) with Weather Days

05/02/24 09:49:19 am

Arizona Department of Transportation
Weekly Time Report

Tracs Number:	F023001C	**Report Number:**	34
Project Number:	040-D-(241)T	**Org:**	4431
Project Description:	HERMOSA DRIVE UP 1368	**Contract Began on:**	02/23/2022
Contractor:	J. BANICKI CONSTRUCTION, INC.	**Schedule:**	Working Days

Gentlemen:

Under the terms of this project it is specified that the work must be completed within 150 working days.

During the week beginning 10/08/2022 this project has been charged with 4 days as shown below:

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
34	10/08/22	0	0	1	1	1	1	X	4

Remarks: Worked on Holiday 10/10/22 - Columbus Day & On 10/13/22 4PM-Granted Substantial Completion

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**		
Contract Days	120		
Extended Days	30		
Subtotal Days	150		
Previous Days	128		
This Week	4		
Days Used to Date	132	=	88 %
Remaining Days	18	=	12 %

____
Resident Engineer

Distribution
Original - Contractor
1 copy - Project File

Exhibit 1204-1 Weekly Time Report (Working Days) with X after Substantial Completion

Arizona Department of Transportation
Weekly Time Report

04/12/24 09:12:41 am

Tracs Number:	F012301C	**Report Number:**	1
Project Number:	101-B-(210)T	**Org:**	4676
Project Description:	101 Pima Princess Dr-Shea Blvd	**Contract Began on:**	01/19/2024
Contractor:	FNF CONSTRUCTION, INC.	**Schedule:**	Calendar Days

Gentlemen:

Under the terms of this project it is specified that the work must be completed within 700 calendar days.

During the week beginning 01/13/2024 this project has been charged with 1 days as shown below:

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
1	01/13/24	X	X	X	X	X	X	1	1

Remarks: Contract Time Started 1/19/24

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**		
Contract Days	700		
Extended Days	0		
Subtotal Days	700		
Previous Days	0		
This Week	1		
Days Used to Date	1	=	0 %
Remaining Days	699	=	100 %

Resident Engineer

Distribution
Original - Contractor
1 copy - Project File

Exhibit 1204-2 Weekly Time Report (Calendar Days) with X's prior to Contract Time Commencing

Arizona Department of Transportation
Weekly Time Report

04/12/24 09:14:58 am

Tracs Number:	F042401C	**Report Number:**	57
Project Number:	303-A-NFA	**Org:**	4676
Project Description:	51st Ave and 43rd Ave Interch	**Contract Began on:**	09/12/2022
Contractor:	FISHER SAND & GRAVEL CO.	**Schedule:**	Calendar Days

Gentlemen:

Under the terms of this project it is specified that the work must be completed within 392 calendar days.

During the week beginning 10/07/2023 this project has been charged with 0 days as shown below:

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
57	10/07/23	S	S	S	S	S	S	S	0

Remarks: Stopped work order started 10/7/2023

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**	
Contract Days	345	
Extended Days	47	
Subtotal Days	392	
Previous Days	390	
This Week	0	
Days Used to Date	390 =	99 %
Remaining Days	2 =	1 %

Resident Engineer

Distribution
Original - Contractor
1 copy - Project File

Exhibit 1204-2 Weekly Time Report (Calendar Days) with Stop Work Order Days

04/12/24 09:16:33 am

Arizona Department of Transportation
Weekly Time Report

Tracs Number:	F042401C	**Report Number:**	72
Project Number:	303-A-NFA	**Org:**	4676
Project Description:	51st Ave and 43rd Ave Interch	**Contract Began on:**	09/12/2022
Contractor:	FISHER SAND & GRAVEL CO.	**Schedule:**	Calendar Days

Gentlemen:

Under the terms of this project it is specified that the work must be completed within 392 calendar days.

During the week beginning 01/20/2024 this project has been charged with 2 days as shown below:

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
72	01/20/24	S	S	S	S	1	1	X	2

Remarks: Resume Work Order started 1/24/24. Substantial completion 1/25/2024

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**		
Contract Days	345		
Extended Days	47		
Subtotal Days	392		
Previous Days	390		
This Week	2		
Days Used to Date	392	=	100 %
Remaining Days	0	=	0 %

Resident Engineer

Distribution
Original - Contractor
1 copy - Project File

Exhibit 1204-2 Weekly Time Report (Calendar Days) with Stop Work Order, Resume Work Order and X marked after Substantial Completion.

05/02/24 09:35:31 am

Arizona Department of Transportation
Weekly Time Report

Tracs Number:	H821401C	**Report Number:**	140
Project Number:	040-E(224)T	**Org:**	4431
Project Description:	METEOR CRATER AND PAINTED	**Contract Began on:**	05/15/2019
Contractor:	FANN CONTRACTING, INC	**Schedule:**	Fixed Date unknown

Gentlemen:

Under the terms of this project it is specified that the work must be completed within

Phase = 01

No.	Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Total
140	01/08/22	1	1	1	1	1	1	X	6

Remarks: Granted Substantial Completion on 01-13-2022

You will, in accordance with the Standard Specification, be allowed to file written protest setting forth in what respect, if any, this weekly statement is incorrect, otherwise it shall be deemed to have been accepted as correct.

Codes:

1 = Day Charged
W = Weather
S = Stop Work Order
H = Holiday
0 = Weekend
X = Other

Phase	**01**
Previous Days	874
This Week	6
Days Used to Date	880

Resident Engineer

Distribution
Original - Contractor
1 copy - Project File

Exhibit 1204-3 Weekly Time Report (Fixed Date). The report "Fixed Date" displays unknown, but is stated in the contract. In this example, the original Fixed Calendar Date was 04/30/2020. Per CO #25, Fixed Calendar Date was changed to 01/13/22.

1205 TIME EXTENSIONS

The ADOT form, "Request for Extension of Time," is to be used to start a time extension supplemental agreement, reference Chapter 108 of this manual for more details. Either the Resident Engineer or the contractor can initiate a request for a time extension. If you have an alternative delivery project, either Design-Build or Construction Manager At Risk (CMAR), a Contract Modification Request Form is required. All requests for extension of time must be processed through a change order via SATS. See Section 104.02 and Section 108.08 of the Standard Specifications for justification of an extension.

The contractor submits a request form explaining the reason for the request, accompanied by a revised construction schedule and any other pertinent supporting information. The request should show the number of days lost for each reason given, the number of additional days required to complete the project, and identify a new completion date on fixed date contracts. The number of days requested in an extension of time cannot exceed the number of days required to achieve Substantial Completion. The Resident Engineer analyzes the request and decides whether or not to recommend the time extension, bearing in mind that any days already granted to the contractor on a Weekly Time Report are not to be duplicated on the request for a time extension. The Engineer's recommendations should be detailed and complete, since they are used by others to evaluate the contractor's request.

The Resident Engineer prepares a change order in SATS in order to process the time extension. The time extension is inputted in SATS during the entry of the change order. The author must enter the Time Extension Request No., DE Signature Date, and Comments. The Resident Engineer should use the Docusign template for signatures. The Unit logs the approvals in SATS as the change order goes through the approval process. After all required approvals are entered the time extension registers in Contract Card, CPE and Weekly Time Reports.

1206 PLANS AND SPECIAL PROVISIONS REVIEW

The Resident Engineer should perform a review of the project plans and special provisions during the design phase; Stage III, 60% is the critical stage to make comments that are design changes. The purpose of this review is to capture potential improvements in contract documents by providing feedback with specific issues that have surfaced on current projects.

Examples include:

1. Constructability issues include items that may be difficult to construct where an alternate design or additional information may be appropriate.
2. Clarification of project documents such as plans, Special Provisions, Standard Specifications, bid tabs/cost estimates, and Standard Drawings.
3. Modifications either dealt with by a Supplemental Agreement or just redlined in the field.
4. Provide known maintenance issues within the project area, e.g. drainage, settlement, etc.

The Resident Engineer should be thorough and candid in his appraisal of the contract documents. This review process can help to improve the documents prepared by the Department and Consultants.

CE Budgets

At 95% design (Stage IV) of each project, the Resident Engineer is responsible for putting together a budget showing the inspectors, surveyors, material testers, office personnel, management staff, lab and Field Reports time needed for the project. This is provided to the Project Manager and Contract and Specifications for inclusion in the recapitulation sheet for authorization of the overall program budget. These plans should go through the District for concurrence of the budget proposed by the RE.

The designer or Contracts and Specifications must provide a detailed schedule of anticipated contract time for the RE to use to establish this budget.

When a contract is awarded, it is recommended that at a minimum the field office should go through the Special Provisions and flag the following:

- 104.04 for Traffic Restrictions/LD's
- 924 items that are specific to the project (MOM and BOP)
- Addendums
- Bituminous Material Price Adjustment (109.16)
- Contract Time
- Diesel Fuel Price Adjustment (109.12)
- DBE requirements
- Line Item Force Accounts
- OJT Requirements
- Payroll requirements
    - Verify wage decision is correct
- Preconstruction conference requirements

1207 FINAL RECORDS AND REPORTS

During construction and at the completion of construction activities, the project must be inspected and documentation must be reviewed to ensure that the project has been completed in accordance with the approved contract documents and federal-aid requirements before final acceptance can be obtained. Final acceptance and closeout of the project involves several steps that typically take 1 to 4 months to complete.

- The final acceptance letter must be prepared and signed by the District Administrator or ADE.
- Project closeout documentation must be compiled and reviewed for accuracy and completeness by the ADOT Resident Engineer.
- The field office must prepare a final construction package that includes applicable project closeout documentation and submit the package to the ADOT Field Reports Section who will, in turn, forward it to the ADOT Contract Payables and the ADOT Final Voucher Section.
- ADOT Contract Payables will review the final construction package and then submit final payment reconciliation to the ADOT contractor, as applicable.
- ADOT's Final Voucher Section will reconcile financial data and prepare a final voucher report that will be submitted to FHWA to request final reimbursement of federal-aid funds.
- FHWA will review the final voucher report and send final reimbursement funds to ADOT to administer as appropriate.

1207-1 Final Acceptance

The construction unit shall prepare a Final Acceptance letter for the District Administrators or the Assistant District Engineer signature, see Exhibit 1202-2 Final Acceptance Letter. There is a Docusign template for the Final Acceptance letter. At a minimum Field Reports, District, BECO, Project Management, applicable Maintenance groups, FHWA, Accounts Receivable, Final Voucher and Consultant Contract Administrators shall be notified. All physical work must have been completed on or before that date, i.e. punch lists, maintenance periods, contractor required red-lines and all contract work. Should the contractor complete a portion of the project and request partial acceptance of this work in accordance with 105.20(A), the RE shall disapprove this request in writing.

1207-2 Field Red-Line Drawings/Record Drawings

In order to provide an accurate permanent record of actual placement of features for maintenance and future development, the Resident Engineer (RE) should promptly record; manually or electronically, any physical modifications to the original design as construction progresses. It is recommended that the field office identify a single drawing set to be used for Red-Lines prior to the start of construction.

The Red-Line Drawings are utilized to create the Record Drawings. Prior to their preparation, the RE should coordinate method and format with the Record Drawings Designer. The ADOT Project Manager (PM) can furnish contact information for the Record Drawings Designer. The Project Resource Office provides additional information on this process. Red-Lines should be drawn accurately, with all necessary explanatory and reference information noted. They shall include all changes from the As-Bid documents, i.e. all permit work, all extra work, all deleted work, supplemental agreements, addendums, field adjustments, pertinent RFIs; and all discovered, relocated, and or abandoned utilities.

Utility information must be included by providing accurate locations on the Record Drawings. Special emphasis should be given to the location of any cables or equipment installed in a manner other than that specified by standard placement conventions. The contractor supplies the Record Drawings survey information, see special provisions for the project.

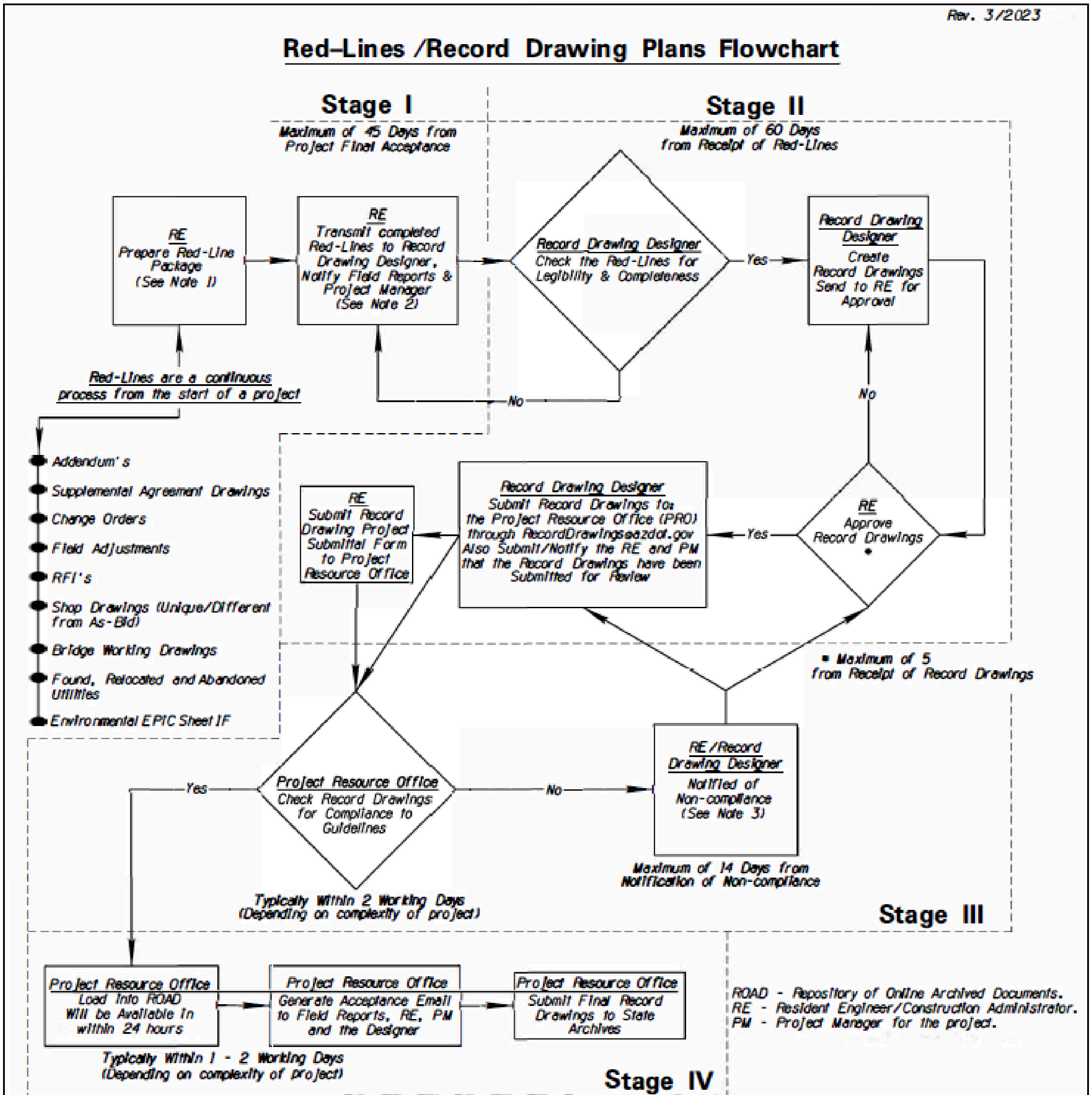
Within 45 days of the project's final acceptance, the RE shall assemble the final Red-Line Drawings and transmit them to the Record Drawings Designer, prior to transmitting, the RE is to complete the Record Drawing Project Submittal Form (Located at the Record Drawing Guidelines web page. Additionally, project information needs to be completed on the Plans Face Sheet, which has been modified to provide fields for "Constructed by" – "Red-Lines by" – and "Record Drawings by". If the Plans Face Sheet does not contain those fields, the RE should request the Record Drawings Designer to provide a new Plans Face Sheet with those fields imprinted. The RE is required to fill out the "Constructed by" and "Red-Lines Completed by" portions. Note that the RE signs where the form calls for the "Construction Administrator".

When the RE transmits the completed Red-Line Drawings to the Record Drawings Designer, the RE e-mails both the ADOT PM and the Field Reports Section at freports@azdot.gov and advises them of the date. Field Reports will enter the Field Red-lines date into the Field Office Automation System (FAST) to be reflected on the Contract Card. The Record Drawings Designer must complete the Record Drawings in a maximum of 60 days from the date the Field Red-Line Plans are received. Once the Designer has transferred all Red-Lines onto the final Record Drawings set, the Designer will return the set in PDF format to the RE for final review. It is the RE's responsibility to confirm that all modifications have been integrated into the Record Drawings. The RE must complete the review within five working days.

Upon acceptance by the RE, the RE will notify the ADOT PM, the Record Drawings Designer and the Project Resource Office (PRO) via e-mail that the Record Drawings are complete and approved. The RE will also instruct the Record Drawings Designer to send the approved Record Drawings to the PRO. Prior to transmittal, the "Record Drawings Completed by" portion of the Plans Face Sheet will be filled in by the Record Drawings Designer to document the acceptance.

If the Record Drawings deliverables contain corrupt or unreadable file(s), the PRO will request delivery of a new file from the Record Drawings Designer and e-mail the PM and RE of the discrepancy. After PRO determines the Record Drawings are acceptable, the information will be loaded into the ADOT ROAD Portal, and will send a notice to Field Reports; as well as to the RE and PM, for entry into the FAST system to record the completion date on the Contract Card.

A flowchart (See Exhibit 1207-2 Red-Line Drawings/Record Drawings Flowchart) illustrates an overview of the process.



NOTES:

1. The RE must coordinate the submittal format (see Methods in Guidelines) with the Record Drawing Designer and Project Manager. The RE, Record Drawing Designer and Project Manager must understand the requirements of the Record Drawing Guidelines and the Project Submittal Request Form checklist to ensure compliance to the Record Drawing Guidelines.

2. The "Information Block" on Face Sheet must be completed and submitted with Red-Lines and the Record Drawing Preperation Estimate to the Record Drawing Designer. The Record Drawing Preparation Estimate can be used as a tool to verify reasonableness of the designer's cost to prepare and submit Final Record Drawings.

3. The Project Resource Office will notify the Record Drawing Designer and RE if the Record Drawing Plans are not in conformance with the Record Drawing Guidelines. The RE/Record Drawing Designer have 2-weeks to revise the Record Drawing Plans and re-submit the them to the Project Resource Office for a 2nd review.

4. The RE or Record Drawing Designer can contact the Project Resource Office if additional time is required on the submission of Record Drawings at any step or stage of the development.

Exhibit 1207-2 Red-Line Drawings/Record Drawings Flowchart

1207-3 Materials Sample Checklist

After receiving the advertisement for a project from Contracts and Specifications, the Material Coordinator should go to the Materials Group website to obtain the Material Sample Checklist in time for the Partnering Meeting. If a checklist is not on the website the Materials Coordinator should reach out to the Regional Materials Engineer for their project to get this. The Materials Sample Checklist indicates the estimated number of required samples for each type of material on the project which requires sampling and testing. The estimated number of samples and tests are a minimum and are based on the plan quantities. The checklist derives the required number of samples from the "Materials Quality Assurance Program" Sampling Guide Schedule. If quantities increase, or more production lots occur than initially estimated, the number of required samples also increases.

The project's Material Coordinator is responsible to assure that all materials used on the project that require sampling and testing are listed on the Materials Sample Checklist, including any materials added by change order. Additionally, it is the responsibility of the Materials Coordinator to assure that the appropriate number of samples and tests are obtained throughout the project, based on varying quantities for each type of project material. Upon completion of the project, the Materials Coordinator finalizes the Materials Sample Checklist. This checklist along with the exceptions report are submitted to Materials Group through the RE using the Docusign template.For further information refer to ADOT Materials Quality Assurance Program.

1207-4 Payroll Closeout

When submitting a Payroll Closing Checklist to Labor Compliance, all items that have a check box must be reviewed and corrected. All dates that have been entered into Contract Card must match the start and completed dates that are listed on the subcontractor Start & Completion Table in Contract Card along with the dates that were entered in LCPtracker. All subcontractors must have interviews uploaded into LCPTracker. If subcontractors are missing interviews, a letter of explanation must be sent to Labor Compliance, listing all subcontractors with missing interviews. The All Notice Report must be cleared along with the Late Summary Report. The field office must sign the checklist with the date that it is being sent to Labor Compliance for review. Once Labor Compliance has reviewed the Payroll Closing Checklist and everything has been completed, the reviewing Labor Compliance Officer will sign, date and return the signed payroll checklist to the field office. The project will be closed in FAST and in LCPtracker and the checklist will be uploaded into the project folder. See Payroll Closing Checklist Exhibit 1207-4 below.

Closing Payroll Checklist

TRACS # :

Unit:

Field Office Representative:

Start Date:

Substantial Completion Date:

Received in Field Reports:
(For Field Reports Only)

Review Items

- ☐ Substantial Completion Memo Sent to Field Reports
- ☐ Check Subcontractor Index in Contract Card- All "NO's" cleared? Any missing info?
- ☐ Check Subcontractor Table in Contract Card- All dates entered?
- ☐ Compare Start Date on CPR #1 to start date in Subcontractor Table
- ☐ Compare End Date on Final CPR to end date in Subcontractor Table

All Final Payrolls Submitted/Accepted in LCPtracker?

- ☐ Verify there are interviews submitted for all subcontractors with working payrolls. Submit a written explanation for subcontractors without interviews. *R.E. MUST CONCUR
- ☐ Review **All Notices Report** - should be blank. There may be issues that are resolved generating on the report
- ☐ Review **Late CPR Summary Report** - should be blank. Contact your LCO for guidance.

Any open issues must be resolved before continuing.

- ☐ Review **Contractor Assignments in LCPtracker screen (CAR)**

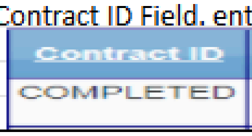
To enter Start and End Dates use the following instructions:

- LCPtracker > Set Up Tab > Contractor Setup Button> Contractor Assignment
- Select Project. In Contractor Assignment Screen > Click "EDIT'
    - For each subcontractor and prime click on'EDIT' and enter a Start & End Date.

This does not include the PNR subs

* Ensure the Prime and Subcontractors, except, for the PNR subs, have the Start and End dates entered.

☐ - In Contract ID Field, enter **'COMPLETED'. DE MINIMIS. DID NOT WORK** see examples:



Please do not write on list. Ensure the checklist is complete before sending in.

The turnaround time is approximately 30 days from when the checklist is received.

*Please respond to emails re: checklist issues found by Labor Compliance within 5 business days.

Submit the Closing Payroll Checklist with requested documents to your LCO.

Field Office Signature:

Labor Compliance Officer Signature:

Date Payrolls Closed :
(For Field Reports Only)

Exhibit 1207-4 Payroll Closing Checklist

1207-5 DBE Closeout

To ensure a smooth and quick receipt of the DBE Closeout Letter the following is required:

- All subcontractors; regardless of the tier of subcontractor, must be in DOORS.
- Ensure all payments are reported in DOORS for all DBE's, Committed and Non-Committed, and marked "Final".
- Certificates of Final Payments for all DBE's, Committed and Non-Committed, must match DOORS prior to submitting to BECO.
- If a committed DBE is short of the Contracted dollar amount, terminated/withdrawn or substituted the field office must ensure there has been a Termination/Substitution/Reduction (TSR) form submitted to BECO and approved by BECO.
- Receipt of A Commercially Useful Function (CUF) including the Diary for all committed DBE's on the project are needed to ensure the prime contractor does not lose credit on the project. If a CUF was not completed for a specific committed DBE please notify BECO as soon as possible.
- If the project has an OJT goal or the prime voluntarily reported OJT hours, the field office should ensure the hours reported and approved in DOORS match the LCPtracker report. If any discrepancies please reach out to the project's compliance technician.

1207-6 Project Final

Once a project has reached final acceptance, the field office administering the project has a goal of 45 days to complete the project final documentation and submit to Field Reports. This is in accordance with Standard Specs 109.09 where the contractor should expect ADOT to review final quantities within 60 days after final acceptance.

The final estimate shall be a zero dollar estimate. For an estimate to be considered final, it must entail no more than zero dollars in payments to the contractor. Any monetary estimate that is submitted after project final acceptance is called a “semi-final estimate”.

The field office prepares the project final documentation. The project final must be submitted electronically via the Google Drive and shared folders. The “Project Final Checklist” Google sheet is located in the Field Reports Resource Center. This document provides detailed instructions for setting up each project within the respective Unit’s shared Google Drive. It also outlines folder organization and the process for sharing these folders with Field Reports. Following these steps and guidelines ensures consistency across the state and facilitates easy access for reference or auditing purposes. The Project Final Checklist includes the following sections:

- Instructions
- Folder Index
- Encumbrances
- Final Documents
- Time Packet
- Supplemental Agreements
- PCCP
- Asphalt Mixes
- 404 Items
- 108 & 109 Pay Items
- Procurement

For the documentation to be considered final, signed copies of the final estimate, final balance, and the summary page of the transaction detail log must be submitted. Field Reports will document the date the project final was received. The Field Reports Project Finals Specialist has a goal of fifteen days to review the project final ensuring pay item quantities and dollars are measured and paid per specifications, and all items are in contract compliance. The Finals Specialist will notify the field office when their review is complete, and will update the Final Remarks in

FAST, Contract Card. The Office Manager, Resident Engineer, and Assistant District Engineer / Administrator will receive an email that the project final was perfect, without errors, or they will receive a Google document with the audit findings.

Once Field Reports has accepted and approved the Final documentation, the Final Balance is sent to the Construction State Engineer for their approval.

Field Reports cannot submit the final documents to Final Voucher until the following are completed and approved:

- Final Estimate signed by the Resident Engineer and the contractor
- Final Balance signed by the Resident Engineer and the State Construction Engineer
- DBE and OJT Closeout letter from BECO
- Material Closeout approved by the State Materials Engineer and FHWA
- Certified Payroll Closeout
- Record Drawings approved by the Project Resource Office
- Encumbrances cleared in all phases of a project

When everything outlined above is complete, Field Reports submits the signed Final Estimate, Final Balance, and Final Acceptance letter to Final Voucher.

1208 TEMPORARY TECHNICIAN CONSULTANT - CALLOUT & CLOSEOUT PROCESS

When a project utilizes the supplemental services Temporary Technician (Temp Tech) contract through Construction Group then the following shall be done by the Field Office when requesting a Temp Tech:

- Fill out the DocuSign Rent-a-Tech Request form, located on the ADOT Construction and Materials Group page, with all applicable information. If filled out by someone other than the RE, the RE must initial all amounts to be encumbered for projects.
- The Consultant Contract Administrator (CCA) will receive and review the request and send resumes of available Temp Techs who match the callout, e.g. all certifications, availability for the district, any other requirements as noted in the callout form.
- The requestor will review the resumes and select the Temp Tech who best fits their requirements based on their qualifications. If the RE or Project Supervisor wants more resumes, email the CCA to reach out to the consultants to see if anyone else is available.
- The requestor will submit their selection to the CCA who sent the resumes on the Qualification Based Selection form, located on the ADOT Construction and Materials Group page. Comments are required for all submitted techs, both the selected tech and the techs who were not selected.
- The CCA will send the completed callout form to the firm and request information in order to submit a service ticket and CARF to request necessary access and a computer for the Temp Tech.

The following shall be done by the Field Office when the consultant assignment is complete (End Callout):

- Notification sent to CCAs (I4@azdot.gov) with the name of individual, company and end date.
- Complete the Temporary Technical Personnel Performance evaluation for the individual; be honest but respectful. This will be a google form sent to the Supervisor of record in Manpower for completion.
- Verify the final date worked by the consultant .
- Contact CCAs to request to have the encumbrance released, they will need the last date the consultant worked and will release the funds once the last invoice is paid.

The following shall be done by the Field Office when the consultant assignment is transferred within the District The Temp Tech Extension-Encumbrance Request form must be filled out in Docusign. This can be found on the Construction Group website. Include information for the new assignment to which the consultant is being assigned, including start date, length of callout, project numbers, and encumbrance amounts.

- The Field Office transferring the individual out shall verify the final date worked by the consultant.
- Contact CCAs to request to have the encumbrance released, they will need the last date the consultant worked and will release the funds once the last invoice is paid.

Field Office Responsibilities for when the assignment is complete:

- The equipment that the consultant came with goes back to their company for return to ADOT Construction Group. The Field Office is NOT to assume responsibility for the laptops, etc that are issued to the consultant firm. Ensure the consultant takes all power cords, docking stations, etc. which were assigned to them by Config & Deploy.
- The Field Office should collect any keys issued and the ID badge.
- PEN access/permissions should be removed by CCA
- Physical Security should be contacted for any alarm code deactivation and any badge access if the consultant is still on an ADOT callout.
- Any Field Office equipment such as sand cones, nuke gauges, etc. should be checked back into the Field Office.
- Any copies of project documents stay with the Field Office as well as any ADOT supplied material.

1209 DISPOSITION OF RECORDS

Once final payment is made to the contractor, the Unit staff shall carefully pack all project records in boxes and store them at the District Office or the Morgue for Central District. As the boxes are being packed, the following information should be noted on the outside of the box:

- Project name
- Project number
- TRACS number
- Completion date
- Resident Engineer
- A list of the contents of the box.
- A Copy of the Project Contract Card outside of the box

Please see below for a quick reference guide for ADOT record liaisons. Each Unit must assign a record Liaison

Record liaisons are responsible for determining when paper or electronic records their units hold are eligible for destruction. Record retention schedules are available online, contact your records officer for assistance.

- Once records have reached their retention timeframe, email recordsofficer@azdot.gov to confirm whether there is a litigation hold that would prevent the records from being destroyed
- If there are no litigation holds, prepare a Certificate of Destruction for each set of records. Certificates of Destruction are available at COD.
- Approved Certificate of Destruction will be returned to record liaison for submission to records@azlibrary.gov.
- Record liaison properly destroys records using shredding bin or deleting electronic records.
- Annual compliance meetings will be held to discuss your records, retention schedules, record storage and destruction, and the certificate of destruction form.

Additional information is available on the ADOTNet under Record Retention Resources. Still have questions? Email recordsofficer@azdot.gov or call 602-819-7803.

1210 LABOR COMPLIANCE FOR FEDERAL AID PROJECTS

1210-1 General

ADOT is responsible for enforcing the required contract provisions for Federal Aid Construction Contracts. The responsibility for the inspection and enforcement of labor standards rests mainly with the Resident Engineer. It is to the Resident Engineer's advantage to resolve any questions that may arise as promptly as possible. The Resident Engineer is expected to be familiar with and able to answer inquiries regarding the Federal Aid contract provisions.

Questions regarding Labor Compliance regulations should be directed to:

ARIZONA DEPARTMENT OF TRANSPORTATION
FIELD REPORTS SECTION
206 South 17th Avenue, Room 184, Mail Drop 133A
Phoenix, AZ 85007
Phone (602) 712-7301

1210-2 Federal Labor Acts

Davis-Bacon Act of 1931 and Davis-Bacon and Related Acts (DBRA)

All laborers and mechanics working on the construction project are required to be paid unconditionally, and not less than once a week, the wage rates contained in the wage decision incorporated into the contract.

The term "laborer" or "mechanic" include those workers whose duties are manual or physical in nature (who use tools or who are performing work of a trade), as distinguished from mental or managerial. The term includes apprentices, trainees, watchmen or guards. The term does not apply to workers whose duties are primarily administrative, executive, or clerical, rather than manual.

Laborers and mechanics must be properly classified and paid according to work actually performed. Laborers or mechanics performing work in more than one classification may be compensated at the rate specified for each classification for the time actually worked therein – provided the employer's certified payroll reports (CPR) accurately set forth the time spent in each classification.

The wage decision and all approved conformed classifications shall be posted at all times at the site of work in a prominent and accessible place where it can be easily seen by all employees.

The Contract Work Hours and Safety Standards Act (CWHSSA) of 1969

This Act contains weekly overtime pay requirements and applies to contracts which may require or involve the employment of laborers or mechanics, including watchmen and guards. This Act applies to federally funded construction projects in excess of $100,000 and also extends to federally-assisted contracts subject to Davis-Bacon and Related Acts (DBRA) wage standards to which the Federal Government is not a direct party.

CWHSSA requires that laborers and mechanics employed on covered contracts be paid not less than one and one-half times their basic hourly rate of pay for hours worked in excess of forty hours in a work week. It also provides for liquidated damages in the sum of $31 for each calendar day (with respect to each employee violation) where an employee was required or permitted to work overtime hours without the payment of overtime wages required by CWHSSA. The Act also provides health and safety standards on covered construction work which are administered by Occupational Safety & Health Administration (OSHA).

The Copeland "Anti-Kickback" Act of 1934

Compliance required with the Copeland Act, or "Anti-Kickback Act."

- The contractor and subcontractor must submit a weekly statement of wages paid to each employee for work performed in the preceding payroll period
- Employees must receive the full pay to which they are entitled to for the work performed
- Employees must be paid on a weekly basis

The certified payroll reports shall contain:

- Employee name and employee number
- Correct classification and rate of pay
- Daily and weekly number of hours worked
- Deductions made and actual wages paid

The willful falsification of a payroll report or "Statement of Compliance" may subject the employer to civil or criminal prosecution and may also be a cause for debarment.

1210-3 Certified Payroll Procedures in LCPtracker (Labor Compliance software)

The field office staff must review the certified payroll reports after they are certified by the contractor or subcontractor.

Certified payroll reports shall be submitted to the Resident Engineer (via LCPtracker) each week, no later than seven days after the close of the previous work week.

Each certified payroll report will be submitted in chronological order, including the work weeks in which no work is performed.

Each employee must have a first and last name and employee identification number included on the certified payroll report.

Each craft/classification that the employee works in will be reported on the certified payroll report.

The basic hourly rate of pay and the subsequent fringe benefit amount included on the certified payroll report must be equal to or greater than the prevailing wage rates required by the applicable wage decision.

The certified payroll report entry for each employee must include all hours worked on the project subject to Davis-Bacon prevailing wages, gross pay for those hours worked and the gross pay earned for all hours worked in the work week.

The overtime rate paid must be included on the certified payroll report for all hours worked over 40 in any given work week. Fringe benefit amounts due will not be included in the calculation of overtime pay, but will be paid for all hours worked in a given work week.

Wage decision prevailing wage			
base	fringe	total	overtime
$15.00	$5.00	$20.00	($15.00 x 1.5) + $5.00 = $27.50
Contractor employee regular hourly rate of pay			
base	fringe	total	overtime
$20.00	$0.00	$20.00	$20.00 x 1.5 = $30.00
Contractor employee regular hourly rate <u>with fringes paid to plan</u>			
base	fringe	total	overtime
$14.50	$5.50	$20.00	($14.50 x 1.5) + $5.50 = $27.25

Any deductions from the employee net or gross pay that are included in the “other deduction” field of the certified payroll report will be noted in the employee payroll record in the notes section at the bottom of the screen. The contractor must upload a copy of a signed Employee Authorization of Deduction form.

The fringe benefit portion of the prevailing wage that is paid to the employee in cash instead of contributed into a fringe fund, plan or program may be entered into the “Rate in Lieu of Fringe” field in the employee payroll record.

The contractor will include those portions of the fringe benefit due the employees that are contributed into funds, plan and programs on the employee’s behalf as “Fringe Contributions paid to others (not the employee) for this project only”. The data will be reflected in the section of the certified payroll report as “Deduction, Contribution and Payments”.

The apprenticeship certificate or trainee agreement must be uploaded by the contractor/subcontractor in the eDocuments tab in LCPtracker. The contractor may not include an employee as an apprentice or trainee on the certified payroll report until Field Reports has accepted the certificate/agreement and approved the apprentice/trainee status of the employee in LCPtracker.

The contractor/subcontractor must denote that the last certified payroll report submitted is the “final” payroll.

The certified payroll must be reviewed by the field office staff for accuracy, compliance with the applicable wage decision and the reporting requirements included in the Contract Special Provisions.

The information documented on the contractor employee interview form will be compared with the information included in the corresponding certified payroll reports. The field office staff will address any issues found with the prime contractor. After all issues and discrepancies have been resolved, the field office will upload the contractor employee interview forms into the LCPtracker eDocuments.

After reviewing the certified payroll, there are a few status options to select from:

- Accepted - payroll is submitted correctly and is approved by the field office.
- Pending - payroll is submitted to field office and is awaiting review
- Rejected - payroll is returned to contractor for misc corrections
- Permit Edit - payroll is opened by the field office at the request of the contractor who needs to make a minor edit

Check the Statement of Compliance (See Exhibit 1210-2 Statement of Compliance) to ensure:

- the contractor selected the correct 4a or 4b checkbox for how fringes were paid
- the payroll certifier is listed on the authorized signature form

If no work was performed, the contractor must submit a Statement of Compliance stating “NO WORK PERFORMED”.

If certified payrolls are not submitted on time per specification 109.06, a Delinquent Certified Payroll Letter will be sent to the prime contractor, with notification of discrepancies, along with an expected due date; a retention may be withheld, see Exhibit 1210-1 Delinquent Certified Payroll Letter.

When the field office staff discovers repeated violations of Davis-Bacon requirements by the contractor or subcontractor it is considered a non-compliance issue. Contact the Field Reports Labor Compliance Office at 602-712-2022.

Revisions to Certified Payrolls

Each time a payroll report is rejected by the field office staff, the system opens a dialog box. The reason for the rejection should be included and saved in the dialog box. The system will generate and deliver an email to the applicable contractor/subcontractor. The field office staff should notify the prime contractor when a subcontractor certified payroll report is rejected, see Exhibit 1210-3 Rejected CPR Notice.

Request that the applicable contractor/subcontractor correct the certified payroll reports. The contractor/subcontractor must upload verification of restitution calculations and back wages paid to the underpaid employees.

After revisions, provide the appropriate information in the Notes section at the bottom and recertify the payroll.

ADOT
Infrastructure Delivery and Operations

Katie Hobbs, Governor
Jennifer Toth, Director
Greg Byres, Deputy Director for Transportation/State Engineer
Steve Boschen, Division Director

Month Day, Year

FirstName LastName Title
Company Name
Address Line #1
City, ST ZIP CODE

REF: Project (TRACS)(PRJ #)
(PROJECT NAME)
(PROJECT LOCATION)

Dear Mr./Ms. LastName:

In accordance with Section 109.06(C) - Payroll Submittals of the ADOT Special Provisions, the following subcontractor's payrolls are due MONTH DAY, YEAR:

Contractor	Payrolls
CONTRACTOR NAME	PAYROLL NUMBERS

Please be advised that all delinquent or incorrect certified payrolls not submitted 10 days after this written notification will be subject to $2,500 retention, per payroll, from the next monthly estimate. Any revised payroll received after 90 days, will only be reimbursed $2,000 per payroll. The Department will retain $500 as liquidated damages per payroll for all payrolls submitted after the 90 days from written request.

The Department will retain ($_________) in the (MONTH) (YEAR) monthly estimate if payrolls are not received by MONTH DAY, YEAR.

Your cooperation in obtaining outstanding payrolls will be appreciated.

If there are any questions, please feel free to contact my office at PHONE NUMBER, or via email at EMAIL ADDRESS.

Sincerely,

FIRST NAME, LAST NAME
TITLE

ARIZONA DEPARTMENT OF TRANSPORTATION
1801 W. Jefferson St., Suite 120, MD 102M | Phoenix, AZ 85007 | azdot.gov

Exhibit 1210-1 Delinquent Certified Payroll Letter

LCPtracker
Labor Compliance Software

Date Tuesday, January 10, 2012

I, *NAME, TITLE* do hereby state:
(1) That I pay or supervise the payment of the persons employed by PRETEND SUBCONTRACTOR on the TEST PROJECT; that during the payroll period commencing on 10/8/2011 and ending on 10/14/2011 all persons employed on said project have been paid the full weekly wages earned, that no rebates have been or will be made either directly or indirectly to or on behalf of said PRETEND SUBCONTRACTOR from the full weekly wages earned by any person and that no deductions have been made either directly or indirectly from the full wages earned by any person, other than permissible deductions as defined in Regulations, Part 3 (29 C.F.R. Subtitle A), issued by the Secretary of Labor under the Copeland Act, as amended (48 Stat. 948, 63 Stat. 108, 72 Stat. 967; 76 Stat. 357; 40 U.S.C. 167; 3145), and described below:
All comments are in the notes on the submitted Certified Payroll Report.
(2) That any payrolls otherwise under this contract required to be submitted for the above period are correct and complete; that the wage rates for laborers or mechanics contained therein are not less than the applicable wage rates contained in any wage determination incorporated into the contract; that the classifications set forth therein for each laborer or mechanic conform with the work he performed.
(3) That any apprentices employed in the above period are duly registered in a bona fide apprenticeship program registered with a State apprenticeship agency recognized by the Bureau of Apprenticeship and Training, United States Department of Labor, or if no such recognized agency exists in a State, are registered with the Bureau of Apprenticeship and Training, United States Department of Labor.
(4)That:
(a) WHERE FRINGE BENEFITS ARE PAID TO APPROVED PLANS, FUNDS OR PROGRAMS
X - in addition to the basic hourly wage rates paid to each laborer or mechanic listed in the above referenced payroll, ;payments of fringe benefits as listed in the contract have been or will be made to appropriate programs for the benefit of such employees, except as noted in section 4(c) below.

(b) WHERE FRINGE BENEFITS ARE PAID IN CASH
X - Each laborer or mechanic listed in the above referenced payroll has been paid, as indicated on the payroll, an amount not less than the sum of the applicable basic hourly wage rate plus the amount of the required fringe benefits as listed in the contract, except as noted in Section 4(c) below.

(c) EXCEPTIONS:
Any exceptions to the above are reported in the certified payroll in the notes section for the specific individual.

REMARKS:

NAME: ________________
TITLE: ________________

Electronic Signature Code: 6027127623-H999901C- ORG 8950-1011412011 12:00:00 AM-RECERT-129706999567013621

THE WILLFULL FALSIFICATION OF ANY OF THE ABOVE STATEMENTS MAY SUBJECT THE CONTRACTOR OR SUBCONTRACTOR TO CIVIL OR CRIMINAL PROSECUTION. SEE SECTION 1001 OF TITLE 18 AND SECTION 231 OF TITLE 31 OF THE UNITED STATES CODE.

Exhibit 1210-2 Statement of Compliance

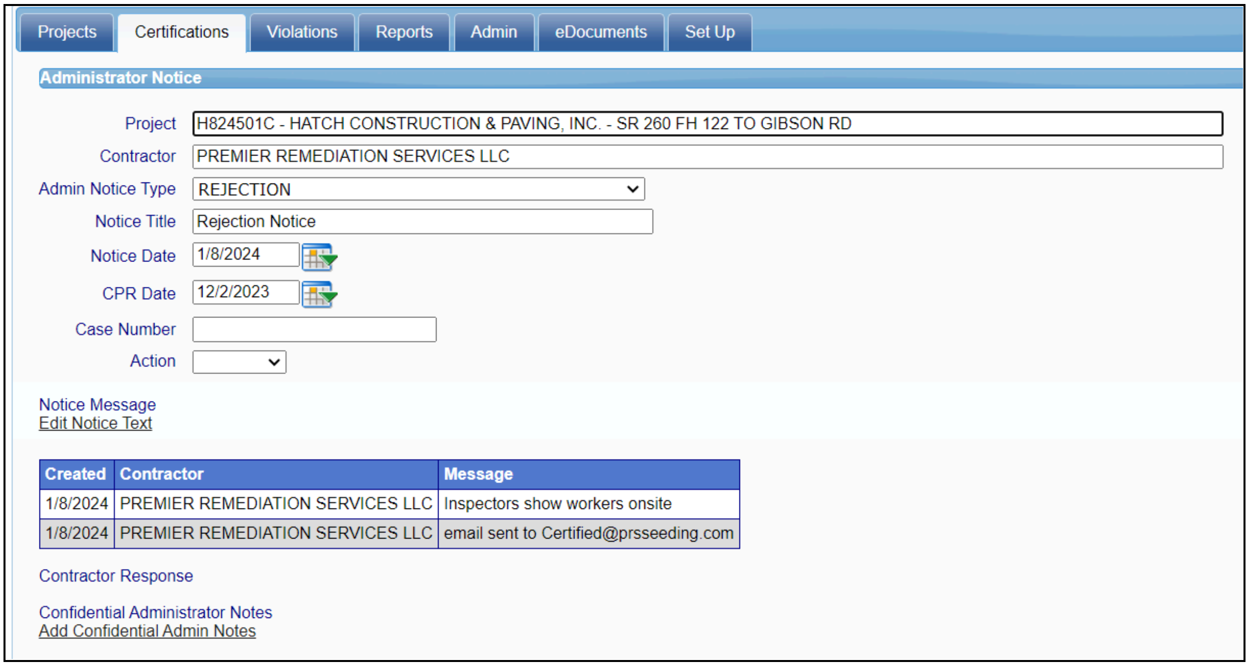


Exhibit 1210-3 Rejected CPR Notice

1210-4 Apprentice and Trainee Documentation

Project based On-the-Job Training (OJT) Program

ADOT's OJT program is an essential element of the Federal-aid highway program for the State of Arizona. Implementation of a successful OJT program by ADOT and its subrecipients helps provide a competent workforce to meet current and future highway construction hiring needs with a focus on the recruitment and inclusion of those who have experienced historical underutilization: minorities, women, and disadvantaged individuals.

ADOT Annual OJT Goal

ADOT is responsible for establishing an annual training goal and submitting the recommended goal to the FHWA for approval. The goal is based upon a review of ADOT’s 5 year plan and a review of future projects. ADOT tracks and reports annual OJT goal accomplishments to the FHWA, based on the calendar year (CY) period.

Project Specific Goals

ADOT will assess each federal-aid construction project for a project specific OJT goals for each Federal-aid construction project by also considering the following criteria:

- No OJT goals are set for projects on Tribal Lands due to Tribal Preference guidelines.
- Projects must have a minimum of 120 working days.
- For projects starting at $3 million up to $500 million, the Department estimates a projected number of trainees based on the project size, multiplied by 600 to arrive at the total OJT hour goal for each project. The contractor will determine the number of actual trainees to be utilized to meet the hourly goal with each trainee to complete a minimum of 600 hours.
- For projects over $500 million, the OJT goal will be evaluated based on the type of project and scope and will require a minimum of 20 percent of trainees to achieve more than 2,000 hours and 10 percent of trainees will be required to graduate to journeymen level status on the project.

The OJT goal for each project will be identified in the project advertisement; even if it is a "0" goal, and will therefore be added in the OJT Special Provisions that will be included in every contract and administered through one of the following special provisions:

- **Training Special Provision, On-the-Job Training With Goals –** Included in federal-aid Department and Certification Accepted (CA) agencies highway construction contracts with OJT opportunities
- **Training Special Provision, On-the-Job Training Without Goals –** Included in all federal-aid Department and CA highway construction contracts without OJT opportunities

DBE & OJT Online Reporting System (DOORS)

The contractor shall complete and submit the following information to the Department in the Departments contract management system known as DOORS:

- OJT Commitment/Schedule shall include the project information, project training plan information, project training schedule.
- The field office gives the first level/initial approval of this plan.
- OJT Enrollment information shall be completed and includes the trainee's name and address, employment status, gender and ethnicity, training program (s), classification/craft.
- The contractors shall report monthly hours for each trainee by the 15th of the month following the month of training hours completed. The accepted quantities of hours will be paid for at a unit price of $3 per hour for training provided to trainee/apprentice in accordance with an approved training program and minimum number of training hour goals on the project.
- BECO has until the 25th of the month to approve the OJT hours submitted by the contractor.
- The field office pays for the approved OJT hours.

Apprenticeship Programs:

Apprenticeship programs are regulated and approved by the Arizona Department of Economic Security, the state agency that has been delegated the authority by the U S Department of Labor.

Apprenticeship programs issue an "Apprenticeship Certificate" which has been approved by the Arizona Department of Economic Security to the laborers and mechanics that are enrolled in the approved programs.

A copy of the U S Department of Labor Apprenticeship Certificate is also required.

The contractors who use apprentices as part of their workforce will be responsible to submit those approved apprenticeship certificates to ADOT Business Engagement & Compliance Office prior to reporting the hours worked on a project subject to Davis-Bacon prevailing wages.

The apprenticeship certificates will include:

- Name of employee
- Apprentice ID Number
- The level of achievement of the apprentice
- The approved program in which he is enrolled in
- The approved apprentice to journeyman ratio that must be met on the project work site
- Authorizing signatures from the apprenticeship program and the Arizona Apprenticeship Office
- Certificate expiration date and the expected date of advancement of the apprentice

Training Programs:

Training Programs are developed by individual contractors and are regulated and approved by ADOT's Business Engagement & Compliance Office and the Regional Federal Highways Administration Civil Rights Office.

The contractors issue a "Training Agreement" signed by the contractor training director and the employee who is enrolled in the program.

The contractors who use trainees as part of their workforce will be responsible to submit those signed training agreements to ADOT Business Engagement & Compliance Office prior to reporting the hours worked on a project.

The training agreements will include:

- The level of achievement of the trainee
- The approved program in which he is enrolled
- Expiration of the training agreement

1210-5 Fringe Benefits

The Davis-Bacon Prevailing wage is made up of two interchangeable components: a basic hourly rate and a fringe benefit rate. The basic hourly rate and the fringe benefit rate listed on the wage decision may be paid entirely in cash wages. Contributions made or costs incurred by the contractor for bona fide fringe benefits may be creditable towards fulfilling the requirement or a combination of cash wages paid and bona fide fringe benefit contributions may be used together to meet the total required prevailing wage. See Exhibit 1210-5 Fringe Plan Information Request Email template.

Please provide our office with the following information for all benefits that apply to the

Name of company: ______________________________

sponsored or union affiliated fringe benefit plans:

1. Employee handbook or written information that is given to employees which provides a description of the company sponsored health and welfare benefits employees can participate in when they go to work for the company. This includes an explanation of how paid time off accrues and how unused paid time off is handled when the employee leaves your company.

2. Detailed description of the contribution amount the company pays to the fringe plan/program on the behalf of the employees for health/welfare benefits (medical, dental, vision, life insurance, etc).
   For example:

   Name of company: ______________________________

   pays $450.00 per month toward the cost of medical coverage for the employee only and the employee pays the remaining for any dependent coverage, etc.

3. Current copies of health care provider's billings; listing the monthly premiums (employer contributions) paid on the employee's behalf along with copies of canceled check or electronic funds transfer as proof of payment. (please provide an invoice and payment verification for one month from the benefit plan year)

4. IF APPLICABLE – Record of deposits for Pension / 401k contributions made on behalf of employees, vesting schedule, account statement listing participating employees and copy of canceled check or electronic funds transfer as proof of payment.

5. IF APPLICABLE – Union Employer Reporting Form(s) listing all contribution levels along with copies of canceled check(s)/EFT or, a letter of good standing from the union trust as proof of payment. (please provide an EFT and payment verification for one month from each union trust)

Electronic documents are acceptable. Redact any full social security numbers on documents before submitting them. Please email your fringe plan documents to

Email: fringe_eval@azdot.gov

You will receive notification of the allowable hourly fringe credit amounts once the documents are reviewed.

Thank you,

Exhibit 1210-5 Fringe Plan Information Request Letter

1210-6 Specific Fringe Benefits

The fringe benefit portion of the required prevailing wages must be paid to the employees for all hours worked under a contract subject to Davis-Bacon.

Some of the most common types of fringe benefit plans that are accepted by the Department of Labor as "bona fide" are:

- Health, Dental and Vision Insurance
- Pension
- Life Insurance
- Accident & Disability insurance
- Vacation and Holiday
- Defrayment of costs of apprenticeship or other similar programs

If the contractor contributes all or some of the fringe benefit portion of the prevailing wage due the employee into fringe benefit plans and applies those contributions to meet the required prevailing wage:

- The ADOT Field Reports Office sends the scripted request for information to the contractor
- The information is forwarded to Field Reports for evaluation
- Use the creditable amounts calculated by Field Reports, distributed as a fringe plan summary, as a benchmark for evaluation of the certified payroll reports

1210-7 Overtime, Fringe Benefits and Zone Pay

Overtime is calculated at one and one-half times the basic rate of pay, plus the fringe benefit requirement for all hours in excess of 40 hours. Employers can pay a higher overtime rate if they choose.

Example:	Base Hourly Rate:	–	$15.00 per hour
	Fringe Benefit Rate:	–	$ 3.00 per hour
	Overtime calculation:	–	($15.00 x 1.5) + $3.00 = $25.50 per hour

If the project Wage Decision indicates an additional amount for Zone Pay, that amount is added to the basic rate of pay.

Power Equipment Oper Grp 3 Wage Rate = $17.25 Fringes = $3.53
Zone 2 - add $1.00 per hour

POWER EQUIPMENT OPERATOR 3 = WORKING IN ZONE 2
FRINGE PAID TO AN APPROVED PLAN

Basic Wage Rate	+	**Zone Pay**			=	**Straight Time rate of Pay**
$17.25	+	$1.00			=	$18.25
(Basic Wage Rate	+	**Zone Pay)**	x 1.5		=	**Overtime Rate of Pay**
($17.25	+	$1.00)	x 1.5		=	$27.38

POWER EQUIPMENT OPERATOR 3 = WORKING IN ZONE 2
FRINGES PAID IN CASH

Basic Wage Rate	+	**Zone Pay**		**+ Fringe Rate**	=	**Straight Time Rate of Pay**
$17.25	+	$1.00		+ $3.53	=	$21.78
(Basic Wage Rate	+	**Zone Pay)**	x 1.5	**+ Fringe Rate**	=	**Overtime Rate of Pay**
($17.25	+	$1.00)	x 1.5	+ $3.53	=	$30.91

1210-8 Back Wage Payments

When ADOT has determined that a contractor must pay compensation to employees that did not receive Davis-Bacon prevailing wages, there are two procedures. The back wage procedures differ depending on whether the contractor and employee are still working on the project or are no longer working on the project.

Back wage procedures when the contractor & employee are still working on the project:

- The contractor may include the monies owed to the employee on a future payroll cycle.
- The contractor will include the reason for the underpayment on the employee payroll record as an “edit:” to the certified payroll report where the underpayment occurred.
- The contractor will include the monies owed to the underpaid employee on a current certified payroll report for all hours earned in that work week.
- The contractor will include notes in the employee payroll record to explain the amount of restitution and reference the certified payroll report number where the underpayment was originally made.
- When underpayments have been made the contractor must upload verification of restitution calculations and back wages paid to the underpaid employees working under the contract, e.g. spreadsheet and canceled paycheck or direct deposit record.
- Back wage procedures when the contractor and employee are no longer working with the contractor:
- The contractor shall make every effort to issue paychecks to the underpaid former employees for the restitution owed by sending the check to the last known address via certified mail.
- If the worker receives the check, the certified mail receipt will indicate that the check was received. The contractor must upload a copy of the completed certified mail receipt showing the worker received the mailed check and a copy of the endorsed check (front/back) as proof that the check was received and deposited/cashed by the worker. This would conclude the process.
- **If the mailed check comes back undeliverable,** The contractor must upload a copy of the completed certified mail receipt showing the check was returned undeliverable and then initiate the **Unclaimed Property Process for Property Holders.** Instructions are available in the Field Reports Resource Center Process Guides. Keep in mind that ADOT must be kept in the loop at all times as we cannot accept the payroll until the process is completed.

1210-9 Contractor Employee Interviews

The Contract Special Provisions includes the Required Contract Provisions Federal-Aid Construction Contracts” direction that the contracting agency must conduct contractor employee interviews (English and Spanish) while the employees are working on the project site of work. The ADOT Inspectors are responsible for conducting the interviews and observing the interviewees as they perform work on the project site. See Exhibit 1210-5 Employee Interview Form & 1210-6 Employee Interview Form (Spanish).

The interviews should be sufficient in number to establish a degree of adequacy and accuracy of records. The interviews should be representative of all classifications of employees on the project work site. The intent is to interview every employee at least once during the life of the project.

The inspector will include the tools and/or equipment used by the employee and the tasks that the employee performs throughout the period of observation.

Employees should not be interviewed in the presence of other employees. The interviews are confidential and are never shown to the contractor.

The inspector will submit the completed interview forms to the construction office staff and complete the Pen version of the interview form within the same week of the interview.

The construction field office staff will review the employee interview forms and compare the information to the applicable certified payroll report.

If discrepancies exist between the interview form and the certified payroll, the construction field office staff will work to resolve the differences. In cases where no classification on the assigned wage decision fits the work being performed by an employee, a “Request for Authorization of Additional Classification and Rate” (Conformance Request) should be submitted to Field Reports at fldrpts-confrqsts@azdot.gov.

Once a conformance request has been submitted to Field Reports, the classification will be added and ready for use. Once Field Reports receives the approval letter from the Department of Labor, it will be forwarded to the Field Office and to the prime contractor & subcontractor.

When all payroll issues have been resolved, the construction field office staff will upload the employee interview forms into LCPtracker eDocuments within the first week of receiving them.

If there are serious non-compliance issues, the Field Office may contact Field Reports for assistance.

TRACS: ______

Project #: ______

ARIZONA DEPARTMENT OF TRANSPORTATION
RECORD OF CONTRACTOR EMPLOYEE INTERVIEW

Prime Contractor: ______ Interview Date: ______ Time: ______

Questions for the employee ADOT Inspector: ______

Name: ______ Employer: ______

Does your paycheck come from that employer? Yes ○ No ○

What is your working craft and classification? ______

Do you work in more than one classification? Yes ○ No ○

Are you paid a different hourly rate for each classification? Yes ○ No ○ N/A ○

Are you an apprentice or trainee? Yes ○ No ○

What is your hourly wage on this project? ______ What is your regular hourly wage? ______

Does your employer offer benefits? Yes ○ No ○ Vacation/Holiday ☐ Health Insurance ☐ Pension ☐

Does your employer pay for some or all of your benefits? Yes ○ No ○

Do you work more than 40 hours in a work week? Yes ○ No ○

Are you paid time and one-half for all overtime hours worked? Yes ○ No ○

Are you paid at least once a week? Yes ○ No ○

Do you know where the wage rates for this job are posted? Yes ○ No ○

Do you believe your employer is paying you the correct wage rate for the work you are performing? Yes ○ No ○

If not, what hourly rate do you believe you should be paid? ______

Would you like to make any comments or do you have any concerns? ______

Inspector Comments: At the time of the employee interview record the following:

Work being performed by employee: ______

Type of tools or equipment used by employee: ______

Make and model of tools or equipment used by employee: (if applicable) ______

Payroll Review		Classification		Basic Hourly Rate		Fringe Hourly Rate	
Certified Payroll Report #:	Week End Date:						
Contract Wage Rate							
Interview in LCPTracker?	Yes ○ No ○	Conformance request required?	Yes ○ No ○	Conformance rate approved?	Yes ○ No ○	Are back wages owed?	Yes ○ No ○
Have all issues above been resolved by Field Office?	Yes ○ No ○	Date Verified:		Verified by:			

Exhibit 1210-5 Employee Interview Form

ARIZONA DEPARTMENT OF TRANSPORTATION
REGISTRO DE ENTREVISTA DE EMPLEADO CONFORME A CONTRATO

Fecha de la entrevista: ________ Hora: ________

TRACS# ________ # del Proyecto: ________ Contratista Principal: ________

Cuestionario para el empleado

Inspector de ADOT: ________

Nombre: ________ Empleador: ________

¿Su cheque es expedido por su empleador? Si ○ No ○

¿Cual es su trabajo y clasificación? ________ ¿Trabaja en más de una clasificación? Si ○ No ○

¿Se le paga diferente por cada clasificación? Si ○ No ○ N/A ○

¿Esta de aprendiz o en entrenamiento? Si ○ No ○

¿Cual es su pago por hora en este proyecto? ________ ¿Cual es su pago regular por hora? ________

¿Su empleador ofrece beneficios? Si ○ No ○ ¿Vacaciones/días feriados? ☐ ¿Seguro? ☐ ¿Pensión? ☐

¿Su empleador paga por algunos/todos sus beneficios? Si ○ No ○

¿Trabaja más de 40 horas por semana laboral? Si ○ No ○

¿Se le paga tiempo y medio por las horas extras? Si ○ No ○

¿Se le paga por semana? Si ○ No ○

¿Sabe en donde se publican los salarios para este trabajo? Si ○ No ○

¿Cree que su empleador le esta pagando el salario justo por el trabajo que usted esta desempeñando? Si ○ No ○

Y si no, ¿que salario por hora cree que le deberían de pagar? ________

¿Le gustaría hacer algún comentario o tiene alguna otra inquietud? ________

Comentarios del Inspector: Durante la entrevista anote lo siguiente:

Trabajo desempeñado por el empleado: ________

Tipo de herramientas o equipo usadas por el empleado: ________

Marca y modelo de herramientas o equipo usados por el empleado: (si se aplica) ________

<table>
<tr><td colspan="2">Revisión de la nomina de pago</td><td colspan="2">Clasificación</td><td colspan="2">Salario Mínimo por Hora</td><td colspan="2">Beneficios Basados en salario por hora</td></tr>
<tr><td>Reporte Certificado de Nomina de Pago:</td><td>Fecha de terminacion de semana:</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Salario de Contrato por hora</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Entrevista en LCPTracker?</td><td>Si ○
No ○</td><td>¿Solicitud de Conformidad Requerida?</td><td>Si ○
No ○</td><td>¿Tarifa de Conformidad Aprobada?</td><td>Si ○
No ○</td><td>¿Se deben salarios atrasados?</td><td>Si ○
No ○</td></tr>
<tr><td>¿Se han resuelto todos los asuntos en la oficina local?</td><td>Si ○
No ○</td><td colspan="3">Fecha de Verificación:</td><td colspan="3">Verificado por:</td></tr>
</table>

Exhibit 1210-6 Employee Interview Form (Spanish)

1210-10 Site of Work, Truck Drivers and Hauling

Site of Work

Davis-Bacon and Related Acts (DBRA) apply to workers on the site of the work.

Limited to the physical place or places where the construction remains after work has been completed.

Any other site where a significant portion of the building or work is constructed, provided such site is dedicated exclusively or nearly so to the performance of a single DBRA-covered project or contract for a specific period of time. Site of the work includes fabrication plants, mobile factories, batch plants, borrow pits, tool yards, headquarters, etc. provided they meet the following requirements:

Located adjacent or virtually adjacent to the site of the work described above and dedicated exclusively to the performance of the contract or project.

Coverage of truck drivers under Davis-Bacon

Truck drivers are covered under these circumstances:

- For time spent on the site of work.
- Time spent loading and or unloading material on the site of work.
- Transporting materials between a facility that is deemed part of the site of work and the project site.
- Onsite driving time unrelated to offsite delivery, e.g. hauling materials from one location on the site of the work to another.
- Time spent transporting significant portions of public works from secondary construction sites.
- Time spent transporting materials to or from adjacent or virtually adjacent dedicated support sites, as well as for any onsite time related to offsite delivery if such time is not de minimis.

Truck drivers are not covered by Davis-Bacon in these circumstances:

- Material delivery drivers while off of the site of work.
- Drivers of a contractor or subcontractor while driving between a commercial facility and a site of work covered by Davis-Bacon.
- Drivers that spend limited time on the site of work for delivery or pick up of materials.
- A bona fide owner operator must own and drive their own trucks. Certified payrolls are required to show the name of the owner operator, but not wages paid or hours worked.
- Overtime pay is required for truck drivers, regardless of whether the hours worked on the contract are on or off the site of work.

The Department of Labor has an enforcement position with respect to bona fide owner-operators of trucks who are independent contractors referred to as an owner-operator. An owner-operator is an individual who owns and drives a single truck, leasing their services to a contractor. Certified payrolls, including the names of such owner-operators, do not need to show the hours worked or rates paid, only the notation “owner-operator”. This position does not apply to owner-operators of other equipment such as bulldozers, backhoes, cranes, welding machines, etc.

Owner-Operators are not required to submit certified payrolls, only the completed Subcontract Request Form.

1210-11 Documentation Required for Proof of Owner-Operator

Owner-operators sign the Subcontract Request Form (SRF) certifying that they are a bona fide owner-operator. It is the prime contractor’s responsibility to verify current Commercial Driver’s License and valid registration.

1211 SUBCONTRACTING

1211-1 Subletting the Contract

The prime contractor can subcontract portions of the work, but is required to perform 40 percent of the original contract amount using its own workforce and resources. The remaining 60 percent of the work can be subcontracted to specialized subcontractors as needed. Subletting any portion of the contract does not relieve the contractor of any responsibility for the fulfillment of the contract.

A written request to subcontract portions of the work and a signed and executed copy of the Subcontractor Request Form (SRF), along with the required attachments shall be submitted to FieldReports-Subcontracts@azdot.gov and approved by the State Construction Engineer, prior to the performance of any work by the proposed subcontractor.

For all projects, the subcontractors' start and complete work dates must be input into the Contract Card System. The inspector should document in his diary when the contractor and subcontractors begin and complete work.

1211-2 Subcontractor Request Form (SRF)

The subcontractor Request Form (SRF), (Exhibit 1211-1 below) is a streamlined form to use in requesting approval for subcontractors. Using this form will save time, eliminate excessive paper and ensure the subcontractor receives all the necessary documents as all required attachments are included in the DocuSign package of documents.

ADOT requires the use of DocuSign for submitting subcontractors for approval. This ensures all signers receive the completed documents. All the necessary versions of the SRF can be found on the Contractor Information Page, in Forms and Documents on ADOT's website, see Exhibit 1211-2 is a screenshot of the webpage. The prime contractor initiates the DocuSign powerform and completes the form electronically. If the subcontract is ready at the time of submitting the subcontractor for approval, it may be attached to the document. If the subcontract is not attached, the contractor has 30 days from the SRF approval date to submit the subcontract.

The SRF needs to contain the contract items to be sublet, with quantity, unit bid price and monetary amount for each. If the item is to be partially subcontracted, it should be noted as such, e.g. place only, haul only, etc. Any contractual agreements between the contractor and the subcontractors covering contract items of work will be counted towards the permissible amount of subcontract work.

1211-3 SRF and Subcontract Approvals

The State Construction Engineer must provide written approval before any of the contract is sublet by the awarded contractor. Written consent will only be provided when the Subcontracts Specialist can verify that each subcontract contains all provisions and requirements of the prime contract.

The Field Reports Subcontracts Specialist completes a thorough review, ensuring the wage decision, if applicable, is correct, the contractor's license is valid and current, the AZUTRACS Registration Number is provided, amongst other items. An Authorized Signature Form (see Exhibit 1211-3 below) must be on file for the project. Only authorized signers shall sign SRFs and subcontracts, otherwise, the DocuSign SRF will be voided.

Allow the Construction Group three business days to review and approve SRF's from the day the SRF is received. A subcontractor can start working after the SRF has been approved by the State Construction Engineer. A completed subcontract is required for all subcontractors within 30 days from the SRF approval, except for DBE subcontractors whereas the subcontract is required with the SRF for approval.

1211-4 What type of work requires a subcontract?

A subcontract is required for any and all work that the prime contractor cannot or does not perform directly. The subcontractors should have a current contractor's license with the Arizona Registrar of Contractors. Sometimes, they are specialty subcontractors or considered professional services, and a license is not required. A Professional Services and Unique Work Activity List (see Exhibit 1211-4) outlined below. This is not a comprehensive list of all work activities, but one that includes unique services, that may or may not require a contractor's license or certified payrolls, and others that may be considered as De Minimis. Examples of exceptions are Field Office Hookups, Portable Restrooms, Material Supplier from a Commercial Source, and Trash Removal Services such as Waste Management.

1211-5 DBE Subcontractors

For subcontractors that are committed DBE's, all pertinent documentation is required at the time the SRF is submitted for approval. The subcontract must be included.

If the committed DBE subcontractor is not approved prior to saving the monthly estimate, the first mobilization payment should not be paid. Field Reports will check monthly estimate number one, ensuring that the committed DBE's have been approved if the first mobilization payment was made. This is in compliance with Standard Specs subsections 901-5(A) and 108.03.

The Special Provisions included in all Federal Aid contracts stipulate that a DBE subcontractor may enter into second-tier subcontracts which are consistent with normal industry practices. However, items which are second-tier subcontracted by a certified DBE subcontractor will not be counted toward the participation goal unless:

- The work is second-tier subcontracted to another certified DBE. Or,
- No more than 30 percent of the DBE subcontract is second-tier subcontracted to a Non-DBE.

1211-6 Lower-Tier Subcontractors

Approved subcontractors will be allowed to sublet any part of their assigned work to lower-tier subcontractors.

A SRF along with the signed and executed copy of the subcontract from the subcontractor should be made to the contractor requesting such action. The SRF and subcontract must show the name and address of the proposed lower-tier subcontractor, item number(s), item description, quantity, unit, price and amount. The appropriate SRF version will be used to submit to the Department for approval.

1211-7 Hauling Only

Unless the hauling is by the commercial supplier/entity or offsite material production plant, trucking companies are to be authorized as subcontractors.

1211-8 Subcontractor versus Supplier

Suppliers need not be authorized as a Subcontractor providing:

- The supplier does not perform a function which is a part of the construction process itself, e.g. spraying asphalt onto the roadway, erection of bridge members, grading and compacting surface materials, etc.
- The supplier does not establish a fabricating or processing facility expressly for the use of the project, i.e., direct use of a Department material pit for the project or a relocation of processing plants where the project is the only recipient of the product.
- The supplier in producing and delivering materials does not perform any work on the project.

1211-9 Consequences for Non-Compliance

If a subcontractor is found working on the project without an approved subcontract, a $1,000 sanction will be assessed, and work shall be stopped on the subcontract.

- The inspector or TES should let the Resident Engineer know what they've observed, and the stop work directive should come from the Resident Engineer.
- The Field Office Staff shall build pay item number 1080300 directly in CPE, and create a subitem in the name of the non-complying subcontractor. The unit price is $1.00, and the quantity is 1,000.00.

If the completed subcontract is not submitted within 30 days, the approval date of the SRF will be revoked.

ADOT

SUBCONTRACTOR REQUEST FORM (SRF)

It is ADOT's responsibility to ensure that prime contractors employ subcontractors in accordance with various Federal and State regulations.
Field Reports / 206 S. 17th Ave, MD 133A Phoenix, AZ 85007 / (602) 712-7301 / FieldReports-Subcontracts@azdot.gov

ADOT TRACS NO. ________ ADOT PROJECT NO. ________ PHONE NO. ________

PRIME CONTRACTOR: ________ ESTIMATED SUBCONTRACT $ ________

SUBCONTRACTOR ________ CONTACT NAME ________

ADDRESS ________ CITY, STATE, ZIP ________

PHONE NO. ________ EMAIL ADDRESS: ________

SUB R.O.C. NO. ________ CLASS ________ FED EIN ________ AZ UTRACS NO. ________

LOWER TIER TO ________

SUBCONTRACTOR IS A DBE: YES ☐ NO ☐

* I CERTIFY THAT I AM A BONA FIDE "**HAUL TRUCK**" OWNER/OPERATOR: YES ☐ NO ☐ ________ Signature of "haul truck" Owner/Operator / ________ Date

SUBCONTRACTED BID ITEMS No.'s

(Check box and provide dollar amount for Joint/Partial Items)

☐	________	$ ________	☐	________	$ ________
☐	________	$ ________	☐	________	$ ________
☐	________	$ ________	☐	________	$ ________
☐	________	$ ________	☐	________	$ ________
☐	________	$ ________	☐	________	$ ________
☐	________	$ ________	☐	________	$ ________
☐	________	$ ________	☐	________	$ ________

SUBCONTRACTED NON-PAY ITEMS

(Provide Description of Work)

____

____

____

____

____

Attach additional bid items? YES ☐ NO ☐

Attach subcontract? YES ☐ NO ☐

CERTIFICATION:

The Prime Contractor and Subcontractor certifies the following :

A) The Subcontractor has received applicable Documents No. 2-12 per Special Provisions.

B) The Prime Contractor and Subcontractor will execute Document No. 1 prior to the start of Subcontractor's work. DBE subcontracts to be submitted at Pre-Construction conference (Spec. 108.01/.03)

C) Upon execution, Prime Contractor will send Field Reports a copy of Document No. 1

1. Subcontract Agreement containing the above Bid Items of Work
2. Standard Specifications 107.18 & 107.19 (FA & Non FA projects)
3. Cargo Preference Act (FA projects only)
4. Prompt Pay specification 109.06 (Non FA projects)
5. Prompt Pay specification 109.06 (FA projects)
6. Title VI Assurances - Appendix A and E of the Civil Rights Act of 1964 (FA & Non FA projects)
7. Standard Federal EEO Construction Contract Specifications (Executive Order 11246) Rev.4/15/1981 (FA & Non FA projects)
8. Notice of Requirement for Affirmative Action to ensure EEO (Executive Order 11246) Rev.4/15/1981 (FA & Non FA projects)
9. FHWA 1273 - FA projects only (Rev.10/23/23)
10. EEO Compliance Reports, March 1, 2015 (FA Projects only)
11. DBE EPRISE -With Goals- FA Projects (Rev.10/20/22)
12. Wage Determination Decision # AZ ________ Mod # ________ (As per contract for this project)

ch Wage Decision

Authorized Prime Contractor Signature		Authorized Subcontractor Signature		Authorized Lower Tier Signature	
Title	Date	Title	Date	Title	Date

According to the appropriate Contract Provisions, the State Construction Engineer has approved this date the subletting of the work items described above.

Subcontract in Field Reports: ☐ YES ☐ NO

☐ Committed DBE ☐ Non-committed DBE

☐ For State Construction Engineer / Date

Field Reports / Date

14-0458/FA-with Goal
Rev. 12/2023

Exhibit 1211-1 Subcontractor Request Form (SRF)

Subcontractor Request Forms (SRF) - SRF's must be submitted in DocuSign for ADOT's final review & approval and to ensure all signers receive the completed documents.

DocuSign SRF Links for Contracts Awarded After 10/23/2023

- SRF - (With Goals) - Prime to Subcontractor - Federal Aid project
- SRF - (With Goals) - Subcontractor to Lower/Tier - Federal Aid project
- SRF -Prime to Sub- NO DBE Goals FA project
- SRF - (With No Goals) - Subcontractor to Lower/Tier - Federal Aid project
- SRF -Prime to Sub- NON-FA project
- SRF - NON-Federal Aid project - Subcontractor to Lower/Tier

DocuSign SRF links for Contracts Bid After 07/01/16

- SRF - (With Goals) - Prime to Subcontractor - Federal Aid project
- SRF - (With Goals) - Subcontractor to Lower/Tier - Federal Aid project
- SRF - (With No Goals) - Prime to Subcontractor - Federal Aid project
- SRF - (With No Goals) - Subcontractor to Lower/Tier - Federal Aid project
- SRF - Prime to Subcontractor - non-Federal Aid project
- SRF - Subcontractor to Lower/Tier - non-Federal Aid project

Exhibit 1211-2 Screenshot of (SRF) PowerForm links on ADOT's Contractor Information Website

ADOT

43-1200 R08/23 azdot.gov

AUTHORIZED SIGNATURE FORM

Clear

WHEREAS, ____________, an ____________ corporation, is required to execute certain
(NAME OF STATE)
documents which are necessary for the prompt and efficient execution of the corporate business:

NOW, THEREFORE, BE IT RESOLVED , by the Board of Directors of the ____________
(CORPORATE NAME)

that (name of parties authorized) ____________, ____________, ____________, ____________, ____________, ____________, ____________, be authorized to execute and sign documents on behalf of said corporate the following documents:

1. The Proposal
2. The Contract
3. The Bond
4. Payrolls
5. Claims
6. Supplemental Agreements
7. Extension of Time
8. Request for Force Account Work
9. All other papers necessary for the conduct of the corporation's affairs and the execution of the contract.
10. Subcontracts
11. Monthly Estimates

The powers and duties herein granted shall be and is hereby granted for the duration of the contract for the construction of ____________, Tracs No. ____________ Project No. ____________, or until express notice of revocation has been duly given in writing, whichever is the lesser period.

Dated and passed by the Board of Directors this ______ day of ____________, ______

(SIGNATURE OF PERSONS AUTHORIZED TO SIGN)	(PRINTED NAME AND TITLE)	(DOCUMENT NO.)

CERTIFICATE

STATE OF ____________)
) ss.
COUNTY OF ____________)

I, ____________ of the ____________, a corporation do hereby certify that the above is a true and correct copy of a resolution adopted by the Board of Directors of said corporation, by unanimous written consent on ____________ and that the same is in full force and effect at this time.
(DATE)

Dated ____________

____
(OFFICER OF THE CORPORATION)

(Seal of Corporation)

STATE OF ____________) s.s.

COUNTY OF ____________)

This instrument was acknowledged before me this ______ day of ____________ by ____________ appearing before the undersigned Notary Public, and state that he executed such instrument on behalf of said corporation for the purpose and consideration therein expressed.

____
(NOTARY PUBLIC)

My Commission Expires: ____________

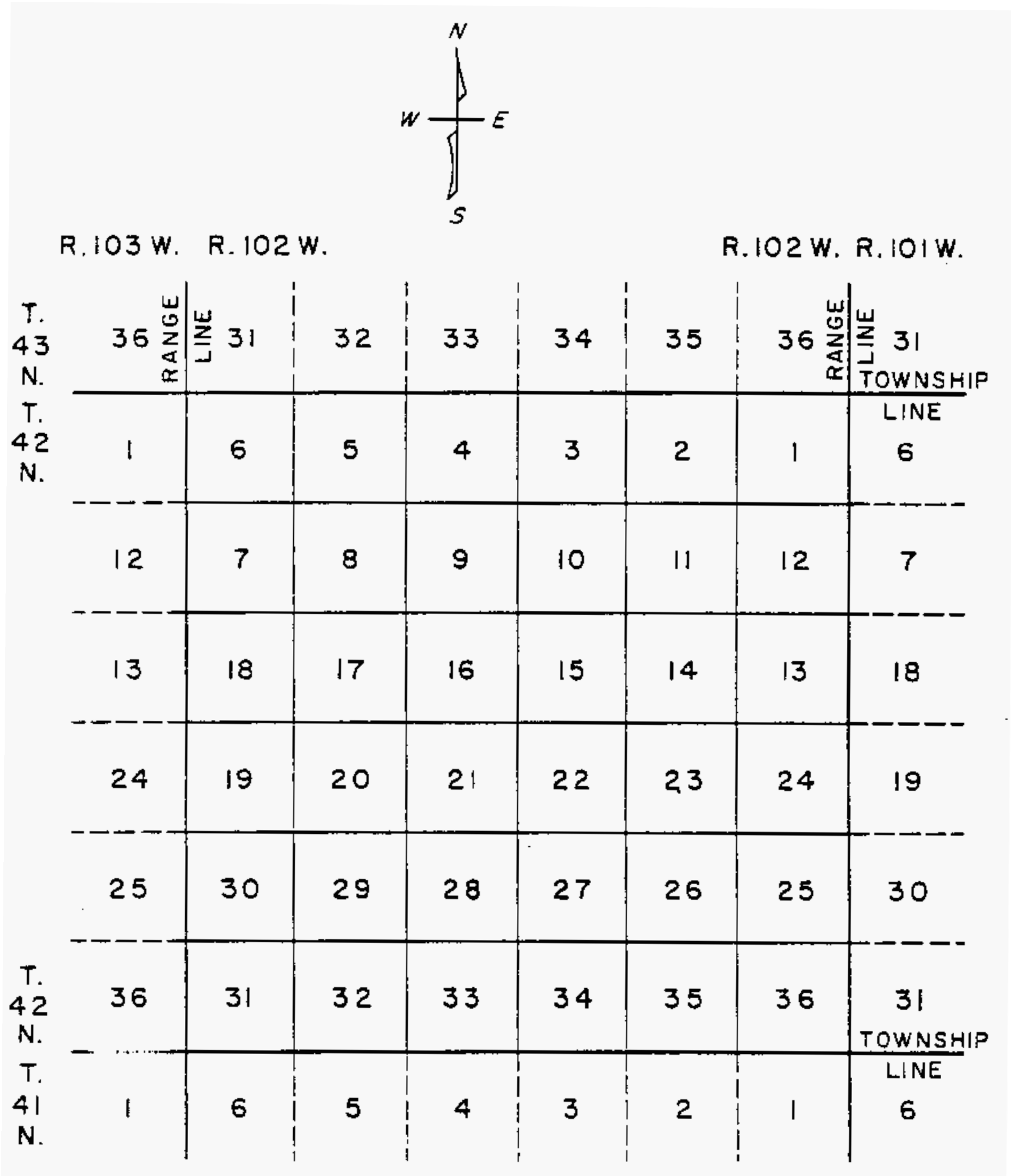
Exhibit 1211-3 Authorized Signature Form

ADOT - FHWA
Professional Services and Unique Work Activity List

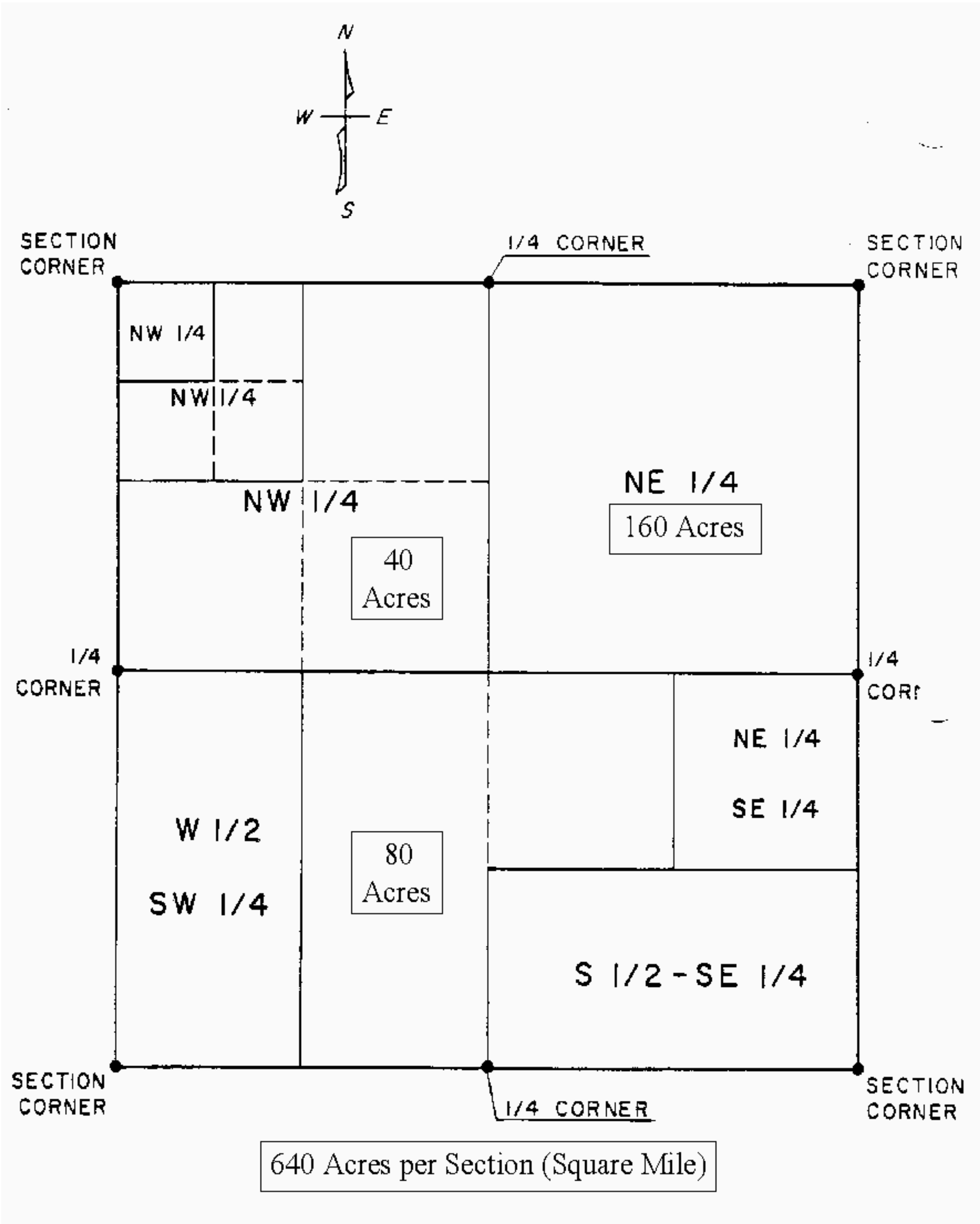
Work Activity	Subcontract Required	Contractor License Required	Payrolls Required	Minor 20 % of work week (De Minimis)
Camera for sewer mains	x			
Cathodic Protection	x			
Concrete Pumping	x		x	
Contractor's Office / Yard - rentals and installations				
Crane Service (With Operator)	x		x	
DPS, Local Law Enforcement, Off Duty Officers	x			
Drilling for Demolition	x	x		
Engineering Services for onsite material analysis / testing	x			
Field Office Hookups				
Gamma Gamma / Cross Sonic Logging testing	x			
Material Supplier - Commercial Source				
Mechanics (for Rental Equipment Services)	x		x	
Misc. Saw cutting	x	x	x	x
Portable Restrooms				
Pre - Wet System (Installation)	x		x	
Quality Control	x			
Railroad Flaggers	x			
Sewer By - Pass Pumping	x		x	
Survey	x			
Sweeping	x		x	x
SWPPP (Inspection & Plans Only)	x			
SWPPP (Labor/Equipment)	x	x	x	
Temporary Fencing	x		x	
Traffic Control - Permanent	x	x	x	
Traffic Control - Temporary	x		x	
Tranport Companies (tranport employee installs or takes down equipment or materials)	x		x	
Tranport Companies (transport employee does not install/take down equipment/materials)				
Trash Removal Services (Waste Management)				
Trucking - Owner/Operator (Individual/Haul trucks)	x			
Trucking Firms	x		x	x
Utility Locating Services	x			
Waterline Chlorination	x	x		
Welding Service	x	x	x	

Exhibit 1211-4 Professional Services and Unique Work Activity List

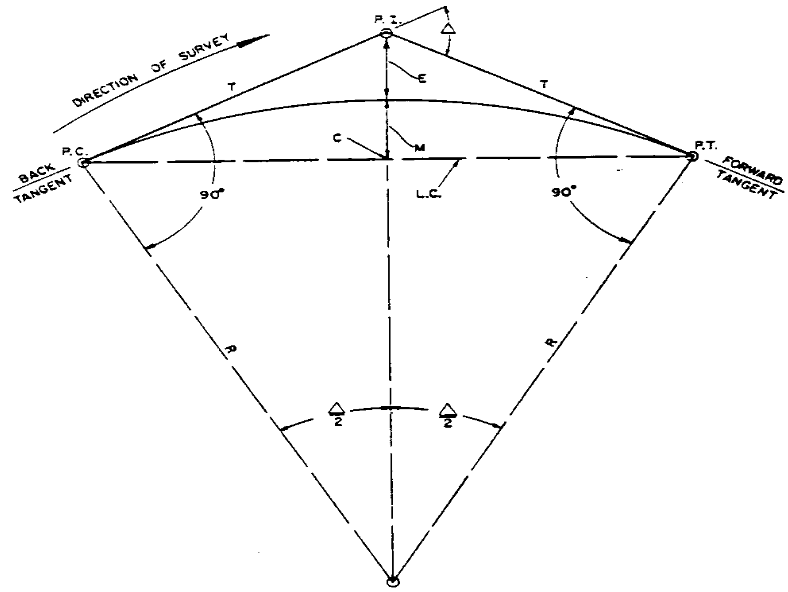
1301 TOWNSHIP SUBDIVISION



1302 SECTION SUBDIVISION



1303 CURVE COMPUTATION BY ARC DEFINITION



P.I. = POINT OF INTERSECTION

P.C. = POINT OF CURVATURE

P.T. = POINT OF TANGENCY

Δ = DEFLECTION ANGLE BETWEEN THE TANGENTS

T = TANGENT DISTANCE

E = EXTERNAL DISTANCE

R = RADIUS OF THE CIRCULAR ARC

M = MIDDLE ORDINATE

L.C. = LONG CHORD (DISTANCE BETWEEN P.C. AND P.T.)

C = MIDPOINT OF LONG CHORD

D = DEGREE OF CURVATURE

GENERAL FORMULAS FOR ARC DEFINITION

T = R TAN (Δ / 2)

D = 5729.578 / R

L.C. = 2 R SIN (Δ / 2)

E = T TAN (Δ / 4)

WHEN ‘R’ IS KNOWN, E = R SEC (Δ / 2) - R = R EXSEC (Δ / 2)

M= E COS(Δ / 2)

WHEN ‘R’ IS KNOWN, M = R (1 - COS(Δ / 2)) = R VERS (Δ / 2)

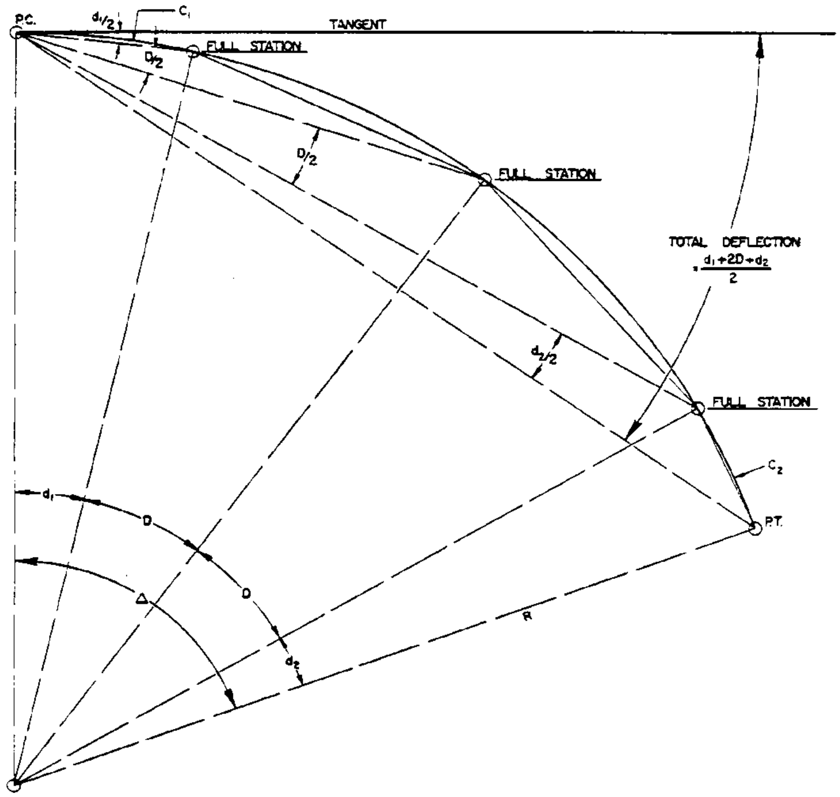
LENGTH OF CURVE, L = (100 Δ) / D WHEN Δ AND ‘D’ ARE IN MINUTES

LOCATING THE P.C. AND P.T.

STA. P.C. = STA. P. I. - T

STA. P.T. = STA. P.C. + L

1304 CURVE COMPUTATION BY DEFLECTION ANGLE



D = CENTRAL ANGLE FOR A FULL STATION OF ARC LENGTH

C_1 = LENGTH OF ARC FROM P.C. TO THE FIRST FULL STATION

C_2 = LENGTH OF ARC FROM THE LAST FULL STATION TO P.T.

1. FROM THE GENERAL FORMULAS IN FIGURE 12-100.1, COMPUTE ‘D’ AND STATIONS P.C. AND P.T.
2. SOLVING FOR THE DEFLECTION ANGLES, IN MINUTES, HAVING LENGTHS OF THE ARC LESS THAN A FULL STATION,

   $d_1 / 2 = 0.30\ C_1\ D$

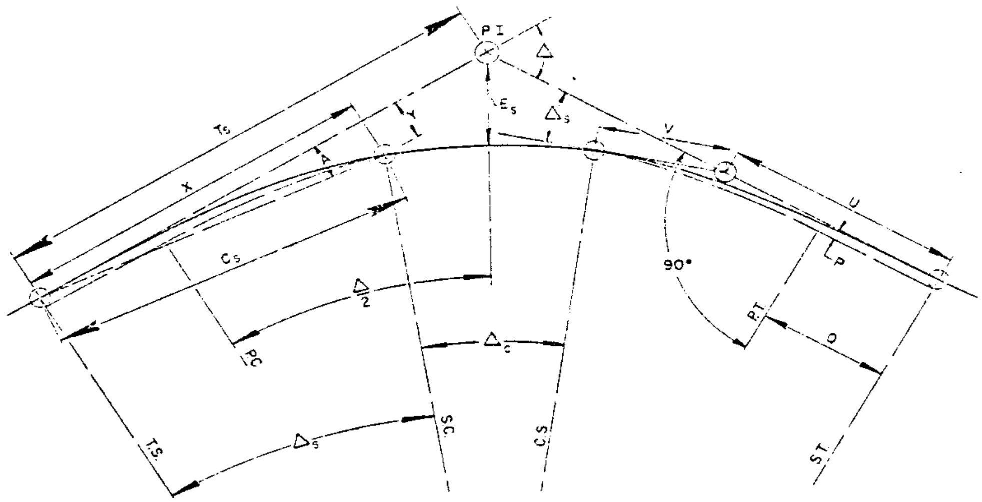
   $d_2 / 2 = 0.30\ C_2\ D$
3. THE DEFLECTION ANGLE IN DEGREES, FOR A FULL STATION ARC

   LENGTH EQUALS D / 2.
4. THE DEFLECTION ANGLE, IN MINUTES, FOR ANY ARC LENGTH,

   DEFLECTION = (1718.873 / R) X ARC LENGTH
5. A RUNNING TOTAL OF STATION TO STATION DEFLECTIONS GIVES THE TOTAL DEFLECTION ANGLE FROM THE P.C.

   COMPUTE CHECK: THE TOTAL DEFLECTION ANGLE TO THE P.T. MUST EQUAL Δ / 2

1305 SPIRAL CURVE TRANSITIONS



L_S = LENGTH OF SPIRAL

D = DEGREE OF CURVATURE OF THE CIRCULAR CURVE

T_S = TANGENT DISTANCE

Δ = DEFLECTION ANGLE BETWEEN THE TANGENTS

Δ_S = SPIRAL ANGLE

Δ_C = CENTRAL ANGLE BETWEEN THE S.C. AND C.S.

E_S = EXTERNAL DISTANCE

C_S = LONG CHORD

U = LONG TANGENT

V = SHORT TANGENT

X = SPIRAL COORDINATE (ABSCISSA)

Y = SPIRAL COORDINATE (ORDINATE)

Q = SIMPLE CURVE COORDINATE (ABSCISSA)

P = SIMPLE CURVE COORDINATE (ORDINATE)

A = DEFLECTION ANGLE OF SPIRAL CURVE

K = CONSTANT OF INCREASING CURVATURE

T.S. = TANGENT TO SPIRAL

S.C. = SPIRAL TO CURVE

C.S. = CURVE TO SPIRAL

S.T. = SPIRAL TO TANGENT

SPIRAL CURVE FORMULAS:

$\Delta_S = (D\ L_S)/200$ $\quad$ $D = K\ L_S$ $\quad$ $\Delta_S = (K\ (L_S)^2)/200$

TO CALCULATE T_S AND E_S OF A SIMPLE CURVE WITH EQUAL SPIRALS:

$T_S = (R+P)\ \mathrm{TAN}\ (\Delta / 2) + Q$ $\quad$ $E_S = (R+P)\ \mathrm{EXSEC}\ (\Delta / 2) + P$

$T_S = T + Q + P\ \ \mathrm{TAN}\ (\Delta / 2)$ $\quad$ $E_S = E + P/\ \mathrm{COS}\ (\Delta / 2)$

TO CALCULATE THE TANGENT DISTANCES OF A SIMPLE CURVE WITH UNEQUAL SPIRALS:

$T_{S1} = ((R+P)_2 / \mathrm{SIN}\Delta) - (R+P\ )_1\ \mathrm{COT}\Delta + Q_1$ $\quad$ $T_{S2} = ((R+P)_1 / \mathrm{SIN}\Delta) - (R+P\ )_2\ \mathrm{COT}\Delta + Q_2$

FOR DEFLECTION ANGLES TO INTERMEDIATE POINTS ON A SPIRAL:

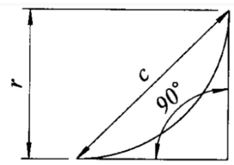
Δ (IN MINUTES) = 10K S^2, WHERE S = DISTANCE IN STATIONS TO POINT. THIS VALUE MAY HAVE TO BE ADJUSTED DOWNWARD. NOTE THAT THE ONE-TENTH MINUTES OF THE TABULATED DEFLECTION ANGLES FORM A WAVE LIKE PATTERN (EQUIVALENT TO THE ABOVE FORMULA) UNTIL THEY FALL OFF NEAR THE BOTTOM OF THE TABLE. ADJUSTMENTS FOR INTERMEDIATE POINTS MAY BE INTERPOLATED.

TO SET STAKES WITH THE INSTRUMENT SET UP AT A POINT ON THE SPIRAL, WE TAKE ADVANTAGE OF THE FACT THAT THE SPIRAL IS LAID OUT ON A SYSTEM OF COORDINATES. WE FIRST SET THE INSTRUMENT PLATE ZERO PARALLEL TO THE TANGENT TO THE SPIRAL. THIS IS DONE BY SIGHTING BACK ON THE T.S. WITH 'A' FOR THE INSTRUMENT SET-UP POINT ON THE PLATES; OR BY BRINGING THE INSTRUMENT TANGENT TO THE CURVE WITH Δ_S FOR THE INSTRUMENT SETUP POINTS ON THE PLATES. THEN THE DIFFERENCE BETWEEN COORDINATES OF POINTS TO BE SET AND THE INSTRUMENT GIVES US DEFLECTION ANGLES:

$$\text{DEFL. ANGLE} = \text{TAN}^{-1}\ (Y_1 - Y_0)/(X_1 - X_0)$$

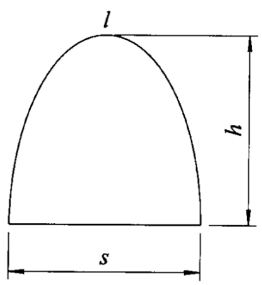
1306 GEOMETRIC SOLUTIONS

1306-1 Areas of Plane Figures



Spandrel

Area = $0.2146 r^2 = 0.1073 c^2$
Example $r = 3$
Area = $0.2146 \times 3^2 = 1.0314$ Ans.



Parabola

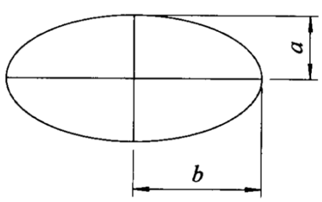
l = length of curvedline = periphery - s

$$l = \frac{s^2}{8h}\left[\sqrt{c(1+c)} + 2.0326 \times \log\left(\sqrt{c} + \sqrt{1+c}\right)\right] \text{ in which } c = \left(\frac{4h}{s}\right)^2$$

Area = $\frac{l}{3} sh$

Example $s = 3$; $h = 4$;

Area = $\frac{l}{3}$ x3x4=8 Ans.

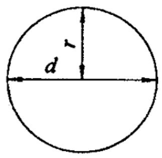


Ellipse

Area = π ab = 3.1416 ab

Circum = $2\pi\sqrt{\frac{a^2+b^2}{2}}$
(close approximation)

Example a = 3; b =4
Area = 3.1416 x 3 x 4 = 37.6992 Ans.
Circum = $2 \times 3.1416 \times \sqrt{\frac{3^2+4^2}{2}} = 6.2832 \times \sqrt{12.5} = 6.2832 \times 3.5355 = 22.21$ Ans.



Circle

π = 3.1416; A = area; d = diameter; p = circumference or periphery; r = radius;

$p = \pi d = 3.1416 d.$ $\qquad p = 2\sqrt{\pi A} = 3.54\sqrt{A}$

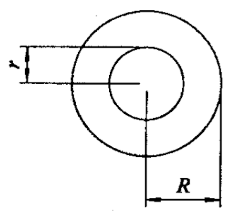
$p = 2\pi r = 6.2832 r.$ $\qquad p = \frac{2A}{r} = \frac{4A}{d}$

$d = \frac{p}{\pi} = \frac{p}{3.1416}$ $\qquad d = 2\sqrt{\frac{A}{\pi}} = 1.128\sqrt{A}$

$r = \frac{p}{2\pi} = \frac{p}{6.2832}$ $\qquad r = \sqrt{\frac{A}{\pi}} = 0.564\sqrt{A}$

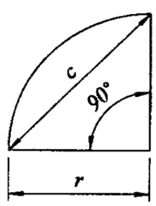
$A = \frac{\pi d^2}{4} = 0.7854 d^2$ $\qquad A = \frac{p^2}{t\pi} = \frac{p^2}{12.57}$

$A = \pi r^2 = 3.1416 r^2$ $\qquad A = \frac{pr}{2} = \frac{pd}{4}$



Circular Ring

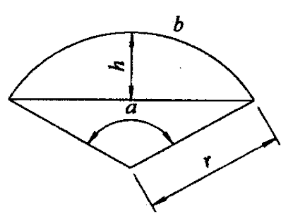
Area = $\pi(R^2 - r^2) = 3.1416(R^2 - r^2)$
Area = $0.7854(D^2 - d^2) = 0.7854(D-d)(D+d)$
Area = difference in areas between the inner and outer circles.
Example. $R = 4$; $r = 2$
Area = $3.1416(4^2 - 2^2) = 37.6992$ Ans.



Quadrant

Area = $\frac{\pi r^2}{4} = 0.7854 r^2 = 0.3927 c^2$

Example. $r = 3$; c = chord
Area = .7854 x 3^2 = 7.0686 Ans.



Segment

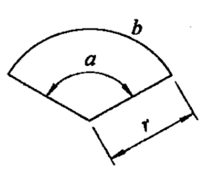
b = length of arc, a = angle in degrees
c = chord = $\sqrt{4(2hr-h^2)}$
Area = $1/2\,[br-c(r-h)]$

or $\qquad = \pi r^2 \frac{a}{360} - \frac{c(r-h)}{2}$

When o is greater than 180° than $\frac{c}{2}$ x difference between r and h is added to the fraction $\frac{\pi r^2}{360}$

Example. $r = 3$; $a = 120°$; $h = 1.5$

Area = $3.1416 \text{x } 3^2 \text{x } \frac{120}{360} - \frac{5.196(3-1.5)}{2} = 5.5278$ Ans.



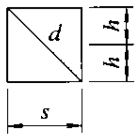
Sector

Area = $\frac{br^2}{2}$ or $\pi r^2 \frac{a}{360°}$

a = angle in degrees; b = length of arc

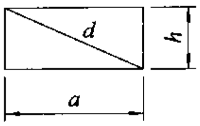
Example. $r = 3$; $a = 120°$

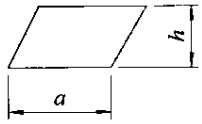
Area = $3.1416 \text{x } 3^2 \text{x } \frac{120}{360} = 9.4248$ Ans.



Square

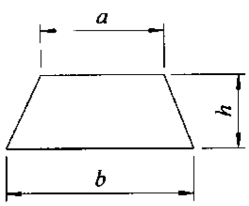
Diagonal = $d = s\sqrt{2}$
Area = $s^2 = 4b^2 = 0.5d^2$
Example. $s = 6;\ b = 3.$ Area = $(6)^2 = 36$ *Ans.*
$d = 6 \times 1.414 = 8.484$ *Ans*





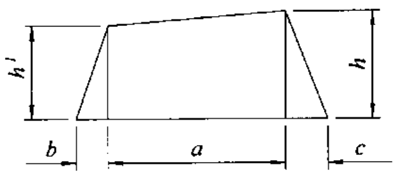
Rectangle and Parallelogram

Area = ab or $b\sqrt{d^2 - b^2}$
Example $a = 6;\ b = 3.$
Area = $3x6 = 18$ *Ans.*



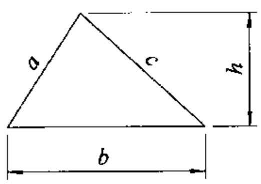
Trapezoid

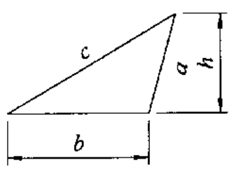
Area = $1/2\ h(a + b)$
Example. $a = 2;\ b = 4;\ h = 3.$
Area = $1/2 \times 3(2+4) = 9$ *Ans.*



Trapesium

Area = $1/2[a(h+h^1) + bh^1 + ch]$
Example. $a = 4;\ b = 2;\ c = 2;\ h = 3;\ h^1 = 2.$
Area = $1/2[4(3+2)+(2x2)+(2x3)] = 15$ *Ans*





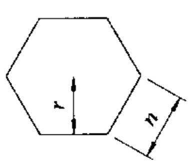
Triangles

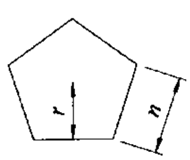
Both formulas apply to both figures

Area = $1/2bh$
Example. $h=3;\ b=5$
Area = $1/2(3x5)=7\ 1/2$ *Ans.*
Area = $\sqrt{S(S-a)(S-b)(S-c)}$ when $S = \dfrac{a+b+c}{2}$
Example. $a=2;\ b=3;\ c=4$

$$S = \frac{2+3+4}{2} = 4.5$$

Area = $4.5(4.5-2)(4.5-3)(4.3-4)=2.0$ *Ans*





Regular Polygons

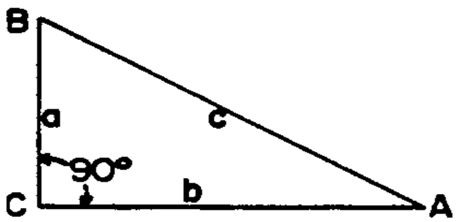
Area	5 sides = $1.720477\ S^2 = 3.63271\ r^2$	
	6 sides = $2.598150\ S^2 = 3.46410\ r^2$	
	7 sides = $3.633875\ S^2 = 3.37101\ r^2$	
	8 sides = $4.828427\ S^2 = 3.31368\ r^2$	
	9 sides = $6.181875\ S^2 = 3.27573\ r^2$	
	10 sides = $7.894250\ S^2 = 3.24920\ r^2$	
	11 sides = $9.365675\ S^2 = 3.22993\ r^2$	
	12 sides = $11.196300\ S^2 = 3.21539\ r^2$	

n= number of sides r= short radius
S= length of side R= long radius

$$\text{Area} = \frac{n}{4} S^2 \cot. \frac{180^\circ}{n} = \frac{n}{2} R^2 \sin. \frac{360^\circ}{n} = nr^2 \tan. \frac{180^\circ}{n}$$

1306-2 Triangles

RIGHT TRIANGLE



(1) sin A = a / c = cos B

(2) cos A = b / c = sin B

(3) tan A = a / b = cot B

(4) cot A = b / a = tan B

(5) sec A = c / b = csc B

(6) csc A = c / a = sec B

(7) vers A = 1 - cos A = 1 - b /c

(8) exsec A = sec A - 1 = c/b -1

(9) a = $\sqrt{(c + b)(c - b)}$

(10) b = $\sqrt{(c + a)(c - a)}$

(11) c = $\sqrt{(a)^2 + (b)^2}$

(12) Area = (1/2) a b

(13) Area = (1/2) b2 tan A

Trigonometric Functions of any Angle

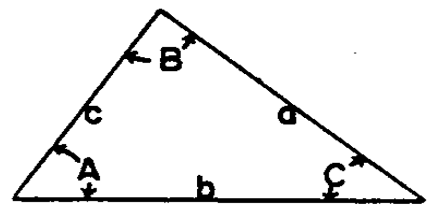
sin (900 + θ) = cos θ

cos (900 + θ) = - sin θ

tan (900 + θ) = - cot θ

cot (900 + θ) = - tan θ

OBLIQUE TRIANGLE



(1) Law of Sines

(When two angles and included sides are known)

(sin A) /a = (sin B) / b = (sin C)/c

(2) Law of Tangents

(When two sides and the included angle are known)

(a +b) / (a -b) =

(tan (1/2) (A + B)) / (tan (1/2) (A-B))

(3) Law of Cosines

(When two sides and the included angle are known

or when all three sides are known)

$a^2 = b^2 + c^2$ - 2bc cos A

$b^2 = a^2 + c^2$ - 2ac cos B

c2 = a2 + b2 - 2ab cos A

(4) Half-angle formula

(when all three sides are known)

* s = (1 / 2) (a + b + c)

sin (1 / 2)A = $\sqrt{\frac{(s-b)(s-c)}{bc}}$

(5) Area = (1/2)ab sin C

Area = (1/2)bc sin A

Area = (1/2)ac sin B

1307 FRACTIONS OF INCH IN DECIMALS

Inches and Fractions of an Inch in Decimals of a Foot:

1/16 Inch = 0.005208333 Foot

Inch	0"	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"	11"
0	**0.0000**	**0.0833**	**0.1667**	**0.2500**	**0.3333**	**0.4167**	**0.5000**	**0.5833**	**0.6667**	**0.7500**	**0.8333**	**0.9167**
1/32	0.0026	0.0859	0.1693	0.2526	0.3359	0.4193	0.5026	0.5859	0.6693	0.7526	0.8359	0.9193
1/16	0.0052	0.0885	0.1719	0.2552	0.3385	0.4219	0.5052	0.5885	0.6719	0.7552	0.8385	0.9219
3/32	0.0078	0.0911	0.1745	0.2578	0.3411	0.4245	0.5078	0.5911	0.6745	0.7578	0.8411	0.9245
1/8	**0.0104**	**0.0938**	**0.1771**	**0.2604**	**0.3438**	**0.4271**	**0.5104**	**0.5938**	**0.6771**	**0.7604**	**0.8438**	**0.9271**
5/32	0.0130	0.0964	0.1797	0.2630	0.3464	0.4297	0.5130	0.5964	0.6797	0.7630	0.8464	0.9297
3/16	0.0156	0.0990	0.1823	0.2656	0.3490	0.4323	0.5156	0.5990	0.6823	0.7656	0.8490	0.9323
7/32	0.0182	0.1016	0.1849	0.2682	0.3516	0.4349	0.5182	0.6016	0.6849	0.7682	0.8516	0.9349
1/4	**0.0208**	**0.1042**	**0.1875**	**0.2708**	**0.3542**	**0.4375**	**0.5208**	**0.6042**	**0.6875**	**0.7708**	**0.8542**	**0.9375**
9/32	0.0234	0.1068	0.1901	0.2734	0.3568	0.4401	0.5234	0.6068	0.6901	0.7734	0.8568	0.9401
5/16	0.0260	0.1094	0.1927	0.2760	0.3594	0.4427	0.5260	0.6094	0.6927	0.7760	0.8594	0.9427
11/32	0.0286	0.1120	0.1953	0.2786	0.3620	0.4453	0.5286	0.6120	0.6953	0.7786	0.8620	0.9453
3/8	**0.0313**	**0.1146**	**0.1979**	**0.2812**	**0.3646**	**0.4479**	**0.5313**	**0.6146**	**0.6979**	**0.7813**	**0.8646**	**0.9479**
13/32	0.0339	0.1172	0.2005	0.2839	0.3672	0.4505	0.5339	0.6172	0.7005	0.7839	0.8672	0.9505
7/16	0.0365	0.1198	0.2031	0.2865	0.3698	0.4531	0.5365	0.6198	0.7031	0.7865	0.8698	0.9531
15/32	0.0391	0.1224	0.2057	0.2891	0.3724	0.4557	0.5391	0.6224	0.7057	0.7891	0.8724	0.9557
1/2	**0.0417**	**0.1250**	**0.2083**	**0.2917**	**0.3750**	**0.4583**	**0.5417**	**0.6250**	**0.7083**	**0.7917**	**0.8750**	**0.9583**
17/32	0.0443	0.1276	0.2109	0.2943	0.3776	0.4609	0.5443	0.6276	0.7109	0.7943	0.8776	0.9609
9/16	0.0469	0.1302	0.2135	0.2969	0.3802	0.4635	0.5469	0.6302	0.7135	0.7969	0.8802	0.9635
19/32	0.0495	0.1328	0.2161	0.2995	0.3828	0.4661	0.5495	0.6328	0.7161	0.7995	0.8828	0.9661
5/8	**0.0521**	**0.1354**	**0.2188**	**0.3021**	**0.3854**	**0.4688**	**0.5521**	**0.6354**	**0.7188**	**0.8021**	**0.8854**	**0.9688**
21/32	0.0547	0.1380	0.2214	0.3047	0.3880	0.4714	0.5547	0.6380	0.7214	0.8047	0.8880	0.9714
11/16	0.0573	0.1406	0.2240	0.3073	0.3906	0.4740	0.5573	0.6406	0.7240	0.8073	0.8906	0.9740
23/32	0.0599	0.1432	0.2266	0.3099	0.3932	0.4766	0.5599	0.6432	0.7266	0.8099	0.8932	0.9766
3/4	**0.0625**	**0.1458**	**0.2292**	**0.3125**	**0.3958**	**0.4792**	**0.5625**	**0.6458**	**0.7292**	**0.8125**	**0.8958**	**0.9792**
25/32	0.0651	0.1484	0.2318	0.3151	0.3984	0.4818	0.5651	0.6484	0.7318	0.8151	0.8984	0.9818
13/16	0.0677	0.1510	0.2344	0.3177	0.4010	0.4844	0.5677	0.6510	0.7344	0.8177	0.9010	0.9844
27/32	0.0703	0.1536	0.2370	0.3203	0.4036	0.4870	0.5703	0.6536	0.7370	0.8203	0.9036	0.9870
7/8	**0.0729**	**0.1563**	**0.2396**	**0.3229**	**0.4063**	**0.4896**	**0.5729**	**0.6563**	**0.7396**	**0.8229**	**0.9063**	**0.9896**
29/32	0.0755	0.1589	0.2422	0.3255	0.4089	0.4922	0.5755	0.6589	0.7422	0.8255	0.9089	0.9922
15/16	0.0781	0.1615	0.2448	0.3281	0.4115	0.4948	0.5781	0.6615	0.7448	0.8281	0.9115	0.9948
31/32	0.0807	0.1641	0.2474	0.3307	0.4141	0.4974	0.5807	0.6641	0.7474	0.8307	0.9141	0.9974

1308 CONVERSION FACTORS

1308-1 Linear Conversions

Units	Inches	Feet	Yards	Rods	Miles	Meters
1 Inch	1	0.08333	0.027778	0.005051	0.0000157828	0.0254
1 Foot	12	1	0.3333	0.060606	0.00018939	0.304801
1 Yard	36	3	1	0.181818	0.000568182	0.914402
1 Rod (Surveyor's Measure)	198	16.5	5.5	1	0.003125	5.029216
1 Mile (U.S. Statute)	63360	5280	1760	320	1	1609.347
1 Meter	39.37	3.280833	1.093611	0.198838	0.00062137	1
1 Link	7.92	0.66	0.22	0.04	0.000125	0.201168
1 Chain (Surveyor's Measure)	792	66	22	4	0.0125	20.117
1 Station	1200	100	33.33	6.060606	0.0189394	30.4801
1 Furlong	7920	660	220	40	0.125	201.168
1 Mile (Int. Nautical)	72913	6076.103	2025.366	368.248	1.15078	1852
1 Millimeter	0.03937	0.003281	0.001094	0.000199	~~~~~~~	0.001
1 Centimeter	0.3937	0.032808	0.010936	0.001988	~~~~~~~	0.01
1 Kilometer	~~~~~~~	3280.833	1093.611	198.836	0.62137	1000

1308-2 Area Conversions

Units	Square Inches	Square Feet	Square Yards	Square Rods	Acres	Square Miles	Square Meters
1 Square Inch	1	0.006944	0.0007716	~~~~~~~	~~~~~~~	~~~~~~~	0.00064516
1 Square Foot	144	1	0.11111	0.0036731	~~~~~~~	~~~~~~~	0.09290341
1 Square Yard	1,296	9	1	0.033058	0.0002066	~~~~~~~	0.8361307
1 Square Rod	39,204	272.25	30.25	1	0.00625	~~~~~~~	25.29295
1 Acre	~~~~~~~	43560	4840	160	1	0.0015625	4,046.873
1 Square Mile	~~~~~~~	~~~~~~~	3,097,600	102,400	640	1	2589998
1 Square Meter	1,550.00	10.76387	1.195985	0.0395367	0.0002471	~~~~~~~	1
1 Square Link	62.7264	0.4356	0.0484	0.0016	0.00001	~~~~~~~	0.040468
1 Square Chain	627264	4356	484	16	0.1	~~~~~~~	404.689
1 Square	14400	100	11.1111	0.367309	0.0022956	~~~~~~~	9.29034
1 Section	~~~~~~~	~~~~~~~	3097600	102400	640	1	2589998
1 Square Centimeter	0.1549997	0.0010764	0.0001196	~~~~~~~	~~~~~~~	~~~~~~~	0.0001
1 Hectare	~~~~~~~	107638.7	11959.85	395.367	2.471044	0.003861	10000
1 Square Kilometer	~~~~~~~	~~~~~~~	1195985	39536.7	247.1044	0.3861006	1000000

1309 WEIGHTS AND MEASUREMENTS

1309-1 General Weights And Measurements

Avoirdupois Weight:

27-11/32 grains		= 1 dram
16 drams	= 437.5 grains	= 1 ounce
16 ounces	= 7,000 grains	= 1 pound
28 pounds		= 1 quarter
4 quarters	= 112 pounds	= 1 hundred wt. (cwt.)
20 cwt.	= 2240 pounds	= 1 long ton

Surveyors Measure:

7.92 inches	= 1 link
25 links	= 1 rod
4 rods	= 1 chain
10 chains	= 1 furlong
8 furlongs	= 1 mile
10 square chains	= 1 acre

Metric Conversion:

2.540 centimeters	= 1 inch
39.37 inches	= 1 meter
0.6214 miles	= 1 kilometer
1.057 quarts	= 1 liter
453.59 grams	= 1 pound (av.)
2.205 pounds (av.)	= 1 kilogram

Dry Measure:

2 pints	= 1 quart
8 quarts	= 1 peck
4 pecks	= 1 bushel

Liquid Measure:

4 gills	= 1 pint
2 pints	= 1 quart
4 quarts	= 1 gallon

Metric Measure:

Micro-	= 0.000001 units	Deca-	= 10 units
Milli-	= 0.001 units	Hecto-	= 100 units
Centi-	= 0.01 units	Kilo-	= 1,000 units
Deci-	= 0.1 units	Mega-	= 1,000,000 units

*** Examples:**

1 centimeter (cm) = 0.01 meters (m)

1 kilogram (kg) = 1000 grams (g)

1309-2 Weight and Measurement Equivalents

A. Volume Equivalents

Cubic Inches	Cubic Feet	Cubic Yards	Liters	U.S. Gallons	British Imperial Gallons
1	0.0005787	0.00002143	0.01639	0.004329	0.003605
1,728.0	1	0.03704	28.32	7.481	6.229
46,656.0	27.0	1	764.6	202..0	168.2
61.02	0.03531	0.001308	1	0.2642	0.2200
231	0.1337	0.004951	3.785	1	0.8327
277.4	0.1605	0.005946	4.546	1.201	1

B. Weight Equivalents

Ounces (Avoirdupois)	Pounds (Avoirdupois)	Short Tons	Long Tons	Metric Tons	Kilograms
1	0.0625	0.00003125	0.00002790	0.00002835	0.02835
16.0	1	0.0005000	0.0004464	0.0004536	0.4536
32,000.0	2,000.0	1	0.8929	0.9072	907.2
35,840.0	2,240.0	1.12	1	1.016	1,016
35,274.	2,205	1.102	0.9842	1	1,000.0
35.27	2.205	0.001102	0.0009842	0.001	1

C. Linear Measure Equivalents

Inches	Feet	Yards	Meters	Rods	Kilometers	Miles
1	0.08333	0.02778	0.02540	0.005051	0.00002540	0.00001578
12.0	1	0.3333	0.3048	0.06061	0.0003048	0.0001894
36.0	3.0	1	0.9144	0.1818	0.0009144	0.0005682
39.37	3.281	1.094	1	0.1988	0.001000	0.0006214
198	16.5	5.5	5.029	1	0.005029	0.003125
39,370.	3,281.	1,094.	1,000.00	198.8	1	0.6214
63,360.0	5,280.0	1,760.0	1,609.00	320.0	1.609	1

D. Square Measure Equivalents

Square Inches	Square Feet	Square Yards	Square Meters	Square Rods	Acres	Square Miles
1	0.006944	0.0007716	0.0006452	0.00002551	~~~~~~~	~~~~~~~
144.0	1	0.1111	0.09290	0.003673	0.00002296	~~~~~~~
1,296.0	9.0	1	0.8361	0.03306	0.0002066	~~~~~~~
1,550	10.76	1.196	1	0.03954	0.0002471	~~~~~~~
39,204	272.25	30.25	25.29	1	0.006250	~~~~~~~
6,272,640.	43,560.	4,840	4,047.	160.0	1	0.001562
~~	~~~~~~~	3,097,600.	2,589,998.	102,400.00	640.0	1

1310 VOLUME CORRECTIONS FOR ASPHALT

The average number of gallons per ton and the average pounds per gallons for various types and grades of asphalt are shown in Table IX.

TABLE IX

AVERAGE WEIGHTS AND VOLUMES OF ASPHALTS

GRADE	GALLONS PER TON @ 60° F.	POUNDS PER GALLON @ 60° F.
LIQUID ASPHALTS:		
MC-70	253	7.91
MC-250	249	8.03
MC-800	245	8.16
MC-3000	241	8.30
PAVING ASPHALTS:		
PG 76-XX	232	8.62
PG 70-XX	233	8.58
PG 64-XX	235	8.51
PG 58-XX	236	8.47
PG 52-XX	238	8.40
EMULSIFIED ASPHALTS:		
All Grades	240	8.33

While actual weights may vary slightly, weights of asphalts used on the Pacific Coast may be considered uniform for all ordinary purposes.

TEMPERATURE - VOLUME CORRECTIONS FOR ASPHALT

Asphalt changes in volume with change in temperature. Change in unit volume, per degree change in temperature, is termed “Coefficient of Expansion”, a factor which varies with the specific gravity of asphalt. A temperature of 60 degrees F., is customarily used as the standard basis for volume determinations of asphalt and other petroleum products. Therefore, if the volume is actually measured at any temperature other than 60 degrees F., a correction factor must be applied to convert the measured volume to volume at 60 degrees F.

The American Society for Testing and Materials prepared and published extensive tables on temperature - volume corrections of petroleum products. These tables appear in a book entitled “ASTM - IP Petroleum Measurement Tables”, published in January 1953 (ASTM Designation D 1250). Temperature-Volume correction tables contained herein have been extracted from this ASTM publication.

Temperature - Volume correction factors are given in the following tabulations for asphalt having a specific gravity at 60 degrees F. above 0.966 (designated by ASTM as Group O materials) and for asphalt having a specific gravity at 60 degrees F. of 0.850 to 0.966 inclusive (designated by ASTM as Group 1 materials), and for emulsified asphalts.

Paving asphalts and liquid asphalts of grades RC, MC and SC 250, 800, and 3000 fall into the Group O classifications. Use Table X for volume corrections. Liquid asphalts of grades RC, MC, SC 70 fall into Group 1. Use Table XI for volume corrections. Use Table XII for temperature-volume corrections factors for emulsified asphalts.

EXAMPLE OF USE: Assume an MC 250 grade of liquid asphalt. Assume also that a volume of this material is measured to be 9,000 gallons at a temperature of 180 degrees F. The volume of this material at the standard temperature of 60 degrees F. is 8,628 gallons (9,000 gallons x 0.9587)

TABLE X
TEMPERATURE - VOLUME CORRECTIONS FOR ASPHALTIC MATERIALS
GROUP 0 - SPECIFIC GRAVITY AT 60° F ABOVE 0.966

LEGEND:

t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oil volumes to the basis of 60° F

t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M
0	1.0211	50	1.0035	100	0.9861	150	0.9689	200	0.952	250	0.9352	300	0.9187	350	0.9024	400	0.8864	450	0.8705
1	1.0208	51	1.0031	101	0.9857	151	0.9686	201	0.9516	251	0.9349	301	0.9184	351	0.9021	401	0.8861	451	0.8702
2	1.0204	52	1.0028	102	0.9854	152	0.9682	202	0.9513	252	0.9346	302	0.9181	352	0.9018	402	0.8857	452	0.8699
3	1.0201	53	1.0024	103	0.9851	153	0.9679	203	0.9509	253	0.9342	303	0.9177	353	0.9015	403	0.8854	453	0.8696
4	1.0197	54	1.0021	104	0.9847	154	0.9675	204	0.9506	254	0.9339	304	0.9174	354	0.9011	404	0.8851	454	0.8693
5	1.0194	55	1.0017	105	0.9844	155	0.9672	205	0.9503	255	0.9336	305	0.9171	355	0.9008	405	0.8848	455	0.869
6	1.019	56	1.0014	106	0.984	156	0.9669	206	0.9499	256	0.9332	306	0.9167	356	0.9005	406	0.8845	456	0.8687
7	1.0186	57	1.001	107	0.9837	157	0.9665	207	0.9496	257	0.9329	307	0.9164	357	0.9002	407	0.8841	457	0.8683
8	1.0183	58	1.0007	108	0.9833	158	0.9662	208	0.9493	258	0.9326	308	0.9161	358	0.8998	408	0.8838	458	0.868
9	1.0179	59	1.0003	109	0.983	159	0.9658	209	0.9489	259	0.9322	309	0.9158	359	0.8995	409	0.8835	459	0.8677
10	1.0176	60	1	110	0.9826	160	0.9655	210	0.9486	260	0.9319	310	0.9154	360	0.8992	410	0.8832	460	0.8674
11	1.0172	61	0.9997	111	0.9823	161	0.9652	211	0.9483	261	0.9316	311	0.9151	361	0.8989	411	0.8829	461	0.8671
12	1.0169	62	0.9993	112	0.9819	162	0.9648	212	0.9479	262	0.9312	312	0.9148	362	0.8986	412	0.8826	462	0.8668
13	1.0165	63	0.999	113	0.9816	163	0.9645	123	0.9476	263	0.9309	313	0.9145	363	0.8982	413	0.8822	463	0.8665
14	1.0162	64	0.9986	114	0.9813	164	0.9641	214	0.9472	264	0.9306	314	0.9141	364	0.8979	414	0.8819	464	0.8661
15	1.0158	65	0.9983	115	0.9809	165	0.9638	215	0.9469	265	0.9302	315	0.9138	365	0.8976	415	0.8816	465	0.8658
16	1.0155	66	0.9979	116	0.9806	166	0.9635	216	0.9466	266	0.9299	316	0.9135	366	0.8973	416	0.8813	466	0.8655
17	1.0151	67	0.9976	117	0.9802	167	0.9631	217	0.9462	267	0.9296	317	0.9132	367	0.8969	417	0.881	467	0.8652
18	1.0148	68	0.9972	118	0.9799	168	0.9628	218	0.9459	268	0.9293	318	0.9128	368	0.8966	418	0.8806	468	0.8649
19	1.0144	69	0.9969	119	0.9795	169	0.9624	219	0.9456	269	0.9289	319	0.9125	369	0.8963	419	0.8803	469	0.8646
20	1.0141	70	0.9965	120	0.9792	170	0.9621	220	0.9452	270	0.9286	320	0.9	370	0.896	420	0.88	470	0.8643
21	1.0137	71	0.9962	121	0.9788	171	0.9618	221	0.9449	271	0.9283	321	0.9118	371	0.8957	421	0.8797	471	0.864
22	1.0133	72	0.9958	122	0.9785	172	0.9614	222	0.9446	272	0.9279	322	0.9115	372	0.8953	422	0.8794	472	0.8636
23	1.0131	73	0.9955	123	0.9782	173	0.9611	223	0.9442	273	0.9276	323	0.9112	373	0.895	423	0.8791	473	0.8633
24	1.0126	74	0.9951	124	0.9778	174	0.9607	224	0.9439	274	0.9273	324	0.9109	374	0.8947	424	0.8787	474	0.863
25	0.0435	75	0.9948	125	0.9775	175	0.9604	225	0.9436	275	0.9269	325	0.9105	375	0.8944	425	0.8784	475	0.8627
26	1.0119	76	0.9944	126	0.9771	176	0.9601	226	0.9432	276	0.9266	326	0.9102	376	0.8941	426	0.8781	476	0.8624
27	1.0116	77	0.9941	127	0.9768	177	0.9597	227	0.9429	277	0.9263	327	0.9099	377	0.8937	427	0.8778	477	0.8621

28	1.0112	78	0.9937	128	0.9764	178	0.9594	228	0.9426	278	0.9259	328	0.9096	378	0.8934	428	0.8775	478	0.8618
29	1.0109	79	0.9934	129	0.9761	179	0.959	229	0.9422	279	0.9256	329	0.9092	379	0.8931	429	0.8772	479	0.8615
30	1.0105	80	0.993	130	0.9758	180	0.9587	230	0.9419	280	0.9253	330	0.9089	380	0.8928	430	0.8768	480	0.8611
31	1.0102	81	0.9993	131	0.9754	181	0.9584	231	0.9416	281	0.925	331	0.9086	381	0.8924	431	0.8765	481	0.8608
32	1.0098	82	0.9923	132	0.9751	182	0.958	232	0.9412	282	0.9246	332	0.9083	382	0.8921	432	0.8762	482	0.8603
33	1.0095	83	0.992	133	0.9747	183	0.9577	233	0.9409	283	0.9243	333	0.9079	383	0.8918	433	0.8759	483	0.8602
34	1.0091	84	0.9916	134	0.9744	184	0.9574	234	0.9405	284	0.924	334	0.9076	384	0.8915	434	0.8756	484	0.8599
35	1.008	85	0.9913	135	0.974	185	0.957	235	0.9402	285	0.9236	335	0.9073	385	0.8912	435	0.8753	485	0.8596
36	1.0084	86	0.9909	136	0.9737	186	0.9567	236	0.9399	286	0.9233	336	0.907	386	0.8908	436	0.8749	486	0.8593
37	1.0081	87	0.9906	137	0.9734	187	0.9563	237	0.9395	287	0.923	337	0.9066	387	0.8905	437	0.8746	487	0.859
38	1.007	88	0.9902	138	0.973	188	0.956	238	0.9392	288	0.9277	338	0.9063	388	0.8902	438	0.8743	488	0.8587
39	1.0074	89	0.9899	139	0.9727	189	0.9557	239	0.9389	289	0.9223	339	0.906	389	0.8899	439	0.874	489	0.8583
40	1.007	90	0.9896	140	0.9723	190	0.9553	240	0.9385	290	0.922	340	0.9057	390	0.8896	440	0.8737	490	0.858
41	1.0067	91	0.9892	141	0.972	191	0.955	241	0.9382	291	0.9217	341	0.9053	391	0.8892	441	0.8734	491	0.8577
42	1.0063	92	0.9889	142	0.9716	192	0.9547	242	0.9379	292	0.9213	342	0.905	392	0.8889	442	0.8731	492	0.8574
43	1.006	93	0.9885	143	0.9713	193	0.9543	243	0.9375	293	0.921	343	0.9047	393	0.8886	443	0.8727	493	0.8571
44	1.0056	94	0.9882	144	0.971	194	0.954	244	0.9372	294	0.9207	344	0.9044	394	0.8883	444	0.8724	494	0.8568
45	1.0053	95	0.9878	145	0.9706	195	0.9536	245	0.9369	295	0.9204	345	0.904	395	0.888	445	0.8721	495	0.8565
46	1.0049	96	0.9875	146	0.9703	196	0.9533	246	0.9365	296	0.92	346	0.9037	396	0.8876	446	0.8718	496	0.8562
47	1.0046	97	0.9871	147	0.9699	197	0.953	247	0.9362	297	0.9197	347	0.9034	397	0.8873	447	0.8715	497	0.8559
48	1.0042	98	0.9868	148	0.9696	198	0.9526	248	0.9359	298	0.9194	348	0.9031	398	0.887	448	0.8712	498	0.8556
49	1.0038	99	0.9864	149	0.9693	199	0.9523	249	0.9356	299	0.919	349	0.9028	399	0.8867	449	0.8709	499	0.8552

TABLE XI
TEMPERATURE - VOLUME CORRECTIONS FOR ASPHALTIC MATERIALS
GROUP 1 - SPECIFIC GRAVITY AT 60° F FROM 0.850 TO 0.966

LEGEND

t = observed temperature in degrees Fahrenheit
M = multiplier for correcting oïl volumes to the basis of 60° F

t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M	t	M
0	1.0241	50	1.004	100	0.9842	150	0.9647	200	0.9456	250	0.9268	300	0.9083	350	0.8902	400	0.8724	450	0.855
1	1.0237	51	1.0036	101	0.9838	151	0.9643	201	0.9452	251	0.9264	301	0.908	351	0.8899	401	0.8721	451	0.8547
2	1.0233	52	1.0032	102	0.9834	152	0.9639	202	0.9448	252	0.926	302	0.9076	352	0.8895	402	0.8717	452	0.8543
3	1.0229	53	1.0028	103	0.983	153	0.9635	203	0.9444	253	0.9257	303	0.9072	353	0.8891	403	0.8714	453	0.854
4	1.0225	54	1.0024	104	0.9826	154	0.9632	204	0.9441	254	0.9253	304	0.9069	354	0.8888	404	0.871	454	0.8536
5	1.0221	55	1.002	105	0.9822	155	0.9628	205	0.9437	255	0.9249	305	0.9065	355	0.8884	405	0.8707	455	0.8533
6	1.0217	56	1.0016	106	0.9818	156	0.9624	206	0.9433	256	0.9245	306	0.9061	356	0.8881	406	0.8703	456	0.8529
7	1.0213	57	1.0012	107	0.9814	157	0.962	207	0.9429	257	0.9242	307	0.9058	357	0.8877	407	0.87	457	0.8526
8	1.0209	58	1.0008	108	0.981	158	0.9616	208	0.9425	258	0.9238	308	0.9054	358	0.8873	408	0.8696	458	0.8522
9	1.0205	59	1.0004	109	0.9806	159	0.9612	209	0.9422	259	0.9234	309	0.905	359	0.887	409	0.8693	459	0.8519
10	1.0201	60	1	110	0.9803	160	0.9609	210	0.9418	260	0.9231	310	0.9047	360	0.8866	410	0.8689	460	0.8516
11	1.0197	61	0.9996	111	0.9799	161	0.9605	211	0.9414	261	0.9227	311	0.9043	361	0.8863	411	0.8686	461	0.8512
12	1.0193	62	0.9992	112	0.9795	162	0.9601	212	0.941	262	0.9223	312	0.9039	362	0.8859	412	0.8682	462	0.8509
13	1.0189	63	0.9988	113	0.9791	163	0.9597	123	0.9407	263	0.9219	313	0.9036	363	0.8956	413	0.8679	463	0.8505
14	1.0185	64	0.9984	114	0.9787	164	0.9591	214	0.9403	264	0.9216	314	0.9032	364	0.8952	414	0.8675	464	0.8502
15	1.0181	65	0.998	115	0.9783	165	0.9589	215	0.9399	265	0.9212	315	0.9029	365	0.8848	415	0.8672	465	0.8498
16	1.0177	66	0.9976	116	0.9779	166	0.9585	216	0.9395	266	0.9208	316	0.9025	366	0.8845	416	0.8668	466	0.8495
17	1.0173	67	0.9972	117	0.9775	167	0.9582	217	0.9391	267	0.9205	317	0.9021	367	0.8841	417	0.8665	467	0.8492
18	1.0168	68	0.9968	118	0.9771	168	0.9578	218	0.9388	268	0.9201	318	0.9018	368	0.8838	418	0.8661	468	0.8488
19	1.0164	69	0.9964	119	0.9767	169	0.9574	219	0.9384	269	0.9197	319	0.9014	369	0.8834	419	0.8658	469	0.8485
20	1.016	70	0.996	120	0.9763	170	0.957	220	0.938	270	0.9194	320	0.901	370	0.8831	420	0.8654	470	0.8481
21	1.0156	71	0.9956	121	0.976	171	0.9566	221	0.9376	271	0.919	321	0.9007	371	0.8827	421	0.8651	471	0.8478
22	1.0152	72	0.9952	122	0.9756	172	0.9562	222	0.9373	272	0.9186	322	0.9003	372	0.8823	422	0.8647	472	0.8474
23	1.0148	73	0.9948	123	0.9752	173	0.9559	223	0.9369	273	0.9182	323	0.9	373	0.882	423	0.8644	473	0.8471
24	1.0144	74	0.9944	124	0.9748	174	0.9555	224	0.9365	274	0.9179	324	0.8996	374	0.8816	424	0.864	474	0.8468
25	0.014	75	0.994	125	0.9744	175	0.9551	225	0.9361	275	0.9175	325	0.8992	375	0.8813	425	0.8637	475	0.8464
26	1.0136	76	0.9936	126	0.974	176	0.9547	226	0.9358	276	0.9171	326	0.8989	376	0.8809	426	0.8633	476	0.8461
27	1.0132	77	0.9932	127	0.9736	177	0.9543	227	0.9354	277	0.9168	327	0.8985	377	0.8806	427	0.863	477	0.8457
28	1.0128	78	0.9929	128	0.9732	178	0.9539	228	0.935	278	0.9164	328	0.8981	378	0.8802	428	0.8626	478	0.8454
29	1.0124	79	0.9925	129	0.9728	179	0.9536	229	0.9346	279	0.916	329	0.8978	379	0.8799	429	0.8623	479	0.8451
30	1.012	80	0.9921	130	0.9725	180	0.9532	230	0.9343	280	0.9157	330	0.8974	380	0.8795	430	0.8619	480	0.8447

31	1.0116	81	0.9917	131	0.9721	181	0.9528	231	0.9339	281	0.9153	331	0.8971	381	0.8792	431	0.8616	481	0.8444
32	1.0112	82	0.9913	132	0.9717	182	0.9524	232	0.9335	282	0.9149	332	0.8967	382	0.8788	432	0.8612	482	0.844
33	1.0108	83	0.9909	133	0.9713	183	0.952	233	0.9331	283	0.9146	333	0.8963	383	0.8784	433	0.8609	483	0.8437
34	1.0104	84	0.9905	134	0.9707	184	0.9517	234	0.9328	284	0.9142	334	0.896	384	0.8781	434	0.8605	484	0.8433
35	1.01	85	0.9901	135	0.9705	185	0.9513	235	0.9324	285	0.9138	335	0.8956	385	0.8777	435	0.8602	485	0.843
36	1.0096	86	0.9897	136	0.9701	186	0.9509	236	0.932	286	0.9135	336	0.8952	386	0.8774	436	0.8599	486	0.8427
37	1.0092	87	0.9893	137	0.9697	187	0.9505	237	0.9316	287	0.9131	337	0.8949	387	0.877	437	0.8595	487	0.8423
38	1.0088	88	0.9889	138	0.9693	188	0.9501	238	0.9313	288	0.9127	338	0.8945	388	0.8767	438	0.8592	488	0.842
39	1.0084	89	0.9885	139	0.969	189	0.9498	239	0.9309	289	0.9124	339	0.8942	389	0.8763	439	0.8588	489	0.8416
40	1.008	90	0.9881	140	0.9686	190	0.9494	240	0.9305	290	0.912	340	0.8938	390	0.876	440	0.8585	490	0.8413
41	1.0076	91	0.9877	141	0.9682	191	0.949	241	0.9301	291	0.9116	341	0.8934	391	0.8756	441	0.8581	491	0.841
42	1.0072	92	0.9873	142	0.9678	192	0.9486	242	0.9298	292	0.9113	342	0.8931	392	0.8753	442	0.8578	492	0.8406
43	1.0068	93	0.9869	143	0.9674	193	0.9482	243	0.9294	293	0.9109	343	0.8927	393	0.8749	443	0.8574	493	0.8403
44	1.0064	94	0.9865	144	0.967	194	0.9478	244	0.929	294	0.9105	344	0.8924	394	0.8746	444	0.8571	494	0.8399
45	1.006	95	0.9861	145	0.9666	195	0.9475	245	0.9286	295	0.9102	345	0.892	395	0.8742	445	0.8567	495	0.8396
46	1.0056	96	0.9857	146	0.9662	196	0.9471	246	0.9283	296	0.9098	346	0.8916	396	0.8738	446	0.8564	496	0.8393
47	1.0052	97	0.9854	147	0.9659	197	0.9467	247	0.9279	297	0.9094	347	0.8913	397	0.8735	447	0.856	497	0.8389
48	1.0048	98	0.985	148	0.9655	198	0.9463	248	0.9275	298	0.9091	348	0.8909	398	0.8731	448	0.8557	498	0.8386
49	1.0044	99	0.9846	149	0.9651	199	0.946	249	0.9272	299	0.9087	349	0.8906	399	0.8728	449	0.8554	499	0.8383

TABLE XII

TEMPERATURE-VOLUME CORRECTIONS FOR EMULSIFIED ASPHALTS

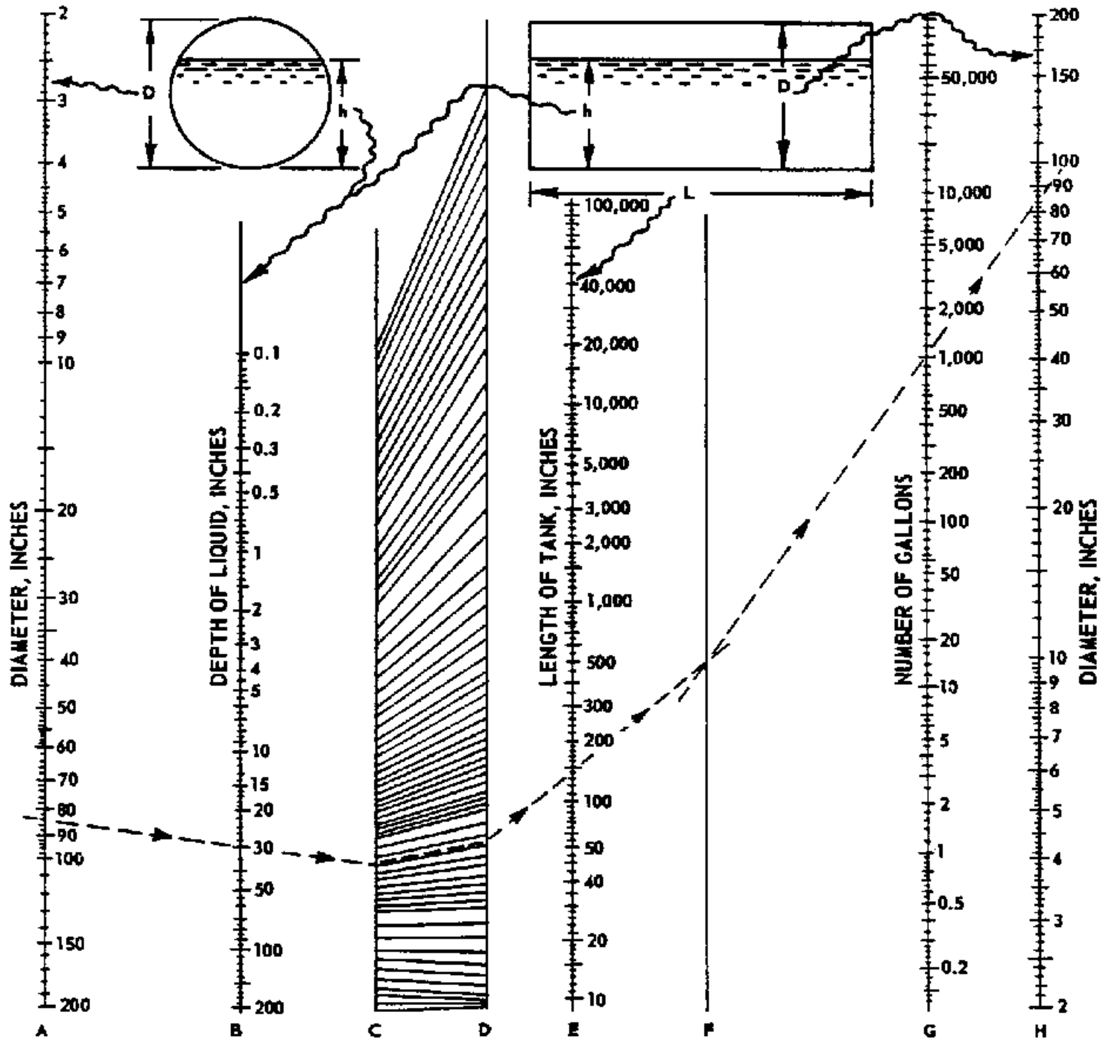
LEGEND:

t = observed temperature in degrees Fahrenheit
M = multiplier for correcting volumes to the basis of 60 degrees Fahrenheit

t	M	t	M	t	M
50	1.0025	95	0.99125	140	0.98
51	1.00225	96	0.991	141	0.97975
52	1.002	97	0.99075	142	0.9795
53	1.00175	98	0.9905	143	0.97925
54	1.0015	99	0.99025	144	0.979
55	1.00125	100	0.99	145	0.97875
56	1.001	101	0.98975	146	0.9785
57	1.00075	102	0.9895	147	0.97825
58	1.0005	103	0.98925	148	0.978
59	1.00025	104	0.989	149	0.97775
60	1	105	0.98875	150	0.9775
61	0.99975	106	0.9885	151	0.97725
62	0.9995	107	0.98825	152	0.977
63	0.99925	108	0.988	153	0.97675
64	0.999	109	0.98775	154	0.9765
65	0.99875	110	0.9875	155	0.97625
66	0.9985	111	0.98725	156	0.976
67	0.99825	112	0.987	157	0.97575
68	0.998	113	0.98675	158	0.9755
69	0.99775	114	0.9865	159	0.97525
70	0.9975	115	0.98625	160	0.975
71	0.99725	116	0.986	161	0.97475
72	0.997	117	0.98575	162	0.9745
73	0.99675	118	0.9855	163	0.97425
74	0.9965	119	0.98525	164	0.974
75	0.99625	120	0.985	165	0.97375
76	0.996	121	0.98475	166	0.9735
77	0.99575	122	0.9845	167	0.97325
78	0.9955	123	0.98425	168	0.973

79	0.99525	124	0.984	169	0.97275
80	0.995	125	0.98375	170	0.9725
81	0.99475	126	0.9835	171	0.97225
82	0.9945	127	0.98325	172	0.972
83	0.99425	128	0.983	173	0.97175
84	0.994	129	0.98275	174	0.9715
85	0.99375	130	0.9825	175	0.97125
86	0.9935	131	0.98225	176	0.971
87	0.99325	132	0.982	177	0.97075
88	0.993	133	0.98175	178	0.9705
89	0.99275	134	0.9815	179	0.97025
90	0.9925	135	0.98125	180	0.97
91	0.99225	136	0.981	181	0.96975
92	0.992	137	0.98075	182	0.9695
93	0.99175	138	0.9805	183	0.96925
94	0.9915	139	0.98025	184	0.969
				185	0.96875

1311 CAPACITY CHART FOR CYLINDRICAL TANKS



Example: How many gallons are in a tank 84 in. in diameter, the depth of the liquid being 30 in. and the length of the tank being 142 in.?

Run a straight line through the 84, column A, and the 30 in column B and locate the intersection with column C. By eye follow the radiating guide lines to column D, locating a second point of intersection. From this last intersection run through the 142, column E, and locate the point of intersection in column F. Then from this point run over to the 84, column H, and the intersection in column G will be found to be close to 1,050 gallons.

1312 TEMPERATURE CONVERSIONS

0C.		0F.
-78.9	-110	-166.0
-73.3	-100	-148.0
-67.8	-90	-130.0
-62.2	-80	-112.0
-56.7	-70	-94.0
-51.1	-60	-76.0
-45.6	-50	-58.0
-40.0	-40	-40.0
-34.4	-30	-22.0
-28.9	-20	-4.0
-28.3	-19	-2.2
-27.8	-18	-0.4
-27.2	-17	1.4
-26.7	-16	3.2
-26.1	-15	5.0
-25.6	-14	6.8
-25.0	-13	8.6
-24.4	-12	10.4
-23.9	-11	12.2
-23.3	-10	14.0
-22.8	-9	15.8
-22.2	-8	17.6
-21.7	-7	19.4
-21.1	-6	21.2
-20.6	-5	23.0
-20.0	-4	24.8
-19.4	-3	26.6
-18.9	-2	28.4
-18.3	-1	30.2
-17.8	0	32.0

0C.		0F.
-0.6	31	87.8
0.0	32	89.6
0.6	33	91.4
1.1	34	93.2
1.7	35	95.0
2.2	36	96.8
2.8	37	98.6
3.3	38	100.4
3.9	39	102.2
4.4	40	104.0
5.0	41	105.8
5.6	42	107.6
6.1	43	109.4
6.7	44	111.2
7.2	45	113.0
7.8	46	114.8
8.3	47	116.6
8.9	48	118.4
9.4	49	120.2
10.0	50	122.0
10.6	51	123.8
11.1	52	125.6
11.7	53	127.4
12.2	54	129.2
12.8	55	131.0
13.3	56	132.8
13.9	57	134.6
14.4	58	136.4
15.0	59	138.2
15.6	60	140.0

0C.		0F.
32.8	91	195.8
33.3	92	197.6
33.9	93	199.4
34.4	94	201.2
35.0	95	203.0
35.6	96	204.8
36.1	97	206.6
36.7	98	208.4
37.2	99	210.2
37.8	100	212.0
38.3	101	213.8
38.9	102	215.6
39.4	103	217.4
40.0	104	219.2
40.6	105	221.0
41.1	106	222.8
41.7	107	224.6
42.2	108	226.4
42.8	109	228.2
43.3	110	230.0
43.9	111	231.8
44.4	112	233.6
45.0	113	235.4
45.6	114	237.2
46.1	115	239.0
46.7	116	240.8
47.2	117	242.6
47.8	118	244.4
48.3	119	246.2
48.9	120	248.0

0C.		0F.
66.1	151	303.8
66.7	152	305.6
67.2	153	307.4
67.8	154	309.2
68.3	155	311.0
68.9	156	312.8
69.4	157	314.6
70.0	158	316.4
70.6	159	318.2
71.1	160	320.0
71.7	161	321.8
72.2	162	323.6
72.8	163	325.4
73.3	164	327.2
73.9	165	329.0
74.4	166	330.8
75.0	167	332.6
75.6	168	334.4
76.1	169	336.2
76.7	170	338.0
77.2	171	339.8
77.8	172	341.6
78.3	173	343.4
78.9	174	345.2
79.4	175	347.0
80.0	176	348.8
80.6	177	350.6
81.1	178	352.4
81.7	179	354.2
82.2	180	356.0

0C.		0F.
99.4	211	411.8
100.0	212	413.6
100.6	213	415.4
101.1	214	417.2
101.7	215	419.0
102.2	216	420.8
102.8	217	422.6
103.3	218	424.4
103.9	219	426.2
104.4	220	428.0
105.0	221	429.8
105.6	222	431.6
106.1	223	433.4
106.7	224	435.2
107.2	225	437.0
107.8	226	438.8
108.3	227	440.6
108.9	228	442.4
109.4	229	444.2
110.0	230	446.0
110.6	231	447.8
111.1	232	449.6
111.7	233	451.4
112.2	234	453.2
112.8	235	455.0
113.3	236	456.8
113.9	237	458.6
114.4	238	460.4
115.0	239	462.2
115.6	240	464.0

0C.		0F.
132.8	271	519.8
133.3	272	521.6
133.9	273	523.4
134.4	274	525.2
135.0	275	527.0
135.6	276	528.8
136.1	277	530.6
136.7	278	532.4
137.2	279	534.2
137.8	280	536.0
138.3	281	537.8
138.9	282	539.6
139.4	283	541.4
140.0	284	543.2
140.6	285	545.0
141.1	286	546.8
141.7	287	548.6
142.2	288	550.4
142.8	289	552.2
143.3	290	554.0
143.9	291	555.8
144.4	292	557.6
145.0	293	559.4
145.6	294	561.2
146.1	295	563.0
146.7	296	564.8
147.2	297	566.6
147.8	298	568.4
148.3	299	570.2
148.9	300	572.0

-17.2	1	33.8	16.1	61	141.8	49.4	121	249.8	82.8	181	357.8	116.1	241	465.8	151.7	305	581.0
-16.7	2	35.6	16.7	62	143.6	50.0	122	251.6	83.3	182	359.6	116.7	242	467.6	154.4	310	590.0
-16.1	3	37.4	17.2	63	145.4	50.6	123	253.4	83.9	183	361.4	117.2	243	469.4	157.2	315	599.0
-15.6	4	39.2	17.8	64	147.2	51.1	124	255.2	84.4	184	363.2	117.8	244	471.2	160.0	320	608.0
-15.0	5	41.0	18.3	65	149.0	51.7	125	257.0	85.0	185	365.0	118.3	245	473.0	162.8	325	617.0
-14.4	6	42.8	18.9	66	150.8	52.2	126	258.8	85.6	186	366.8	118.9	246	474.8	165.6	330	626.0
-13.9	7	44.6	19.4	67	152.6	52.8	127	260.6	86.1	187	368.6	119.4	247	476.6	168.3	335	635.0
-13.3	8	46.4	20.0	68	154.4	53.3	128	262.4	86.7	188	370.4	120.0	248	478.4	171.1	340	644.0
-12.8	9	48.2	20.6	69	156.2	53.9	129	264.2	87.2	189	372.2	120.6	249	480.2	173.9	345	653.0
-12.2	10	50.0	21.1	70	158.0	54.4	130	266.0	87.8	190	374.0	121.1	250	482.0	176.7	350	662.0
-11.7	11	51.8	21.7	71	159.8	55.0	131	267.8	88.3	191	375.8	121.7	251	483.8	179.4	355	671.0
-11.1	12	53.6	22.2	72	161.6	55.6	132	269.6	88.9	192	377.6	122.2	252	485.6	182.2	360	680.0
-10.6	13	55.4	22.8	73	163.4	56.1	133	271.4	89.4	193	379.4	122.8	253	487.4	185.0	365	689.0
-10.0	14	57.2	23.3	74	165.2	56.7	134	273.2	90.0	194	381.2	123.3	254	489.2	187.8	370	698.0
-9.4	15	59.0	23.9	75	167.0	57.2	135	275.0	90.6	195	383.0	123.9	255	491.0	190.6	375	707.0
-8.9	16	60.8	24.4	76	168.8	57.8	136	276.8	91.1	196	384.8	124.4	256	492.8	193.3	380	716.0
-8.3	17	62.6	25.0	77	170.6	58.3	137	278.6	91.7	197	386.6	125.0	257	494.6	196.1	385	725.0
-7.8	18	64.4	25.6	78	172.4	58.9	138	280.4	92.2	198	388.4	125.6	258	496.4	198.9	390	734.0
-7.2	19	66.2	26.1	79	174.2	59.4	139	282.2	92.8	199	390.2	126.1	259	498.2	201.7	395	743.0
-6.7	20	68.0	26.7	80	176.0	60.0	140	284.0	93.3	200	392.0	126.7	260	500.0	204.4	400	752.0
-6.1	21	69.8	27.2	81	177.8	60.6	141	285.8	93.9	201	393.8	127.2	261	501.8	207.2	405	761.0
-5.6	22	71.6	27.8	82	179.6	61.1	142	287.6	94.4	202	395.6	127.8	262	503.6	210.0	410	770.0
-5.0	23	73.4	28.3	83	181.4	61.7	143	289.4	95.0	203	397.4	128.3	263	505.4	212.8	415	779.0
-4.4	24	75.2	28.9	84	183.2	62.2	144	291.2	95.6	204	399.2	128.9	264	507.2	215.6	420	788.0
-3.9	25	77.0	29.4	85	185.0	62.8	145	293.0	96.1	205	401.0	129.4	265	509.0	218.3	425	797.0
-3.3	26	78.8	30.0	86	186.8	63.3	146	294.8	96.7	206	402.8	130.0	266	510.8	221.1	430	806.0
-2.8	27	80.6	30.6	87	188.6	63.9	147	296.6	97.2	207	404.6	130.6	267	512.6	223.9	435	815.0
-2.2	28	82.4	31.1	88	190.4	64.4	148	298.4	97.8	208	406.4	131.1	268	514.4	226.7	440	824.0
-1.7	29	84.2	31.7	89	192.2	65.0	149	300.2	98.3	209	408.2	131.7	269	516.2	229.4	445	833.0
-1.1	30	86.0	32.2	90	194.0	65.6	150	302.0	98.9	210	410.0	132.2	270	518.0	232.2	450	842.0

Note: The numbers in white face type refer to the temperature, either in degrees Centigrade or Fahrenheit, which it is desired to convert. If converting from ^{0}F. to ^{0}C., the equivalent temperature will be found in the left column. If converting from ^{0}C. to ^{0}F., the answer will be found in the right column: ^{0}F. = (1.8 ^{0}C.) + 32 and ^{0}C. = (^{0}F. - 32) / 1.8.

1313 MISCELLANEOUS INFORMATION

Freezing point of water = 32^o F. = 0^o C.

Boiling point of water at atmospheric pressure = 212^o F. = 100^o C.

Absolute zero = -459.7^o F. = -273.2^o C.

^{o}C. = 5/9(^{o}F. - 32^o)

^{o}F. = (9/5 ^{o}C.) + 32^o

1 hp = 550 ft. lbs./sec. = 33,000 ft. lbs./min.

1 hp = 2544 BTUs/hr.

1 hp = 745.5 watts.

1 BTU = 778.26 ft. lbs.

1 cu. ft. of water at 39.2^o F. and atmospheric pressure = 62.428 lbs.

1 cu. ft. of water at 60^o F. and atmospheric pressure = 62.30 lbs.

1 cu. ft. of water at 212^o F. and atmospheric pressure = 59.83 lbs.

Approximate heat capacity of superheated steam at atmospheric pressure = 0.47 BTU/lb/^{o}F.

Total heat of saturated steam at atmospheric pressure = 1150.4 BTU's.

π = 3.1416 = ratio of circumference of circle to diameter. (C/d)

= ratio of area of circle to square of radius. (A/r^2)

Circumference of circle = diameter x π. ($C = \pi d$)

Diameter of circle = circumference x 0.31831. ($d = 0.31831 C = C / \pi$)

Area of circle = square of diameter x 0.7854. ($A = 0.7854d^2 = \pi / 4 (d^2) = \pi (r^2)$).

Double diameter of the circle increases its area four times. ($4 A = 0.7854 (2d)^2$)

Area of rectangle = length x width. (A = l w)

Area of triangle = base x 1/2 perpendicular height. (A = (1/2) b h)

Volume of cone = area of base x 1/3 perpendicular height. (V = (1/3) b h)

Doubling the diameter of a pipe increases its capacity four times.

A gallon of water (U.S. standard) weighs 8.33 pounds and contains 231 cubic inches.

A cubic foot of water contains 7.5 gallons or 1728 cubic inches, and weighs 62.5 pounds.

To find the approximate pressure in pounds per square inch of a column of water, multiply the height of the column in feet by 0.434.

Steam rising from water as its boiling point (212° F.) has a pressure equal to the atmosphere (14.7 lbs. per square inch).

Approximate heat capacity of superheated steam at atmospheric pressure equals 0.47 BTU's per lb. per ° F.

Total heat of saturated steam at atmospheric pressure equals 1150.4 BTUs.

To find the capacity in U.S. gallons of cylindrical tanks knowing the dimensions in inches, square the diameter, multiply by the length, and multiply by 0.0034.

CONVERSION TABLE:

MULTIPLY	BY	TO OBTAIN
Acres	43,560	Square Feet
Barrels of cement	376	Pounds of cement
Bags of cement	94	Pounds of cement
Cubic feet	7.48052	U.S. Gallons
Cubic feet	1.728	Cubic inches
Cubic feet	0.03704	Cubic yards
Cubic inches	0.0005787	Cubic feet
Cubic inches	0.004329	U.S. Gallons
Cubic yards	27	Cubic feet
Cubic yards	46.656	Cubic inches
Cubic yards	202.0	U.S. Gallons
Fathoms	6	Feet
Feet	0.3048	Meters
Meters	3.281	Feet
Meters	39.37	Inches
Meters	1.094	Yards
Miles	5,280	Feet
Pounds of water	0.01602	Cubic feet
Pounds of water	27.68	Cubic inches
Pounds of water	0.1198	U.S. Gallons
Square feet	144	Square inches
Square miles	640	Acres
Square yards	9	Square feet
Square yards	0.0002066	Acres
Tons (short)	2,000	Pounds
Tons (long)	2,240	Pound

1314 MEASUREMENT OF GRADES

Under the commonly accepted system of measuring gradients, grade is defined as the change in elevation divided by the horizontal distance traveled, and is expressed as a percentage.

A grade of 100 percent corresponds to an angle of 45 degrees. A 1 in 3 grade is the same as 33 1/3 percent grade, and a 1 in 2 grade the same as a 50 percent grade.

Table of Gradients

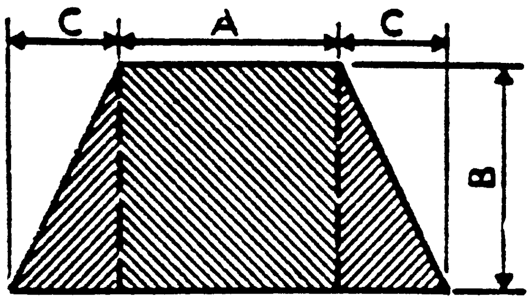
SLOPE	PERCENT GRADE	CORRES- PONDING ANGLE (degrees)	RISE or FALL IN ONE MILE (feet)	RISE or FALL IN ONE KILOMETER (meters)
1 in 1	100.00	45.00	5280	1000.0
1 in 2	50.00	26.57	2640	500.0
1 in 3	33.33	18.43	1760	333.3
1 in 4	25.00	14.03	1320	250.0
1 in 5	20.00	11.32	1056	200.0
1 in 6	16.67	9.47	880	166.7
1 in 7	14.29	8.13	754	142.9
1 in 8	12.50	7.12	660	125.0
1 in 9	11.11	6.33	587	111.1
1 in 10	10.00	5.72	528	100.0
1 in 11	9.09	5.20	480	90.9
1 in 12	8.33	4.77	440	83.3
1 in 13	7.69	4.40	406	76.9
1 in 14	7.14	4.08	377	71.4
1 in 15	6.67	3.82	352	66.7
1 in 16	6.25	3.58	330	62.5
1 in 17	5.88	3.37	311	58.8
1 in 18	5.56	3.18	293	55.6
1 in 19	5.26	3.02	278	52.6
1 in 20	5.00	2.87	264	50.0
1 in 25	4.00	2.28	211	40.0
1 in 30	3.33	1.90	176	33.3
1 in 35	2.86	1.63	151	28.6
1 in 40	2.50	1.43	132	25.0

1315 WEIGHTS OF MATERIALS

MATERIAL	Approximate Kilograms per Cubic Meter	Approximate pounds per Cubic Foot	
Aluminum	2659.1	166	
Ashes	688.8	43	
Asphalt	1297.5	81	
Brass	8393.7	524	
Brick (Common)	1922.2	120	(About 3 tons per thousand)
Brick (Fire)	2322.7	145	
Bronze	8553.9	534	
Cement	1505.7	94	(= one sack)
Concrete	2402.8	150	(4050 lbs. per cubic yard)
Copper	8601.9	537	
Crushed Rock	1521.8	95	(2565 lbs. per cubic yard)
Dry Earth Loose	1217.4	76	(2052 lbs. per cubic yard)
Granite	2867.3	179	
Lead	11341.1	708	
Lumber -- Fir,Spruce	512.6	32	(2666 lbs. per thousand feet)
Lumber -- Oak	993.1	62	(5166 lbs. per thousand feet)
Mortar	1601.8	100	
Portland Cement	1505.7	94	(376 lbs. per barrel)
River Sand	1922.2	120	(3240 lbs. per cubic yard)
Steel	7849.0	490	
Water	1001.2	62.5	
Zinc	7000.1	437	

1316 WINDROW CONTENTS

To calculate the quantity of aggregate in cubic feet,
lineal foot of windrow:
Take measurements "A", "B", and "C".” Then,
("A" x "B" x 1 ft.) + ("C" x "B" x 1 ft) = cubic feet
windrowed aggregate per lineal foot.



Example:
"A" = 2' - 0", "B" = 2' - 0", and "C" = 1' - 0"
Then, (2' - 0" x 2' - 0" x 1') + (1' - 0" x 2' - 0" x 1')
= 4.0 ft.^{3} + 2.0 ft.^{3} = 6.0 cubic feet of
windrowed aggregate per lineal foot.

* Note: If measurement "C" is not the same on b
sides of windrow, use the average measurement.

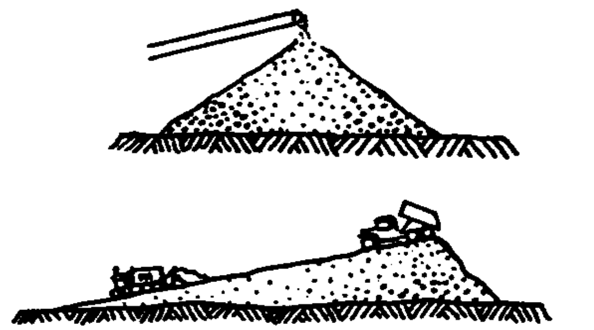
EQUIVALENT WEIGHTS OF AGGREGATES

Pounds per Cubic Foot	Pounds per Cubic Yard	Tons per Cubic Yard	Cubic Yards per Ton	Kilograms per Cubic Meter
60	1620	0.81	1.23	961
65	1755	0.88	1.14	1041
70	1890	0.95	1.06	1121
75	2025	1.01	0.99	1201
80	2160	1.08	0.93	1281
85	2295	1.15	0.87	1362
90	2430	1.22	0.82	1442
95	2565	1.28	0.78	1522
100	2700	1.35	0.74	1602
105	2835	1.42	0.71	1682
110	2970	1.49	0.67	1762
115	3105	1.55	0.64	1842
120	3240	1.62	0.62	1922
125	3375	1.69	0.59	2002
130	3510	1.76	0.57	2082
135	3645	1.82	0.55	2162
140	3780	1.89	0.53	2243

EQUIVALENT WEIGHTS OF AGGREGATE

Pounds per Cubic Yard	Pounds Per Cubic Foot	Tons per Cubic Yard	Cubic Yards per Ton	Kilograms per Cubic Meter
1800	66.7	0.90	1.11	1068
1850	68.5	0.93	1.08	1098
1900	70.4	0.95	1.05	1127
1950	72.2	0.97	1.03	1157
2000	74.1	1.00	1.00	1187
2050	75.9	1.03	0.98	1216
2100	77.8	1.05	0.95	1246
2150	79.6	1.08	0.93	1276
2200	81.5	1.10	0.91	1305
2250	83.3	1.13	0.89	1335
2300	85.2	1.15	0.87	1365
2350	87.0	1.18	0.85	1394
2400	88.9	1.20	0.83	1424
2450	90.7	1.23	0.82	1454
2500	92.6	1.25	0.80	1483
2550	94.4	1.28	0.78	1513
2600	96.3	1.30	0.77	1543
2650	98.1	1.33	0.75	1572
2700	100.0	1.35	0.74	1602
2750	101.9	1.38	0.73	1632
2800	103.7	1.40	0.71	1661
2850	105.6	1.43	0.70	1691
2900	107.4	1.45	0.69	1721
2950	109.3	1.48	0.68	1750
3000	111.1	1.50	0.67	1780
3050	113.0	1.53	0.66	1809
3100	114.8	1.55	0.65	1839
3150	116.7	1.58	0.63	1869
3200	118.5	1.60	0.63	1898
3250	120.4	1.63	0.62	1928
3300	122.2	1.65	0.61	1958
3350	124.1	1.68	0.60	1987
3400	125.9	1.70	0.59	2017
3450	127.8	1.73	0.58	2047
3500	129.6	1.75	0.57	2076
3550	131.5	1.78	0.56	2106
3600	133.3	1.80	0.56	2136
3650	135.2	1.83	0.55	2165
3700	137.0	1.85	0.54	2195
3750	138.9	1.88	0.53	2225
3800	140.7	1.90	0.52	2254

1317 STOCKPILING AGGREGATE



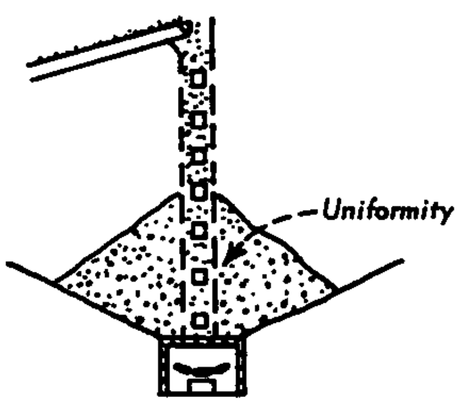
CORRECT

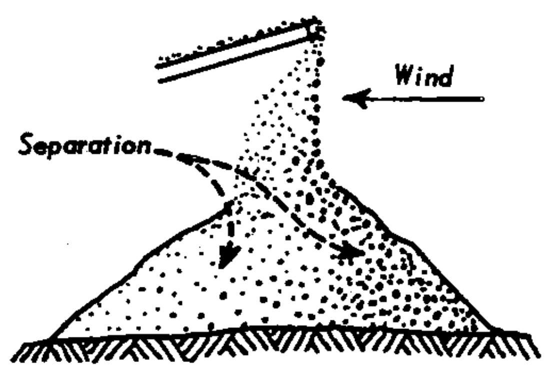
Methods which place material in the pile in individual units not larger than a truck load and which do not permit the aggregate to run down the slopes at the edge of the pile.

INCORRECT

Methods which permit the aggregate to roll down the slope as it is added to the pile. The use of bulldozers is also incorrect.

UNFINISHED AGGREGATE STORAGE





CORRECT

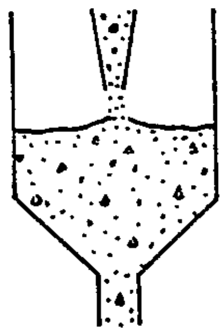
Chimney surrounding material falling from end of conveyor belt to prevent wind from separating fine and coarse material. Openings provided as required to discharge material at various elevations of the pile.

INCORRECT

Free fall of material from high end of conveyor belt permitting wind to separate fine from coarse material.

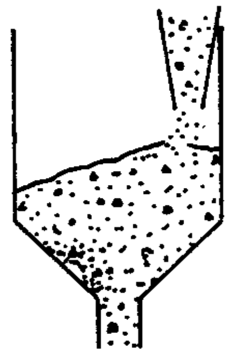
1318 LOADING HOPPERS

LOADING HOPPERS



CORRECT

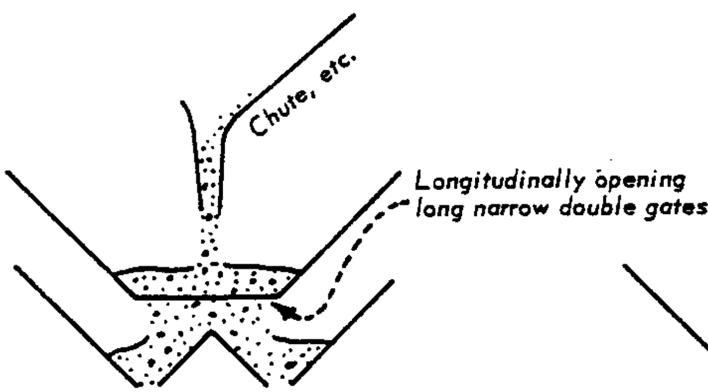
Dropping of concrete directly over gate opening.



INCORRECT

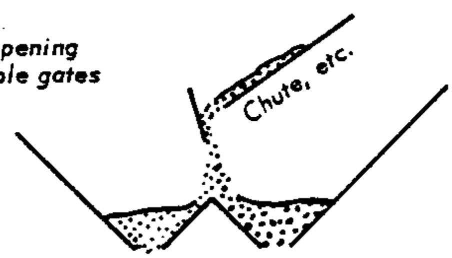
Dropping of concrete on the sloping side of the hopper.

DIVIDED HOPPERS



CORRECT

The above arrangement shows the only acceptable method if a divided hopper must be used. (Single discharge hoppers are to be used whenever possible.)

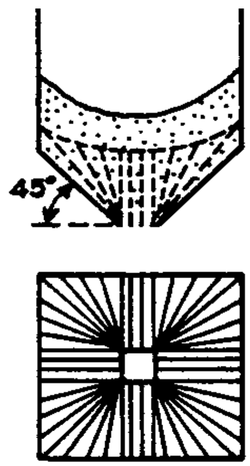


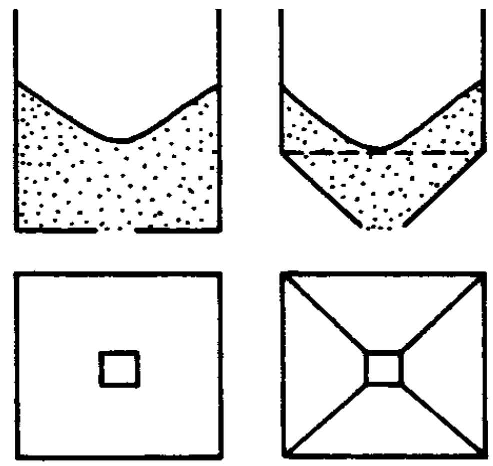
INCORRECT

Filling of divided hopper by flow of concrete. Separation and lack of uniformity in concrete delivered from either gate is inevitable.

1319 FILLING AGGREGATE BINS

SHAPE OF AGGREGATE BIN BOTTOMS





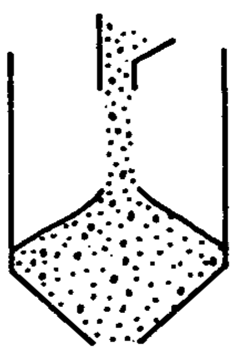
CORRECT

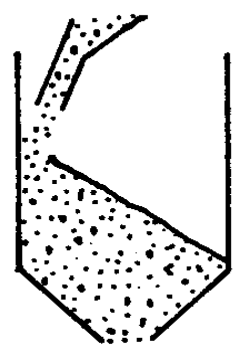
Bottom to slope up from outlet in all directions at not less than 450 from the horizontal. Corners to be filled and rounded to maintain required slope at all points.

INCORRECT

Flat bottom bins or those with any arrangement of slopes having corners or areas such that all material in the bin will not flow quickly through the outlet without shoveling.

AGGREGATE BIN FILLING





CORRECT

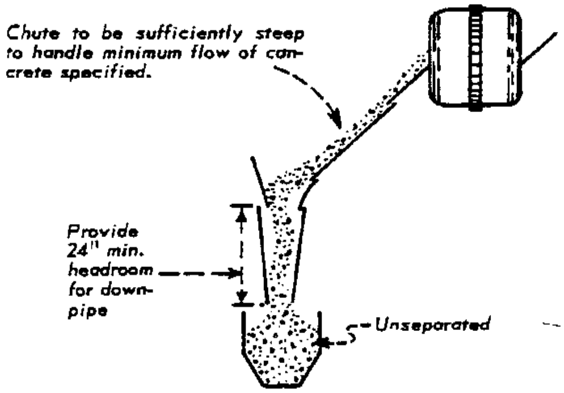
Dropping of material vertically and over discharge.

INCORRECT

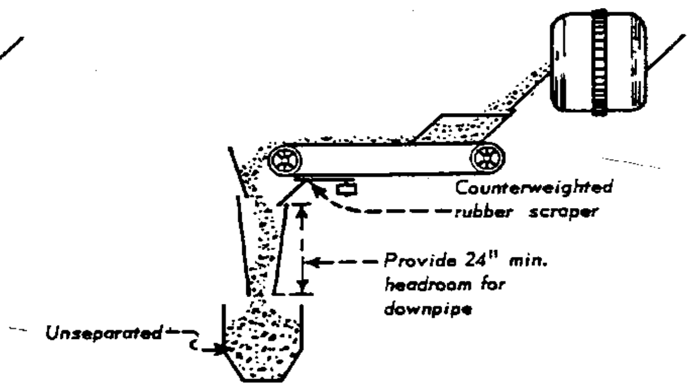
Chuting material into bin on an angle so material falls other than directly over discharge.

1320 DISCHARGING CONCRETE

CONTROL OF SEPARATION
AS CONCRETE IS DISCHARGED FROM MIXERS

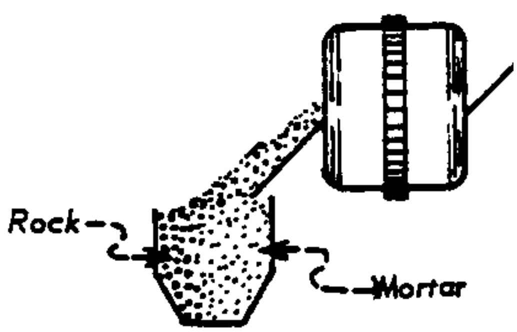


CORRECT



CORRECT

When discharging concrete into buckets, cars or hoppers, regardless of length of chute or conveyor, either of these arrangements are acceptable for preventing separation.

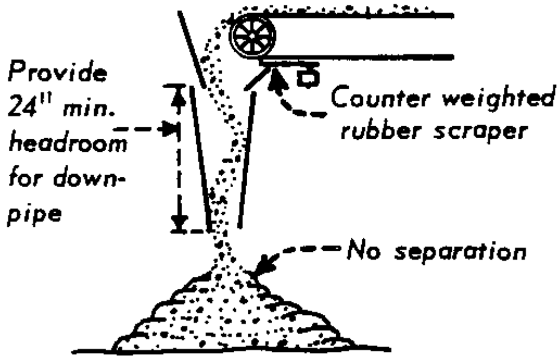


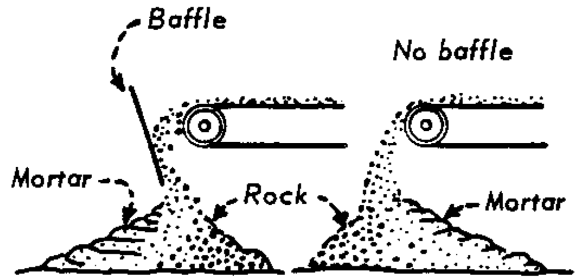
INCORRECT

When discharging concrete directly from any type of mixer into buckets, cars or hoppers.

1321 STOCKPILING FROM CONVEYOR BELTS

CONTROL OF SEPARATION OF CONCRETE
AT THE END OF CONVEYOR BELTS





CORRECT

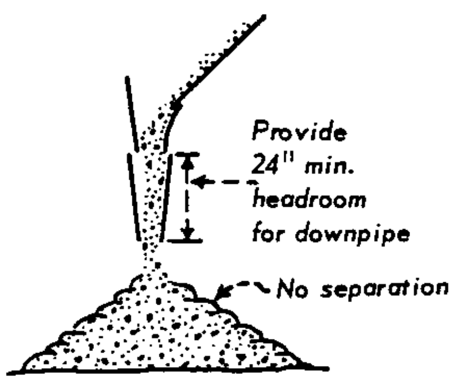
The above arrangement for prevention of separation whether discharging concrete into hoppers, buckets, cars, forms or etc.

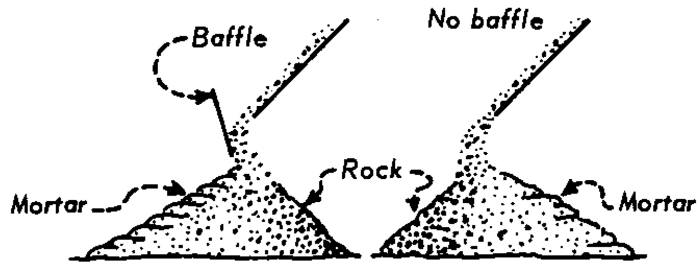
INCORRECT

Improper or complete lack of control at the end of the belt. Baffles or shallow hoppers usually merely change the direction of separation.

CONTROL OF SEPARATION
AT THE END OF CONCRETE CHUTES

This applies to sloping discharges from mixers, transit mixers, etc., as well as to longer chutes but does not apply when concrete is discharged into another chute or on to a conveyor belt.





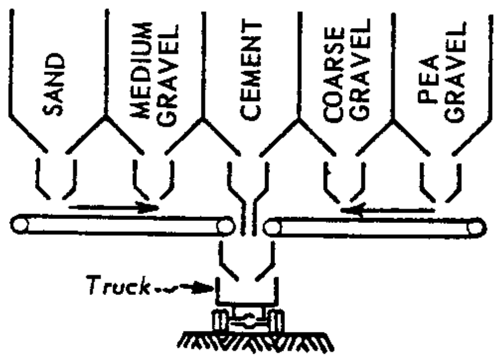
CORRECT

The above arrangement for preventing separation regardless of length of chute, whether discharging concrete into hoppers, bucket cars, forms or etc.

INCORRECT

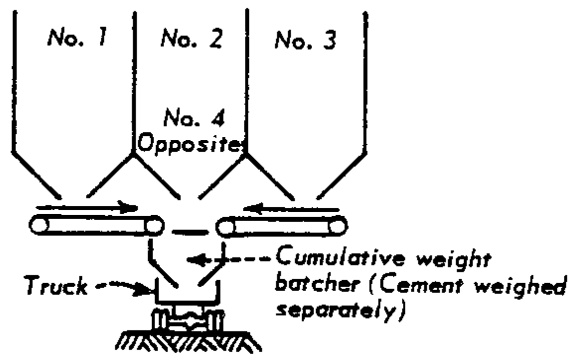
Improper or lack of control at the end of any concrete chute regardless of length. Baffles usually merely change the direction of separation.

1322 BATCHING EQUIPMENT



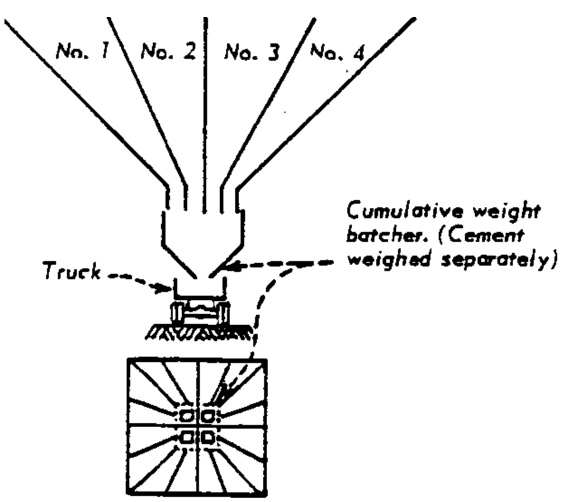
CORRECT

Individual automatic weighing of ingredients assembled into truck or mixer loading hopper by conveyor belts. Discharge of cement batches to be controlled so that cement is flowing full time aggregate is being delivered by conveyor belts.



CORRECT

Cumulative automatic weighing of aggregates using conveyor belts automatically started and stopped by the weighing equipment and having no gates to stick. Access for representative sampling is afforded.

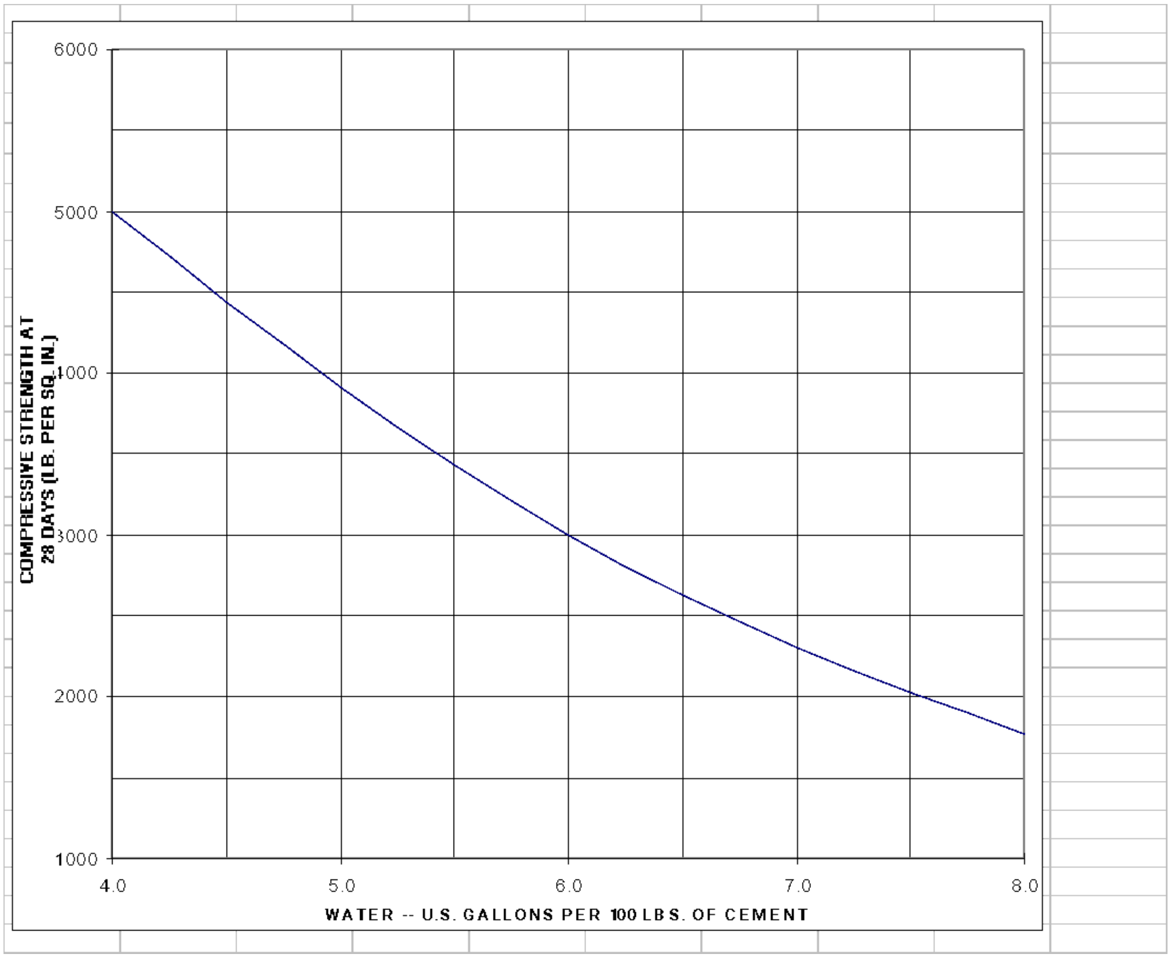


INCORRECT

Close groupings of bin discharges which cause long slopes of material in bins with resulting separation as material is lowered.

1323 WATER CEMENT RATIO AND PROBABLE STRENGTH

For workable mixes using clean sound aggregates, the strength and other desirable features of concrete are governed by the net quantity of mixing water used per unit of cement. The effect of the water-cement ratio is seen in the curve below.



1324 APPROXIMATE CYLINDER STRENGTH

Strength of Concrete Cylinders -- Specification requirements are normally based upon the strength of the concrete at 28 days but it is usually advisable, especially at the start of a project, to submit cylinders for 7 and 14 day tests so that the 28 day strength may be forecast, and to see that the concrete shows normal progressive hardening. For concrete without fly ash, the following formula will give a close approximation of the 28 day strength which may be expected from a known 7 day strength.

$$\text{English: } S_{28} = S_7 + (30\sqrt{S_7})$$
$$\text{Metric: } S_{28} = S_7 + (78.8\sqrt{S_7})$$

In which S_{28} = approximate 28 day strength and S_7 = known 7 day strength.

For approximating strengths at other ages from known strengths at various ages the following table may be used.

Probable Compressive Strength For Concrete Without Fly Ash

AGE	psi	kPa	psi	kPa	Psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa
100	1550	10690	2250	15510	2900	19990	3490	24060	4150	28610	4720	32540	5400	37230	5970	41160	6560	45230
90	1500	10340	2180	15030	2830	19510	3440	23720	4050	27920	4620	31850	5240	36130	5840	40270	6430	44330
80	1460	10070	2110	14550	2740	18890	3350	23100	3950	27230	4510	31100	5150	35510	5710	39370	6290	43370
70	1390	9580	2030	14000	2640	18200	3250	22410	3830	26410	4380	30200	5000	34470	5550	38270	6110	42130
60	1330	9170	1940	13380	2540	17510	3120	21510	3690	25440	4220	29100	4840	33370	5370	37020	5930	40890
55	1290	8890	1890	13030	2470	17030	3050	21030	3610	24890	4140	28540	4750	32750	5270	36340	5820	40130
50	1250	8620	1840	12690	2410	16620	2970	20480	3520	24270	4050	27920	4640	31990	5170	35650	5700	39300
45	1200	8270	1780	12270	2330	16060	2890	19930	3420	23580	3950	27230	4520	31160	5040	34750	5570	38400
40	1150	7930	1700	11720	2250	15510	2790	19240	3310	22820	3830	26410	4400	30340	4910	33850	5430	37440
38	1130	7790	1670	11510	2220	15310	2760	19030	3280	22610	3790	26130	4350	29990	4860	33510	5380	37090
36	1110	7650	1640	11310	2190	15100	2720	18750	3230	22270	3740	25790	4300	29650	4800	33090	5310	36610
34	1080	7450	1610	11100	2140	14750	2670	18410	3180	21930	3680	25370	4220	29100	4720	32540	5240	36130
32	1050	7240	1580	10890	2100	14480	2620	18060	3120	21510	3620	24960	4160	28680	4650	32060	5170	35650
30	1030	7100	1540	10620	2050	14130	2560	17650	3060	21100	3560	24550	4090	28200	4570	31510	5090	35090
28	1000	6900	1500	10310	2000	13840	2500	17190	3000	20730	3500	24150	4000	27590	4500	31050	5000	34460
26	960	6620	1450	10000	1950	13440	2450	16890	2930	20200	3410	23510	3930	27100	4400	30340	4900	33780
24	920	6340	1400	9650	1890	13030	2380	16410	2850	19650	3340	23030	3840	26480	4300	29650	4800	33090
22	890	6140	1350	9310	1830	12620	2310	15930	2780	19170	3250	22410	3750	25860	4200	28960	4700	32410
20	850	5860	1300	8960	1770	12200	2240	15440	2700	18620	3160	21790	3640	25100	4100	28270	4590	31650
19	830	5720	1270	8760	1730	11930	2200	15170	2650	18270	3110	21440	3590	24750	4040	27850	4510	31100
18	800	5520	1240	8550	1690	11650	2150	14820	2600	17930	3050	21030	3520	24270	3980	27440	4450	30680
17	780	5380	1200	8270	1650	11380	2100	14480	2550	17580	3000	20680	3460	23860	3910	26960	4380	30200
16	750	5170	1170	8070	1600	11030	2050	14130	2490	17170	2940	20270	3400	23440	3830	26410	4300	29650
15	720	4960	1130	7790	1550	10690	2000	13790	2430	16750	2870	19790	3310	22820	3770	25990	4210	29030
14	690	4760	1090	7520	1500	10340	1950	13440	2360	16270	2800	19310	3250	22410	3690	25440	4130	28480
13	660	4550	1050	7240	1450	10000	1890	13030	2300	15860	2740	18890	3180	21930	3600	24820	4050	27920
12	630	4340	1000	6890	1400	9650	1820	12550	2230	15380	2660	18340	3090	21300	3500	24130	3960	27300
11	590	4070	950	6550	1350	9310	1750	12070	2150	14820	2570	17720	3000	20680	3400	23440	3850	26540
10	550	3790	900	6210	1280	8830	1680	11580	2070	14270	2490	17170	2900	19990	3300	22750	3730	25720
9	510	3520	840	5790	1200	8270	1590	10960	1980	13650	2380	16410	2780	19170	3170	21860	3600	24820
8	460	3170	780	5380	1130	7790	1500	10340	1880	12960	2280	15720	2650	18270	3050	21030	3460	23860
7	400	2760	700	4830	1040	7170	1380	9510	1750	12070	2120	14620	2500	17240	2890	19930	3280	22610
6	340	2340	600	4140	920	6340	1260	8690	1610	11100	1980	13650	2340	16130	2700	18620	3100	21370

1325 CULVERT PIPE THICKNESS

CORRUGATED GALVANIZED STEEL (Class 1, Zinc or Aluminum Coated)								
	THICKNESS		MINIMUM THICKNESS					
GAUGE			PIPE	PIPE	PIPE PLATE	PIPE PLATE	KILOGRAMS / m2	OUNCES / SQ. FT.
NO.	mm	in.	mm	in.	mm	in.	OF BASE MATERIAL	OF BASE MATERIAL
24	0.71	0.028	0.61	0.024				
22	0.86	0.034	0.76	0.030				
20	1.02	0.040	0.91	0.036			7.32	24
18	1.32	0.052	1.17	0.046			9.76	32
16	1.63	0.064	1.45	0.057			12.21	40
14	2.01	0.079	1.83	0.072			15.26	50
12	2.77	0.109	2.57	0.101	2.46	0.097	21.36	70
10	3.51	0.138	3.28	0.129	3.20	0.126	27.46	90
8	4.27	0.168	4.04	0.159	3.96	0.156	33.57	110
7	4.78	0.188			4.47	0.176	36.62	120
5	5.54	0.218			5.23	0.206	42.72	140
3	6.32	0.249			6.02	0.237	48.82	160
1	7.11	0.280			6.81	0.268	54.93	180

1326 CALIBRATION OF SLURRY SEAL MACHINE

Width of belt = 1.79’
Length of belt Travel per Revolution = 1.67’
Depth of Material (Gate Opening) 3-1/2 = 0.29’
Weight of Aggregate per Cubic Foot = 86.51 pounds

1.79 x 1.67 x 0.29 = 0.866897 Cubic Feet

0.866897 x 86.51 = 75.00 Weight of Material per Revolution

1 Revolution = 1.75 Gallons Emulsion
Weight of Emulsion = 8.33 Pounds

1.75 x 8.33 = 14.58 Pounds Emulsion per Revolution

75.00	Weight of Aggregate per Revolution
14.58	Weight of Emulsion
89.58	

14.58 / 89.58 = 16.3% Specification -- 14-18

75.00 / 89.58 = 83.7% Specification -- 82-86

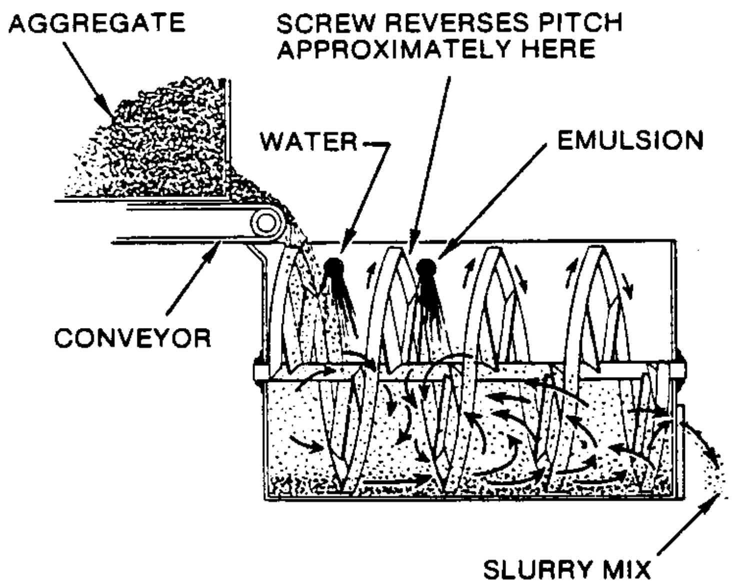
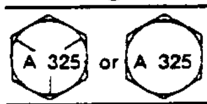
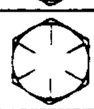


Figure A
Flow diagram of slurry mixer

The mixer contains a specially designed agitator built with a change of pitch in the blades at a point approximately one-third from the feet end. This causes the material in the mixer to be blended toward the middle from both ends of the unit. The product is a homogeneous slurry mix. It is forced by the outer spiral of the agitator to the rear of the mixer where it is allowed to flow out into the spreader. Figure “A” is a diagram of this mixing operation. Note that the emulsion is fed into the mixer at the point where opposing forces are motion met. This ensures that the emulsion does not contact dry material which is important to the success of the process.

1327 MARKINGS FOR STEEL BOLTS

ASTM AND SAE GRADE MARKINGS FOR STEEL BOLTS AND SCREWS

GRADE MARKING	SPECIFICATION	MATERIAL
 NO MARK	SAE-Grade 1	Low or Medium Carbon Steel
	ASTM-A 307	Low Carbon Steel
	SAE-Grade 2	Low or Medium Carbon Steel
	SAE-Grade 5	Medium Carbon Steel, Quenched and Tempered
	ASTM-A 449	
	SAE-Grade 5.2	Low Carbon Martensite Steel, Quenched and Tempered
	ASTM-A 325 Type 1 ASHTO-M 164	Medium Carbon Steel, Quenched and Tempered
	ASTM-A 325 Type 2 ASHTO-M 164	Low Carbon Martensite Steel, Quenched and Tempered
	ASTM-A 325 Type 3 ASHTO-M 164	Atmospheric Corrosion (Weathering) Steel, Quenched and Tempered
	ASTM-A354 Grade BB	Low Alloy Steel, Quenched and Tempered
	ASTM-A 354 Grade BC	Low Alloy Steel, Quenched and Tempered
	SAE-Grade 7	Medium Carbon Alloy Steel, Quenched and Tempered Roll Threaded After Heat Treatment
	SAE-Grade 8	Medium Carbon Alloy Steel, Quenched and Tempered
	ASTM-A-354 Grade BD	Alloy Steel, Quenched and Tempered
	ASTM-A 490 ASHTO-M 253	Alloy Steel, Quenched and Tempered

ASTM Standards:

A 307 - Low Carbon Steel Externally and Internally Threaded Standard Fasteners.
A 325 - High Strength Steel Bolts for Structural Steel Joints, including Suitable Nuts and Plain Hardened Washers.
A 449 - Quenched and Tempered Steel Bolts and Studs.
A 354 - Quenched and Tempered Alloy Steel Bolts and Studs with Suitable Nuts.
A 490 - Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints.

SAE Standards:

J429 – Mechanical and Quality Requirements for Externally Threaded Fasteners.

1328 STEEL WIRE GAUGES

GAUGE	DECIMAL EQUIVALENT	DECIMAL EQUIVALENT	GAUGE	DECIMAL EQUIVALENT	DECIMAL EQUIVALENT
NO.	mm	in.	NO.	mm	in.
0/7	12.446	0.490	9	3.759	0.148
0/6	11.735	0.462	9 1/2	3.607	0.142
0/5	10.922	0.430	10	3.429	0.135
0/4	10.008	0.394	10 1/2	3.251	0.128
0/3	9.195	0.362	11	3.048	0.120
0/2	8.407	0.331	11 1/2	2.870	0.113
0/1	7.772	0.306	12	2.692	0.106
1	7.188	0.283	12 1/2	2.515	0.099
1 1/2	6.909	0.272	13	2.337	0.092
2	6.655	0.262	13 1/2	2.184	0.086
2 1/2	6.426	0.253	14	2.032	0.080
3	6.198	0.244	14 1/2	1.930	0.076
3 1/2	5.944	0.234	15	1.829	0.072
4	5.715	0.225	15 1/2	1.702	0.067
4 1/2	5.486	0.216	16	1.575	0.062
5	5.258	0.207	16 1/2	1.473	0.058
5 1/2	5.080	0.200	17	1.372	0.054
6	4.877	0.192	17 1/2	1.295	0.051
6 1/2	4.674	0.184	18	1.219	0.048
7	4.496	0.177	18 1/2	1.118	0.044
7 1/2	4.318	0.170	19	1.041	0.041
8	4.115	0.162	19 1/2	0.965	0.038
8 1/2	3.937	0.155	20	0.889	0.035

The steel wire gauge outlined in this table has been taken from the original Washburn and Moen Gauge Chart. In 20 gauge and coarser, sizes originally quoted to 4 decimal equivalent places have been rounded to 3 decimal places in accordance with rounding procedures of ASTM Standard Practice E29.

1329 CEMENT CONVERSION FACTORS

Change from bags to Pounds of Portland Cement and Gallons per bag to a Weight Ratio

Cement Content		Water - Cement Ratio	
Bag/C.Y.	**Lb./C.Y.**	**Gal./Bag**	**Weight Ratio**
4.0	376	4.0	0.36
4.5	423	4.5	0.40
5.0	470	5.0	0.44
5.5	517	5.5	0.49
6.0	564	6.0	0.53
6.5	611	6.5	0.58
7.0	658	7.0	0.62
7.5	705	7.5	0.66
8.0	752	8.0	0.71
8.5	799	8.5	0.75
9.0	846	9.0	0.80

1330 EQUIVALENT VELOCITIES

MIles Per Hour		Feet Per Minute		Feet Per Second		Kilometers Per Hour		Meters Per Minute		Meters Per Second
1	=	88	=	1.46	=	1.61	=	26.82	=	0.45
2	=	176	=	2.94	=	3.22	=	53.64	=	0.89
3	=	264	=	4.40	=	4.83	=	80.47	=	1.34
4	=	352	=	5.87	=	6.44	=	107.29	=	1.79
5	=	440	=	7.33	=	8.05	=	134.11	=	2.24
6	=	528	=	8.80	=	9.66	=	160.93	=	2.68
7	=	616	=	10.26	=	11.27	=	187.76	=	3.13
8	=	704	=	11.73	=	12.87	=	214.58	=	3.58
9	=	792	=	13.20	=	14.48	=	241.40	=	4.02
10	=	880	=	14.67	=	16.09	=	268.22	=	4.47
11	=	968	=	16.13	=	17.70	=	295.05	=	4.92
12	=	1056	=	17.60	=	19.31	=	321.87	=	5.36
13	=	1144	=	19.07	=	20.92	=	348.69	=	5.81
14	=	1232	=	20.52	=	22.53	=	375.51	=	6.26
15	=	1320	=	22.00	=	24.14	=	402.34	=	6.71
16	=	1408	=	23.47	=	25.75	=	429.16	=	7.15
17	=	1496	=	24.93	=	27.36	=	455.98	=	7.60
18	=	1584	=	26.40	=	28.97	=	482.80	=	8.05
19	=	1672	=	27.87	=	30.58	=	509.63	=	8.49
20	=	1760	=	29.33	=	32.19	=	536.45	=	8.94
21	=	1848	=	30.80	=	33.80	=	563.27	=	9.39
22	=	1936	=	32.26	=	35.41	=	590.09	=	9.83
23	=	2024	=	33.72	=	37.01	=	616.92	=	10.28
24	=	2112	=	35.20	=	38.62	=	643.74	=	10.73
25	=	2200	=	36.67	=	40.23	=	670.56	=	11.18
26	=	2288	=	38.14	=	41.84	=	697.38	=	11.62
27	=	2376	=	39.60	=	43.45	=	724.20	=	12.07
28	=	2464	=	41.04	=	45.06	=	751.03	=	12.52
29	=	2552	=	42.50	=	46.67	=	777.85	=	12.96
30	=	2640	=	44.00	=	48.28	=	804.67	=	13.41

1331 RANDOM NUMBER TABLE

0.489	0.190	0.093	0.625	0.045	0.033	0.925	0.366	0.138	0.706
0.352	0.851	0.078	0.627	0.566	0.667	0.099	0.615	0.056	0.994
0.230	0.388	0.759	0.266	0.921	0.814	0.910	0.757	0.939	0.349
0.367	0.710	0.575	0.545	0.705	0.206	0.682	0.053	0.839	0.401
0.589	0.011	0.481	0.292	0.413	0.233	0.188	0.682	0.800	0.109
0.309	0.487	0.633	0.607	0.585	0.041	0.733	0.300	0.705	0.564
0.081	0.811	0.585	0.443	0.605	0.594	0.662	0.484	0.047	0.444
0.973	0.788	0.954	0.660	0.312	0.418	0.318	0.245	0.236	0.493
0.894	0.070	0.209	0.893	0.740	0.395	0.661	0.199	0.991	0.659
0.243	0.058	0.414	0.944	0.060	0.601	0.769	0.016	0.170	0.084
0.507	0.358	0.115	0.410	0.838	0.092	0.778	0.678	0.699	0.198
0.350	0.428	0.651	0.944	0.667	0.728	0.245	0.920	0.730	0.762
0.878	0.596	0.661	0.079	0.670	0.799	0.887	0.152	0.412	0.024
0.844	0.418	0.082	0.981	0.961	0.429	0.000	0.278	0.221	0.301
0.116	0.662	0.077	0.095	0.494	0.710	0.999	0.295	0.499	0.383
0.441	0.036	0.731	0.344	0.502	0.245	0.240	0.458	0.066	0.345
0.037	0.363	0.703	0.675	0.452	0.529	0.113	0.290	0.356	0.719
0.386	0.299	0.787	0.234	0.871	0.384	0.004	0.877	0.929	0.673
0.506	0.015	0.349	0.604	0.046	0.673	0.716	0.960	0.168	0.038
0.502	0.711	0.303	0.305	0.173	0.827	0.950	0.249	0.079	0.719
0.979	0.447	0.425	0.463	0.585	0.545	0.091	0.467	0.917	0.484
0.584	0.725	0.929	0.080	0.914	0.333	0.472	0.879	0.658	0.405
0.155	0.683	0.010	0.061	0.024	0.658	0.086	0.628	0.567	0.419
0.273	0.723	0.098	0.026	0.898	0.368	0.039	0.256	0.003	0.795
0.126	0.104	0.502	0.096	0.088	0.871	0.505	0.371	0.817	0.792
0.091	0.546	0.560	0.571	0.308	0.489	0.171	0.758	0.681	0.612
0.948	0.350	0.016	0.590	0.098	0.550	0.770	0.368	0.335	0.060
0.780	0.103	0.680	0.838	0.623	0.209	0.956	0.714	0.394	0.147
0.044	0.772	0.182	0.126	0.396	0.910	0.021	0.368	0.871	0.473
0.603	0.095	0.399	0.383	0.535	0.891	0.519	0.647	0.412	0.598
0.315	0.681	0.499	0.405	0.784	0.322	0.295	0.273	0.166	0.966
0.763	0.372	0.272	0.712	0.507	0.674	0.333	0.938	0.680	0.354
0.407	0.204	0.902	0.173	0.877	0.889	0.962	0.475	0.060	0.474
0.601	0.977	0.478	0.873	0.146	0.997	0.800	0.721	0.273	0.273
0.004	0.015	0.696	0.036	0.777	0.035	0.045	0.496	0.698	0.928
0.724	0.385	0.220	0.882	0.036	0.725	0.998	0.272	0.337	0.475
0.574	0.718	0.522	0.203	0.978	0.424	0.611	0.458	0.246	0.730
0.717	0.979	0.413	0.279	0.187	0.413	0.990	0.694	0.183	0.682
0.473	0.181	0.497	0.677	0.906	0.967	0.869	0.410	0.034	0.968
0.606	0.304	0.071	0.601	0.765	0.754	0.626	0.150	0.691	0.644
0.797	0.578	0.193	0.941	0.995	0.210	0.134	0.055	0.500	0.176
0.716	0.102	0.297	0.030	0.248	0.730	0.215	0.455	0.669	0.669

REFERENCES AND ADDITIONAL INFORMATION

Chapter 01 - Section 100

- ADOT Project Development Process Handbook, Arizona Department of Transportation, Phoenix, AZ
- ADOT Project Management Training Manual, The Advisory Group, Phoenix, AZ

Chapter 01 - Section 104

- PARTNERING: Changing Attitudes in Construction, Associated General Contractors of America, Washington, DC
- PARTNERING: A Concept for Success, Associated General Contractors of America, Washington, DC
- Partnering for Success, Thomas R. Warne, ASCE Press, New York, NY
- Arizona Pollutant Discharge Elimination System General Permit De Minimis General Permit (DGP) No. AZG2004-001. Arizona Department of Environmental Quality, Phoenix, AZ
- Arizona Pollutant Discharge Elimination System General Permit for Discharge from Construction Activities to Waters of the United States. ADEQ. Arizona Department of Environmental Quality, Phoenix, AZ
- Statewide Stormwater Management Plan. Arizona Department of Transportation, Phoenix, AZ
- Stormwater Monitoring Guidance Manual for Construction Activities. Arizona Department of Transportation, Phoenix, AZ
- Erosion and Pollution Control Manual. Arizona Department of Transportation, Phoenix, AZ
- National Pollution Discharge Elimination System General Permit for Stormwater. Discharges From Construction Activities. Environmental Protection Agency, Washington, DC
- National Pollution Discharge Elimination System Permit for Stormwater Discharges from the Municipal Separate Storm Sewer System (MS4) Operated by Arizona Department of Transportation (ADOT) NPDES Permit No. AZS00018, U.S. Environmental Protection Agency. Environmental Protection Agency, Washington, DC

Chapter 01 - Section 105

- Blue Stake “811 Booklet”, Arizona Blue Stake Inc., Phoenix, AZ
- Construction Delay Claims (Construction Law Library), Barry B. Bramble, Esq. and Michael T. Callahan, Esq., John Wiley & Sons Inc., New York, NY
- Construction Change Order Claims (Construction Law Library), Robert F. Cushman, Esq. and Stephen D. Butler, Esq., John Wiley & Sons Inc., New York, NY
- Differing Site Condition Claims (Construction Law Library), Robert F. Cushman, Esq. and David R. Tortorello, John Wiley & Sons Inc., New York, NY
- Construction Industry Arbitration Rules and Mediation Procedures (July 1st 2015), American Arbitration Association, New York, NY

Chapter 01 - Section 107

- OSHA Safety and Health Standards for the Construction Industry (29 CFR Part 1926), Industrial Commission of Arizona, Arizona Division of Occupational Safety and Health, Phoenix, AZ

  Note: This publication is updated every year or two so contact ADOSH for the latest publication date.

- Occupational Safety and Health Standards for General Industry (29 CFR Part 1910), Industrial Commission of Arizona, Arizona Division of Occupational Safety and Health, Phoenix, AZ

  Note: This publication is updated every year or two so contact ADOSH for the latest publication date.

- Construction Contracting, 6th Edition, Richard H. Clough and Glenn A. Sears, John Wiley & Sons Inc., New York, NY

Chapter 01 - Section 108

- Scheduling Construction Projects, Edward M. Willis, John Wiley & Sons Inc., New York, NY
- CPM Scheduling For Construction, Best Practices and Guidelines, Carson, Oakander, Relyea, Project Management Institute

Chapter 01 - Section 109

- Construction Costs, published yearly, Arizona Department of Transportation, Contracts and Specifications Section, Phoenix, AZ
- Means Heavy Construction Cost Data, published yearly, R. S. Means Company, Kingston, MA
- Public Works Costbook, published yearly, BNi Building News, Los Angeles, CA
- Pay Item Documentation for Inspectors, Arizona Department of Transportation, Phoenix, AZ

Chapter 02 - Section 200

- ADOT Erosion and Pollution Control Manual, Arizona Department of Transportation, Intermodal Transportation Division, Phoenix, AZ
- ** Materials Testing Manual, Arizona Department of Transportation, Materials Group, Phoenix, AZ
- ARIZ 105f - Sampling Soils and Aggregates
- ARIZ 222b - Rock Correction Procedure for Maximum Density Determination of Cement Treated Mixtures
- ARIZ 223 - Field Density of Cement Treated Mixtures by Sand Cone Method or Rubber Balloon Method
- ARIZ 230a - Field Density by Sand Cone Method
- ARIZ 235 - Density and Moisture Content of Soils and Soil-Aggregate Mixtures by the Nuclear Method
- ARIZ 246b - Moisture-Density Relationship using Typical Moisture-Density Curves (One-Point Proctor) Alternate method D
- AASHTO T 217 - Determination of Moisture in Soils by means of the Calcium Carbide Gas Pressure Moisture Tester
- * Quality Assurance Program Manual, Arizona Department of Transportation, Materials Group, Phoenix, AZ
- * Appendix C (Sampling Guide)
- Policy Practice and Procedure Directives (PPD) Manual, Arizona Department of Transportation, Materials Group, Phoenix, AZ

**** - Individual copies recommended for inspection staff***

Chapter 02 - Section 203

The INSTITUTE OF MAKERS OF EXPLOSIVES (IME) is the safety association of the commercial explosive industry in the United States and Canada. This non-profit, incorporated association is concerned primarily with safety in the manufacture, transportation, storage, handling, and use of explosive materials and other essential applications. The IME has a Safety Library comprised of publications pertaining to:

- Construction Guide for Storage Magazines
- American Table of Distances
- Suggested Code of Regulations
- Warnings and Instructions for Consumers in Transporting, Storing, Handling and Using Explosive
- Materials.
- Handbook for the Transportation and Distribution of Explosive Materials 6. Safety in the Transportation, Storage, Handling and Use of Explosive Materials 7. Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Detonators
- Caterpillar Performance Handbook

Chapter 03

- * Materials Testing Manual, Arizona Department of Transportation, Materials Group, Phoenix, AZ
- ARIZ 105f - Sampling Soils and Aggregates
- ARIZ 222b - Rock Correction Procedure for Maximum Density Determination of Cement Treated Mixtures
- ARIZ 223 - Field Density of Cement Treated Mixtures by Sand Cone Method or Rubber Balloon Method
- ARIZ 230a - Field Density by Sand Cone Method
- ARIZ 235 - Density and Moisture Content of Soils and Soil-Aggregate Mixtures by the Nuclear Method
- ARIZ 246b - Moisture-Density Relationship using Typical Moisture-Density Curves (One-Point Proctor) Alternate method D
- AASHTO T 217 - Determination of Moisture in Soils by means of the Calcium Carbide Gas Pressure Moisture Tester
- * Quality Assurance Program Manual, Arizona Department of Transportation, Materials Group, Phoenix, AZ
- * Appendix C (Sampling Guide)
- Practice and Procedure Directives (PPD) Manual, Arizona Department of Transportation, Materials Group, Phoenix, AZ

- Individual copies recommended for inspection staff

Chapter 05 - Section 501

- Concrete Pipe Handbook, American Concrete Pipe Association, Vienna, VA
- * Concrete Pipe Installation Manual, American Concrete Pipe Association, Vienna, VA
- * Construction Standards for Excavation (29 CFR 1926:650-.652) Subpart P, Promulgated by OSHA, Arizona Department of Occupational Safety and Health, Phoenix, AZ
- Excerpts of Federal Register, 29 CFR Part 1926, OSHA Standards-Excavations; Final Rule, Arizona Department of Transportation, Phoenix, AZ
- Handbook of Steel Drainage & Highway Construction Products, American Iron and Steel Institute, Washington, DC
- * Installation Manual for Corrugated Steel Pipe, Pipe Arches, Structural Plate, National Corrugated Steel Pipe Association, Washington, DC
- Lynch Manual - Cast-in-Place Concrete Pipe Process, Tremont Equipment Co., Dixon, CA
- Recommendations for Cast-in-Place Non Reinforced Concrete Pipe, ACI 346R-90, American Concrete Institute, Detroit, MI
- * Workbook for Pipe Placement Inspection (Course Number 103), Arizona Department of Transportation, Phoenix, AZ

Chapter 05 - Section 502

- * Installation Manual for Corrugated Steel Pipe, Pipe Arches, Structural Plate, National Corrugated Steel Pipe Association, Washington, DC
- Handbook of Steel Drainage & Highway Construction Products, American Iron and Steel Institute, Washington, DC, pg. 317 – 330

Chapter 05 - Section 503, 504, 505

- * Workbook for Incidental Concrete Structures Inspection (Course Number 202), Arizona Department of Transportation, Phoenix, AZ

- individual copies recommended for inspection staff

Chapter 07 - Section 701

- Manual on Uniform Traffic Control Devices for Streets and Highways, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.
- Manual on Uniform Traffic Control Devices for Streets and Highways Part VI, Standards and Guides for Traffic Controls for Street and Highway Construction, Maintenance, Utility, and Incident Management Operations, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C.
- ADOT Traffic Control Design Guidelines, Arizona Department of Transportation, Traffic Group, Phoenix, AZ
- Flagging Handbook, American Traffic Safety Services Association, Fredericksburg, VA Quality Standards for Work Zone Traffic Control Devices, American Traffic Safety Services Association, Fredericksburg, VA
- Quality Guidelines for Temporary Traffic Control Devices and Features Handbook, American Traffic Safety Services Association, Fredericksburg, VA

Chapter 08 Section 807

It is recommended that each office administering roadside planting, roadside parks, view point development, and Rest Area contracts, obtain and maintain a library of the following books and reference materials before the contractor commences work.

Required Category

These books should be readily available to all Landscape Inspectors and Resident Engineers:

- Any literature referred to in the Special Provisions and Standard Specifications.
- American Standards for Nursery Stock - American Association of Nurserymen, Inc.
- Inspection Guide for Landscape Planting - AASHTO Subcommittee on Roadside Development.

Recommended Category

Recommended reading and reference material for all personnel involved in landscaping, roadside planting, and rest area projects:

- A Technical Glossary of Horticultural and Landscape Terminology - The Horticulture Research Institute.
- Common Weeds of the United States - United States Department of Agriculture. Dover Edition.
- Ground Cover Plants - Donald Wyman.
- Hortus Second, a Concise Dictionary of Gardening -L.H Bailey and Ethel Zoe Bailey
- Manual of Cultivated Trees and Shrubs - Alfred Rehder.
- Shrubs and Vines for American Gardens - Donald Wyman.
- Standardized Plant Names - American Joint Committee on Horticultural Nomenclature.
- The Sunset Western Garden Book - Sunset Editors, Published by Lane Books
- Trees for American Gardens - Donald Wyman.
- Plants for Dry Climates - Duffield & Jones.
- Landscaping for the Southwest Desert - James D. Claridge.

Chapter 10

- APPROVED PRODUCTS LIST (APL) - *(Found on the ADOTNet and on the public webpage)*

ASSOCIATED FORMS

Note - *Unless otherwise noted, the below forms are found within "Forms - ADOT Construction Manual" links within Construction and Materials Group (ADOTNet), Engineering and Construction, and the Construction (public web pages).*

Chapter 01:

- ADOT JOBSITE DUST CONTROL PLAN
- CONSTRUCTION ISSUE RESOLUTION ROUTING FORM - *Found on the "Partnering Forms and Links" web page*
- ELECTRONIC DATA TEMPORARY USE AGREEMENT
- FORCE ACCOUNT DAILY REPORT
- PARTNERING EVALUATION PROGRAM (PEP) - *(No longer a form, Partnering Group will supply a tailored version for each project)*
- PRIME CONTRACTOR FORCE ACCOUNT WEEKLY DETAIL SUMMARY SHEET - *(Found within the Forms and Documents Contractor Information public web page)*
- PROJECT FINAL CHECKLIST - *(See Form Exhibits in Chapter 1208 of this manual)*

Chapter 02

- RECEIPT FOR SALVAGED MATERIALS
- WATER TRUCK CERTIFICATION (ENGLISH)
- DUST PALLIATIVE AGREEMENT
- DAILY DUST PALLIATIVE (ENGLISH)

Chapter 05

- NRCI PCP DAILY OBSERVATION REPORT
- PRE-ACTIVITY MEETING AGENDA

Chapter 07

- DETECTION LOOP - PRELIMINARY TEST REPORT

Chapter 08

- CENTRAL DISTRICT LANDSCAPE ARCHITECT RESOURCE GUIDE