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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 obligated to hold two pre-paving meetings--the first with the Contractor and ADOT project personnel, and the second with his or her own personnel.

The purpose of the first meeting will be to:

1. 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.
2. Reinforce the "ground rules" necessary for an uninterrupted operation.
3. Introduce the Department's inspection team and establish the lines of communication between the Contractor's personnel and the Department.
4. **Review safety procedures.**

Review of the Contractor's Paving Plan

The minimum requirements for a paving plan include:

1. 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);
2. 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);
3. 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);
4. 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 (for example; 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;
 5. 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, etc.), legal load limits, and haul and cycle times);
 6. 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);
 7. 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);
 8. Discussion on the tining and curing methods to be used (check subsections 401-3.04 (F) & (G) for conformance);
 9. 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);
 10. 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 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 front of a \$2,000 per hour 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 (with ADOT personnel) covers responsibility, 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, and
- core layout and coring.

The Resident Engineer and Project Supervisor have flexibility in how they assign Inspectors to each of these operations. The goal, however, 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 pickup 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 (15 to 30 meters) 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 (75 mm to 100 mm). For the slip-form method of paving, the optimum slump is usually 1 inch (25 mm). 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. If the Contractor does not maintain sufficiently large stockpiles to assure uniformity of moisture in them, 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. The problems should be thoroughly discussed and solutions arrived at before the paving is started.

Continual emphasis must be made to stress the importance of not adding water to the concrete after mixing, except by the fog spraying method when conditions are particularly hot or windy. Inspectors should closely monitor concrete temperatures during hot and cold weather for compliance with the specifications. During hot weather, concrete temperatures will run at or near the specified limit. It is important for Inspectors not to allow the concrete temperature to exceed its specified limit. Hot concrete is susceptible to shrinkage cracking which directly affects durability and longevity of concrete pavement.

There are two strength requirements called out in the Standard Specifications. A compressive strength of 3000 psi (20 MPa) 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 (30 MPa). 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; and
- the concrete strength has reached a minimum of 3000 psi (20 MPa).

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 preapproved. 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 preapproved 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 preapproved material and must be the on the [Approved Products List](#) maintained by the Arizona Transportation Research Center.

Curing Compound

This may be a preapproved material and if so, all the barrels will be "green tagged" by ADOT Materials Group. Materials that were not preapproved must be sampled per lot and submitted to Central Lab for testing prior to use. Certificates of compliance shall accompany the material whether preapproved, or not.

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 (100 meters) long. The width would depend on the type of screed used: rolling and Texas (vibratory) screeds are limited to a maximum of 18 feet (6 meters), 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, or bituminous treated base. 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 problems as does rapid surface moisture loss. Subsection 401-3.02 requires the surface to be uniformly moistened immediately prior to placing concrete when the ambient temperature is greater than 85°F (29°C).

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 will provide recommendations.

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--all of which 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); and
- 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:

1. 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.
2. 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.
3. 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 (600 mm) on center. The vibrators shall be checked to verify they operate at a minimum of 8,000 impulses per minute.
4. 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 at the beginning of 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. The measurement shall be recorded in a field book. The grade stabbing serves as 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 (600 mm) 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 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, and
- 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 usually 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 case entire slabs have been removed to the nearest longitudinal joint. In other cases, where the damage is near the edge, only a 1-foot (0.3 meter) 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. All measurements shall be recorded in field books set up specifically for the paving operation.

The placement of concrete at a construction joint is particularly critical. Care must 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 (150 mm to 250 mm) 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.

Edge Slump

One of the earliest and best indicators of the quality of a PCCP paving operations 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. Inspectors must keep a record of their edge slump measurements in a field book so that areas that need 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. Tine 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 tining on the finished concrete surface must meet the required tolerances in Subsection 401-3.04(F) of the Standard Specifications.

The Contractor should be aiming for the mid-range specified for tining depth. If the Contractor is continually tining too lightly or too heavily, the operation should be adjusted so that the mid-range tining depth can be achieved.

The burlap drag and the tine 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.

AR-ACFC Overlay

Many PCCP pavements now receive a 3/4" lift of rubberized ACFC on top. The rubberized ACFC absorbs traffic noise, thus making it quieter for adjacent residential neighborhoods. In addition the ride is quieter and smoother for the driver.

The requirements for tining as described above are not necessary should the plans specify rubberized ACFC. If traffic is required to temporarily use the new PCCP, prior to placement of the rubberized ACFC, tining is required.

Some sort of texturing on the PCCP is required so the rubberized ACFC 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 rubberized ACFC, the PCCP needs to be thoroughly cleaned, removing any curing compound; otherwise the rubberized ACFC may not bond to the PCCP.

(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. The cured surface should still be moist when the coating is applied. 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.

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. It is important that the concrete retains all the moisture it needs for the chemical reaction of hydration and to avoid shrinkage cracks.

Note that whenever the ambient air temperature is above 85°F (30°C), 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 for 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 [150 mm to 300 mm] 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
<p>Weakened Plane, or Contraction (most common)</p> <p>TWP = transverse weakened plane joint</p> <p>LWP = longitudinal weakened plane joint</p>	<p>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.</p>	<p>transverse and longitudinal</p>	<p><i>transverse:</i> none, except on interstate projects where load transfer dowels are used in TWP type joints.</p> <p><i>longitudinal:</i> tie bars are used in LWP type joints</p>	
<p>Expansion</p> <p>E = Doweled transverse expansion joint</p> <p>H = non-doweled longitudinal expansion joint</p> <p>K = non-doweled; constructed around the perimeter of a misc. structure</p>	<p>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.</p>	<p>transverse and longitudinal</p>	<p><i>transverse:</i> E type joints have load transfer dowel.</p> <p><i>longitudinal:</i> K & H type joints do not have dowels.</p>	<p>A sufficient gap must be left to allow the joint to both close and open.</p>
<p>Construction</p> <p>TC = transverse construction joint</p> <p>LC = longitudinal construction joint</p>	<p>Used to join a new Portland cement concrete (PCC) pavement to an existing PCC pavement.</p>	<p>transverse and longitudinal</p>	<p><i>transverse:</i> TC type joints use epoxy coated smooth dowels</p> <p><i>longitudinal:</i> LC type joints use epoxy coated smooth dowels</p>	<p>Joints are saw cut and sealed like a weakened plane joint. However, the saw cut is 1-1/4" (32 mm) rather than 1/3 the slab depth</p>
<p>Edge Seal</p> <p>S = AC / PCCP edge joint</p>	<p>Used to join edge of Portland cement concrete pavement (PCCP) to edge of Asphaltic concrete (AC) pavement.</p>	<p>transverse And longitudinal</p>	<p><i>none</i></p>	<p>Saw cut or rout joint in AC and seal with rubber sealant.</p>

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 (6 mm) 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:

1. Transverse construction joints are placed at the end of a run or whenever operations will be interrupted for more than one hour.
2. When adjoining lanes are placed separately, the TWP joints must match.
3. All construction and weakened plane joints shall be sawed.
4. 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.
5. 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:

1. 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);
2. 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);
3. spacing of construction joints;
4. how joints will be made around openings and other appurtenances in the pavement;
5. tolerances of sawed joint locations versus the center of dowel baskets when load transfer dowels are used;
6. proper matching of transverse weakened plane joints with adjacent lanes (this will require some thought when dealing with transverse construction joint);
7. the importance of having joints of correct width and depth along with having clean joints before sealing;

8. test results on the sealant with concern for the age of the material. If it 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 amount of moisture such as paper products are not desirable; they may reduce the effectiveness of the sealant;
9. stress keeping the top of the sealant 1/4 inch (6 mm) below the surface; and
10. 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.

If the Contractor falls behind in his or her sawing, it may be necessary to increase the joint spacing (up to 60 feet [18 meter]) 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. It is, therefore, 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 (square meter) 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 (square meters) 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 4-1)	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 (1.4 meter), or less than 12 inches (0.3 meter) 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 (1.5 meter) of a transverse contraction (weakened plane) joint.
 - a. Transverse contraction joint has not cracked.
 - b. Transverse contraction joint is cracked.
4. Transverse crack more than 5 feet (1.5 meter) 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 smaller portion of slab.
- f. Deepen uncracked transverse contraction joints on each side of the crack to ½ inch (13 mm) 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 (1 meter) are considered to be longitudinal cracks.

Table 401-4.03-1. Crack Repair

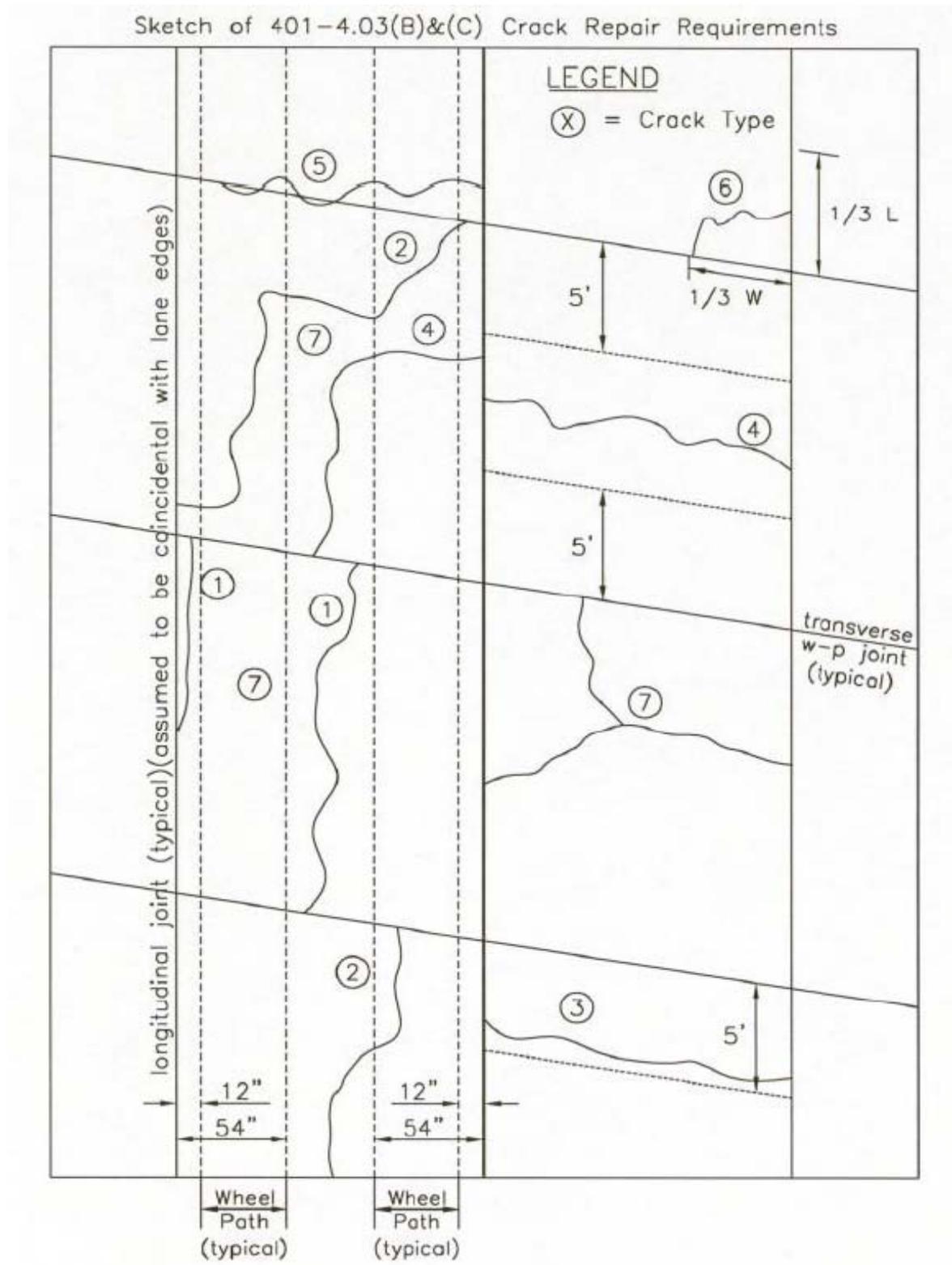


Exhibit 401-4.03-1. Crack Repair Diagram

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 insure 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 T148. 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 (15 mm) or more. The additional cores must be obtained at intervals not exceeding 10 feet (3 meter) in each direction from the deficient core, until one core is obtained in each direction which is not deficient by 0.60 inches (15 mm) 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 contractor's proposal for rejected sections of the pavement and shall determine the proportion of the unit bid price to be paid 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 (square meter) but adjustments are made to the unit price for:

- thickness,
- compressive strength,
- cracking, and
- 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 spread sheets, 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.

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 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 (15 MPa) 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 method 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 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 by 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; and
- 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 "Double-Application Seal Coat" 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 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 (Liters per square meter). Therefore, inspectors must complete a "Project Asphalt Report" for each type of bituminous material applied during their shift. Refer to Exhibit 42 for an example of the completed form. A blank form is included at the end of this chapter 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 (spread sheets) 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, Pavement Materials Testing Section 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 GuidelinesBituminous Materials

1. Is the type and grade of asphalt in accordance with the project specifications?
2. Are asphalt samples being witnessed and taken in accordance with methods that assure representative samples?
3. Are test results and certificates of compliance satisfactory?
4. At what temperature is the material being applied or mixed?
5. Are checks being made to verify delivery and complete emptying of cars or tank trucks?

Aggregate Materials

1. Have the aggregates been tested and approved before use on the project?
2. Does the blotter sand meet the gradation requirements?
3. Has the cover material for a chip seal operation been tested for;
 - A. loss of Abrasion (AASHTO T 96),
 - B. percent carbonates (ARIZ 238),
 - C. percent (crushed faces) fractured coarse aggregate particles (ARIZ 212),
 - D. flakiness Index (ARIZ 233), and bulk Oven Dry Specific Gravity (ARIZ 210)?

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, preapprove 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 (see also Subsection 404-3.05).

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. It is sometimes helpful to witness a trial run (say 30 feet [10 meters]) to be sure these requirements are fulfilled.

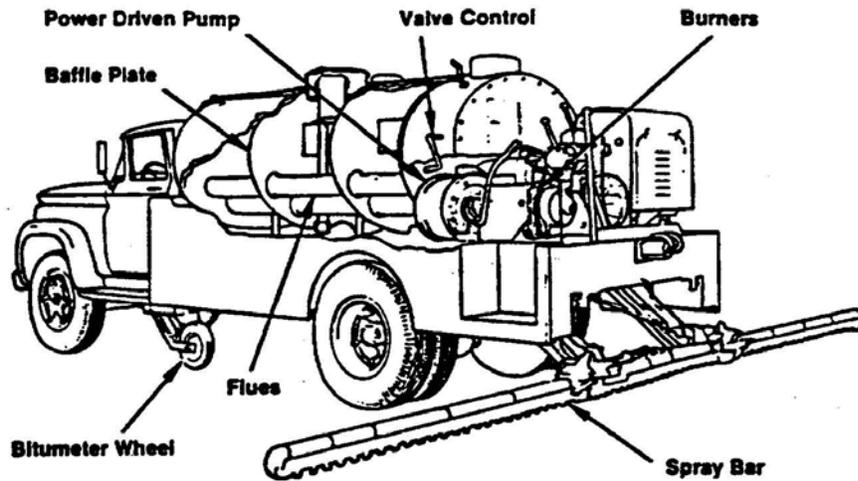
The Contractor is required to furnish evidence that the distributor has been tested and found to be capable of a uniform rate of application. The testing must have been done within the previous twelve months. Distributors used for chip seals should be retesting in accordance with Arizona Test Method (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.

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 (12 mm).

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.

Project Supervisors and Lead Inspectors should not hesitate in removing distributor trucks from the project, which are not operating acceptably.



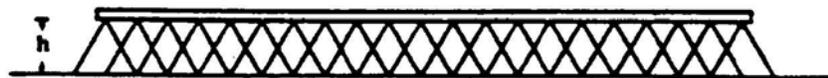
A TYPICAL ASPHALT DISTRIBUTOR



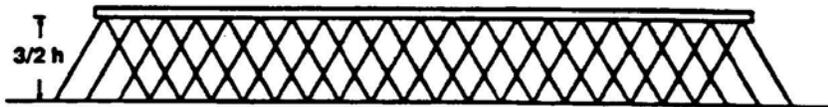
PROPER ANGLING OF NOZZLES



Incorrect Spray Bar Height



Correct Spray Bar Height - Double Coverage



Correct Spray Bar Height - Triple Coverage

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

404-3.11 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; and
- 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.

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 larger aggregate around and break it loose. Areas heavily paved with asphalt may pick up.

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.

Normally, sanding the areas which are only slightly rich is adequate. Small areas under 50 square feet (5 square meters) 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 at the back of this chapter.

Inspection Guidelines

1. Does the surface need prime coat? Will it hold up against construction traffic? Does it need to be sealed for poor weather?
2. Is surface to be primed of acceptable smoothness?
3. Is the surface moist?
4. What is the application rate? Does it need adjustment? Are the asphalt applications uniform?
5. Is the bituminous material suitable for its intended use?

404-3.12 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 pavement. Its purpose is to lessen the possibility of a slippage plane at the interface of the two courses. Uniform application, whether by hand spray or distributor truck, is necessary. If the tack coat is streaked or stringy, there is something 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. The necessary adjustments should be made and the spread checked before resuming the work.

All exposed contact surfaces that are not asphaltic concrete (AC), such as curbs, should always be tacked. If the contact surface is AC, the Contractor and Resident Engineer must evaluate its condition to decide if the tack should be eliminated. Usually, new AC that is relatively free of dust and dirt is not tacked. Some judgment is needed to determine how clean and how new an AC pavement needs to be before eliminating the tack coat. 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. Keep in mind that AC can be placed directly on unprimed aggregate base (AB). It is not necessary for most AC mats to bond to the AB; therefore, tacking the prime coat is usually unnecessary. The 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 operation is to be avoided because it gets dirty and loses its tackiness quickly. Traffic shall not be permitted on the tack coat. 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 before it is covered with new AC.

The type and grade of asphalt, as well as recommended rate of application, shall be as shown on the project plans, and as required by Section 1005 and Subsection 404-3.12 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.

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 at the back of this chapter.

Inspection Guidelines

1. Is tack coat necessary? When a new course is placed directly on an existing course that is only three to five days old that has not been turned over to traffic, tacking is probably not necessary.
2. Is the surface clean and free of dust? Did the broom get against the curb or pavement edge?
3. Is the application of tack uniform?
4. What is the rate of application?
5. Are haul truck tires free and clear of debris?
6. Is contractor making continuous effort to minimize tracking?

404-3.13 Fog Coat

A fog coat is a very light (about one pint per square yard [half a liter per square meter]) 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 material is normally diluted 1:1 after receipt on the project by adding one part water to one part of the agent. 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 reducing the viscosity of 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.

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 (blotted) in order to permit earlier use of the pavement. Sanding 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 Policy and Procedure Directive (PPD) #96-9, "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 at the back of this chapter.

404-3.14 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 new non-skid wearing surface that is watertight. 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 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.

Application Rates of Bituminous and Cover Material

The application rates shown in the specifications for bituminous material and cover material are estimates only. The bituminous and cover material application rates will be determined by the Regional Materials Engineer using the chip seal coat design formula (See ARIZ 819). The Resident Engineer may adjust the rate slightly at the time of construction. 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 50 to 70% (voids filled 50 to 70% with bituminous material), depending on the anticipated traffic volume and, to some degree, the climatic conditions. For heavy traffic and lower desert climates, 50% embedment of average size particles is adequate. For light traffic and high altitude 70% embedment would be proper. In cases where chip seals are to be applied to new AC, the rate of bituminous application should be reduced since some embedment into the new surface may be expected. This is especially important when the chips are heated and pre-coated with asphalt, and when asphalt is the bituminous material. 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.

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.

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 at the back of this chapter. 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.

Preparation of Pavement Surface

The application of the chip seal coat should have been anticipated weeks 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 be made as far in advance of the chip seal coat as possible to prevent fresh asphalt from bleeding through the seal coat.

Just prior to application of asphalt, the surface of the pavement must be cleaned by whatever method is necessary. The use of a good power broom supplemented by hand brooming where necessary is usually adequate. It may be necessary in rare instances to wash the surface with high-pressure water. 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 coat of chips to cover a spill; clean it up.

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.

When applying 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 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.

SPEED OF THE DISTRIBUTOR AND LENGTH OF SPREAD

Distributor speed may be determined by:

where:
$$v = \frac{9Q}{WA(1+c)}$$

v = road speed, fpm;

Q = spray bar output, gal per min;

W = spray bar width, ft;

A = application rate, gal per sq yd; and

c = expansion coefficient resulting from heating the asphalt.

where:
$$c = \frac{T - 60}{30(100)}$$

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:

where:
$$L = \frac{9V}{WA}$$

L = length of spread, ft; and

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:

where:
$$V = \frac{AW_a}{S}$$

W_a = weight of aggregate on hand, lb; and

S = spreading rate of aggregate, lb 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 pre-determined 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:

where:
$$A_1 = \frac{9TM}{WL}$$

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); and

M = multiplier for correcting asphalt volume to basis of 60 F, from temperature-volume tables.

RELATIONSHIP OF QUANTITY OF ASPHALT REQUIRED TO SIZE OF CHIPS

Correct asphalt quantity, voids 50% to 70% filled



Insufficient asphalt, screenings not firmly held



Excess asphalt submerges chips and causes bleeding

Exhibit 404-3.14-1. 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 (30 degrees Celsius). 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. 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 the effectiveness and uniformity of the asphalt coating.

When emulsified asphalt is used, the cover material shall be wet, but free of running water at the time of spreading. When bituminous material other than emulsified asphalt is used, the cover material, at the time of spreading, shall be at least as dry as the material dried to a saturated surface dry condition in accordance with the requirements of Arizona Test Method 210. Wetting stockpiles for dust control is not permitted. Do not use wet aggregate with cutback or paving asphalts.

Cover aggregate is weighed as it is delivered, and the weight of water is deducted to determine the dry weight per ton. This dry weight is converted to cubic yards by dividing by the dry weight per cubic yard. Dry weight per cubic yard is determined in accordance with the requirements of AASHTO T 19. The quantity of cover material in cubic yards is the basis of payment to the Contractor. 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 (25 km/h) 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 aggregate immediately to get good chip retention. The entire operation must be organized to achieve a rolled chip surface as quickly as possible after the asphalt is applied.

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 (15 to 20 meters). Close coordination between the distributor truck and the chip spreader will assure that when the chip spreader stops the asphalt distributor will stop.

Joints

The specifications permit the Contractor some latitude in the method he or she uses 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 (30 to 60 meters) 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 surely 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— 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

Subsection 404-3.03 covers 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 flagger. 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 404-3.14 provides that the speed of motor vehicles shall not exceed 15 mph (25 km/h) 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. 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, the traffic-free period may have to be longer. 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

Specifications state that all loose cover material shall be removed in not less than 12 hours nor 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 is 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:

- $15 \text{ mph} \times 4 \frac{1}{2} \text{ hours} = 67.5 \text{ miles per shift.}$
- $67.5 \text{ miles} / 3 \text{ passes per lane} = 22.5 \text{ miles of 12 foot wide pavement per day.}$

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

1. Is the Contractor contaminating the cover material with the loading operation?
2. How is the weighing of cover material being handled? Is there adequate documentation of the conversion of tons of cover material to cubic yards?

3. If using emulsified asphalt, are the chips wet, but free of running water?
4. Are weather conditions suitable and is the surface temperature within specifications?
5. Has the surface been properly prepared?
6. Has the absorptive property of the surface been inspected and is the asphalt application rate proper for the existing surface conditions?
7. Are the asphalt distributor and the spreader box mechanically capable of making a uniform application?
8. Have tests been made to determine uniformity of application of the asphalt and of the cover material?
9. Are proper precautions taken to prevent spattering of asphalt on curbs, handrails, traffic, etc.?
10. In making transverse joints, is the Contractor using roofing paper or some other suitable material to ensure a proper junction with the preceding work?
11. Does the Contractor have sufficient labor force to do the necessary brooming and disposing of surplus cover material?
12. Is the cover material being promptly and properly rolled after application?
13. What types of rolling equipment are being used?
14. Are rollers staying close behind the aggregate spreader?
15. Is traffic control effective in keeping traffic off of the fresh seal?
16. Are the Contractor's haul units damaging the fresh seal by excessive speed, sharp turns, etc.?
17. Is traffic kept off the fresh seal the minimum time required by the specifications?

404-3.20 Slurry Seal Coat

Slurry seal consists of a mixture of sand, Portland cement, water, 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. See the Special Provisions for slurry seal coat requirements. Slurry seal coats are normally used to fill cracks and minor depressions in older AC pavement and to provide a quieter riding surface. Cracks will usually reappear but will be smaller. ADOT has been quite successful in using slurry seal coats to skid-proof bleeding areas of older pavements.

Most slurry seal 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, and emulsion into the mixing chamber in predetermined, specified proportions. The emulsion shall be 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.

Calibration Check of Slurry Seal Machine (Example)

The following is a sample calculation the Inspector can use to check the emulsified asphalt content of the slurry seal mix.

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 = 2.75 gallons
- Density of Emulsion = 240 gallons per ton (see **Standard Specification** table 1005-6)

Calculate Weight of Aggregate Per Revolution

$$\begin{aligned} &(\text{belt width}) \times (\text{belt travel}) \times (\text{material depth}) \times (\text{density}) = \text{Aggregate Weight} \\ &(20/12) \times (3) \times (3/12) \times (100) = 125 \text{ pounds} \end{aligned}$$

Calculate Weight of Emulsion per Revolution

$$\begin{aligned} &(\text{gallons per revolution}) \times (\text{gallons per ton}) = \text{Emulsion Weight} \\ &2.75 \times 2000 / 240 = 22.9 \text{ pounds} \end{aligned}$$

Calculate Emulsified Asphalt Content

$$\begin{aligned} &(\text{Emulsion Weight}) / (\text{Aggregate Weight}) \times 100 = \text{Emulsion Content} \\ &22.9 / 125 \times 100 = 18.3\% \end{aligned}$$

The specifications require approximately 18% emulsion per weight of dry aggregate (sand), and approximately 22 pounds of dry aggregate per square yard of pavement. ADOT's interpretation of "approximately" is $\pm 1\%$ for the emulsion and ± 1 pound for the dry aggregate.

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 Slurry Seal Inspection Points:

All materials including the emulsion, sand, Portland cement, and source of water should be approved before work begins. Only potable water should be used. Water from irrigation canals or wells that are unfit to drink (regardless of the reason) should not be allowed.

Mixing, placing, spreading and surface preparation shall conform to Subsections 404-3.04 and 3.05 of the Standard Specifications. 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.

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.

404-3.30 Crack Sealing (Asphaltic Concrete Pavement)

See the Special Provisions for Crack Sealing requirements. Cracks are sealed in asphaltic concrete (AC)

pavements for two reasons:

1. To prevent the intrusion of incompressible materials (like small stones or sand).
2. To prevent the 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.

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. 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 Inspector shall spot check the depths of the cleaned cracks for conformance to the specifications prior to sealing. 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.

404-3.40 Joint Sealing (Asphaltic Concrete Overlay)

Joint sealing is used for a different purpose than crack sealing. Joint sealing is required when an asphaltic concrete (AC) overlay is placed directly on an existing Portland cement concrete pavement (PCCP). The AC must be saw cut and sealed at every PCCP joint to prevent reflective cracking. See the Special Provisions for Joint Sealing requirements.

404-5 Basis of Payment

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 60/40. 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 50/50 mixture of water and emulsified asphalt. The effect is to further dilute the asphalt cement reducing the asphalt/water ratio.

When the special type of emulsified asphalt is used, a pay factor adjustment (see the **Standard Specification** table in Subsection 404-3.12) 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 404-5 of the Standard Specifications).

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 \times 60\% = \12 per ton used, and the adjustment for asphalt-rubber material would be $\$20 \times 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 404-5-1 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 404-5-1 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 404-5-1) should contain the following:

1. price of asphalt cement at bid time;
2. the pay times affected;
3. the month the material was used;
4. the price at the time of use;
5. difference between current and bid prices;
6. total tons for the month;
7. pay factor (when applicable); and
8. 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:

1. invoices, and
2. recap sheet(s) (Exhibit 404-5-1) of bituminous treatments used on the project containing:
 - A. date material used,
 - B. pay tons,

- C. weigh backs (when partial loads are used), and
- D. accumulative 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
 EHRENBURG - 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
				86.61			-4,909.16	-258.47	0.00	-5,167.63

TOTALS

Exhibit 404-5-1. Bituminous Material Price Adjustment Example

405 ROAD MIXED BITUMINOUS PAVEMENT

Road mixed surfacing is a mixture of mineral aggregate and liquid asphalt (cutback), mixed on the roadbed, or on a "mixing table" using travel mixers and/or motor graders.

405-2 Materials

Bituminous Material

Bituminous material used in road mix may be cutback asphalt or emulsified liquid asphalt and may be one of several grades available in each of the types. The grade of bituminous material will be specified in the Special Provisions. The types and grade of bituminous material used will depend on the grading of the mineral aggregate, the atmospheric temperature at the time of mixing and laying, and the traffic requirements. It should, when incorporated with the mineral aggregate, be of such viscosity that it will readily mix with the aggregate at the prevailing ambient temperature. The resulting mix should harden, or "set up" after a reasonable curing period, to support the traffic without bleeding or instability.

Mineral Aggregate

Mineral aggregate is usually produced from sources on the project. The aggregate must conform to requirements specified in the Special Provisions.

In order to obtain a uniform mix, it is first necessary to have uniform distribution of mineral aggregate on the road. Mineral aggregate will usually be placed on the road and bladed into uniform windrows. If the material has not been weighed and placed in the windrow by a controlled weight per foot, the windrows will need to be cross sectioned to get an accurate measure of the quantity of aggregate so that the correct amount of asphalt can be determined. Windrows should be sized using a device that will assure the correct amount of aggregate exists along the entire length of the windrow. Several samples of the mineral aggregate should be taken and asphalt percentage determined prior to the incorporation of asphalt into the aggregate.

The specifications require that the aggregate for liquid asphalt have 1.5% or less moisture.

Emulsion mixes generally require about 3% moisture in the aggregate.

405-3 Construction Requirements

405-3.04 Mixing

Mixing will usually be done by one of several types of traveling plants or by means of motor graders. When a motor grader is used, the top of the windrow is flattened or dished and a portion of the asphalt is sprayed onto the flattened windrow. The motor grader then folds the asphalt into the aggregate, reforms the windrow, and the process is repeated. After all the asphalt has been added, the windrow is mixed by repeatedly carrying it back and forth across the mixing table until the asphalt appears to be uniformly distributed over the aggregate particles. Complete coverage of all the aggregate will usually not occur at this time. In the event that a traveling mixing plant is used, the bituminous material will usually be incorporated and metered through the mixer. If additional mixing is required, it may be done with the traveling mixer or may be done with motor graders. In either case, mixing should continue until the aggregate is uniformly coated. When mixing with motor graders, attention should be given to the vertical angle of the blade so that a complete rolling action of the material is obtained instead of merely drifting the material from side to side.

When the volume of road mix is too large to be handled by the mixer or motor grader, the Contractor should use more than one windrow, or mix and lay in more than one lift. Road mix must be placed in more than one layer when the compacted lift thickness exceeds 2 inches.

Under certain conditions, many materials will form balls of fines and asphalt which are sometimes difficult to break up. Mixing should continue until these "asphalt balls" have disappeared. If ordinary mixing will not break them up, the condition can often be corrected by moving the mixture into a compact windrow and allowing it to cure for a few days. The heat of the sun's rays on the dark colored windrow will usually raise the temperature of the entire windrow to such an extent that the asphalt balls will break up more easily. Before final spreading, the completed mixture should have a uniform appearance and texture without alternate "fat" and "lean" sections.

When using a road-mixing machine, it may be necessary to make a number of passes through the material to obtain a uniformly mixed product. A machine that successfully mixed in one pass at some other location is no guarantee that it will do equally well on all jobs. If the machine cannot operate through partially mixed material, the mixing should be completed by motor graders.

If it should start to rain on a mix before compaction, one method used to minimize the amount of moisture entering the material is to blade the mixture into as steep a windrow as possible, and then compact the top of the windrow with a couple of passes with the wheels of the motor grader. The Contractor may have other methods he or she wishes to use to accomplish the same results; the choice of methods remains with the Contractor.

Whatever the method, the mix should be protected from moisture to reduce the time and effort necessary for aeration. The weather should be watched closely so that aeration or mixing will not be attempted when there is a high probability of rain. Moisture in the aggregate makes it more difficult to remove the volatile material resulting in more difficult mixing and compacting. Excess water also causes instability of the mix that may result in rutting or corrugating.

Bituminous material should be applied when the air temperature in the shade is above 70 °F. The aggregate is slow to coat when mixing at a lower temperature, and consequently does not quickly attain the normally black appearance of a good mixture.

It is advisable to take representative samples (40 pounds "quartered down" to approximately 10 pound) of the partially mixed material, after the proposed amount of bituminous material has been applied. Heat samples to a temperature of 100 to 140 °F and thoroughly hand mix until uniformly coated. Any excess or insufficiency of the bituminous material is readily apparent to the experienced Inspector by observation and "feel" of the mixture. Compare the mixture from the road with the samples that have been warmed and hand mixed. The samples are a measure or gauge by which the Inspector can determine when the mixture on the road has all the soil/asphalt globules thoroughly broken up and disseminated through the mixture. This test is also advantageous when road mixing mineral aggregates that have inherent properties that make them difficult to coat. Succeeding applications of bituminous material should, of course, be in accordance with the information developed by such trial hand mixing. Correction should be made to the windrow by adding asphalt or mineral aggregate whichever adjustment the tests indicate is necessary.

Aerating

Aerating is necessary for driving off excess solvent and/or moisture. The presence of an excess of either can result in corrugating and instability of the mat by overfilling the voids with liquid. The amount of moisture permitted in the mix at the time of laying should be strictly in accordance with the specifications.

The only cure for corrugations and rutting is to break up the pavement and remix it along with additional aeration. Corrugations and ruts due to excess liquid will not roll out.

In general, it can be stated that the finer graded mixtures lose their moisture and solvent more slowly than the coarser graded mixtures. They are also more sensitive to any excess of either moisture or solvent. Too much aeration, especially where the rapid-cure bituminous material is used, is also possible. This will result in a dry, "lifeless" mix, which will ravel and disintegrate under the action of traffic. Test Method AASHTO-T110 is recommended as a suitable test for determining the percentage of moisture or volatile in the mixture. Mixes can usually be laid satisfactorily when the moisture and solvent has been reduced approximately 50%.

405-3.05 & 3.06 Spreading & Compacting

Prior to allowing the spreading of the mixture over the area to be surfaced, the mixing must be complete and satisfactory. Any contention that completion of mixing will be accomplished by the spreading operation is not valid because any mixing accomplished by this operation is negligible. Some Contractors have found the use of self-propelled pavers to be to their advantage. This should be encouraged because normally it will result in a more uniform thickness and a superior riding surface.

A better appearing finished product is obtained if the tires of the grader are smooth and if the front wheels are equipped with large tires.

The appearance and riding quality of the surfacing are dependent on the skill of the operator. A skilled operator will avoid the excessive manipulation of the controls that results in poor riding quality.

It is considered good practice to lay the mixture in as many thin layers as possible; consideration being given to the size and amount of coarse material. The pneumatic compactors should be in operation throughout the entire laying operation in order to avoid differential compaction. Emulsified asphalt mixes must be compacted while there is still some moisture present--while the "break" is taking place ("break" occurs when the asphalt particles separate from the water and attach to the aggregate). The length of time it takes an emulsion to break is variable, depending upon the type of emulsifier used, aggregate characteristics, temperature, and other factors. There is a marked color change when "break" occurs, which will make a good visual guide to judging mix conditions. When there is considerable coarse material in the final lay, it should be taken across the roadway and deposited on the shoulder if there is any possibility that it might cause a rough riding surface. Final compaction will usually be done with a steel-wheel tandem compactor. Thorough compaction is necessary to develop the inherent stability of the mixture. Excessive amounts of compaction or too heavy equipment, as evidenced by displacement of the mat, are to be avoided.

405-3.07 Surface Requirements and Tolerances

Specifications require the surface to be checked with a straightedge. Surface tolerances, especially at joints, should be checked as soon as rolling is completed. If found to be unsatisfactory, corrections should be made as soon as possible. The records must show that the surface has been tested for tolerance.

ASPHALTIC CONCRETE

Description

ADOT has developed a wide variety of hot mix asphaltic concrete (AC) specifications. There are dense graded hot mixes (AC and ARAC) versus open graded hot mixes (ACFC and ARACFC). There are hot mixes (AC and ACFC) that use asphalt cement versus hot mixes that use asphalt-rubber (ARAC and ARACFC) for the binder. Some AC specifications use similar or even identical hot mix designs, but use different contract administration requirements. 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 406, 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. 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, provide excellent information on the “how to” of asphalt paving and plant inspection. 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.

The Resident Engineer and Project Supervisor should have a basic understanding of the design concept behind each type of AC specification. The 406 AC specification is most commonly used in urban areas where the pavement surface must match numerous manholes, catch basins, and gutter lips; therefore spread is not enforced. The 406 specification was changed in the 2000 version of the ADOT Standard Specifications from a method specification to an end-product type. For larger rural projects, Specification 416 or 417 asphaltic concrete (also end-product specifications) are used. The 416 specification is currently used most frequently while 417 is expected to gain more in popularity in the next few years. Specification 408 and 413 are recycled and asphalt-rubber binder pavements respectively. The 409 specification is used for much smaller projects or areas where pavement structural strength is not as critical. Specification 407, 411 and 414 are asphaltic concrete friction courses (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. Specification 414 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 406, 416 and 417 specifications also use “method” requirements for compacting thin lifts (1 ½” or less).

They have very similar inspection procedures because the specification requirements are nearly identical for production and placement, only the material properties are different. The Resident Engineer is responsible for adjusting construction methods to fit field conditions.

Their method of measurement and basis of payment are similar.

The following table summarizes the various asphaltic concrete specifications.

Application	Specification	Description
Asphaltic Concrete (AC)	406 408 (recycled), 413 (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.
Asphaltic Concrete Friction Course (ACFC)	407 414 (rubber)	Open graded mixes used for riding surfaces only; expensive, but provide superior skid resistance when needed.
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.

Asphaltic Concrete Mix Design Criteria

Specification bands are given to identify acceptable starting points for the mix design, they are NOT for production control. Once the mix design is complete and accepted there is no need for the inspector to refer to this subsection. End-product specifications, such as 406-7.04, 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 acceptance subsection of the specifications.

Mineral Aggregate

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.

As the Contractor produces the aggregate stockpiles, it is recommended that aggregate production be closely monitored and several samples be taken for gradation testing so that a correlation between the Contractor labs and the acceptance lab (regional, central or consultant lab) can be established. One of the biggest factors that affects the variations in asphalt mix properties is the aggregate crushing operation. Careful attention to this process on both the Inspector's and Contractor's part will definitely improve the chances of producing high quality asphaltic concrete for the project. Refer to the ADOT Training Manual 301R for more information on how to sample and test aggregate stockpiles.

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.

Bituminous Material

Verification testing for asphalt cements is only required when the Contractor proposes to use a new source. If this is the case, the testing should begin as soon as possible. Typically, the Department will allow the Contractor to begin paving while verification testing is underway. Certificates of Compliance or Analysis must accompany each load of asphalt cement along with a weigh ticket or bill of lading.

Pretesting is only required in the event that serious problems have recently been experienced with a particular source. The ADOT Central Lab will determine this. They also will later determine when pretesting will no longer be required.

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.

The Resident Engineer will submit the mix design to either a Regional Lab or the Central Lab for their review. 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, the test results on aggregates and the mix itself, a list of material sources and suppliers, 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.

When a mix design is submitted, the Project Supervisor should have an Inspector witness the Contractor's sampling of the aggregate stockpiles.

If the Contractor proposes to use a previously used mix design, samples do not need to be submitted. The Contractor's paperwork still needs to be reviewed for compliance with the specification before forwarding to the Regional or Central lab. Occasionally the acceptance lab 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 equivalence.

Contractor Quality Control

The Resident Engineer should discuss the Contractor's quality control (QC) procedures at each weekly meeting.

QC Procedures Checklist:

1. Is the sampling frequency the same or greater than frequencies shown in the Standard Specifications or Special Provisions?
2. Are all the testing technicians ATTI certified with the appropriate certifications as required by the specifications?
3. 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 workbooks on bituminous

pavement construction and the appropriate Asphalt Institute publications)?

4. Are there plans to do adequate testing of the mineral aggregate during crushing? As previously mentioned, crushing has the biggest impact on mix variations.
5. What are their procedures for checking equipment such as the rollers, laydown machine, and plant both before and during production?
6. Are the lines of authority clearly established; who has the ability to reject unsatisfactory materials and workmanship?

ADOT Materials Group will provide guidance in 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 described in the specifications. QC may only run a portion of a test or sample at a different point in order to expedite results and make necessary corrections.

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. It 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.

Pre-paving Meeting

It's always a good idea before any paving operation, whether it's an AC, ARAC, ACFC, ARACFC, 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; and
- what contingency plans are in place for equipment failures.

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:

1. how the test results will be reported to the Contractor;
2. who will be responsible for each type of test
3. procedures for joint construction;

4. how grades will be controlled and what type of shoes or skis should be used on the paver;
5. any areas of the project that require special treatment such as hand work or blade leveling;
6. how random sample times and locations will be established;
7. establishing a correlation between Contractor's lab and ADOT's;
8. procedures for changing any of the target values.

Hot Plant Inspection

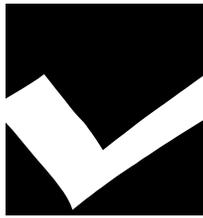
Hot plants used in the production of asphaltic concrete are of two general types: batch mix and drum mix (see Exhibit AC-2). The most important basic controls necessary to produce high quality asphaltic concrete within the required specifications are uniformity of grading, asphalt content, temperature, 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, 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 (for example 406, 409, 416, or 417);
- where the asphaltic concrete will be placed (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 potential 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; and
- 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.

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 Department of Weight and Measures, 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.



Pre-paving Meeting Project No. XXX-XXX-XX

07/25/00
8:00 AM to 9:10 AM
ADOT XXXXX Field Office

Facilitator:	Resident Engineer (RE)
Attendees:	RE, Superintendent, paving foremen, 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

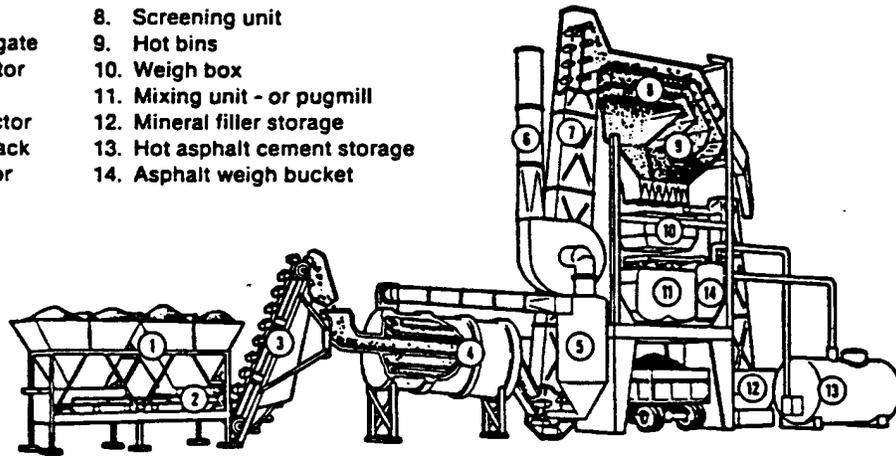
Observers:

Special notes:

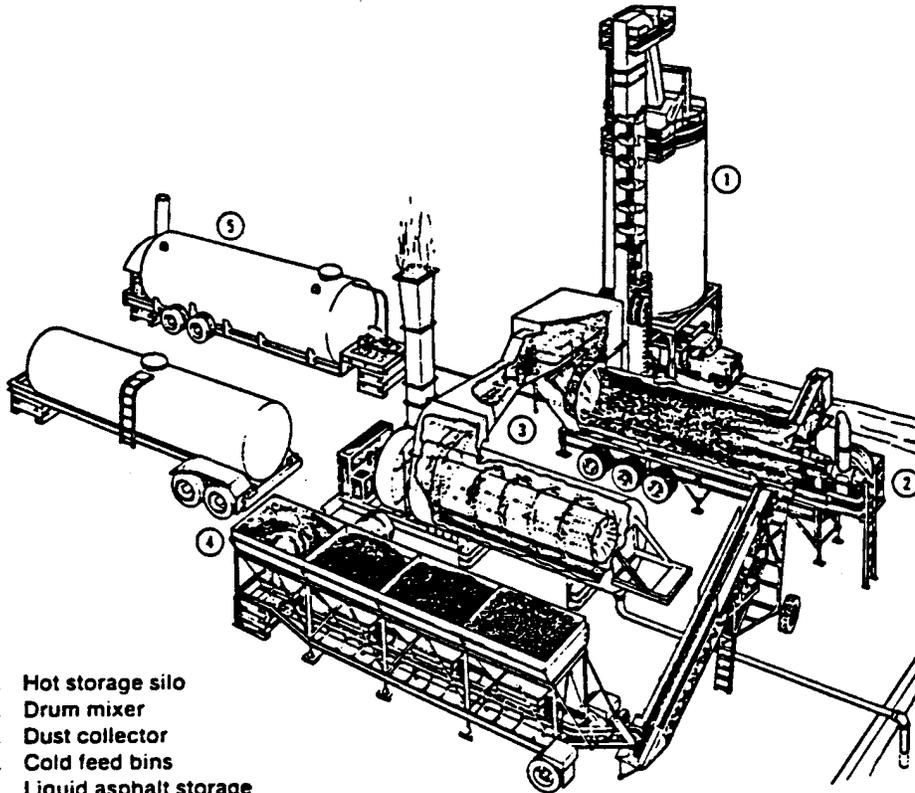
Exhibit AC-1. Pre-paving Meeting Agenda

Fourteen Major Parts

- | | |
|-------------------|--------------------------------|
| 1. Cold Bins | 8. Screening unit |
| 2. Cold feed gate | 9. Hot bins |
| 3. Cold elevator | 10. Weigh box |
| 4. Dryer | 11. Mixing unit - or pugmill |
| 5. Dust collector | 12. Mineral filler storage |
| 6. Exhaust stack | 13. Hot asphalt cement storage |
| 7. Hot elevator | 14. Asphalt weigh bucket |



Cutaway View of Typical Batch Plant



1. Hot storage silo
2. Drum mixer
3. Dust collector
4. Cold feed bins
5. Liquid asphalt storage

Typical Drum Mix Plant

Exhibit AC-2. Batch And Drum Mix Plants

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; and
- 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).
- That the admixture will be introduced without significant loss of the product during mixing.

Pugmills should be checked to ensure that the material is carried at least 3 feet (1 meter) 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°F (160°C) for AC (some high temperature PGs such as 76-XX may require 335°F [166°C]), and 350°F [175°C] 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.

The following subsections describe how each element of a hot plant operates and how to inspect it

A. Stockpiles and Cold Feeders

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.

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, cold feed, or stockpile. 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.

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 could 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 gases. 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 gases 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 drier 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 indicating 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 (409 & 411) require a recording pyrometer.

The sensing element should be installed at the discharge end of the drier in such manner that the element protrudes into the flow of the mix. It may be held by setscrews 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

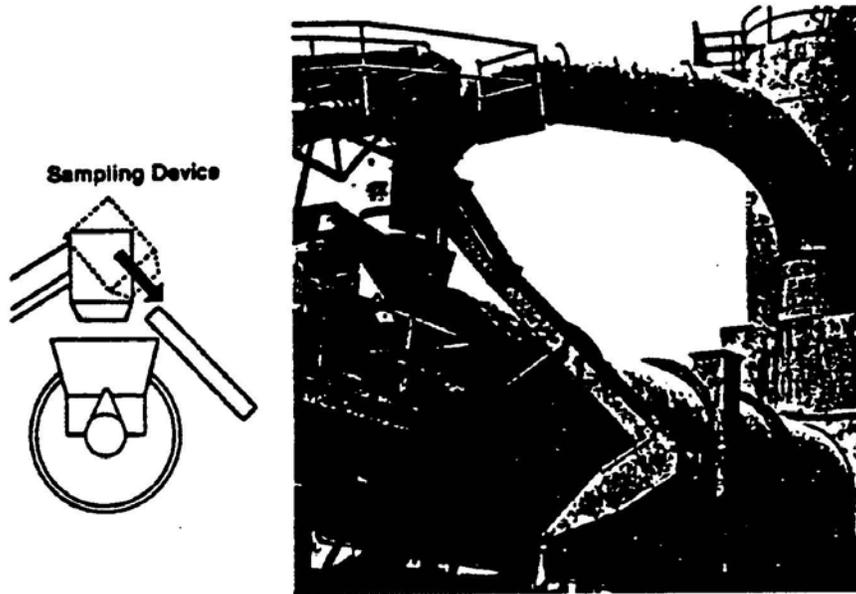


FIGURE 4.60 - Typical Sampling Device

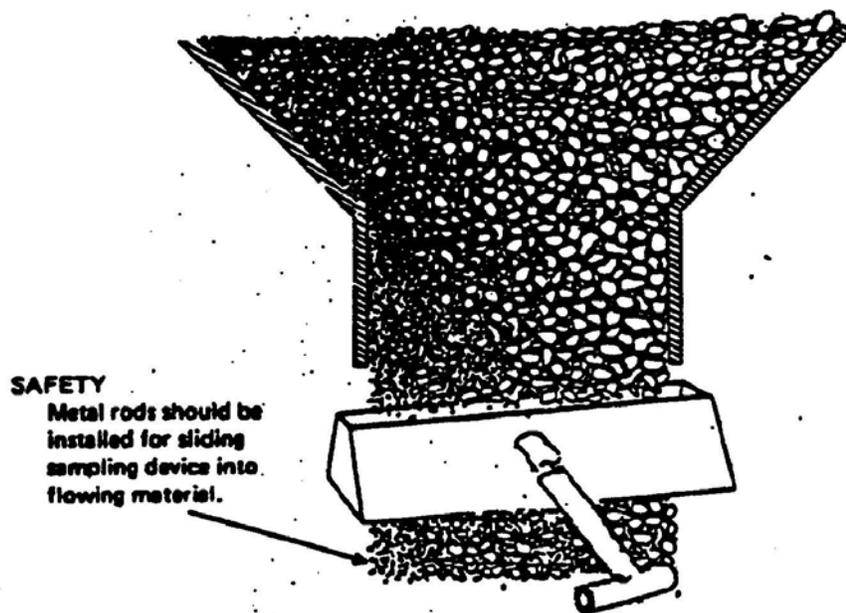


Figure III-16—Correct use of sampling device

Exhibit AC-3. Hot Plant Sampling Device.

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.

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 gases 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

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 [-75 μ m] 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.

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. Some specifications, such as subsection 406-6, describe 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; and
- 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.

On drum mix plants the samples are taken from the cold feed prior to the addition of the mineral aggregate from the stockpiles.

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.

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.

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 $\frac{1}{4}$ 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, carry-over (aggregate that does not get screened, but spills over into the next bin) occurs. 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/little 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; and
- 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;
- and

- 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 (advances) to the lower end. In a parallel flow drum (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 limited 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.

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 (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.

One last point on subgrade concerns compaction problems with the AC mix. Often, failing compaction densities will be 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 surface— 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.

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 (known as a "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.

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; or
- 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 (or two, or 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 175°F (80°C). 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.

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. 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 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.

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 occurring, 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 (2.5 meter) to 15 feet (4.5 meter). 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 affect as over controlling a motor grader or any other piece of paving equipment. Since it is known that it takes 8 feet (2.5 meter) to 15 feet (4.5 meter) 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 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.

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, semiautomatic, 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 over-rides 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 material, 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" the mat at the end, and should straightedge 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 or hot-lapped. The sloped joint is formed with a shoe attached to the end of the screed to form a slope of about 4:1 to 6:1 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. The joint should be pinched while rolling so that there is overlap by the roller between the new mat and the existing mat. As with the rest of the pavement, the compacting must be done while the mix is hot. The

density required on the sloped joint 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.

The amount of time longitudinal joints are exposed to traffic shall be kept to a minimum. They 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 the exposure of these joints can be minimized. This sometimes complicates traffic control procedures 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.

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. 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; and
- 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 (0.3 meter) by 2-foot (0.6 meter) 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

PROJECT CODE 3563

MIX TYPE 3/4 INCH

PROJ & TRAC NO.	CONTRACTOR	LOCATION			R.E./SUPVR.		
H328601C	FNF CONST.	PARKER STREETS			N. RICHARDS		
SOURCE OF M.A.	ASPH SUPPLIER	ASPH REFINERY	ASPH GRADE	ADMIX SOURCE	ADMIX TYPE		
FNF & TANNER	EOTT	PARAMOUNT, CA	AC-40	PHX. CEMT			
SAMPLE DATE	LOT NO.	TONS IN LOT	STATION	STATION	LANE	LIFT	PLANS THICKNESS
05/17/95	5	1689.77	30+35	TO 90+66	S.B	1	2.50

REMARKS:

MIX DESIGN LBS/CU FT 143.7
% ADMIXTURE 1.00

	TARGET VALUES			SAMPLE RESULTS:				AVG.	STD DEV
	UL		LL	#1	#2	#3	#4		
3/8 IN.	85	79	73	82	79	82	82	81.3	1.50
# 8	50.0	44	38.0	43	41	43	43	42.5	1.00
# 40	25	20	15	20	20	21	20	20.3	0.50
#200	5.6	3.6	1.6	4.5	4.5	4.7	4.6	4.6	0.10
% ASPH	5.40	4.90	4.40	4.63	4.73	4.75	4.93	4.76	0.12
% VOIDS	7.0	6.0	3.6	5.5	5.4	5.1	5.1	5.3	0.21
STABILITY (MINIMUM)	1750			5554	5109	5150	5323	5284	202.49
COMPACTION	146.9	142.9	138.9					143.8	1.93
BULK DENS.				146.0	145.5	145.8	146.0	145.8	0.24
RICE DENS.				154.5	153.8	153.7	153.8	154.0	0.37

CORE NO.	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
BULK DENS	146.8	141.2	144.5	145.5	142.2	142.0	145.0	145.8	143.0	142.2

FAY FACTOR CALCULATIONS:

	Q U	Q L	P U	PL	PT	PF
3/8 IN.	2.467	5.533	100	100	100	\$ 0.00
# 8	7.500	4.500	100	100	100	\$ 0.00
# 40	9.400	10.600	100	100	100	\$ 0.00
#200	10.000	30.000	100	100	100	\$ 0.00
% ASPH	5.333	3.000	100	100	100	\$ 0.00
% VOIDS	8.095	8.095	100	100	100	\$ 1.00
STABILITY						
COMPACTION	1.606	2.539	96	100	96	\$ 0.50

MIX	LOT NO.	Q L P F	TONS	PAY ADJUSTMENT
MIX	5	\$ 1.00	1689.77	\$ 1689.77
COMP	5	\$ 0.50	1689.77	\$ 844.89

LAB CODE 4
 RES. ENGR./PROJ. SUPVR: [Signature] DATE: 5/19/95
 PROJ. LABMAN: [Signature] DATE: 5-19-95
 CONTRACTOR: [Signature] DATE: _____

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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 results 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 (9.5 mm) sieve	7.0%
No. 8 (2.36 mm) sieve	6.0%
No. 40 (425 μ m) sieve	3.0%
No. 200 (75 μ m) sieve	1.0%
% asphalt	0.5%
% voids	1.5%
Compacted Density	5 lb. (2.0 kg)

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 a necessary for good contract administration.

**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.

$$\begin{aligned} \text{LO} &= \text{Avg.} - T \cdot \text{Std} \\ \text{UO} &= \text{Avg.} + T \cdot \text{Std} \end{aligned}$$

- 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 -

$$\text{LO} = 145.0 - 2.1 \cdot 2.41 = \underline{139.9} \qquad \text{UO} = 145.0 + 2.1 \cdot 2.41 = \underline{150.1}$$

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

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 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. Authority to change mix design target values lies with the Bituminous Engineer of ADOT's Pavement Material Testing Section or the State Materials Engineer.

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:

1. the underlying surface does not provide a suitable platform for compaction;
2. the existing pavement surface is too variable to obtain compaction;
3. the mix is stiff and difficult to compact;
4. the mix is tender and can be over-rolled before compaction is attained; and
5. 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,
 1. speed (should be operated within the manufacturer's recommended speeds),
 2. tire pressures on pneumatic rollers,
 3. 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.

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 for relief of 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:

1. Written justification.
2. Documentation of compaction operations including:
 - A. temperatures of the mix at discharge from hot plant and during each stage of compaction. This should be documented several times throughout the day;
 - B. production rate in tons per hour;
 - C. roller weights (from truck scales);
 - D. rolling pattern-sequence, amount of coverage, number of passes and speed of each roller (include manufacturer's recommendations);
 - E. tire pressures, frequency, and amplitude during various roller sequences and coverages;
 - F. statement regarding operating conditions of rollers; and
 - G. analysis of weather conditions, specifically temperatures, winds, and effect on compaction.

3. Nuclear gauge and core results for each Contractor test strip, and for other compaction quality control measures taken by the Contractor.
4. 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 verified. 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 nominal thickness show on the plans. They may be permitted to do so provided that compaction, testing, and acceptance of density is done in the manner required for the plans original nominal thickness. All changes in nominal layer thickness are

to be cleared with ADOT Materials Group, and verified by a change order in which the compaction thickness specifications will be stated.

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. 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 agents other than water to wet rubber or steel tires, the specification requires the 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.

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 (5 km/h) for steel wheel, and 5 mph (8 km/h) for rubber tire. 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 is 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 (95°C).

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 (18.5 km/h), an air temperature at 40°F (5°C), a dense cloud cover, and a minimum compaction temperature of 175°F (80°C). The cutoff point is 175°F (80°C), 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.

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 with a wind of 11.5 Mph. and air temperature of 40°.

TABLE A

Recommended Minimum Laydown Temperature

Base Temp.	1/2"	3/4"	1"	1-1/2"	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, Minutes	4	6	8	12	15	15

TABLE B
WIND-CHILL CHART

Wind Speed MPH	ACTUAL THERMOMETER READING °F.								
	65	60	55	50	40	30	20	10	0
	Equivalent Temperature								
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:

$$\text{Weight of pavement per foot} = 1.5 / 12 \times 13 \times 150 / 2000 = 0.12 \text{ tons per foot}$$

$$\text{Paver speed} = \frac{\text{plant production}/60}{\text{tons per foot}} = \text{feet per minute}$$

$$\text{Paver speed} = \frac{300 / 60}{0.12} = 42 \text{ feet per minute}$$

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.

$$\text{Compactor production rate} = \text{compactor speed} \times \text{efficiency} = \text{feet per minute}$$

$$\text{Steel wheel} = \frac{3 \text{ mph} \times 5280 \times 0.85}{60} = 225 \text{ feet per minute}$$

$$\text{Rubber tire} = \frac{5 \text{ mph} \times 5280 \times 0.85}{60} = 375 \text{ feet per minute}$$

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.

$$\frac{\text{width of mat}}{\text{compactor width} - \text{overlap per pass}} = \text{required passes per coverage}$$

$$\frac{13}{8 - 2} = 3 \text{ passes per coverage (always round up, not down)}$$

$$\text{Passes per coverage} \times \text{required coverages} = \text{total required passes}$$

$$3 \times 1 = 3 \text{ initial passes by steel wheel compactors}$$

$$3 \times 4 = 12 \text{ intermediate passes by rubber tire compactors}$$

$$3 \times 2 = 6 \text{ finish passes by steel wheel compactors}$$

4. Calculate the number of compactors required.

$$\frac{\text{Paver speed} \times \text{total required passes}}{\text{Compactor production rate}} = \text{required number of compactors}$$

$$\frac{42 \times 3}{225} = 1 \text{ steel wheel compactor for initial rolling}$$

$$\frac{42 \times 12}{375} = 2 \text{ rubber tire compactors for intermediate rolling}$$

$$\frac{42 \times 6}{225} = 2 \text{ steel wheel compactors for final rolling}$$

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 (25 millimeters) thick or when the mat temperature is less than 180°F (80°C). 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 (40 millimeters). To help maintain the desired spacing, the following relationships can be used as a guide.

Speed	Millimeters Between Impacts					
	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 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", such as 406-6, 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:

1. Frozen subgrade as evident by the fact that a shaded surface thermometer reads 32°F (0°C) or less, or the subgrade is excessively hard- the entrapped water has turned to ice.
2. For thin lifts and ACFCs certain surface temperature requirements such as 80°F (27°C) for an AR-ACFC are not being met.
3. Muddy subgrade due to the material being too wet.
4. Standing water on the subgrade. This can usually be remedied by using pumps and/or an air hose.
5. Precipitation. A light rain or snow is sometimes OK as long the mat does not cool down too quickly.
6. 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,

7. 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 have 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 than 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 value 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 406, 407, 408, 409, 411, 413, 414, 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 406 is based on the content determined from ignition furnace testing multiplied by the number of tons in each lot (after the asphaltic concrete wasted is subtracted from the daily tonnage)
- AC 409 Miscellaneous Structural; bituminous material is not measured for payment.
- AC 413 asphalt-rubber content is determined with a nuclear asphalt content gauge.

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's intended that the Contractor submits the following information on a daily basis:

1. Tracs No. (or Project No.)
2. Contractor
3. Date of Asphaltic Concrete Production
4. Tons of Asphaltic Concrete (AC) Produced
5. Tons of Asphaltic Cement (Asphalt) Used (plant information)
6. Tons of Mineral Admixture Used (Use A or B below)

- A. Hot Plant computer printout indicating actual weight (attach printout to the submittal).
- B. Silo weight at beginning and end of shift plus Mineral Admixture added to silo during the shift (attach invoices to the submittal).

7. 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 (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:

$$\text{Percent Admixture} = \frac{(\text{Admixture})}{(\text{AC}) - (\text{Verified Asphalt}) - (\text{Admixture})}$$

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.): IR-10-1(10)

CONTRACTOR: J.R. Good

DATE PRODUCED: B May 2001

TONS OF ASPHALTIC CONCRETE (AC) PRODUCED: 2,294.35

TONS OF ASPHALT CEMENT (Asphalt) USED: 102.10

TONS OF MINERAL ADMIXTURE (Admixture) USED: 21.28

Attachment (A or B) B

A) Hot plant computer printout indicating actual weight

B) Invoices showing silo weights (beginning and end of shift) plus admixture added

$$\begin{aligned}
 \text{PERCENT ADMIXTURE} &= \frac{(\text{Admixture})}{(\text{Aggregate})} = \frac{(\text{Admixture})}{(\text{AC}) - (\text{Asphalt}) - (\text{Admixture})} \\
 &= \frac{(21.28)}{(2294.35) - (102.10) - (21.28)} \\
 &= \underline{0.98} \% \text{ Admixture} \\
 &\hspace{15em} (\text{Not for Payment})
 \end{aligned}$$

This percentage complies with the approved mix design.
 does not comply with the approved mix design.

Blow N. Go
 Signature (Contractors Representative)

The Pay Item Documentation for Inspectors Manual provides guidance in how to field document AC paving operations. Field Office documentation includes:

1. Recap of asphaltic concrete payments by lot (see Exhibit AC-8). As a minimum, the recap should include:
 - A. date material used,
 - B. lot number,
 - C. asphaltic concrete pay tons,
 - D. percent asphalt cement from the materials lab sheet (see Exhibit AC-4),
 - E. asphalt cement pay tons,
 - F. percent admixture,
 - G. admixture pay tons,
 - H. bonus/penalty pay factors,
 - I. accumulative totals for the above items.
2. Daily Mineral Admixture Report (see Exhibit AC-7).
3. Hot plant computer printout.
4. Materials lab sheets for each lot (see Exhibit AC-4).
5. Documentation for penalties/bonuses (any changes to the Standard Specifications or Special Provisions will require a change order or minor alteration).

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:

1. Mix temperature and pavement depth field book.
2. Straightedge and rolling pattern field book.
3. Laboratory test reports on mix properties and compaction.
4. Asphalt cement invoices.
5. Daily mineral admixture reports.
6. Daily pyrometer readings from the plant.
7. Basis of payment recap sheets performed on MS Excel spreadsheet.
8. Daily asphalt spread calculation sheets.
9. Daily inspection diaries complete with weather conditions and air temperatures.

**PROJECT # IR-10-1(10)
ASPHALT CONCRETE RECAP SHEET**

(416 & 417)
(only)

DATE	LOT #	A.C. PAY TONS	% ASPH. CEMENT	PAY ASPH. CEMENT	% MIN ADMIX	PAY ADMIX	MIX PAY FACTOR	MIX BONUS/PENALTY	COMP. PAY FACTOR	COMP. BONUS/PENALTY	SPREAD LOT PAY FACTOR
1-May-01	1	1,247.80	4.53%	56.53	1.00%	11.79	(\$0.50)	(\$623.90)	\$0.00	\$0.00	\$0.00
2-May-01	2	1,891.72	4.11%	77.75	1.00%	17.96	\$0.75	\$1,418.79	\$0.00	\$0.00	\$0.00
3-May-01	3	2,372.26	4.46%	105.80	1.00%	22.44	\$0.50	\$1,186.13	\$0.00	\$0.00	\$0.00
4-May-01	4	3,247.47	4.12%	133.80	1.02%	31.44	\$0.00	\$0.00	\$0.00	\$0.00	\$0.00
5-May-01	5	2,835.11	4.31%	122.19	1.05%	28.19	\$1.00	\$2,835.11	\$0.00	\$0.00	\$0.00
6-May-01	6	1,484.69	4.39%	65.18	0.95%	13.36	\$1.00	\$1,484.69	(\$0.25)	(\$371.17)	\$0.00
7-May-01	7	821.91	4.51%	37.07	1.00%	7.77	\$1.00	\$821.91	\$0.50	\$410.96	\$0.00
8-May-01	8	2,294.35	4.45%	102.10	0.98%	21.28	\$1.00	\$2,294.35	\$1.00	\$2,294.35	(\$458.87)
9-May-01	9	2,454.40	4.31%	105.78	1.00%	23.25	\$0.50	\$1,227.20	\$1.00	\$2,454.40	\$0.00
10-May-01	10	3,052.84	4.34%	132.49	1.00%	28.91	\$1.00	\$3,052.84	\$1.00	\$3,052.84	\$0.00
11-May-01	11	2,992.63	4.37%	130.78	1.04%	29.46	\$1.00	\$2,992.63	\$0.50	\$1,496.32	\$0.00
12-May-01	12	1,300.50	4.36%	56.70	1.00%	12.31	\$1.00	\$1,300.50	\$0.00	\$0.00	(\$130.05)
13-May-01	13	1,344.58	4.22%	56.74	1.00%	12.75	\$0.25	\$336.15	\$1.00	\$1,344.58	\$0.00
14-May-01	14	3,230.68	4.39%	141.83	1.01%	30.89	\$1.00	\$3,230.68	\$0.50	\$1,615.34	\$0.00
16-May-01	15	3,715.15	4.53%	168.30	1.00%	35.12	\$1.00	\$3,715.15	\$0.50	\$1,857.58	\$0.00
17-May-01	16	2,655.69	4.65%	123.49	0.99%	24.82	\$0.50	\$1,327.85	\$0.50	\$1,327.85	\$0.00
18-May-01	17	3,451.20	4.62%	159.45	1.00%	32.59	\$0.25	\$862.80	\$0.50	\$1,725.60	\$0.00
19-May-01	18	3,371.26	4.52%	152.38	1.00%	31.87	\$0.50	\$1,685.63	\$0.50	\$1,685.63	(\$337.13)
20-May-01	19	2,048.45	4.43%	90.75	0.97%	18.81	\$1.00	\$2,048.45	\$1.00	\$2,048.45	\$0.00
21-May-01	20	3,502.50	4.47%	156.56	1.03%	34.11	\$1.00	\$3,502.50	(\$0.50)	(\$1,751.25)	\$0.00
TOTALS:		49,315.19		2,175.66		469.12		\$34,699.45		\$19,191.46	(\$926.05)

Exhibit AC-8. Recap Sheet

406 ASPHALTIC CONCRETE

Specification 406 asphaltic concrete is most commonly used in urban areas where the pavement surface must match numerous manholes, catch basins, and gutter lips; therefore spread is not included in the specifications. This specification was changed in the 2000 version of the ADOT Standard Specifications from a method specification to an end-product specification. These changes are significant in several ways.

1. The Contractor no longer follows a set of prescribed procedures (method specification) in producing and placing the asphalt. Now 406 is a quality assurance (end-product) specification where the Contractor generally has more freedom in how the material is placed and produced.
2. The material properties have changed, but the inspection procedures have not changed much since the specification requirements are nearly identical for production and placement.
3. The method of measurement and basis of payments have changed.

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 406.

406-2 Asphaltic Concrete Mix Design Criteria

Specification bands are given to identify acceptable starting points for mix design, they are NOT for production control. Once the mix design is complete and accepted there is no need for the inspector to refer to this subsection. The upper and lower limits of production control bands are found in 406-7.04 and are based on the target values given in the particular mix design for each individual project.

406-3 Materials

Fine aggregate must be obtained from crushed gravel or crushed rock in accordance with subsection 406-3.01 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 but the blend of all the fine aggregate must meet the uncompacted voids requirement and the natural fines cannot have more than 4% finer than the #200 sieve.

Mineral admixture may be called for in the mix design. If it is required, the mineral admixture will be 1.0% by weight of the mineral aggregate. It can be as much as 2.0% if testing shows that amount is necessary to meet the Index of Retained Strength (Immersion Compression) requirements. The specifications allow three types of mineral admixture. 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 that these dry materials have been wetted during storage. 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 slaked. It can still look like a dry powder even though there is some water combined in it. The inspector is made aware of these differences because CaO is dangerous to handle and if blended into the asphaltic concrete it will damage it.

Bituminous material will be a PG grade and the type will be found in the Special Provisions for the project.

406-4 Mix Design

The best way to check a mix design is to carefully read Subsections 406-2, 3, 4, and 5 of the Standard Specifications and verify that each provision is included in the mix design.

406-6 Construction Requirements

Although the 406 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.

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 406-6 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 AC.

406-7 Acceptance

Although acceptance testing is done by random sampling, the Inspector still has the authority under 406-7.01 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.

Significant deviations in asphalt content from the percentage called for in the design (more than $\pm 0.2\%$) 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.

For acceptance, rejection, and payment purposes, asphaltic concrete paving production is broken down into "lots." The lot usually represents the amount of asphaltic concrete placed during one shift (416-7.04 for example), or one-half shift of production (416-7.03 for example), but there are exceptions (for example 406-7.04 allows combination of multiple shifts). Sometimes the lot is limited to a maximum specified quantity (407-9.03 for example). 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.

Once a section of paving has been completed, the Inspectors are now in a position to accept or reject that portion of the work. The Inspector should:

1. Check for straightedge tolerances particularly, at the joints.
2. Layout the compaction core locations.
3. Mark lots which are in reject due to any failures in mix properties (such as 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 the test results show failure of any of the mix properties or compaction requirements, the area represented by the samples should be rejected. However, keep in mind that these samples are not to be included in the random samples for lot acceptance and pay factor adjustments. They pertain only to isolated areas. Only the test results of the random samples apply to the entire shift's production.

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" and it is generally the best method for ensuring the most representative distribution of random samples. Stratified Random Sampling is not discussed in the 2000 ADOT Standard Specifications and therefore it is neither required nor prohibited. The choice to utilize this method must be made 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 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 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.

406-7.05 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. 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. 10 cores will be taken from each lot at random locations. The target is 98% of lab density. Results will be furnished to the contractor within 5 working days of receipt of the samples.

Carefully review subsection 406-7.05(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 implied (tacit) approval of any method.

The Resident Engineer has the ability under 406-6 to suspend paving operations if weather conditions would adversely affect the quality of the asphalt pavement. 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.

406-7.06

This section has been removed

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 $\frac{1}{2}$ to $\frac{3}{4}$ inch (12 to 19 millimeters). 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 for specification 407. There are important differences.

1. ACFC mix properties are different than AC, including the aggregate gradations, asphalt content, abrasion, percent of limestone in the aggregate, and specific gravity.
2. A higher percent of fractured coarse aggregate particles (crushed faces) is specified for ACFC and there is a flakiness index requirement.
3. 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.
4. 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.
5. There are ACFC placement date restrictions and surface temperature requirements.
6. Paving machine grade control devices are limited to short and long skis . Longitudinal pavement joints are permitted only at the centerline between adjacent lanes.
7. There is no ACFC compaction density requirement.
8. 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.
9. 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. Therefore, it is important that the Resident Engineer check with the acceptance lab to ensure that they can complete the verification testing within the prescribed time.

Occasionally, the Contractor requests referee testing on a mix design that has failed verification testing. Only labs approved by ADOT's Materials Section can be used for referee testing. The acceptance lab will keep a split of the sampled materials used in the verification testing for use by the referee lab.

Compaction devices are limited to steel wheel compactors. Vibratory steel wheel compactors may be used in the static mode as long as the weight requirements are met. Because ACFC is porous and placed in thin lifts, it cools quickly (which is the reason for the surface temperature requirements). The rollers need to stay close behind the laydown machine, especially when the air is cool or when there is a wind.

The binder will separate from the aggregate when ACFC is stored for long periods of time in hot storage silos, or when the haul distance is long and the weather is hot. Typically, the asphalt will drain down resulting in a leaner mix at the top and richer mix at the bottom. When placed, this segregated mix will result in rich spots on the surface. Inspectors need to be alert for this condition and ensure it does not become a chronic problem.

It is important for the Inspector to control the spread. ACFC is an expensive material and should be used prudently (not in turn-outs or guard rail areas for example).

408 RECYCLED ASPHALTIC CONCRETE

Recycled asphaltic concrete is actually a mixture of new aggregates and asphaltic concrete salvaged from an existing pavement. Materials, testing procedures, and construction requirements are quite similar 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 408. The differences are brought about by the addition of salvaged pavement to the mix and the fact that 408 is a method specification with an end-product compaction specification for lifts greater than 1-½" thick (40 millimeters).

A self-propelled milling machine designed to break up the pavement into smaller, aggregate-sized pieces usually removes the existing asphaltic concrete. Usually, the pavement is removed for only a fraction of the existing depth, making a trench with undisturbed material on either side and on the bottom. The plans will give details of the depth and width of the trench. The specifications should limit the amount of time the trench will remain open, or limit the length of milled trench ahead of the re-paving. The vertical sides of the trench are a safety hazard to the traveling public because the abrupt drop-off may cause motorists to momentary loose control. Work out a plan at the pre-paving meeting with the Contractor so that the exposure of these vertical trench edges can be minimized. This sometimes complicates traffic control procedures but in the end it is the best thing for the traveling public.

The salvaged aggregate will come from previously stockpiled material or from material removed from the existing roadway. This will be determined by the contract documents. Crushing and screening are required before the salvaged material can be added to the mix. Any crushed pavement must be fine enough that only a small amount of screening is necessary to remove a superficial quantity of oversize.

The inspection and testing for recycled asphaltic concrete construction differs from new asphaltic concrete construction in a number of ways.

1. The Contractor will select an aggregate source then submit a 300 pound (135 kilogram) sample of new aggregate for tentative approval together with a letter that identifies the aggregate source, asphalt cement source, mineral admixture source and type. A mix design will be made using the Contractor's new material and salvaged asphaltic concrete pavement material obtained by the Resident Engineer.
2. When samples are obtained for the trial mix designs, they need to weigh at least 150 pounds (70 kilograms) for each stockpile. The new mineral aggregate has to be stockpiled in at least three piles with the gradation requirement given in the specifications. The Resident Engineer may approve grading limits for more than three piles. The salvaged asphaltic concrete is required to be placed in two stockpiles for which the grading limits are specified. All the salvaged asphaltic concrete must pass a 1-½ inch (37.5 millimeter) sieve but the milling technique must create a minimum amount of fines.
3. Once the stockpiles have been established, the Resident Engineer may vary the amounts used from proportions set up in the Special Provisions by 10% without the need for a change order. The percent of recycled aggregate used in the mix may also vary (see Subsection 408-3.07)
4. The trial mix design made from these materials will be used by the Contractor to start production. As soon as production has stabilized during the first shift, the mix will be sampled to check the mix design. If all the design criteria are met, the mix being used will be considered the initial mix design. Once there is an approved initial mix design, acceptance at the cold feed will be based on the

average of three consecutive tests.

5. It is important to test the stockpiles daily during stockpile production. As with other asphalt mixes, the successful control of mix properties is often best achieved by strict control of the crushing operation. This is especially important with recycled asphalt because of the inconsistent nature of the recycle materials. During asphalt production the amount of material used from each stockpile may be varied up to 5% from the design percentages without a new mix design.
6. The Department has the right under Subsection 408-4.02 to stop the work after the first day of production if the mix design or gradation criteria are not being consistently met. This allows enough time to formulate a new mix design. Experience has shown that the mix properties of recycled asphalt are highly variable and adjustments to the aggregate proportions are often needed. This is due to the fact that the recycled materials themselves are variable. Recycled materials frequently contain pavements (and thus asphalt cements) of different ages and gradations, as well as part of the underlying material that is unavoidably picked up by the milling and removal operations.

Resident Engineers and Project Supervisors should realize that every recycled project is different because of the unique combinations of recycled materials that are encountered. This uniqueness affects mix properties and thus the inspection requirements for each project. Some recycled asphalts compact very well on one project, but poorly on others. Materials from older pavements may affect flow and stability on the last project but may not be an issue on the current one. In addition, during the life of a project, certain mix properties may fall out of specification as the characteristics of the recycled materials change. ADOT's Inspectors and Project Supervisors may need to be flexible in recycled asphalt plant and pavement inspection because the material cannot be controlled as well as some other types of paving projects.

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. Applications include guardrail pads, temporary paving (example: detours), erosion control measures, and areas where constructability issues limit compaction (spot milling, leveling, narrow roadway widening, turnouts, etc.). 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 409. The main differences are as follows.

1. Acceptance is based on "reasonable conformance" instead of sampling and testing.
2. The asphalt cement and mineral admixture are not paid separately, but are included in the basis of payment for Asphaltic Concrete - Miscellaneous Structural.

409-2 Materials

Two Gradations are given in the Standard specs., one for lifts of 2" or less and the other for lifts greater than 2". The mix design should be checked against this table.

Bituminous material shall be a PG grade shown in the Special Provisions.

409-3 Construction Requirements

The temperature of the mix discharged at the plant cannot exceed 325°F. The surface temperature must be 65°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 on are 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 asphaltic 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.

410 ASPHALT-RUBBER STRESS-ABSORBING MEMBRANE

Stress-absorbing membranes containing asphalt-rubber mixtures are used as an interlayer under asphaltic concrete pavement or as a chip seal coat. A stress-absorbing membrane is designed to seal cracks with a strong, resilient material that will absorb the future crack movement without the membrane 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. The Inspector should not confuse Special Provisions for a "Prefabricated Membrane" (for bridges) with those for a "Stress-absorbing Membrane" (for roadways). They have similar names, but they are different products and have different specifications.

Stress-absorbing membrane requirements are similar to 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 saturated surface dry (SSD) and pre-coated with asphalt cement; never wet the chips for dust control.

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 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, dependent on elevation. If the various steps in the operation are not timed correctly, there probably will be a loss of chips. Unlike a regular chip seal, the membrane requires approximately a 4-inch (100 millimeter) lap of the longitudinal joint.

411 ASPHALTIC CONCRETE FRICTION COURSE (MISCELLANEOUS)

Miscellaneous asphaltic concrete friction course does not require that a formal mix design be developed. The project may involve small quantities or specialized work involving the asphaltic concrete friction course. The Contractor may elect to use a commercial source or any source approved by the Resident Engineer to produce the aggregates. The Engineer will specify the content of asphalt cement and ensure that the mix produced is acceptable. 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 240°F. Although this is not specified in 411 it is a useful guideline for the Inspector to be able to help identify problems if necessary.

411-3 Construction Requirements

Temperature just prior to compaction must be at least 200°F. The surface temperature must be 85°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.

The paver is required to have automatic screed controls and paving must be stopped if the system does not function properly.

The contractor is not required to submit a daily pyrometer record.

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°F (175°C) and 400°F (205°C) 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 (75 μ m) 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 a dirtier (out of specification) 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 (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 some water combined in it. The inspector is made aware of these differences because CaO is dangerous to handle and 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 check 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 gage. 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 "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 set up 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 (18°C), 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 (21°C) 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 (21°C), then it should be OK to continue paving, especially when it's acceptable to begin paving when the surface temperature is only 65°F(18°C). 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 probably 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” (25 millimeters) 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.

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 a product approved by the Resident Engineer. 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.

Some other inspection points include:

1. Verify that the crumb rubber and asphalt cement have been in the reaction tank at 325°F to 375°F (163°C to 191°C) for at least one hour prior to use in the mix (see Subsection 1009).
2. Keep a daily count of the number of bags of crumb rubber used.
3. Asphalt-rubber that has been kept in the reaction tank for more than 10 hours above 325°F (163°C) 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 & 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;

1. Asphalt-rubber is measured and paid instead of asphalt cement.
2. 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 weight directly, or calculated from the weight of asphalt cement and crumb rubber used minus the waste.
3. 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 (ARACFC) 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°F (163°C) and 375°F (191°C) 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.

ARACFC 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, ARACFC 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 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.

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. 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 check with the acceptance lab to ensure that they can complete the verification testing within the prescribed time.

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. 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.

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 correlation with the Department's gages. The daily standard counts should be checked for significant variations. Nuclear gages are required to be calibrated for each asphalt mix.

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 documented.

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 "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 set up 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 ARACFC than for other types of asphaltic concrete. Strict adherence to the temperature specifications is required because ARACFC is placed in thin lifts that cool very rapidly. The rate of cooling is directly related to surface temperatures and weather conditions.

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 should be well documented. 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 ARACFC 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 a product approved by the Resident Engineer. 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.

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:

1. 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.
2. Keep a daily count of the number of bags of crumb rubber used.
3. Asphalt-rubber that has been kept in the reaction tank for more than 10 hours at temperatures above 325°F (163°C) should not be used. "Carry-over" should be allowed to cool before the 10-hour time limit and then re-heated. 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's Training Manual for the Inspection of Bituminous Roadway Construction should serve as a guideline for assigning inspection duties.

414-8 & 9 Method of Measurement & Basis of Payment

The method of measurement for ARACFC is the same as for Specification 407 ACFC, except as follows;

1. Asphalt-rubber is measured and paid instead of asphalt cement.

2. 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 weight directly, or calculated from the weight of asphalt cement and crumb rubber used minus the waste.
3. 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.

416-2 Mix Design Criteria

Specification bands are given to identify acceptable starting points for mix design, they are NOT for production control. Once the mix design is complete and accepted there is no need for the inspector to refer to this subsection. The 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.

416-3 Materials

416-3.01 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. 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.

416-3.02 Mineral Admixture

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 fines but the blend of all the fine aggregate must meet the uncompacted voids requirement and the natural fines cannot have more than 4% finer than the #200 sieve.

Mineral admixture may be called for in the mix design. If it is required, the mineral admixture will be 1.0% by weight of the mineral aggregate. It can be as much as 2.0% if testing shows that amount is necessary to meet the Index of Retained Strength (Immersion Compression) requirements. The specifications allow three types of mineral admixture. 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 that these dry materials have been wetted during storage. 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 there is some water combined in it. The inspector is made aware of these differences because CaO is dangerous to handle and if blended into the asphaltic concrete it will damage it.

416-3.03 Bituminous Materials

Bituminous material will be a PG grade and the type will be found in the Special Provisions for the project.

When there is a source of asphalt cement that has not previously been used, it is a good practice to sample the asphalt cement as soon as it arrives at the plant. The acceptability of this “new” material should be determined as quickly as possible before too much pavement is placed. 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

Under any end-product specification (406, 416, & 417), ADOT does not verify the Contractor's mix design. ADOT only approves the lab that does the mix design. The Resident Engineer should check to ensure that a lab from the Materials Group's list of approved labs is used to perform the mix design.

The Contractor will submit the finished mix design, with the split samples used to develop it, to the field office. Before the field office forwards the mix design to the Regional Materials Lab or the Materials Pavement Testing Section for review, the Resident Engineer or Project Supervisor should review the mix design to ensure that all the information required by subsections 416-2 and 4 have been met. In addition, checking for compliance with the mix design criteria, aggregate gradation limits, and asphalt to dust ratio, the Resident Engineer 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 ADOT Materials Group.

For a previously used mix design, the Resident Engineer should still submit the design to the Regional Materials Lab for review to determine if additional testing is needed.

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 and Inspectors should become very familiar with these target values and a copy of the mix design should be available at the project site. During paving, changes to target values may occur which will affect payment factors for each lot. The Project Supervisor or Lead Inspector should track the target values on a daily basis in the daily diary. This will make sorting out acceptance values and pay adjustments 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.

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. Subsection 416-6 of the Standard Specifications:

1. Describes the requirements for admixture mixing and control.
2. Requires the use of the automatic screed control device on laydown machines.
3. Requires the contractor to submit a copy of the pyrometer record at the end of each shift.
4. Specifies the use of a system to stop the mixing if mineral admixture flow is stopped.
5. Requires all core holes to be patched within 48 hours
6. Requires all vertical edges to be tacked as directed.
7. 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 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 $\pm 0.2\%$) 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:

1. Check for straight edge tolerances particularly, at the joints.
2. Layout the compaction core locations.
3. Mark lots which are in reject due to any failures in mix properties (such as 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 the test results show failure of any of the mix properties or compaction requirements, the area represented by the samples should be rejected. However, keep in mind that these samples are not to be included in the random samples for lot acceptance and pay factor adjustments. They pertain only to isolated areas. Only the test results of the random samples apply to the entire shift's production.

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" and it is generally the best method for ensuring the most representative distribution of random samples. Stratified Random Sampling is not discussed in the 2000 ADOT Standard Specifications and therefore it is neither required nor prohibited. The choice to utilize this method must be made 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 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 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

The main difference between 416 and 406 is the requirement for spread lots. 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 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 416-9).

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:

1. 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.
2. 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).
3. 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.

Example Calculation

A Contractor places 1,260 tons of asphaltic 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 416-2 of the Standard Specifications).

	PT	PF (from table 416-2)
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 factor for sieve and % asphalt)
Compaction	95	+\$0.50

If the Contractor's unit price for asphaltic concrete is \$18 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	<u>1250</u>			Placed	<u>1445</u>		
Excluded	25			Excluded	0		
Net Spread	<u>1225 tons</u>			Net Spread	<u>1445 tons</u>		
Calc. Spread	1210 tons			Calc. Spread	1510 tons		
Yield	1.24%	$\frac{\text{net-calc.}}{\text{calc.}} \times 100$		Yield	-4.30%		
Pay Factor	\$0.00			Pay Factor	-\$0.30		
(Table 416-2)				(Table 416-2)			

Note: the rumble strip quantity is included in 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

Project No. IM—010-C(9) / H999901C

Type of Material ¾ inch AC

Date 7/30/01

Lot Number 3 AM

Calculation of Quantity Required (Tons)							
Laboratory Mix Design Density = <u>142.2</u> pounds per cubic foot							
Location	Station	to	Station	Length	*Width	Average Thick. (inch)	
WB	507+00		451+00	5600	16.5	1.5	
Total Calculated Cubic Foot in Lot =						11,550	
<p>Calculated Tons Required = $\frac{(\text{Total Calculated Cubic Foot in Lot}) \times (\text{Lab Mix Design Density})}{2000}$ = _____</p> <p style="text-align: center;">= $\left(\frac{11,550}{2000} \right) \times (142.2)$ = <u>817.6</u> ton</p>							
<p>* For areas with varying widths, such as tapers, use average width</p> <p>** Calculated Cubic Foot = $\frac{(\text{Length}) \times (\text{Width}) \times (\text{Average Thickness})}{12}$</p>							
Actual Quantity Placed = <u>833.1</u> ton						Table 416-2	
<p>% Variance from Quantity Reported = $\frac{(\text{Quantity Placed}) - (\text{Quantity Required})}{(\text{Quantity Required})} \times 100$ = _____ %</p> <p style="text-align: center;">= $\frac{(833.1) - (817.6)}{(817.6)} \times 100$ = <u>+1.9</u> %</p> <p>If the percent variance from the required quantity is more than 5.0%, no payment is made for material that exceeds 5.0% (record calculations and deductions for asphalt cement and mineral admixture in the Remarks area below). If the percent variance from the required quantity is +5.0% to -2.0%, no adjustment is made. If the percent variance from the required quantity is -2.1% to -12.0% the appropriate pay factor determined from Table 416-2 = _____</p>						Pay Factors for Material Spread	
						Negative Variance %	Pay Factor (Dollar)
						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

Remarks: Ticket No. 319878 thru 320072 (3tons not used)

Asphalt Cement Deduction (if applicable): _____ ton

Mineral Admix. Deduction (if applicable): _____ ton

Contractor's Signature: _____

Inspector's Signature: _____

Exhibit 416-7.03-1. Spread Determination Form

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. 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 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 implied (tacit) 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 NOT for production control. Once the mix design is complete and accepted there is no need for the inspector to refer to this subsection. The 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.

417-3 Materials

417-3.01 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. 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.

417-3.02 Mineral Admixture

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 but the blend of all the fine aggregate must meet the uncompacted voids requirement and the natural fines cannot have more than 4% finer than the #200 sieve.

Mineral admixture may be called for in the mix design. If it is required, the mineral admixture will be 1.0% by weight of the mineral aggregate. It can be as much as 2.0% if testing shows that amount is necessary to meet the Index of Retained Strength (Immersion Compression) requirements. The specifications allow three types of mineral admixture. 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 that these dry materials have been wetted during storage. 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 there is some water combined in it. The inspector is made aware of these differences because CaO is dangerous to handle and if blended into the asphaltic concrete it will damage it.

417-3.03 Bituminous Materials

Bituminous material will be a PG grade and the type will be found in the Special Provisions for the project.

When there is a source of asphalt cement that has not previously been used, it is a good practice to sample the asphalt cement as soon as it arrives at the plant. The acceptability of this "new" material should be determined as quickly as possible before too much pavement is placed. 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 Procedure

Specification bands are given to identify acceptable starting points for mix design, they are not for production control. Once the mix design is complete and accepted there is no need for the inspector to refer to this subsection. The upper and lower limits of production control bands are found in 406-7.04 and are based on the target values given in the particular mix design for each individual project. 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 Gyrotory 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%.

There is one more allowable self-directed target change ($\frac{3}{4}$ inch sieve; +/- 2%) and the +/-1% allowed on the No.40 sieve under the 416 Standard Specifications is now changed to the No.30 sieve instead.

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.

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:

1. Describes the requirements for admixture mixing and control.
2. Requires the use of the automatic screed control device on laydown machines.
3. Requires the contractor to submit a copy of the pyrometer record at the end of each shift.
4. Specifies the use of a system to stop the mixing if mineral admixture flow is stopped.

5. Requires all core holes to be patched within 48 hours
6. Requires all vertical edges to be tacked as directed.
7. 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.

Significant deviations in asphalt content from the percentage called for in the design (more than $\pm 0.2\%$) 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.

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.

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:

1. Check for straight edge tolerances particularly, at the joints.
2. Layout the compaction core locations.
3. Mark lots which are in reject due to any failures in mix properties (such as 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 the test results show failure of any of the mix properties or compaction requirements, the area represented by the samples should be rejected. However, keep in mind that these samples are not to be included in the random samples for lot acceptance and pay factor adjustments. They pertain only to isolated areas. Only the test results of the random samples apply to the entire shift's production.

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. 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 2000 ADOT Standard Specifications and therefore it is neither required nor prohibited. The choice to utilize this method must be made 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 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 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.

417-7.04 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.

The inspector must also be aware of the increased sample size require for this type of mix. The Standard Specifications call for a 130-pound (60 kilograms) minimum sample weight due to the larger size of the laboratory specimens. On lifts of less than 3 inches (75 millimeters) this will usually require two plates to get an adequate sample weight and it will fill more than one bucket as well.

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. 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 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 implied (tacit) approval of any method.

Instead of a compaction target of 98% of laboratory density as called for under 416; the 417 target is 7% in-place air voids. The UL and LL are +2% and -3% voids respectively, instead of +/- 4 pounds per cubic foot as in 416.