401 PORTLAND CEMENT CONCRETE PAVEMENT

401-1 Description

High quality concrete pavement requires characteristics of durability and structural soundness in order to withstand the destructive forces of traffic, changes in moisture, temperature, and variable soil conditions. Current requirements for smoothness are very demanding. To meet these demands, it is necessary to have vigilant inspection of many operations concurrently.

It is essential that only specified materials are used and that the equipment, methods, and procedures are satisfactory in every respect. Resident Engineers (RE) and inspectors of a concrete paving project have the responsibility of building a paving project that will render many years of service. They are also responsible for many thousands of dollars of complicated work that must be done quickly and right the first time.

The best way to direct attention to the necessary interaction required to achieve quality work is through communication. Before every paving operation, the Resident Engineer is encouraged to hold two pre-paving meetings; the first meeting is held with the contractor and ADOT project staff, the second meeting is with the Engineer and the ADOT project staff.

The purpose of the first meeting will be to:

- Review the contractor's paving plan (see subsection 401-3.01) including discussions on organization, coordination, schedule, traffic control, construction procedures, materials, equipment, and personnel.
- Reinforce the ‘ground rules’ necessary for an uninterrupted operation.
- Introduce the Department's inspection team and establish the lines of communication between the contractor's personnel and the Department.
- Review safety procedures.

Review of the Contractor's Paving Plan

The minimum requirements for a paving plan include:

- Paving layout drawing(s) showing the beginning, end, length, width, thickness and area of each paving pass, the areas to be hand poured, and the location of longitudinal, transverse and construction joints. Check for conformance with the project plans for ultimate pavement width, thickness, location of joints, tapers, and breaks, as well as ensure hand pours are only called for in areas inaccessible to the paving machine.
- Bar chart schedule showing when each pass will be poured, cure times, expected production rates, and days and hours of operations. Check the realism of this schedule based on crew size, equipment production rates, temperature specifications, allowable cure times, haul rates, batching capacity, and traffic control requirements.
- List of proposed equipment including manufacturer's operational specifications on key pieces of equipment such as the paving machine, vibrators, and finishing equipment. Check to ensure the contractor uses the correct type of equipment called out in the specifications, ensure the contractor is operating equipment within the limits specified by the manufacturer, and that the equipment meets any ADOT performance specifications, as well as have an inspector check the condition of the equipment.
- Discussion regarding Quality Control testing of concrete aggregate to ensure testing is leading and not lagging so that material is sampled and tested prior to material being used for production to allow deficiencies to be identified and corrected. Aggregate testing must include sand equivalent, and elutriation (wash) for both coarse and fine aggregate to ensure the flexural strength of the concrete is not compromised due to dirty aggregate or excessive fines.
- Discussion on stockpiling and batching procedures, including storage of aggregate to prevent contamination, how aggregate moisture will be monitored, batching procedures, mixing times, and control of water so that a concrete mix is as consistent as possible while still meeting the specifications. Identify

who will be the contractor's representative authorized to make adjustments to the mix. A plan needs to be in place for handling rejected concrete; not meeting the target range for slump, or temperature. Check to ensure the contractor can produce consistent, high quality concrete to the Department's satisfactions; order trial batches if you're unsure.

- If concrete operations will occur during hot weather and it is expected to approach/exceed the 90°F limitation, discussion regarding options available to mitigate excessively high concrete temperatures and what will result in concrete being rejected.
- Specifications on proposed concrete hauling equipment and the expected haul route. Check to ensure hauling equipment will not segregate or otherwise adversely affect the mix; consider traffic control requirements, flaggers, signing, legal load limits, and haul and cycle times.
- Staging plan showing how the paving will be accomplished while maintaining traffic through the project. This is sometimes integrated into the traffic control plans or paving layout drawings and requires careful attention on both the contractor's part and ADOT's inspection staff so that traffic disruptions are kept to a minimum; check the project traffic control plans and construction phasing diagrams for conformance.
- Traffic control plan conforming to subsection 701-1 showing how the work will be safely separated from traffic including ingress and egress points as well as protection of the concrete during curing; it is important that the work and traffic are clearly separated and that entrance and exits are well delineated and do not confuse motorists.
- Discussion on the tining and curing methods to be used (check subsections 401-3.04 (F) & (G) for conformance).
- Discussion on sawing and sealing procedures including how joints will be located, what equipment will be used, when the joints will be cut, cleaned and sealed, and the manufacturer's installation requirements for the sealant (check subsections 401-3.05 & 3.06 for conformance).
- Detailed staking plan showing the spacing and offset subgrade control stakes and the methods used for setting the wire line and verifying its accuracy before paving (should conform to generally accepted survey and PCCP procedures).

The Department is not expecting the contractor to produce a large, bound report. As a minimum, the contractor needs to submit layout and staging drawings, traffic control plans, a schedule, and several pages of narration on covering stockpiling, batching, hauling, placing, finishing, curing, sawing, sealing, staking, and any other special areas of which you may want additional information. Information on equipment can be attached to the submittal. The pre-paving conference is used to review and clarify the paving plan to the extent that you understand it, and to prevent an endless cycle of re-submittals.

The Ground Rules Necessary for Uninterrupted Paving

It should be very clear to the contractor what circumstances would lead the Department to not allow a paving operation to begin, or halting a paving operation in progress. A PCCP paving operation is a very expensive undertaking involving many pieces of equipment and an increase in labor. Shutting down or suspending these operations often creates disputes between the contractor and the Department's field personnel. One of the objectives of the pre-paving meeting is to avoid such a circumstance. The review of the paving plan is a good start, but you need to let the contractor know what malfunctions in the paving operation could lead to a shut down.

There is no set of rules that outline when to halt or suspend the contractor's paving operation. Base your decision on the particular circumstances and the ability of the contractor to quickly rectify the problem. However, it is best for the Resident Engineer and the contractor to create a list of ‘red flags' that could affect the quality of PCCP and discuss the list with the paving crew and the inspection staff. The list could cover such things as out-of-spec materials, target values, changes in plan by the contractor that conflict with his or her proposed procedure, equipment that doesn't perform, emergency vehicles, weather, safety, insufficient lighting, traffic, and changes to such operations as finishing, sawing, and previously encountered problems. It's better to have these discussions in a meeting room than in the field during a paving operation.

The importance of this pre-paving meeting with the contractor cannot be over emphasized. The aim must be to sit down with the contractor’s crew and obligate them to explain their plan to your satisfaction. In effect, ADOT and the contractor are building the pavement on paper. This should be the forum where you talk about problems, and expectations for the contractor's paving operation. There should be complete agreement on methods, materials, workmanship, and equipment before concrete is placed. The Department wants no surprises out on the grade. Talk about the details. The meeting should be a discussion of any potential problems suspected by the inspectors, and any solutions proposed by the contractor.

Introducing the Department's Inspection Crew

Historically, the Department's paving inspection team has worked very closely with the contractor's paving crews. The intensity of the work, as well as the unusual working conditions, requires teamwork by ADOT and the contractor. The pre-paving meeting should also serve as an introduction of the key personnel on both sides. It is important to highlight the duties and responsibilities of each member, as well as establish the lines of authority on various issues. You may want to establish goals for the paving team and articulate how each member's duties will contribute to achieving these goals. It is important that each member of the team meets the other members and has an idea of their duties and expected actions.

The second meeting held with ADOT project staff only covers responsibilities, assignments, and contingency plans. It is important to clearly describe the expectations, assignment, and schedule for each inspection role.

Operations that require inspection include:

- Subgrade trimming and approval
- Wire line checking and grade stabbing
- Base material placement
- Batching and stockpile operations
- Paving
- Tining and curing
- Initial saw cutting
- Profilograph measurements
- Grinding
- Construction joint preparation
- Sawing and sealing
- Core layout and coring

The Resident Engineer and Project Supervisor have flexibility in how they assign inspectors to each of these operations. However, the goal is to ensure each operation is adequately inspected so that the contractor is complying properly with the specifications. Lines of authority should be established as well as an issue escalation procedure that can be utilized by both the inspectors and the contractor. Scheduling and shift staggering should be discussed, as well as who will pick up cylinders on non-work days.

Paving operations run the smoothest when decisions are made at the lowest possible level and inspectors are empowered to make those decisions. Their ability to make well-informed, timely decisions is based on their level of training and experience in PCCP. More importantly, their effectiveness as empowered decision makers depends largely on how clearly the Resident Engineer and Project Supervisor have communicated what corrective actions may be taken when the contractor's work does not meet the specifications. Documentation and equipment requirements and issues should also be discussed

Paving Book

Maintaining a paving book is an excellent method of documentation. This not only provides a history of the project, but more importantly, it assists quality control. The following items should be periodically checked and documented to assure a quality pavement.

- Thickness
- Edge slump

- Offset distance
- Tining depth
- Vibrator frequency
- Cure application rate
- Rebar placement
- Air temperature
- Remarks as needed

Most items listed above should be measured and entered into the paving book every 50 to 100 feet so corrective action can be taken immediately.

401-2 Materials

Concrete

The details for batching, hauling, and mixing materials for Portland cement concrete used in concrete pavements will be discussed in Section 1006 of this manual and the applicable portions of Section 401-3.

One of the most important requirements for obtaining a smooth and durable concrete pavement is maintaining a uniform slump in the concrete mix. The optimum slump for fixed form pavement is usually about 3 to 4 inches. For the slip-form method of paving, the optimum slump is usually 1 inch. Dry batches cause high spots and surface tearing which cannot be corrected by the necessary hand finishing. Batches which have slumps appreciably higher than the optimum will result in excessive shrinkage and low spots in the pavement.

In order to obtain the necessary slump uniformity, it is essential that there be good control of aggregate grading, moisture content, proportioning of all ingredients, mixing, and frequent testing of the fresh concrete. The inspector at the batch plant must be alert to see that the gradation and moisture content of the aggregates, particularly the sand, does not vary without making compensating adjustments.

Subsection 1006-4.02 (C) of the Standard Specifications requires that variations of moisture in the aggregate shall not exceed 3% during any day's concrete production. In order to meet this requirement, it is essential that the sand be inspected for moisture content as it is brought from the washing plant. It may be necessary to delay mixing operations until the entire stockpile reaches a stable moisture content. The ideal moisture content is a saturated condition where no further absorption of water is occurring. If the contractor does not maintain sufficiently large stockpiles, or sprinkle the stockpile to assure uniformity of moisture in a saturated condition, the Resident Engineer may suspend mixing operations until the necessary uniformity is reached and can be maintained. Uniformity in concrete consistency cannot be maintained unless there is uniform moisture in the aggregate from batch to batch. The importance of moisture control at the plant should be discussed at the pre-paving conference. This is especially important when the concrete is furnished by an independent material supplier.

Commercial plants present problems in the control of aggregate moisture. Aggregates from several sources, as well as the lack of time these stockpiled aggregates have to reach a uniform moisture, are the major contributors to poor moisture control at commercial plants. Aggregate not saturated will continue to absorb water and admixtures during and after the batching process. This will result in fluctuating properties of the freshly mixed concrete often resulting in failure to meet slump and entrained air requirements. Excess or free water in the aggregate is not a concern because it is measured by the batch plant moisture probe and is compensated for by reducing the amount of water added to the mix during batching. The potential problems should be thoroughly discussed and solutions arrived at before the paving is started.

The importance of not adding water to the concrete after batching should be continuously emphasized, especially for air entrained concrete in hot weather. There is a tendency for concrete in truck mixers to be re-tempered by adding water (during transport) to the batch without rotating the drum at mixing speed which results in an inconsistent mix. Even if water is added and the drum rotated at mixing speed, this may result in a phenomenon known as air void clustering in air entrained mixtures. This significantly reduces the strength and durability of the concrete and the likelihood of such increases as concrete temperature rises.

During hot weather, concrete temperatures will run at or near the specified limit. The contractors and suppliers may be able to mitigate excessively high concrete temperatures to some extent. If not mitigated, high temperatures may accelerate cement hydration which should not begin prior to concrete placement. Prior to concrete placement, temperature forecasts should be reviewed and discussed during the pre-activity meeting. Inspectors should closely monitor concrete temperatures and slump during hot weather for compliance with the specifications and determine if concrete is acceptable for placement. Once at the specified limits, rejection should be considered for concrete that experiences further increase in temperature or reduction in slump. Once placed, hot concrete is susceptible to evaporation of surface moisture and shrinkage cracking which directly affects durability and longevity of concrete pavement. A fog spraying method (fogging) can be used when conditions are particularly hot or windy to mitigate evaporation.

There are two strength requirements called out in the Standard Specifications. A compressive strength of 3000 psi must be attained before traffic is allowed on the pavement (including construction traffic), and a strength requirement for acceptance based on the minimum 28-day design strength of 4000 psi. The strength requirement for acceptance is determined statistically by sampling and testing per subsection 1006-7, then calculating the Lower Quality Index (QL), the Percent of lot Within Limits (PWL), and the Pay Factor per subsection 401-6. The Pay Factor will determine if the concrete lot will be accepted, or rejected, or allowed to remain in place at a reduced price in accordance with Standard Specification table 401-3. Pay Factors for thickness and compressive strength are applied separately and totaled to determine a total pay factor for each lot. Any lot with a total Pay Factor less than minus $5.00 will be rejected. Unit price adjustments for pavement smoothness, and cracked pavement slabs which require repair may also be required, but they are not included in the Total Pay Factor calculation for compressive strength and thickness. Approval to leave rejected pavement in place shall be reviewed with the District Engineer and ADOT’s Materials Group, Pavement Design Section.

Unless otherwise approved by the Engineer, traffic is not allowed on the pavement before these three conditions have been met (see subsection 401-3.07):

- 7 calendar days of cure time
- All joints have been sawed and sealed
- The concrete strength has reached a minimum of 3000 psi

Joint Filler and Sealant

The Approved Products List has a list of accepted filler (backer rod) and sealant materials. The Material Laboratory Supervisor can find out if the contractor's filler and sealant have been pre-approved. If not, samples will have to be taken and tested prior to the use of these materials on the project.

Certificates of Compliance are required for these materials. Materials that were not pre approved must be sampled as specified in the ADOT Materials Testing Manual.

Tie Bars and Dowels

These are short pieces of steel bars that are used for the various types of joints. The type and spacing will be shown on either the Project Plans or in the Standard Drawings. These bars shall be accompanied by certificates of compliance.

When the bid schedule, or plans include Load Transfer Dowel Assembly then see the Special Provisions for additional requirements.

When epoxy coated dowels are used, a certificate of compliance for the coating is required. Random samples shall also be taken for checking coating thickness in accordance with subsection 1003-5. The powdered epoxy resins are pre approved material and must be on the Approved Products List maintained by the ADOT Research Center.

Curing Compound

This may be a pre approved material and if so, a Certificate of Analysis is required for all production lots to which the material is associated. Materials that are not pre approved must be sampled per lot and submitted to Central Lab for testing and acceptance prior to use. For PCCP, curing compound with white pigment (Type 2) is required, for which the certification is good for six months from the production date.

401-3 Construction Requirements

Prior to paving, the contractor is required to submit a paving plan, which will be reviewed and approved by the Resident Engineer. Section 401-1 of this manual establishes the guidelines for accepting a paving plan.

All mainline PCCP paving shall be done by the slip-form paving method with ramps and irregular areas done by either slip-form or fixed form methods. Crossroads may be done by fixed form methods.

The Department has allowed the fixed form methods for mainline paving on short, narrow, isolated stretches of pavement no more than 300 feet long. The width would depend on the type of screed used: rolling and Texas (vibratory) screeds are limited to a maximum of 18 feet, while Bidwells are usually allowed to run up to the same width as slip-form pavers. The Contractor must still meet the smoothness specifications regardless of the equipment used.

Subsections 401-3.04 and 1006-5 of the Standard Specifications describe the weather limitations under which PCCP may be placed. When hot, cold, or rainy weather is anticipated, the Resident and Project Supervisor should discuss the requirements with the contractor and schedule the paving operation accordingly.

401-3.02 Pavement Base

The first requirement of an acceptable and successful concrete pavement is a well-prepared, stable, and adequately compacted base and subgrade.

Grading of the base should be a primary concern to the contractor because the base has a significant effect on the thickness pay factor.

The base may be subgrade, aggregate base, lean concrete base, cement treated base, bituminous treated base, or asphaltic concrete. Normally only a well graded, well-compacted, granular base is required. However, certain conditions may require a treated stabilized base in order to provide additional load support capacity.

Keeping the base or subgrade moist is important because a dry base will pull moisture from the fresh concrete. This causes the same shrinkage and durability problems as does rapid surface moisture loss. Subsection 401-3.02 requires the surface to be uniformly moistened immediately prior to placing concrete.

Cement treated materials require a minimum cure time with the application of either a bituminous material or curing compound, as stated in the project special provisions.

Before any base material is placed, the entire subgrade should be proof-rolled with heavy, rubber-tired equipment such as a loaded water truck or dump truck. The inspector should observe for any soft spots in the subgrade. Corrective actions should include removing any soft or wet subgrade material and replacing it with an approved aggregate base (see subsections 203-3.03(D), 305-3.01, and 304-3.01 of the Standard Specifications). Any backfilling of trenches that has been necessary in the preparation of the subgrade should also be proof-rolled and corrected before pavement is placed.

Expansive clays are potentially damaging to any pavement and especially to concrete pavement since they may cause serious pavement distortion and poor riding qualities. If any subgrade soils are encountered which are suspected of being of this type, samples should be promptly submitted to the ADOT Materials Group for tests. Corrective measures will depend on the results of tests, the extent and the location of the expansive material with respect to subgrade elevation, and other factors. If corrective measures are needed, it may become a design problem at which time the ADOT Materials Group and or Geotechnical Services Section will provide recommendations. Estimate the quantity of unsuitable material and the size of the affected area as this may determine how the deficiencies are mitigated.

It has become common practice among paving contractors to use automatic grading machines in the preparation of bases for concrete pavement principally because they facilitate finishing to very close tolerances in a minimum of time. These machines can do excellent work when they are in good mechanical condition and are properly operated.

401-3.04 Placing and Finishing

Paving trains are made up of several units of equipment having gears, hydraulic systems, fuel lines, and water systems that can leak or malfunction. Leaking equipment should not be allowed to continue operating since it is harmful to the pavement.

(B) Slip-Form Method

The slip-form method of concrete paving involves spreading, consolidating, and finishing concrete pavement with a self-propelled machine on which short sections of side forms are attached. The machine operates on a previously prepared base. The surface grade is controlled by means of a tightly stretched guide wire. The equipment consists of a slip-form paving machine, texturing devices, curing machinery, and hand tools. A diagonal pipe float has been used on some slip-form paving projects for additional smoothness of surface.

The paving machine is self-propelled and equipped with:

- A crawler track assemblies which are outside the pavement section
- A device for regulating the amount of fresh concrete fed to the primary screed, which may be an initial strike off blade or a distribution hopper
- A system for vibration of the concrete
- A screed system, which may be a pan, belt, auger, or other devices
- Short lengths of side forms for each edge which hold the edge vertical for a short time and move forward with the paver

The function of the slip-form paver is to receive freshly mixed concrete, spread it to the required width and thickness, consolidate it by vibration, screed or float it to the proper cross section and profile, and final finish all in one operation.

Slip-form machines must be stable to prevent deviation from line and grade. The form faces must be in good condition to minimize dragging and displacement of the concrete. The slip-form must be long enough to provide support until the concrete edge can stand behind the trailing form end.

It is very important that the Resident Engineer and inspectors become familiar with the equipment being utilized. Care must be taken to ensure that the equipment is assembled according to the manufacturer's recommendations and is operated accordingly. Key requirements to assure proper assembly and preparation include:

- Assuring the main pan is flat from side to side. Check it with a straight edge or string line. Several adjustments may be necessary, and this is where manufacturer's recommendations and instructions are important.
- The tamper bars should be adjusted so that they are in the lowest position, with the bottom of the tamper bar even with the bottom of the main pan.
- Adjust vibrators up or down so that the tip of the vibrator is centered in the thickness of the concrete slab. If placing over steel mesh or dowels, it may be necessary to position the vibrators above center. The vibrators should be positioned at a maximum of 24 inches on center. The vibrators shall be checked to

verify they operate at a minimum of 8,000 impulses per minute. The contractor shall be able to provide proof of vibrators calibration performed within the previous 12 months.
- When adjusting the machine to line, the frame should be parallel to the string line guide.

The specification tolerances for edge alignment and edge slump should be carefully checked and adhered to throughout the paving operation.

When automatically controlled slip-form paving is used, the guide wires are the grade control of the pavement surface, similar to the form edges in fixed form paving. The pavement surface cannot be any smoother than the degree of accuracy in the installation of the control wire. The setting of accurate control grades and the care in installation of the wires from these grades is of utmost importance.

The wires should be carefully checked against the survey stakes for alignment and grade. They should be firmly held in the brackets, free from kinks and bends, and they should be uniformly taut to avoid sags between supports. A final visual check and adjustment of the wire should be made immediately before paving operations are allowed to begin. The wires should also be checked occasionally throughout the paving operations because they are easily disturbed by workers.

After the wires have been checked, ADOT Inspectors and the contractor's field staff should stab the grade. This involves running a string line across the grade to each wire line and then measuring the height of the string line above the grade. Record all stab measurements in your daily diary and your field book (if one is used). The grade stabbing serves as a final check on the wire line placement so that the correct concrete thickness is obtained.

The wire line should be clearly delineated by the contractor by means of ribbon or tape. The line is not only a tripping hazard but can be run over by heavy equipment and other construction traffic.

Paving

The slip-forming operation should be smooth and continuous. The Department does not allow frequent stopping and starting of the paver—this directly affects the pavement smoothness. Often an insufficient number of delivery trucks or recurring problems with the batch plant are the trouble. In the past the Department has let the operation continue until the end of the shift, but after a few occurrences, the contractor has not been allowed to start a paving shift until assurances were given to the inspectors of a smooth continuous operation with the paver maintaining a constant speed.

Slip-form machines are equipped to receive concrete either in a hopper or on the grade immediately ahead of the paver. When the hopper method is employed, care must be taken to deposit the concrete without causing sudden shock loads or unbalancing of the paving machine.

When concrete is placed upon the grade in advance of the slip-form paver, the pattern of distribution becomes very important. Pavers that receive concrete in this manner are normally equipped with augers. The action of the strike-off device is under the control of the operator. It is important that adequate material be maintained ahead of the paver at all times. The contractor should maintain an even distribution or uniform head of the concrete during placement. An even push across the width of the paver is the desired outcome. Mounding of the concrete in one area should be avoided since this tends to twist and surge the paver as it tries to push through the mound. Backing up the paver to correct grade deficiencies can usually be done but should be avoided if possible.

Non-agitating trucks are often used to deliver the concrete. Cleanliness and good repair are very important since caked concrete, bends, dents, roughness, cracks, and other imperfections can cause segregation. Insist that the load containers are kept clean and in a smooth, well repaired condition. Good coordination is needed when non-agitating trucks are used since only 45 minutes are allowed to dump the concrete once the cement is added.

Consolidation of concrete in slip-form paving is accomplished by spud vibrators mounted on the rear of the paver. They are spaced up to 24 inches apart and in such a manner that the concrete will be vibrated full depth and width.

On some equipment, the lowest point of the vibrators will be near the top of the concrete to prevent tearing. The efficiency of each spud should be observed by the inspector, at least once each hour during operation.

Vibrator failure is immediately evident by observing lack of vibration waves in the fresh concrete around the spud. The frequency can be checked with a frequency indicator. Amplitude is variable and can be adjusted to fit the speed of the paver which is directly related to the consistency of the concrete. Under no conditions should the frequency of the vibrators be lowered below the minimum allowed by the specifications.

Checking the efficiency of each spud is important. Serious consequences have resulted from malfunctioning of one spud. Experience indicates that spud motors fail frequently. Spares should be kept on the project site at all times to avoid interruptions in the paving. The Department has shut down paving operations because the failure of a single vibrator with the contractor having no spares. Vibration of the concrete must cease at the instant that forward movement of the paver ceases.

The Project Supervisor should be alert to paving operations that may damage existing or newly placed concrete pavements. This includes:

- Driving equipment over freshly placed concrete
- Placing heavy equipment on concrete too weak to carry the weight
- Dropping materials or equipment on the pavement
- Running equipment over the pavement that gouges or scars the surface

The last item usually involves dragging the pan of the paver over a previously placed section of pavement. Regardless of the cause, it is the Department’s policy not to accept scared, indented, or cracked pavement (see Subsection 108.07). Patching is not an acceptable alternative since patched pavement becomes a long-term maintenance problem.

When the contractor’s operations damage existing pavements, the procedure to be followed involves full depth removal and replacement of the damaged areas to the nearest transverse joints. See subsection 401-4.03 for help in evaluating pavement cracks. In some cases entire slabs have been removed to the nearest longitudinal joint. In other cases, where the damage is near the edge, only a 1-foot strip of pavement has been removed similar to an edge slump correction and poured with the adjacent pass.

During placement, the inspectors should be periodically checking edge slump, pavement thickness both at the ends and in the center of the slab, straight edge tolerance, and concrete slump. Record all edge slump measurements in your daily diary and your field book (if one is used).

The placement of concrete at a construction joint is particularly critical. Care must be taken to ensure that only the best concrete is used at the joint.

Finishing

The primary screed is rigidly attached to the frame of the paver. It gives the top surface of the pavement its shape and preliminary finish. The finish is completed by a secondary transverse ironing screed or oscillating belt, sometimes followed by a free-floating smoothing float. Very little hand finishing is necessary if the slump of the concrete remains constant and the paving operation runs at a smooth, steady pace.

Mechanical equipment is specified for finishing because its consistency and uniformity is superior to hand finishing when all the equipment is operating properly. If handwork is needed to supplement or replace the machine work, the operation should be stopped so that replacement, repairs, or adjustments can be made, and machine finishing resumed. Hand finishing should be necessary only beyond the limits of the machine capabilities and for minor touch up. Excessive hand finishing, particularly at the edge, is grounds for ADOT Inspectors to halt any further PCCP placement after the end of that shift. The contractor must be able to slip-form concrete without having to continuously hand finish the edge and other areas. Continuous hand finishing weakens the concrete surface.

Pipe Float

A pipe float is used with some pavers but is not required by the specifications.

The pipe float consists of an aluminum pipe 6 to 10 inches in diameter and of sufficient length to span the full width of the pavement when oriented at approximately 60 degrees to the centerline. It may be towed forward and backward over the pavement either by a self-propelled carriage running on rubber tire wheels alongside each edge of the pavement, or it may be towed by two workmen, one on each side of the pavement.

If the pipe float is the type which is towed by workmen, the towing ropes should be long enough that there is not the slightest vertical movement of the pipe--only a smooth horizontal movement. When not in use, the pipe should rest on the bridges spanning the pavement. Resting the pipe on the fresh concrete surface creates a depression when it settles.

The function of the pipe float is to cut off small bumps and fill small depressions with grout. Because of its light weight, it cannot cut off large bumps. It is sometimes desirable to insert uniform weight (such as rebar or pipe) inside the pipe for additional weight.

If there are isolated areas of considerable size where the pavement is low (which may be evident after one or two passes of the pipe float), the contractor must place a sufficient amount of fresh concrete into these areas, rather than to build them up with excessive thickness of mortar. It is also sometimes desirable to spray a fine mist of water on the pavement surface to prevent tearing by the float. This should be done only with the Resident Engineer's approval. The amount of water applied should never be more than that necessary for efficient functioning of the floating operation since any water applied to the surface tends to reduce the strength and scaling resistance of the surface mortar. The water applied by fog spray is intended only to compensate for rapid evaporation due to wind, high temperature, or low humidity.

The timing of the operation of pipe floating is important. It is desirable to make the first pass or two as close behind the paver as possible. Also, it is desirable to make the last pass somewhat later to accomplish the best results, but not so late as to require more than one or two light applications of mist. The use of the float should be discontinued as soon as a uniform surface has been achieved.

Hand Finishing

Hand finishing is necessary but should be kept to a minimum. It is vital to ensure that finishers do not overwork the surface of the concrete, bleed water, evaporation retarders (90% water), or any other water that may have been applied to the surface. Doing so increases the water/cement ratio of the surface paste and will result in significantly reduced durability of the surface which will delaminate after only a few freeze-thaw cycles while in a moist condition.

Edge Slump

One of the earliest and best indicators of the quality of a PCCP paving operation is the variation in edge slump. Excessive edge slump causes bumps and water to pond over the longitudinal joints; both reduce the long term durability of the pavement. The paving machine must produce an edge that is within tolerance. Continual fixing and finishing of the edge is not acceptable to the Department and is grounds for either halting paving immediately or allowing no more after the end of the shift. Record all edge slump measurements in your daily diary and your field book (if one is used) so that areas needing to be corrected later can be easily located.

(C) Fixed Form Paving

The fixed form method involves installing steel headers or side forms at the precise line and grade for each edge of the pavement, then placing, consolidating, and finishing concrete to the reference plane established by these headers.

The equipment necessary when this technique is employed consists of a spreader, screeding/tamping finisher, machine float finisher, texturing device, and hand tools.

It is best to obtain prior approval of the forms before they are delivered to the project site. The forms should be checked for smoothness with a straight edge and with a tape measure for the correct depth. Do not allow the contractor to berm-up under the forms in order to achieve the desired depth. The forms need to rest on a well-compacted, level base for stability reasons.

Fixed form methods involve self-propelled mechanical equipment—machines that move forward along the forms by themselves. A Bidwell is an example of a self-propelled paver. Fixed form manual methods involve equipment that is not self-propelled and must be handled by the finishers in order to move it along the forms. Rolling and Texas screeds are examples.

The intent of the specifications has always been that the Department prefers self-propelled paving equipment wherever possible - it produces the best PCCP. Mainline must be done by slip-form pavers, while ramps and crossroads must be done by either slip-form or self-propelled, fixed form pavers. Manual methods should be used only as a last resort. Many contractors continue to dispute this specification, however keep in mind that manual methods must be approved by the Resident Engineer because the Department wants these methods to be used on a very limited basis.

(F) Surface Texturing

A satisfactory skid resistance is very important. There are a number of ways that the skid resistance can be developed, but texturing the surface is the most common method.

The intent of texturing is to obtain a series of grooves that are cut into the surface and spaced far enough apart to assure a strong wall between the grooves. Grooves formed by windrows of grout raised above the concrete surface are not acceptable. They break off and wear down quickly. The groove depth specified is necessary to allow for wear without losing the groove.

When testing the groove depth, the plane of reference is the undisturbed surface. The timing of the grooving operation is most important. If the concrete is too wet, the grooves will flow together. If it is too dry, the grooving will dig out material that will be ragged and weak. Either extreme will result in less groove depth than is needed.

It sometimes improves grooving if the tines of the grooving tool are set at a 10 to 15 degree angle vertical to the pavement surface. This arrangement will allow greater pressure without tearing the surface.

Texturing is usually done by using a burlap drag followed by longitudinal texturing using steel tines. Tinning size and spacing is very important in obtaining an effective, long wearing texture. Texturing equipment should be carefully inspected prior to use to assure that it conforms to the specifications.

It is important that the steel tines are correctly spaced. The tinning on the finished concrete surface must meet the required tolerances in Subsection 401-3.04(F) and 601-3.05(D) of the Standard Specifications.

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

The burlap drag and the tinning texture device are required to be supported on separate bridges.

It is necessary to have tools for hand texturing available for use in areas inaccessible to equipment or when equipment breaks down.

Friction Course (AR-ACFC or ACFC) Overlay

Some PCCP pavements receive at least a ¾ inch lift of rubberized asphaltic concrete friction course (AR-ACFC or ACFC) on top. The rubberized friction course absorbs traffic noise, thus making it quieter for adjacent residential neighborhoods. In addition the ride is quieter and smoother for the driver. AR-ACFC with inclusion of crumb rubber asphalt (CRA) is typically used below an elevation of 3,000 ft. At 3,000 ft and above, ACFC with a TR+ (tire rubber and polymer modified) binder is utilized.

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

Some sort of texturing on the PCCP is required so the friction course adheres to the pavement. This is developed by dragging a mat of Astroturf, extending the full width of the new pavement, behind the paving operation. Placing weight in the form of 2 x 4's on top of the Astroturf mat assists in developing the required texture.

Prior to placing the friction course, the PCCP needs to be thoroughly cleaned, removing any curing compound; otherwise the friction course may not bond to the PCCP. Additionally, the tack coat for friction course must be applied correctly at the required application rate with either PG asphalt or concentrate and allowed to fully break to ensure an adequate bond with PCCP surface.

Where construction traffic and ambient conditions are such that the tack is significantly tracked off of the PCCP, the use of a trackless tack should be considered to ensure the tack coat remains in place at the time the friction course is paved. Trackless tack is also formulated to break faster than conventional tack and may reduce standby time, especially during periods of cool or humid weather and for night paving.

(G) Curing

Curing the concrete is as important to achieving strong, durable concrete as any of the other phases of concrete construction. Whatever method of curing is used, the purpose is to seal off the surface to retain moisture that is needed for hydration and to reduce drying stress. Loss of moisture, particularly at the surface, will result in weak concrete that will be subject to shrinkage cracking with reduced durability.

The specifications provide for only the membrane method of curing Portland cement concrete pavement. This method consists of spraying the entire surface of the freshly placed concrete pavement, including the edges, with a liquid membrane curing compound (Type 2 with white pigment for PCCP). The curing compound must be applied without delay as soon as the finishing operation is complete to prevent moisture loss due to evaporation. This ensures complete hydration of the concrete, particularly at the surface, and reduces the potential for shrinkage cracking. This application of compound must be sprayed by equipment capable of applying a smooth, even textured coat. Care must be taken to see that all exposed surfaces and edges receive an application of the curing compound applied at the rate specified. Application at the specified rate should be insisted on because a continuous seal is vital to the eventual toughness of the pavement surface.

A visual confirmation that there are no dull or grayish looking areas when viewed from different directions is a good indicator that an adequate amount of curing compound has been applied, However, the rate of application of curing compound should be checked several times daily by calculating the area of pavement to be covered versus the amount of cure used. This amount should then be compared to the required application and noted in a diary or paving book for future reference.

To ensure a uniform content of white pigment in the curing material, it is necessary that the curing compound be applied in an agitated condition. It must be either freshly or continuously agitated, because the pigment has a higher specific gravity than the emulsifier and tends to settle.

If the curing membrane is being applied during wind, shielding (a burlap drape) should be provided to prevent loss and avoid bare spots on the surface. If the application of curing membrane should be delayed for any reason, water in the form of a mist should be applied until the curing membrane can be applied to maintain moisture

Note that whenever the ambient air temperature is above 85°F, the contractor will continually fog mist the concrete surface until the initial saw cutting is completed. Even if the contractor wants to double the amount of curing compound sprayed, there are no exceptions.

401-3.05 Joints

The performance of concrete pavement depends to a large extent upon satisfactory performance of the joints. Most concrete pavement failures can be attributed to failures at the joint, as opposed to inadequate structural capacity. Pavement distresses that may result from joint failure include faulting, pumping, spalling, corner breaks (D-cracking), blow-ups, and mid-panel cracking. Both research and field experience has confirmed that adequate load transfer and proper concrete consolidation contribute significantly to joint performance.

Stresses in concrete pavements come from two principal sources; the force applied by vehicles, and the volume changes that take place during curing and temperature changes. When the top of the pavement shrinks more rapidly than the bottom, stresses are set up in the slab, which tend to warp the edges upward. This tendency to warp results in severe stresses since the pavement is actually lifted off of the subgrade a slight distance at all four edges. Studies indicate that the critical loading in a pavement slab is highest in the corners due to the accumulation of edge stresses.

Joints control cracking and expansion of concrete slabs, which allow the concrete to release the build up of internal stresses. There are basically four types of joints:

1. Weakened Plane
2. Expansion
3. Construction
4. Edge seal

The characteristics of each type of Portland cement concrete pavement (PCCP) joint is described in Exhibit 401-3.05-1. See Standard Drawing C-07.01 for further details.

Transverse expansion joints are located at pavement junctions with bridge approach slabs and at other locations shown on the plans. The plan detail for expansion joints shows a reservoir for joint filler. It is important that the joint is correctly made so that a good seal will result.

Load transfer dowel bars are sometimes specified for transverse weakened plane joints so that loads will be transferred between slabs after a crack has formed. It is important that these dowels are lightly coated with heavy waterproof grease approved by the Resident Engineer, which will allow the dowels to slide after they are cast into the pavement. This is necessary in achieving a truly weakened plane joint that will control random cracking. Thick coatings of grease should be avoided since they may result in large voids in the concrete around the dowels.

When load transfer dowel basket assemblies are specified, a predetermined alignment system is necessary to assure accurate layout of the basket assemblies and to assure centering of the initial saw cut over the dowels. Experience has shown that a nail on each side of the pavement slab highlighted with paint works well. The references should be set back far enough to avoid their loss under concrete slobbers and curing compound application (recommend 6 to 12 inch offset). Consolidation around the dowel basket assemblies is critical. Check for proper consolidation with a straight edge on the concrete surface over the dowels approximately one half to one hour after concrete placement. Any depressions under the straight edge would indicate that good consolidation is not being achieved during placement.

Joint Type	Description	Direction	Reinforcing	Remarks
Weakened Plane, or Contraction (most common) **TWP** = transverse weakened plane joint **LWP** = longitudinal weakened plane joint	Serves to control random cracking in concrete slabs; a saw cut of 1/3 of the slab depth is made in a predetermined pattern, both transversely and longitudinally. The saw cut weakens the concrete at the joint and, thus, any cracking in the slab occurs at the joint and under the saw cut; longitudinal (LWP) joints promote cracking caused by warping stresses in the slab.	transverse and longitudinal	***transverse:*** none, except on interstate projects where load transfer dowels are used in TWP type joints. ***longitudinal*****:** tie bars are used in LWP type joints	
Expansion **E** = Doweled transverse expansion joint **H** = non-doweled longitudinal expansion joint **K** = non-doweled; constructed around the perimeter of a misc. structure	Preformed Expansion Joint Material allows for thermal expansion and contraction of PCC pavements near fixed objects such as bridge approaches, box culverts, and where ramps meet cross roads.	transverse and longitudinal	***transverse:*** E type joints have load transfer dowel. ***longitudinal*****:** K & H type joints do not have dowels.	A sufficient gap must be left to allow the joint to both close and open.
Construction **TC** = transverse construction joint **LC** = longitudinal construction joint	Used to join a new Portland cement concrete (PCC) pavement to an existing PCC pavement.	transverse and longitudinal	***transverse:*** TC type joints use epoxy coated smooth dowels ***longitudinal*****:** LC type joints use epoxy coated smooth dowels	Joints are saw cut and sealed like a weakened plane joint. However, the saw cut is 11/4” (32 mm) rather than 1/3 the slab depth
Edge Seal **S** = AC / PCCP edge joint	Used to join the edge of Portland cement concrete pavement (PCCP) to edge the of Asphaltic concrete (AC) pavement.	transverse And longitudinal	*none*	Saw cut or routed joint in AC and seal with rubber sealant.

Table 401-3.05-1. Joint Types

The dowel basket detail should be checked to make sure the dowels are held firmly at proper grade and alignment during concrete placement. No dowels should deviate more than 1/4 inch from being parallel with the surface or edge of pavement. Significant deviations in dowel alignment may restrict the movement of the pavement at the transverse joints. This movement is needed to prevent cracking that can result from temperature changes in the slabs, as well as subgrade movements and long term shrinkage.

Some of the important points to keep in mind relating to joints are:

- Transverse construction joints are placed at the end of a run or whenever operations will be interrupted for more than one hour.
- When adjoining lanes are placed separately, the TWP joints must match.
- All construction and weakened plane joints shall be sawed.
- When two or more lanes are placed concurrently, the tie bars in the longitudinal joint are placed automatically by the paving machine. The bar placing operation should be checked to be sure that the equipment is working properly. Tie bars for longitudinal construction joints are to be placed by acceptable mechanical methods while the concrete is still plastic or other approved process after the concrete has hardened. In addition, the inspector should perform random measurements of how deep each tie bar is placed in the fresh concrete. Consistently placing the bars at the incorrect depth is grounds for halting any further concrete placement.
- Smooth epoxy coated dowels are used for longitudinal construction joints to provide load transfer and to allow for some joint movement. The epoxy helps prevent corrosion of the dowel should the joint sealant fail.

Joint details should be thoroughly discussed prior to start of work, preferably as part of the pre-paving meeting. The items to review should include the following:

- The contractor's responsibility for timely and proper sawing of joints (since saw blades are round, it is necessary for the center of the blade to be over the edge of pavement or the last point to be sawed, otherwise, the proper depth of cut will not be obtained. On fixed form pavements, the contractor may have to remove the forms in order to achieve the proper depth cut at the edge.
- The sawing plan to ensure that the contractor keeps a spare saw of the proper type on site at all times when initial sawing is to be performed (see subsection 401-3.06).
- Spacing of construction joints.
- How joints will be made around openings and other appearances in the pavement.
- Tolerances of sawed joint locations versus the center of dowel baskets when load transfer dowels are used.
- The proper matching of transverse weakened plane joints with adjacent lanes; this will require some thought when dealing with transverse construction joint
- The importance of having joints of correct width and depth along with having clean joints before sealing
- The test results on the sealant with attention to the age of the material. If sealant has a limited shelf life, test results and certifications of sealant should be required prior to beginning paving operations. The backer rod material should be compatible with the sealant manufacturer's recommendations, backer rod is required to be expanded closed cell polyethylene foam, backer rod materials that hold excessive amounts of moisture such as paper products are not desirable; they may reduce the effectiveness of the sealant.
- Stress keeping the top of the sealant 1/4 inch below the surface.
- Discuss any additional requirements of the Special Provisions, Plans, and Standard Drawings (C-07.01, 07.02, 07.03, and 07.04).

401-3.06 Joint Construction

Pavement joints provide a means to allow for expansion and contraction and to control cracking. If constructed without joints, a concrete pavement will crack in a random pattern wherever the stresses get too great for the concrete strength.

The dimensions of the saw cut should conform to the project plans or Standard Drawings C-07.01, 07.03, and 07.04. The minimum depth is important for directing any crack that will develop below the saw cut.

It is required that sawing be done before random cracking develops, but not so soon that tearing or raveling of the concrete occurs. It is the contractor's responsibility to determine the time to saw. Different aggregates, weather conditions, and other factors can require changes in sawing procedures; what was workable on one project may not be best for the next. The proper time will have to be found by the trial and error method. Sawing should be avoided when the slab is under tension because uncontrolled cracking can develop. Concrete is in tension when it rapidly cools - such as in the early morning. The amount of tension will depend on temperature differences so experimentation will determine if there is a problem. Early morning is a good time to examine the pavement to see if there are any uncontrolled cracks. The contractor should be discouraged from attempting to perform the sawing by a predetermined schedule because changing temperatures, humidity, and wind speed may alter the optimum time for sawing. If a crack should open up at a joint where sawing is being performed, the sawing at the joint should be stopped. Otherwise, there could be two cracks causing spalling of the concrete between the cracks.

Sawing is usually performed with a circular diamond blade saw. The specifications require the contractor to keep an additional saw on the project site in case any of the saws in use breakdown. Exceptions have been made if the contractor or concrete sawing subcontractor has a saw at their yard, which is less than 20 minutes from a project site and it is not dedicated to another project. The specifications also require that the additional saw to be a span saw. This type of saw spans the entire width of the slab and cuts the slab much more quickly than a circular saw. If the contractor has not had chronic problems with random cracking before or during the initial saw cuts then exceptions have been made to not require the contractor's standby saw to be a span saw.

Placement of PCCP should not exceed the contractor's ability to keep up with the saw cutting. In the0 event a contractor falls behind on sawing, it may be necessary to increase the joint spacing up to 60 feet to control early cracking. Intermediate joints can be cut later, once early cracking has been controlled. The Project Supervisor or Resident Engineer should be alerted to this condition.

Joint Sealant

The purpose of a joint sealant is to deter the entry of water and incompressible material (such as small stones and pebbles) into the joint and the pavement structure. Minimizing the amount of water that enters the pavement structure will reduce moisture-related distresses such as pumping and faulting. Incompressibles, if allowed to enter the joint, will prevent it from closing normally during slab expansion. This will lead to joint spalling and blow-ups.

Sawed joints should be cleaned and filled with joint sealant as soon as possible while they are still relatively clean and to help promote curing. It is recommended that any required grinding be completed prior to joint sealing. However, contractors have been allowed to seal before grinding with the understanding that any ground joints will be cleaned and resealed.

Careful attention should be given to the manufacturer's recommended installation procedures. Joint preparation and sealant installation are very important to the successful performance of the joint. Therefore, it is strongly recommended that the inspector pay particular attention to both the construction of the joint and installation of the sealant material.

Key inspection items include:

- Regularly check joint depth while joints are being cut
- Ensure sandblasting of the joints to help promote bonding of the sealant
- Ensure cleanliness of the joint and removal of all loose material while joints are being cleaned, and check the joints again just before the backer rod and sealant are applied
- Closely monitor the installation of the sealant to ensure conformance with every aspect of the manufacturer's recommendation; sealant properties, application rate, correct equipment, etc.

- Randomly remove small sections of sealant after it has hardened to check for the required thickness, the contractor must reseal areas where you have removed joint material.

Hydraulic jetting of the joints is required in areas where fugitive dust is a recognized air pollution hazard. The common practice is to hydraulic jet one day, then air jet the joint the following day just prior to sealing.

401-4 Pavement Evaluation and Remedial Measures

401-4.02 Pavement Smoothness

Arizona Test Method 801 and 401-4.02 of the Standard Specifications outline the procedures for measuring and evaluating the surface profile of the pavement and for correcting any deficiencies by the removal of high areas or bumps in the surface through grinding with a multiple diamond blade machine.

The surface profile of all sections of pavement placed shall be tested with the profilograph furnished by the Department and by other means required by the specifications as soon as possible. Straight edging should be done while the pavement is being placed so that any deficiencies can be repaired immediately. Straight edging can be accomplished from the back of the paving machine and along the edge of the pavement. It is not necessary to straight edge every square yard of pavement. However, much of the straight edging should be done when the contractor first begins the daily paving operation and then random straight edging should be done thereafter at a rate acceptable to the Project Supervisor.

The Department has allowed the use of the contractor's profilograph to measure pavement smoothness as long as Arizona Test Method 801 is strictly followed and the work is witnessed by an ADOT Inspector. The inspector should check the calibration of the contractor's profilograph for conformance with current Department policy. The inspector may want to verify the accuracy of the profilograph by running a test section and correlating the results with one of the Department's profilographs. Currently, the trend in the Department is to favor the use of the automated profilographs since their readings tend to be less subjective and open to interpretation than the manual instruments.

All PCCP shall be measured for smoothness with a profilograph. The results should be reported to the contractor within 48 hours of placement, when possible. The intent is to get feedback on the smoothness of the pavement to the contractor's paving operation as quickly as possible. This allows the contractor time to fine tune the paving operation before many thousands of square yards of pavement have been placed. Locating areas of the pavement that are to be ground can be simplified if the operator of the profilograph will mark areas for grinding on the pavement and on the profilogram when he or she makes the initial profilograph test. It will also be helpful if stationing is well marked prior to profiling the pavement by using paint or on stakes alongside the pavement.

Bumps required to be ground to meet specification requirements can be located approximately by correlating the profilogram with the stationing. A straight edge should be used to define the exact location and limits of the bump. The bump cutter or grinder is then set for the proper depth of cut and operated over the bump, moving parallel with the centerline. The machine is moved repeatedly over the bump making parallel cuts until the entire area and depth of the bump has been removed. A straight edge should be used repeatedly during the operation to check the depth of cut and the uniformity of the profile. After the cutting operation has been completed, the profilograph should be used again to determine if tolerances have been met. If not, the grinding should be repeated until the tolerances have been met. The profilograph should be run again over the corrected sections as a documentation record.

401-4.03 Pavement Cracks

Large concrete slabs have a tendency to crack. This is a natural process as the concrete shrinks. Tensile stresses build up in the concrete, and cracking is the means by which the concrete releases those stresses. We cannot stop cracking, but we can control it. Jointed slabs cause the cracking to occur at the joints where the concrete thickness has been reduced by sawing. Sometimes, however, the concrete cracks away from the joint. This random cracking may be due to many causes such as lack of a uniform water/cement ratio between batches, segregation, improper curing, or not sawing joints early enough. Regardless of the cause, the procedures outlined in Subsection 401-4.03 of the Standard Specifications must be followed to ensure long lasting, low maintenance pavements.

On or just before the 28th day after the concrete has been placed, the inspector will perform a crack survey of the PCCP showing the location, orientation, and length of each visible crack on a diagram. A copy of this diagram must be given to the contractor. In turn, the contractor will submit to the Department a crack repair plan which needs to be reviewed and approved by the field office. Crack repair procedures must begin seven days after the pavement crack survey, so an expeditious submittal and review process will be needed.

The crack repair procedure depends upon the orientation and location of the crack. In general, transverse cracks are repaired by the routing and sealing method, except when the transverse joints contain load transfer dowels. Then the crack is epoxy injected and the joint is cut deeper. Longitudinal cracks that do not fall within the wheel path (this area is wider than the wheel path for the profilograph) can also be routed and sealed. However, longitudinal cracks that do fall within the wheel path are not repaired; instead the entire slab is removed. Slabs with multiple cracks should always be rejected in accordance with subsection 401-4.03(C), even when each crack would be acceptable if evaluated individually. The goal is to have the largest slab possible by keeping cracks and joints to a minimum. The crack repair requirements are summarized in Table 401-4.03-1 and Exhibit 401-4.03-1.

Before the pavement is opened to traffic under either a final or partial acceptance of the project, the inspectors shall perform another crack survey as described previously. The cost of any repairs is shared equally between the contractor and the Department.

It's important for inspectors to note that the amount of crack repair in lieu of slab replacement should be kept down to the absolute minimum required by the specifications. When there is doubt about whether the inspector should allow the contractor to repair a crack, err on the side of removing the cracked concrete from joint to joint. The Department refrains from buying cracked or patched PCCP wherever possible, since both present long-term maintenance problems.

Crack Type (Exhibit 41)	Crack Repair Methods	
	PCCP Joints With Load Transfer Dowels	*PCCP Joints Without Load Transfer Dowels*
1	a.	a.
2	d.	d.
3-a	f. and g.	a. and b.
3-b	g.	a
4	g.	a. and c.
5	f. and g.	a. and b.
6	e.	e.
7	d.	d.

Crack Type (See Exhibit 401-4.03-2 for an illustration of crack types):

1. Longitudinal crack more than 54 inches, or less than 12 inches from a longitudinal joint.
2. Longitudinal crack inside the wheel path. The wheel path is the surface area between 12 inches and 54 inches of a longitudinal joint.
3. Transverse crack that is approximately parallel and within 5 feet of a transverse contraction (weakened plane) joint.
    a. The transverse contraction joint has not cracked.
    b. The transverse contraction joint is cracked.
4. Transverse crack more than 5 feet away from a transverse contraction (weakened plane) joint.
5. Transverse crack crossing or terminating in a transverse contraction (weakened plane) joint.
6. Diagonal crack (intersecting the transverse and longitudinal joints within 1/3 the width and length of the slab).
7. Multiple cracks separating the slab into three or more parts.

Repair methods:

a. Rout and seal crack.
b. Epoxy uncracked portion of transverse contraction joint.
c. Resaw and reseal the transverse contraction joints on each side of the crack.
d. Remove and replace the entire slab.
e. Remove and replace a smaller portion of slab.
f. Deepen uncracked transverse contraction joints on each side of the crack to ½ inch above the load transfer dowel and seal joint.
g. Repair transverse crack by epoxy injection method.

Notes:

- Slabs with multiple cracks (type 7) should always be rejected even when each crack would be acceptable if evaluated individually.
- Cracks at angles less than 45 degrees to the direction of travel and longer than 3 feet are considered to be longitudinal cracks.

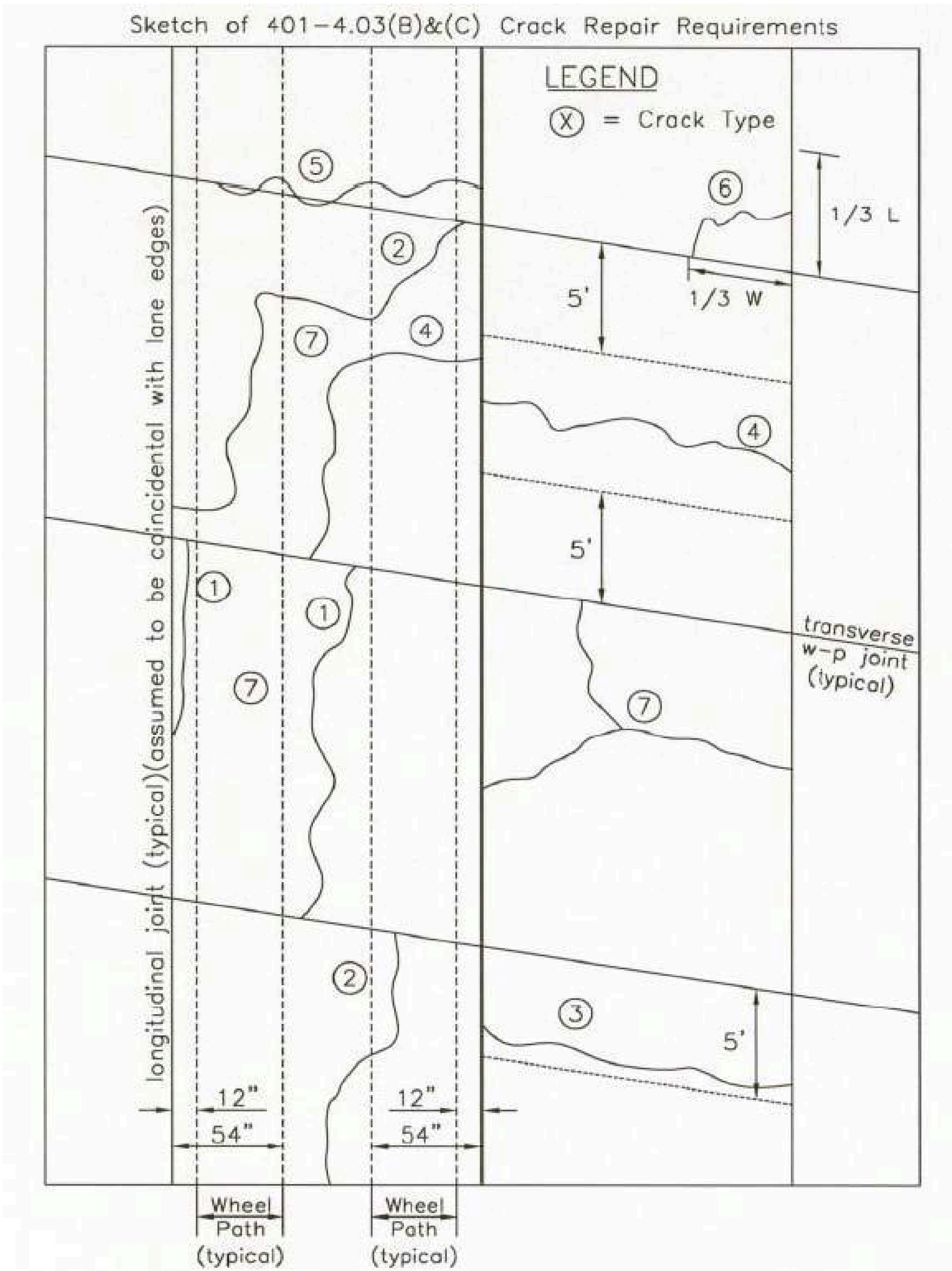


Exhibit 401-4.03-1. Crack Repair Diagram

401-4.04 Pavement Thickness

Pavement thickness is evaluated for acceptance by lot. Lot limits are identical to those specified in subsection 1006-7.03 for compressive strength acceptance of class P concrete. The contractor must obtain ten cores per lot at random locations determined by the Engineer. The inspector must observe the coring operation, and immediately take custody of the cores. The inspector must be familiar with requirements of AASHTO T 24 to ensure the contractor removes the cores properly. All cores obtained for thickness acceptance shall be clearly identified as to lot and location, then sent to the Regional or Central Lab for measurement by appropriate measuring device according to AASHTO T 148. Cores should be returned to the project and retained for inspection by interested parties until final acceptance of the project. Cores taken in areas requiring grinding must be re-cored to determine lot thickness. Additional acceptance cores are required if any core indicates a deficiency in thickness of 0.60 inches or more. The additional cores must be obtained at intervals not exceeding 10 feet in each direction from the deficient core, until one core is obtained in each direction which is not deficient by 0.60 inches or more. The pavement between these cores shall be rejected. Any thickness checks made in the field are approximate and are for informational purposes only. The inspector or Project Supervisor shall prepare a log showing precise lot, location, and thickness of all cores. From this log, the determination can be made as to the need for and location of additional cores. These cores shall be taken and their locations and measurements entered in the log. Copies of the log shall be supplied to the contractor and to ADOT Materials Group.

The contractor should be notified in writing when pavement is rejected in accordance with Section 1006 or 401 of the Standard Specifications. The rejected pavement must be removed and replaced, unless the contractor submits a written proposal to accept the pavement at a reduced price. The contractor's proposal must be received within 10 days of the rejection notice. The Resident Engineer and the ADOT Materials Group, Pavement Design Section shall evaluate the acceptability of the contractors proposal for rejected sections of the pavement and shall determine the proportion of the unit bid price to be paid to the contractor. The State Materials Engineer or the Materials Pavement Designer shall be consulted before any action is taken with respect to the acceptance of any section of the pavement without pay.

401-6 Basis of Payment

PCCP is paid for by the square yard but adjustments are made to the unit price for:

- Thickness
- Compressive strength
- Cracking
- Smoothness

These adjustments can become complicated, and Project Supervisors should use a computer-generated spreadsheet to track these adjustments for each section of pavement. Because the unit price adjustments to PCCP is so complicated, it is very important that the Project Supervisor document to the fullest extent possible the justifications for the price adjustments. Profilograph measurements, marked up drawings, computerized spreadsheets, core measurements, and test reports should be part of the documentation kept with the Project Supervisor's diaries that support the pay adjustments.

402 PORTLAND CEMENT CONCRETE PAVEMENT REPAIRS

Rehabilitation of Portland cement concrete pavement to comply with safety standards and extend the durability and life of an existing pavement may involve several types of repairs. It is essential that the Resident Engineer and inspectors become familiar with the applicable methods and specifications for materials.

402-2 Spall Repairs

Spall repair shall be performed prior to any required pavement grinding or grooving and shall include removing all loose material and temporary bituminous patch material from potholes, damaged joints, and spalled areas of concrete. Cleanliness and the removal of loose material are of the utmost importance.

The Resident Engineer should ensure that the accelerated strength Portland cement concrete patch material is in accordance with the specifications when required, or rapid setting patch material meeting his or her approval is being used. The Arizona Transportation Research Center maintains the Approved Products List which contains approved patch materials.

When rapid setting patching materials are used, check to ensure that the contractor has a qualified manufacturer's representative at the site who can inspect the preparation work and oversee the mixing, placing, and finishing of the patching material. The Standard Specifications require the concrete surface being repaired to be clean and dry, however, for hydraulic cement based repair products, unless otherwise stated by the product literature or manufacturer’s representative, the surface should be kept moist prior to application of the repair material to ensure the repair material is not starved of water where it will bond to the existing concrete.

Heavy-duty jackhammers should not be used for patch repair, or against existing concrete in full depth repairs. These hammers impart too much energy and can micro-crack the existing concrete.

The Resident Engineer or authorized representative will mark those areas designated as spall areas. These areas will then be saw cut, removed to the minimum depths called for in the specifications or the project plans, and patched material applied accordingly.

When load transfer dowel bars are used, their alignment and orientation is critical to the success of the joint and the repair. The bars must be aligned and well greased so that they can slip when the pavement expands and contracts at the joint.

402-3 Full Depth Slab Repairs

The Resident Engineer will designate which areas require full depth replacement. These areas will be shown on the project plans and marked on the slab. Repair work must be completed before any specified pavement grinding or grooving.

Prior to construction, the Resident Engineer or Project Supervisor should thoroughly investigate the existing Portland cement concrete pavement in order to determine what portion of pavement slabs require replacement and whether this will be a complete replacement or partial only. The specifications provide details to determine the amount of replacement necessary.

The inspector must ensure that care is taken in the removal of slabs to avoid disturbing granular subbase and concrete which is to remain in place. Any damage to the subbase or concrete which is to remain in place shall be corrected by the contractor at no additional expense to the Department.

For areas where the roadway will be opened immediately to traffic, the specifications require that the patching material for this work be an accelerated strength Portland cement concrete mixture which includes Type III Portland cement and an accelerator. The resulting mix should attain a compressive strength of 2000 psi in 6 hours. When the areas to be repaired will be closed to traffic to allow normal Portland cement concrete pavement placement and cure conditions, the patch material may conform to Class P concrete, and shall be placed and cured accordingly.

402-4 Pavement Grinding

Before grinding, spalled areas and areas requiring full depth slab replacement shall have been repaired to the satisfaction of the Resident Engineer. Grinding shall be performed prior to any specified sawing and sealing of transverse and longitudinal joints. The Resident Engineer should be satisfied that the equipment used by the contractor will provide the specified surface texture. This will require that a test section be set up at the beginning of the operation, to demonstrate to the Resident Engineer that the resulting surface will be in conformance with plans and specifications.

The Resident Engineer and inspectors should thoroughly review the methods, disposal plan, and equipment proposed by the contractor to remove residue and excess water from the roadway. Consideration should be given to ensure the contractor has several methods available to control this operation in the event changes are necessary once construction starts.

The Resident Engineer should check that all equipment conforms to the specifications and will not damage the existing pavement. This equipment must be capable of providing a uniform surface without requiring overlapping of previous passes. Pavement surface shall be ground longitudinally.

402-5 Pavement Grooving

Prior to grooving, spalled areas and areas requiring full depth slab replacement shall have been repaired to the satisfaction of the Resident Engineer. Grooving shall be performed prior to any specified sawing and sealing. The Resident Engineer should be satisfied that the equipment used by the contractor will provide the specified pattern and depth of groove.

Project personnel should thoroughly review the methods, disposal plan, and equipment proposed by the contractor to remove residue and excess water from the roadway. The contractor should be prepared with an alternate plan in the event changes must be made during construction.

The Resident Engineer should check that all equipment conforms to the specifications and will not damage existing pavement. This equipment must be capable of providing a uniform pattern at the depth specified. A test section should be established at the beginning of work in order to demonstrate that the specifications can be met.

Pavement surfaces shall be grooved longitudinally

402-6 Joint and Crack Repair

The Resident Engineer should thoroughly inventory the project under construction in order to designate those areas requiring repair. These areas must be cleaned of all loose material and prepared in accordance with the plans or specifications. The materials used must be applied in accordance with the manufacturer's recommendations and must be acceptable to the Department.

When load transfer dowels are used for joint repair, the alignment and orientation of the dowels is critical to the success of the joint.

404 BITUMINOUS TREATMENTS

A bituminous surface treatment is not a pavement in and of itself. Rather, it provides a protective cover that helps to resist traffic abrasion, and provides a waterproof cover over the underlying structure. Specifically, surface treatments:

- Prevent surface water from penetrating pavements that have become weathered or cracked.
- Plug voids, coat, and bond loose aggregate particles in pavement surfaces.
- Renew a surface and restore skid resistance to traffic worn pavements.
- Provide a temporary cover in cases of delayed or staged paving.
- Control dust on low volume roads.
- Promote adhesion of subsequent asphalt courses to aggregate bases.
- Ensure a bond between new or existing asphalt courses.

Special Provisions will normally have requirements that supplement the Standard Specifications for bituminous treatments. For example, type of material, spread rate, and basis of payment are usually specified in the Special Provisions. Some bituminous treatments, such as Slurry Seal or Microsurfacing cannot be found in subsection 404 of the Standard Specification. Never assume a new project has the same bituminous treatment requirements as another project you are familiar with. Always carefully read the Special Provisions, including bid items, and review the pavement structural sections in the plans for each project to understand the bituminous treatment requirements.

Prior to starting any asphalt operation, the contractor's equipment should be checked to see that it is working properly and that no badly worn parts exist which would have an adverse effect on the finished product. The Project Supervisor is responsible for seeing that necessary Department personnel are on the project to perform the weighing and inspection operations without undue delay to the contractor.

Bituminous materials are measured for payment by the ton, but the application rate is calculated in gallons per square yard. Therefore, inspectors must complete a Project Asphalt Report for each type of bituminous material applied during their shift. Refer to Exhibit 404-1 for an example of the completed form. A blank form is included in the Construction Manual Forms page online and can be copied as needed.

At the end of each day's operation, the Lead Inspector shall collect all weight sheets, weight tickets, ticket books, and Project Asphalt Reports (spreadsheets) and balance them before turning them into the field office for checking and pay purposes. This should be done before leaving for the day.

The specifications for some items allow a choice of grades or types of asphalt while others do not. If circumstances indicate that a change from the specified type or grade of asphalt is desirable, the Resident Engineer (after consulting with the District and the ADOT Materials Group) will prepare a change order for the work. Consultation on changes is very important because a change in type or grade of asphalt may cause a serious modification of the qualities desired from the bituminous treatment.

When a specific application rate for prime, tack, and fog coats is not indicated in the Special Provisions, the Resident Engineer will determine the rate. It is recommended that the Resident Engineer talk to ADOT Materials Group when deciding on a specific application rate. Application rates are generally a function of the pavement or base conditions, weather, traffic, and the bituminous material being used.

Inspection and Observation Guidelines:

Bituminous Materials:

- Is the type and grade of asphalt in accordance with the project specifications?
- Are asphalt samples being witnessed and taken in accordance with methods that assure representative samples?
- Are test results and certificates of compliance satisfactory?

- At what temperature is the material being applied or mixed?
- Are checks being made to verify delivery and complete emptying of cars or tank trucks?

Aggregate Materials:

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

Release Agents:

- Wheels and tires of compactors shall be wetted with water, or if necessary soapy water, or a release agent. All other equipment surfaces shall be treated when necessary with a release agent.
- Release agents which degrade, dissolve, or in any way damage the bituminous material shall not be used.
- Solvents such as Diesel fuel or WD40 shall not be used as a release agent.
- Only release agents evaluated through NTPEP are acceptable for use in accordance with the requirements of Section 407-7.04 of the specifications.

PROJECT NUMBER: ____________ DATE: ____________ TYPE OF APPLICATION: ____________

PROJECT NAME: ____________ SPEC. PROV. RATE OF APPLICATION: ____________

SUPERVISOR: ____________ TYPE & GRADE OF ASPHALT: SS 1H 1:1 CHANGE ORDER NOS. ____________ SUPPLIER: ____________

LBS PER GALLON = 8.33

CAR OR TRUCK & TRAILER NUMBERS	AIR TEMP	OPTIMUM MOISTURE OF AB / IN PLACE MOISTURE OF AB	START TIME / STOP TIME / ACCUM HRS & MINS	STATION TO STATION & LOCATION WITH RESPECT TO CENTERLINE	LENGTH / SPRAY BAR WIDTH	AREA (SY)	AUGE RE / AUGE RE	FIELD MEASURED GALS	TEMP. OF ASPH. (FAREH.) / ASPH. CORR. FACTOR	CORRECTED FIELD MEASURED GALLONS	GALLONS PER SQUARE YARD	SUPPLIERS TICKET NUMBER	ACTUAL WEIGHT USED (TONS)	REMARKS (INCLUDE VISUAL OBSERVATIONS OF PENETRATION OR CONDITION OF ROADWAY SURFACES WHERE POSSIBLE)
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		
				TO								OUT		
												BACK		

BOOT TRUCK TOTAL TIME		
Start Time:	SHEET TOTALS	
Ending Time:	TOTALS OF ALL PREVIOUS SHEETS	
Hours:Mins	ACCUMULATIVE TOTALS & USAGE	
	TOTAL CORRECTED FIELD MEASURED GALS. =	
	TOTAL APPLICATION TIME (HRS:MINS) =	
	ACTUAL TONS=	

INSPECTOR: ____________ DATE: ____________ SHEET ______ OF ______

SUPERVISOR: ____________ DATE: ____________ LOT NO: ______

CC. FIELD REPORTS, PROJECT FILES & DISTRICT LAB

Exhibit 404-1. Project Asphalt Report Example

404-3 Construction Requirements

404-3.02 Equipment

(A) Distributor Truck

The single most important piece of equipment on any surface treatment operation is the distributor truck. The field office should, whenever possible, pre-approve all distributor trucks for use on the project. Subsection 404-3.02(A) covers requirements of the asphalt distributor and its operation. These requirements are all important and should be reviewed by every inspector prior to starting work on which a distributor is to be used. All of these requirements shall be enforced. Insist on getting test results for spread rates. Older trucks that do not have gauges and accessory equipment that meet specification should not be allowed on the project.

In order to prevent streaking in a seal coat, care must be exercised to see that the spray bar is operated at the proper distance from the pavement surface and that each nozzle is functioning properly and turned to the proper angle. Ensure the contractor has a spotter during each day's initial application who can alert the distributor truck operator to stop should the spray bar not be functioning properly.

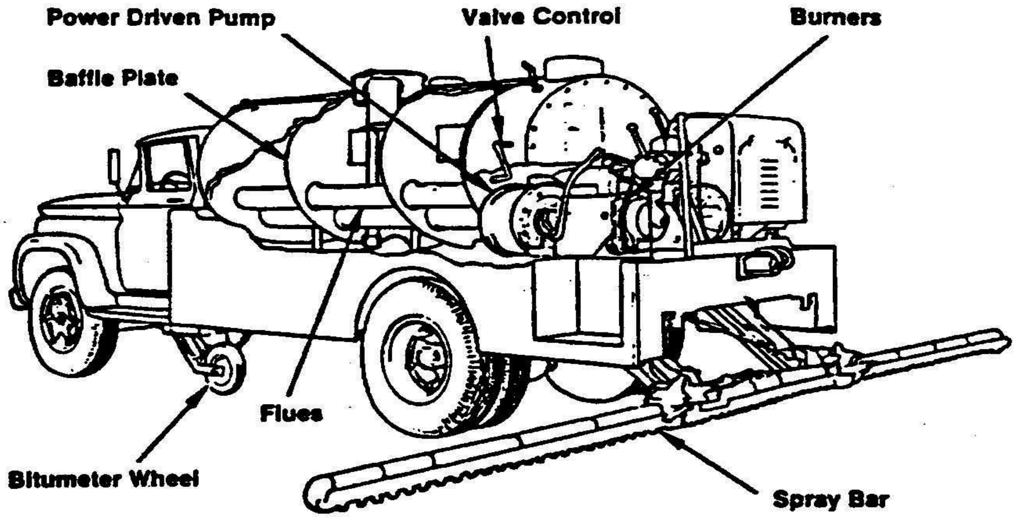
The contractor is required to furnish evidence that the distributor has been tested and found to be capable of a uniform rate of application. The testing must have been done within the previous twelve months. Distributors used for chip seals should be retested in accordance with Arizona Test Method, ARIZ 411, unless only a short time has elapsed since the last test by the contractor. Even a recently tested distributor may not provide a uniform rate of application if the nozzles or bituminous material has changed. ADOT Materials Group maintains a list of all certified distributor trucks in the state.

The most important part of the distributor truck is the spray bar. The spray bar height, the type of nozzles, and the nozzle angle all affect the uniformity of the asphalt coverage. A spray bar that is set at the incorrect height causes streaking. If it is set too high, the wind may distort the spray causing spotty coverage. If the height varies along the roadway, the coverage width will not be uniform (see Exhibit 404-3.02-1). For best results, the spray bar height should not vary by more than 1/2 inch.

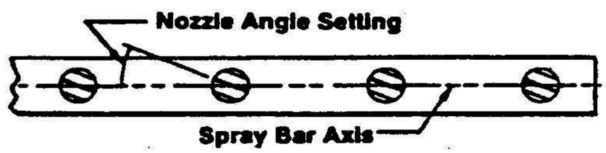
The correct nozzle sizes for the type and grade of asphalt must be used. It may be necessary to change nozzles to get acceptable coverage or rate of application. Distributor truck operators are sometimes reluctant to change nozzles. However, if uniform coverage at the required rate of application cannot be achieved, the Resident Engineer should not allow the work to proceed. If all other adjustments have been tried, it will probably be necessary to change the nozzles. Damaged nozzles shall be removed.

The nozzle angles are usually set between 15 to 30 degrees so that the spray from each nozzle does not interfere with the spray from adjacent nozzles. A wrench specific to the distributor truck exists to ensure the angle is set properly; this is the wrench the operator should be using to ensure the nozzle angles are all uniform.

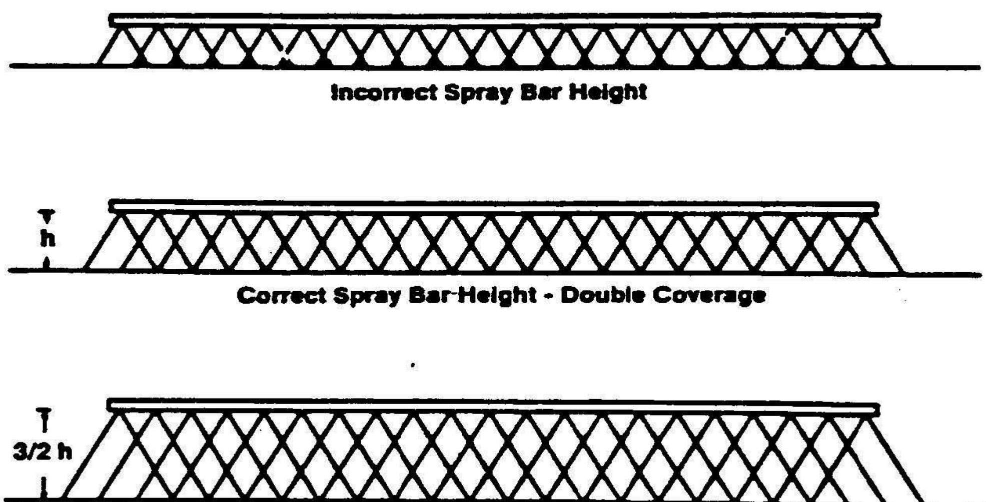
Project Supervisors and Lead Inspectors should not hesitate in removing distributor trucks from the project which are not operating acceptably.



A TYPICAL ASPHALT DISTRIBUTOR



PROPER ANGLING OF NOZZLES



SPRAY BAR HEIGHT AND COVERAGE

NOTE:
On occasion, some operators will set end nozzles at a different angle (60 to 90 degrees with respect to the spray bar) in an attempt to obtain a good edge. This practice should NOT be permitted as it will produce a fat streak on the edge and rob the adjacent spray fan of the lap from this nozzle. A curtain on the end of the bar for a special end-nozzle with all nozzles set at the same angle will provide more uniform coverage and make a better edge.

Exhibit 404-3.02-1. Asphalt Distributor Spray Bar Height and Coverage

Preparation of Pavement Surface (all bituminous treatments)

The application of the bituminous treatment should have been anticipated weeks if not months in advance by the District Engineer, and needed pavement repairs should have been made. Use asphaltic concrete to build-up any low areas and fill any holes in the pavement surface well in advance of seal coating so proper compaction can be obtained by traffic, and the surface will be comparable to pavement surrounding the patches. It is important that pavement repairs, especially crack sealing, be made as far in advance of the treatment as possible to prevent fresh asphalt from bleeding through the treated surface. This is also true for slurry type treatments, asphaltic concrete overlays, and thin bonded overlays such as bonded wearing course.

Pavement markings with glass beads will likely need to be removed/obliterated prior to the treatment, especially when the treatment includes polymer modified asphalt. The glass beads do not provide a good surface for the asphalt in the treatment to adhere to and these areas will be prone to delamination. The centerline on a road with a crown cross section where snow plow activity occurs and skip lines with recessed pavement markers are particularly vulnerable to delamination.

Just prior to application of asphalt, the surface of the pavement must be cleaned adequately to the satisfaction of the Engineer. Cleaning methods should be discussed at the pre activity meeting and approved by the Engineer in advance. The use of a good power/kick broom supplemented by hand brooming is usually adequate. If a film remains adhered to the surface after milling, or if dirt or mud is tracked onto the surface to be treated, a broom alone may not be sufficient to adequately prepare the surface; it may be necessary in these and other instances to wash the surface with high-pressure water. If water is used, the surface must be allowed to sufficiently dry, as appropriate, prior to the treatment being placed.

If there are areas where motor vehicles have dripped accumulations of oil and grease, it may be necessary to burn off the deleterious materials. If asphalt is spilled on the pavement, the spill area should not be sealed over without first cleaning the surface. Don't apply an extra heavy treatment to cover contaminated areas; clean it up. Any areas of contamination or from where dust or other deleterious substances/coatings remain on the surface will be prone to delamination and premature pavement failure. Do not afford the contractor any leeway on proper surface preparation.

Utility covers for manholes, valves, and any other feature in the pavement surface that must remain accessible after the treatment has been applied must be identified and properly covered to prevent adherence of the surface treatment to the feature. This may include applying release agents or securing a thick construction paper or similar material to the surface of the feature. Drains and catch basins must also be adequately protected to prevent material from the surface treatment infiltrating the drainage system or blocking/clogging inlets. The location of any features that are not identified on the plans should be recorded/documented on the plan sheets to ensure these are found and made accessible following the treatment. After curing treatment is complete, all protective material, as well as any loose material, shall be removed and disposed of properly. All loose material after treatment shall be cleaned from manholes, valves, gutters, and drainage systems.

404-4 Prime Coat

Prime coats may be eliminated from the work in those cases where the aggregate base surface is tightly bound and will not displace under the laydown machine and hauling equipment. Except, never eliminate the prime coat on a secondary road project that has a chip seal, or an asphaltic concrete friction course applied directly on top of the prime coat. A change order is required to eliminate the contract item.

The purpose of the prime coat is to protect and stabilize the surface of the base and provide a uniform, firm-working platform for the next course. The prime coat is designed to:

- Coat and bond loose mineral particles on the surface.
- Waterproof the surface of the base.
- Provide adhesion between the base and the next course.

Before a prime coat is applied, the base should be tested for proper compaction and cross section tolerances. Since the prime coat can frequently be eliminated, the Resident Engineer should evaluate the condition of the base before allowing the application of the prime coat. ADOT Materials Group is available for consultation.

The surface of the aggregate base must be smooth and true to grade and cross-section. The surface should be slightly damp (no free water on the surface) when the prime coat is applied. A water application one to two hours ahead of the prime coat application generally causes deeper asphalt penetration, which is highly desirable.

The type and grade of asphalt to be used and its approximate rate of application will be indicated in the Special Provisions. The rate of application should be determined by observing the rate and the depth of penetration; bearing in mind the traffic conditions and schedule of paving operations. After applying a section of prime, look at the results and then adjust the rate of application as necessary. An excessive rate of application is not only wasteful but may cause a slippage plane between the base and pavement, or may cause instability and bleeding of the pavement since the extra surface asphalt will migrate upwards in warm weather through the action of traffic. Too light a rate of application may cause raveling of the surface, requiring repairs prior to paving. Asphalt in thin films is an adhesive, but asphalt in thick films may act as a lubricant.

A prime coat should not be applied until all specified weather and temperature requirements can be met.

In some cases it may be desirable to establish a guideline for the distributor operator to drive by for the first pass.

The bituminous material for prime coat is applied by means of a distributor truck, allowed to cure, and then compacted, preferably with a pneumatic compactor. Traffic is permitted on the primed surface only after compaction. Adequate cure time for prime coats is essential (usually 24 hours) to allow volatilization of solvents prior to placing an asphalt overlay. If the primed surface is picked up by tires, sanding or blotter shall not be used unless the initial designed cure period has passed. Instead, all traffic should be removed from the primed surface until it has cured sufficiently.

Note that there is no method of payment for compaction provided in the prime coat item. When compaction of the primed surface is started, the condition of the surface should be watched closely and if the compactor damages the surface, the operation should be altered or stopped. Sometimes the compactor action will roll a larger aggregate around and break it loose.

During the curing period, the primed surface should be protected from traffic (including all construction traffic) until there is no tackiness to the surface. The surface should then be examined for lean or rich areas. Small lean areas should be hand sprayed. Any rich areas should be corrected before any pavement is laid over them. The corrective measures should depend on the degree of richness and the size of the areas involved.

Following the initial cure period, sanding the areas which are only slightly rich is adequate. Small areas under 50 square feet can be hand worked. In some cases, it has been necessary to pick up the primed surface together with an inch or more of the base, and blade mix the prime coat throughout long sections. This added expense is justified in preference to laying a pavement on a prime coat where there is free asphalt on the surface.

The prime coat application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online.

Inspection Guidelines:

- Does the surface need a prime coat?
- Will the surface hold up against construction traffic?
- Does the surface need to be sealed for poor weather?
- Is the surface to be primed of acceptable smoothness?
- Is the surface damp?
- What is the application rate?
- Does the application need adjustment?

- Are the asphalt applications uniform?
- Is the bituminous material suitable for its intended use?

404-5 Tack Coat

A tack coat is a light application of asphalt applied to a pavement, primed base, or stabilized base immediately prior to laying a course of asphaltic concrete (AC) pavement. Its purpose is to lessen the possibility of a slippage plane or delamination at the interface of the two courses. The structural capacity of the pavement is dependent on the pavement behaving as a single layer of asphaltic concrete, any discontinuity in the pavement section will significantly reduce the strength of the pavement and will result in premature fatigue cracking and potholes.

Tack coats are applied e with a concentrated asphalt emulsion or paving grade (PG) asphalt. The application shall be uniform, whether applied by hand spray or distributor truck. If the tack coat is streaked or stringy, something is wrong with the equipment or with the material being applied. The work should not be allowed to proceed when the tack coat is not uniform. Adjustments should be made and the spread checked before resuming the work.

Exposed contact surfaces, including curbs, should always be tacked. If the existing AC surface exhibits excessive asphalt content (but will be allowed to remain in place), the tack coat may be eliminated from typical paving operations. A prime coat that has been in place for a long period of time may need to be tacked. The Resident Engineer should evaluate the condition of the grade after traffic has used it. AC can be placed directly on an unprimed aggregate base (AB). It is not required for most AC mats to bond to the AB; therefore, tacking the prime coat is usually unnecessary. Materials Group is available for consultation, and should a tack coat be necessary, it would probably be a light coat.

The contractor should protect all adjacent facilities, construction, or traffic from possible damage from over spray during application of a tack coat.

Spreading the tack too far ahead of the AC paving operation is to be avoided because it easily gets dirty or may be tracked off, losing its adhesive properties. Traffic shall not be permitted on the tack coat. If tack coat is tracked off of the grade prior to being paved, tack coat should be reapplied. Excessive tracking is likely to occur when daytime temperatures are warm (pavement surfaces reach or exceed 140 degrees F).

If weather and traffic conditions likely to result in excessive tracking of the tack coat are expected, consider use of a trackless tack to ensure proper bond between layers of asphalt pavement. Trackless tack may also be advantageous where it is desired to maintain the aesthetics of nearby pavements and driveways, and during cooler weather or nighttime paving because of the chemical formulation which results in a much faster break time (potentially less than 20 minutes in sub-40 degree F temperatures).

Under no circumstances should the tack coat be omitted unless the exposed AC has a flushed surface.

If an emulsified tack coat is used, and it has not yet broken, the paving train must halt. The water in the emulsion must evaporate freely, i.e. by itself before it is covered with new AC, the thickness of which is too great to allow all moisture to escape.

The type and grade of asphalt, as well as recommended rate of application are typically shown in the Special Provisions, and as required by Section 1005 and Subsection 404-5 of the Standard Specifications. If the Resident Engineer is given a choice, he or she should not guess which one is the best. Each type of tack has its advantages. If the Resident Engineer is given a choice, then ADOT Materials Group will advise the project as to which would be best suited for the climate and circumstances. Changing the rate of application beyond the limits specified should be done cautiously and with the advice of the District office and ADOT Materials Group.

Adjustments to the application rate may be appropriate depending on pavement type, age, and surface texture. If unsure, perform a short test strip to confirm the application rate is appropriate .

When paving grades of asphalt are used, a more uniform coverage will be obtained by heating the asphalt to the upper limits of the recommended range. Care should be used in heating because flash points differ between the various asphalt types.

The tack coat application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online.

Inspection Guidelines

- Is the surface clean and free of dust? Did the broom get against the curb or pavement edge?
- Is the application of tack uniform?
- What is the rate of application?
- Are haul truck tires free and clear of debris?
- Is the contractor making continuous effort to minimize tracking?

404-6 Fog Coat

A fog coat is a very light (about one pint per square yard single application of asphalt material without a cover material. Over application will cause the surface to bleed or become unstable, resulting in rutting. This treatment is often called a flush coat. It is occasionally used to rejuvenate deteriorated pavement ahead of chip seals (to prevent too much absorption of the chip seal's asphalt). Fog coats may also be applied using various emulsions to help retain the chips on an older seal coat, which is beginning to strip. Considerable use has been made of fog coats as an asphalt rejuvenating agent, sealing small cracks, and surface voids and inhibiting raveling. This material has a petroleum resin oil base, emulsified in water. The asphalt in asphaltic concrete goes through an aging process, which starts immediately when the asphalt is exposed in thin films to heat and air. An asphalt-rejuvenating agent prolongs the life of old and new pavements by rejuvenating the aged asphalt. The material is applied through a distributor; heating of the material is not required. The rate of application depends on the condition of the surface. The Special Provisions will specify the type of bituminous material and the approximate application rate determined by the ADOT Materials Group. The Resident Engineer should contact the ADOT Materials Group before changing the type of material or application rate.

Caution should be exercised when recently placed or excessive crack seal material exists in an area that will receive a fog coat. These materials often contain a high percentage of asphalt rubber and if a rejuvenating fog seal is placed, the solvents in the rejuvenating asphalt emulsion may cause the crack seal material to become extremely tacky, especially during warm weather. This typically results in the crack seal material getting picked up by traffic and tracked down the road causing a significant and immediate maintenance issue.

Before applying the fog coat, the surface should be cleaned by brooming or by some other cleaning method. Areas of oil and grease drippings should be removed by burning off with a weed burner or by other means. Holes or badly eroded areas should be patched prior to applying the fog coat

In most cases the fog coat leaves the surface extremely slippery, so it is sanded (referred to as blotting) in order to permit earlier use of the pavement. Blotting also appears to have beneficial effects in that it aids in healing cracks and pitted surfaces. The Special Provisions will indicate an approximate application rate for blotter. Either under applying, or over applying, the blotter can be hazardous to traffic. Never open to traffic without sufficiently blotting to eliminate the slippery surface. Over application may require brooming to keep excessive blotter material from damaging vehicles, or personnel.

The Resident Engineer is strongly urged to familiarize himself or herself with the ADOT Materials Group Practice and Procedure Directive (PPD) 6, Provisional Seal Coat. This document will answer most questions concerning the need and desirability of fog coats.

Since fog coats may be necessary on short notice while on a paving project, the Resident Engineer should consult with the contractor prior to beginning the paving operation in order to ensure the availability of acceptable materials on short notice.

Traffic is kept off fog coats for at least 2 hours except as needed to accommodate turning or crossing traffic. Use of a fog coat is not recommended for new pavement surfaces that are to receive a chip seal or friction course. This is because the surface is softened, causing excessive aggregate embedment.

The fog coat application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online.

404-7 Chip Seal Coat

General

A chip seal coat consists of an application of bituminous material followed by cover material. This type of surface treatment is used to provide a new watertight non-skid wearing surface. The source of the cover aggregate normally is not specified so it is the contractor's responsibility to locate a source and to furnish samples to be tested by ADOT. All the specification requirements pertaining to pits must be complied with, and the contractor must pay all costs involved in the use of the source. Chip sealing consists of a single application of asphalt, either a hot-applied PG or emulsion, followed immediately by a single application of cover material. The approximate rate of application for both the asphalt and the cover material will be in the Special Provisions.

Sampling Materials

Bituminous materials are sampled as is typically done for emulsions or PG. Cover material for emulsion chip seals is sampled at the final stockpile. Cover material for hot-applied chip seals is sampled at the final stockpile prior to pre-coating. Regardless of the type of chip seal, it is important that the condition of the cover material does not change after it has been sampled and prior to delivery to the chip spreader or hot plant for pre-coating. If contamination (exposure to dust) or other change (moisture content) in material is suspected, additional samples must be taken.

Cover material is often produced and placed in designated stockpiles which are clearly identified. This allows each individual stockpile to be qualified for acceptance, and for correction of stockpiles with deficiencies; once pre-coating is performed, it is difficult to assess the quality of the cover material.

After the pre-coating process for hot-applied chip seals, the chips should be inspected to ensure adequate coverage with 0.40% to 0.60% asphalt (by total weight); chips near 0.40% asphalt will have a speckled appearance to nearly complete coverage at 0.60%. While we do not sample and test to verify asphalt content, the supplier's hot plant report for tons of cover material and tons of asphalt may be used to confirm. If the pre-coated chips contain adhered conglomerations of sand or finer material, the virgin stockpile should be inspected to ensure the absence of contamination or adhesions of dust or other coatings.

Application Rates of Bituminous and Cover Material

The application rates shown in the specifications for bituminous material and cover material are estimates only. The initial bituminous and cover material application rates will be determined by the contractor using the chip seal coat design formula (See ARIZ 819) and must be approved by the Regional Materials Engineer. The design rate should result in the asphalt/chip relationship shown in Exhibit 4-4. The depth of embedment of average size particles should be 70% to 80% depending on the anticipated traffic volume and the climatic conditions. For light traffic and high altitude, 80% embedment would be proper. The contractor should identify areas where the surface conditions of the pavement changes, as well as areas that will experience increased slowing/stopping/turning movements, to determine appropriate adjustments in application rate.

The initial application shall consist of a test strip to ensure proper application of materials and adequate embedment of cover material without excessive chip loss or tracking of bituminous material. The test strip may include multiple application rates to better optimize the process.

The contractor and the Resident Engineer may adjust the application rates slightly at the time of construction based on field conditions and observation during placement. Special attention should be given where chip seals are to be applied to new AC as the rate of bituminous application may need to be either increased, due to the new surface absorbing more asphalt than typical, or reduced since some embedment into the new surface may occur. This is especially important for hot-applied chip seals when the cover material has retained a significant amount of heat at the time applied.Excessive amounts of chips above the desired single layer can also have a detrimental effect on the overall quality of the chip seal coat. The excess chips can act as wedges during the rolling process, which in turn will dislodge, or weaken the bond of embedded chips. Ideally, no more than about 5% of the cover material will be swept off and no wedged or stacked chips will remain, and there will exist no empty spaces with exposed asphalt.

ADOT Inspectors should be actively involved in overseeing and inspecting the entire operation continuously. The Project Supervisor should rotate inspectors so that lunch and restroom breaks can be provided. The inspector should continually check the completed chip seal coat to determine if there is satisfactory embedment of cover material and if the surface is completely covered. The surface should be examined immediately after rolling and also after the seal has cured enough to withstand having the excess cover aggregate brushed away by hand. This evaluation requires good judgment and experience.

Embedment can be verified by using a needle nose pliers and plucking an average size chip from the surface and visually assessing the percent of its depth which has been covered with asphalt. This should be repeated in a few areas representative of the placement, at frequent intervals during the chip seal placement.

The bituminous material application rate must be calculated and documented on the Project Asphalt Report spreadsheet. Exhibit 404-1 is an example of the completed spreadsheet. A blank Project Asphalt Report can be found in the Construction Manual Forms page online. Actual roadway widths should be checked against those shown in the plans before starting the seal coat, and the contractor should be notified of any quantity adjustments.

Application of Binder

Section 404 indicates the necessity for checking the distributor against the requirements of the Standard Specifications. In addition to determining that the distributor has the required equipment and accessories, it must be determined that this equipment, accessories, instruments, etc., are in proper working order. Nozzles are all to be of the same type and size and set at the proper angle. The spray bar is kept at the proper elevation so that the desired spray pattern will result. Verify there is no excessive dripping when the nozzles are closed and each nozzle remains free of slugs while in operation. The proper functioning and operation of the nozzles and spray bar is the responsibility of the operator but the inspector should be certain that all equipment is operating properly. If equipment is not operating properly, the chip seal operation must cease immediately until corrections have been made.

When applying emulsified binder in areas with steep grades or sharp curves, it is very important to have the chip spreader as close to the distributor truck as possible to prevent the binder from running down the cross slope or grade. The truck should have adequate power so that a constant speed can be maintained, even on hills, while in the process of spraying. Hydraulic pumps on some newer distributors have resolved many problems including uniform flow at the bar tips. The same is true for hot-applied PG and to ensure adequate heat is maintained to facilitate embedment.

The distributor driver should be able to operate the truck in a manner that will result in longitudinal and transverse joints that have no overlaps or skips. Building paper can be used to make transverse joints when starting and stopping the distributor truck.

When the distributor runs out of asphalt, the flow may not stop abruptly. The flow may sputter and spurt as differing amounts of air and asphalt enter the flow. Emptying the distributor truck is called blowing and should never be permitted on the pavement. The spray bars should be cut off when 200-300 gallons of asphalt are still in the tank. The results of blowing are an extremely spotty and uneven application with everything from grossly over-rich areas to no asphalt at all. Blowing is to be done in an approved area where the asphalt can be safely disposed of.

SPEED OF THE DISTRIBUTOR AND LENGTH OF SPREAD

Distributor speed may be determined by:

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

v = road speed, feet per minute

Q = spray bar output, gal per min

W = spray bar width, feet

A = application rate, gal per sq yd

c = expansion coefficient resulting from heating the asphalt

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

T = application temperature, F

Based on the number of loaded aggregate trucks on hand when operations begin, the length of spread may be determined by:

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

L = length of spread, feet

V = total gallons to be applied to the surface

The number of gallons sprayed is limited by the capacity of the tank. But, for the loaded aggregate trucks on hand, the number of gallons, V, may be determined by:

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

W_a = weight of aggregate on hand, Ib

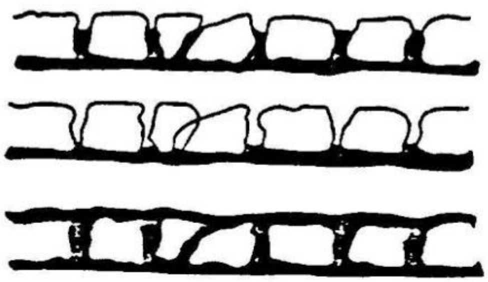
S = spreading rate of aggregate, Ib per sq yd

Asphalt should be at the proper temperature for spraying viscosity. If it is, application at the correct rate presents no problem. The driver merely maintains the predetermined speed as indicated on the dial of the bitumeter.

Checks on the amount of asphalt used are made after each run with the distributor. This is done quickly and easily by calculating the gallons per square yard applied, using the formula:

$A_1 = \frac{9TM}{WL}$	A_1 = actual rate of application, 60 F, gal per sq yd T = total gallons spread from the distributor at spraying temperature (H equals gauge stick reading before spread minus gauge stick reading after spread) M = multiplier for correcting asphalt volume to basis of 60 F, from temperature-volume tables (See Section 1310)

RELATIONSHIP OF QUANTITY OF ASPHALT REQUIRED TO SIZE OF CHIPS



Correct asphalt quantity, voids 70% to 80% filled	
Insufficient asphalt, screenings not firmly held	
Excess asphalt submerges chips and causes bleeding	

Exhibit 404-43.14-1. Speed of Distributor & Length of Spread

No bituminous material shall be spread when weather conditions are unsuitable or when the temperature of the pavement surface is below 85 degrees Fahrenheit. The application of bituminous material shall not be permitted unless there is complete assurance that cover material will be available to immediately cover the application in its entirety. No matter how hot the asphalt is when sprayed, it will cool to the temperature of the pavement in one minute or less.

When the chip spreader stops, the distributor should stop. There are some methods of constructing a joint on the run that allow the spreader to keep moving. The contractor must supply some way of signaling the distributor driver to stop the spread of bituminous material in case there is any delay in the application of the cover material.

Inspection and Application of Cover Material

Cover material for a chip seal coat must meet all the requirements described in Subsection 404-2.02(C). Aggregates should be as uniform in size and shape as possible so that the seal coat will have essentially one layer of aggregate.

Care must be exercised in the stockpiling and handling of cover material to avoid contamination from dust, intermingling with other aggregates, and other contaminants. This includes picking up underlying soil or stones when cover material is being loaded from stockpiles. If the particles are coated with dust, silt, or clay, the coating forms a film that prevents asphalt-aggregate adhesion. A very small amount of certain contaminants can render a large amount of cover material unusable. Oversize stones can plug the spreader box.

The specifications require cover material, when used with emulsified asphalt, to be wet but free from running water at the time of spreading. The purpose of requiring the wet cover material is to nullify the effect of any dust on the aggregate particles. The wet aggregate also reduces the absorption of the water in the emulsion. Dusty aggregate and absorption of water tend to cause an early break which may reduce embedment and the effectiveness and uniformity of the asphalt coating.

When the bituminous material is a PG asphalt for hot-applied application, the cover material, at the time of spreading, shall be dry. Wetting stockpiles for dust control is not permitted. Do not use wet aggregate with cutback or paving asphalts.

Cover material for chip seal is measured by the square yard. However, for the Resident Engineer to determine/confirm the application rate (pounds per square yard), the weight of the cover material must be known. Therefore, cover material is weighed as it is delivered or as produced if pre-coated for hot-applied and transported immediately, and the weight of water is deducted to determine the dry weight per ton; not necessary if pre-coated for hot-applied. Dry weight is determined in accordance with the requirements of AASHTO T 19. This also provides the Resident Engineer with the means by which he or she can determine the actual rate of application whether by the load or over an extended distance. This can be compared with the theoretical rate.

Any deficiencies or any excesses in the application of the cover material should be remedied by hand methods where necessary in order to avoid bleeding areas or build-up areas.

Careful operation of the chip spreader and the hauling equipment is essential to obtaining a uniform surface. Truck drivers should be instructed before the work starts that they are to:

- Stay off asphalt which has not been covered with aggregate,
- Avoid speeds in excess of 15 mph and driving in the same wheel tracks repeatedly when driving on new seal coats,
- Avoid turning movements and sudden applications of brakes on new seal coats, and
- Avoid lining up a number of trucks behind the spreader and preventing the rollers from working as close to the spreader as possible.

The spreader box should not be allowed to be emptied completely between loads because the spread rate is usually affected.

Because of the rapid cooling of the asphalt as it hits the pavement, it is necessary to apply the cover material immediately to get good embedment and chip retention. The entire operation must be organized to achieve a rolled chip surface as quickly as possible after the asphalt is applied; if lag between operations is not minimized, the operation should cease immediately until corrected

The distance between the distributor trucks and the chip spreader should always be the minimum distance that safety will allow. A good operating range is 50 to 75 feet. Close coordination between the distributor truck and the chip spreader will assure that when the chip spreader stops the asphalt distributor will stop; the distributor truck must not outrun the chip spreader and the rollers must not fall behind the chip spreader.

Joints

The specifications permit the contractor some latitude in the method used in making transverse joints. The use of building paper has been a generally accepted method to make a clean bituminous material cut-off. With proper coordination, the contractor may also switch distributor trucks in one of two ways that eliminate the use of paper. If the chip spreader is stopped just before the end of the shot of emulsion it can then be backed out of the way and the second distributor truck can tie onto the fresh end of the previous shot. This must be done quickly enough to allow the chips to be dropped onto the emulsion before it breaks. The variation on this theme is to allow the spreader to fall back 100 to 200 feet and then move as slow as practical while the distributor trucks are switched out. This works better in cooler weather since the emulsion will not break as fast. If the distributor truck operators are not able to tie onto the fresh edge without overlapping the emulsion, then the contractor must use the paper stop and go method.

It is important that the distributor is at proper speed when application of asphalt starts; also, the spray bar should be shut off before it blows or pumps air at the end of each application.

It is important that the Resident Engineer and the contractor work out a satisfactory procedure to be used when the threat of rain requires the work to be stopped. Equally important is an agreement between the inspectors and the contractor's paving crew as to what constitutes a dry pavement after the pavement has become wet.

The specifications are clearly defined in requiring the butt-type longitudinal joint. This method requires the full rate of application of both asphalt and cover material to the extreme edge of the lay ribbon. Care must be taken to not get too much asphalt along the butt joint. A cut off nozzle should be used to attain a sharp cut off of asphalt at a butt joint rather than using a shield. Turning the end nozzle 90 degrees is not acceptable.

The correct speed is also important in the operation of the chip spreader. The rate of application will usually be heavy until the spreader gets up to speed. When starting the spreader, there is also a slight delay until the full flow of chips begins. The spread at the joints should be overlapped enough to allow for the delay in the flow of chips. If the contractor tries to hit the joint too close, it will probably result in a strip having little or no chips that must be covered by hand and will commonly result in a bump.

If the operator is not careful when starting a spread, the wheels of the spreader will slip slightly before getting traction. The wheel slip usually leaves a spot the size of the tire print that will be stripped of cover aggregate and/or asphalt. The stripped areas cannot be patched without leaving a permanent mark.

It is often difficult to get contractors to perform the necessary handwork to get a first-class job. When necessary, handwork needs to be done in a timely manner. Typical of handwork often needed is the cleanup of piled aggregate spilled when trucks dump into the spreader. The piles are to be cleaned up before the roller gets to them. Areas deficient in aggregate also need to be corrected before being rolled. A hand-sprayer, aggregate, and labor should be available just behind the spreader so that handwork can be done without delay and before rolling.

Rolling

The specifications require that a sufficient number of rollers be provided to cover the width of the material in one pass and that rolling will continue for a specified number of passes. The number of rollers needed will be governed by the speed and width of the spreader. The optimum time for rolling is immediately after spreading chips so that it will be done before the emulsion breaks, or the asphalt cools. Remember, the asphalt cools to the pavement temperature in less than a minute. One pass coverage immediately behind the chip spreader is a key requirement for a successful chip seal coat.

If a roller breaks down, the operation should be stopped at once until repairs are made or a replacement is in operation. Furthermore, rolling should not stop to wait for pavement repairs to keep rolling, even if it means they have to remove part of the seal coat later to make the repairs.

The completed seal coat should be examined at intervals after the rolling has been completed. The aggregate should be properly embedded without excessive asphalt showing through. Complete coverage should be achieved, see Exhibit 4-4.

Traffic Control on Chip Seal

Subsections 404-3.03 and 404-7.05 cover the handling of traffic through or around work which involves the application of bituminous treatments. For safety and inspection considerations, the chip seal operation should be completed in time to return traffic to normal by sunset. The contractor should organize his or her work to avoid the sunset hazard and to only rarely restrict traffic after sunset. Most seal coat projects require the use of pilot cars and flaggers. Attention should be paid to the Special Provisions of each chip seal coat contract since traffic control features are often changed for particular job conditions, or to reflect the most recent revisions in traffic safety policies.

Subsection 404-7.05 provides that the speed of motor vehicles shall not exceed 15 mph when it is necessary to travel on a new chip seal coat. This includes the pilot vehicle, the vehicles being piloted, the contractor's vehicles, and ADOT vehicles. The minimum 3 hour traffic-free period shall be observed for emulsion chip seals. For hot-applied chip seals, depending on conditions, it may be appropriate to return the traffic in as little as 30 minutes provided the reduced speed limit is strictly enforced.

Often ADOT and contractor's vehicles are the worst offenders. It is necessary that the Resident Engineer be firm in enforcing the speed limit and the traffic-free period. If weather conditions are adverse to rapid curing of the asphalt, an extended traffic-free period may be required. It is mandatory that the contractor's and ADOT's drivers, as well as the public, observe all traffic controls. Sharp turns and hard braking on fresh chip seals are to be avoided. The contractor should not be allowed to turn his or her trucks around on a fresh seal.

Removal of Loose Cover Material

For hot-applied applications, loose cover material is removed prior to returning to traffic and at least 30 minutes after placement. Therefore, because this happens in a rather short period of time, it is extremely important to ensure removal equipment does not mar the surface during warm/hot conditions; provide additional time for the surface to cool if necessary.

Specifications state that all loose cover material shall be removed in not less than two hours but no more than 36 hours except when conditions dictate a longer period is desirable. Power brooms are required for removal. Broom pressure that dislodges material from the asphalt is not permitted. The surplus material should not be allowed to remain on the pavement edges. It should be removed completely from the paved surface. In the event there are curbs alongside the pavement, it will be necessary for the contractor to pick up the surplus cover material and remove it from the road.

Extra care is necessary when brooming chips in town, or in front of businesses or homes close to the roadway. Chips and dust thrown out by the broom can cause damage and inconvenience, so a change in procedure may be needed. Speeds should be adjusted to eliminate throwing chips and dust. It may be necessary to hold down the dust by watering lightly. Running the broom so as to leave the chips in the center of the pavement is effective but it may require more handwork. The primary thing to consider is that the comfort and convenience of the property owners are at least as important as the contractor's convenience.

Brooming during hot weather is generally limited to cooler morning hours. Heat will loosen the chips so that they are either torn out or rolled over. Stop the brooming at the first sign of chip loss. The inspector will need to be out on the road to observe the operation properly.

The number of brooms provided by the contractor will govern the distance he or she can seal and still remove the excess chips in time. The number of brooms required can be quickly determined by the following procedure:

Assume:

- Three passes are needed for one broom to sweep a 12-foot wide pavement.
- Broom speed is 15 mph.
- 4-1/2 hours are available for brooming.

Calculate what one broom can cover:

- 15 mph x 4 1/2 hours = 67.5 miles per shift.
- 67.5 miles / 3 passes per lane = 22.5 miles of 12 feet wide pavement per day.

Determine the required brooming operations:

- One broom is needed for cleaning up in front of the sealing operation.
- One broom is needed to remove the previous day's loose cover material.
- One broom should be available as a spare or to speed up the other operations.

Therefore, three is the minimum number of brooms normally needed for a chip seal coat covering up to 23 miles of 12 feet wide pavement per day.

After the brooming is completed, the centerline is replaced, usually by state forces. The Resident Engineer is responsible for keeping the District informed so that the centerline can be repainted as quickly as possible. Temporary reflective markers must be placed until the painting has been done, and they must be placed before dark. Do not neglect necessary warning signs.

Chip Seal Inspection Guidelines

- Is the contractor contaminating the cover material with the loading operation?
- How is the weighing of cover material being handled? Is there adequate documentation to determine dry tons of cover material to verify application rates?
- If using emulsified asphalt, are the chips wet, but free of running water?
- If hot-applied, are chips adequately pre-coated?
- Are weather conditions suitable and is the surface temperature within specifications?
- Has the surface been properly prepared?
- Has the absorptive property of the surface been inspected and is the asphalt application rate proper for the existing surface conditions?
- Have areas requiring a change in application rate been identified (painted/marked on shoulder)?
- Are the asphalt distributor and the spreader box mechanically capable of making a uniform application?
- Have tests been made to determine uniformity of application of the asphalt and of the cover material?
- Are proper precautions taken to prevent spattering of asphalt on curbs, handrails, traffic, etc.?
- In making transverse joints, is the contractor using roofing paper or some other suitable material to ensure a proper junction with the preceding work?
- Does the contractor have sufficient labor force to do the necessary brooming and disposing of surplus cover material?
- Is the cover material being promptly and properly rolled after application?
- What types of rolling equipment are being used?
- Are rollers staying close behind the aggregate spreader?

- Is embedment adequate? Check rollers for proper ballasting.
- Is traffic control effective in keeping traffic off of the fresh seal?
- Are the contractor's haul units damaging the fresh seal by excessive speed, sharp turns, etc.?
- Is the initial brooming operation sweeping off more than 5% of the chips to the shoulder? Are there any empty spaces on the surface not filled with chips?
- Is traffic kept off the fresh seal the minimum time required by the specifications?

Slurry Seal Coat & Microsurfacing

Slurry systems consists of a mixture of sand, Portland cement, water, set controlling admixture, and emulsified asphalt mixed to a rich, creamy consistency. It is spread in a thin layer over the pavement. Portland cement is added to aid in stabilizing and setting the slurry. Relatively fast setting polymer modified emulsified asphalt is used to facilitate a quick return to traffic.

A contractor-furnished mix design is necessary for slurry seal and microsurfacing mixtures, which must be reviewed and approved by the Engineer prior to placement. See the Special Provisions for slurry seal coat/microsurfacing mix requirements.

In addition to sealing the surface, slurry seal coats are normally used to fill minor cracks and surface irregularities in AC pavement to prevent further deterioration and to provide a quieter riding surface. Slurry seal coats have also been used to improve surface friction, including pavements where bleeding has occurred.

Microsurfacing is often used to extend the life of older pavements with mild to moderate surface distresses including cracking, raveling, and minor rutting. Microsurfacing may be placed in two separate passes, the first being a scratch coat to fill in minor to moderate irregularities, followed by a second pass, material for which, is applied to the entire width of the area (lane) receiving the treatment. Initial scratch coats must be allowed to cure sufficiently and opened to traffic for at least 24 hours prior to placing the second coat.

Both slurry seal coats and microsurfacing may be placed as the upper most application for a Cape seal for which the initial treatment is a chip seal. In this instance, the chip seal should be exposed to traffic for several days to allow the chips to reorient and become fully embedded prior to placing the slurry seal or microsurfacing.

Most slurry work is now being applied with continuous flow mixing and spreading units. Such units must be equipped with metering devices and feeders that will introduce the aggregate, Portland cement, water, other additives, and emulsion into the mixing chamber in predetermined, specified proportions as determined by the mix design. The emulsion is introduced into the mixing chamber by means of a positive displacement pump which is synchronized with the aggregate feeder belt. There should be an active control for the amount of water introduced that can be used to quickly adjust the flow rate of water.

In general, these slurry type treatments allow for rapid surface treatment and return to traffic provided mix formulation, equipment calibration, field adjustments, and weather conditions are considered.

Calibration Check of Slurry Seal/Microsurfacing Machine (Example)

The following is a sample calculation the inspector can use to check the emulsified asphalt content of the slurry seal mix relative to the approved mix design. A similar calculation is done for microsurfacing, however, the application rate of aggregate will be greater than that for a slurry seal.

Determine the following values:

- Width of Belt = 20 inches
- Length of Belt Travel per Revolution = 3 feet
- Depth of Material (Gate Opening Height) = 3 inches
- Density of Aggregate = 100 pounds per cubic foot
- Emulsion added per Revolution = 1.92 gallons

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

Calculate Weight of Aggregate Per Revolution

- (belt width) x (belt travel) x (material depth) x (density) = Aggregate Weight
- (20/12) x (3) x (3/12) x (100) = 125 pounds

Calculate Weight of Emulsion per Revolution

- (gallons per revolution) x (gallons per ton) = Emulsion Weight
- 1.92 x 2000 / 240 = 16.0 pounds

Calculate Emulsified Asphalt Content

- (Emulsion Weight) / (Aggregate Weight) x 100 = Emulsion Content
- 16.0 / 125 x 100 = 12.8%

The specifications require approximately 13% emulsion per weight of dry aggregate (sand), and approximately 22 pounds of dry aggregate per square yard of pavement for slurry seals, and 30 pounds for microsurfacing. ADOT's interpretation is approximately ± 1% for the emulsion and ± 1 pound for the dry aggregate. These application rates should remain fairly consistent with placements of uniform thickness on relatively even surfaces; adjustments are typically made to the additional water and set controlling admixture to achieve the desired consistency and set times.

The slurry seal machine will have an adjustable squeegee at the rear of the mixer that spreads and squeezes the mixture into any cracks and holes both on grades and level pavements. Sufficient water should be sprayed on the pavement ahead of the machine so that the surface is damp by the time the slurry seal is applied.

Other Inspection Points:

All materials including the emulsion, sand, Portland cement, and source of water should be approved before work begins. Aggregate quality is critical to the performance of slurry type seal systems. Aggregate quality should be determined by sampling the final stockpile prior to delivery to the mixing unit and at the required frequency. Quality requirements and gradation limits for mineral aggregate are provided in the Special Provisions.

Water from irrigation canals or wells that are unfit to drink (regardless of the reason) should not be allowed, unless tested for impurities, as this may affect the chemistry of the emulsion formulation and/or durability of the treatment.

Mixing, placing, spreading, and surface preparation shall conform to Subsections 404-3.04 and 3.05 of the Standard Specifications. Proper preparation/cleaning of the existing surface is paramount to ensure proper adhesion of the slurry to the existing pavement. Any pavement markings with glass beads should be obliterated/removed prior to placement as polymer modified asphalts may not adhere adequately to glass-like surfaces. The spreader box should be equipped with a canvas, or burlap drag to provide a rough surface texture. The drag must be replaced daily in accordance with the Special Provisions.

Oversized aggregate may get caught and dragged by the equipment causing streaks in the surface. Such aggregate must be cleared immediately and any streaks or depressions immediately repaired by hand. If dragging of oversized aggregate is a frequent occurrence, attention should be given to measure and correct deficiencies in the mineral aggregate stockpile(s).

Special care must be taken with longitudinal and transverse joints to prevent either excessive buildup of slurry (ridging) or streaking. The adjoining lane should be allowed to completely cure before making the joint.

Test Strip

At the start of production, a test strip should be constructed to ensure placement and behavior of the material is as expected given surface and weather conditions. Allow the contractor the opportunity to make adjustments to ensure proper mix consistency and to control set time. If adjustments are thought to be excessive, or behavior/appearance of the material is not as expected (too runny, bulky, dry, or wet), or the emulsion does not break or the slurry set up within the expected amount of time, consult with the Regional Materials Engineer and ask the contractor to contact the emulsion supplier and/or mix designer.

Weather

Changes in weather often require adjustments to the mix and will affect break/set times, including throughout each day as the temperature changes. This should be considered and weather monitored as in some instances, the daily work schedule may need to be modified in order to return traffic to the road by the required time.

Opening to Traffic

Slurry seals and microsurfacing must have had time to completely set/cure prior to allowing traffic on the material. As with fog seals, the initial mix will be brown in appearance but will become black as moisture evaporates from the material. Once the emulsion has broken, additional time should be allowed to facilitate curing/setting of the material; it should not be easily marred under foot. The contractor should first test the material under construction traffic before removing traffic control. Additional time should be afforded in areas where stopping/turning movements are likely to occur. Typically, one to four hours is needed to achieve adequate cure prior to return to traffic.

Bonded Wearing Course

Bonded Wearing Course (BWC), also sometimes referred to as a Nova Chip, consists of a relatively thin application of a polymer modified asphaltic concrete mixture that resembles properties similar to both a dense graded AC as well as an open graded friction course, with construction techniques adapted from chip seal coats. It is a hot mix asphalt placed at a thickness of either 1 or 1-½ inches with a spray paver that places a polymer modified emulsion membrane. The membrane is a heavy tack coat, sprayed at an increased application rate compared to conventional tack, immediately ahead of the paving screed. The mixture is embedded into the emulsion membrane during compaction with conventional compaction equipment to ensure a strong bond with the existing pavement.

BWC is an appropriate treatment for roads which are experiencing mild to moderate surface deterioration where a more robust treatment than a slurry seal or chip seal is needed, and it is desired to extend the service life without milling and removing a significant depth of the pavement. BWC is a good treatment option for older pavements with sound pavement structure and support, but will not prevent distresses, e.g. potholes or significant fatigue/alligator cracking, where pavement support is inadequate due to base or subgrade issues or disintegrated pavement. The existing AC must be sound with no evidence of stripping or delaminated layers of pavement.

BWC course typically has greater air voids than dense graded asphaltic concrete, but fewer than an open graded friction course, and provides sufficient friction and will reduce, to some extent, the spray effect behind vehicles during inclement weather. The material relies on a proper bond to the existing pavement surface and a thick asphalt film thickness with a polymer modified binder, the PG of which is typically one grade higher than that used for the dense graded AC (similar to friction course), to ensure stability and performance.

A contractor furnished mix design, to be reviewed and approved by the Regional Materials Engineer, is required for BWC construction. The contractor's quality control facility must be inspected by the ADOT Materials Group Quality Assurance Section to ensure properly working equipment including a calibrated nuclear asphalt content gauge, used to measure asphalt content similar to that performed for acceptance of friction course. The contractor's QC must calibrate the gauge with the materials to be used for the BWC.

The mineral aggregate must also be verified to be in compliance with sand equivalent, fractured faces, and the gradation requirements prior to production (similar to that for friction course, but only a single test for gradation).

The BWC may be placed on either the existing pavement surface or a milled surface. A pre-activity walk through should be performed to ensure the exposed or milled pavement surface is in proper condition to receive the BWC, and any areas requiring adjustments in application rate for the emulsion membrane identified. Proper preparation of the surface is absolutely critical to ensure proper bond and performance. Any areas with residual dust or films must be cleaned.

A test strip of approximately 1,000 feet in length should be placed by the contractor. During construction of the test strip, all equipment must be verified to be operating properly with particular attention toward delivery of the mixture to the material transfer vehicle (required to be used for BWC) in such a manner that there is no interruption, or disturbance to the paving screed, which would reduce smoothness. It is also important that the spray bar is applying a complete and uniform emulsion membrane to the surface (approximately 0.24 gal/sq.yd.). The application rate of the emulsion membrane and spread lot of BWC of approximately 100 lb/sq.yd per inch should be verified at the conclusion of the test strip. When all is confirmed to be in order, paving may resume.

Any spray nozzles that become plugged or spray intermittently must be immediately cleared and corrected or the operation must cease immediately. This can be a dangerous task and it may be necessary that the contractor have a spotter who is visible to the paving screed operator to alert the operator if any workers become immobilized ahead of the paving equipment.

Where BWC differs significantly from typical paving with hot mix asphalt is that the tack coat will not yet have broken at the time the mixture is placed with the paving screed. The reason for this is that the BWC must be embedded into the polymer modified emulsion membrane (heavy tack coat) that is applied with the spray paver. This would not be possible if the emulsion was left to break and cool prior to paving. Because the BWC is relatively thin but thicker than a friction course, and is also somewhat open graded, the intent is that moisture in the emulsion membrane will be flashed out and escape prior to compaction. For this reason, sufficient heat must exist within the existing pavement, asphalt emulsion, and hot mix asphalt.

To ensure sufficient heat exists during placement and compaction, the following requirements must be strictly adhered to:

- Ambient temperature of at least 60 degrees F and rising.
- Surface temperature of at least 75 degrees F.
- No sustained wind speed forecasted to be in excess of 15 mph (unless ambient temperature is 75 degrees and rising, as approved by the Engineer).
- Emulsion temperature of at least 120 degrees F (preferably near but not exceeding 180 degrees F)
- Asphaltic Concrete placed within 5 seconds of applying emulsion membrane
- Mix temperature of 290 to 330 degrees F at time of placement.
- Minimum mat temp of 275 degrees F prior to compaction.

Although a vibrating screed is required, this may result in surface/quality irregularities, and vibration may be discontinued to resolve such issues if so directed by the Engineer.

Compaction should immediately follow placement and be performed with ballasted steel double drum compactors operated in static mode only; 2 to 3 roller passes are required and there must be a sufficient number of rollers for initial breakdown to cover the entire width of the mat in a single pass when staggered. A separate roller is required to finish rolling. Every effort should be made to complete compaction prior to the mat cooling to 250 degrees F; with the finish roller off the mat when the temperature has dropped below 220 degrees F. The use of a warm mix additive is permitted and this may result in the recommended rolling completion temperatures being slightly lower; discuss with the Regional Materials Engineer if warm mix additive is utilized.

Sampling for acceptance includes a gradation sample for the mineral aggregate and a sample for asphalt content every 500 tons or fraction thereof. Gradation must meet the production tolerances in Table 9, and asphalt content must meet both the single and triple specification requirements.

After placement of the test strip, and periodically throughout paving, the BWC should be checked to confirm embedment of the mix into the emulsion membrane. This is impossible to do by looking at the surface of the BWC, but may be accomplished by looking at the edge of the mat, potentially removing a very slight amount of material from the edge with a shovel or trowel, and visually inspecting the vertical profile of the emulsion membrane and BWC. There should be some evidence that the emulsion membrane has migrated up into the lower portion of the BWC mixture rather than the aggregate riding only on the surface of the membrane. Little to no evidence of embedment may suggest that the emulsion membrane application rate should be increased slightly, or that there is insufficient heat present to facilitate embedment of the mixture during placement and by the breakdown rollers during compaction.

The presence of fractured aggregate may indicate that too thin a placement is being paved in which case the spread lot should be determined and thickness increased as appropriate.

Similar to friction course, which is also a very binder rich material, excessive drain down may occur for loads that are delayed and remain in the haul vehicle for an extended period of time. To prevent this from occurring, and to maintain as much heat as possible, it is critical that the contractor balance the rate of material supplied from the hot plant with the forward speed of the paver, and have a sufficient number of haul vehicles to maintain a continuous paving operation of 30-50 feet per minute.

If rain is likely during the scheduled day of placement, or if temperatures dropping below 40 degrees the evening or day following paving are forecast, placement of the BWC should be delayed or temporarily suspended until more favorable conditions are expected.

Crack Sealing (Asphaltic Concrete Pavement)

See the Special Provisions for Crack Sealing requirements. Cracks are sealed in asphaltic concrete (AC) pavements to reduce the rate at which existing cracks will propagate and prevent what will otherwise become rapid deterioration of the road by preventing both of the following:

- Intrusion of incompressible materials (like small stones or sand).
- Intrusion of water into the underlying pavement layers.

Asphalt-rubber sealant is used by ADOT as crack sealant. A certificate of compliance must accompany the material before the use on the project. Several commonly used products are on the Approved Products List. Ensure the correct type of sealant is being utilized based on project location/elevation.

Prior to sealing, it is absolutely necessary that all cracks be thoroughly cleaned to remove incompressible material by either high-pressure air or by routing. Heavily oxidized/weathered material exposed within the cracks must be removed by routing or sawing to ensure the crack seal material will be applied to competent pavement. If grass or weeds are growing through the crack, those areas should be marked prior to cleaning and an approved liquid herbicide should be injected in the crack after cleaning.

The surfaces to which the crack seal material will be applied must be completely dry. Any moisture in the pavement must be allowed to dissipate or torches may be used to heat the pavement in the vicinity of the cracks to facilitate drying. Any moisture remaining in the crack will result in failure of the crack seal application.

The inspector shall spot check the depths of the cleaned cracks for conformance to the specifications prior to sealing. In addition to routing to remove incompetent material from the surface of the cracks, the contractor may have to rout some of the cracks in order to achieve the specified depth. Depth is important in order to achieve a long lasting seal.

Once the crack has been properly prepared, and is completely dry, the crack should be completely filled with the crack sealing compound with a heated wand from the bottom up. If no overlay or surface treatment will occur following the crack sealing, an overband should be made with heated disk or squeegee so that as the pavement expands/contracts (warms/cools), the crack remains sealed. If an overlay, wearing course, or seal coat other than a fog seal will be placed, no overband should be created but the crack seal material should be kept flush or perhaps slightly below the surface of the pavement.

Slightly underfilling the crack when an additional paving application will be placed over the crack sealed surface is necessary to avoid both of the following:

- The presence of an excessive amount of asphalt material at the location of the cracks which may then result in flushing/bleeding of excess asphalt to the surface, or slippage of the overlay during periods of hot weather.
- A phenomenon where the tenacity of the crack seal material grabs onto the slight mound of hot mix asphalt being pushed ahead of the forward wheel of the roller, resulting in a slight accumulation of material and a bump in the overlay.

Ideally, any crack sealing operations are completed well in advance of the surface treatment or overlay to minimize these two potential effects. Where crack fill on the surface of the pavement will be subject to traffic for an extended period of time during hot weather, it may be necessary to apply what is commonly referred to as a bond breaker or blotter sand to prevent the material from becoming adhered to traffic tires and getting picked up. Once this begins, the issue will quickly propagate and cause a significant amount of damage to a crack sealed road.

404-8 Method of Measurement

Tack Coats

Asphalt cement is the only approved tack coat for Specification 407 ACFC, 413 AR-AC, and 414 AR-ACFC. Emulsified asphalts are typically used for all other tack coats. Emulsified asphalt is a mixture of asphalt cement and water. This asphalt/water ratio is about two-thirds asphalt. Sometimes a special type of emulsified asphalt is specified in the Special Provisions or by the Resident Engineer. The special type of emulsified asphalt is a 50/50 mixture of water and emulsified asphalt. The effect is to further dilute the asphalt cement reducing the asphalt/water ratio. Diluted emulsions are used where it is desired for the emulsion to further penetrate the existing asphalt

When the special type of emulsified asphalt is used, a pay factor adjustment (see the Standard Specification table in Subsection 404-5) is needed to account for the dilution. Since the pay item in the bid schedule is for undiluted emulsified asphalt, a cost adjustment needs to be made to the pay item 4040111. The field office should create a subitem for the cost adjustment and pay at a rate of 70% of the unit price for the bituminous tack coat item. The payment amount should be adjusted to the nearest dollar (see Section 404-9 of the Standard Specifications).

407 ASPHALTIC CONCRETE FRICTION COURSE (ACFC)

Asphaltic Concrete (AC) and Asphaltic Concrete Friction Course (ACFC) serve very different purposes in the pavement structural section. AC gives the roadway strength to carry wheel loads and it can be used as a base course, or for leveling. ACFC is used as the final riding surface on high speed roadways where superior skid resistance is needed; such as rural highways and interstates. ACFC thickness is typically at least ½ inch on asphalt concrete overlays and 1 inch on PCCP. ACFC is never used as a leveling or base course since it should never be overlaid. ACFC mixes are open graded which means the mineral aggregate is all approximately the same size with very little fines. This type of mix produces a porous surface that not only provides excellent skid resistance but improved drainage as well.

ACFC is more inspection intensive than other AC operations. It is almost entirely a materials and method type specification requiring both the inspectors and Project Supervisor to closely monitor the plant and paving operations, and to also know and enforce each parameter of the specifications thoroughly.

For the sake of brevity, many inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements specific to specification 407.

Here are some important differences:

- ACFC mix properties are different from AC properties, including the aggregate gradations, asphalt content, abrasion, percent of limestone in the aggregate, and specific gravity.
- A higher percent of fractured coarse aggregate particles (crushed face) is specified for ACFC and there is a flakiness index requirement.
- Acceptance of the ACFC mix is based on grading and asphalt content as with AC, but there are no requirements for voids, stability, or flow.
- The requirement that the mix be free flowing and homogeneous is reinforced by the citing of special measures that the contractor may have to take to assure these characteristics.
- There are ACFC placement date restrictions and surface temperature requirements.
- Paving machine grade control devices are limited to short and long skis. Longitudinal pavement joints are permitted only at the centerline between adjacent lanes.
- There is no ACFC compaction density requirement.
- ACFC mixing, placement, and compaction temperatures are lower than AC. This is important to be able to place a mix with the higher amount of voids as intended.
- ADOT develops the mix design based on the aggregate and asphalt cement samples provided by the contractor. There are time constraints placed on the Department for producing the mix design. The Resident Engineer is responsible for ensuring that the time periods for reviewing and verifying a mix design by the Department are strictly followed unless different arrangements are made in writing with the contractor.
- Add in any changes specific to 407 from section 407-604 from the Standard Specifications.

407-6.04 Material Spread

See Asphaltic Concrete Section for requirements.

407-8 & 407-9 Method of Measurement & Basis of Payment

- Asphaltic concrete is measured by the ton and paid for at the contract unit price per ton, adjusted as necessary for waste and spread.
    - If the quantity in a spread lot is found to vary by more than +5%, no payment will be made for the material that exceeds the +5%, including the asphalt cement and the mineral admixture.
- Asphalt Cement will be measured and paid by the ton.
    - Subsection 407-9 does not allow the 407-6.03(B) nuclear gauge test results to be used as a

    method of measurement for asphalt cement.
    - Asphalt binder penalties apply if the asphalt binder does not meet the requirements of section 1005-3.01.
    - A bituminous material price adjustment may be applicable if the 109.16 specification is included in the special provisions for each contract.
- Mineral Admixture is measured and paid by the ton, at the predetermined price established in the bidding schedule.
- When required in the Special Provisions, payment for smoothness shall be made in accordance with the requirements of Subsection 109.13 of the specifications.

408 COLD RECYCLING (BITUMINOUS SURFACE)

Cold recycled asphaltic concrete may be 100% reclaimed asphalt pavement from millings (RAP) or may be a combination of RAP and virgin aggregate (corrective aggregate). Additionally, Cold in-Place Recycling recycling (CIR) may be performed in place, or performed by transporting millings to a location away from the grade for processing, or processing previously existing millings already stockpiled; referred to as Cold Central Plant Recycling (CCPR). Both processes are very similar in terms of materials, but are deployed differently depending on project vicinity, equipment maneuverability and horizontal roadway alignment, depth of which it is desired to remove material from the existing grade, and the quantity of suitable RAP already stockpiled and the distance from this material to the project.

For example, a project with numerous tight curves will be difficult to perform CIR due to the length of the equipment to perform this process. Therefore, it is likely the millings will be transported to a central plant where the millings are fractionated to become RAP, and then treated and mixed with an engineered asphalt emulsion prior to hauling back to the project. Projects with gradual geometry are most often recycled with a CIR train, which is a mobile process that performs the operation directly on the grade, thus eliminating the need to haul millings from the project; this is ideal for remote projects. Depending on project length and quantity of materials, both processes may be deployed and central plant recycling may be performed by use of the CIR train set up to operate stationary.

CIR is not recommended where the base aggregate is poor. In poor base areas, another recycling technique may be used called Full Depth Reclamation (FDR). FDR is the process of pulverizing and blending asphalt pavement with the underlying aggregate base material to provide a homogenous material upon which to place new asphalt pavement. FDR is generally six to eighteen inches thick and is commonly designed to be a 50/50 blend of asphalt and aggregate. FDR is commonly recommended where the pavement has excessive cracking, rutting, frost heaving, or high percentage of fines in the aggregate causing subgrade drainage issues. FDR may be bladed on the surface in order to correct minor variations in the roadway profile or cross slope prior to placing new layers of asphalt.

In some instances, it is desirable to deploy both CIR and CCPR or FDR together for the same project. For example, if a rather thick pavement has full depth cracks, it is more desirable to address the full depth of the asphaltic concrete pavement to prevent reflective cracking rather than a conventional mill and overlay which leaves underlying cracked pavement in place. To accomplish this, all but the lower four inches of AC may be removed by milling and transported to a central plant for processing, while the remaining three or four inches is recycled in place by means of CIR.

If all remaining AC will not be recycled, CIR works best when there is at least two inches of existing asphalt remaining below the CIR layer to serve as a working platform for CIR operations. The mixture of underlying aggregate base with the CIR is not desirable and needs to be monitored during the milling operations if any thinner than expected asphalt sections are encountered, if not accounted for during development of the mix design.

If base or subgrade stabilization is desired, rather than performing CIR for only the lower portion of the AC, FDR may be utilized to process the remaining AC as well as substantial depth of base and/or subgrade material. Once the lower portion of the AC and any underlying issues have been addressed, the CCPR material is then hauled to the grade and placed and compacted with conventional paving equipment.

One of the challenges with FDR is that the finished grade is often many inches higher than existing. Adjacent intersections and driveways must be reconstructed to match the new grade. Vertical tapered sections are required at the project limits and at bridge structures. In addition to drainage considerations, curb, barriers, and guardrail are typically required to be replaced as a result of FDR. Similarly, CIR also has a slight bulking effect. A preliminary mill of the existing pavement may alleviate some of the need to address changes in elevation.

When combined, these processes (CIR, CCPR, & FDR) completely address all distresses in the existing pavement and provide a new pavement section upon which a relatively thin, two or three inch, mat of new asphaltic concrete pavement may be placed. For lightly traveled roads, a chips seal or other surface wearing course may be all that is needed. Cold recycling minimizes the use of virgin materials, minimizes costs associated with hauling materials, and provides a long lasting pavement suitable for use on any transportation facility including interstates.

There is a misconception that recycled material will only perform well on lightly traveled rural routes. While this may have been true for cold recycling performed with the initial technologies developed for the process nearly half a century ago, this is certainly not true for the modern practice of cold recycling, as is evident by numerous state DOTs performing pavement preservation and pavement rehabilitation each and every year by means of cold recycling with much success at a substantially reduced cost.

Materials, testing and inspection procedures, and construction requirements for cold recycling are very different from both typical asphaltic concrete materials as well as what was performed previously for cold recycling. This subsection of the manual contains inspection procedures and contract administration requirements for Specification 408 that are both in addition to those for typical asphaltic concrete and what was performed previously for cold recycling. The differences are brought about by the use of millings or existing RAP, the need to perform a mix design with an engineered asphalt emulsion and conduct mixture performance testing, and the need to continuously confirm proper processing of material, compaction, readiness to open to traffic, and behavior once opened to traffic. Therefore, 408 is primarily a method specification but includes an end-product-like compaction specification for acceptance.

408-2 Cold Recycle Materials

Materials used in cold recycling include millings or RAP, engineered asphalt emulsion or a solventless emulsion, mineral admixture, either hydrated lime or portland cement, water, and may include corrective aggregate.

RAP is either screened, crushed, and re-screened during the CIR process, or is screened, fractionated, and placed in two or more stockpiles for CCPR. Once screened, RAP typically has a top size of either 1 or 1-¼ inches. Deleterious materials including crack seal material and cold patch material in excess of that which has been accounted for in the mix design must be removed prior to the CIR process if the CIR train is unable to adequately screen out these materials.

Corrective aggregate, i.e. virgin or processed/screened RAP, may be placed on the grade ahead of the CIR train, or stockpiled for inclusion in CCPR. Corrective aggregate is used to address any inadequacies in RAP gradation or fractured faces to ensure a dense, stable recycled mix.

Engineered emulsion is mixed with the RAP during the process to provide an additional coating of new asphalt cement to produce an asphalt bound material similar to hot mix asphalt. An engineered emulsion is one which both meets the PG requirements for the project location and climate, is capable of sufficiently coating the aggregate during the process, and will break within a reasonable amount of time to facilitate compaction and return to traffic. Engineered emulsions are often referred to as solventless emulsions because they exhibit good ability to coat aggregate without the inclusion of no more than 1% of a solvent such as kerosene or diesel fuel, which are found in cutback asphalts or high float emulsions that were previously used for cold recycling operations.

Mineral admixture is used to enhance the performance of the cold recycled material including anti-stripping, increased strength, and more rapid development of strength for stability when returned to traffic. The performance of recycled material which includes a mineral admixture is superior to that which does not; ADOT now requires a mineral admixture be included in the recycled material. The mineral admixture is most commonly added near the cutter head as a lime slurry to both facilitate adequate distribution within the mix, but also to cool the teeth of the cutter head.

Water is added within the pugmill mixer of the CIR train to facilitate both coating with the asphalt emulsion, also added at the pugmill, as well as compaction after lay down.

It is critical that all materials added be metered and/or quantified to confirm conformance to the mix design prepared for the segment of road or fractionated RAP being recycled.

408-3 Mix Design

The mix design is the contractor's responsibility and must be prepared by a licensed professional engineer with cold recycling experience.

The quantities of each additive/material that will be included in the cold recycled mixture are determined by development of a mix design for the project, and for each unique segment of the project as determined by the presence of different materials. Material is systematically obtained from within the roadway and then undergoes mixing at different gradations with different quantities of additives and liquids content, and is then subjected to mixture performance testing to both identify optimum additive dosages, as well as ensure compaction and performance once constructed. For this reason, it is imperative that material be produced in accordance with the mix design.

Both the percentages or addition rates of all materials/additives is provided on the mix design, as well as the volumetric and performance characteristics of the cold recycled mixture. Fortunately, due to the improvements now utilized for design, and the control of material during construction, performance characteristics need not be tested during construction unless a change in material is suspected. The mix design process requires high temperature verification if the mat temperature is expected to exceed 85 degrees F to ensure stability for construction in warm weather.

408-4 Equipment

CIR Train equipment requirements, including those for calibration, are provided in subsections 408-4.01. CCPR requirements are provided in subsection 408-4.02. In addition to having all of the necessary functionality, what is of the utmost importance, is the verification of metering and control mechanisms to ensure proper addition of each of the materials prescribed in the mix design. If any component, control, or metering device is suspected of being faulty or inaccurate, the operation should halt until a calibration is performed and proper operation is confirmed. Specific requirements are found in 408-4.01 for trains and 408-4.02 for central plants. Requirements for other necessary equipment are found in 408-4.03 thru 4.10.

The equipment needed for cold recycling in addition to that for typical hot mix asphalt production and paving most commonly includes an agitated storage tank for mixing the lime slurry, and both heavy steel drum rollers and pneumatic tire rollers. Rollers must be adequately ballasted in order to achieve compaction of the recycled material. If Portland cement is used as the mineral admixture, it is most often placed ahead of the mill head on the existing pavement surface provided the wind is sufficiently calm to facilitate such placement.

Pre-Activity Meetings and Submittals

Because the modernized practice of cold recycling is unfamiliar to many within the Department, the contractor is required to provide 'Just-in-Time Training' to project personnel (both working for the contractor or subcontractors, and the Department) who will be involved in cold recycling operations. The training must be provided by a person with extensive cold recycling experience on projects with similar mixture and construction requirements. See section 408-5 for specific requirements.

A Pre-Cold Recycling Meeting is required to discuss cold recycling operations, equipment that will be used and calibration thereof, production sequences, road preparation, weather, safety, quality control, and any other pertinent items. During this meeting, a Cold Recycling Operations Plan is submitted to the Department to detail how the recycling will progress and any expected changes that will occur during the recycling operation. A Quality Control submittal will also be provided to the Department to identify the personnel charged with performing quality control related duties as well as how necessary changes in dosage/addition rates will be determined. See section 408-6 for specific requirements.

Quality Control

Quality control for cold recycling is an intensive process that relies on the timely obtaining of processed material, testing this material, and also testing in-place compacted material at multiple times prior to full acceptance. The specific quality control measures to be performed by the contractor are provided in subsection 408-9. Most notable, are the needs to confirm quantities of materials and establish that processed material is adequately compacted. There is no time for standing around during the recycling operation and there must be a sufficient number of QC personnel to perform all of the required tasks, adequate QC personnel should be addressed with the contractor at the pre activity meeting.

All gauge and control monitor readings for all materials/additives must be confirmed accurately by measuring the actual quantities used to ensure production is both consistent and as prescribed by the mix design.

Compaction control is performed by obtaining a sample of processed material, field compacting this into a 6-inch proctor mold, determining the wet density of the compacted specimen, and then subsequently using this information to ensure that the maximum attainable compaction is being achieved in the cold recycled mat. This includes determining the moisture content necessary for compaction and proctor density of processed material from the windrow at 1,000 ft intervals, and subsequently measuring the wet density with a thin lift nuclear density gauge.

Additionally, the dry density of the mat is determined at these locations and this value is compared to the maximum theoretical density shown on the mix design to ensure adequate compaction is being achieved or if perhaps the mix design is no longer representative of the material being produced.

Prior to opening to traffic, both shear-vane (ARIZ 429) and flow strength (ARIZ 430) tests are performed to ensure the cold recycled material has achieved adequate strength to resist deformation once opened to traffic.

Prior to full acceptance and the contractor placing the surfacing or asphaltic concrete overlay on the cold recycled material, the contractor must again measure the density with a thin lift nuclear density gauge, following secondary compaction, discussed below and core the cold recycled material to determine the in-situ moisture content, both of which must meet the criteria in subsection 408-10.02

408-7 Construction Requirements

The contractor should perform a pre-construction investigation (see 408-7.01 of the Standard Specifications) that may include additional coring and milling to aid in developing their cold recycling operations plan. Any areas milled must be patched by the contractor.

The contractor must adequately prepare the road ahead of in-place recycling operations. See section 408-7.02 of the Standard Specifications.

Once cold recycling operations have begun, there are very specific requirements for the addition of each material. These requirements are provided in sections 408-7.03 through 408-7.07.

After all additives have been thoroughly mixed, the cold recycled material is placed with a paving screed similar to a hot-mix asphalt. Both cold recycling trains and central plants are equipped with alarms and lights should any part of the process not stay within tolerances. The cause of any such sounding of an alarm must be addressed by the contractor to the satisfaction of the Engineer; do not ignore sounding alarms.

The placed material should appear homogeneous without any segregation or conglomerations/pockets of asphalt-saturated aggregate. Raised pavement markers and loop detectors should have been removed prior to recycling, and if paving fabric is encountered, the contractor must adjust the operation accordingly. Handwork should be kept to a minimum and work should cease if the placed material requires constant attention from handworkers.

Any material with emulsion that begins to break prior to being placed by the paver must be removed. Once acceptable material is placed however, compaction does not begin until after the emulsion has begun to break. The time for this to occur is dependent on the specific emulsion used but usually breaks between 30 minutes to 2 hours.

Prior to compaction, the contractor's QC must collect recycled material from the grade and compact specimens at 1,000 foot intervals. A thin lift nuclear density gauge must be used to monitor compaction of the cold recycled material . See section 408-9 for specific requirements.

Compaction rollers must be properly ballasted, and operators should be careful to not stop/start on any uncompacted cold recycled surfaces. The rolling pattern must be constantly monitored by the contractor (500 ton intervals max). The rolling pattern should be that which achieves the maximum density without inducing cracking.

To confirm compaction, the wet density of the thin lift nuclear gauge measurements is compared to and should achieve at least 98% of the wet density determined by compacting specimens in the 6-inch proctor mold. The dry density is also compared to that in the mix design to confirm air voids and consistency in the mix. See section 408-7.08.

Once compacted a fog coat is applied with blotter sand to help reduce raveling of the surface once returned to traffic. To return to traffic, shear vane testing (ARIZ 429) and in-place flow testing (ARIZ 430) must be performed and be within acceptable tolerances (see Sections 408-7.09 & 7.10). These tests help ensure the recycled material has attained sufficient strength to withstand deformation under traffic. However, it is imperative that traffic control resulting in repeated stop and go traffic be avoided.

Once opened to traffic, the contractor is required to both monitor and maintain the surface of the cold recycled pavement including removing loose material and patching any potholes that develop. If corrugations or instability of any kind are observed in the recycled material, the operation must cease immediately until the contractors QC has investigated to determine the cause, which may include confirming the metering system is functioning properly, that the correct quantities of materials (primarily the emulsion) have been used, and possibly a new mix design.

Prior to placing surfacing or an asphalt overlay, the recycled mat must be allowed to fully cure and be accepted by the Department. Sufficient cure is achieved when the moisture content is no more than 2.0% after three days without precipitation. The contractor will take nuclear density gauge readings and core the recycled material to collect specimens to determine moisture content and compaction. See sections 408-7.12 & 408-10.02.

Secondary compaction may be necessary if the density achieved after the initial compaction is determined to be inadequate. Secondary compaction is performed with both pneumatic and double steel drum rollers after sufficient cure is attained and the pavement temperature is at least 80 degrees F. Secondary compaction should be performed on the warmest day possible, unless directed otherwise by the Regional Materials Engineer.

These requirements, up to curing, must be demonstrated satisfactorily during placement of a test strip at least 1,500 ft in length. Adjustments must be made by the contractor as needed to facilitate placement and satisfaction of the compaction requirements. Once the Engineer is satisfied, full production may commence.

During placement of the test strip and during full production the contractor may adjust the engineered emulsion rate by 0.1% increments provided the addition rate remains within 0.3% of the mix design target. The QC must closely monitor and adjust the rolling pattern, if necessary, any time such an adjustment is made. The intent is to maximize the density achieved.

Periodic monitoring of the test strip is required for the duration of the day during which it was placed to confirm no adverse effects once returned to traffic.

Section 408-7.15 provides ambient weather condition requirements, within which, cold recycling may be performed. Be aware that high temperature verification of the cold recycled mixture must have been performed during the mix design if the mat is expected to exceed 85 degrees F; this is likely to occur for nearly all cold recycling projects. Cold recycling operations must cease any time the existing pavement reaches or exceeds 160 degrees F, and traffic should not be allowed on any cold recycled material that exceeds 160 degrees F. Cold recycling is not allowed when ambient temperatures are expected to drop below 35 degrees F or rise above 95 degrees F within 48 hours following placement. Unexpected high or low temperatures should be discussed with the emulsion supplier.

408-10 Acceptance

Cold recycled material is accepted based on adequate emulsion content as measured during production, compaction and moisture content, as confirmed by testing, and surface requirements and tolerances immediately prior to placement of the surface wearing course or asphalt overlay. Be careful not to indicate acceptance until equipment and mixture is ready to be placed on the cold recycled material. The surface should be visually inspected for defects and checked with a 10 foot straight edge to ensure variations are within a ⅜ inch tolerance.

For acceptance of compaction, it is extremely important that locations of field compacted specimens and cores are accurately documented since final core or nuclear gauge density measurements are compared to the closest field compacted specimen.

This section provides means for corrective action should any of the acceptance criteria not be met, including re-recycling the material or removal and replacement with asphaltic concrete. Of particular note is that any areas removed and replaced with asphaltic concrete are accepted as cold recycled bituminous mixture and paid as the same.

409 ASPHALTIC CONCRETE (MISCELLANEOUS STRUCTURAL)

Miscellaneous structural AC is used in areas where a lower strength asphaltic concrete is acceptable to the Department, or a smaller amount of asphaltic concrete is required and it would not be practical to use a percent within limits (PWL) calculation to accept the material such as that done for end product AC. Applications include guardrail pads, temporary paving such as detours, erosion control measures, and areas where constructability issues limit compaction, spot milling, leveling, narrowing or widening of the roadway, turnouts, etc. Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. Most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for Specification 409.

Here are some important differences:

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

Where a Miscellaneous Structural Special Mix is required, both mixture properties and compaction remain critical. However, because conditions are likely not conducive to a consistent paving operation in a linear fashion, and possibly with relatively small quantity of production, compaction will inherently be inconsistent and low tonnage precludes applying the PWL calculation. Therefore, the compactive effort must be to the satisfaction of the Engineer, and the mixture must meet the specification requirements. The Engineer may core the AC if compaction is thought to be inadequate.

409-2 Materials

Two Gradations are given in the Standard Specifications, one for lifts of two inches or less and the other for lifts greater than two inches. The mix design should be checked against this table. Both 416 and 417 mixtures may be approved for use as 409. Generally, ½ mixtures should be used for thicknesses of 2 inches or less and ¾ mixtures may be used for 2.5 inches or thicker.

For Special Mixes, the mineral aggregate must also meet the requirements for Sand Equivalent and Uncompacted Void Content. These are to ensure both durability and stability of the pavement.

The contractor may also make self directed target changes in accordance with the limitations in 409-2.04 of the stored specifications.

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

409-2.05 Sampling and Testing

While miscellaneous structural material is not required to be sampled and tested, miscellaneous structural special mix is sampled at 500 ton intervals.

409-3 Construction Requirements

The temperature of the mix discharged at the plant cannot exceed 325 degrees F. The surface temperature must be 65 degrees F or higher in order to pave.

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

This specification does not require the contractor to submit the daily pyrometer record.

409-3.02 Compaction

The inspector shall ensure that the surfaces on which the asphaltic concrete is to be placed is acceptable and in accordance with the Contract Plans or Special Provisions. The Resident Engineer shall select the compaction option and verify that the contractor complies with the specified procedures. In order to compact the asphalt concrete properly, the contractor should have the right type of equipment and it must be of the size required to properly perform the work specified. There is no density specification, only a method specification; so careful monitoring of the compaction operation is an important task of the inspectors. Rolling pattern and number of coverages shall be documented in the daily diary.

409-3.03 Acceptance

Test results must be within the allowable variation shown in the table, otherwise, price reductions are enforced. Similar to end product AC, an Engineering Analysis is required for the Department to consider material that failed to meet requirements to be allowed to remain in place.

410 ASPHALT-RUBBER STRESS-ABSORBING MEMBRANE

Stress-absorbing membrane interlayers (SAMIs) containing asphalt-rubber mixtures and cover material are used to reduce the onset of reflective cracking in new asphaltic concrete overlays. SAMIs are effective for pavement surfaces with general age related block cracking; they are not effective against transverse thermal shrinkage cracks or cracks that remain excessively active.

A stress-absorbing membrane is designed to both seal cracks and absorb minor future crack movements and stresses that would otherwise concentrate in the asphalt overlay. Because the membrane is rather thick, it is expected to remain intact between the two layers of asphaltic concrete without breaking or deteriorating.

The Standard Specifications for the work are quite detailed and should be followed closely. The Special Provisions for stress-absorbing membrane will identify the asphalt-rubber type and the placement dates. Stress-absorbing membrane requirements are similar to hot-applied chip seals, but there are differences that must be carefully adhered to. Proportioning of the rubber, asphalt, and extender oil must be done carefully. Chips must be pre-coated with asphalt cement; never wet the chips for dust control. Chip Seals are considered a bituminous treatment and are discussed in Chapter 404.

Covering the asphalt-rubber with chips and initial compaction must be done in the least possible time. The timing of the asphalt chip rolling operation is even more critical than with a regular chip seal and there are time and temperature limitations that must be adhered to, refer to the Table in Section 410-3.04 of the Standard Specification). The asphalt-rubber is very sensitive to temperature variations and can be placed only at certain times of the year, depending on elevations. If the various steps in the operation are not timed correctly, there may be a loss of chips. Unlike a regular chip seal, the membrane requires approximately 4 inches of lap on the longitudinal joint.

If placed as a hot applied chip seal, the surface must be dry. If the surface has been milled, it must also be clean and meet mean macrotexture requirements.

Once placed, there is a minimum three-hour traffic free period to allow the membrane to set. Prior to the overlay, it is imperative that any loose cover material be removed by sweeping. Under most circumstances, a tack coat should be applied prior to the overlay and this is required if traffic has been allowed on the SAMI. The overlay must be placed within seven days of placing the membrane, but there is no minimum wait time beyond the initial three-hour traffic free period.

411 ASPHALTIC CONCRETE FRICTION COURSE (MISCELLANEOUS)

Miscellaneous asphaltic concrete friction course does not require that a formal mix design be developed or approved; the requirement is for the contractor to provide mineral aggregate that has been shown to meet the gradation and aggregate quality requirements in the specification. The Engineer is responsible for reviewing the proposed composite gradation and, in consultation with the Regional Materials Engineer, selecting an appropriate target binder content for production. A target binder content of 6.0% is commonly used, which is communicated to the contractor via written or email correspondence.

If a previously used aggregate composite or 407 mix design is proposed, unless the data for the aggregate is very recent, i.e. from the same paving season, the contractor must submit recent test data to confirm the properties of the proposed aggregate remain consistent with the previously approved material.

Typically, projects with a miscellaneous friction course involve small quantities or specialized work. See Subsection 407 of this manual for recommended methods and inspection checkpoint items. For instance, 407 specifies that the temperature of the mix discharged at the plant cannot exceed 325 degrees F. Although a maximum discharge temperature of 275 degrees F is provided in 411, a discharge temperature of up to 325 degrees F is frequently approved for mixtures with rubberized or polymer modified binders because these binders are less workable and more difficult to compact and achieve smoothness at lower temperatures.

411-3 Construction Requirements

Temperature just prior to compaction must be at least 200 degrees F. However, a minimum temperature of 250 degrees is recommended to ensure adequate time for compaction, especially for mixtures with rubberized or polymer modified binders. The surface temperature must be 75 degrees F or higher in order to pave. This is because ACFC is placed in thin lifts and is also very porous; it will cool very fast.

One of the most critical items to look for with significant lengths of 411 paving is to make sure that delivery of the material, if placed in windrows with belly dumps, does not outrun the paver, and also that the rollers are able to keep up with the speed of the paver, which can be rather quick compared to typical paving with dense graded AC.

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

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

No sampling is required unless a significant deficiency in the material is observed or suspected.

413 ASPHALTIC CONCRETE (ASPHALT-RUBBER)

Asphalt-rubber asphaltic concrete (ARAC) is a dense graded hot mix similar to 406, 416, and 417, asphaltic concrete (AC), except the binder is Asphalt-Rubber instead of asphalt cement. Crumb rubber is blended with the asphalt cement to form the asphalt-rubber binder. The blending takes place in a reaction tank at temperatures between 350 degrees F and 400 degrees F for at least one hour. During this time, the rubber partially melts and is thoroughly mixed with the asphalt cement to form a binder material known as Crumb Rubber Asphalt or CRA.

Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. For the sake of brevity, most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 413. Subsection 1009 Asphalt Rubber Material will also be useful.

413-3 Materials

413-3.02 Mineral Aggregate

Existing stockpiles can be used if satisfactory documentation, and testing, for uncompacted voids (ARIZ 247) can be provided by the contractor. Samples should be taken so that the Department can perform verification testing. However, it is important to note that the use of existing stockpiles should be the exception, not the rule. The Project Supervisor needs to be in contact with the contractor early on in the project to ensure that crushing is not performed without the Department's oversight.

Another important element of mineral aggregate production is the requirement that no individual stockpile shall have more than 6.0% passing the number 200 sieve. This requirement provides the higher consistency in aggregate fines needed for asphalt-rubber. The contractor may offer to adjust the feed rates from different cold feed bins to offset the effects of an out of specification (dirtier) stockpile. This is unacceptable. Even if the contractor manages to keep the composite gradation within specifications, the resulting material will likely be near one of the gradation limits for the intermediate sieve sizes. This is not the intent of the specification, and is a violation of subsection 105.03. The intent is to provide a quality mineral aggregate for the pavement that is properly crushed and stockpiled.

413-3.03 Mineral Admixture

ARAC requires 1.0% mineral admixture to help prevent stripping. There are only two types allowed. The type will be stipulated in the mix design. The Portland cement, type II must be added as a dry powder to the mineral aggregate for mixing in the pugmill. Blended Hydraulic cement is not allowed. The lime must be hydrated and can be added as a dry powder or as a slurry (with water). Large chunks of mineral admixture are not allowed into the mix and the inspector should look for signs that these dry materials have been wetted during storage. There is another lime product called quicklime or burnt lime (CaO) that cannot be added to the mix. When CaO is mixed with water it is slaked (hydrated) which means the water is chemically combined with it. The hydrated lime called for in the specification has been slaked. It may still look like a dry powder, but there is still some water that has now been combined in it. The inspector is made aware of these differences because CaO is caustic and dangerous to handle, if blended into the asphaltic concrete it will damage it.

413-3.04 Bituminous Material

The specifications for asphalt-rubber are found in Subsection 1009 of the Standard Specifications. Type B crumb rubber is the only type allowed for ARAC. Material properties, as well as mixing, temperature, storage, and certification requirements are all found in Subsection 1009.

The contractors must submit an asphalt-rubber design showing the amount of rubber that will be blended with the asphalt cement. This must be done before a mix design can be developed.

413-4 Mix Design

Unlike AC, the Department's Pavement Materials Testing Section develops the mix design for ARAC. Some modified test procedures are used. However, a mix design cannot be performed until the contractor does an asphalt-rubber design. It is important for the Project Supervisor or Resident Engineer to make the contractor aware, as early on in the project as possible, of the need for an asphalt-rubber design.

The Resident Engineer is responsible for ensuring that the time periods for reviewing and verifying a mix design by the Department are strictly followed unless different arrangements are made in writing with the contractor. Therefore, it is important that the Resident Engineer checks with the acceptance lab to ensure that they can complete the verification testing within the prescribed time.

413-5 Mix Design Revisions

Occasionally, a revision to the mix design will be required to adjust for unanticipated or changing field conditions, or for a change in aggregate properties. When the change to a mix design is an adjustment to the asphalt-rubber content, then the contractor is not entitled to any additional costs for operating the plant or equipment. If more asphalt-rubber is needed, the Department will pay for the material at a unit price below or at the contract unit price.

Cases where a contractor is entitled to additional plant and operating costs include changes in the aggregate source, required changes in the asphalt-rubber properties, or changes in the aggregate properties themselves without changing sources. These are situations where the properties of the mix may change significantly enough to affect plant procedures and lay down or compaction methods.

413-6 Acceptance of Materials

It cannot be emphasized enough that ADOT field staff must closely monitor the crushing operation and stockpile production. Even though aggregate sampling and testing have been done during stockpile production, samples still need to be taken and tested from the cold feed during asphalt production. This serves as a final check to ensure the mineral aggregate will stay within acceptable tolerances for gradation, sand equivalence, and fractured coarse aggregate particles.

Asphalt-rubber content shall be checked at least four times a day using the contractor's nuclear gauge. See Subsection 414-6 of this manual for further information.

413-7 Construction Requirements

Please note that the requirements for incorporation of the mineral admixture into the mix are the same as for most other types of asphaltic concrete. Refer to the Construction Requirements subsection in the Asphalt Concrete section of this manual for further information and instructions.

The method in which the asphalt-rubber is introduced into the mix must be carefully inspected. On a typical batch mix or drum mix plant (refer to Exhibit AC-3), asphalt cement is stored in a storage tank, and a series of lines and pumps move the asphalt cement from the storage tank to the pugmill or drum mixer. There is an automatic feedback system that controls the amount of asphalt cement based on flow of mineral aggregate and admixture. When asphalt-rubber is used, a reaction tank is introduced between the asphalt cement storage tank and the pugmill or drum mixer. The reaction tank is used to blend together the asphalt cement and crumb rubber. The inspector may discover a line leading directly from the reaction tank to the pugmill or drum mixer with no automated control system that regulates the flow of the asphalt-rubber based on the flow of the mineral aggregate and admixture. This type of setup is unacceptable to the Department. An automated control system needs to be in place for asphalt-rubber asphaltic concrete (ARAC) mixing just like it does for regular asphaltic concrete (AC) mixing. Do not allow the contractor to manually control the addition of asphalt-rubber. This method is imprecise and prone to human error that will adversely affect the consistency of the mix produced by the plant. It is recommended that the Resident Engineer address this point at the pre-paving conference.

Another important difference in asphalt-rubber paving is that surfaces need to be tacked with asphalt cement; no cutbacks or emulsions are to be used. Although not harmful to asphalt-rubber, volatiles in asphalt-rubber can react with cutbacks and emulsions, so they will not bond as well as asphalt cement.

Specification 413 ARAC has strict air and surface temperature requirements that must be followed. There are two conditions. The first condition applies to start-up. Both the surface temperature and the air temperature must be at least 65°F, with the air temperature rising before paving can begin. The second relates to when paving must stop. In this case, if the air temperature is at or below 70°F and falling, the paving must stop.

It is important to note that this second condition does not have a surface temperature requirement. The contractor may argue that as long as the surface temperature is above 70°F, then it should be OK to continue paving, especially when it's acceptable to begin paving when the surface temperature is only 65°F°. The inspector should not accept this argument. A falling air temperature is a good indicator that the surface temperature is beginning to fall as well; there is lag time between the two. By the time the contractor gets the plant shut down, all the asphalt placed and compacted that was delivered, the surface temperature will have dropped significantly. This is why the specification is based on a falling air temperature rather than a falling surface temperature.

Compaction requirements for ARAC are method specifications. Regardless of the lift thickness, the contractor must follow a prescribed compaction procedure and rolling pattern. All compactors must be steel wheel (no rubber tires allowed), and for lifts greater than 1 inch two of the compactors must be vibratory. Inspectors are required to continually document the contractor's rolling operation since there are no density requirements for the finished mat. Compaction acceptance is based on rolling pattern, not density. Rolling pattern and number of coverages shall be documented in the daily diary.

The specifications require construction of a transverse construction joint if the paver is stopped for more than three minutes. This is to ensure that there is adequate time to place and compact the mix that is held in the laydown machine before the mix cools. Field personnel occasionally show some leniency in this regard for thicker lifts only, especially if weather conditions are favorable. It is suggested that the temperature of the mix in the laydown machine be closely monitored if paving is stopped for more than three minutes. Never allow an exception for thin ARAC lifts, or for AR-ACFC where the same language is found in subsection 414. Thinner lifts have more exposed surface area per volume than thicker lifts, so they will cool faster.

The Project Supervisor and Resident Engineer have some latitude in specifying how many rollers are required behind the laydown machine. Even if the production exceeds 250 tons per hour, engineering judgment may be used to determine if an additional roller is needed to obtain density.

ARAC is placed at a higher temperature than regular AC. This results in more pick-up by the steel wheel compactors. The specifications address this problem by requiring the compactor wheels to be wetted with water to prevent pick-up. Specifications also permit soapy water, or release agents evaluated through NTPEP in accordance with the requirements of Section 407-7.04 of the specifications. The Department discourages the use of lime water since it can't be sprayed in a fine mist. The high alkalinity of the lime tends to sterilize the surrounding soils and makes landscaping or re-vegetation more difficult later on.

Additional inspection points include:

- Verify that the crumb rubber and asphalt cement have been in the reaction tank at 325°F to 375°F for at least one hour prior to use in the mix. See Subsection 1009.
- Keep a daily count of the number of bags of crumb rubber used.
- Asphalt-rubber that has been kept in the reaction tank for more than 10 hours above 325°F should not be used. Carry-over must be cooled before the 10-hour time limit and then re-heated. The specifications only allow one re-heating cycle for any particular batch. In some cases, the Central Lab can test carry-over

to see if it is still suitable. See Subsection 1009 of the Standard Specifications for further information.

For asphalt-rubber paving, the Department generally requires a full time inspector at the plant to oversee the stockpiling and batching operations, including the blending of the asphalt-rubber. The Project Supervisor should carefully outline the duties of the inspector at the plant so that the most effective use can be made of this person. Section 304 of the ADOT Training Manual for the Inspection of Bituminous Roadway Construction should serve as a guideline for assigning inspection duties.

413-8 & 413-9 Method of Measurement & Basis of Payment

The method of measurement and basis of payment for ARAC is similar to other AC except as follows:

- Asphalt-rubber is measured and paid instead of asphalt cement.
- Subsection 413-9 does not allow the 413-6.03(B) nuclear gauge test results to be used as a method of measurement for asphalt-rubber. Asphalt-rubber must be weighed directly, or calculated from the weight of asphalt cement and crumb rubber used, minus the waste.
- There are no price adjustments for compaction since the acceptance is based on rolling pattern only.

414 ASPHALTIC CONCRETE FRICTION COURSE (ASPHALT-RUBBER)

Asphalt-rubber asphaltic concrete friction course (AR-ACFC) is the asphalt rubber version of the 407 Standard Specifications for ACFC. Crumb rubber is blended with the asphalt cement to form an asphalt-rubber binder. The blending takes place in a reaction

tank at temperatures between 325 degrees F and 375 degrees F for at least one hour. During this time, the rubber partially melts and is thoroughly mixed with the asphalt cement to form a binder material.

AR-ACFC Standard Specifications are similar to the 407 Standard Specifications for ACFC in both plant and field inspection requirements. Subsection 1009 (Asphalt Rubber Material) of the ADOT Standard Specifications will also be useful. The other plant processes and field operations are nearly identical to non-AR asphalt paving. Most of the inspection procedures and documentation requirements are covered in Subsection 407 and the Asphaltic Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 414.

414-3 Materials

414-3.03 Mineral Admixture

Like ARAC, AR-ACFC uses 1.0% mineral admixture to help prevent stripping. The type will be stipulated in the mix design. Mineral admixture certification and documentation requirements are identical to those in the Mineral Admixture subsection of the Asphalt Concrete section of this manual.

414-3.04 Bituminous Material

The requirements for asphalt-rubber are found in Subsection 1009 of the Standard Specifications. Type B crumb rubber is the only type allowed for ARACFC. Material properties, as well as mixing, temperature, storage, and certification requirements are all found in Section 1009.

The contractors must submit an asphalt-rubber design showing the amount of rubber that will be blended with the asphalt cement. This must be done before a mix design can be developed.

414-4 Mix Design

ADOT produces a mix design for all asphalt-rubber products. The mix design procedure is the same as described in Subsection 413-4 of this manual. This requires the contractor to provide necessary materials to the Department, sampled under the observation of the Engineer. An asphalt rubber blend design must first be performed to confirm conformance of the asphalt rubber to Subsection 1009-2. The Resident Engineer is responsible for ensuring that the time periods for reviewing and verifying a mix design by the Department are strictly followed unless different arrangements are made in writing with the contractor.

414-5 Mix Design Revisions

Occasionally, a revision to the mix design will be required to adjust for unanticipated or changing field conditions, or for a change in aggregate properties. When the change to a mix design is an adjustment to the asphalt-rubber content, then the contractor is not entitled to any additional costs for operating the plant or equipment. If more asphalt-rubber is needed, the Department will pay for the material at a unit price below or at the contract unit price.

Cases where a contractor is entitled to additional plant and operating costs include changes in the aggregate source, required changes in the asphalt-rubber properties, or changes in the aggregate properties themselves without changing sources. These are situations where the properties of the mix may change significantly enough to affect plant procedures and lay down or compaction methods.

414-6 Acceptance of Materials

One of the primary functions of field personnel in any asphalt paving operation is the acceptance of the materials used to produce the pavement. Specifications 407, 413 and 414 are based on instructing the contractor how to produce the asphalt and how to place it. The Department takes a very active role in overseeing production and placement. The inspector must be actively involved in the acceptance of materials as they are both produced and placed. This is especially true for asphalt-rubber products.

Mineral aggregate must be sampled and tested on a daily basis as the stockpiles are being produced. Don't wait until asphalt production to start aggregate testing, it is usually too late; friction course paving progresses very rapidly. Experienced inspectors in asphalt paving know that the crushing operation has the single biggest influence on mix properties and will concentrate their efforts in that area to ensure uniformity and consistency.

If there is an existing stockpile the contractor wishes to use, then the stockpile should be sampled in several places and tested for gradation, sand equivalent, and fractured course aggregate (crushed faces). Ask the contractor for test results that were performed on that stockpile. Mineral aggregate must meet both the single and triple spec requirements. Failure to meet these requirements necessitates recalibration. If reasonable to do so, in the opinion of the Engineer, the contractor may be allowed to recalibrate on the fly, however, recalibration typically requires halting of production and running only the cold feed bins to confirm acceptable material prior to resuming production.

In addition to the mineral aggregate, the granulated crumb tire rubber, virgin asphalt, and asphalt-rubber material must be sampled and tested for acceptance. Refer to Sampling Guide, Appendix C, of the Quality Assurance Manual for specific sampling and testing requirements.

Asphalt-rubber content for process control must be measured by the contractor and witnessed by the inspector at least four times per shift using the contractor's nuclear gage. It is important for the inspector to check the contractor's nuclear gage at the beginning of the job for correct calibration to the mix (preparation of the knowns) and if desired, correlation with the Department's gages. The daily standard counts should be checked for significant variations. The equipment used by the contractor to perform this testing must be verified by the Quality Assurance Section; a complete lab inspection is not necessary.

Subsection 1009 of the Standard Specifications requires the contractor to have equipment at the plant that can be used for checking the viscosity of the asphalt-rubber. The contractor must test each batch of asphalt-rubber binder and the results are documented. Material that fails to meet the viscosity requirement is an indication of improper reaction, overheating, or inadequate crumb rubber content; material represented by failing viscosity tests should not be used.

414-6.04 Material Spread

See Asphaltic Concrete Section for requirements.

414-7 Construction Requirements

Please note that the requirements for incorporation of the mineral admixture into the mix are the same as for most other types of asphalt. Refer to the Construction Requirements sub-section in the Asphalt Concrete section of this manual for further information and instructions.

The method in which the asphalt-rubber is introduced into the mix must be carefully inspected. On a typical batch mix or drum mix plant (refer to Exhibit AC-3), asphalt cement is stored in a storage tank and a series of lines and pumps move the asphalt cement from the storage tank to the pugmill or drum mixer. There is an automatic feedback system that controls the amount of asphalt cement based on flow of mineral aggregate and admixture. When asphalt-rubber is used, a reaction tank is introduced between the asphalt cement storage tank and the pugmill or drum mixer. The reaction tank is used to blend together the asphalt cement and crumb rubber. Typically a line will lead directly from the reaction tank to the pugmill or drum mixer with no automated control system that regulates the flow of the asphalt-rubber based on the flow of the mineral aggregate and admixture. This type of setup is unacceptable to the Department. An automated control system needs to be in place for asphalt-rubber asphaltic concrete mixing just like it does for regular asphaltic concrete mixing. Do not allow the contractor to manually control the addition of asphalt-rubber. This method is imprecise and prone to human error that will adversely affect the consistency of the mix produced by the plant. It is recommended that the Resident Engineer address this issue at the pre-paving conference.

Another important difference in asphalt-rubber paving is that surfaces need to be tacked with asphalt cement; no cutbacks or emulsions are to be used. Although not harmful to asphalt-rubber, volatiles in asphalt-rubber can react with cutbacks and emulsions, so they will not bond as well as asphalt cement.

The temperature requirements and placement dates are much more restrictive for AR-ACFC than for other types of asphaltic concrete. Strict adherence to the temperature specifications is required because AR-ACFC is placed in thin lifts that cool very rapidly. The rate of cooling is directly related to surface temperatures and weather conditions. Time available for compaction could be less than five minutes following laydown.

This quick cooling characteristic makes early compaction of the mix an important task. It is important that the right equipment be used and kept within the prescribed speed and distance from the paver. The compaction process including rolling pattern and number of coverages should be well documented in the daily diary. Pick up of the material is often a problem with compaction equipment. Do not use blotter sand to prevent pick up since the sand only clogs the pores of AR-ACFC and reduces its drainage ability. The specifications address this problem by requiring the compactor wheels to be wetted with water to prevent pick-up. Specifications also permit soapy water, or release agents evaluated through NTPEP in accordance with the requirements of Section 407-7.04 of the specifications. Although permitted by the specifications, the use of lime water should be discouraged since it can’t be sprayed in a fine mist. The high alkalinity of the lime tends to sterilize the surrounding soils and makes landscaping or re-vegetation more difficult later on.

The specifications require construction of a transverse construction joint if the paver is stopped for more than three minutes. This is to ensure that there is adequate time to place and compact the mix that is held in the laydown machine before the mix cools. The thin lift as well as the greater surface area due to the voids will cause this mix to cool very rapidly.

Some other inspection points include:

- Verify that the crumb rubber and asphalt cement have been in the reaction tank for at least one hour prior to use in the mix.
- Keep a daily count of the number of bags of crumb rubber used.
- Asphalt-rubber that has been kept in the reaction tank for more than 10 hours at temperatures above 325°F should not be used. Carry-over should be allowed to cool before the 10-hour time limit and then reheated. In some cases, the Central Lab can test carry-over to see if it is still suitable. See Subsection 1009 of the Standard Specifications for further information.

For asphalt-rubber paving, the Department generally requires a full time inspector at the plant to oversee the stockpiling and batching operations including the blending of the asphalt-rubber. Blending may occur at the asphalt terminal in the transport tankers in lieu of the contractor using a blending plant at the hot plant. The Project Supervisor should carefully outline the duties of the inspector at the plant so that the most effective use can be made of this person. Section 304 of the ADOT’s Training Manual for the Inspection of Bituminous Roadway Construction should serve as a guideline for assigning inspection duties.

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

- Asphaltic concrete is measured by the ton and paid for at the contract unit price per ton, adjusted as necessary for waste and spread.

    - If the quantity in a spread lot is found to vary by more than +5%, no payment will be made for the material that exceeds the +5%, including the asphalt cement and the mineral admixture.
- Asphalt-rubber will be measured and paid by the ton.
    - Subsection 414-9 does not allow the 414-6.03(B) nuclear gauge test results to be used as a method of measurement for asphalt-rubber. Asphalt-rubber must be weighed directly, or calculated from the weight of asphalt cement and crumb rubber used minus the waste.
    - Asphalt binder penalties apply if the asphalt binder does not meet the requirements of section 1009-2.03.
    - A bituminous material price adjustment may be applicable for the asphalt cement in the asphalt-rubber blend if the 109.16 specification is included in the special provisions for each contract.
- Mineral Admixture is measured and paid by the ton, at the predetermined price established in the bidding schedule.
- When required in the Special Provisions, payment for smoothness shall be made in accordance with the requirements of Subsection 109.13 of the specifications.
- There are no price adjustments for compaction since the acceptance is based on rolling pattern only.

416 ASPHALTIC CONCRETE – END PRODUCT

It is the intent of the 416 end-product specification to allow the contractor the freedom to control the production and placement of asphaltic concrete in its entirety. With few exceptions, the contractor is responsible for meeting the specified properties of the final product and is free to determine the best way to achieve those results. It is important to note that the contractor performs the quality control. The inspector's role is more of an overseer who documents construction methods, as well as the accepting of the final product. However, when problems with the contractor's plant or paving operation arise, the inspector should closely monitor the situation and assist the contractor in reaching an expedient solution.

Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. For the sake of brevity, most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 416.

Please reference the supplemental chapter for Asphaltic Concrete for important information relating to asphaltic concrete; the subsections within this chapter are specific to only the 416 specification.

416-2 Mix Design Criteria

Specification bands are given to identify acceptable starting points for mix design; they are found in 416-2 and are not for production control. Once the mix design is complete and approved for use by the Regional Materials Engineer, there is no need for the inspector to refer to this subsection unless the contractor initiates a Self-Directed Target Change. The allowable variations to upper and lower limits of production control bands are found in 416-7.04 and are based on the target values given in the particular mix design for each individual project.

The allowances for contractor self-directed target changes are provided in the table in 416-4. Targets must remain with the design upper and lower limits found in the table in 416-2. It is good practice to forward such requests to the Regional Materials Engineer for review, however RME approval is not required.

416-3 Materials

416-3.01 Mineral Aggregate

Fine aggregate must be obtained from crushed gravel or crushed rock in accordance with subsection 416-3.01 of the Standard Specifications. All uncrushed material finer than the #4 sieve must be removed before crushing the aggregate. This will ensure that the fines are manufactured and less rounded. This helps achieve higher stability in the mix. The contractor may blend back as much as 15% natural sand (10% if the mix includes RAP) but the natural fines cannot have more than 4% passing on a #200 sieve.

Additional requirements exist for mixtures referred to as a Special Mix. This is to ensure improved stability and to accomplish this, the blend of all the fine aggregate must meet the uncompacted voids requirement, and that for both one and two crushed faces stipulated in the table notes in 416-3.04(D).

416-3.02 Mineral Admixture

For additional information see the ASPHALTIC CONCRETE GENERAL GUIDANCE Section.

416-3.03 Bituminous Materials

For additional information see the ASPHALTIC CONCRETE GENERAL GUIDANCE Section.

Prior to use, acceptable certificates of compliance will be required for each load of asphalt cement, as well as for any mineral admixture before these materials are incorporated into the project.

416-4 Mix Design

The contractor will submit the finished mix design, with the split samples used to develop it if new, to the field office. Ideally, the Materials Coordinator will witness the sampling performed and obtain material at that time for ignition furnace calibration. Before the field office forwards the mix design to the Regional Materials Engineer, the Materials Coordinator should review the mix design to ensure that all the information required by subsections 416-2 and 416-4 have been met. In addition, checking for compliance with the mix design criteria, aggregate gradation limits, and asphalt to dust ratio, the Materials Coordinator should check that the method of adding the admixture to the aggregate (with wet or dry aggregates) matches the method that will be used at the plant. Only mix designs with complete information that meet the specifications should be forwarded to the Regional Materials Engineer.

For a previously used mix design, the Resident Engineer/Materials Coordinator should still submit the design to the Regional Materials Engineer for review to determine if additional testing is needed or if recent issues have occurred when using a particular mix design.

When the Department has reviewed the mix design, the target values for each mix property (such as AC content, stability, compaction, etc.) will be established from the results of the mix design. The Project Supervisor, Materials Coordinator, and inspectors should become very familiar with these target values and a copy of the mix design should be available at the project site. The Materials Coordinator or hot plant inspector should track the target values on a daily basis in the daily diary to ensure any self-directed target changes are properly accounted for. This will make sorting out any discrepancies much easier.

416-6 Construction Requirements

Although the 416 Standard Specifications allow the contractor significant latitude on how asphalt is produced and placed, some inspections at the plant and at the project site will still be required. It is also a good idea to document the contractor's materials handling procedures for future reference even if we do not control the individual steps of this process. For this reason, a designated hot plant inspector, who has received the proper training and experience is critical. For safety purposes the hot plant inspector must make his presence known during activities to both the plant manager and the ADOT project supervisor.

Hot plant inspection should include the following (see current Quantlist for list):

- Stock Pile Management; both mineral aggregate and RAP
- Fractionation of RAP
- Loader Operations and condition of Cold Feed Bins
- Certification of weigh and belt scales
- Water available/moisture condition of mineral aggregate prior to pugmill
- Condition of mineral admixture and means of adding to mineral aggregate
- Mix Design on hand and Hot Plant Control Room Production Targets and any adjustments made
- Sampling of Mineral Aggregate and Bituminous Material
- Introduction of any additional materials, e.g. RAP, Fiber, WMA, etc.
- Condition & Accuracy of Temperature Sensing Probe at point of discharge from mixing drum
- Temperature at Discharge from mixing drum
- Release Agent on Hand
- Cleanliness of Haul Trucks
- Method of loading Haul Trucks
- Interruptions in production or supply of a material
- Document any deviations from standard practices
- Equipment breakdown and failures

Since the contractor has the responsibility for quality control, the contractor's staff should do most of the routine inspection work. ADOT Inspectors still have some involvement during paving, but most of their effort should be focused on ensuring that both the contractor's production and QC work are done properly and consistently. See Subsection 416-6 of the Standard Specifications:

- Describes the requirements for admixture mixing and control.
- Requires the use of the automatic screed control device on laydown machines.
- Requires the contractor to submit a copy of the pyrometer record at the end of each shift.
- Specifies the use of a system to stop the mixing if mineral admixture flow is stopped.
- Requires all core holes to be patched within 48 hours
- Requires all vertical edges to be tacked as directed.
- Specifies the authority to stop the work to prevent weather conditions from damaging the asphaltic concrete pavement.

416-7 Acceptance

Although acceptance testing is done by random sampling, the inspector still has the authority under 416-7.01 to take plate samples and cores at any time and from any place if the material appears to be defective. If the inspector observes what appears to be defective material coming from behind the paver or out of the delivery trucks, then take additional samples. This direct sampling is allowed under any of ADOT's paving specifications even though some are end products. Directed samples by the Department are not allowed for any part of the statistical analysis for the lot. The inspector is reminded to review the information on stratified random sampling and to be familiar with the proper use of random number tables (see 1331-1) or a calculator as a random number generator.

For acceptance, rejection, and payment purposes, asphaltic concrete paving production is broken down into lots. The inspector must always read the specifications to determine the lot size. Under the quality lot, ADOT compares mix properties such as aggregate gradation, asphalt cement content, effective voids, and stability, with the values specified in the mix design and contract documents. If any one of these properties is in rejection, the entire lot is rejected and not just the area of pavement where the particular sample was taken. Compaction lots are handled in the same way.

Sand equivalent, fractured (faces) coarse aggregate particles, uncompacted void content, and smoothness are part of the acceptance testing, but when failures occur only the sections of pavement represented by that particular test are rejected. The contractor has the option of submitting a revised mix design or reworking the stockpiles to correct the deficiencies. Continual retesting until a passing result occurs is not a valid solution.

Significant deviations in asphalt content from the percentage called for in the design (more than ±0.2%) should be discussed and resolved with the contractor. If the plant is dedicated to exclusive production for one project, the Engineer can evaluate the asphalt content reported from the acceptance lab and compare it with the contractor's hot plant report. If the discrepancy is greater than 0.1%, a correction value should be applied.

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

- Check for straight edge tolerances, particularly at the joints.
- Layout the compaction core locations.
- Mark lots which are rejected due to any failures in mix properties, e.g. asphalt cement content, gradation, or stability.

For each mixture-properties lot, the acceptance lab will test for gradation, AC content, effective voids, and stability; from the four plate samples. For each compaction-lot the acceptance lab will test density from the cores. They will issue the results on a form similar to the one shown in Exhibit AC-4. This form will have the pay factors computed for the lot. If an individual test result indicates failure of any of the mix properties or compaction requirements, the area represented by the samples should be observed to ensure acceptance is appropriate. However, keep in mind that lot acceptance and the pay factor adjustments are based on the percent of the lot within limits (PT value) for each respective acceptance property, not the individual test results; they pertain only to isolated areas.

Plate Sampling

Four random plate samples are taken behind the laydown machine during each lot (shift) to determine the mix property pay factors. Samples must be 75 pounds minimum. It is important that samples are indeed taken randomly and that the contractor is unaware ahead of time when the samples will be taken. Advance notice to the contractor may defeat the purpose of random sampling. During an 8-hour shift, a mix sample should be taken in each 2-hour period on a random basis within that period. This is called Stratified Random Sampling, it is generally the best method for ensuring the most representative distribution of random samples. Stratified Random Sampling is not discussed in the ADOT Standard Specifications and therefore it is neither required nor prohibited, however Stratified Random Sampling may be utilized to avoid clustering of sample locations on a project. Regardless of what method is used, it must be discussed at the pre-paving meeting, because any method used must be applied consistently and not switched to and from throughout the project.

The contractor shall have the necessary personnel on the site at all times during paving so samples can be taken on a moment's notice; 20 minutes maximum notice is permissible. The Project Lab should have the samples promptly delivered to the acceptance lab; whether that is the regional lab, the central lab, or a consultant's lab.

Unless specified otherwise, the method of administering low tonnage lots, or lots where a sufficient number of samples were not obtained should be mutually agreed upon with the contractor. Options available include obtaining additional samples through coring or jack hammering, evaluating with n = 3, or combining lots with the next day’s production. Combining this with the following day’s production is the most preferable choice.

The referee mixture-properties lot sample must be a split of the acceptance sample. The referee sample should not be taken from a separate plate. Extreme care should be taken in the handling, transporting and storage of referee samples.

ADOT must furnish acceptance test results to the contractor within four working days of receipt of the samples. The test results are reported to the contractor as soon as they are available. This allows the contractor to quickly correlate test results in order to produce the best pavement for the project. Occasionally, the acceptance lab (with the Resident Engineer's permission) may fax results directly to the contractor and the Engineer at the same time.

416-7.03 Material Spread

See ASPHALTIC CONCRETE GENERAL GUIDANCE for spread

416-7.05 Compaction

For lifts of 1 ½’’ or less the compaction of the AC follows a method specification and the inspector will have to monitor the temperatures and the rolling to ensure compliance with the specifications. Rolling pattern and number of coverages shall be documented in the daily diary. Although there is no compaction lot in this case there will still be a quality lot that is to be evaluated by the 4 random plate samples.

For lifts greater than 1 ½ inch there will be a compaction lot that is identical to the tonnage of the quality lot. The contractor is responsible for the compaction technique and the lot is evaluated statistically by end product methods. 20 cores will be taken from each lot at random locations. The 10 that are not used will be held for 15 days in case of a request for referee. After that time they must be discarded. Results will be furnished to the contractor within 5 working days of receipt of the samples.

Carefully review subsection 416-7.05(B) of the Standard Specifications before laying out the core locations. Inspectors must mark the exact core locations as calculated from the random numbers since bonuses and penalties are associated with the compaction core results. Furthermore, inspectors should be watchful over the contractor's coring operation so that the exact location specified is cored.

In addition to responsibility for compaction methods, the contractor is responsible for the compaction characteristics of the mix design. Field personnel should not advise the contractor on compaction procedures, so it will remain the contractor's responsibility. The inspector should not give tacit (implied) approval of any method.

417 ASPHALTIC CONCRETE (END PRODUCT) SHRP VOLUMETRIC MIX

SHRP is the abbreviation for the Strategic Highway Research Program. The 417 specification is similar to the 416 specification in some ways but it takes advantage of new technology in the testing of the asphaltic concrete mix.

Materials, testing procedures, and construction requirements are basically the same for the various types of asphaltic concrete pavement. For the sake of brevity, most inspection procedures can be found in the Asphalt Concrete section of this manual. This subsection of the manual contains additional inspection procedures and contract administration requirements for specification 417.

417-2 Mix Design Criteria

Specification bands are given to identify acceptable starting points for mix design; they are found in 417-2 and are not for production control. Once the mix design is complete and approved for use by the Regional Materials Engineer, there is no need for the inspector to refer to this subsection unless the contractor initiates a Self-Directed Target Change. The allowable variations to upper and lower limits of production control bands are found in 417-7.04 and are based on the target values given in the particular mix design for each individual project.

The allowances for contractor self-directed target changes are provided in the table in 417-4. Targets must remain within the design upper and lower limits found in the table in 417-2. It is good practice to forward such requests to the Regional Materials Engineer for review, however RME approval is not required.

417-3 Materials

417-3.01 Mineral Aggregate

Fine aggregate must be obtained from crushed gravel or crushed rock in accordance with subsection 417-3.01 of the Standard Specifications. All uncrushed material finer than the #4 sieve must be removed before crushing the aggregate. This will ensure that the fines are manufactured and less rounded. This helps achieve higher stability in the mix. The contractor may blend back as much as 15% natural fines (10% if the mix included RAP) but the natural fines cannot have more than 4% passing on a #200 sieve.

417-3.02 Mineral Admixture

For additional information see the ASPHALTIC CONCRETE GENERAL GUIDANCE (ACGG) Section.

417-3.03 Bituminous Materials

Prior to use, acceptable certificates of compliance will be required for each load of asphalt cement, as well as for any mineral admixture before these materials are incorporated into the project.

417-4 Mix Design

The contractor will submit the finished mix design, with the split samples used to develop it, if new, to the field office. Ideally, the Materials Coordinator will witness the sampling performed and obtain material at that time for ignition furnace calibration. Before the field office forwards the mix design to the Regional Materials Engineer, the Materials Coordinator should review the mix design to ensure that all the information required by subsections 417-2 and 417-4 have been met. In addition, checking for compliance with the mix design criteria, aggregate gradation limits, and asphalt to dust ratio, the Materials Coordinator should check that the method of adding the admixture to the aggregate (with wet or dry aggregates) matches the method that will be used at the plant. Only mix designs with complete information that meet the specifications should be forwarded to the Regional Materials Engineer.

The SHRP mix design must be formulated using the coarse or fine grading bands shown in the specifications. These bands pass below or above (respectively) the restricted zone on the gradation chart.

Overall the voids in the mineral aggregate (VMA) is lower in this type of mix. Specifications require that the lab compacted test specimens, except for Arizona Test Method 802, shall be prepared using the Gyratory Compactor in accordance with AASHTO Provisional Standard TP-4.

Fractured faces in the coarse aggregate (+ No.4 sieve) are 85% minimum with two faces instead of 70% minimum with one fractured face as under the 416 Standard Specifications. There is also a requirement for flat and elongated particles (5:1 ratio) not to exceed 10%.

417-6 Construction Requirements

Although the 417 Standard Specifications allow the contractor significant latitude on how asphalt is produced and placed, some inspections at the plant and at the project site will still be required. It is also a good idea to document the contractor's materials handling procedures for future reference even if we do not control the individual steps of this process.

For this reason, a designated Hot Plant Inspector, who has received the proper training and experience is critical. For safety purposes the Hot Plant Inspector must make his presence known during activities to both the plant manager and the ADOT project supervisor.

- Hot Plant inspection should include the following:
- Stock Pile Management; both mineral aggregate and RAP
- Fractionation of RAP
- Loader Operations and condition of Cold Feed Bins
- Certification of weigh and belt scales
- Water available/moisture condition of mineral aggregate prior to pugmill
- Condition of mineral admixture and means of adding to mineral aggregate
- Mix Design on hand and Hot Plant Control Room Production Targets (and any adjustments made)
- Sampling of Mineral Aggregate and Bituminous Material
- Introduction of any additional materials, e.g. RAP, Fiber, WMA, etc.
- Condition & Accuracy of Temperature Sensing Probe at point of discharge from mixing drum
- Temperature at Discharge from mixing drum
- Release Agent on Hand
- Cleanliness of Haul Trucks
- Method of loading Haul Trucks
- Interruptions in production or supply of a material
- Document any deviations from standard practices
- Equipment breakdown and failures

Since the contractor has the responsibility for quality control (QC), the contractor's staff should do most of the routine inspection work. ADOT Inspectors still have some involvement during paving, but most of their effort should be focused on ensuring that both the contractor's production and QC work are done properly and consistently. Subsection 417-6 of the Standard Specifications:

- Describes the requirements for admixture mixing and control.
- Requires the use of the automatic screed control device on laydown machines.
- Requires the contractor to submit a copy of the pyrometer record at the end of each shift.
- Specifies the use of a system to stop the mixing if mineral admixture flow is stopped.
- Requires all core holes to be patched within 48 hours
- Requires all vertical edges to be tacked as directed.
- Specifies the authority to stop the work to prevent weather conditions from damaging the asphaltic concrete pavement.

417-7 Acceptance

Although acceptance testing is done by random sampling, the inspector still has the authority under 417-7.01 to take plate samples and cores at any time and from any place if the material appears to be defective. If the inspector observes what appears to be defective material coming from behind the paver or out of the delivery trucks, then take additional samples. This direct sampling is allowed under any of ADOT's paving specifications even though some are end product. Directed samples by the Department are not allowed for any part of the statistical analysis for the lot. The inspector is reminded to review the information on stratified random sampling and to be familiar with the proper use of random number tables (see 1331-1) or a calculator as a random number generator.

For acceptance, rejection, and payment purposes, asphaltic concrete paving production is broken down into lots. The inspector must always read the specifications to determine the lot size. Under the quality lot, ADOT compares mix properties such as aggregate gradation, asphalt cement content, effective voids, and stability, with the values specified in the mix design and contract documents. If any one of these properties is in reject, the entire lot is rejected and not just the area of pavement where the particular sample was taken. Compaction lots are handled in the same way.

Sand equivalent, fractured (faces) coarse aggregate particles, uncompacted void content, and smoothness are part of the acceptance testing, but when failures occur only the sections of pavement represented by that particular test are rejected. The contractor has the option of submitting a revised mix design or reworking the stockpiles to correct the deficiencies. Continual retesting until a passing result occurs is not a valid solution.

Significant deviations in asphalt content from the percentage called for in the design (more than ±0.2%) should be discussed and resolved with the contractor. If the plant is dedicated to exclusive production for one project, the Engineer can evaluate the asphalt content reported from the acceptance lab and compare it with the contractor's hot plant report. If the discrepancy is greater than 0.1%, a correction value should be applied.

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

- Check for straight edge tolerances particularly, at the joints.
- Layout the compaction core locations.
- Mark lots which are rejected due to any failures in mix properties, e.g. asphalt cement content, gradation, or stability.

For each mixture-properties lot, the acceptance lab will test for gradation, AC content, effective voids, and stability from the four plate samples. For each compaction-lot the acceptance lab will test density from the cores. They will issue the results on a form similar to the one shown in Exhibit AC-4. This form will have the pay factors computed for the lot.

If an individual test result indicates failure of any of the mix properties or compaction requirements, the area represented by the sample should be observed to ensure acceptance is appropriate. However, keep in mind that lot acceptance and the pay factor adjustments are based on the percent of the lot within limits (PT value) for each respective acceptance property, not the individual test results; they pertain only to isolated areas.

Plate Sampling

Four random plate samples are taken behind the laydown machine during each lot (shift) to determine the mix property pay factors. Samples must be 130 pounds minimum, requiring two plate samples. This is because the samples compacted in the gyratory compactor are much larger and require more material. It is important that samples are indeed taken randomly and that the contractor is unaware ahead of time when the samples will be taken. Advance notice to the contractor may defeat the purpose of random sampling. During an 8-hour shift, a mix sample should be taken in each 2-hour period on a random basis within that period. This is called Stratified Random Sampling and it is generally the best method for ensuring the most representative distribution of random samples. Stratified Random Sampling is not discussed in the ADOT Standard Specifications and therefore it is neither required nor prohibited, however Stratified Random Sampling may be utilized to avoid clustering of sample locations on a project. Regardless of what method is used, it must be discussed at the pre-paving meeting, any method used must be applied consistently and not switched to and from throughout the project.

The contractor shall have the necessary personnel on the site at all times during paving so samples can be taken on a moment's notice (20 minutes maximum notice is permissible). The Project Lab should have the samples promptly delivered to the acceptance lab; whether that is the regional lab, the central lab, or a consultant's lab.

Unless specified otherwise, the method of administering low tonnage lots, or lots where a sufficient number of samples were not obtained should be mutually agreed upon with the contractor. Options available include obtaining additional samples through coring or jack hammering, evaluating with n = 3, or combining lots with the next day’s production. Combining this with the following day’s production is the most preferable choice.

The referee mixture-properties lot sample must be a split of the acceptance sample. The referee sample should not be taken from a separate plate. Extreme care should be taken in the handling, transporting and storage of referee samples.

ADOT must furnish acceptance test results to the contractor within four working days of receipt of the samples. The test results are reported to the contractor as soon as they are available. This allows the contractor to quickly correlate test results in order to produce the best pavement for the project. Occasionally, the acceptance lab (with the Resident Engineer's permission) may fax results directly to the contractor and the Engineer at the same time.

417-7.03 Material Spread

See ASPHALTIC CONCRETE GENERAL GUIDANCE for spread

417-7.04 Gradation, Asphalt Cement Content, and Effective Voids

The requirement for Stability testing is eliminated. Arizona Test Methods 416 and 424 are modified to replace all references to Marshall testing with Gyratory testing in accordance with the AASHTO Provisional Standard TP-4.

The UL and LL for acceptable production limits are given in four different tables depending on the maximum aggregate size and the type of mix (coarse or fine band). The inspector must be sure of which mix is being produced for the project before utilizing these tables.

Generally speaking, these mixes are allowed to be designed with larger particles and some bands are allowed a little more variation from the target value. The idea being that strong support and rock-to-rock contact along with better control of the other parameters (especially voids and compaction) will ensure a more durable pavement.

417-7.05 Compaction

For lifts of 1 ½’’ or less the compaction of the AC follows a method specification and the inspector will have to monitor the temperatures and the rolling to ensure compliance with the specifications. Rolling pattern and number of coverages shall be documented in the daily diary. Although there is no compaction lot in this case there will still be a quality lot that is to be evaluated by the 4 random plate samples.

For lifts greater than 1 ½’’ there will be a compaction lot that is identical to the tonnage of the quality lot. The contractor is responsible for the compaction technique and the lot is evaluated statistically by end product methods. 20 cores will be taken from each lot at random locations. The 10 that are not used will be held for 15 days in case of a request for a referee. After that time they must be discarded. Results will be furnished to the contractor within 5 working days of receipt of the samples.

Carefully review subsection 417-7.05(B) of the Standard Specifications before laying out the core locations. Inspectors must mark the exact core locations as calculated from the random numbers since bonuses and penalties are associated with the compaction core results. Furthermore, inspectors should be watchful over the contractor's coring operation so that the exact location specified is cored.

In addition to his or her responsibility for compaction methods, the contractor is responsible for the compaction characteristics of the mix design. Field personnel should not advise the contractor on compaction procedures, so it remains the contractor’s responsibility. The inspector should not give tacit (implied) approval of any method.

ASPHALTIC CONCRETE GENERAL GUIDANCE (ACGG)

Description

The following acronyms are used in this chapter:

- AC Asphaltic Concrete
- ARAC Asphalt-Rubber Asphaltic Concrete
- ACFC Asphaltic Concrete Friction Course
- AR-ACFC Asphalt-Rubber Asphaltic Concrete Friction Course
- SMA Stone Matrix Asphalt
- CIR Cold In-place Recycling
- HIR Hot In-place Recycling
- BWC Bonded Wearing Course
- CRA Crumb Rubber Asphalt
- RAP Recycled Asphalt Pavement

ADOT has developed a wide variety of hot mix asphaltic concrete (AC) specifications due to the different needs, objectives, and limitations that may exist for a given project or asphalt mixture. There are dense graded hot mixes (AC,ARAC, SMA) versus open graded hot mixes (ACFC and AR-ACFC). There are hot mixes (AC and ACFC) that use asphalt cement versus hot mixes that use asphalt rubber (ARAC and AR-ACFC) for the binder. BWC is similar to both dense graded and open graded hot mixes in some respects.

Some AC specifications use similar or even identical hot mix designs, but use different contract administration requirements depending on quantity, geometric confining limitations, and need to validate acceptability. For example, end product specifications allow the contractor more freedom to control the production and placement of asphaltic concrete (416 is an example), but method specifications require the contractor to follow prescribed procedures (407 is an example). Under end product specifications, the contractor is responsible for meeting the specified properties of the final product and has more flexibility in determining the best way to achieve those results.

Materials, testing procedures, and construction requirements are basically the same for the various types of hot mix asphaltic concrete (AC) specifications used by ADOT. For the sake of brevity, most inspection procedures can be found in this manual. Subsections 407, 408, 409, 411, 413, 414, 416, and 417 of this manual will have additional instructions that supplement, or refer back to this asphaltic concrete section of the manual. The material has been condensed so the inspector can quickly review the manual.

Although materials and processes for products such as CIR or HIR may share some commonality with requirements for those materials discussed above, they may be substantially different depending on the material and application. Regardless of which material is specified, never assume the current project has the same specification as last time you used it. Always read the Special Provisions carefully to determine which specification(s) apply to the current project. This manual supplements, but does not replace the Standard Specifications, or project Special Provisions, and it is NOT a part of the contract. The inspector should review the appropriate subsections of the Standard Specifications, project Special Provisions, and this manual at the start of each new project.

The 300 (Asphalt) Series of ADOT’s construction training and certification manuals, as well as the Asphalt Institute publication listed at the end of this chapter, and the AASHTO Technical Training Solutions which can be accessed online, provide excellent information on the how to of asphalt production and paving operations, hot plant and paving inspection, and quality assurance. These references describe in great detail some of the key elements of asphalt paving and plant inspections. It is highly recommended that the inspector who may be unfamiliar with recent changes in asphalt construction carefully review these references in conjunction with the material presented in this manual.

The Resident Engineer and Project Supervisor should have a basic understanding of the design concept behind each type of AC specification. For large projects, material under Section 416 or 417 Asphaltic Concrete (End-Product) is used. These paving mixtures are the workhorses of ADOTs asphalt structural paving bid items and are used relatively equally, and are in some instances interchangeable or may be substituted where other materials may have been specified. For smaller placements or where the pavement's structural strength is not critical, Section 409 and 413 miscellaneous structural mixtures are specified. If pavement structure is vital, but statistical end-product acceptance is not practical, Section 409 or 413 (Special Mix) may be specified.

Specification 407, 411 and 414 are asphaltic concrete friction courses (ACFC & AR-ACFC). These are open graded asphalt mixes that are porous and used as the final riding surface in areas where it is desirable to have enhanced wet-weather skid resistance. BWC may also be used for this type of application. Specification 414 (AR-ACFC) is the asphalt rubber version of 407. Specification 411 is only used for miscellaneous work.

ACFC 407, AC 409 and ACFC 411 paving specifications have several things in common; they are method specifications where the contractor must follow a set of prescribed procedures in producing and placing the asphalt. End product 416 and 417 specifications also use method requirements for compacting thin lifts, 1 ½" or less.

These materials have very similar inspection procedures because the specification requirements are nearly identical for production and placement, only the material properties are different with a few additional tests for rubberized asphalt mixtures. Their method of measurement and basis of payment are also similar. The Resident Engineer is responsible for identifying the need to adjust construction methods to fit field conditions.

The following table summarizes the various asphaltic concrete specifications.

Application	Specification	Description
Asphaltic Concrete (AC)	408 (recycled) 413 (rubber) 415 (rubber) 416 (end-product) 417 (end-product) SHRP	General purpose, hot mixed, paving materials used for leveling, and base courses as well as surface courses; broadly graded, dense mixes.
Stone Matrix Asphalt (SMA)	924 (end-product)	Used where increased pavement strength, fatigue resistance, and durability are necessary. May also serve as a surface course. Is a gap graded dense mix
Asphaltic Concrete Friction Course (ACFC)	407 414 (rubber)	Open graded mixes used for riding surfaces only; expensive, but provide superior skid resistance when needed.
Bonded Wearing Course	404 (stored spec)	Used as an overlay alternative to ACFC. Mix design is similar to that for dense graded but includes some requirements similar to friction course, including quality assurance and acceptance criteria.
Miscellaneous Structural	409 (AC) 411 (ACFC)	AC with broad material bands and method rolling. Used for small project applications. Also used for special situations such as temporary detours and erosion control.

Asphaltic Concrete Mix Design Criteria

Specification bands (design limits) are given to identify acceptable starting points for the mix design, but they are NOT for production control or acceptance. Once the mix design is complete and approved for use by the Regional Materials Engineer, there is typically no need for the inspector to refer to this subsection unless the contractor makes a permissible self-directed target change. End-product specifications, such as 416-7.04, will have production control bands (upper and lower limits) that are based on the target values given in the particular mix design for each individual project. Production control bands should not be confused with mix design specification bands. The production control bands are found in the acceptance subsection of the specifications.

The contractor is afforded some flexibility in the production targets for 409 (special), 415, 416, and 417, which is realized by means of a self-directed target change. These allow for reasonable adjustment of mix design targets without necessitating development of a new mix design. Because this impacts the design and possibly other mix parameters, it is always a good idea to forward such requests to the Regional Materials Engineer to ensure the change is acceptable. The Materials Coordinator must retain this documentation with the mix design and inform the laboratory supervisor to allow for the new targets to be established for determination of acceptability and pay factors for subsequent placements.

Self-directed target changes are not retroactive but apply to the subsequent paving lots, as indicated by the contractor in written correspondence to the RE. However, if applying a self-directed target change removes a lot from reject status, the original pay factor will remain unchanged prior to the target change. An Engineering Analysis will no longer be required for the Department to consider allowing the material to remain in place however the contractor must still submit a letter to the Engineer to request that the material be allowed to remain in place.

Mineral Aggregate

The biggest factors that affect the variations in asphalt mix properties are the aggregate crushing, screening, and stockpile operations. Often problems in compaction and gradation can be traced back to poor controls during crushing resulting in excessive variability. It is very important for ADOT Inspectors to carefully monitor this operation and ensure the contractor is doing all the sampling and testing properly. The contractor has complete control of the crushing operation and ADOT does not usually interfere with this unless there is a regulatory violation referred to in Subsection 1001.

It is very important for the field office to verify contractor compliance with all environmental regulations and permit requirements (local, state, and federal) for the mineral aggregate source(s). Refer to Section 1001 of both the Standard Specifications and this manual for further information and instructions. Verification is not required for established commercial sources, however, the contractor must provide a completed and signed Materials Source Environmental Analysis Update, the form may be found on ADOT's Environmental Planning web page under Materials Source Guidance. As the contractor produces the aggregate stockpiles, their QC should be closely monitoring the properties of the material to ensure both consistency and acceptability for use in asphaltic concrete mixture. This includes crushing, stockpiling methods, and stockpile management. It is appropriate for the inspector to periodically observe these processes and if any material is suspected of being deficient, sample the stockpiles to confirm properties.

Materials produced for End Product and Special Mix specification items have requirements in addition to those for Miscellaneous items. Be sure to familiarize yourself with what these requirements include.

Mineral Admixture

Typically the Department does not test mineral admixture unless a problem is suspected. Each load of mineral admixture delivered to the plant must be accompanied by a Certificate of Compliance and a Bill of Lading. The Daily Mineral Admixture Report form is found at the end of this chapter.

All asphaltic concrete items require mineral admixture as an anti-stripping additive to facilitate good adhesion of the asphalt cement to the aggregate to ensure pavements are durable during moist conditions. The mineral admixture will be 2.0% by weight of the mineral aggregate unless Immersion Compression (moisture sensitivity) testing indicates a satisfactory Index of Retained Strength, in which case it may be reduced to as little as 1.0%.

The specifications allow three types of mineral admixture (Portland Cement Type I or II, Blended Hydraulic Cement - Type IP, and Hydrated Lime). The two types of cement must be added as a dry powder to the mineral aggregate for mixing in the pugmill. The lime must be hydrated and can be added as a dry powder or as a slurry (with water). Large chunks of mineral admixture are not allowed into the mix and the inspector should look for signs to determine if these dry materials have been wetted during storage. Contaminated mineral admixture may also cake itself to the inside of the hot plant mixing drum and then break off in chunks which become asphalt coated. Conglomerations of such defective mineral admixture may present themselves as a raveled surface or deteriorating weak aggregate and become apparent in the surface of completed pavements several days after placement

There is another lime product called quicklime (CaO) that cannot be added to the mix. When CaO is mixed with water it is slaked (hydrated) which means the water is chemically combined with it. The hydrated lime called for in the specification is slaked, but it can still look like a dry powder even though it has been hydrated with water. The inspector must be aware of these differences because CaO is dangerous to handle and if blended into the asphaltic concrete it will damage it since it remains reactive.

It is of the utmost importance that the mineral aggregate contains an adequate amount of moisture in order for the mineral admixture to remain adhered to the aggregate and serve its purpose. Look for adequate mixing in the pugmill, and if dry mineral admixture is observed blowing off the cold feed belt prior to entering the drum, require the producer (contractor) to make adjustments as needed. Under no circumstance should production be allowed without the inclusion of the mineral admixture; hot plants must be equipped with an alarm and automatic shut off if the supply of mineral admixture is interrupted, refer to section 4.03 for these requirements.

Bituminous Material

Bituminous material will be a performance grade (PG) asphalt cement or crumb rubber asphalt (CRA) and the required type will be found in the Special Provisions for the project. If the PG grade/CRA Type in the specials does not match that in the bid item list, consult the Regional Materials Engineer to determine the appropriate PG, then discuss with the project manager and contractor as soon as possible. A procedural change order may be necessary depending on which PG was included on the bid item list; the change order will be predicated on if sufficient funds exist to cover any potential cost increase.

Certificates of Compliance (CoC) or Certificates of Analysis (CoA) must accompany each load of PG asphalt along with a weigh ticket or bill of lading. Sampling and testing for PG asphalt acceptance may begin with AC production unless the asphalt cement is from a new source/supplier or recent issues with a particular material have been identified by ADOT Materials Group. For such instances, samples should be sent to the Central Lab for preliminary acceptance testing as soon as possible. The viscosity of CRA must always be verified in the field after the reaction period and prior to use.

Pretesting on material that has not been previously used is recommended, as well as when serious problems have recently been experienced with a particular source. The ADOT Central Lab may request this and will determine when pretesting will no longer be necessary.

Mix Design Procedure

Specifications require the contractor to be responsible for obtaining an acceptable material source and producing mineral aggregate that will meet all of the specifications. Utilizing mineral aggregate, crushed, processed, separated, and stockpiled, the contractor shall formulate a mix design which meets all of the specified design criteria. The mix design shall be submitted to the Resident Engineer. If CRA is being used, a rubber blend design is also required.

The Resident Engineer will submit the mix design to the project's designated Regional Materials Engineer or the State Bituminous Engineer for their review; allow up to 5 days. Before the mix design is submitted, the Resident Engineer should verify that all the information contained in the mix design is complete and meets the requirements shown in the specifications. This includes checking for an approved testing lab (identified on ADOT's List of Approved Labs) the test results on aggregates and the mix itself. A list of material sources and suppliers will be on ADOT's List of Commercial Materials Sources having completed an Environmental Analysis and the inclusion of the required certifications. The best way to check a mix design is to carefully read the Special Provisions and Standard Specifications to verify that each provision is included in the mix design.

ADOT Materials Group does not test and verify the contractor’s mix design for material or volumetric properties unless there exist very specific circumstances such as the use of a new mineral aggregate source or source which has recently been problematic, e.g highly absorptive aggregate. The Regional Materials Engineer will confirm mix properties meet the project requirements and that calculations and volumetrics are correct.

When a new mix design will be prepared and submitted, the Project Supervisor should have the Materials Coordinator or an inspector witness the contractor's sampling of the aggregate stockpiles. At the same time, the materials should be gathered for the ADOT acceptance lab to perform any necessary calibrations and/or verifications for the mix.

If the contractor proposes to use a previously used mix design, samples may not need to be submitted but confirm this with the project lab. The contractor's paperwork still needs to be reviewed for compliance with the specification before forwarding to the Regional or Central lab. Occasionally the Resident Engineer or Regional Materials Engineer may want to sample the contractor's aggregate stockpiles to ensure that each material still meets the original tolerances for gradation, fractured coarse aggregate particles (crushed faces), and sand equivalent. If appropriate, the Regional Materials Engineer will approve a previously used mix design for use on a particular project. The contractor must state clearly in a written correspondence cover letter to the Department, their intent to use the previously used mix design, for what purpose (mix type/bid item), and for which project (TRACS No., Route, and Name).

The contractor may propose the use of a mix design that includes an asphalt cement of a grade that is different than that specified due to limited availability from local hot mix suppliers, or request that a mix design be approved, but with a different PG than what is shown on the design for the same reason. In either event, the Regional Materials Engineer will determine if the proposed design and/or PG are appropriate for use on the project, which may require a change order to account for a material different than what is on the bid item list.

In some instances, a 1-pt verification will be necessary to confirm volumetrics remain acceptable if a PG and PG source other than those indicated on the mix design are proposed. If the Index of Retained Strength on the original mix design is less than 90%, Immersion Compression testing is also required. The testing for a 1-pt verification typically takes at least one week. The Regional Materials Engineer will review the 1-pt verification and compare to the original mix design to ensure production will result in a viable mix for the project.

Contractor Quality Control

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

QC Procedures Checklist:

- Is the sampling frequency the same or greater than frequencies shown in the Standard Specifications or Special Provisions?
- Does the QC Supervisor(s) meet all of the certification and experience requirements listed in Table 2 of *P.P.D #19 - ADOT SYSTEM FOR THE EVALUATION OF TESTING LABORATORIES*.
- Are all the testing technicians ATTI certified with the appropriate certifications as required by Table 3 of P.P.D. #19?
- Are all the elements of the contractor’s QC operations adequately discussed to evaluate conformance to current industry or ADOT practices? Refer to ADOT’s applicable Technical Training workbooks on bituminous pavement construction and the appropriate Asphalt Institute/FHWA publications and training workshops.
- Are there plans to do adequate testing of the mineral aggregate during crushing? As previously mentioned, crushing has the biggest impact on mix variations.
- What are their procedures for checking equipment such as the rollers, laydown machine, and plant both before and during production?
- Are the lines of authority and communication clearly established; who has the ability to reject unsatisfactory materials and workmanship, and how are necessary changes communicated?

If needed, ADOT Materials Group will provide guidance to the Materials Coordinator for evaluating the contractor's quality control (QC) procedures. However, it is the Resident Engineer who must be satisfied that the contractor's procedures (as described in the weekly meetings) are complete, credible, and an accurate portrayal of how the contractor will actually carry out the work.

Inspectors should periodically check the contractor's QC operations to ensure the procedures being used are as stipulated in the specifications..

Construction Requirements

Construction requirements for an end-product specification are often similar to a method specification, but most of the responsibility is shifted to the contractor. End-product specifications allow the contractor significant latitude on how asphaltic concrete is produced and placed, but some inspections at the plant and at the project site will still be required. Miscellaneous paving is performed under a method-specification and therefore, it is necessary for the inspector to observe and confirm paving is accomplished in accordance with specification requirements. Regardless, iIt is always a good idea to document the contractor's materials handling procedures for future reference even if we do not control the individual steps of this process. LIkewise, any conditions or actions that deviate from what would be expected given the particular bid item should be thoroughly documented.

Pre-paving Meeting

It's always a good idea before any paving operation, whether it's an AC, ARAC, ACFC, AR-ACFC, or chip seal, to hold a pre-paving meeting. The intent of the pre-paving meeting should be to have the contractor describe:

- how the plant and paving operations will be conducted
- how the work will be sequenced
- how quality control will be performed
- what are the lines of authority
- what equipment will be used
- any areas/locations thought to be structurally deficient or inadequate to support paving equipment
- what contingency plans are in place for equipment failures and weather disturbances

The Resident Engineer should be prepared to discuss how the work will be inspected, who will inspect it, and how acceptance sampling and testing will be performed. A sample agenda is shown in Exhibit AC-1.

Some important points to bring up at the pre-paving meeting include:

- how the test results will be reported to the contractor
- who will be responsible for each type of test
- procedures for joint construction
- how grades will be controlled and what type of shoes or skis should be used on the paver
- any areas of the project that require special treatment such as hand work or blade leveling
- how random sample times and locations will be established
- establishing a correlation between contractor's lab and ADOT's
- procedures for changing any of the target values
- sampling dry screened RAP for gradation and RAP binder content correction
- limitations of RAP content and RAP binder content
- how/when samples will be delivered to the lab
- haul trucks and approved release agents
- traffic control set up/take down, hot plant fire up, mix on grade times
- surface preparation and tack coat
- mat/joint compaction requirements

RE's should refer to the asphalt paving pre-activity meeting agenda and include any additional items not covered above.

Hot Plant Inspection

Hot plants used in the production of asphaltic concrete are of two general types: batch mix and drum mix (see Exhibit AC-2). Drum mix plants provide for continuous production and produce asphaltic concrete at a higher rate than do batch mix plants, and therefore, drum mix plants are the most common. The most important basic controls necessary to produce high quality asphaltic concrete within the required specifications are uniformity of grading, asphalt content, temperature, and moisture content.

If the Project Supervisor or Lead Inspector seriously doubts the ability of the contractor's plant to consistently produce asphaltic concrete that will meet all of ADOT specifications (Section 403), then a plant inspection should be performed to assure conformance with AASHTO M 156. This type of plant inspection should be the exception and not the rule and used only in situations where plant operations are clearly marginal or expected to be so. When deciding whether to place full time or part time inspector(s) at the hot plant, the Resident Engineer or Project Supervisor should consider the following:

- the quantity of asphaltic concrete to be produced
- the type of asphaltic concrete to be produced, e.g. 407, 409, 415, 414 416, or 417.
- where the asphaltic concrete will be placed, e.g. mainline, shoulders, guardrail pads, etc.
- the plant’s hours of operation
- the track record of the hot plant including the consistency in producing specification asphalt
- the contractor’s quality control efforts
- the current condition of the plant’s equipment and the past performance of the plant operators
- long haul times and the tendency to overheat the asphaltic concrete
- the materials and equipment requirements of the inspector(s)
- the duties the inspector(s) will perform and the procedures for acceptance and rejection of materials
- how the inspector(s) will coordinate plant inspections with the site inspectors and the acceptance lab

The inspector at the hot plant has a role in producing a quality pavement that is just as important as the inspector behind the laydown machine. Experience in asphalt paving has shown that the highest quality pavements are the result of both a consistent mix that is produced at a skillfully operated plant and tight controls over placement conditions and compaction. Production is a continuous process which means the inspector must be continuously monitoring and documenting hot plant operations. The use of quantlists by inspectors can be useful in establishing these processes.

Although calibration of the plant is the contractor's responsibility, scales need to be checked for certification before production begins. This is a matter of checking for a tag or sticker from the Weights and Measures Services Division (WMSD), or a designated authority. It is best to have the scales calibrated and certified after the plant has been up and running the trial batch or lot for a few hours or a day if possible. This allows time for the scales to settle into place as the vibrations of the plant and the weight of moving aggregate or trucks can cause settlement of the scale assembly.

Control of the mineral admixture is another area that needs to be carefully checked. In a drum mix plant, the aggregate and mineral admixture is mixed together in a pugmill before being loaded into the drum. In a batch mix plant, the admixture is loaded into the batching pugmill and mixed with the dried aggregate before the asphalt cement is added.

Daily documentation of the amount of mineral admixture incorporated into the mix must be furnished. Prior to paving, the inspector should verify:

- the positive signal system and limit switch on the admixture feeder is working so when no admixture is fed into the pugmill, the plant automatically shuts down
- there is a positive means of weighing the admixture before it goes into the pugmill

- calibration of the admixture feeder. The inspector should do a manual calculation to prove that the correct number of pounds of admixture is being added to each ton of asphaltic concrete.
- Adequate moisture in mineral aggregate when combined with mineral admixture
- That the admixture will be introduced without significant loss of the product during mixing or moving on the cold feed belt

Pugmills should be checked to ensure that the material is carried at least 3 feet horizontally and that the blades are not overly worn.

The pyrometer at the discharge chute needs to be checked periodically to ensure it is accurately recording temperatures and the temperatures are within the specified maximum limits. Typical maximum temperature limits are 325°F for AC (some high temperature PGs such as 76-XX may require 335°F, and 350°F for ARAC.

The cold feed sampling device should be checked to ensure that a representative sample can be obtained safely from the belt discharge per Arizona Test Method 105 while the plant is running. If not, the belt should be stopped and samples taken in accordance with Arizona Test Method 105. The stopped belt method is the control method in case of disagreement between the results. It is important to indicate if the sample includes mineral admixture.

Pre-paving Meeting

Project No. XXX-XXX-XX

00/00/00

00:00 AM to 00:00 AM

ADOT XXXX Field Office

Facilitator:	Resident Engineer (RE)
Attendees:	RE, Superintendent, paving foreman, Project Supervisor, inspectors, testers
Please review:	Section 406, the Construction Manual, Special Provisions, Project Plan Sheets X to Y, Materials Testing Manual
Please bring:	paving schedule, layout diagrams, TC plans, list of equipment, QC plan, sample forms and test reports, list of contacts

----- Agenda Topics -----

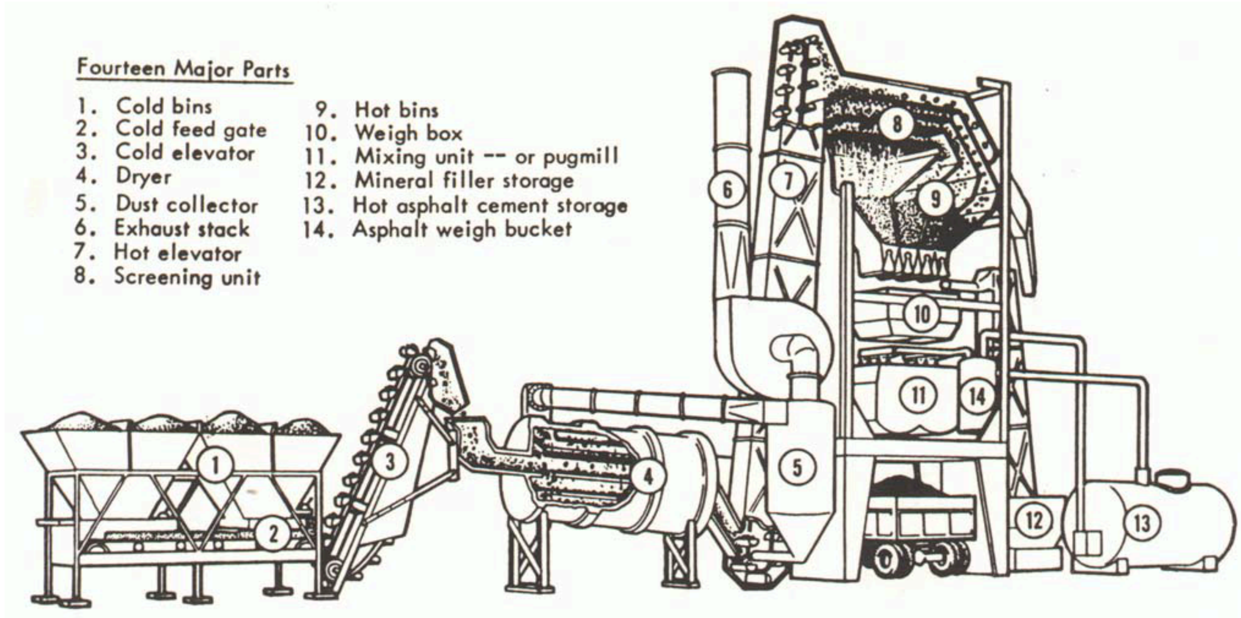
1. Introductions	RE & Superintendent	8:00-8:03 AM
2. Contractor's Schedule & Paving Layout	Superintendent	8:03-8:13 AM
3. Haul Routes & Traffic Control	TC Coordinator	8:13-8:18 AM
4. Proposed Equipment	Superintendent	8:18-8:23 AM
5. Contingencies – damaged subgrade, equip., plant failures, weather	Superintendent & RE	8:23-8:30 AM
6. Quality Control	QC Administrator	8:30-8:37 AM
7. Inspection Procedures	Project Supervisor	8:37-8:42 AM
8. Acceptance Sampling & Testing	RE & Project Supervisor	8:42-8:45 AM
9. Subgrade/Base Acceptance	RE & Project Supervisor	8:45-8:48 AM
10. Target Values & Changing Targets	RE	8:48-8:51 AM
11. Other ADOT Concerns	RE	8:51-8:54 AM
12. Safety	RE & Superintendent	8:54-8:58 AM
13. Lines of Authority & Site Escalation	RE & Superintendent	8:58-9:02 AM
14. Documentation & Payment Procedures	RE	9:02-9:05 AM
15. Q&A / Adjourn	RE & Superintendent	9:05-9:10 AM

Other information

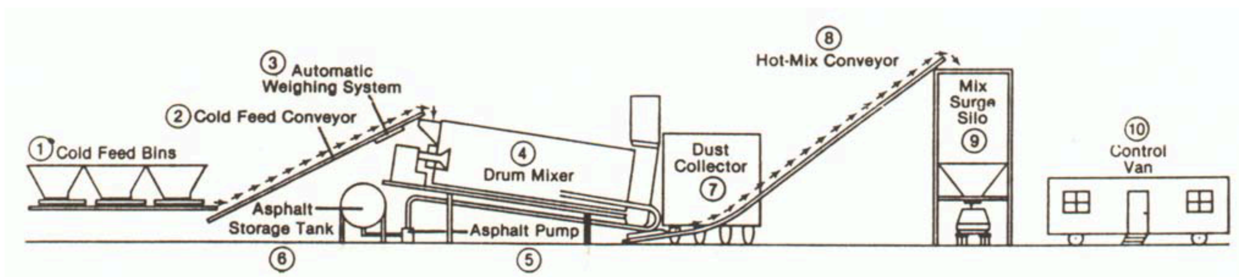
Observers:

Special notes:

Exhibit AC-1. Pre-paving Meeting Agenda



Cutaway View of Typical Batch Plant



Typical Drum Mix Plant

Exhibit AC-2. Batch And Drum Mix Plants

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

A. Stockpiles and Cold Feeders

Stockpile management and loader operations are essential to avoid segregation, contamination, running the cold feed bins empty or causing them to become overfilled, and doing these things properly help ensure consistent asphalt production.

In order to prevent intermingling of material in the stockpiles, it is necessary to have good bulkheads or adequate separation of stockpiles. A bulkhead that does not prevent intermingling of the aggregates is of little or no value. The bulkhead should start at ground level and extend above the highest contact point of either stockpile. It should also be long enough to keep the piles completely separated.

Uniform stockpiles and good feed control are also important because a weight sensor on the feed belt monitors the aggregate flow and adjusts the asphalt cement being added.

The loader operator must not gather materials from the lowest 12 inches or so of a stockpile. Doing so may increase the amount of fines going into the mix and will interfere with gradation and mix volumetrics. This is because fines tend to accumulate in the lower portions of the stockpile as the stockpile is manipulated and sprinkled with water or it rains, and underlying soil can also become disturbed and find its way into the cold feed bins.

On drum mix plants, the cold feed control is especially important because it is the only gradation control in the plant and for ACFCs this is the point of acceptance for gradation. The stockpiles for drum mix plant operation must be very uniform. If there is moisture in the sand, it may not flow freely. A vibrator may be necessary to keep the damp sand from bridging over the gate opening. Frozen sand may also give similar trouble.

If using a batch plant, the Resident Engineer must verify the batch weights used in sampling a batch-type plant so that the composite grading can be accurately calculated.

B. Sampling of Mineral Aggregate

All samples for the purpose of accepting materials shall be taken from the hot bin, or cold feed. The sample size shall reasonably conform to the minimums recommended by the Sampling Guide Schedule.

Batch Mix Hot Plants: The inspector shall observe the contractor sample each size as the mineral aggregate is falling from the hot bin into the weigh hopper.

Drum Mix Plants: Samples of the mineral aggregate shall be taken after the various sizes are combined, by interrupting the full flow of material as it is delivered to the mixer. The contractor shall take the sample under the observation of the inspector and shall immediately furnish it to the inspector. A bucket with a sealable lid must be used to ensure accuracy of testing for moisture content.

The mechanical or manual device used for sampling must interrupt the full flow of material. It will be considered acceptable if the contractor can demonstrate to the Resident Engineer that the full flow of material can be interrupted in such a way that all portions of the flow are diverted for an equal amount of time. The ideal sampler moves laterally across the flow without excessively disrupting the large particles. This type of device satisfies the requirements, providing its speed is uniform through the flow, see Exhibit AC-3.

Other devices that travel into the flow and back out along a path perpendicular to the flow obviously have a move in time, a residence time, and an exit time. Considerable judgment may be needed to determine if the sum of the move in and move out time in ratio to the residence time is excessive. The ratio of travel time to residence time should be minimized by fast-acting systems such that the combined travel time is not greater than 10% of the residence time.

If a representative sample cannot be obtained while the belt is in motion, then the inspector has the right to direct the contractor to stop the belt so that a representative sample may be removed from a stationary section of the belt as per Arizona Test Method 105. Comparative samples may be taken at the start to reasonably assure that the sampling device does not create unacceptable systematic error, i.e. catch more rock or fines than is truly flowing into the mixer.

It will be necessary to reduce the field sample conforming to the required minimum size by a process described in AASHTO T-248. The portion selected for testing shall reasonably conform to the minimum size specified in the respective test method.

C. Drum mixer

The Drum mixer (see Exhibit AC-2) is a revolving steel drum or cylinder where aggregate is dried and heated by burning fuel oil or gas in the upper end and the asphaltic concrete is mixed in the lower end. This drum must be set up with some amount of slope along the axis of the drum or the material will not move through it efficiently. The drum at a batch plant is shorter since it is only for drying material, not mixing. The cylinder walls have cups or channels called, flights or lifting flights, spaced at intervals on the inside wall of the cylinder, in rows down the full length of the drum. The flights raise the aggregate as the cylinder turns, and drop the aggregate through the hot gasses. The heat is generated at the burner. Air is necessary to atomize the fuel oil as it is ejected from the burner nozzle to provide complete combustion, and to provide draft or suction necessary to carry combustion gasses through the drum. Mixing flights are positioned at the lower end of the drum.

When the fuel oil is not completely burned, it tends to deposit a black, oily residue on the hot aggregate particles making it difficult to coat them with asphalt. An indication of incomplete combustion of fuel oil in the drier is heavy, black smoke coming from the dryer exhaust stack. Indications of insufficient draft through the drier are spasmodic puffbacks at the combustion end of the drier, or flame entering the drum only a short distance. The flame should penetrate about one-third the length of the drum.

Common drum mix plant problems involve temperature. Either it fluctuates, or it is too high or too low. The main causes for these problems will usually be found in the cold feed. It could be moisture variation in the cold aggregates, variation in the feed rate, overloading the drier beyond its capacity to dry and heat, or a change in the character of the material. Additional causes that may contribute to the problem are over control of the burner flame, insufficient draft, and an inaccurate heat-indicating device.

D. Heat Indicating Device

It is desirable to hold the temperature of the aggregate in the drier to the minimum that will effectively dry it, allow the individual particles to be uniformly coated with asphalt, and allow for the mix to arrive at the job site at the recommended temperature. The temperature-indicating device is probably the most important single plant control accessory because the service life of the pavement is shortened if the asphalt is overheated. The following types are common:

- Thermometers (mechanical). Metal thermometers with large face dials are inexpensive, rugged, durable pieces of equipment that can be easily replaced.
- Indicating Pyrometers (electrical). This type of heat indicating device is generally a galvanometer that measures a very small electrical current induced by the heat of the aggregate passing over the sensing element.
- Recording Pyrometers (electrical). This type of instrument is similar to the indicated pyrometer except that the head is a potentiometer. Temperatures are recorded on paper in graphic form providing a permanent record. The contractor is required to give a copy to ADOT at the conclusion of each shift of production

All asphaltic concrete specifications except miscellaneous ACs, e.g. 409 & 411, require a recording pyrometer.

The sensing element should be installed at the discharge end of the drier in such a manner that the element protrudes into the flow of the mix. It may be held by set screws inside a short sleeve that is attached to the walls of the drier discharge chute. It should be located so that it is not affected by the reflected heat of the burner and is insulated from the sleeve. The sleeve may shield the element but should not delay, distort, or alter the accuracy of the temperature readings.

To check the accuracy of the heat-indicating device, an accurately calibrated thermometer and the heating device are inserted together into a hot asphalt bath that is slowly heated above the temperature range expected of the dried aggregate. The readings of the two instruments are compared. Alternatively, material from the discharge of the drum can be captured with a shovel and placed in a metal bucket and a thermometer or temperature probe inserted immediately into the material.

E. Dust Collector

Exhibit AC-2 shows typical dust collector systems. The purpose of the dust collection system is:

- Collect the fine aggregate particles floating about in the drum and various parts of the plant
- Provide the draft that carries the hot gasses through the drum via the blower for the dust collector system

Dust collectors may be the bag house type, cyclone type, or one of many different styles of wet collector.

The specifications require that the dust collector system be capable of removing dust from the aggregate, either wasting this material, or returning it uniformly to the mixer when authorized by the Department. The dust in the mix is an important fraction of the aggregate that must be strictly controlled to narrow tolerances.

Significant changes in the percent passing the #200 sieve for the mix report could be an indication that either the dust collector system is not functioning as intended, or the MA is inconsistent. The MA cold feed results should be able to capture inconsistencies in the MA (increased sampling frequency may be necessary) to isolate the cause to the dust collection system.

F. Aggregate Bins

Exhibit AC-2 shows typical aggregate bins for both drum mix plants and batch plants.

The specifications require low-level bin detectors on both batch type and drum mix type plants. Make certain that this equipment is in place and that it is operating before allowing the plant to start. On drum mix plants, the device will automatically stop the feed of aggregate and asphalt to the mixer when the level of the aggregate in any bin approaches the strike off capacity of the feed gate. On batch plants the device consists of a mechanical arm or a set of lights, one for each bin.

Typical aggregate bin problems include a shortage/excess of material in one bin or another, worn gates at the bottom of the bin which allow a leakage of aggregate into the weigh hopper, and sweating of the bin walls. This sweating condition normally occurs only at the beginning of a day's operation and does not cause much trouble after the bins reach a stable temperature.

In batch plants, the screened aggregate falls from the screens to the hot bins below. The purpose of the hot bins is to hold the heated and screened aggregate in the various desired size fractions for proportioning into the mix. It is a good practice to verify the overflow chutes from each hot bin are functioning properly and that the bin partitions have no holes in them so that the material from one bin cannot flow into and contaminate the material in an adjacent bin.

G. Mineral Admixture Feeders

Most aggregate sources in Arizona have an adequate amount of fines (- #200 sieve) to provide dense asphaltic concrete. More often than not, dust has to be removed by the dust collector or other means in order to maintain sufficient air voids in the compacted pavement.

Mineral admixture, in the form of dry lime or cement, may be added to the mineral aggregate for the purpose of improving the affinity of the aggregate for asphalt and reducing the potential for stripping.

Control of the mineral admixture is another area that needs to be carefully checked. In a drum mix plant, the aggregate and mineral admixture are mixed together in a pugmill before entering the drum. In a batch mix plant, the admixture is loaded into the batching pugmill and mixed with the aggregate before the asphalt cement is added. Subsection 403-2 describes in detail the requirements for admixture mixing and control. Before paving, the inspector should check for:

- a working interlocking device on the admixture feeder, so if no admixture is fed into the pugmill, the plant shuts down
- a positive means of weighing the admixture before it goes into the pugmill
- calibration of the admixture feeder, the inspector should do a manual calculation to prove that the correct number of pounds of admixture is being added to each ton of asphaltic concrete

H. Sampling Device

On batch mix plants, the samples of aggregate are taken from each bin as they are discharged into the weigh hopper. The specifications require that adequate facilities be provided for sampling at this location. Make certain that the facility is safe and also that representative samples are assured.

Sampling equipment should be checked with the plant operating before production is started.

As mineral aggregate flows over the plant screens, the finer particles fall through the screens first and deposit near the wall of the bin next to the head of the screen. The coarser material will travel farther across the screen and deposit on the other side of the bin. This is most common in the fines bin. This tendency is important to remember when analyzing the methods used to obtain a representative sample of the material in the bins.

It is recommended that a sampling device be used similar to that illustrated in Exhibit AC-3. Using a shovel or pan as a means of obtaining samples is not allowed because of the problem of obtaining representative samples.

On some batch mix plants, the sampling devices are a part of the plant and representative samples are secured from the material diverted into the separate compartments of the hopper.

I. Asphalt Storage Tanks

All asphalt storage tanks, feeder lines, and pumps (See Exhibit AC-2) must have heating devices and insulation to effectively maintain the asphalt at the desired temperature. The temperature of the stored asphalt should be near the required mixing temperature of the finished mix and should be checked frequently. Return lines discharging into storage tanks must be submerged below the asphalt surface level in the tanks at all times. This prevents oxidation and hardening of the asphalt since it has less exposure to oxygen in the atmosphere.

It is important to note that Crumb Rubber Asphalt (CRA) and other asphalt cements that contain granulated crumb rubber (for bituminous mixtures such as ARAC or AR-ACFC) require agitation in addition to heating. If not adequately agitated while stored, the granulated rubber and asphalt cement will separate resulting in a non-homogeneous material that will cause significant production, construction, and pavement performance problems. However, rubberized asphalt such as TR+, is not susceptible to separation/settling and therefore, agitation is not needed for TR+ binders.

Complete permanent records shall be kept of all asphalt cement delivered to the storage tanks as well as the quantity of asphalt used during the paving operation.

J. Avoiding Incorrect Asphalt Content

One of the most common causes of failure in asphaltic concrete pavements is incorrect asphalt content and the associated variability in the effective voids. The reasons for incorrect asphalt content can stem from inaccurate scales (either asphalt or aggregate), variations in aggregate grading, porosity of aggregate, incorrect mix design values, or poor interpretation of preliminary test results.

Constant attention must be paid to the scales at the asphalt plant to be sure they are functioning properly. It is a good practice to check how the asphalt cement is weighed and dispensed into the mix. The plant operator should show the inspector how the asphalt cement is weighed and the dispenser calibrated. At a batch plant this will be a type of weigh bucket with its own scale dial. On a drum mix plant the continuous flow is measured with a mass-flow meter in the supply line. Asphalt cement weights should be checked against those computed from the mix design. Whenever it is suspected that the asphalt delivery system is malfunctioning, tests should be run to verify the condition of the system.

Be aware that until a volumetric correction for the asphalt content is established by the Materials Coordinator using the RAP Spreadsheet to compare laboratory determined asphalt content to volumetric measurements of the actual quantity of asphalt used (as reported on the hot plant reports) for the first five lots of representative production, the laboratory reported asphalt content is preliminary.

K. Batch Mix Plant

Exhibit AC-2 shows a typical batch plant. The aggregate travels up a hot elevator to the screen deck of the asphalt plant. The screen deck separates the aggregate into sizes and drops each size into the proper bin. The arrangement of screens on the screen deck of a plant is usually such that the fine material is screened first, followed by increasingly larger sizes. The capacity of the fine screen is generally the limiting factor in plant production rates. A ¼ inch screen will separate approximately one ton per hour per square foot of screening area. When an attempt is made to increase production beyond the capacity of the screens causing carry-over; aggregate that does not get screened, but spills over into the next bin. Carry-over can be corrected by decreasing the rate of production, increasing the available screening area, or modifying the screen sizes and arrangement.

The capacity of the screens will be exceeded at normal production rates if the openings become plugged with material. This condition demands constant inspection and cleaning of the screens involved. Someone should inspect the screens at least once each day to make sure they are not plugged and to see that they are cleaned when necessary.

Positive evidence of carry-over is obtained from the individual bin gradation analysis. Even before sieve analysis, excessive carry-over will show during visual inspection of aggregate samples drawn from the bins. In the event such an observation is made, or a carry-over shows from test results, the material affected should be completely discharged and wasted, and the condition corrected.

The purpose of batch plant scales is to weigh the batch ingredients. The aggregate hopper and the asphalt bucket have separate scale systems. The indicators for the scale systems are usually load cells. One of the most common causes for scale malfunction is the buildup of asphalt, dust, etc. In addition, particles of aggregate can lodge in the scale supports and obstruct the free movement of the levers. Sometimes the asphalt bucket or the weigh hopper for aggregate will not swing freely, causing it to bind against another plant part.

The coarser aggregate is withdrawn from the batch plant bins first so it is deposited at the bottom of the weigh hopper and reaches the pugmill first. The tips of the mixer paddles readily pick up the coarse aggregate allowing it to scour the bottom of the pugmill, and through the movement of the coarse aggregate, to also ensure a thorough mixing of the entire mass. The sand is last because, if it were withdrawn first, it would be deposited on the bottom of the weigh hopper with the coarse aggregate on top. If the pugmill is worn so that there is an excessive clearance between the paddle tips and the liner, the sand could lay in a dead area below the reach of the paddle tips and never be picked up and mixed into the batch.

An obscure, infrequent situation may arise that could influence the bin withdrawals. In the event the aggregate being used in the mix is of low specific gravity, a much larger volume of material is needed for the same batch weight. This can cause insufficient weigh hopper capacity. If the sand is on the bottom, the coarse aggregate will sit on top rubbing against the bin gates, thereby preventing further flow of material into the weigh hopper. This results in insufficient coarse aggregate in the batch, and an inaccurate scale reading. If, on the other hand, the coarse aggregate is withdrawn first, the smaller aggregates will infiltrate into the spaces, thereby taking up less of the volume available in the weigh hopper.

At this point in the batch plant production, a timing device indicates how long the combined materials stay in the pugmill mixer. The inspector should note exactly when the timing device begins its operation. Most plants are equipped so that the timing cycle starts when the weigh hopper gates open to allow material to fall into the pugmill. This means that the mixing timing cycle has started before all of the material has entered the pugmill. It normally takes about five seconds for all the material to fall from the hopper to the pugmill. These five seconds should be deducted from the actual mixing time. Mixing time should be computed only from the time that asphalt is introduced into the pugmill. From this, it can be seen that if the timer is set for a 35 second mixing time, the actual mixing time will be approximately 30 seconds. In most cases, this need not be considered a critical item as long as the inspector realizes what is happening. The actual mixing time should be only that length of time necessary for complete coating of the aggregate particles with asphalt, and to provide a uniform homogeneous mixture. The shorter the time that the mixture remains in the pugmill, the less oxidation of the asphalt will occur. The longer the mix remains in the pugmill at elevated temperatures, the harder the asphalt becomes and, theoretically, the shorter the service life of the finished pavement.

It is important that the proper material level be maintained in the pugmill mixer. When a mixer is overloaded, a part of the material will float above the paddle tips and not be drawn down into the mixing mass. Conversely, a mixer with too little material in it will not thoroughly mix, as the tips of the paddles will rake through the material, providing little mixing action. With a proper size batch it should be possible to see the paddles as they rotate. In no instance should the depth of material in the mixer, during operation, be such that the paddles are invisible. Under most conditions, it is good practice to keep the batch sizes close to the capacity recommended by the plant manufacturer.

It is a good practice to make frequent visual checks of the mix as it is being discharged from the pugmill to the truck, and observe the top of the load as it leaves the plant. Any serious problems in the mix will probably be visible, such as segregation, too much/little asphalt, too much or insufficient heat, chunks of deleterious materials, or poor mixing. The inspector should attempt to watch as many of the discharged loads as possible, since early rejection or sampling of problem loads is clearly to everyone's benefit. The contractor may not appreciate this until it saves him or her several rejected loads at the paving site.

Some of the common causes for visible non-uniformity in the completed mix are as follows:

- insufficient mixing time
- poor distribution of asphaltic concrete across the pugmill
- poor distribution of fines in pugmill
- improper aggregate temperature
- worn paddles or liner in the pugmill
- leaking pugmill gate
- The finished product everyone is striving for is an asphaltic concrete mixture:
- with well blended aggregate having a uniform asphalt content
- mixed at a minimum temperature to allow thorough coating of the aggregate particles with the asphalt
- hot enough to allow for proper handling and compacting on the roadway

This is a difficult responsibility for both the producer and the inspector at the plant.

L. Drum Mix Plant

The principle of the drum mix plant is totally different from batch mix plants. Exhibit AC-2 shows a typical drum mix plant. There are several drum mixer designs, but they all have the common feature of simultaneous drying, heating, and asphalt coating of the aggregate. The plant consists of a cold feed system, pugmill, asphalt storage, dust collection, drum mixer, and a surge silo.

Aggregate gradation is controlled entirely by the cold feed. To be adequately controlled at the cold feed, it is imperative that very close production control is maintained when manufacturing and stockpiling the aggregate. Multiple bin feed arrangements are usually provided using individual gate controls adjustable from the control console. The aggregate feed belt incorporates a belt scale that continuously monitors the tons per hour being delivered into the plant. This aggregate delivery information is used in the asphalt pump control to meter the correct amount of asphalt cement into the mix. The belt scale must be certified for accuracy and kept in good working condition.

It is important that the proper material level be maintained in the pugmill mixer. When a mixer is overloaded, a part of the material will float above the paddle tips and not be drawn down into the mixing mass. Conversely, a mixer with too little material in it will not thoroughly mix, as the tips of the paddles will rake through the material, providing little mixing action. With a proper size batch it should be possible to see the paddles as they rotate. In no instance should the depth of material in the mixer, during operation, be such that the paddles are invisible.

The initial drying is accomplished in the upper end of the drum and as the drum rotates the aggregate falls, advancing to the lower end. In a parallel flow drum (see Exhibit AC-2) some type of shielding is used to prevent the direct flame from extending into the area where the asphalt is added. In a counterflow drum the burner extends into the drum such that the asphalt is added behind it.

The asphalt spray bar can be moved within the drum to adjust for particular problems such as a need to capture more fines or asphalt smoking because of hot aggregate. When the aggregate reaches the asphalt spray pipe, it has not lost all of its moisture. The small amounts that remain are sealed into the mix when it is compacted.

The time the aggregate is in the drum can be controlled to some extent by changing the slope of the drum. Adjusting the drum slope involves adjustments to plant accessories so it is usually not done except during the initial setup. Although it is not a popular adjustment, the Resident Engineer should know that it can be done and may effectively solve some problems.

The plant control console can adjust the aggregate asphalt proportioning, burner control, and pollution control.

When the plant is operating close to the pollution limits, small changes in the plant operation or materials can cause failure to meet air quality standards. The pollution control equipment used on a drum mix plant is similar to the types available for other kinds of plants.

Placing and Finishing

A. Plans and Specifications

ADOT field personnel are responsible for most of the inspection and quality control when acceptance is based on method specifications. One primary benefit of an end-product specification is the reduction in inspection that is required by ADOT field personnel. Since the contractor has the responsibility for quality control, the contractor’s staff should do most of the routine inspection work. ADOT Inspectors still have some involvement during paving, but most of their effort should be focused on ensuring that both the contractor's production and QC work are done properly and consistently.

The first thing the Project Supervisor and inspectors should do is become completely familiar with the plans and specifications for the job. This may sound odd as a beginning statement in describing the duties and functions of paving inspection. However, too frequently it has been observed that the inspector is merely satisfied that the material is being placed just like on the last project. The common assumption that this job specification is exactly the same as the last one is rarely true. Whether the specification is the same or not, it should be reviewed in the light of what is to be accomplished on the present job. Even with end-product specifications it is not sufficient that he or she merely sit by and observe operations as they progress. The inspector must take an active part in the actual functioning of the paving operation. The inspector should be adequately equipped with the tools for the job, such as a notebook, thermometers, string lines, straight edge, etc.

It is important for the Resident Engineer to allow adequate time for the Project Supervisor and the assigned inspectors to review the Standard Specifications, the Project Plans, Special Provisions, ADOT's training manuals on asphalt paving, and this chapter of the Construction Manual. In fact, the Resident Engineer should actively encourage the inspection staff to review all these documents prior to paving. An inspector's effectiveness can be increased enormously if that inspector has carefully read all the information available on the items of work to be inspected.

The inspector should also have a working knowledge of the construction equipment being used by the contractor. This means that he or she should know enough about it to be able to determine by visual inspection whether or not the equipment is in good mechanical condition and properly adjusted.

In addition to being present to see that the job specifications are complied with, the inspector should always be alert to see that the construction crew follows good practices and that workmanship is not substandard. Each little detail of workmanship in itself may seem insignificant, but when all the details are added together, they assume considerable magnitude. It is the attention to these seemingly minor details that can make the difference between a poor job and a good job. According to the Asphalt Institute, and assuming design and base preparation are adequate, 80% of pavements performing poorly can be traced back to poor workmanship during construction.

B. Job Site Safety

Job site safety must be observed. Often inspectors and construction workers are so absorbed in the details of their work that they overlook basic safety precautions and may take unnecessary risks. Project Supervisors should be especially on alert for safety violations during the first few days of paving. Until the operation settles into a routine where everyone is aware of what others are doing, the risk of an accident is high. In addition, it's always good to emphasize safety at the very beginning of every project so that no bad habits are overlooked.

C. Traffic Control

Before the paving begins, the Project Supervisor or Lead Inspector must ensure that the work can be done without jeopardizing the safety of the traveling public. The contractor must have traffic control devices set in place in accordance with an approved traffic control plan. Field adjustments to the plan are often needed to enhance safety and improve the continuity of the paving operation. The Project Supervisor should drive through the project a few times with the contractor's traffic control coordinator to check for conformance with the plan and make any necessary adjustments, see Subsection 701 of this manual for further instructions.

D. Subgrade and Base

Inspectors need to pay close attention to pavement subgrade and base. By now, the subgrade or base should have been inspected and approved. The inspector's job is to ensure that the subgrade and base are not damaged, disturbed, or contaminated by the contractor's paving operation. Talk to the contractor ahead of time about how delivery trucks will enter the project and reach the laydown machine. What measures are going to be used to ensure that no damage to the base occurs? What will be done if damage does occur?

The inspector will make certain that the surface upon which the asphaltic paving is to be placed is reasonably true to grade and cross section, being sound and with no soft areas or excess loose material. The smoothness of the finished riding surface is dependent to a large degree on the smoothness and firmness of the grade on which the paving is placed. Asphalt is considerably more expensive than base or subgrade materials; therefore, it should not be used as a leveling course over the less expensive materials.

It is very beneficial for the contractor and the inspector to pay attention to base density ahead of the paving train since this can in some cases affect the AC density. Any areas that appear to move under normal loads are not stable and therefore unsuitable, necessitating corrective action such as aeration, re-compaction, replacement, prime coat, cement/lime treatment, etc. It is not acceptable to pave over these areas.

Occasionally, the subgrade, base, or milled pavement will become damaged by heavy equipment traffic. The Project Supervisor, inspector, and contractor should meet before paving begins to discuss how damaged areas will be identified and repaired. It is important to have a contingency plan in place with the necessary resources so as to not unduly hold up the paving operation.

Finally, failing compaction densities for AB and/or AC, are often blamed on less than perfect subgrade conditions. Typically, the responsibility is the contractor's; however, the inspector should periodically observe the condition of the subgrade and note it in the daily diary. Observe the delivery trucks rolling over the surface to check for pumping or deflection of the base or subgrade. Report the observations in the diary. If you observe other disturbances, report them. This information could be invaluable in resolving pavement problems at a later time.

Some projects allow for only very minimal corrective work to base and/or subgrade and if such conditions prevent quality construction of the pavement, to minimize the potential for escalation or claims against the Department, the circumstances must be identified, documented, discussed with the contractor, and means of resolution determined by Partnering prior to performance of the work.

E. Scale-person (when applicable)

The scale-person will check weigh procedures at the hot plant and sign each delivery ticket. The scale-person will check delivery trucks for conformance with MVD length and weight restrictions, as well as authenticating tare weights shown on the delivery tickets. Refer to Subsection 109.01 for further information.

F. Transporting Asphaltic Concrete

The asphaltic concrete is normally transported from the central mixing plant to the spreading operation in trucks. Uniformity as to type and size of hauling equipment on the job is desirable and is often necessary for a given operation. If spreading and finishing machines are to receive the materials in their hopper directly from the trucks, the trucks must be of the end dump type, or be adaptable to the hopper to prevent spillage. They must not jar or place any vertical load on the paver while it is placing AC.

If material is windrowed in front of the paving machine by bottom dump trucks, the trucks must be of a type that will permit controlled sizing of the windrow. In this operation, the windrow is picked up by means of a windrow elevator, aka Kol-cal, and placed in the hopper of the laydown machine. The windrow elevator must be designed to carry all its weight and not put a load on the laydown machine.

More advanced equipment such as a material transfer vehicle (MTV) may be used to transfer material from the haul truck or windrow to the paver hopper. The use of MTVs is generally favorable due to the ability to reduce/eliminate both aggregate and thermal segregation as well as supply additional heat to the material during cold weather paving operations. This also may eliminate the need for haul vehicles to drive and disturb or contaminate tacked surfaces.

The problem of temperature control of the mixed materials may become acute due to:

- bunching of the trucks prior to arriving at the paver and dumping
- retention of mixed materials in the paving machine hopper
- cooling of the mixture in transit
- spreading or windrowing too far ahead of the paving machine

Any material that has cooled enough to cause it to be out of specification limits or cause poor workmanship should be rejected. The inspector should be aware that load temperatures vary according to time. Some hot plant operators do not want to run the first load any longer than normal, nor do they want to waste material. Often, the first load (possibly up to three) of the day may not meet specification. Every load should have its temperature checked at the beginning of AC shifts until they begin arriving consistently within the required temperature range. This should be documented. Also, do not hesitate to take samples for gradation and asphalt cement content testing if you suspect the first few loads don’t meet the specs. If the samples fail, the pavement area represented by the samples should be rejected.

Adequate density becomes extremely difficult to achieve when the mix cools to below 180°F. Scheduling of the work to provide for completion of rolling before this temperature is reached is necessary for a durable, long lasting pavement. To achieve this in the morning is often difficult if the contractor insists on high production starts. The operation should start off slowly so that necessary joint raking/rolling/straight edging/re-raking/re-rolling are accomplished before the paver goes very far. Online or mobile app based tools such as Pavecool or Multicool are available to help inspectors estimate the time available for compaction based on mixture, grade, project, and ambient conditions.

Weigh tickets shall be collected by the inspector or the contractor’s QC at the time of delivery of the material to the grade. If the contractor is taking weigh tickets for spread lots (416-7.03 and 417-7.03) the completed spread form must be turned in at the end of each spread lot (twice a day). By definition there are two spread lots per shift. The time and station should be written on the back of each ticket as it is taken. This can be invaluable when attempting to evaluate any particular situation at a later date.

G. Balancing Plant and Paver Operations

Nothing is gained by having a paving machine placing an asphaltic mixture at a rate faster than the plant can produce the mix; paving must be a continuous, uninterrupted operation without frequent stops and starts of the paver in order to achieve a smooth and uniform pavement. This condition will cause a non-uniform operation that may result in roughness and cold joints and therefore it is beneficial to pace the paving to match the operation of the plant and the delivery of the mix. When AC cools under the screed, or in the augers, it is usually below specification temperature by the time the paver moves ahead. The rollers cannot compact AC in this condition, and a high spot develops which is noticed by traffic. Balancing the loads prevents this. The paver speed (forward speed of the paver) is maintained at a rate that is in balance with the plant production and the capacity to deliver the material to the paver. Usually, it is preferred that the paver adjusts its speed. If the contractor's operations result in long delays and proper compaction is not achieved in accordance with the contract, the Resident Engineer or inspector should take action to reject non-specification material and provide proper cold joints.

When material is supplied from a commercial plant, especially when quantities are small, it will probably not be possible to balance the plant and paver. On large paving projects the Resident Engineer should expect reasonable cooperation from the supplier and contractor. A simple calculation can be made to determine the appropriate forward speed of the paver (in feet per second) based on the bulk unit weight of the AC, thickness and width of the mat being paved, number of haul trucks and truck capacity, and production rate at the hot plant. Refer to the Asphalt Institute’s literature if more information is needed.

H. Correct Use of Paving Machine

The inspector should be familiar with accepted practices of operating the laydown machine, and with the principles of its mechanical operation. Teamwork between the Paving Inspector and the contractor's Foreman usually results in the best finished product.

There are several points of importance with all paving equipment that have a bearing on the quality of work that may be performed. These points of importance are concerned with the mechanical condition of the paver, as well as the adjustment of working parts. Adjustments will not mean much if the machine is in poor mechanical condition; therefore, the first and most important part of checking a machine is to see that the parts are not excessively worn or otherwise damaged.

There are several parts on a paving machine that should be checked prior to the start of paving operations, some of which should be examined periodically thereafter during progress of the job. These parts involve moving or working parts of the paver such as the tracks, tamper bar, screed, distributing augers, the engine governor, and the feeder bars in the hopper. A single check of most of these items will usually be sufficient during the life of any job. Others, however, should be checked almost daily to make sure they remain in proper operating condition.

For example, if the tracks on which the tractor portion of the paver moves are not snug, it is possible for the paver sprockets (on which the tracks are mounted) to climb the tracks with a rhythmic, bumping movement. This movement may be reflected to the screed in the rear, which in turn, may cause a ripple effect on the surface of the pavement. Normally a simple adjustment of these tracks will correct the problem.

The tractor unit and the screed unit of a laydown machine are essentially two separate units, joined by the tow arms that are connected to the tractor at the tow point with a pin. Probably the most important portion of the paving machine to observe is the screed unit. The screed unit consists of:

- The leveling arms mentioned before
- A screed plate which gives the ironing action to the mat
- On some machines a tamping bar, which is the compacting medium as well as the strike off medium for The screed (most pavers now have a vibratory screed instead)
- The thickness control (hand crank) by which the tilt of the screed plate is changed in order to increase or decrease the thickness of the mat being placed
- The augers in front of the screed, which distribute the material transversely in front of the screed plate

The augers are actually mounted on the tractor unit but function with the screed. The screed mechanism is also equipped with a heater that is used prior to starting the operation, or when air temperatures or mix temperatures are low. Heating the screed plate, when necessary, results in a smoother texture of the mat.

Control of mat thickness is maintained by adjusting the tilt of the screed plate. When the laydown machine is operating uniformly without an increase or decrease in thickness being necessary, the path of the face of the screed plate is parallel to the path of the hinge pins at the front of the leveling arms where the screed unit is connected to the tractor unit. If the screed is tilted up, it allows more material to crowd under the nose of the screed causing it to build a ramp for itself to climb until its path is again parallel to the path of the hinge pins. The distance required for this change to take place is normally 8 feet to 15 feet. Most paving machines in use now require this approximate distance to make a thickness change.

Over manipulation of the manual thickness control handles have the same effect as over controlling a motor grader or any other piece of paving equipment. Since it is known that it takes 8 feet to 15 feet for a thickness change to occur, one should then make the thickness control changes accordingly. It is quite common for inexperienced screed operators to over manipulate the controls and repeatedly overcorrect because they do not realize what is happening.

For example, they turn the handles and measure the material thickness directly behind the screed. They find no change in thickness because they measured too soon. They increase the tilt of the screed plate and measure again. By this time they may notice a thickness change resulting from the first adjustment. Suddenly, they realize that they have increased the thickness excessively. This causes them to spin the handles in the opposite direction in order to decrease the thickness. This same procedure is repeated. The result is that they have built waves into the surface of the mat being placed. Naturally, if they continue to operate in this manner, the result is a series of waves and a surface having poor riding qualities. Proper control by a skilled screed operator who looks ahead rather than behind can do much to improve the surface smoothness of the finished pavement. Too much emphasis cannot be placed on the proper operation of the thickness control handles and the trust of the automatic controls.

With the advent of the automatic screed control, the problems described above have been practically eliminated. The specifications require that all pavers have functioning automatic controls. It is useful, however, for the inspector to know the principles involved in manual control and the problems that can be encountered.

Good paver operators carefully control both the paver and haul units. In the case of a hopper-dump paver, the operator should signal the haul units to stop slightly in front of the paving unit. He or she should then move the paver slowly into the haul unit (which is waiting in neutral with the brakes off). The load can be lifted to dump while the haul unit is being pushed forward. This eliminates the sharp shove that the paver is often given when the dump truck hits the paver. It also eliminates the resulting indentation in the mat caused by the screed being shoved in reverse.

Seldom used in Arizona, but an asphalt paving best practice, is utilization of the vibrating screed feature, of which, most pavers are now equipped. If the contractor is struggling to achieve the expected initial breakdown density, turning on the vibratory screed may be all that is necessary to facilitate improved compaction. It should be noted that some materials such as Bonded Wearing Course may not benefit from the use of a vibratory screed.

The ADOT spread-person should watch the dump units to ensure that the rear wheels stay on the ground. Enforcement of this has proven to be difficult. Usually, neither the paver operator nor the driver can see those wheels, and often they don't feel that it is important. The contractor's spread-person should then assume this responsibility. The Resident Engineer should cover this with the contractor, and take action to ensure proper procedures are being followed in the event the paving crew ignores these precautions.

I. Automatic Screed Control

This device is designed to maintain desired grade and slope by automatically raising or lowering the pivot points of the screed arms to control the screed angle of attack. The elevation is controlled by a reference independent of the tractor unit of the paver, which may be a traveling ski, a string line, or a matching shoe. If this device is not working the contractor will not be allowed to pave.

Close control of transverse and longitudinal slope needs to be considered when establishing the initial control grade. When using method specifications, the Resident Engineer should work with the contractor to decide which leveling sensor will be needed if it is not specified. When using end-product specifications, the contractor is responsible for ensuring the leveling sensor will achieve proper grade control.

Cross slopes that will provide adequate surface drainage must be maintained or restored on overlay projects. Cross slope correction may result in substantial quantity variations so the District should be kept informed of the situation.

The four main components of an automatic screed control are the sensor, control box, command panel, and motors or cylinders to adjust the tow point height. The sensor gets its information from a sensing device riding on a grade reference, a ski, or shoe riding on the grade itself. The type of external reference to be used depends upon the existing surface and the desired results. If the existing surface does not provide the desired riding qualities or if it is desired to pave to a predetermined profile grade, an effective string line reference is usually a necessity. When paving a single lift, where a minimum thickness is required, a long ski should be used. The longer ski will cause the paver to lay the mat down thicker in the low spots usually giving the surface smoothness desired. The matching shoe is designed to match a previously laid adjoining mat and can also be used to match a gutter grade, providing the gutter grade is satisfactory. Remember that the laydown machine will only pave to the accuracy of the reference. It will not correct any errors in the reference. The paver itself must correct any undesirable surface texture and short span irregularities that may exist. Automatic screed controls are not designed to do this.

A paver with automatic screed control is capable of being operated in a manual, semi automatic, or fully automatic position. In manual position, the thickness of the mat is controlled with the thickness control screws - where conditions dictate. In semiautomatic position, one side of the screed is controlled manually while the other is controlled by the system – this is not allowed. In automatic position, both sides of the screed are controlled by the system and the screws are not used as overrides to change the mat thickness. In the automatic position, one side of the machine may be controlled by the sensor and the other side by the pendulum, or both sides may be controlled by sensors on separate external references.

To begin a paving operation with automatic screed controls, the screed is blocked up at the correct height, and the thickness control screws are set to give proper screed angle of attack to obtain the desired mat thickness. The slope control is set, if the pendulum is being used, and the height of the sensor is set for the external reference being used.

Once the operation has started, adjustments in mat thickness should be made with the sensor control screw. Adjustments can be made with the grade control knob on the command panel but this is not as easy or convenient. The manual screed control screws should not be used.

In order to understand the operation of the automatic screed control and to know whether it is working properly, an inspector should acquire an operation manual for the machine with which he or she is working. The contractor should be required to furnish the manual until the paving operation is completed.

J. Joints

The transverse joint is made whenever the paving is stopped long enough for the asphalt in the hopper and screed to cool below the specified temperature, during bad weather, or for any other reason. Transverse joints are usually constructed by hand. The most common way is to end the ribbon with a hand-worked face that is cut to nearly vertical, covering this with roofing paper, and throwing more AC over it to form a ramp. The next day, the material over the roofing paper is removed to expose the vertical face, the area is tacked, and paving is resumed. Sometimes boards that are the mat thickness are placed against the vertical face, and AC is ramped down from there. The inspector must be aware of the tendency to thin out the mat at the end, and should straight edge the end of the day's run. Any thin or wavy sections should be removed before continuing.

Often the ribbon will begin by butting against a sawed joint. If the sawing is very old, it will be broken-up and ragged. In this case, the butt must be re-cut. It has been found effective to wheel cut at the project limit, remove this AC, and do the work as planned. Just before paving, a saw cut can be made a couple of feet farther back, the AC removed, and the new mat butted to the existing pavement. Only the final saw cut is paid for since the first was for the contractor's convenience.

For good joint compaction, the importance of the vertical face cannot be overemphasized. In any instance where the contractor has ramped up or down, material must be cut back to vertical before paving.

Longitudinal joints shall be formed by a slope shoe,hot-lapped, or may be saw cut/milled back to a vertical face. If materials is to be removed from an unconfined edge prior to placing the adjacent mat, the Resident Engineer must first determine an appropriate width and if the removed quantity or portion thereof will be included in the lot quantity on which payment is determined. Any edge of new AC, confined or unconfined, must be compacted with a pneumatic rubber tire roller unless prohibited by the specification (BWC, SMA, etc.), or the material at the joint will be subsequently removed prior to paving the adjacent mat.

The use of a pneumatic roller is seldom enforced, but in addition to being required, is vital to ensure adequate compaction at a longitudinal joint, especially in instances where the joint is both confined and starved of material. When the joint is starved of material, there is the likelihood that the majority of the compactive effort will bridge across the joint and onto the existing adjacent surface (previous mat of AC, gutter, etc.). A pneumatic roller is better suited to compact starved joints because each tire is independent rather than a straight rigid surface.

It is a best practice to begin paving at the low end of the pavement cross section and with each adjacent ribbon placed toward the high end, place sufficient material so that the new mat is 1/16 to 1/8 inch higher at the joint (when fully compacted) than the previous adjacent mat. This ensures no starvation of material at the joint and does not interrupt the shedding of surface water during precipitation events. If the two adjacent mats are perfectly flush, there is a high probability that the joint did not have an adequate thickness of material prior to compaction. The necessary amount of material at the joint should be determined during construction of the test strip with slight adjustments made thereafter as necessary.

To ensure good compaction at a joint, the best practice is to pinch the joint so that dense material exists to both the hot and cold side of the joint before the joint itself is compacted. Compaction should first be performed with a steel drum roller as part of the initial breakdown sequence, the pneumatic roller is most often positioned as an intermediate roller or an additional roller between the breakdown and intermediate steel drum rollers.

Poor longitudinal joint compaction will present itself as either deterioration at the joint itself, or fatigue (alligator) cracking in the adjacent wheel path because a poorly compacted joint allows surface water to drain through the joint and into the base and subgrade, compromising the structural capacity of the pavement section adjacent the joint.

When possible, ADOT tries to reduce traffic exposure to unconfined edges, or vertical edges and a trench condition. Traffic should be properly maintained away from all such areas with cones or barricades, and in some instances protected by temporary concrete barrier. Exposed edges are a safety hazard to the traveling public because the abrupt drop-off may cause motorists to momentarily lose control. Work out a plan at the pre-paving meeting with the contractor so that no exposure to these joints occurs. This sometimes complicates traffic control procedures and shortens time available for construction but in the end, it is the best thing for the traveling public.

K. Outside Edges

The sloped outer edges of pavement require compaction. This part of the specification has not been uniformly enforced in the past so there may be reluctance on the part of the contractor to provide the necessary equipment to compact it in a timely manner. The Resident Engineer should not let this affect his or her enforcement of this specification.

The sloped joint for an unconfined edge that will remain in place, or a safety edge, is formed with a shoe attached to the end of the screed to form a slope of about 1.8:1 (30 degrees) beyond the screed. The width and slope will vary with the depth of the pavement being laid. The sloped edge is then compacted using a pneumatic roller. As with the rest of the pavement, the compacting must be done while the mix is hot. The density required on the sloped edge is the same as for the rest of the mat. Steel rollers cannot compact the slope. Insist that the contractor provides equipment that will do an acceptable job.

It should be noted that once the thickness of the AC becomes less than 3 to 4 times the maximum aggregate size, compaction becomes increasingly difficult and mat integrity is reduced. Therefore, attention to grading to try and accommodate an adequate thickness with consideration for the slope at an unconfined edge is appropriate.

L. Rumble Strips

The new standard for rumble strips is to cut them into the surface of the paved shoulder after the mix has been compacted and cooled. This eliminates the under-compacted shoulder issues that often occurred when forming the indentations with a special roller. Rumble strip requirements will be found under Subsection 928 of the Special Provisions.

M. Quantity and Quality Issues

The Project Supervisor should check on a daily basis, the information received from the plant on the amount of admixture and asphalt cement used. The daily batch weights for both materials should be compared with the amount of asphaltic concrete batched at the plant. The admixture can be checked against the mix design value, while the asphalt content can be checked against the daily ignition furnace values. When RAP is used in the mix, it is also important to ensure that the quantity of both the RAP aggregate and RAP binder does not exceed that indicated on the mix design.

Proper workmanship and paving practices are important, whether or not an end product specification is used. The following items should be brought to the attention of the Project Supervisor or Resident Engineer and rectified should they occur:

- paving in weather conditions unsuitable for paving
- placement and handling practices which result in segregation of the mat leaving coarse rock pockets
- rolling practices, such as vibratory rolling at cool mat temperatures or excessive pickup on a rubber tire roller, which will have a detrimental effect on the pavement surface
- excessive roughness in the finished mat
- pavement thickness measurements inconsistent with plan dimensions

Acceptance

Acceptance requirements vary for each type of asphaltic concrete specified. The inspector must always read the Standard Specifications, and Special Provisions to determine the requirements for each type of asphaltic concrete used on the project.

Directed Sampling Versus Random Lot Sampling

Although acceptance testing is done by plate sampling and coring, the specifications still give the inspector authority to take plate samples and cores at any time and from any place if the material appears to be defective. If the inspector observes what appears to be defective material coming from behind the paver or out of the delivery trucks, then take additional samples. This direct sampling is allowed under any of ADOT's paving specifications even though some are end-product. Directed sampling by the Department is not allowed for any part of the statistical analysis for the lot. This also applies to coring. Any areas outside the random locations that appear to be under compacted should be cored.

Coring

Carefully review the specifications before laying out the core locations. An inspector should spray paint a 1-foot by 2-foot box (with the longest dimension parallel to centerline) to limit the area where cores can be taken at each location.

If the inspector doubts the authenticity of the cores, the Resident Engineer should be alerted. If it is determined that the contractor should re-core, the project personnel shall collect all the existing cores from that lot and have them promptly destroyed so they cannot be tested. The lot should be entirely re-cored using a new set of random numbers. It is important not to test two sets of cores for the same lot, since this would distort the statistical basis for the incentive/disincentive specification. Do not allow the contractor to keep the cores. Coring a second time should be done on an extra work basis, regardless of the reason.

After coring, the inspector delivers the cores to the acceptance lab. They will determine the density of each core and calculate the compaction pay factor for each lot. They will issue the test results on a form similar to the one shown in Exhibit AC-4. The form shown in Exhibit AC-4 includes the computed mixture properties, lot pay factors and the compaction lot pay factors. Plate samples are used for mixture property lots, not cores.

Retesting of Samples and the Determination of Outliers

Referee testing is used for end-product specifications. Retesting per this subsection should only be used for method specifications on an as-needed basis. When acceptance test results indicate that a contractor's material is unacceptable, the contractor may request a retest or question if some of the test results are determined to be outliers. The Resident Engineer must determine if a sample should be retested, or be regarded as an outlier. The following guidelines shall be used to determine retesting or discarding a test result as an outlier.

A. When to Retest

Retesting of a contractor's material should normally occur only after the contractor has taken corrective action. Retesting of a material that has not received corrective action should be the exception, not the rule. Certainly a material should not be retested when the sole basis is that the material failed the test, or that the test result was close to acceptable. However, there is some legitimate basis for retesting. They are:

- The test method was not followed in performing the test
- The test data was recorded in error
- The sample or area tested was clearly unrepresentative
- The sample was damaged prior to testing

In fairness to the contractor, the Resident Engineer should inquire as to the possibility of variations in testing and sampling procedures that may have skewed the test results. Testing labs are naturally apprehensive about discussing their procedures when failures do occur, so it's important that the Resident Engineer approach them as a neutral fact-finder and not one who is trying to assign blame and seek retribution.

Arizona Department of Transportation
Materials Section
Mix / Compaction Report

Project No.	Federal Project No.	Sample Date	Lot No.	Tons in Lot	Station		Station	Lane	Lift	Plans Thickness
F009201C	008-A-(233)T	01/11/2021	22	2726.96	2165+00	to	2085+00	W.B.	1	4.00

Location: Avenue 36E - MP 46

Mix Design **Effective Date** 11/12/2020

					Asphalt %	Voids	3/8	#8	#40	#200	In-Place Voids
Material Type	3/4	**with RAP**		**UL**	5.70	7.0	83	46	20	6.9	9.0
Marshall Density	142.4	**Admixture**	1.0	**TV**	5.20	5.5	77	40	15	4.9	7.0
Rice Density	150.8	**Stability**	5010	**LL**	4.70	3.5	71	34	10	2.9	3.5

Samples **Lab - Yuma Lab**

Lab Test #	Sample No.	Sample Date	Mat Code	3/8	#8	#40	#200	Stability	Bulk Density	Asphalt Content	Voids	Rice Density
21-0041	1	01/11/2021	AC	77	41	15	5.1	3350	143.9	5.31	4.3	150.4
21-0042	2	01/11/2021	AC	76	41	16	5.4	3780	145.0	5.32	3.3	150.0
21-0043	3	01/11/2021	AC	76	38	14	5.0	3410	145.0	5.17	3.8	150.7
21-0044	4	01/11/2021	AC	76	40	15	5.0	3900	144.1	5.32	4.4	150.7

Cores **Lab - Yuma Lab**

Core No:	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Inplace Voids:	4.4	4.7	4.7	6.0	3.7	3.9	5.6	5.9	4.5	5.7

Pay Factor Calculations - 416

	Avg	Std Dev	QU	QL	PU	PL	PT	PF
3/8"	76.3	0.50	13.400	10.600	100	100	100	$ 0.00
#8	40.0	1.41	4.255	4.255	100	100	100	$ 0.00
#40	15.0	0.82	6.098	6.098	100	100	100	$ 0.00
#200	5.1	0.19	9.474	11.579	100	100	100	$ 0.00
% Asphalt	5.28	0.07	6.000	8.286	100	100	100	$ 0.00
%Voids	4.0	0.51	5.882	0.980	100	83	83	$ -0.50
Compaction (Inplace Voids)	4.9	0.83	4.940	1.687	100	96	96	$ 0.50
Stability	3610.0	271.17						
Bulk Density	144.5	0.58						
Rice Density	150.5	0.34						

* - "% Asphalt" results includes a Tank Stick correction.

	Tons	Reject	Refereed	QLPF	Pay Adjustment	Source
Mix	2726.96	No	——	$ -0.50	$ -1363.48	ADOT Results
Compaction	2726.96	No	——	$ 0.50	$ 1363.48	ADOT Results

Mix PF Comments: ______

Compaction PF Comments: ______

[redacted]	1/12/2021	[redacted]	1/13/2021
Lab Supervisor \ Mix Pay Factor	Date:	Lab Supervisor \ Compaction Pay Factor	Date:
DocuSigned by: [redacted]	2/10/2021	[redacted]	1/25/2021
Contractor Signature:	Date:	Res Engr/Proj Supr	Date:

Exhibit AC-4. Materials Lab Sheet

B. Outliers

Provided there is not a known testing error, a test result can only be discarded as outlier for one of two reasons. The first reason would be that the test results are outside the range of possible results. An example of this type of results would be an embankment density of 75% of the maximum density when the test area appeared to be thoroughly compacted. The second reason for eliminating a test result as an outlier, when sufficient test data is available, is on the basis of a statistical analysis. If a statistical analysis is performed, it should be performed in accordance with ASTM E 178 for a 1% significance level. A minimum of ten test results should be available in order to perform the analysis. Any test results that are outside the range of possible results should be removed prior to making the analysis. Clearly, a test value should not be regarded as an outlier if there is an assignable cause, such as plant malfunction, which results in the questioned test result.

The following table should be used as a screening tool to evaluate the potential for outliers:

Characteristics	Deviation from the Average
3/8 inch sieve	7.0%
No. 8 sieve	6.0%
No. 40 sieve	3.0%
No. 200 sieve	1.0%
% asphalt	0.5%
% voids	1.5%
Compacted Density	5 lb.

This table is intended as a screening tool only. The values in this table are based on the analysis of actual lot data. If the values in this table are exceeded, a statistical calculation for outliers should be made. Exhibit AC-5 is a form with a completed example that can be used for a statistical outlier analysis.

If a test result is determined to be an outlier for the reasons noted above, the results should be discarded. If an outlier is determined, there may be sufficient data available in the remaining samples to calculate pay factors. Provided the contractor is agreeable, as few as 3 mix samples or 7 cores may be used to calculate lot pay factors. Calculating the lot pay factor on a reduced number of samples is preferable to attempting to obtain additional samples, because of the difficulty in obtaining a representative sample from a completed roadway. Retesting of a sample to replace an outlier should only be attempted if the test area is accessible and a representative sample can be obtained.

There is no substitute for good judgment in review and use of test results to determine the acceptability of material. When not abused, the prudent use of a retest to fairly evaluate material acceptability or the elimination of test data that is clearly incorrect are both actions that are necessary for good contract administration.

STATISTICAL ANALYSIS FOR OUTLIERS USING ASTM E178 AT A 1% SIGNIFICANCE LEVEL

Definition of Terms:

Term	Description
T	Test Criterion (Obtained from the Table Below)
Avg.	Average of the Test Data
Std.	Standard Deviation of the Test Data
LO	Lower Outlier Limit
UO	Upper Outlier Limit
n	Number of Samples

Statistical Analysis Procedure:

1) The average and standard deviation for the test data is calculated.
2) Using the following formulas and the table below, the lower and upper outlier limits are determined.

LO = Avg. - T*Std

UO = Avg. + T*Std

3) Test data which falls outside of the lower and upper outlier limits is discarded, provided there is no assignable cause for the occurrence of the result in question.

Example:
Assume: Avg. = 145.0 Std. = 2.1 n = 10 Then T = 2.41 - and -

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

LO = 145.0 - 2.1*2.41 = 139.9 UO = 145.0 + 2.1*2.41 = 150.1

Exhibit AC-5. Statistical Outlier Analysis

Changes to the Mix Design

On occasion, contractors may request revisions for certain measured characteristics of the mix design. Two methods are normally utilized for such requests:

A. New Mix Design

In accordance with the specifications, a new mix design is fully allowable. However, the new mix design should be thoroughly reviewed to assure that it contains all the required information, and that the mix design values comply with the specified requirements. A maximum of one working day is allowed for this review. Please note that it will be necessary to determine a new sand equivalent, fractured coarse aggregate particles, uncompacted void content, and ignition furnace calibration if new materials are utilized and/or percentages of existing stockpiles are revised.

B. Mix Design Changes Based on Asphaltic Concrete Test Values

In some instances, contractors may request revisions (referred to as a self-directed target change) based on production test results, especially if they are producing material that tends to vary significantly from the mix design and may possibly subject them to penalty. Therefore, this type of mix design change should only be approved on the basis of an engineering evaluation, and with the concurrence of the ADOT Materials Group.

Changes to Compaction Requirements

A. General

The most-often-requested change by the contractor usually contends that the specified compaction requirement cannot be met because of one or more of the following reasons:

- The underlying surface does not provide a suitable platform for compaction
- The existing pavement surface is too variable to obtain compaction
- The mix is stiff and difficult to compact
- The mix is tender and can be over-rolled before compaction is attained
- Unknown, however, every possible means has been utilized to obtain compaction, without success

If these reasons do not get to the cause of the compaction problem, several different factors may affect how well an asphalt mix is compacted.

B. Factors Affecting Compaction

Normally, the following influence the ability to compact a lift of asphaltic concrete:

- Air temperature and wind speed
- Temperature of the mix and underlying pavement during the compaction process
- Lift thickness
- High stability/low flow mixture
- Tender mix (usually a very fine graded mix or one with well-rounded fine aggregate)
- Type and number of compaction equipment, including ballasted weight
- Sequence and timing of compaction equipment
- Number of passes and amount of coverage of each piece of equipment
- Operation of equipment including:
  - Speed (should be operated within the manufacturer's recommended speeds)
  - Tire pressures on pneumatic rollers
  - Frequency and amplitude on vibratory rollers

- Inconsistent compaction effort (constant stopping/starting of the laydown machine results in some areas receiving greater rolling than others and inconsistencies in temperatures during rolling)
- Condition of underlying material (subgrade, base, previous lift, or old pavement)
- Plant production rate
- Mixture and temperature segregation

The consistency of the compactive effort and the values obtained are also very important. It is possible (via highly variable results which indicate inconsistent compaction) to have most of the core densities show results above the target and still have to assess a significant penalty. This is directly related to the statistical basis for the PU and PL tables found within the specifications. The inspector must understand that consistent compaction is the solution to this problem.

C. Procedure for Resolving Requests for Revision of Requirements

In most cases, requests to waive the compaction requirements will begin after the contractor is notified of material with a penalty or rejection due to compaction. This ordinarily occurs at the beginning of paving or after the weather cools. Upon notification by the contractor that relief is being requested, the District and acceptance lab shall be advised. The Resident Engineer shall contact ADOT's Pavement Materials Testing Section for assistance and input at this time, and at each further step as outlined below. In addition, the FHWA Area Engineer should be advised if the project funding includes federal-aid.

At the earliest notice that the contractor is experiencing difficulties in obtaining compaction, the Resident Engineer may begin to monitor and document the efforts made by the contractor to obtain compaction.

Most specifications advise the contractor that quality control is his or her responsibility. Therefore, it is expected that he or she will be actively engaged in this function through test strips, nuclear densities, and informational cores.

The following items should be included if relief is requested by the contractor:

- Written justification
- Documentation of compaction operations including:
  - Temperatures of the mix at discharge from the hot plant and during each stage of compaction. This should be documented several times throughout the day
  - Production rate in tons per hour
  - Roller weights (from truck scales)
  - Rolling pattern-sequence, amount of coverage, number of passes and speed of each roller (include manufacturer's recommendations)
  - Tire pressures, frequency, and amplitude during various roller sequences and coverages
  - Statement regarding operating conditions of rollers
  - Analysis of weather conditions, specifically temperatures, winds, and effect on compaction
- Nuclear gauge and core results for each contractor test strip, and for other compaction quality control measures taken by the contractor
- Analysis of mix data for factors influencing compaction such as stability, flow, asphalt content, and gradation

Upon receipt of the written request, the Resident Engineer shall immediately review it to assure that it contains sufficient documentation, and that the contractor has made a comprehensive effort to obtain compaction. If not, the written request shall be promptly returned to the contractor with a letter outlining the reasons for rejection.

Among the factors most easily overlooked by the contractor in obtaining compaction are the characteristics of the mix he or she has provided. Should test results indicate a stiff or tender mix, the contractor has the responsibility to submit a revised mix design. A poorly conceived mix design is not justification for lowering density targets.

Frequently, the contractor's compaction difficulties can be traced to marginal weather conditions. In some cases, the logistics of construction, or the safety and convenience of the motorists make postponement of paving a less desirable alternative than the completion of the paving with a lowered compaction requirement. Such a decision can only be made with the concurrence of the District, Deputy State Engineer, and the FHWA (if applicable).

Should it be determined that adequate justification and documentation has been provided, the contractor's request should be promptly reviewed and accepted by the Engineer. This may be accomplished in the following manner:

- Verify roller weights
- Verify operating conditions of rollers
- Verify hot plant pyrometer readings and production rates
- Verify mix temperatures during compaction
- Verify weather conditions

Should this verification indicate discrepancies or deficiencies that, in the opinion of the Resident Engineer, are sufficiently significant to invalidate the contractor's justification, the request shall be promptly returned to the contractor with a letter outlining the reason(s) for the rejection.

Compaction

Adequate compaction is vital to the success of asphalt pavements. Good compaction can often offset some of the other deficiencies in asphalt mixes and lead to a long lasting durable pavement. Asphalt pavements are designed to achieve a critical range of effective voids in the mix when compacted as specified. Too much or too little compaction can be harmful to the performance of the pavement.

Compaction methods are specified according to the nominal thickness of the layer being placed. The nominal thickness referred to in the specifications is the thickness of each individual layer shown in the typical section drawing of the project plans. For thick lifts the end-product specification will apply. For thin lifts, the method specification will apply. The definition and treatment of thick lifts and thin lifts varies so the inspector must read the specifications for each type of asphaltic concrete.

The contractor may request permission to place the pavement in a thickness less than or greater than the nominal lift thickness shown on the plans. They may be permitted to do so provided that compaction, testing, and acceptance of density is done in the manner required by the plan's original nominal thickness.

Which types of compactors should be used, and in what sequence, can vary. The ADOT specifications approach the problem in several different ways. The end-product specification will require a density to be achieved and leave it completely in the contractor's hands to select the type, size, and application of the equipment. Method specifications allow several different options. Each option will state which type and size of equipment must be used and will require a specific number of coverages by each type. ADOT may require end-product and/or method specifications to best fit the particular needs of the project. End-product specifications are used to ensure quality of high production paving operations. Method specifications are normally used for thin lifts, small quantities, or areas that are hard to construct such as turnouts, narrow widening, and leveling courses. When the Resident Engineer has the option to select the compaction method, it should not be based entirely on the contractor's available equipment. Pick a method that is best for the pavement taking into account subgrade condition, mix properties, weather conditions, available equipment, and constructability.

A. Types of Compaction Equipment (Rollers)

There are three basic types of compaction equipment used on asphalt pavement:

1. The pneumatic compactors have rubber tires and may be equipped so that tire pressure can be changed on-the-run. To be acceptable, the tires must be enclosed to retain the heat, which prevents asphalt sticking to the tires. The compactors are equipped with a means of wetting the tires, usually by spraying

water onto mats that uniformly wet the tires. The mats are retractable so they can be raised when the machine is running with dry tires. The individual wheels are built to move up or down (oscillate) so that they will conform to irregularities in the roadway while still maintaining compactive forces. The rubber tires impart a kneading motion that some authorities believe improves inter-particle contact and helps to fill surface irregularities in the base. It is important that all tires are inflated to the same pressure and that the correct amount of ballast is being carried. It may be necessary to adjust the tire pressure but the highest possible tire pressure will usually give the best performance. Rubber tired equipment will often heal cracking or surface looseness that has developed under steel wheeled compactors.

2. Steel wheel compactors are simply large, smooth steel cylinders equipped with a device for wetting the drum to prevent pick up of asphalt. The cylinders are designed to be ballasted, which may be necessary to meet the individual wheel loading called for in the contract specifications. The manufacturer's operator’s manual contains information on weights carried by each axle; empty and ballasted. The contractor should allow the Resident Engineer to check this information to be sure the drive wheel carries the specified weight. Most steel wheel rollers are designed to be loaded heavier on the drive wheel than on the guide wheel. The gross weight must be obtained within the manufacturer's recommendations. This makes it important to check the operating literature of the roller.

3. Vibratory compactors used on asphaltic concrete are steel wheel compactors having an internal vibration mechanism. The control for the frequency and amplitude of the vibration function can be turned off and the unit used as a static compactor. The contractors generally like the vibratory units because, for most situations, they achieve density faster and with less equipment than other combinations of machines. If the contractor proposes using a vibratory compactor in the static mode, the manufacturer's literature should be checked to determine whether the unit will meet the weight requirements. Some vibrators will not be heavy enough to meet the static load specification.

All compactors tend to pick up asphaltic concrete, especially when the compactors are cold, so they have been designed to minimize the problem. Steel wheels are usually kept wet with clean water. After they get hot, a minimum amount of water should be used. Pneumatic tired compactors are required to have skirting which will reduce heat loss so the machine can be run with hot dry tires. The tires will pick up asphalt pavement until they are heated adequately. A built in water system is used to prevent pickup until the tires are heated. The wetting should be stopped as soon as possible.

Some roller operators feel the reason that they can't get close to the paver is the AC is too hot. They think the proof is that their rollers are picking up the AC. The truth is the AC is rarely too hot, but the roller wheels are just too cold. The operators should gradually get closer, heating their wheels as they do. The pick-up will stop when the wheels get hot enough. Eventually, rollers can usually operate immediately behind the screed, where they should be.

If the contractor elects to use release agents other than water to wet rubber or steel tires, the specification requires the release agent to be approved by the Resident Engineer. Acceptable agents are usually some kind of detergent or non-solvent. Fuels and solvents may not be used. Release agents previously approved for use may be found on the Approved Products List.

B. Rolling Pattern Calculations

It is necessary to consider a number of factors other than density when a rolling pattern is set up. When using vibratory equipment, the frequency being used must be matched to the speed of the compactor if pavement ripple is to be kept under control.

Speed of the compactors has to be matched to the paver speed and time available for compaction as governed by the temperature of the asphaltic concrete. Slowing the last couple of passes is preferable to stopping the rollers, since resting on the mat causes it to sink into the mat and a sitting roller has tires/wheels that are cooling off. When a roller has to stop, it should be moved off the hot mat.

In some cases, it may be necessary to adjust production rates or add compactors in order to meet all the criteria relating to time, temperature, and equipment requirements.

Widely accepted top speeds of compactors are 3 mph for steel wheel rollers, and 5 mph for rubber tire rollers. However, observation and manufacturer's literature may modify these initial estimates.

The first concern is the compaction time: How much time is available to compact the pavement under the conditions of a given base temperature and mix temperature at the time of laydown?

Although there are no end-product specifications for lift compaction to be finished within a given temperature range, the Resident Engineer and inspector should be aware of the factors involved. On thin lifts ADOT requires that initial (or breakdown) and intermediate compaction be done before the mat cools to less than 200°F.

Exhibit AC-6 shows rolling time available for various combinations of base temperature and temperature of mix at laydown. The table is based on mix temperatures that have been adjusted to provide at least 15 minutes to complete compaction. The controlling conditions reflected in the chart are a wind speed of 11.5 mph, an air temperature at 40°F, a dense cloud cover, and a minimum compaction temperature of 175°F. The cutoff point is 175°F, because after this point, the mat temperature is so low that compaction possibilities decrease rapidly. Exhibit AC-6 shows that even with fairly high base temperatures and increasing mix laydown temperature, the time available to complete rolling becomes more and more critical as the depth decreases. The problem is even more acute when wind is considered.

Other compaction estimating tools available and recommended for use when conditions become questionable are MultiCool, maintained by Auburn University, and PaveCool, developed by MnDOT. More specific project and mixture information can be accounted for to estimate available time for compaction. A smartphone app is available for PaveCool while MultiCool is a web-based program.

When the wind chill reduces the apparent temperature to the range so that rolling time is drastically reduced, it becomes necessary to cease operations or increase the number of rollers. If the contractor is operating with the minimum number of rollers under marginal weather conditions, the Resident Engineer should treat any predictions for worse weather seriously. The contractor should be notified that it is unlikely that compaction can be achieved, and the operation should be modified or stopped by the contractor. Specifications allow the Resident Engineer to direct the contractor to stop work or adjust paving operations in marginal weather, see the weather limitations subsection. Possible modifications are a higher mix temperature, reduced production, more compaction equipment, or a combination of these.

Time available to complete compaction before the pavement cools to 175°. The table is based on: cloudy weather, Wind of 11.5 miles per hour, and an air temperature of 40°.						
Table A - Recommended Minimum Laydown Temperature						
Base Temp.	**½”**	**¾”**	**1”**	**1” - ½”**	**2”**	**3” and greater**
20 - 32	—	—	—	—	—	285
+32 - 40	—	—	—	305	295	280
+40 - 50	—	—	310	300	285	275
+50 - 60	—	310	300	295	280	270
+60 - 70	310	300	290	285	275	265
+70 - 80	300	290	285	280	270	265
+80 + 90	290	280	275	270	265	260
+90	280	275	270	265	260	255
Rolling time, in minutes	**4**	**6**	**8**	**12**	**15**	**15**

Wind speed MPH	**Actual Thermometer reading**								
	65	**60**	**55**	**50**	**40**	**30**	**20**	**10**	**0**
Equivalent Temperatures									
Calm	65	60	55	50	40	30	20	10	0
5	63	58	54	48	37	27	16	6	-5
10	59	43	46	40	28	16	5	-9	-21
15	56	49	43	36	22	9	-5	-18	-36
20	54	47	39	32	18	4	-10	-25	-39
25	52	45	37	30	16	0	-15	-29	-44
30	50	44	35	28	13	-2	-18	-33	-48
35	49	41	34	27	11	-4	-20	-35	-49
40	48	42	33	26	10	-6	-21	-37	-53

Exhibit AC-6. Laydown Temperature Charts

The number of compactors needed for a given production rate can be determined as follows:

1. Determine the paver speed based on the contractor's proposed production.

   Example: Assuming the plant production is 300 tons per hour and the paver will lay a 1-½ inch mat 13 feet wide, then if the material weighs 150 pounds per cubic foot, the paver will be able to operate at rate of 42 feet per minute:

   Weight of pavement per foot = 1.5 / 12 x 13 x 150 / 2000 = 0.12 tons per foot

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

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

2. Estimate production rate per compactor.

   Example: Assume 3 mph for steel wheel compactors, and 5 mph for rubber tire compactors. Assume 85% efficiency to allow for direction changes, reloading with water, etc.

   Compactor production rate = compactor speed x efficiency = feet per minute

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

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

3. Calculate the total number of passes each type of compactor in the rolling train must make to obtain all the required coverages.

   Example: Assume 406 asphaltic concrete is specified. Option Number 1 in Subsection 406-7.05(A)(3) of the Standard Specifications requires one initial steel wheel breakdown coverage, four rubber tire intermediate coverages, and about two steel wheel finish coverages. Assume the compactors are six to eight feet wide and must overlap the previous pass by at least two feet.

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

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

   Passes per coverage x required coverages = total required passes

   3 x 1 = 3 initial passes by steel wheel compactors

   3 x 4 = 12 intermediate passes by rubber tire compactors

   3 x 2 = 6 finish passes by steel wheel compactors

4. Calculate the number of compactors required.

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

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

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

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

The use of these calculations in the pre-paving meeting is helpful in assisting the contractor in determining the equipment requirements before work starts. Starting out with the necessary amount of equipment, operated under favorable weather conditions, will save all parties a lot of frustration.

After the paving operation is balanced, the roller operation must also be balanced. To achieve the maximum density, the asphalt pavement must be compacted while the temperature is high enough to keep the viscosity of the asphalt low. This allows the rock particles to move around under pressure and reposition into a dense mass.

C. Inspecting Vibratory Compactor Operation

Vibratory compactors have their own special peculiarities and operating techniques. The Inspector should read the equipment's operator manual carefully so he or she can be sure the machine is being operated correctly.

The specifications prohibit using vibratory compaction on lifts under 1 inch thick or when the mat temperature is less than 180^{o}F. Vibratory compaction of thin lifts can cause the aggregate to fracture.

The vibrators should be checked to see that they operate over the full range of amplitude and frequency.

Generally, a higher frequency and lower amplitude are used for thin lifts and the amplitude is increased as the lifts get thicker. Vibrators on the newer units turn off automatically when the machine stops. On older machines, make certain that the operator knows that he or she has to turn the vibrators off before the machine stops. Before changes in amplitude or frequency are made, be sure that the effects of the change are understood. Industry studies suggest that to achieve maximum smoothness and compaction, the distance between impacts should not exceed 1½ inches and there should be a minimum of eight impacts per foot. To help maintain the desired spacing, the following relationships can be used as a guide.

Millimeters Between Impacts						
Speed	Frequency of Vibrator (Hz)					
mph	**20**	**25**	**30**	**35**	**40**	**50**
1.5	35	28	24	20	18	14
2.0	45	36	30	26	23	18
2.5	56	44	37	32	28	22
3.0	69	56	46	40	35	28
3.5	80	64	53	46	40	32
4.0	90	72	60	52	45	36
5.0	111	89	74	63	56	44

Vibration of thin lifts can cause the aggregate to fracture.

D. Resolving Compaction Problems

In some cases, the material is too hot to be properly compacted. This is noticeable from the instability of the material under the roller. Indications are: it shoves out from the sides of the wheels, produces a wave ahead of them, or is still unstable after the roller has passed over it. The inspector should be aware that some mixes are more tender than others. If the mix is too hot, a delay in the breakdown roller should correct the problem. A change in roller weight, type, or pattern may also work.

Cracking is very common when using steel wheeled compactors. There may be several reasons for cracking. Thermal cracks are usually small surface cracks caused by the surface of the mat cooling faster than the interior. These cracks can be usually removed by additional rolling. A tender mix may crack under normal rolling effort due to its inability to bind together. The problem could be the rollers, but the inspector should not rule out a problem with the subgrade. Cracks caused by subgrade problems are usually long and deep cracks that are much wider than other types of cracks. If just one area is cracking, the contractor may have to skip that section until the subgrade can be corrected. Cracks on a good base can be kneaded together with a pneumatic roller, however, it is best to correct the subgrade since the healing may only be on the surface. The remaining unhealed portion of crack leaves the pavement weakened and exposed to weathering.

Unless the types of equipment and compaction sequence are specified, the contractor has the option of using rubber or steel rollers. Regardless of the type of equipment used for the initial breakdown compaction, it is essential that the first pass be made as soon as possible so that the temperature relationships mentioned above will be maintained. The greatest part of compaction is attained with the first breakdown pass.

In order to eliminate or minimize compactor marks the final finishing passes may have to be delayed until the mat cools to the proper temperature. Trial and error testing of equipment and procedures is necessary to achieve the specification density in the least time.

Weather Limitations

Construction Requirements, e.g. 407-10.06(A)(1), 413-7.06(A), 414-7.06(A)(1), 416-6, and 417-6, give the Resident Engineer the ability to suspend paving operations if weather conditions, either existing or expected, would adversely affect the quality of the asphaltic concrete pavement.

Adverse weather conditions include:

- Frozen subgrade as evident by the fact that a shaded surface thermometer reads 32°F or less, or the subgrade is excessively hard- the entrapped water has turned to ice.
- For thin lifts and friction courses, temperature requirements such as an 85°F surface for AR-ACFC are not being met.
- Muddy subgrade due to the material being too wet.
- Standing water on the subgrade. This can usually be remedied by using pumps and/or an air hose.
- Precipitation. A light rain or snow is sometimes OK as long the mat does not cool down too quickly.
- Threat of precipitation. It does not have to be actually raining or snowing to stop the work. During seasons where precipitation is common, the Resident Engineer should discuss with the contractor what set of weather conditions would lead to a shut down. This would help prevent the contractor from going through the unnecessary expense of firing up the hot plant and sending out a paving crew only to have the project shut down before the first truck arrives
- Cooler temperatures with a lot of wind. The heat loss from the pavement can be too much for the rollers to keep up, especially on thin lifts

Obviously the Resident Engineer and the Project Supervisor will have to exercise some judgment. If you shut a paving operation down, you should document the reason(s) for your decision and list the sources you used, such as weather forecasts, in arriving at your decision. Paving and plant operations are expensive affairs and back charges by construction companies, especially if it doesn't rain, are not uncommon. However, keep in mind that pavement will be there long after the plant and equipment are gone, and its quality should come first.

Smoothness

Specifications for asphaltic concrete surfaces contain tolerances that must be checked with a straightedge. Straightedge tolerances vary, so the inspector must refer to the appropriate specifications. Pavements on selected interstate and major highways must also meet smoothness requirements based on International Roughness Index (IRI) values. These numbers are an indicator of pavement roughness.

A specialized van that contains an inertial profilometer measures pavement roughness and computes the IRI values. ADOT's Materials Group, Pavement Management Section, operates the van and may help the contractor with interim measurements during paving if requested and availability permits.

The Special Provisions will have a maximum IRI value called a correction value or (CV) that the contractor must meet (the smaller the number, the smoother the pavement). The maximum IRI value requirement depends on the type of riding surface. ACFC riding surfaces on top of new AC will have stricter smoothness requirements than new AC pavements without an ACFC.

The Special Provisions contain information that is used to calculate the bonus or penalty for payment or reduction in payment to the contractor. The bonus or penalty is applied to each 1/10 of a lane mile.. Bridges and the transverse joints at the project limits are usually excluded from smoothness testing for bonus or penalty but they still must meet the straightedge requirements.

Special provisions for pavement smoothness are used to distinguish between the different riding surfaces. Carefully check the smoothness requirements in the Special Provisions since they may be different from the requirements of the last project.

The IRI values correlate well with the public's perception of pavement ride quality. ADOT uses an incentive/disincentive payment approach to encourage contractors to build a smoother pavement. A look at the payment schedule reveals that the bonus payments are much better than the penalties. This payment structure may appear to favor the contractor, but we must keep in mind the difficulty of eliminating all roughness. While the formula for the incentives and penalties is mathematically a linear function, the effort the contractor must add to achieve a unit improvement in smoothness is not. The ability to achieve a two unit improvement in smoothness is proportionally more difficult than a one unit improvement, at or near the required level of smoothness. However, as lower and lower IRI values are achieved, it continues to become progressively more difficult to achieve the next incremental increase in smoothness.

Several publications contain excellent recommendations on how to achieve pavement smoothness. Following the recommendations is no guarantee that the contractor will produce a smooth pavement. Inspectors should not actively assist the contractor in constructing smoother pavements, or take any action that could shift responsibility for smoothness from the contractor to ADOT.

Several past projects have shown that contractors can meet the minimum non-penalty smoothness level, even on rough existing pavements. By using the recommended tools and best practices of the trade, some contractors have earned significant bonus payments.

A separate lump sum pay item (1090010) is created in the project estimate to handle bonuses and penalties. The Pavement Management Section will calculate the bonuses and penalties for each 0.1-lane-mile increment of pavement and the total payment or deduction for the project. The report you receive from the Pavement Management Section is used as the supporting documentation for the pay estimate. A copy of all reports should be submitted with the final estimate.

Method of Measurement and Basis of Payment

Measurement and payment techniques vary depending on whether the asphaltic concrete (AC) is specification 407, 408, 409, 411, 413, 414, 415, 416, 417, or a special design for local government work. Always check the Special Provisions and Standard Specifications carefully to determine the method of measurement and basis of payment for each type of asphaltic concrete used on the project.

A. Asphalt Cement

Methods used for determining asphalt cement content vary. For example:

- AC 407 asphalt content is determined with a nuclear asphalt content gauge
- AC 409 Miscellaneous Structural; bituminous material is not measured for payment
- AC 411 ACFC (Miscellaneous); bituminous material is not measured for payment
- AC 413 asphalt-rubber content is determined with a nuclear asphalt content gauge
- AC 414 asphalt-rubber content is determined with a nuclear asphalt content gauge
- AC 415 asphalt-rubber may be measured by invoice quantities, adjusted as necessary for waste. Waste generated from startup of the asphalt plant will be considered to have a binder content of 3.0 percent. In no case shall the measured amount of asphalt cement for payment be greater than the total of the invoice quantities, adjusted for waste.
- AC 416 and 417 asphalt cement may be measured by invoice quantities, adjusted as necessary for waste. Waste generated from startup of the asphalt plant will be considered to have a binder content of 3.0 percent. In no case shall the measured amount of asphalt cement for payment be greater than the total of the invoice quantities, adjusted for waste. Applies to both AC mixes, with and without RAP.

B. Mineral Admixture

The Special Provisions will indicate the percent of mineral admixture, if it is required in the mix. Specifications require the contractor to submit documentation on a daily basis to the Resident Engineer showing the approved amount of mineral admixture has been incorporated into the asphaltic concrete. This requirement is to verify that the mineral admixture is being added at the required rate and to furnish information to allow the contractor to adjust the process.

It is intended that the contractor submits the following information on a daily basis:

- Tracs No. or Project No.
- Contractor
- Date of Asphaltic Concrete Production
- Tons of Asphaltic Concrete (AC) Produced
- Tons of Asphaltic Cement Used (plant information)
- Tons of Mineral Admixture Used (Use A or B below)
  - Hot Plant computer printout indicating actual weight (attach printout to the submittal)
  - Silo weight at beginning and end of shift plus Mineral Admixture added to silo during the shift (attach invoices to the submittal)
- Contractor's Signature

Exhibit AC-7 is an acceptable example of a Daily Mineral Admixture Report form. This specific form doesn't have to be used, and any submittal giving the above information is acceptable. The advantage to this form is that it provides the equations to check the percent admixture. Note that the weight of admixture is divided by the weight of the aggregate, so the weight of both the asphalt cement and the admixture must be subtracted from the weight of the asphalt concrete to find the weight of aggregate.

The quantity of mineral admixture to be paid should be a summation of the tons of mineral admixture used, taken from the Daily Mineral Admixture Report submitted by the contractor. The daily quantities can be added up monthly for progress payments and totaled for final payment.

Verification of the asphalt content should be made by the ADOT Field Office upon receipt of the test data (see Exhibit AC-4) to assure the payment quantities for mineral admixture are not significantly different from the mix design requirement.

The following formula can be used:

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

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.): F123401C

CONTRACTOR: ABC Contractor, Inc.

DATE PRODUCED: 11/20/2023

TONS OF ASPHALTIC CONCRETE (AC) PRODUCED: 2,220.29

TONS OF ASPHALT CEMENT (Asphalt) PRODUCED: 93.48

TONS OF MINERAL ADMIXTURE (Admixture) PRODUCED: 21.82

Attachment (A or B) A

A) Hot plant computer printout indicating actual weight

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

PERCENT ADMIXTURE =

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

$$= \frac{(21.82)}{(2{,}220.29) - (93.48) - (21.82)}$$

= 1.05 % Admixture

This percentage

- ☑ complies with the approved mix design.
- ☐ does not comply with the approved mix design.

Contractor Signature

Signature (Contractors Representative)

01/08

Exhibit AC-7. Daily Mineral Admixture Report Example

The ADOT Asphalt Unit Price Adjustment course provides guidance in how to field document AC paving operations. Field Office documentation includes:

- AC Summary Report, recap of asphaltic concrete payments by lot (see Exhibit AC-8). As a minimum, the recap should include:
    - date material used
    - lot number
    - asphaltic concrete pay tons
    - percent asphalt cement from the materials lab sheet (see Exhibit AC-4)
    - asphalt cement pay tons
    - percent admixture
    - admixture pay tons
    - bonus/penalty pay factors
- Cumulative totals for the above items
- Daily Mineral Admixture Report (see Exhibit AC-7)
- Hot Plant Report
- Bituminous Material delivery invoices
- Mineral Admixture delivery invoices
- ADOT Mix and Compaction Report (see Exhibit AC-4)
- AM and PM Spread Determinations
- ADOT RAP Material tabulation - Ignition Oven Lab Report
- Disposition memo from Materials Engineer for end product AC production lots, or 409 Misc. structural special mix material represented by failing laboratory tests.
- Asphalt Binder Failure summary spreadsheet, along with the failing lab reports.
- Documentation for penalties/bonuses (any changes to the Standard Specifications or Special Provisions will require a change order or a procedural change order).
- The above documentation should be submitted to the Field Reports Section for review with the final estimate. The following documents are recommended as part of any asphalt paving operation:
- Mix temperature and pavement depth field book.
- Straightedge and rolling pattern field book.
- Daily pyrometer readings from the plant.
- Daily reports from AC Forms.
- Summary report from AC Forms.
- Daily inspection diaries complete with weather conditions and air temperatures.

416 Summary - Asphaltic Concrete - End Product

Project: [redacted]

Contractor: [redacted]

Date of Report 11-20-2023

Mix Design		
Percent Admixture	Required	1.00
	Maximum	1.05
Percent Binder Target Value		4.68

Sec	Date Produced	Lot	AC Prod.	AC Waste	AC Placed	Avg. % Oil	Asphalt Cement Based on Lab or UL	Virgin Binder	RAP Binder	Virgin + RAP Binder	% Admix Paid	Admix Paid	Mix Excl. From Mix Props	Mix QLPF	Mix Pay Adj.	Mix Excl. From Comp'n	Comp. QLPF	Comp'n Pay Adj.	AM Spread	AM Spread Penalty	AM Spread Penalty Amount	PM Spread	PM Spread Penalty	PM Spread Penalty Amount
4160004 - ASPHALTIC CONCRETE (3/4" MIX) (END PRODUCT) (SPECIAL MI (Section: 1 - ROADWAY)																								
1					4160004		4040266	4040000		4040266		4160031			1090011			1090011			1090011			1090011
	07/09/2020	01	967.76	16.00	951.76	5.49	52.25	43.64	10.36	54.00	0.98	8.73	0.00	$1.00	$951.76	0.00	$0.50	$475.88	517.08	$0.00	$0.00	434.68	$0.00	$0.00
	07/13/2020	02	1,819.96	24.00	1,795.96	5.44	97.70	81.54	18.72	100.26	0.98	16.48	0.00	$1.50	$2,693.94	0.00	$0.00	$0.00	861.25	$0.00	$0.00	934.71	$0.00	$0.00
	07/14/2020	03	1,182.40	7.00	1,175.40	5.51	64.76	54.07	12.74	66.81	1.05	11.54	0.00	$2.00	$2,350.80	0.00	$0.00	$0.00	616.32	$0.00	$0.00	559.08	$0.00	$0.00
	07/15/2020	04	2,152.70	19.09	2,133.61	5.77	123.11	100.56	22.80	123.36	1.05	20.89	0.00	$2.00	$4,267.22	0.00	$0.50	$1,066.81	1,053.62	$0.00	$0.00	1,080.00	$0.00	$0.00
	07/16/2020	05	1,177.41	12.00	1,165.41	5.71	66.54	51.59	10.67	62.26	1.05	11.42	0.00	$2.00	$2,330.82	0.00	$0.50	$582.71	584.89	$0.00	$0.00	580.52	$0.00	$0.00
	07/20/2020	06	1,767.55	8.00	1,759.55	5.60	98.53	79.62	15.08	94.70	1.01	16.61	0.00	$2.00	$3,519.10	0.00	($1.00)	($1,759.55)	869.41	$0.00	$0.00	890.14	$0.00	$0.00
	07/21/2020	07	1,766.29	9.41	1,756.88	5.47	96.10	79.21	15.46	94.67	1.01	16.61	0.00	$2.00	$3,513.76	0.00	$0.00	$0.00	798.15	$0.00	$0.00	958.73	$0.00	$0.00
	07/22/2020	08	2,429.96	16.00	2,413.96	5.58	134.70	110.32	19.24	129.56	1.05	23.68	0.00	$2.00	$4,827.92	0.00	$2.00	$4,827.92	1,108.00	$0.00	$0.00	1,305.96	$0.00	$0.00
	07/23/2020	09	1,341.40	16.00	1,325.40	5.73	75.95	59.10	12.25	71.35	1.01	12.49	0.00	$0.50	$662.70	0.00	$0.50	$662.70	583.77	$0.00	$0.00	741.63	$0.00	$0.00
	07/27/2020	10	2,424.73	7.00	2,417.73	5.73	138.54	111.80	21.69	133.49	1.02	23.01	0.00	$2.00	$4,835.46	0.00	$0.50	$1,208.87	1,197.64	$0.00	$0.00	1,220.09	$0.00	$0.00
	07/28/2020	11	1,793.92	11.50	1,782.42	5.73	102.13	85.13	15.98	101.11	1.02	16.97	0.00	$2.00	$3,564.84	0.00	$0.50	$891.21	892.56	$0.00	$0.00	889.86	$0.00	$0.00
	07/29/2020	12	2,313.52	15.00	2,298.52	5.75	132.16	105.80	23.29	129.09	1.02	21.87	0.00	$2.00	$4,597.04	0.00	$0.50	$1,149.26	1,197.00	$0.00	$0.00	1,101.52	$0.00	$0.00
	07/30/2020	13	2,134.11	15.00	2,119.11	5.85	123.97	98.35	21.21	119.56	1.02	20.14	0.00	$1.50	$3,178.67	0.00	$0.50	$1,059.56	1,103.60	$0.00	$0.00	1,025.51	$0.00	$0.00
					23095.71		1306.44	1060.73	219.49	1280.22		220.44			$41,294.03			$10,165.37			$0.00			0.00
1					4160004		4040230	4040000		4040230		4160031			1090011			1090011			1090011			1090011
	08/13/2020	3A	2,412.79	18.00	2,394.79	5.37	128.60	108.69	20.17	128.86	1.01	22.66	0.00	$2.00	$4,789.58	0.00	($0.25)	($598.70)	1,129.00	$0.00	$0.00	1,265.79	$0.00	$0.00
					2394.79		128.60	108.69	20.17	128.86		22.66			$4,789.58			($598.70)			$0.00			0.00
	Total				25,490.50		1,435.04	1,169.42	239.66	1,409.08		243.10			$46,083.61			$9,566.67			$0.00			$0.00

Exhibit AC-8. Recap Sheet

D. Spread

407, 414, 416 and 417 mixes require spread lots for payment.

For 407 and 414:

For spread compliance, a lot represents a half shift of production; this is called a spread lot. Under a spread lot, ADOT compares the actual amount of material placed versus the targeted amount that should have been placed. At the end of each spread lot, either the Project Supervisor or Lead Inspector should receive and review the contractor's completed spread lot forms. These forms must be reviewed and approved on a daily basis. Do not wait until the end of the week, month, or project. Agreements should be reached on how much material was wasted, what areas are to be excluded from the spread, and how the material on any sloped edges will be handled.

Spread Control

The estimated target spread rate will be as shown in the table in Subsection 414-3 of the Special Provisions. The Engineer may adjust the estimated target spread rate, and establish a new target spread rate, as necessary to maintain a suitable thickness. Target values for the spread— widths and length—should be agreed to before paving begins, so the target values can be calculated. Once the paving begins, the contractor is responsible for continuously measuring the thickness behind the screed throughout each spread lot to ensure that the minimum compacted thickness specified in subsection 414-3 of the Special Provisions is being met. Exhibit 414-7.03-1 should be used by the inspector to get a daily agreement on the spread quantities. The Resident Engineer can obtain permission to delete this portion of the specification if conditions warrant.

The calculated quantity required in each spread lot will be compared to the actual quantity placed. A spread lot will be considered to be acceptable if the actual quantity placed does not vary by more than +5.0 percent from the required quantity.

Determination of Lot Material Spread Quantity Required for Acceptance and Payment of ACFC (407) and AR-ACFC (414)

Project Number: ____________ Material: ____________

Tracs Number: ____________ Lot Number: ____________ ☐ AM ☐ PM

Date: ____________

CALCULATION OF QUANTITY REQUIRED (Tons)

Target Spread Rate (in Special Provisions) ______ pounds per square yard

Location	From Station	To Station	Length (SF)	Average Width (SF)	Calculated Quantity (SF)	Calculated Quantity (SY)
					Total Calculated Square Yards in Lot =	

Calculated Tons Required = (Total Calc. Sq Yds in Lot X Target Spread Rate) / 2,000.00 = ______ Tons

X / **2,000.00** **=** **TONS**

CALCULATION OF VARIANCE

Actual Quantity Placed = ______ Tons

(Quantity Placed) - (Quantity Required) x 100 / (Quantity Required) = % Variance from Required Quantity

- **X 100** = ______ %

If the quantity in a spread lot is found to vary by more than +5.0 percent from the required quantity, as determined in accordance with Subsection 414-6.04, no payment will be made for the material which exceeds the +5.0 percent, including asphalt-rubber and mineral admiixture.

Remarks:

Asphalt Cement Deduction (If applicable): ______ Ton

Mineral Admixture Deduction (If applicable) ______ Ton **Tons over 5%** -

Contractor's Signature: ____________ Inspector's Signature: ____________

Exhibit 414-6.04-1 Spread Determination

416 and 417:

For spread compliance, a lot represents a half shift of production; this is called a spread lot. For compliance with the material properties of the asphalt mix itself, a lot represents an entire shift of production and is called a mix-properties lot in the specifications. The mix-properties lot is often called the quality lot in the field.

Under a spread lot, ADOT compares the actual amount of material placed versus the targeted amount that should have been placed. At the end of each spread lot, either the Project Supervisor or Lead Inspector should receive and review the contractor's completed spread lot forms. These forms must be reviewed and approved on a daily basis. Do not wait until the end of the week, month, or project. Agreements should be reached on how much material was wasted, what areas are to be excluded from the spread, and how the material on any sloped edges will be handled.

Spread Control

Target values for the spread—pavement depths, widths, and lengths—should be agreed to before paving begins, so the target values can be calculated. The target value is determined using the bulk unit weight in the mix design for the mix being used. Production bulk density (determined by laboratory testing of acceptance samples) may be slightly different than that shown in the mix design. In such instances, the contractor may request that ADOT use the average bulk density of the first three production lots not in reject (and representative of the mix being produced). The Regional Materials Engineer should be included in this discussion to ensure values utilized do not differ excessively from the mix design.

The inspector may occasionally check pavement thickness and width dimensions in the field to verify that target values are being met. Once the paving begins, the contractor is responsible for controlling the spread and laydown operation. The Project Supervisor may exclude irregular areas from the spread. Irregular areas are defined as uneven surfaces where placing uniform depth of asphalt would be too difficult. Some gore and taper areas fit into this category where deep depressions exist due to severe rutting or subgrade settlement. While the spread gets more difficult to control as the existing surface becomes rough and irregular, the specifications can still be enforced on all but the roughest surface conditions. Conditions such as swelling clay areas may cause such a high degree of roughness to make the application of the spread specification impractical. One key method to avoiding problems in enforcing the specification is to explain carefully to the contractor exactly how the day's tonnage will be calculated. Exhibit 416-7.03-1 should be used by the inspector to get a daily agreement on the spread quantities and penalties for each spread lot. Flexibility should be exercised in the interpretation of this specification so that the contractor can expect to obtain compliance without minute-by-minute screed adjustments. The Resident Engineer can obtain permission to delete this portion of the specification if conditions warrant.

Asphaltic concrete is measured based on a day's production including the quantities that were excluded from the spread lots or mix properties lots for irregular areas. Waste quantities, quantities in rejection, and quantities over the 5% spread limit are excluded from measurement. The AM and PM spread lots are usually combined to allow for unit price adjustments. Typically there are no price adjustments due to spread variations, since contractors will avoid underrunning the spread. However, if there were a spread penalty, the AM and PM lots would have to be analyzed separately (see example calculation). Payments are best calculated on a daily production basis. Deductions or bonuses are calculated separately and added to the contractor's payment:

Placed Quantity x bid unit price	= initial amount owed to Contractor
AM Spread Quantity x AM spread pay factor	= AM spread price adjustment
PM Spread Quantity x PM spread pay factor	= PM spread price adjustment
Mix Prop Quantity x Mix prop pay factor	= Mix prop. price adjustment
Compaction Quantity x Comp. pay factor	= Comp. price adjustment
	______________________________
	= Net amount paid to contractor

The placed quantity is the amount of asphalt placed that day (from the weigh tickets) less any amounts wasted and less any amounts above the 5% spread quantity limit. This may be different than the mix property and compaction pay quantities if there are rumble strips or isolated areas the Resident Engineer elects to exclude from these lots (see subsection 417-9).

The calculations can become quite tedious since some quantities are not included for some types of lots (spread versus compaction for example) and excluded from others. A spreadsheet has been provided with this manual (see Exhibit 416-7.03-1) to assist the Field Office in making these calculations. Please keep these points in mind:

- When a formed rumble strip is specified, the last lift placed on that shoulder is excluded from the compaction pay factor adjustments, but included in the spread and mix properties pay factors adjustments.
- Irregular areas identified as being excluded from the AM or PM spread lots may or may not be excluded from the compaction lot and/or mix property lot quantities (check with the Project Supervisor or Resident Engineer).
- Spread quantities that exceed the 5% spread limit are not included in any pay factor adjustments since the Department does not pay for them — this includes the asphalt cement and mineral admixture.

In some instances, depending on the bulk density (unit weight) used to estimate the quantity of AC needed on the project for bidding purposes, and the actual bulk density of the AC produced for the project, the cost of the AC may result in an overrun for the bid item or a substantial savings may be realized which could be used elsewhere on the project. Be mindful that if the bulk unit weight increases during production, and a heavier unit weight is used to to determine spread lot, this combined with the 5% allowance may grossly exceed the bid item cost for the material.

Example Calculation

A contractor places 1,260 tons of asphalt concrete in the morning and 1,460 tons in the afternoon. During the morning shift, 10 tons were wasted and the inspector and the contractor agreed to exclude an additional 25 tons from the spread lot, but include in the compaction and mix properties lots. During the afternoon, 15 tons were wasted and the inspector determined that 750 tons were placed in a formed rumble strip area. Also, the inspector calculated the theoretical spreads for the morning and afternoon to be 1,210 tons and 1,510 tons, respectively. The calculated PTs for that day's quality lot were done by the acceptance lab, with the respective pay factors taken from table 416-1 of the Standard Specifications.

	PT	**PF (from table 416-1)**
3/8 inch sieve	75	-$0.50 (disregard - not the lowest)
No. 8 sieve	100	$0.00
No. 40 sieve	98	$0.00
No. 200 sieve	70	-$0.75 (lowest pay factor)
% asphalt cement	90	$0.00
% voids	97	+$0.50
Total Mix Pay Factor Adj.		-$0.25 (sum of voids plus lowest pay factor for sie and % asphalt)
Compaction	95	+$0.50

If the contractor's unit price for asphaltic concrete is $70 per ton, how much is owed to the contractor for that day's production?

Solution

Compute the Spread Lot Pay Factors per 416-9(A) of the Standard Specifications:

AM Spread				PM Spread		
Batched	1260	tons		Batched	1460	tons
Waste	10			Waste	15	
Placed	1250			Placed	1445	
Excluded	25			Excluded	0	
Net Spread	1225	tons		Net Spread	1445	tons
Calc. Spread	1210	tons		Calc. Spread	1510	tons
Yield	1.24%	= net- calc. / calc.	x 100	Yield	-4.30%	
Pay Factor (Table 416-1)	$0.00			Pay Factor (Table 416-1)	-$0.30	

Note: the rumble strip quantity is included in the spread lot.

Mix. Prop. Lot Quantity (416-9(B))	2695	ton (1250+1445)	PF =	-$0.25
Compaction Lot Quantity (416-9(C))	1945	ton (1250+1445-750)	PF =	$0.50

Calculate Pay Adjustments

	Quantity	Unit Price	Amount
Placed	2695	$18.00	$48,510.00
AM Spread	1225	$0.00	$0.00
PM Spread	1445	-$0.30	-$433.50
Mix Prop.	2695	-$0.25	-$673.75
Compaction	1945	$0.50	$972.50
Total Price Paid			$48,375.25

Determination of Lot Material Spread Quantity Required and Pay Factor for End product Method of Acceptance and Payment for AC (Standard)

Project Number: ____________ Material: ____________
Tracs Number: ____________ Lot Number: ____________
Date: ____________

CALCULATION OF QUANTITY REQUIRED (Tons)

Laboratory Mix Design Density = ______ pounds per cubic foot

Location	From Station	To Station	Length	Average Width (ft)	Average Thickness	Cubic Feet
					Total Calculated Cubic Feet in Lot	

Calculated Tons Required = (Total Calc. Cubic Ft in Lot X Lab Mix Design Density) / 2,000.00 = ______ Tons

______ **X** ______ / **2,000.00** = **TONS**

CALCULATION OF VARIANCE AND PAY FACTOR

Actual Quantity Placed ______ Tons

(Quantity Placed) - (Quantity Required) x 100 = / (Quantity Required) ______ % Variance from Required Quantity

- / ______ **X 100 = %**

- The calculated quantity required in each spread lot will be compared to the actual quantity placed. A lot will be considered to be acceptable, with a zero pay factor, if the actual quantity placed varies by no more than -2.0 to +5.0 percent from the required quantity.
- If the quantity in a lot is found to vary from the required quantity by -2.1 to -12.0 percent, the appropriate pay factor will be determined in accordance with Table 416-1. This pay factor will be utilized in determining the pay adjustment as outlined in Subsection 416-9 of the specifications.
- If the quantity in a spread lot is found to vary by more than +5.0 percent from the required quantity, no payment will be made for the material which exceeds +5.0 percent, including asphalt cement and mineral admixture.
- If the quantity is found to vary by more than -12.0 percent from the required quantity, the spread lot will be rejected.

Table 416-1

Negative Variance	Pay Factor (dollars) per ton
2.1-3.0	-0.10
3.1-4.0	-0.20
4.1-5.0	-0.30
5.1-6.0	-0.40
6.1-7.0	-0.50
7.1-8.0	-0.60
8.1-9.0	-0.70
9.1-10.0	-0.80
10.1-11.0	-0.90
11.1-12.0	-1.00

PAY FACTOR ______

Remarks:

Asphalt Cement Deduction (If Applicable): ______ Ton
Mineral Admixture Deduction (If applicable) ______ Ton **Tons over 5%** -

Contractor's Signature: ____________ Inspector's Signature: ____________

Exhibit 416-7.03-1. Spread Determination Form

E. Lots in Reject

Lots in reject due to failure to meet mixture, compaction, or spread lot requirements, or which include asphalt materials that failed to meet requirements, are subject to one or more of the following below. However, if applying an allowable self-directed target change to the mixture production targets results in the mixture no longer being in reject, the mixture is no longer in reject, i.e. not subject to removal and replacement at no cost to the Department. In this instance, an engineering analysis is not required for the Department to allow the material to remain in place, and no disposition is issued, but the entire quantity in the lot is subject to the maximum disincentive being applied for the pay factor(s) representing the quality characteristic(s) in question, i.e. the target change is retroactive for reject status, but the pay factor remains. The same applies to 409 miscellaneous structural (special mix).

- Maximum Penalty - Reject status results in the maximum disincentive being applied to the end product lot or quantity of material represented by a failing 409 sample; if allowed to remain in place. However, if the lot/material is removed by the contractor and replaced, the new material is subject to determination of a new pay factor on its own merits. The lot/material removed and quantity therein not incorporated into the project is no longer of concern for any further action by the Department. For 409 mixtures, the quantity of material represented by failing test results is most often determined by interpolating between consecutive passing and failing samples based on the tonnage at which the samples were taken, but may also be based on time if there occurred significant disruption to or production was not continuous for the material represented by the samples being considered.
- Referee testing - If requested by the contractor within 15 days of receiving the Department-furnished Mix/Compaction Payfactor Report for the respective end product lot, the portion of the mixture acceptance samples and/or AC cores set aside for referee testing will be sent to an independent laboratory for referee testing. The referee test results are binding and the associated pay factors replace those on the initial Mix/Compaction Payfactor Report. It should be noted that asphalt content for mixtures containing RAP cannot be refereed.

If referee testing is requested by the contractor, it must be in writing and specifically state if mixture or compaction, or both, is to be refereed. the materials coordinator must notify the acceptance lab, which will then furnish the referee materials and specimens to the materials coordinator, or designee from the project, to transport the materials and a copy of both the contractor’s request letter and the mix design including any subsequent target changes, to the Mix Design Laboratory at ADOT’s Central Lab. The Mix Design Lab Supervisor will coordinate referee testing and will provide notification of the results to the Materials Coordinator and Regional Materials Engineer. Note that the contractor may request to referee mixture or compaction even though the lot is not in reject. The non-prevailing party is responsible for the cost of the referee testing.

- Removal and Replacement - material that is in reject status, or remains in reject status subsequent to referee testing, is subject to removal and replacement at no cost to the Department. Exceptions to this may occur upon the Department receiving an Engineering Analysis (see Item 4 below). from the contractor, performed by a qualified firm, which substantiates that the associated pavement will perform satisfactorily or to a degree considered acceptable by the RE and the State Materials Engineer.
- Request to allow reject material to remain in place by means of an Engineering Analysis 416-9(E) - If requested by the contractor within 15 days of receiving notice of a mixture, compaction, or a spread lot, or miscellaneous structural special mix material in reject, the contractor may propose that the material remain in place at the maximum applicable negative pay factor(s) and submit to the Department, an Engineering Analysis (EA) that substantiates acceptable pavement performance for the lot/material in question. Upon review of test results and the EA, the State Materials Engineer has the sole authority to

determine if the material represented by the lot in reject will be removed or allowed to remain in place. However, before making this determination, much input will be requested from the construction unit.

In such an event, the project should be prepared to provide any information related to the material in question that will aid in determining whether or not the material should be allowed to remain in place. The opinion of the RE and observations of construction personnel are taken into serious consideration. This includes entries in daily diaries describing issues with production, delivery, placement, weather/ambient conditions, or otherwise, as well as a visual assessment of the condition of the pavement with any defects or indication of poor quality noted. The location of the pavement and if subject to mainline traffic, stopping/slowing/turning movements, heavy trucks, or if generally outside of traffic areas/shoulders, etc. Also considered is the position within the pavement structure and if additional lifts are yet to be placed or have already been placed.

Occasionally, depending on the properties in question, the decision to accept or require removal will be delayed until additional investigation/testing can be performed and/or the pavement has received traffic and been observed to be unaffected. This is most common when air voids are low and/or asphalt content is high, but neither are excessively outside of the production limits.

When a lower lift of AC is determined to be in reject, this may pose a difficult decision for both the contractor and the construction unit regarding, if paving a lot which will cover up a lot in reject should commence. When it is necessary to continue paving operations and such an instance occurs, guidance from the Regional Materials Engineer should be sought to aid in confirming the likelihood that material will be allowed to remain in place or if removal will be required. Typically extremely low mix and in-place air voids in areas that receive traffic, low asphalt content, or excessive in-place air voids require removal, while gradation issues, high asphalt content, and low mix voids, especially from areas that do not receive regular traffic, will be allowed to remain in place. It should never be assumed, regardless of location, traffic, or other conditions, that pavement will be allowed to remain in place.

Once the Regional Materials Engineer has received the engineering analysis, and gathered all pertinent information from the construction unit, the RME will make a recommendation to the Bituminous Engineer and State Materials Engineer, who will then confer to make a determination on the matter. The decision is provided by issuing a disposition memo that states if the material shall be removed and replaced at no additional cost to the Department, or if it will be allowed to remain in place and at what pay factor(s), and any additional stipulations such as a performance monitoring period followed by re-evaluation or other corrective action.

Any lot or material in reject and allowed to remain in place must be identified and described in the Materials Exception Report, including reference to the associated disposition memo, to be submitted to the FHWA as part of the Final Materials Certification process.

REFERENCES AND ADDITIONAL INFORMATION

There are references or additional information associated with this chapter at the present time.

ASSOCIATED FORMS

There are no blank forms associated with this chapter at the present time.