DIVISION 400
Asphalt Pavements

SOUTH CAROLINA
DEPARTMENT
OF TRANSPORTATION

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Hot-Mix Asphalt Pavement

401.1 DESCRIPTION OF WORK

A hot-mix asphalt (HMA) mixture is a combination of high-quality, sieve-graded coarse and fine aggregate materials, mineral filler, asphalt binder, admixtures (e.g., anti-stripping agent) and, as permitted by the Contract, recycled materials, such as recycled asphalt pavement, glass and shingles. These component materials must be selected, proportioned and mixed mechanically at an HMA plant based on a Job Mix Formula. One or more types of HMA courses may be specified for the pavement, and mix design, construction, acceptability and payment will depend on the type of HMA course to be constructed. The HMA Mix Design Technician will be responsible for:

- evaluating the suitability and gradation of aggregate material,
- designing the HMA mixture in an SCDOT-approved laboratory, and
- submitting the proposed material sources and Job Mix Formula for approval.

All component materials for the HMA mixture must be supplied from SCDOT-approved sources, as listed on SCDOT Approval Sheets. The design objective is to balance the properties of the mixture (e.g., workability vs. stability), while maintaining established parameters within specified limits (e.g., gradation, asphalt binder content). The properties of primary concern to the HMA Mix Design Technician include:

- moisture susceptibility – ability to resist stripping of asphalt binder;
- stability – ability to resist deformation under applied traffic loading;
- durability – ability to sustain original properties during in-service use and aging;
- permeability – ability to resist water and air entry;
- flexibility – ability to bend slightly under loading without cracking;
- workability – ability to be easily placed and compacted;
- fatigue resistance – ability to resist repeated traffic loading without failure; and
- skid resistance – ability to resist slipping and skidding of vehicular traffic.

Once the material sources and Job Mix Formula have been approved, the mixture will be produced at an HMA plant (e.g., batch plant, drum-mix plant). Prior to production, the HMA plant will be inspected for acceptability by the District Asphalt Manager or the Asphalt Materials Engineer, as appropriate. Scale certification, calibration of proportioning equipment, plant emissions and the following plant components are of primary concern:

- cold aggregate storage and feed system,
- aggregate heating and drying equipment,
- aggregate screening equipment,
- hot aggregate storage and weighing system,
- asphalt binder and admixture storage and metering system,

- mixing equipment, and
- storage silos.

At the start of production, the HMA plant will be calibrated to blend, heat and dry the required proportion of coarse and fine aggregate materials, add the proper quantity of asphalt binder and anti-stripping agent and thoroughly mix these component materials into an HMA mixture suitable for silo storage or immediate hauling, laydown and compaction. The HMA Quality Control Technician will be primarily responsible for monitoring compliance of the parameters established for the component materials and HMA mixture at the plant.

At the project site, the Asphalt Roadway Technicians will be responsible for ensuring that the HMA mixture is hauled, placed and compacted to meet the parameters established in the Contract Plans and Specifications for the HMA course (e.g., density, thickness, cross slope, grade). The Resident Construction Engineer and SCDOT Inspectors will be responsible for verifying Contract compliance and the acceptability of the HMA mixture delivered, placed and compacted. The HMA Quality Manager oversees both plant and roadway operations, troubleshoots production problems and is the Contractor's primary contact with SCDOT personnel. Section 401 of this *Manual* presents significant discussion on topics that are important to the day-to-day responsibilities of both SCDOT and Contractor plant and roadway personnel. Specifically, the content in Section 401 applies to the following Sections of the *Standard Specifications*:

- Section 401 – Hot-Mix Asphalt Pavement,
- Section 402 – Hot-Mix Asphalt Intermediate Course,
- Section 403 – Hot-Mix Asphalt Surface Course,
- Section 404 – Cold-Mix Asphalt Intermediate Course,
- Section 405 – Cold-Mix Asphalt Surface Course,
- Section 409 – Open-Graded Friction Course, and
- Section 410 – Hot-Mix Asphalt Thin-Lift Seal Course.

401.2 HMA QUALITY CONTROL / QUALITY ASSURANCE PROCEDURES

HMA mixtures are typically used for base courses, intermediate courses and surface courses. The Contract Plans and Specifications will designate the structure of the pavement required for the facility. This section describes the Department's HMA Quality Control/Quality Assurance (QC/QA) procedures, including the HMA QC/QA Program; HMA Technician Certification Program; and quality control, acceptance and verification sampling and testing parameters, frequencies, methods and responsibilities.

401.2.1 HMA QC / QA Program: Overview

SCDOT administers all of its HMA construction projects under a statistical HMA QC/QA Program. Under this Program, SCDOT is responsible for establishing verification and acceptance parameters (e.g., samples, tests, target values, acceptance criteria, payment adjustment schedules), while the Contractor is responsible for controlling work and materials to ensure that the HMA pavement is constructed within established parameters. This contributes

significantly to the production of a more consistent, higher quality pavement. Field acceptance criteria for HMA mixtures is typically based on:

- binder content (%AC),
- percent air voids (%AV),
- percent voids in mineral aggregate (%VMA), and
- the in-place density of the HMA mat.

Acceptance, rejection or acceptance at an adjusted price will be based on the acceptance criteria and the percentage of the Lot that is within specified limits. Where deficiencies are found, the Contractor is responsible for ceasing production until corrective action can be taken to bring production into compliance.

401.2.2 HMA Technician Certification Program

The HMA Technician Certification Program was jointly developed by SCDOT, FHWA and the Asphalt Paving Industry to ensure that personnel working under the HMA QC/QA Program are properly qualified to perform their respective duties. The HMA Technician Certification Task Force, composed of representatives from SCDOT, FHWA, Clemson University and the Asphalt Paving Industry, provides oversight; and the Department of Civil Engineering, Clemson University, administers the coursework, including formal classes and examination. By implementing this Certification Program, SCDOT can:

- improve the quality of both field and laboratory sampling and testing;
- enhance communications with the HMA paving industry; and
- increase HMA pavement performance and reduce overall life-cycle costs.

The South Carolina Certification Board, composed of one FHWA and eight SCDOT representatives, oversees the implementation of the HMA QC/QA Program and, as needed, the HMA Technician Certification Program.

Additional information regarding the HMA Technician Certification Program is available on the SCDOT website.

401.2.3 HMA Job Mix Formula

401.2.3.1 Design Responsibilities

The control parameters for each type of HMA mixture will be specified. The HMA Mix Design Technician (Level 2S), will be responsible for designing the mixture and preparing the Job Mix Formula in accordance with SC-T-80. The design will be prepared in a laboratory approved by the Research and Materials Engineer. A Job Mix Formula is not required for Sand Asphalt Base Course or Asphalt Aggregate Base Course; however, the asphalt binder content for the required HMA mixture will be verified and a Mix Design Form generated.

401.2.3.2 Submittals

Prior to production, the HMA Mix Design Technician will submit the proposed sources of component materials and the Job Mix Formula for the HMA mixture on the proper SCDOT Construction Forms to the Research and Materials Laboratory for approval. The Job Mix Formula will include the percentage of aggregate passing each required sieve, the percentage of asphalt binder not absorbed by aggregate and the percentage of anti-stripping agent in the HMA mixture. Note that a Job Mix Formula is specific to mixture type and HMA plant supplier and is to be approved by the Research and Materials Engineer for application on individual projects. There will need to be an approved Job Mix Formula submitted to the Resident Construction Engineer for each HMA mix used on any given project.

The Asphalt Materials Engineer will notify the HMA Mix Design Technician of any needed adjustments to the initial Job Mix Formula. Do not allow production to begin without written approval of the material sources and the Job Mix Formula from the Research and Materials Engineer.

401.2.3.3 Revisions

If the HMA Mix Design Technician or HMA Quality Manager determines that a revision to the HMA mixture design is necessary, a copy of the revision and supporting data will be forwarded to the District Asphalt Manager, Research Materials Engineer and District Materials Laboratory, when appropriate. SCDOT approval is necessary for any Job Mix Formula revision. Implementation of the revision must occur between production lots. Pay particular attention to the Contract Specifications with respect to expiration period, number of revisions allowed and the requirements for a new Job Mix Formula.

401.2.4 HMA Production Lot Numbering

Once a series of Lot Numbers has been initialized on a project for a specific type of mixture supplied from a particular HMA plant, the Lot Numbers will run continuously until the type of mixture is no longer required for the project. Lot Numbers will be initialized at the beginning of the project and run continuously throughout the project, regardless of the need for a new Job Mix Formula for the same type of mixture from the same plant. There will be no calibration period. Lot Numbers begin immediately upon production.

401.2.5 HMA Laboratory and Sampling Platform Requirements

The Contractor is responsible for supplying and furnishing the HMA laboratory in accordance with SC-T-81 or SC-T-82, as appropriate, including all supplies necessary to perform quality control testing at the asphalt plant. When SC-T-75 is used, pay particular attention to compliance with the manufacturer's recommendations for venting, calibrating, operating and maintaining the ignition oven. The Contractor is also responsible for supplying a platform high enough to allow sampling and inspection of the HMA mixture in truck beds. On an annual basis, the SCDOT Asphalt Materials Engineer will inspect the laboratory for acceptability and verify that the HMA Mix Design Technician has calibrated the laboratory equipment in accordance

with SC-T-94 and, as needed, check the Technician's calibration records. Non-compliance of laboratory and test equipment is grounds for halting production.

401.2.6 Notification of HMA Production and Acceptance Results

The HMA Quality Manager will notify the District Asphalt Manager prior to each day's production so that SCDOT may arrange for verification testing. Failure to receive such notification is grounds for withholding payment for the day's production. The HMA Quality Manager also is responsible for submitting the results of acceptance tests to the District Asphalt Manager within three production days after the completion of the mixture Lot. Non-compliance is grounds for halting production.

401.2.7 Quality Control Program (Contractor and SCDOT)

401.2.7.1 HMA Quality Control Plan (Contractor)

The Contractor is responsible for preparing and submitting a Quality Control Plan to the Research and Materials Engineer for approval. The Quality Control Plan will define the process control activities for HMA mixture design, production and placement, including inspection, sampling, testing, coordination and adjustment. During the project, verify that the Contractor operates within this Plan. Non-compliance is grounds for halting production.

401.2.7.2 HMA Plant QC Samples and Tests (Contractor)

The HMA Quality Manager will ensure that the HMA Quality Control Technician performs the necessary samples and tests. Note that these are minimum requirements and should be increased, as needed, to ensure compliance. The allowable limits of test parameters will be specified in the Contract. Non-compliance with minimum specified requirements is grounds for halting production.

401.2.7.3 HMA Roadway QC Samples and Tests (Contractor and SCDOT)

The HMA Quality Manager and Asphalt Roadway Technicians are responsible for compaction control, including compaction rollers and the rolling pattern. Verify the proper use of the density gauge to control the compaction process and document the results. The Resident Construction Engineer and Roadway Inspectors are responsible for verifying and documenting results of testing in the Daily Work Report and on SCDOT Form 400.04 – Daily Report of Asphalt Plant Inspection.

401.2.8 Acceptance Program (Contractor)

401.2.8.1 Basis of Payment

Only acceptance samples that have been obtained randomly in accordance with specified requirements will be used for computing daily pay factors. Any other type of sample, with the exception of quality control samples, will be performed for the exclusive use of the Contractor's HMA Quality Manager.

401.2.8.2 HMA Plant Acceptance Samples and Tests

Prior to production, the District Asphalt Manager or Resident Construction Engineer, as assigned, will verify that the HMA Quality Manager has properly calibrated the HMA plant to the Job Mix Formula and field acceptance criteria. The HMA Quality Manager will ensure that HMA plant acceptance sampling and testing is performed. The allowable limits of test parameters will be specified in the Contract.

401.2.8.2.1 Binder Content Analysis (%AC)

The HMA Quality Control Technician will be responsible for determining %AC. Verify that SC-T-62 is used to obtain an HMA mixture sample of the required size and that SC-T-72 is used to split the sample into acceptance, verification and referee samples. The acceptance sample should be tested for compliance and the verification and referee samples should be separately bagged, labeled with the proper SCDOT Sample Identification Card (see Appendix B) and stored. The Asphalt Materials Engineer will be responsible for determining the need to request the verification sample for testing under the Verification Program. The HMA Quality Control Technician must retain the referee sample until otherwise notified by the Asphalt Materials Engineer, and the disposition of samples should follow the specified disposal schedule. When an ignition oven is used to determine binder content, ensure that it is furnished and calibrated in accordance with SC-T-75. If acceptance and referee tests are not within allowable limits, check the HMA Mix Design Technician's calibration log and, as needed, require re-calibration. Complete SCDOT Form 400.01 – Ignition Oven Worksheet.

401.2.8.2.2 Voids Analysis (%AV, %VMA)

Verify that sample specimens are prepared and compacted in accordance with SC-T-66 and that %AV and %VMA are determined in accordance with SC-T-68. The acceptance sample should be tested for compliance and verification and referee samples, as appropriate, should be separately labeled using the proper SCDOT Sample Identification Card (see Appendix B) and stored. The Asphalt Materials Engineer will be responsible for determining the need to request the verification sample for testing under the Verification Program. The Technician must retain the samples until otherwise notified by the Asphalt Materials Engineer, and the disposition of samples should follow the specified disposal schedule. The maximum specific gravity (MSG) will be determined in accordance with SC-T-83. Percent air voids (%AV) will be determined by comparing the bulk specific gravity (BSG) of the compacted mixture to the mixture's maximum specific gravity (MSG). Base course work does not require a %AV analysis.

401.2.8.2.3 Washed Mixture Gradation Analysis

The HMA Quality Control Technician will be responsible for the washed mixture gradation analysis. Verify that acceptance tests for washed mixture gradation are performed for each sublot in accordance with SC-T-63, SC-T-76 and SC-T-92, as appropriate. Payment for asphalt aggregate base course will be based on the evaluation of each sublot, separately.

401.2.8.3 HMA Roadway Acceptance Samples and Tests (Contractor)

The Asphalt Roadway Technician is responsible for evaluating for acceptance the in-place density of the HMA mat in accordance with the minimum requirements. Note that these are minimum requirements and should be increased, as needed, to ensure compliance. The allowable limits of test parameters will be specified in the Contract.

401.2.8.3.1 In-Place Density Analysis (%Maximum Theoretical)

The Asphalt Roadway Technician is responsible for obtaining core samples for in-place density analyses at the locations determined by SCDOT using SC-T-101. This procedure is applicable to most intermediate courses and surface courses (see Section 403 of the *Standard Specifications*) placed at a rate equal to or greater than 140 pounds per square yard. Verify that the Asphalt Roadway Technician obtains one 6-inch core in accordance with SC-T-87 at each randomly selected location, as determined using SC-T-101. Each of these verification samples should be labeled using the proper SCDOT Sample Identification Card (see Appendix B) and stored, as specified. The Asphalt Materials Engineer will be responsible for determining the need to request the verification sample for testing under the Verification Program. The HMA Quality Control Technician must retain the samples until otherwise notified by the District Asphalt Manager or Asphalt Materials Engineer, and the disposition of samples should follow the specified disposal schedule.

401.2.8.3.2 In-Place Density Analysis (%Control Strip Target Density)

The Asphalt Roadway Technician is responsible for performing in-place density analyses using the density gauge, and the District Asphalt Manager or Resident Construction Engineer, as assigned, must witness this procedure. The density gauge must be approved by the Research and Materials Engineer and certified for use and transport by SCDHEC. Certification is the Contractor's responsibility. Ensure that the Asphalt Roadway Technician adheres to the safety requirements associated with the use of the nuclear gauge and is prepared to mitigate and notify proper authorities in the event of a mishap. Verify that each Lot is subdivided corresponding to the number of density values required and that test locations within each sublot are randomly selected using SC-T-101. Density will be expressed as a percent of target density, as determined from a control strip constructed in accordance with SC-T-65. Calculations will be carried out to the hundredths (0.01) and rounded to the nearest tenth (0.1) in accordance with AASHTO R 11.

401.2.8.4 HMA Check Samples (Contractor)

When an acceptance sample fails to meet specified limits for %AC, %AV, %VMA, Job Mix Formula gradation or dust-to-asphalt ratio, the HMA Quality Manager may opt to obtain another sample. This will be considered a check sample and will not be used to calculate pay factors. If two consecutive samples fail for any acceptance parameter, the HMA Quality Control Technician is required to immediately notify the District Asphalt Manager or Resident Construction Engineer. The HMA Quality Manager will analyze the problem and require adjustment to plant production. After adjustment, production will resume and the third truck load of mix will be sampled. The HMA Quality Manager will suspend further production until the test results on the sample has been obtained. If the test passes, production may resume; however, if the test fails, the mixture in the storage silo will be discarded and the plant cleared of all non-complying material. This procedure may be altered, as needed, by the Asphalt Materials Engineer.

401.2.9 Verification Program (SCDOT)

401.2.9.1 General

The District Asphalt Manager, Resident Construction Engineer and Roadway Inspectors should, on a regular basis, witness and document in the Daily Work Report and on SCDOT Form 400.03 – Daily Report of Asphalt Plant Inspection and SCDOT Form 400.04 – Daily Report of Asphalt Road Inspection the sampling and testing performed by the Contractor's Technicians. Although SCDOT verification tests will equal or surpass 10% of those required by the Contractor, SCDOT may elect to obtain additional samples or run additional tests for compliance verification. Within the first two days of production, at least one verification test each will be conducted for %AC, %AV, %VMA and in-place density. Under the Verification Program, SCDOT may select any or all of the Contractor's retained verification samples for testing or run tests on independently selected random locations, as appropriate. SCDOT may use the Contractor's test equipment or its own equipment, calibrated in accordance with SC-T-94. The HMA Quality Manager may opt to inspect SCDOT test equipment for concurrence. If non-compliance is observed through verification testing, SCDOT will immediately notify the HMA Quality Manager. The results of verification tests will be provided to the HMA Quality Manager. The District Asphalt Manager will investigate deficiencies and, if not immediately corrected, will request the HMA Quality Manager to halt production until corrective action is taken.

401.2.9.2 HMA Plant Verification Samples and Tests

401.2.9.2.1 Binder Content Analysis (%AC)

For %AC and maximum specific gravity (MSG), SCDOT will compare the results of testing the split samples made for acceptance and verification. If found within allowable difference, no further testing will be performed and the Contractor's acceptance test results will be used to compute the pay factor for the Lot of asphalt binder. If found to be outside allowable difference, the Research and Materials Engineer will test the referee sample and compare the result to the Contractor's acceptance results. If found within allowable difference, no further testing will be

performed and the Contractor's acceptance test results will be used to compute the pay factor for the Lot of asphalt binder. If found to be outside allowable difference, then the result of testing the referee sample will be used in lieu of the Contractor's acceptance test results in computing the pay factor for the Lot of asphalt binder. The District Asphalt Manager will immediately investigate (e.g., additional testing, observation of Contractor's procedures) recurring problems and, as needed, halt production of the HMA mixture. Complete SCDOT Form 400.01 – Ignition Oven Worksheet.

401.2.9.2.2 Voids Analysis (%AV, %VMA)

For %AV and %VMA, SCDOT will compare the average value from testing verification samples to the average value obtained from the Contractor's acceptance tests. The verification tests will be obtained from samples obtained from the same Lot as the Contractor's acceptance samples. A statistical analysis will be used, as specified, to compare the verification and acceptance values to determine if the Contractor's acceptance values or additional testing is required to obtain values to compute the Lot pay factor for air voids. Follow the procedure specified in the Contract to perform this task. The District Asphalt Manager will immediately investigate (e.g., additional testing, observation of Contractor's procedures) recurring problems and, as needed, halt production of the HMA mixture.

401.2.9.3 HMA Roadway Verification Samples and Tests

401.2.9.3.1 In-Place Density Analysis (%Maximum Theoretical)

This procedure applies to intermediate courses and all surface courses, unless otherwise specified. The District Asphalt Manager will compare the bulk specific gravity (BSG) value obtained from testing the SCDOT verification core sample with that obtained from the Contractor's acceptance test. If the comparison is within allowable difference, no further testing will be required and the Contractor's value will be used to compute the in-place density Lot pay factor; otherwise, the Research and Materials Engineer will test the referee sample and use the referee test value to compute the in-place density Lot pay factor. The District Asphalt Manager will immediately investigate recurring problems and, as needed, halt production of the HMA mixture.

401.2.9.3.2 In-Place Density Analysis (%Control Strip Target Density)

This procedure applies to Asphalt Aggregate Base Courses and specified surface courses. The District Asphalt Manager, Resident Construction Engineer or Roadway Inspector, as assigned, will obtain independent nuclear density readings for verification testing using the same type of density gauge as the Contractor. For each Lot selected for verification testing, SCDOT will use SC-T-101 to select 10 random locations within the Lot. SCDOT then will obtain one nuclear density value at each of these locations. A statistical analysis will be used, as specified, to comparing the verification and acceptance values to determine if the Contractor's acceptance values or additional testing is required to obtain values to compute the Lot pay factor for in-place density. Follow the procedures specified in the Contract to perform this task. The District

Asphalt Manager will immediately investigate (e.g., additional testing, observation of Contractor's procedures) recurring problems and, as needed, halt production of the HMA mixture.

401.2.10 Acceptance Procedures (SCDOT)

401.2.10.1 HMA Main-Line Paving

Main-line paving refers to the construction of an HMA roadway pavement, including shoulders, ramps and acceleration/deceleration lanes. The Contract will define the following:

- acceptance procedures for the HMA mixture and mat;
- allowable deviations for HMA mixture properties in the Job Mix Formula;
- specification limits for test parameters;
- method for determining percent within limits; and
- methods for determining pay factors for base, intermediate and surface courses.

Only those tests specified as acceptance tests will be used in computing pay factors. The Contractor will be responsible for performing the required quality control and acceptance tests. To assess acceptability, SCDOT will utilize and compare the Contractor's acceptance tests with those obtained from SCDOT verification tests. As needed, the District Asphalt Manager, Asphalt Materials Engineer or Resident Construction Engineer may conduct additional testing and monitor the Contractor's procedures to assess problems and verify compliance.

401.2.10.2 HMA Non Main-Line Paving

Non main-line paving refers to the HMA courses that are not controlled by density requirements, which generally include patching, leveling, less than 8-foot widening, wedges and driveways. The acceptance and pay factors for non main-line paving for %AC, %AV, and %VMA will be based on the absolute average difference from the target value for each acceptance characteristic. The Contract Specifications will define the following for non main-line paving:

- acceptance procedures for the HMA mixture and mat;
- method for determining average absolute difference; and
- method for determining pay factors for non main-line paving lots.

Only those tests specified as acceptance tests will be used in computing pay factors. The Contractor is responsible for performing the specified quality control and acceptance tests. To assess acceptability for payment, SCDOT will utilize and compare the Contractor's acceptance test values with those obtained from SCDOT verification tests. As needed, the District Asphalt Manager, Asphalt Materials Engineer or Resident Construction Engineer may conduct additional testing and monitor the Contractor's procedures to assess problems and verify compliance.

401.2.10.3 HMA Low-Tonnage Paving

Low-tonnage paving refers to production of a specific HMA mixture on a project as described in the Contract Specifications. The acceptance and pay factors for low-tonnage paving for %AC, %AV and %VMA will be based on the absolute average difference from the target value for each acceptance parameter. The Contract Specifications will define the following for low-tonnage paving:

- acceptance procedures for the HMA mixture and mat;
- specification limits for test parameters;
- method for determining percent within limits; and
- method for determining pay factors for low-tonnage lots (i.e., density and non-density).

Only those tests specified as acceptance tests will be used in computing pay factors. The Contractor is responsible for performing the specified quality control and acceptance tests. In-place density acceptance tests do not apply. To assess acceptability for payment, SCDOT will utilize and compare the Contractor's acceptance test values with those obtained from SCDOT verification tests. As needed, the District Asphalt Manager, Asphalt Materials Engineer or Resident Construction Engineer may conduct additional testing and monitor the Contractor's procedures to assess problems and verify compliance.

401.2.11 QC / QA Program Documentation Requirements

The HMA Quality Manager will ensure that all quality control and acceptance inspections and test results are recorded and maintained daily on the appropriate SCDOT Construction Forms, including all observations, records of inspection, mixture adjustments and corrective actions. The HMA Quality Manager will submit this documentation to the District Asphalt Manager, Asphalt Materials Engineer or Resident Construction Engineer, as appropriate, within 30 calendar days of completing the HMA work on the project. The District Asphalt Manager, Asphalt Materials Engineer or Resident Construction Engineer will provide the HMA Quality Manager with reproducible or printable copies of the appropriate SCDOT Construction Forms. During prosecution of the work, verify that these records are being properly maintained and review the documents, as needed, to ensure compliance. All SCDOT personnel are required to maintain thorough and accurate project records in the Daily Work Report and appropriate SCDOT Construction Forms.

401.3 AGGREGATE MATERIALS

401.3.1 Sources of Aggregate Materials

Aggregate materials are commonly used for subbase, base course, Portland cement concrete, drainage features and HMA mixtures and are obtained from excavating pits or by dredging water courses. Explosives are commonly used to blast the rock material in roadway cuts and hillside or subsurface quarries, which will then be processed through crushers to reduce the size of the rock particles, alter their shape and create one or more fracture faces on each particle.

401.3.2 Aggregate Components of HMA Mixtures

401.3.2.1 Coarse Aggregate

Pay attention to the type of HMA surface course to be constructed because the requirements for coarse aggregate will differ based on the type of HMA mixture specified. The coarse aggregate component may consist of crushed stone, gravel, slag, reprocessed aggregate from SCDOT RAP milling projects, or a combination of these materials. Coarse aggregate material must be supplied from a source listed on SCDOT Approval Sheet 2. Prior to production, properties such as density, abrasion loss, fractured faces, gradation, sodium sulfate soundness and maximum absorption will be evaluated by the Research and Materials Engineer to assess suitability. Sampling and testing procedures SC-T-89, AASHTO T 96, AASHTO T 85 and AASHTO T 104 will be used to assess compliance. Other test procedures may be necessary as determined by the District Asphalt Manager or Research and Materials Engineer. To facilitate mix control, the source of aggregate material should not be changed during production.

401.3.2.2 Fine Aggregate

Depending on the type of HMA course to be constructed, the fine aggregate component of the HMA mixture may consist of sand; stone, slag or gravel screenings; or a combination of these materials. Fine aggregate material must be supplied from an approved SCDOT source, as listed on SCDOT Approval Sheet 1. The sampling and testing procedures SC-T-5 and SC-T-34 will be used to evaluate sand, and SC-T-5 and AASHTO T 176 will be used to evaluate screenings. The District Asphalt Manager or Research and Materials Engineer will ensure that the fine aggregate materials stockpiled at the plant are sampled and tested for compliance verification.

401.3.2.3 Mineral Aggregate and Filler

Depending on the gradation requirements of the type of HMA course to be constructed, the mineral aggregate required for the HMA mixture may be composed of fine aggregate material or a combination of coarse and fine aggregate materials. Note that the use of chrome slag is prohibited in HMA surface courses. To facilitate proportioning at the plant, the coarse and fine aggregate components will be stored separately in cold-feed bins, and the percent of each component, coarse and fine, will be based on the material retained or passing the No. 4 sieve, respectively. The District Asphalt Manager or Research and Materials Engineer will ensure that gradation and effective specific gravity of mineral aggregate are tested for compliance verification and that mineral filler conforms to the requirements of AASHTO M 17. Mineral filler is added for stabilization, but the quantity and type added can significant affect the mixture. If too much is added, the mixture may be difficult to roll and may become hard and brittle. During production, the source of mineral filler should not be changed and the amount added should be closely monitored. Note that mineral fillers must be kept dry in storage. If too much moisture is present, the mixture will look shiny and foamy, and the HMA will flatten in the truck bed.

401.3.2.4 Crusher-Run Material

The use of crusher-run material in HMA mixtures is prohibited, with the exception of select low-volume HMA mixes. If it is evident or suspected that crusher-run material is causing segregation in the mix, require the producer to screen the material so that the coarse and fine components can be separately stored in cold-feed bins and combined in the proper proportion at the plant.

401.3.3 Sampling Aggregate Materials

Unless an aggregate sample is truly representative of the material to be tested, the test results may be useless. Sampling accuracy is just as important, if not more so, than testing accuracy. Consider the following when obtaining aggregate samples from plant stockpiles:

1. Coarse Aggregate. Where coarse aggregate samples are obtained from plant stockpiles, the samples should be taken at random locations at or near the top of the stockpile, the base of the stockpile and at some intermediate point. When obtaining the sample, shove a board or piece of metal into the pile of material to prevent it from segregating while the sample is being removed.

2. Fine Aggregate. Where fine aggregate samples are obtained from plant stockpiles, first remove the dry layer of fines where most segregation occurs. Sample the wet or damp material underneath by inserting a sampling tube approximately 1.25 inches in diameter and 6 feet long into the material to obtain the sample.

It is difficult, but not impossible, to obtain accurate and representative samples from plant stockpiles. It is therefore good practice, where practical, to obtain aggregate samples from the cold-feed belt at the plant. Use caution when obtaining aggregate samples from the cold-feed belts. It is first necessary to stop the belt. Then, randomly select an area approximately 3 feet long for the sample. Use a board at each end of the sample to prevent segregation. Clean the entire sample area of the belt, and use a sample splitter to reduce the sample size, if necessary.

401.3.4 Aggregate Proportioning

Many methods are available to proportion aggregate materials to achieve the gradation for the HMA mixture; however, the most common method is trial and error used in conjunction with sound engineering judgment and experience. Generally, all that is needed for the procedure is a mechanical shaker, calculator, pencil and paper. The procedures are as follows:

- select the critical sieves for the blend and the initial proportion settings;
- calculate the blend on each sieve and check the blend against the specified limits; and
- adjust the proportion, as needed, to meet the specified limits.

401.4 ASPHALT MATERIALS

401.4.1 Types of Asphalt Materials

The following describes the types of asphalt materials typically used for HMA mixtures, asphalt tack coats and asphalt prime coats:

1. Asphalt Binder. The term asphalt binder refers, generically, to the asphalt material that is used in HMA mixtures to help bind aggregate particles together. The material is solid or semisolid at ambient temperature and is liquefied by the application of heat. Consider the following:

    a. Asphalt Cement. The term asphalt binder is not synonymous with the term asphalt cement. Asphalt cement is an asphalt binder that is graded based on viscosity and penetration values obtained through standardized testing, predicated on an older grading system. The nomenclature for asphalt cement includes, for example, AC-20 and AC-30. Asphalt cement is rarely used by SCDOT in HMA mixtures.

    b. Performance Graded (PG) Binder. Performance graded binders are based on a performance based specification developed by the Strategic Highway Research Program as part of the Superpave Method of HMA design. The nomenclature for performance graded binders includes, for example, PG 64-22 and PG 76-22. Performance graded binders are used exclusively by the Department for HMA mixtures.

    c. Polymer Modified Asphalt (PMA) Binder. A polymer modified asphalt binder, meeting the requirements of PG 76-22, is typically specified when high traffic loads are of concern. Prior to loading and transport, an elastomer polymer material is blended with a PG 64-22 or PG 67-22 base binder material to meet the specification.

2. Emulsified Asphalt. Emulsified asphalt is an emulsion of asphalt material, water and emulsifying agent that is used for various applications in HMA pavement construction, typically tack coats. It is liquid at ambient temperature. The components of asphalt emulsions tend to separate over time.

3. Cutback Asphalt. Cutback asphalt is a blend of asphalt material and petroleum solvents that is used for various applications in HMA pavement construction, typically asphalt prime coats on subgrade. It is liquid at ambient temperature. Cutback asphalts lose their volatile spirits by evaporation.

Asphalt materials must be supplied from SCDOT-approved sources as listed on SCDOT Approval Sheet 37, for asphalt binders, and Approval Sheet 38, for emulsion and cutback asphalts.

401.4.2 Properties of Asphalt Materials

Asphalt materials, such as asphalt binders for HMA mixtures, are suitable for highway construction because they are adhesive, waterproof, durable and flexible. The flowability (i.e., viscosity) and the specific gravity of an asphalt material changes with temperature. The higher the temperature, the more flowable the material becomes and the greater its volume becomes at the same weight. To assess the material's susceptibility to temperature with respect to flow, the viscosity of the material is typically measured. The specific gravity of asphalt material does not vary substantially with temperature; however, the volume of a given weight of asphalt material will increase with increasing temperature. This property must be considered when determining quantities of liquid asphalt material. Consider the following:

- ensure hauling and storage containers are clean to avoid cross-contamination;
- check storage tanks and coils regularly for signs of damage and leaks;
- ensure a calibrated thermometer is used to obtain temperature readings;
- record the material temperature in the tank regularly and safely;
- ensure the temperature is maintained far below the material's flash point;
- do not take readings near heating coils or the shell or bottom of the tank; and
- use the proper temperature-volume conversion factor to calculate quantities.

401.4.3 Performance Graded Binders

Prior to Superpave, asphalt binders were typically graded and selected based on viscosity and penetration values obtained from standardized tests. These asphalt binders, or asphalt cements, were commonly specified with nomenclature such as AC-20 and AC-30. Performance graded binders are based on a new performance based specification, developed as part of the Superpave Method. The physical properties of performance graded binders are identical to asphalt cements; however, the method of specifying and selecting the binder for an HMA mixture has changed and depends on the pavement's geographic location and application. Binder selection is based on factors such as climate, pavement temperature and traffic loading. Consider the following nomenclature for performance graded binder PG 64-22:

1. PG. The PG in PG 64-22 stands for "Performance Grade."

2. 64. The 64 in PG 64-22 indicates that the binder's physical properties must meet the high temperature requirements at least up to 64°C (147°F), which represents the average 7-day consecutive maximum design temperature. This number would be the high pavement temperature in the climate in which the binder is expected to serve.

3. -22. The -22 in PG 64-22 indicates that the binder's physical properties must meet the low temperature requirements at least down to -22°C (-8°F), which represents the minimum 1-day design temperature. This number would be the low pavement temperature in the climate in which the binder is expected to serve.

401.5 ANTI-STRIPPING MATERIALS

An anti-stripping additive is typically used in an HMA mixture to help prevent the asphalt binder from stripping off the aggregate under the influence of moisture and traffic. Liquid anti-stripping agents must be supplied from SCDOT-approved sources and their use must be approved by the Research and Materials Engineer. If hydrated lime is approved for use as an anti-stripping additive, verify that it conforms to the requirements of AASHTO M 303, Type 1 and is supplied from an SCDOT-approved source, as listed on SCDOT Approval Sheet 39. Alternatively, as approved for use, hydrated lime will be added at a specified rate as a percentage of the weight of dry aggregate.

401.6 RECYCLED MATERIALS

401.6.1 Recycled Asphalt Pavement (RAP)

401.6.1.1 SCDOT RAP Milling Projects

As an integral part of the Department's pavement rehabilitation program, SCDOT routinely performs milling projects on asphalt pavements. The material removed from the surface of the old asphalt pavement will be either reused or disposed of at an approved site. If disposed, the Contractor must dispose of the material in accordance with the requirements of and at a site approved by SCDHEC. However, the milled material, or RAP, tends to be a good source of aggregate and asphalt binder material for new HMA courses. If the RAP material is recycled, it will be properly stockpiled for use on other SCDOT projects. There are critical administrative and testing requirements associated with managing RAP stockpiles and using RAP in new HMA mixtures.

401.6.1.2 RAP Stockpiles

When RAP material is permitted in an HMA mixture it should be free of debris, properly crushed, uniformly graded and stockpiled at an HMA plant. RAP stockpiles will be thoroughly tested prior to use and must be identified and maintained separately. Stockpile identification numbering is critical to SCDOT operations and will be strictly enforced to minimize intermingling of different RAP materials, which causes production problems after the stockpile has been tested and approved for use. The HMA Quality Manager will be responsible for maintaining records at the plant for all RAP stockpiles used on the project.

The District Asphalt Manager will visually inspect RAP stockpiles to ensure compliance. Ensure that stockpile numbers are used to properly track materials from source through production.

401.6.1.3 Recycled HMA Mixtures

The Contract Specifications will define the allowable percent RAP in each mixture; however, a limited amount of RAP will be permitted if the material is introduced in the plant's hot elevator. The percent RAP will directly affect the quantity of screenings and No. 789 stone used in the recycled HMA mixture. The HMA Mix Design Technician will be responsible for submitting the following to the Research and Materials Engineer for approval:

- RAP stockpile records, including results of extraction testing;
- sample of stockpiled RAP material or cores from pavement to be milled; and
- Job Mix Formula reported on Research and Materials Laboratory Form 269.

Note that if the RAP material to be used in the recycled HMA mixture has not yet been milled and stockpiled, extraction testing will be based on a specified minimum number of extraction tests and random field tests conducted by the Research and Materials Engineer or District Asphalt Manager, as appropriate. Approval of the recycled asphalt binder will be based on viscosity criteria in accordance with the specifications.

401.6.2 Asphalt Roofing Shingles

401.6.2.1 Source of Shingles

Asphalt roofing shingles found in construction debris are a potential material source for HMA mixtures. The shingles are generally obtained from landfills, cleaned of foreign matter (e.g., nails) and ground at ambient temperature so that the size of the remaining particles are smaller than 0.5 inch. The shingle material must be free of hazardous materials (e.g., asbestos) and meet the environmental requirements of SCDHEC.

401.6.2.2 Use of Shingles in HMA Mixtures

The use of recycled asphalt shingles is permitted in an HMA mixture, as specified. The Job Mix Formula for each type of mixture will define the allowable quantity of shingles and is generally limited to 3% to 8% by total weight of aggregate. The Job Mix Formula, will be submitted to the Research and Materials Engineer for approval and include the proposed type and quantity of recycled shingles, fine and coarse aggregates, asphalt binder and anti-stripping additive. Gradation and asphalt binder content will be tested in accordance with AASHTO T 27 and SC-T-75, respectively. Because the shingle material contains asphalt material, a correction factor will need to be applied to determine the correct quantity of virgin asphalt binder required for the mixture.

401.7 DESIGN OF HMA MIXTURES

An HMA mixture is a combination of high quality aggregate, asphalt binder and admixtures. The mixture will be designed to meet the physical and chemical properties specified for the particular type of HMA course to be constructed. HMA mixtures are designed by the Contractor and approved by the Research and Materials Engineer.

401.8 HMA MIX PRODUCTION AND HAULING

401.8.1 General

HMA plants mechanically blend aggregate and asphalt binder materials together to produce a hot, homogeneous paving mixture. The HMA Quality Manager, District Asphalt Manager and Research and Materials Engineer are responsible for verifying plant conditions and operations (e.g., certification, scales and weights, materials, mix proportions, mix temperatures). Before production, become familiar with the features of the type of plant being used and thoroughly examine the plant for compliance with the Contract Specifications. Any mechanical or safety deficiencies should be corrected immediately. The Contractor is responsible for ensuring that the plant laboratory is provided in accordance with the Contract Specifications. The laboratory should be located so that production operations are readily visible. The laboratory should contain copies of all necessary reference materials applicable to the project.

401.8.2 Plant and Production Considerations

Consider the following during HMA plant and production inspection:

1. Use of Multiple Plants. The use of multiple plants to supply HMA on a day-to-day basis is generally not permitted unless needed for separate paving operations at different locations on the project. Prior SCDOT approval is required.

2. QC / QA Procedures. Before production, check the Contractor's Quality Control Plan for compliance with the Contract Specifications, and ensure the Contractor has provided the required number and type of Certified HMA Technicians. Make sure you understand both Contractor and SCDOT responsibilities with respect to quality control, verification and acceptance procedures. During production, check that the HMA Technicians are sampling and testing in accordance with the Quality Control Plan. Make sure the Contractor submits the required test reports in a proper and timely manner.

3. Plant Laboratory. Check that the plant laboratory has been certified by the Research and Materials Engineer for compliance with the Contract Specifications, and ensure all test equipment has been properly calibrated.

4. Storage Silos. Requests for overnight storage of HMA will be evaluated based on SC-T-79 and must be approved by the Asphalt Materials Engineer. Reject HMA stored in a silo that does not comply with specified requirements.

401.8.3 Loading and Hauling Considerations

Consider the following during loading and hauling inspection of the HMA mixture:

1. Scale Certification. Check that the truck scale has been properly certified. The seal of current approval should be affixed to the scale.

2. Truck Weighing. Frequently check the truck weighing process to ensure that it is in compliance with the requirements of the Contract Specifications. Pay particular attention

to the weighing platform. It should be clean and free to move with no binding. Check that scale tickets have complete and proper information and are supplied with each load of mix.

3. Release Agents, Tarps and Insulation. Visually inspect haul trucks and truck beds for compliance during loading. Release agents must be supplied from an SCDOT-approved supplier, as listed on SCDOT Approval Sheet 17. Ensure that truck beds are clean, with no foreign substances or dried chunks of mix present. Ensure that proper tarps in good condition are being used on every load.

4. Truck Loading. If trucks are not loaded properly, segregation of the mix is inevitable. Trucks should be laterally centered (i.e., left to right) under the discharge gate of the surge silo. Do not allow trucks to be loaded in one big dump or by slowly driving forward while dropping the mix from the silo. Trucks should be loaded in multiple (e.g., first drop at the rear, second drop at the front, alternating drops in between). From three to seven drops may be necessary depending on the size of the truck (e.g., single unit, semi). Under no circumstance allow the mix to dribble from the bottom gate of the surge silo into the bed of the truck.

5. Mix Appearance. Develop a mental picture of the appearance of the proper mixture when loaded in the truck. A load of mix that peaks more than usual is an indication of a lean mix (i.e., too much fines and/or insufficient asphalt binder). A load that flattens in the truck bed indicates a fat mix (i.e., too much asphalt binder, too much coarse aggregate, and/or insufficient fines). Occasionally check with the Resident Construction Engineer at the laydown and compaction site concerning the workability and uniformity of the mixture being delivered.

401.8.4 Production and Hauling Inspection – Summary

401.8.4.1 Component Materials and Job Mix

The District Asphalt Manager or SCDOT Plant Inspector, as assigned, should inspect the materials and mix at the HMA plant as follows:

- Verify there is an approved Job Mix Formula for the project.
- Check that materials on the Job Mix Formula are being used in the mix.
- Verify compliance of fine and coarse aggregates with Contract Specifications.
- Check that aggregates in stockpiles and bins are not intermixing.
- Verify aggregate stockpiles are constructed to avoid segregation and contamination.
- As applicable, verify compliance of the HMA mixture with respect to:

  - gradation,
  - asphalt binder content,
  - dust-to-asphalt ratio,
  - gradation spread between sieves,
  - air voids,
  - voids in mineral aggregate,

- stability,
- lime rate, and
- other mix properties, as applicable.

401.8.4.2 Production and Hauling Equipment

The District Asphalt Manager or SCDOT Plant Inspector, as assigned, should inspect HMA plant equipment and operation as follows:

- Verify compliance with Contract Specifications and SC-T-94.
- Check that equipment is in good mechanical condition.
- Verify approval of hydrated lime system by Research and Materials Engineer.
- Check proper operation of baghouse.
- Ensure fines are properly reintroduced into the mix.
- Check that scales have been certified within the last 6 months.
- Check the adequacy and accuracy of the plant scale tickets.
- Check compliance of haul trucks and truck-bed covers.
- Verify use of approved release agent in truck beds.
- Ensure field laboratory has been approved by Research and Materials Engineer.
- Verify loader operator is working the full face of stockpiles.

401.8.4.3 Production, Loading and Hauling Operations

The District Asphalt Manager or SCDOT Plant Inspector, as assigned, should inspect production operations at the HMA plant as follows:

- Verify Contractor inspection, sampling and testing of mix production is adequate.
- Check compliance of asphalt binder, aggregate and mix temperature.
- Verify calibration of the plant by the Contractor.
- Verify that cold-feed bins are feeding properly.
- Check that the mix is uniformly coated with asphalt binder.
- Check for segregated mix in truck beds.
- Verify proper loading of trucks (i.e., front, back, middle).
- Verify that hydrated lime is feeding and mixing properly.
- Check that conveying device is depositing mix into center of silo or batcher.
- Verify that batcher is being used at top of the silo.
- Check for proper closure of gates on batcher.
- Ensure mix is not dribbled into truck to complete a load.

401.9 HMA MIX LAYDOWN AND COMPACTION

401.9.1 General

Although construction may take several months, public opinion of the Department is ultimately based on the final quality of the pavement and the effectiveness of traffic maintenance during

construction. Unsafe or inefficient traffic operations during construction and bumps, choppy waves, long swells and the early appearance of cracks, potholes and raveling joints are highly criticized. The Resident Construction Engineer, Roadway Inspectors, HMA Quality Manager and Asphalt Roadway Technicians at the laydown and compaction site must be proactive in enforcing the Contract Specifications to ensure the provision of safe and efficient traffic operations and a smooth riding surface. The principal duties of the Resident Construction Engineer and Roadway Inspectors at the laydown and compaction site are to verify that the Contractor constructs the HMA pavement to the lines, grade and cross-section required by the Contract Plans and to the density, riding surface and texture required by the Contract Specifications. To achieve this objective, the Roadway Inspectors must continually monitor surface preparation, mix delivery, paving operations, compaction operations and the finished surface for compliance.

401.9.2 Pre-Paving Considerations

401.9.2.1 General

Prior to starting paving, become thoroughly familiar with the Contract Plans and Specifications, including the requirements of the Quality Control Plan, Job Mix Formula, Contractor's paving plan, and Traffic Control Plan. Verify that the proper Certified Asphalt Roadway Technicians, traffic control and paving and compaction equipment are in place and in conformance before paving begins. Inspect the paving surface for correct grade and cross-section and that the surface has been adequately prepared. If the paving surface is soil or aggregate, check that any required asphalt prime coat has been applied and properly cured and/or that water has been applied for dust control. To ensure paving continuity, check that pavement edges are marked at the correct width and grade by taut stringline or electronic paver guide.

401.9.2.2 Longitudinal Joint and Pavement Marking Plan

The Contractor and Resident Construction Engineer should review and agree on a plan for the location and configuration of longitudinal joints and pavement markings prior to beginning work. The longitudinal joint for the final lift should be offset 6" from the lane line.

401.9.2.3 Contractor's Paving Plan

Prior to the start of work, the Resident Construction Engineer and the Contractor should review the Contractor's plan for paving the project. Review the plan and discuss with the Contractor any needed adjustments. During the project, verify that the Contractor places the HMA as previously agreed upon.

401.9.2.4 Communications During Production and Paving

During the project, quality and safety depend on continued positive and meaningful communication between the Research and Materials Engineer, District Asphalt Manager,

Resident Construction Engineer, Roadway Inspectors, HMA Quality Manager, HMA Mix Design Technician and Asphalt Roadway Technicians. Frequent informal meetings provide a forum for meaningful dialog to mitigate potential cost and scheduling problems. In addition, frequent communications between plant and project personnel provides critical feedback to ensure a quality pavement. Key points of discussion should be noted in the Daily Work Report.

401.9.2.5 Weather Considerations

Weather plays an important role in determining whether or not the Contractor should begin or continue with HMA paving, tacking or priming operations. Consider the following guidelines:

1. Wet Weather. Monitor the weather forecast regularly to assess the possibility of rain. The laydown surface must be dry (i.e., no standing water) and the weather conditions must permit the proper handling, finishing and compaction of the mix. If rain is imminent or the surface is wet – DON'T PAVE. As soon as practical, direct the HMA Quality Manager to consider halting production. Paving should not be started again until standing water is no longer visible on the surface. When downpours occur, the paver should be stopped, the receiving hopper covered and the crew advised to wait until there is no standing water on the surface.

2. Cold Weather. The ambient air temperature will be measured in the shade away from artificial heat with a calibrated thermometer in accordance with SC-T-84. During cold weather paving, measure temperature at least once an hour, monitor mix temperature for each truckload delivered and measure mat temperature at final density to ensure conformance with the Contract Specifications. Mix temperatures will be recorded on the mix delivery ticket and Daily Work Report.

401.9.3 Equipment Considerations

401.9.3.1 Paving Machines

One of the most important pieces of equipment is the paver. The paver must be capable of spreading and finishing the HMA mixture to the required cross-section and profile. The self-propelled paver must be equipped with a heated strike-off assembly or activated screed and either mechanical or automatic grade and slope controls. Automatic controls are necessary only if specified in the Contract. If automatic controls fail, allow the Contractor to complete the day's work via manual control. The controls must be fixed prior to resuming production. Check grade and slope controls periodically for proper working order. Consider the following additional points of inspection:

- hoppers and distribution screws or augers are in good condition;
- paver motor governor is operating smoothly without missing;
- track linkage, if present, is properly adjusted and tracks and pins are not excessively worn;

- pneumatic tires, if present, are inflated to correct pressure and chain drives are properly adjusted and not excessively worn;
- tamper bars are adjusted to correct RPM, proper clearance from screed, proper length of stroke and are not excessively worn;
- screed vibrator, if provided, is operating properly;
- strike-off plate is set at proper height above screed;
- screed plates are not excessively worn and are adjusted for proper height, crown and tilt;
- screed heater is operating properly;
- screed extensions, if used, are in a true plane and flush with screed bottom; and
- automatic controls for cross slope, thickness and longitudinal profile, including 40-foot long mobile stringline or ski, leveling reference and grade sensor, have been calibrated and are operating properly

Roadway Inspectors must be familiar with the surface defects that can be caused by improper adjustment or operation of the paver (e.g., segregation, tearing, shoving, gouging). Poor results will not be accepted. If adjusted and operated properly, little hand work should be required. Hand methods and special equipment may be used for small or irregular areas, if previously approved. However, it is poor practice to scatter loose material to improve mat texture due to paver problems. Proper paver speed will result in a quality mat with uniform texture and density across the full width, provided the mixture and other conditions are satisfactory. Paver speed must be in balance with mix delivery and sufficiently slow to avoid tearing the mat. If tearing occurs, repairs must be made and the paver speed adjusted. Stop and go operations of the paver should be avoided.

401.9.3.2 Compaction Equipment

Depending on the sequence of operation established by the Contractor for placing, compacting and finishing, the rollers used for breakdown, compaction and finishing rolling will include steel-wheel rollers, pneumatic-tire rollers, vibratory rollers, or some combination of the three. However established, the rolling operation must compact the HMA mat to target density and provide a smooth surface without excessively crushing the aggregate. Pneumatic-tire rollers are equipped with smooth tires of equal size and ply. Tire pressures and loading of the roller can be varied to achieve the desired contact pressure. Pneumatic-tire rollers should have a contact rolling width of not less that 60 inches and be capable of developing contact pressures from 40 to 90 pounds per square inch (80 psi is recommended). The tire pressure in all wheels should not vary more than 5 pounds per square inch. Vibratory rollers should weigh at least 8 tons with one or both wheels capable of vibrating. In inaccessible areas, hand held rollers and vibrating plates are generally used. Consider the following points of inspection:

- wheels are capable of rolling in a true plane and are free from flat spots or ridges;

- steering and driving mechanism is free of excessive play or backlash;
- motor and transmission free from leaks;
- roller's water tank, wetting mats and spray bars are properly operating;
- pneumatic tires are properly inflated and in good condition without wobble or creep;
- vibration and propulsion controls of vibratory rollers are set and operating properly; and
- total weight, weight per inch of width, average ground contact pressure and/or vibrations per minute and amplitude set and properly documented.

The compaction density obtained by pneumatic-tire and steel-wheel rollers is related to the weight, speed and the number of roller passes. A maximum speed of 3 miles per hour is recommended for steel-wheel static and vibratory rollers and 5 miles per hour for pneumatic-tire rollers. The density obtained by a vibratory roller is primarily related to the frequency (i.e., number of vibrations or downward impacts per minute, VPM) and the amplitude (i.e., the greatest amount of movement in one direction from a position at rest). As the vibratory roller travels, the vibrating drum produces rapid impacts on the surface of the mat. These impacts produce pressure waves of equal frequency that pass through the mix. The pressure waves cause the particles to move closer together, thus densifying the mix.

401.9.3.3 Miscellaneous Equipment

Where rumble strips will be constructed, verify compliance of the milling equipment. It is also good practice before the paving day begins to visually check to see that the Contractor has available an adequate supply of rakes, lutes, shovels, brooms and other needed miscellaneous equipment.

401.9.4 Surface Preparation Considerations

Before placement of the HMA mixture, the surface must be shaped to the correct grade and cross-section and properly prepared. The preparation activities primarily will depend on the type of surface over which the HMA will be placed. Consider the following:

1. Subgrade. The subgrade will be prepared in accordance with the requirements discussed in Section 208.

2. Subbase and Base Course. Subbase and base course will be prepared as discussed in the respective sections of Division 300.

3. Patching and Leveling. Depending on the condition of the underlying surface, rough and uneven asphalt surfaces are typically leveled by either placing a patching and leveling course or by milling high spots on the existing surface. The purpose of the patching and leveling course is to repair potholes, correct surface irregularities (e.g., short dips), shape the cross-section and raise the existing outside edge to provide a uniform template. If designated, the application of asphalt tack coat will be applied before the

patching and leveling course is laid. If patching and leveling is not specified in the Contract, ensure that the Contractor corrects surface irregularities with an appropriate mix material. Where extensive base failures are encountered and no Contract provisions are specified for repairs, notify the Resident Construction Engineer. It may be necessary to modify the Contract to correct the problem.

4. Full-Depth Patching. At locations designated by the Resident Construction Engineer, verify compliance of full-depth patching.

5. Cleaning and Sweeping. Once the underlying surface is repaired, the paving surface must be cleaned of all dust, dirt and caked or loose debris. This is usually accomplished using multiple passes of a mechanical broom and/or flushing with air or water. The limits of cleaning and sweeping are generally beyond the width of paving.

6. Asphalt Prime Coat. Prior to HMA paving, an asphalt prime coat is generally applied over new base construction such as sand-clay base course, coquina shell base course and macadam base course to prevent slippage and base shifting and to protect against weather. Note that an asphalt prime coat is not required when paving directly over the subgrade.

7. Asphalt Tack Coat. Prior to paving over existing pavement, unsealed asphalt surface courses and successive layers of Sand Asphalt Base Courses, including adjacent contact surfaces, an asphalt tack coat will be applied to promote bonding. Consider the following:

   a. Material. Asphalt tack coat will be either asphalt binder or emulsified asphalt. Note that emulsified asphalt must be diluted at the manufacturing plant, not at the project site. Check that the grade of material conforms to specified requirements. The nomenclature used is as follows:

      RS = Rapid Setting (cannot be diluted);
      MS = Medium Setting;
      SS = Slow Setting; and
      HF = High Float.

   b. Rate of Application. Check and record the rate of application on SCDOT Form 400.04 – Daily Report of Asphalt Road Inspection. SCDOT procedure SC-T-86 will apply. The specified rate will be verified and monitored throughout application by the Resident Construction Engineer. Verify uniform application and lapping. Hand sprayers should only be used where necessary, such as for inaccessible areas and contact surfaces. Ensure the Contractor cleans up overspray and does not foul traffic.

   c. Timing of Application. The application of asphalt tack coat should be far enough ahead of paving to allow curing, but not so far in advance that the tack loses its adhesiveness. Contact surfaces (e.g., headers, curbings, gutters, edges of existing pavement, manholes, catch basins) should be tacked just before HMA is placed against them.

401.9.5 Delivery of Mix

401.9.5.1 General

The construction of an HMA pavement begins with the delivery to the paving site of a workable mix that is proportioned and heated to conform to the requirements of the *Standard Specifications* and the Job Mix Formula. The pavement will not perform as intended if the temperature or material proportions exceed the limits specified for the type of HMA course being constructed. For example, if the quantity of asphalt binder is too low, the pavement will become brittle and crack under traffic loading. Brittleness also may occur if the binder material itself is too hard as a result of overheating the mix. Excessive binder material will cause the pavement to move under traffic and push up in waves or cause the binder itself to come to the surface, which causes a hazardous traffic condition during wet weather. During production, it is good practice to visually check the mixture for signs of unacceptability. If a problem is encountered or suspected, contact the HMA Quality Manager immediately to take corrective action.

401.9.5.2 Mix Temperature

Upon delivery to the spreader, mix temperature must be within tolerance of the limits specified in the Contract Specifications. Otherwise, the mix should be rejected. If cold weather production is approved the mix temperature should be increased, but not beyond the master temperature threshold. Monitor mix temperature at both the plant and the paving site. To obtain mix temperature, a calibrated dial-type thermometer can be inserted through the access panel in the gate of the haul truck. When operating under cold weather paving provisions, the temperature of each truckload should be recorded, checked for compliance and documented on SCDOT Form 400.04 – Daily Report of Asphalt Road Inspection.

401.9.5.3 Inspection Upon Delivery

Loads of mix must only be allowed to leave the plant if they can be placed and compacted the same day. To prevent unnecessary heat loss, the tarp over the truckbed should remain in place until just before the truck is emptied. Pay attention to the length of time the load remains in the truck. Excessive haul times and layovers promote heat loss, which may render the mix unacceptable. Visually inspect the mix for acceptability. It is better to reject a bad mix than to reject a bad pavement. Unacceptable mix should be rejected at the plant before it is hauled to the project; however, Roadway Inspectors and Asphalt Roadway Technician's must be able to spot non-complying mix before it is placed and compacted. In addition, a rapid means of communication between plant and roadway personnel is essential to establishing a workable mix and keeping load rejections to a minimum. There are several common mix deficiencies that should be monitored. Consider the following:

1. Mix Temperature. Reject the mixture if its temperature is not within tolerance of the Job Mix Formula and the master range of the Contract Specifications. A mix that is too cold may appear stiff or have an improper coating of the larger aggregate particles. A mix that is too hot may have blue smoke rising from the truck or spreader hopper. Temperature deficiencies are common and should be closely monitored and documented in the Daily Work Report.

2. Asphalt Binder Content. A mix that has too much or not enough asphalt binder should be rejected. If there is too much binder, the mix generally will not peak, but flatten in the truck bed. It may also appear slick under the paver screed. If there is too little binder, the mix may appear granular and lack a shiny black luster. The aggregate also may not be completely coated.

3. Aggregate Proportioning. Reject the mix if aggregate proportioning fails to meet specified requirements. A mix that has too much coarse aggregate generally will have a coarse appearance and exhibit poor workability (i.e., tough to spread and compact). A mix that has too much fine material will usually have a dull brown appearance and be difficult to work with.

4. Moisture Content. Too much moisture in the mix is grounds for rejection. A mix with too much moisture may have steam rising when dumped into the hopper and may be bubbling and popping.

5. Contamination. Check the mix for contamination, which may include gasoline, kerosene, oil, rags, dirt or trash that has inadvertently found its way into the mix. Minor contamination may be removed; serious contamination warrants rejection of the load.

6. Segregation. Segregation of the coarse and fine aggregate components is a very common problem with HMA mixtures and occurs because of improper handling and many other factors. Segregation is serious and is grounds for rejection.

7. Non-Uniform Mixing. Non-uniform mixing produces a mixture that contains spotty, dull brown appearing mix intermingled with mix that has a rich and shiny appearance. This type of mix is unacceptable and should be rejected.

401.9.6 Placement Considerations

Once production has been established, the Contractor will begin placing the mix. It is good practice for Roadway Inspectors to observe the paver operation for obvious substandard or improper operation. Soon after the first load of mix has been spread, check the surface of the mat to ensure that a uniform texture is achieved and that the thickness, grade and cross-section are in compliance with the Contract Plans. Ensure that the Contractor makes any needed repairs to the mat when the material is still hot and properly adjusts the paving operation. Consider the following guidelines:

1. Edge of Pavement. The exact edge of pavement should be established by a string or chalk line for a distance of not less than 500 ft ahead of the paving operation.

2. Screed Temperature. The screed should be heated to the proper temperature before the paving operation begins.

3. Transfer Operation. Verify that the haul truck aligns properly with the paver hopper. Haul trucks should not bump or transfer weight to the paver. Otherwise, the paver may be thrown off line, or the screed may be pushed into the mat. Each truck should stop short of the paver and allow the paver to pick up the truck instead of the truck backing up

and possibly bumping the paver. Use of a material transfer device (e.g., shuttle buggy) is encouraged.

4. Dumping Procedure. Before the tailgate of the truck is opened, verify that the operator first raises the truck bed to move the mix to the tailgate. Once the tailgate is opened, the mix will surge, not dribble, into the hopper, which minimizes segregation. Check that the truck bed is completely emptied. If mix is spilled on the roadway in front of the paver, ensure that it is removed before the paver moves ahead.

5. Hopper Level. Verify that the paver hopper is kept more than half full at all times. The mix level in the hopper should not drop below the bottom of the flow gates. The hopper should not be emptied to the point where slat conveyors are visible, and the hopper should not be so full that mix runs out the front.

6. Clinging Mix. Fresh hot mix that clings to the sides and corners of the hopper should be continually loosened and pushed into a relatively full hopper. Clinging mix cools rapidly and, if permitted to reach the mat, will result in a non-uniform surface texture. Verify that such mix is not pushed into the hopper. Wings on the paver can be folded into a full load if necessary; however, it is preferred that paver wings be dumped and the mix properly disposed of at the end of each day.

7. Paver Movement. The paver should be operated in manner to avoid gradual deceleration and acceleration. This will minimize imperfections and damage to the mat such as holes, tears and drags. Maintaining a constant paver speed will improve rideability. The operator should use the slowest paver speed that will accommodate production and delivery of the mix and maintain a constant head of mix in front of the screed. If the mix pulls or tears under the paver, suspend paving until the cause can be determined and corrected. The speed of the paver may be too fast.

8. Flow Control. Flow gates should be set at a height that permits the slat conveyor and auger to operate at close to 100% capacity. The key to a smooth surface is a constant head of mix in front of the screed, which depends on constant paver speed and continuous operation. The mix in front of the screed should be located near the center of the auger shaft. If automatic flow-control devices are used, the flow-control device should be set at a location near the end plate. This will cause the auger to run continuously and maintain a constant head in front of the screed; otherwise, mix may be carried at the screed's outside edge.

9. Thickness, Grade and Slope Controls. Prior to paving, thickness, grade and slope controls should be established and then monitored during paving for proper operation. If automatic screed controls are used for grade and slope adjustment, it is good practice for the Roadway Inspector to become familiar with their proper operation. Consider the following:

   a. Screed Adjustment. The paver operator should not adjust thickness controls for the purpose of changing the screed's angle of attack, unless the mat thickness actually needs to be adjusted.

   b. Grade Sensor. The grade sensor should be in constant working order. If the wand is raised through input from the stringline or mobile reference, there should

be a corresponding movement of the actuator. If not, sensitivity adjustments may be needed. During paving, sensor indicators should properly indicate the signal being received.

c. Tow-Point Actuator. The movement of the tow-point actuator should be smooth, without a constant up and down movement.

d. Stringline. If a stringline is used as the grade reference, the line should be taut without sags between vertical supports, as visually verified by sighting down the line. The vertical supports must not interfere with the path of the wand. Once set, the integrity of the stringline should be protected.

e. Mobile Reference. If a mobile reference (e.g., 40-foot ski) is used for grade control, its length should be sufficient to compensate for variations in surface elevation, and each shoe should be checked to ensure that it is clean and free to move. The sensor should be checked for proper operation.

f. Joint Matching Shoe. If a joint matching shoe is used for grade control, check the shoe for proper operation. It should be clean and free to move.

g. Combined Grade/Slope Control. If the paver has grade control on one side and slope control on the other, regularly check the cross slope for compliance. This is particularly important on wide paving jobs.

h. Failure of Automated Controls. If the automated control system of the paver fails, suspend paving until the Contractor fixes the control system.

10. Joint Alignment. Joints in a lift or course should be offset from the joint in the underlying lift or course in accordance with the Contract Specifications.

11. Temperature of Underlying Lifts. Prior to paving a subsequent lift, check to ensure the interior of the previous lift has cooled appropriately (i.e., typically to about 175°F).

12. Spread Rate. Verify that project stationing has been clearly marked for the purpose of documenting mix placement and yield checks. Review the method that will be used to perform rate checks. The procedures of SC-T-85 will apply. The rate should be checked frequently to ensure the proper quantity of mix is being placed.

13. Hand Methods. Approved hand methods will be used to place mix in areas that are inaccessible to the paver (e.g., turnouts, driveways). Verify that raking is performed without causing the mix to segregate or requiring excessive rework.

14. Height Above Adjacent Structures. Verify that the final surface is approximately 0.25 inches above the edges of adjacent structures such as gutters and manholes.

401.9.7 Compaction Considerations

401.9.7.1 General

The Contractor will be responsible for establishing the number, type and pattern of rollers needed to achieve target density in the HMA mat and for monitoring the density obtained during compaction. Approved hand methods will be used for those areas inaccessible to rollers. The Resident Construction Engineer and Roadway Inspectors will be responsible for verifying and assessing Contract compliance and adjusting payment, if necessary. Sampling, testing and documentation procedures differ based on the type of HMA course being constructed. Know the quality control, acceptance and verification responsibilities of Contractor and SCDOT personnel with respect to sampling, testing and documentation (e.g., SC-T-65, SC-T-101), in-place density, density gauge testing, core sampling and testing. Documentation of the compaction operation and the density obtained are critical project records. Use SCDOT Form 400.16 – In Place Density Contractor QA or SCDOT Form 400.17 – In Place Density Contractor QC / QA PWL, as appropriate.

401.9.7.2 Maximum Compacted Lift Thickness

Based on the thickness specified for the HMA course to be constructed, the course may need to be constructed in multiple lifts. To compensate for the densification that occurs during compaction, the paver will need to place the mixture in a thicker layer than that required for the compacted lift, subject to this maximum criteria. The final compacted lift thickness should not exceed the specified maximum.

401.9.7.3 Factors Influencing Compaction

Factors such as aggregate, asphalt binder, mix properties, mix temperature, lift thickness and weather conditions will affect the compaction of HMA courses. Use Figure 401A to guide decision making when evaluating problems and potential changes to the compaction operation.

401.9.7.4 Temperature Susceptibility

The time available for compaction is related to temperature and the thickness of the HMA material being placed. An increase in lift thickness can substantially increase the time available for the roller to densify the mix. Mix temperature greatly influences the compaction operation and affects mix stiffness and workability. If too high, the mix will move or shove under the roller. If too low, the mix will be difficult to compact. The proper mix temperature will allow sufficient time to achieve the required density before the mat cools too much for further rolling to be effective. An increase in laydown temperature can significantly increase the amount of time available for compaction; however, the feasibility of using this approach depends on the properties and tenderness of the mix at the selected temperature and compaction effort. Ambient temperature is a primary consideration, particularly in the spring and fall seasons. As needed, contact the Asphalt Materials Engineer for information on mix temperature and optimum compaction time. The required density should be obtained prior to the mat

temperature reaching 175°F. Mat temperature is normally measured using a non-contact infrared thermometer.

The “tender zone” is a temperature range where compactive effort causes the mix to move or shove under the roller. Above and below the range of the tender zone, the mix is generally stable enough to be rolled. The tender zone greatly affects the rolling sequence and the time allowed for compaction, especially during hot weather. For example, because tender mixes generally cure much slower, the finish rolling operation can be significantly delayed. Tenderness occurs more often with fine-graded surface mixtures and mixes with high asphalt binder content and excessive moisture. Some mixtures can sometimes be problematic, because they often exhibit tenderness within the temperature range required for target density.

Where mix tenderness becomes an issue, it is desirable to compact the mix to target density at a temperature above the tender zone. This may be achieved by performing breakdown and intermediate rolling immediately behind the paver and finish rolling at a temperature below the tender zone. If unsuccessful, breakdown rolling should commence immediately behind the paver and both intermediate and finish rolling should begin as soon as the mix becomes stable. The latter, however, may result in compaction occurring at a temperature less than the desired minimum of 175ºF. Under such situations, the criteria specified in the Contract for minimum density and minimum temperature requirements may be in conflict. It is generally more important to obtain target density than it is to conform to the specified minimum temperature requirement.

The compaction equipment and procedures established by the control strip should be used to circumvent anticipated problems with tender mixes. Be aware, however, that inadvertent changes in mix production (e.g., excessive binder content, wet aggregate, improper gradation) can change the behavior of the mix with regard to the tender zone and should be closely monitored during compaction. If problems are experienced during the project, contact the Research and Materials Engineer for guidance and recommendations.

401.9.7.5 Roller Pattern and Speed

The optimum combination of rollers and the roller pattern for one type of HMA material may not be the same as that required for another. Test sections, such as control strips, are used to establish the most effective combination of rollers and patterns to obtain target density in the HMA mixture being produced. It is not good practice to make more roller passes than required to obtain target density. Two rollers running side by side may produce better results than two rollers operated end to end behind the paver. In general, the compaction operation will be sequenced as follows:

1. Breakdown Rolling. Breakdown rolling is the first series of passes of rollers on the freshly placed mat just behind the paver. It is used to breakdown and consolidate the mix.

2. Intermediate Rolling. Intermediate rolling is the second series of passes of rollers and takes place just after breakdown rolling. It is typically performed to obtain the required mat density before the mix cools to 175ºF.

CHARACTERISTIC	INFLUENCE	COUNTERMEASURE
Aggregate		
Smooth Surfaced	Low interparticle friction.	Use light rollers. Lower mix temperature.
Rough Surfaced	High interparticle friction.	Use heavy rollers.
Unsound	Breaks under steel-wheeled rollers.	Use sound aggregate. Use pneumatic rollers.
Absorptive	Dries mix – difficult to compact.	Increase asphalt binder in mix.
Asphalt Binder		
High Viscosity	Particle movement restricted.	Use heavy rollers. Increase temperature.
Low Viscosity	Particles move easily during compaction.	Use light rollers. Decrease temperature.
High Content	Unstable and plastic under roller.	Decrease binder in mix.
Low Content	Reduced lubrication – difficult to compact.	Increase binder in mix.
Mix Properties		
Excess Coarse Aggregate	Harsh mix – difficult to compact.	Reduce coarse aggregate.
Excess Sand	Too workable – difficult to compact.	Reduce sand in mix. Use light rollers.
Too Much Filler	Stiffens mix – difficult to compact.	Reduce filler in mix. Use heavy rollers.
Too Little Filler	Low cohesion – may come apart.	Increase filler in mix.
Mix Temperature		
High Temperature	Mix lacks cohesion – difficult to compact.	Decrease mix temperature.
Low Temperature	Mix too stiff – difficult to compact.	Increase mix temperature.
Course Thickness		
Thick Lifts	Holds heat – more time to compact.	Roll normally.
Thin Lifts	Loses heat – less time to compact.	Roll before mix cools. Increase mix temperature.
Weather Conditions		
Low Air Temperature	Cools mix rapidly.	Roll before mix cools.
Low Surface Temperature	Cools mix rapidly.	Increase mix temperature.
Windy Conditions	Cools mix – crusts surface.	Increase mix temperature.

FACTORS INFLUENCING COMPACTION OF HMA MIXTURES
Figure 401A

3. Finish Rolling. Finish rolling is performed after intermediate rolling to improve the finish of the surface. It is performed while the mix is warm enough to permit the removal of roller marks.

Once the roller pattern has been established to obtain target density for the mixture, the method should not changed unless the mixture or lift thickness changes. Monitor the roller pattern to ensure that the same compactive effort is being applied at all points transversely across the lane being paved. The following rolling sequence, in the order listed, is generally used when paving with two pavers (i.e., in tandem) or abutting a previously placed lane:

- transverse joints,
- longitudinal joints,
- edges,
- breakdown rolling,
- intermediate rolling, and
- finish rolling.

Rollers should be oriented with the drive wheel toward the paver. Rolling should begin at the edge of the pavement and proceed longitudinally parallel to the roadway centerline. Each trip should overlap the proceeding trip. Rolling should gradually progress from the edge of the pavement to the crown of the cross-section. On superelevated curves, rolling should begin at the low side and progress to the high side by overlapping longitudinal strips parallel to the centerline. Breakdown and intermediate rollers should be operated with the drive wheel as close to the paver as practical. Roll as close to the paver as the stability of the mix will permit. Shoving or cracking of the mat or having the mix pick up on the roller wheels is a sign of mix instability and tenderness. If the mat is unstable or subject to too much lateral displacement, drop the rollers back a sufficient distance behind the paver to eliminate displacement and not unduly influence the pattern for intermediate and finish rollers. The finish rolling should be completed while the mat is sufficiently workable for the removal of roller marks.

Establishing roller speed is very important. A decrease in speed will increase the compactive effort applied to the mix; however, the objective is to obtain target density before the mix cools below the minimum specified temperature. Roller speed will depend on the roller type and its position in the roller pattern. A maximum speed of 3 miles per hour is recommended for steel-wheel static and vibratory rollers and 5 miles per hour for pneumatic-tire rollers. In general, rollers should be operated at a slow and uniform speed with smooth deceleration and acceleration to avoid shoving the mix. Rollers that are used in the breakdown position are generally run at approximately 2.5 to 3.0 miles per hour. If rollers cannot keep up with the paver because of laydown productivity, do not change the rolling pattern or increase the roller speed. Add another roller or slow down the paver to better balance compaction with production.

During rolling, the roller wheels should be kept moist with only enough water to avoid picking up the mix. This, as well as tire temperature, is especially important where pneumatic-tire rollers are used. Changes in direction should be effected gradually and rollers allowed to roll or slowly brake to a complete stop before reversing. Stopping points for alternate trips should be staggered at least 3 feet. It is best to park rollers off of the new mat, or on a portion that has cooled; however, where rollers have to park on the mat, they should do so at a 45-degree angle with the centerline so that subsequent rolling will remove any depressions.

401.9.7.6 Vibratory Roller Considerations

Compaction of an HMA course is a complex process made even more complicated by the use of vibratory rollers. Various makes and models are available for various compaction needs. This section emphasizes their characteristics and proper operation, with which the Roadway Inspector should become familiar. The addition of a vibratory mode to static rollers makes it possible to increase and vary the total force applied to the pavement. This makes the roller versatile and able to achieve satisfactory results under a wide variety of conditions, including fewer roller passes. No vibratory roller compacts by vibration alone; and, at times, its static weight must be considered to avoid overstressing the pavement, even when the vibratory mode is not being used. The features of the vibratory roller that influence compaction are:

- frequency in vibrations per minute;
- amplitude of the up and down movement of the roller;
- downward force applied; and
- the travel speed of the roller.

Each of the above factors must be set and maintained in proper relationship with each other to achieve target density. Usually, vibratory rollers can operate at higher mix temperatures because of their ability to adjust the total force applied to the mix. As a result, density can usually be achieved with fewer roller passes. Although operating a vibratory roller, in many respects, is no different than operating a static roller, the following guidelines should be considered:

1. Tandem Vibratory Rollers. Some tandem vibratory rollers provide vibration in either or both rollers. Depending on the stability and the temperature of the mix, the breakdown rolling operation may be performed with both rollers vibrating, with only one roller vibrating, or none vibrating. However, watch for shearing or shoving of the mat and, if necessary, reduce the compactive effort by lowering or turning off the vibratory mode in either the forward or both rollers. After satisfactory breakdown rolling, the vibration can be increased for secondary and intermediate rolling. Finishing rolling (i.e., to iron out roller marks) is accomplished most effectively in the static mode.

2. Rolling Pattern. The basic rolling pattern is similar to that which is used for static rollers, except that after the roller completes a pass toward the paver, the roller should be reversed along the same path. The vibratory mode of the roller must be turned off when the roller stops to reverse direction. The adjacent pass then proceeds in the same manner (i.e., in and out, back and forth) on the same path with overlap. Vibratory rollers should be operated as close as practical behind the paver.

3. Frequency / Amplitude Adjustment. Frequency and amplitude must be properly selected. When running the test pattern, try to select the highest frequency that will result in the fewest number of passes without blemishing the mat. In general, at least 8 to 10 impacts per foot are needed to obtain adequate density and layer smoothness.

4. Roller Speed. There is an important relationship between vibration frequency and roller speed. The spacing between tamps will be too great at high speeds, resulting in low density and roughness. The roller speed should be selected so that the distance between blows of the roll is approximately equal to the depth of the mat being placed,

without exceeding the maximum allowable operating speed. Remember, thin lifts can be easily over-compacted. The amplitude value is very critical and should be kept as low as practical.

5. Longitudinal Joints. The longitudinal joint is not "pinched" by having most of the roller on the previously compacted lane, but with most of the roller on the uncompacted material. The joint may be pinched in the standard manner with the vibratory mode turned off.

401.9.8 Other Considerations

401.9.8.1 Joint Construction

To ensure pavement durability and a smooth riding surface, Roadway Inspectors should pay particular attention to how the Contractor constructs pavement joints. Consider the following:

1. Longitudinal Joints. Longitudinal joints are used between two adjacent lanes of paved mix and will be rolled directly behind the paver. The paver will overlap the adjacent lane by approximately 1 to 2 inches; if greater, raking is usually required. Minimal raking should be needed. Ensure rakers do not broadcast material across the newly placed mix. Excess material should be carefully pushed to within 1 to 2 inches of the joint on the uncompacted side. Extraneous mix must be removed by broom or lute before rolling. Rolling is usually accomplished from the hot side, overlapping the cold mat. In multiple lifts or courses, the longitudinal joint in the top layer will be offset 6 inches from the centerline or lane line, and the longitudinal joints of underlying layers will be laterally offset a minimum of 6 inches from the previous lift. The Contractor should start placement of the adjoining lane in sufficient time to close the joint at the end of the day. If the joint is not closed, a hazardous traffic condition is created, and proper traffic control devices must be erected.

2. Transverse Joints. Transverse joints at the beginning and end of the project and at other locations where the new HMA terminates against an existing asphalt pavement will be "heeled-in" in accordance with the Contract Plans. The heeled-in joint will provide a smooth transition between the old and new surface. The Contractor should use a straightedge or stringline to ensure smoothness of the joint. Construction joints occur where one day's operation ends and the next day's operation begins. If required, treated paper is normally used as the bond breaker. Prior to beginning the day's operation, a transverse vertical cut will be made in the mat to the full depth of the new course, and the vertical face tacked prior to paving. Because the mix placed on the downstream side must be higher than the compacted side to allow for compaction, screed adjustments are needed initially. Minimal raking should be necessary; however, if performed, rakers should not disturb the paver-placed mix except to clear away extraneous material. Ideally, the joint should be compacted in a transverse roller direction. However, on a practical basis, the joint can be properly compacted in the longitudinal direction. Construction joints in overlying layers should be offset by a minimum of 6 feet. All construction joints should provide a smooth transition free from irregularities.

401.9.8.2 Rumble Strips and Pavement Markers

When specified in the Contract, rumble strips will be milled into the mainline paved shoulders. Verify that the Contractor mills rumble strips in accordance with the dimensions specified and at the locations designated on the Contract Plans. In addition, check compliance of the type and location of placement of raised pavement markers.

401.9.9 Laydown and Compaction Inspection – Summary

401.9.9.1 Job Mix and Asphalt Prime and Tack Materials

The Resident Construction Engineer or SCDOT Roadway Inspector, as assigned, should inspect materials at the project site as follows:

- Ensure asphalt prime and/or tack is supplied from an approved source.
- Ensure tack is not diluted on site.
- Determine quantity of asphalt in emulsion, if required.
- Verify appearance and temperature of mix.
- Retain original plant tickets and note rejected mix.

401.9.9.2 Laydown and Compaction Equipment

The Resident Construction Engineer or SCDOT Roadway Inspector, as assigned, should inspect equipment and operation at the project site as follows:

- Check that paver complies with Contract Specifications as follows:
  - Screed checked for trueness using a stringline.
  - Equipped with full-width augers.
  - Equipped with full-width vibratory screed.
  - Uses automatic leveling ski of proper length.
  - Hopper kept more than half full at all times.
  - Material kept at mid point of augers.
  - Producing an acceptable finish without segregation and within tolerance.
  - Placing mix at proper thickness.
  - Rate adjustment made for full length of screed, not just one side.
  - Moves at a consistent speed.
- Check compliance of static steel-wheel rollers and pneumatic-tire rollers.
- Verify compliance of vibratory rollers at highest frequency and proper amplitude.
- Check compliance of roller operation as follows:
  - Correct tire pressure in pneumatic-tire rollers.
  - Density obtained before mat cools.
  - Roller marks removed.
  - Not picking up material.
  - Traveling at proper speed.

- Producing required density with consistent roller pattern.
- Not crushing aggregate.
- Not operating in vibratory mode on final pass.
- Intermediate rolling completed before pavement temperature below 175°F.
- Ceases rolling after roller pattern achieved.
- Not stopping on a hot mat.
- Changes direction gently while at an angle to lane being compacted.

- Check compliance of tack distributor as follows:

  - Equipped with proper spread rate and temperature controls.
  - Capable of positive cut-off.
  - Spray bar/nozzle delivering material uniformly without streaking.
  - Spray width properly set.
  - Spray bar used to apply asphalt tack coat.
  - Hose used only when situation demands.

401.9.9.3 Laydown and Compaction Operations

The Resident Construction Engineer or SCDOT Roadway Inspector, as assigned, should inspect construction operations at the project site as follows:

- Verify stations have been established to allow field checks on material placement.
- Check that weather and surface temperature are acceptable for paving.
- Ensure subgrade or existing pavement has been properly prepared as follows:

  - Graded and compacted properly.
  - Soft spots removed and corrected.
  - Cross slope, elevation and alignment checked.
  - Distressed pavement has been patched.
  - Cracks are properly sealed.
  - Surface dry and swept clean for full width.

- Check compliance of prime or tack application as follows:

  - Type and grade identified by Certificate of Compliance and delivery ticket.
  - Properly sampled.
  - Applied at proper rate and temperature.
  - Properly diluted with water.
  - Properly stored.
  - Allowed to break after application.
  - Compliance of application rate.
  - Producing desired results.
  - Verified by test section.
  - Placed on edges of pavement and curbs.
  - Approved by Resident Construction Engineer.

- Verify that density requirements are being met.
- Check compliance of longitudinal joints in relation to lane lines and offset in multiple lifts.
- Ensure that transverse joints are smooth, within tolerance and straightedged.

401.9.9.4 HMA Construction Troubleshooting Guidelines

Equipment and mat problems are defects that occur in the HMA mixture during or soon after laydown and compaction. These problems can be divided into two basic categories: equipment-related problems and mixture-related problems. By observing the surface texture behind the paver and checking the surface with a straightedge, a malfunction in the paver or non-uniformity of the mix can be easily detected. Segregation is a common and persistent problem with HMA mixtures that must be closely monitored by Roadway Inspectors. At key points during HMA construction (e.g., material stockpiling, aggregate blending, mixing, conveying, storing, loading, unloading, laydown), the mixture has an opportunity to segregate. Segregation creates a non-uniform mixture that usually results in gradation that does not conform to the Job Mix Formula. Where segregation occurs, a concentration of coarse materials will appear in some areas of the mat, while other areas will exhibit finer gradation. Pavement problems associated with segregation are serious and will result in poor pavement performance and durability (e.g., potholes), undesirable surface textures, shorter pavement life and higher maintenance costs. The Roadway Inspector at the laydown site must insist on prompt action to locate and correct any trouble that occurs. Use the guidelines in Figure 401B to troubleshoot common problems with HMA mixtures. Pay attention to the *Standard Specifications* with respect to corrective work and related payment adjustments.

401.10 POST-CONSTRUCTION CONSIDERATIONS

401.10.1 Acceptability of Final Surface, Crown and Grade

After compaction, verify that the finished surface is smooth, uniform in texture and true to the specified crown and grade. Where Cross-Slope Verification is specified in the Contract, it may be performed by an independent vender listed on SCDOT Approval Sheet 52, a manual survey, or a combination of both. Ensure the Contractor corrects mat and cross-slope deficiencies to within the limits specified in the Contract. Where checked with a 10 foot straightedge applied parallel to the centerline of the pavement, the finished surface of Intermediate Courses will not vary more than 0.25 inch and the finished surface of Surface Courses will not vary more than 0.125 inch, as measured from the bottom of the straightedge to the top of the finished surface.

401.10.2 Smoothness of Final Surface

As specified in the Contract, the final riding surface will be subject to rideability testing to assess its smoothness. SCDOT will test the surface in accordance with the Test Method for Determining Pavement Roughness. Pay particular attention to the rideability criteria and schedule of payment adjustments, because they differ for new construction and resurfacing projects. The Resident Construction Engineer will contact the Pavement Evaluation Unit when the pavement is ready for testing. The Pavement Evaluation Unit will run the test and prepare a report, indicating whether or not the ride conforms to specified requirements.

TROUBLE	POSSIBLE CAUSES	POSSIBLE TREATMENT
Mat Tearing on Edges	• End plate not square. • Cold material building up at end of feeder screws. • Extensions installed incorrectly. • Feeder gate closed down too far.	• Adjust. • Clean off material buildup. • Check installation. • Open gates.
Screed Raises Each Time Machine Starts Forward	• Feeder screws — loaded too heavy. • Sensor mounting. • Feeder screws worn out. • Sitting long periods between loads. • Temperature varying in mix.	• Check feeder control paddles. • Refer to Auto Grade Control information. • Replace. • Correct problems at plant or with trucks. Slow down paver speed. • Correct problem at plant.
Feeder Screws Shadows	• Feeder screws loaded too heavy. • Feeder screws high. • Feeder screws worn out. • Segregation in mix.	• Check feeder control paddles. • Lower feeder gates. Lower feeder screws. • Replace. • Correct problem at plant.
Streak at Quarter Point (wide width)	• Screed out of adjustment. • Feeder gates closed down too far.	• Adjust torque arms. • Raise feeder gates.
Bright Streak Down Center	• Too much lead crown. • Feeder screws worn out. • Feeder gates open too far.	• Adjust torque arms. • Replace. • Lower gates.
Unable to Control Screed	• Cold screed. • Mat thinner than largest aggregate. • Screed pivot loose. • Unstable mix.	• Heat screed. • Increase mat thickness. • Tighten at torque tube and leveling arm connection. • Correct problem at plant.
Fluctuating Mat Texture	• Temperature varying in mix. • Head of material fluctuating. • Sitting long periods between loads. • Vibratory running too slow. • Mat thinner than largest aggregate. • Extensions installed incorrectly. • Screed plate worn out. • Running hopper empty between loads. • Trucks holding brakes. • Feeder screws worn out. • Cold screed. • Material too cold. • Segregation in mix. • Pre-strike off not adjusted properly.	• Correct problem at plant or with trucks. • Adjust feeder control paddles. • Correct problem at plant or with trucks. Slow down paving speed. • Increase vibrating drive speed. • Increase mat thickness. • Check installation. • Replace. • Do not run feeders empty. • Instruct drivers. • Replace screws. • Heat screed. • Correct problem at plant. • Correct problem at plant. • Adjust pre-strike off.

HMA CONSTRUCTION TROUBLESHOOTING GUIDELINES
Figure 401B

TROUBLE	POSSIBLE CAUSES	POSSIBLE TREATMENT
Heat Checking – short transverse cracks during compaction	• Tender mixture. • Uneven cooling of mat during compaction	• Adjust paving speed. • Adjust roller pattern – roll while mix is above 240°F. • Verify mix design's stability and component materials.
Screed Marks	• Trucks bumping Finisher. • Sitting long periods of time between loads. • Pre-strike off not adjusted properly.	• Instruct drivers. • Correct problem at plant or with trucks. Slow down paving speed. • Adjust pre-strike off.
Ripples	• Head of material fluctuating. • Feeder screws loaded too heavy. • Auto grade control hunting. • Speed too fast. • Screed plates worn out. • Roller in poor mechanical condition. • Feeder screws worn out. • Unstable mix. • Too much crown. • Not enough lead crown. • Trucks holding brakes. • Temperature varying in mix. • Pre-strike off not adjusted properly. • Too much play in thickness control.	• Adjust feeder control. • Check feeder control. • Adjust sensitivity. • Cut down on paver speed. • Replace screed plates. • Repair roller. • Replace feeder screws. • Check problem with plant. • Adjust torque arms. • Adjust torque arms. • Instruct drivers. • Correct problem at plant. • Adjust pre-strike off.
Poor Surface Texture	• Head of material fluctuating. • Feeder screws loaded too heavy. • Extensions installed incorrectly. • Trucks holding brakes. • Material too cold. • Excessive moisture in mix. • Speed too fast. • Temperature varying in mix. • Screed plates worn out.	• Adjust feeder paddles. • Check feeder control paddles. • Check installation. • Instruct drivers. • Correct problem at plant. • Correct problem at plant. • Cut paving speed. • Correct problem at plant. • Replace screed plates.
Wavy Surface (Long)	• Running hopper empty between loads. • Head of material fluctuating. • Feeders loaded too heavy. • Temperature varying in mix. • Overcorrecting thickness controls. • Poor grade reference. • Feeder screws worn out. • Feeder gates open too high. • Segregation in mix. • Sitting long periods between loads.	• Cut paving speed. Do not run feeders empty. • Adjust feeder control paddles. • Adjust feeder control paddles, lower feeder gates. • Correct problem at plant. • Instruct screed operator. • Improve reference. • Replace feeder screws. • Lower feeder gates. • Correct problem at plant. • Correct problem at plant or with trucks. Slow down paving speed.

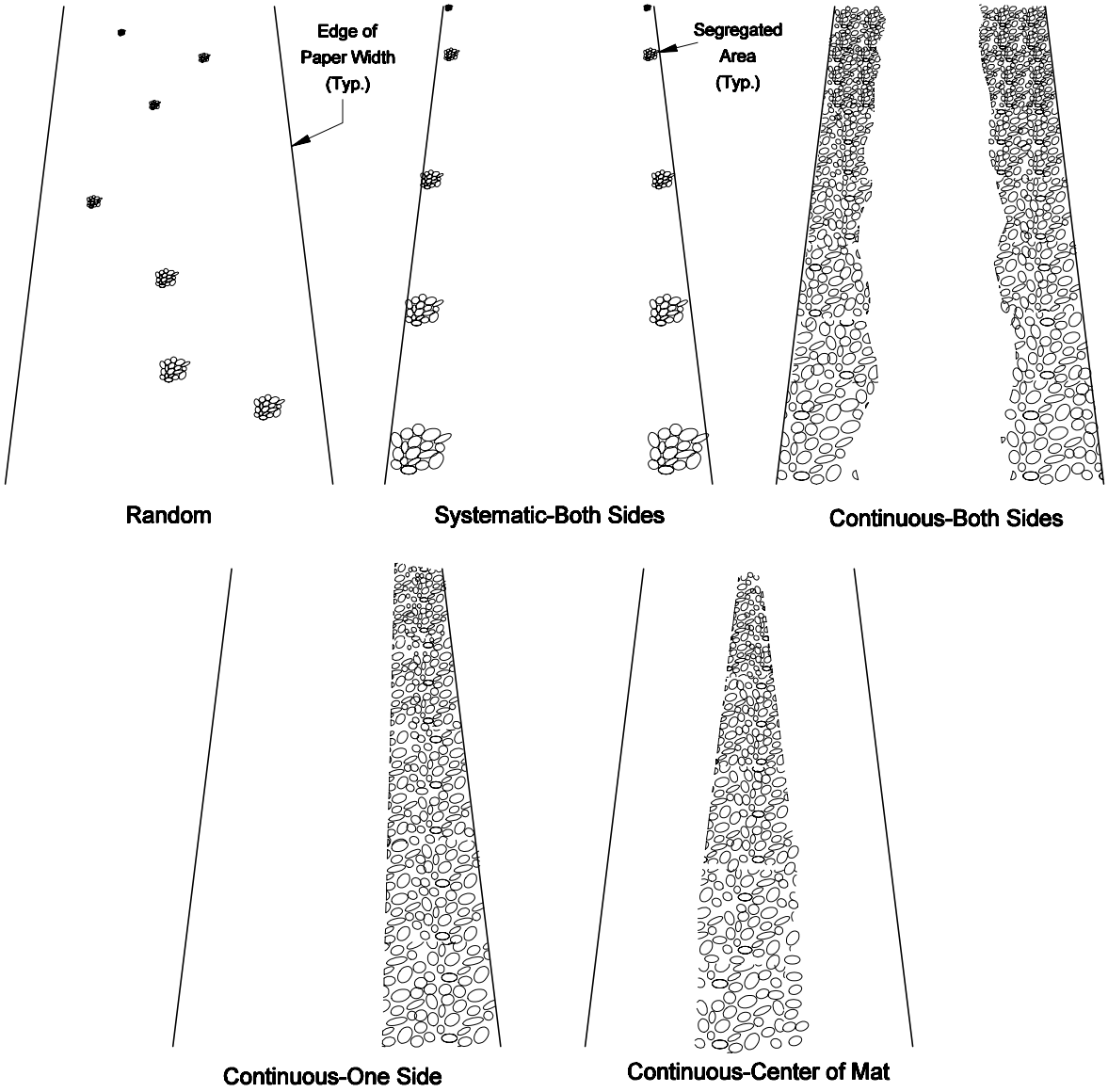
HMA CONSTRUCTION TROUBLESHOOTING GUIDELINES
Figure 401B
(Continued)

TROUBLE	POSSIBLE CAUSES	POSSIBLE TREATMENT
Wavy Surface (Short)	• Auto grade control hunting. • Head of material fluctuating. • Feeder screws loaded too heavy. • Overcorrecting thickness control screws. • Segregation in mix. • Feeder screws worn out. • Roller in poor mechanical conditions.	• Adjust sensitivity. • Adjust feeder control paddles. • Lower feeder gates. • Instruct screed operator. • Correct problem at plant. • Replace feeder screws. • Repair or replace roller.
Rich or Fat Spots (Bleeding)	• Excessive moisture in mix. • Poor rolling operation. • Pre-strike off not adjusted properly. • Vibratory running too fast. • Eccentric weights set wrong.	• Correct problem at plant. • Instruct roller operator. • Adjust pre-strike off. • Cut vibrating drive speed. • Correct weight, check timing.
Poor Longitudinal Joint	• Not rolling joint soon enough. • Overcorrecting thickness control screws. • Feeder screws loaded too heavy. • Too much or too little screed overlap. • Poor raking.	• Instruct roller operator. • Instruct screed operator. • Lower feeder gates. • Correct steering. • Instruct raker in proper procedures.
Poor Compaction	• Vibratory running too slow. • Eccentric weight set incorrectly.	• Increase vibrating drive speed. • Reset, check timing.
Tearing Full Width of Mat	• Speed too fast. • Temperature varying in mix. • Screed plates worn out. • Cold screed. • Mat thinner than largest aggregate. • Material too cold. • Excessive moisture in mix. • Pre-strike off not adjusted properly. • Vibratory running too slow.	• Cut down on paving speed. • Correct problem with trucks or with the plant. • Replace. • Heat screed. • Increase thickness. • Correct problem at plant. • Correct problem at plant. • Adjust pre-strike off. • Increase vibrating drive speed.
Streak Down Center of Mat	• Not enough lead crown. • Feeder gates closed down too far. • Feeder screws worn out.	• Adjust torque arms. • Raise feeder gates. • Replace.
Segregation in Mat	• Worn augers. • Segregated mix in trucks. • Running feeders out of mix between trucks.	• Replace screws. • Load trucks in large batches and multiple batches at plant. Don't "dribble" mix into trucks. • After truck pulls out, dump hopper and stop paver before mix falls below fender gates.

HMA CONSTRUCTION TROUBLESHOOTING GUIDELINES
Figure 401B
(Continued)

TROUBLE	POSSIBLE CAUSES	POSSIBLE TREATMENT
Systematic Spot Segregation on Both Sides	• Surge or Storage Silo	• Adjust timing on batcher gates or make sure batcher full indicator is working properly. • Make sure batcher gates are not leaking. • Adjust production rate to lower level of material in silo to prevent cone formation. • Make sure material drops vertically into batcher.
	• Truck	• Load trucks in multiple drops (front, back, center).
	• Paver	• Prohibit emptying hopper between loads. • Minimize dumping of hopper wings. • Maintain constant gate opening between loads. • Make sure auger is not prematurely turned off or otherwise starved for mixture.
Continuous Segregation Both Sides	• Surge or Storage Silo	• Make sure batcher gates open and close at the proper time or batcher full indication.
	• Paver	• Make sure augers are not starved for mixture. • Check for worn or improperly installed augers. • Prohibit excessive raking of longitudinal joints on multiple lane paving.
Continuous Segregation One Side	• Surge or Storage Silo	• Eliminate horizontal trajectory of materials being placed in silo or batcher.
	• Paver	• Check for worn or improperly adjusted gate on affected side. • Check for worn or improperly installed auger on affected side. • Prohibit excessive raking of longitudinal joint.
Continuous Segregation Center of Mat	• Paver	• Check for worn or improperly installed reverse augers.
Random Segregation	• Segregated Stockpile	• Use multiple stockpiles of single-sized aggregates. • Construct stockpile in layers for multiple sized materials. • Place material in stockpile rather than casting material.
	• Cold Bins	• Do not load out of bottom of segregated stockpile or other segregated areas. • Load into center of cold bins. • Avoid forming cone in cold bins. • Adjust loading operation to maintain constant aggregate level; do not empty bins. • Check for occasional aggregate spillage between bins due to overloading; install bulkheads if necessary.
	• Surge or Storage Silos	• Make sure batcher gates are operating correctly. • Make sure level of mixture is always above cone on bottom of silo.
	• Truck Loading/Unloading	• Load all trucks in multiple drops (front, back, center). • Surge tail gate during unloading.
	• Paver	• Maintain constant gate opening. • Maintain constant auger speed and operation. • Maintain uniform speed of paving operations. • Prohibit random dumping of wings. • Prohibit improper raking operations.

HMA CONSTRUCTION TROUBLESHOOTING GUIDELINES
Figure 401B
(Continued)



HMA CONSTRUCTION TROUBLESHOOTING GUIDELINES
Figure 401B
(Continued)

Distribution of the report will include the Resident Construction Engineer, District Engineering Administrator, Director of Construction and the Contractor. In some cases, prior to resurfacing, the existing pavement must be tested to obtain a baseline ride index value. The Resident Construction Engineer should contact the Pavement Evaluation Unit prior to resurfacing if the initial rideability test results have not yet been received. Upon completion of the overlay, the Resident Construction Engineer will contact the Pavement Evaluation Unit to perform final rideability testing, as soon as practical.

401.10.3 Protection from Damage

To minimize water from infiltrating and deteriorating the base course, where Intermediate Courses or Surface Courses are placed over a Graded Aggregate Base Course or a Sand-Clay Base Course, verify that the placement of the HMA course follows closely behind the base course. On a day-to-day basis, ensure that the Contractor protects the new HMA surface from damage, and require repair work, as needed based on the Contract provisions.

401.11 DOCUMENTATION AND PAYMENT CONSIDERATIONS

In general, the Resident Construction Engineer and SCDOT Inspectors must review the Contract and clearly understand, for each pay item:

- key points of inspection;
- acceptance criteria;
- applicable deductions for non-compliance;
- criteria for outright rejection;
- unit of measurement used to determine the quantity for payment;
- measurements that need to be obtained to calculate the quantity;
- location where the measurements need to be obtained (i.e., field or plants);
- work and materials that should not be measured separately for payment;
- calculations required for determining progress payments; and
- supplemental documents required (i.e., automatic printout tickets, invoices).

The criteria for measuring and paying for Division 400 pay items will be defined in the Contract Specifications and are primarily based on the weight of accepted and approved mix. The net weight of each load of HMA mixture and the accumulated net weight of the loads for the day's production will be recorded on the load ticket. Retain the original copy of the plant ticket for each load delivered to the project. Check all information on the ticket, including the calculations. Note on the tickets any quantity changes due to rejection, including the reason for the rejection. As needed, perform spot checks of truck weights on approved platform scales. Pay particular attention to the provisions for price and payment adjustments that are specified for the type of HMA course to be constructed. Record pay quantities in the Daily Work Report and monthly price adjustments should be calculated and retained in the project files.

Section 402
Hot-Mix Asphalt Intermediate Course

Section 401 presents preconstruction, construction and post-construction responsibilities of SCDOT and Contractor plant and roadway personnel that are applicable to the construction of Hot-Mix Asphalt Intermediate Courses. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 402 of the *Standard Specifications*, applicable Supplemental Specifications and the Special Provisions of the Contract.

Section 403
Hot-Mix Asphalt Surface Course

Section 401 presents preconstruction, construction and post-construction responsibilities of SCDOT and Contractor plant and roadway personnel that are applicable to the construction of Hot-Mix Asphalt Surface Courses. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 403 of the *Standard Specifications*, applicable Supplemental Specifications and the Special Provisions of the Contract.

Section 404
Cold-Mix Asphalt Intermediate Course

Section 401 presents preconstruction, construction and post-construction responsibilities of SCDOT and Contractor plant and roadway personnel that are applicable to the construction of Cold-Mix Asphalt Intermediate Courses. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 404 of the *Standard Specifications*, applicable Supplemental Specifications and the Special Provisions of the Contract.

Section 405
Cold-Mix Asphalt Surface Course

Section 401 presents preconstruction, construction and post-construction responsibilities of SCDOT and Contractor plant and roadway personnel that are applicable to the construction of Cold-Mix Asphalt Surface Courses. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 405 of the *Standard Specifications*, applicable Supplemental Specifications and the Special Provisions of the Contract.

Section 406
Asphalt Surface Treatment – Single Treatment

406.1 DESCRIPTION OF WORK

Asphalt surface treatment is a broad term describing several types of asphalt and asphalt-aggregate applications. A single surface treatment involves spraying asphalt material on the surface followed immediately by application of an aggregate cover, which is rolled as soon as practical. For multiple surface treatments, the process will be repeated a second or third time with the aggregate size becoming smaller with each application. Section 406 of this *Manual* applies to the following sections of the *Standard Specifications*:

- Section 406 – Asphalt Surface Treatment – Single Treatment
- Section 407 – Asphalt Surface Treatment – Double Treatment
- Section 408 – Asphalt Surface Treatment – Triple Treatment

The sequence of operations for asphalt surface treatment is as follows:

1. Prepare Surface. Clean the surface to be treated with a rotary broom or other approved method.

2. Prime Surface. Prime the clean, dry surface, if the treatment requires prime, and allow the prime to cure.

3. Application of Asphalt Material. Spray the surface with asphalt material at the specified rate of application.

4. Application of Cover Aggregate. Spread cover aggregate at the specified rate of application immediately behind the asphalt spray application (i.e., emulsion still brown in color) to achieve maximum aggregate wetting.

5. Rolling. Immediately roll the aggregate to seat the particles in the asphalt membrane. The asphalt emulsion should break just after the first roller pass has been made.

Note that when asphalt surface treatment – double treatment is specified, Step 3 through Step 5 will be repeated twice and, similarly, three times for asphalt surface treatment – triple treatment.

406.2 PRECONSTRUCTION CONSIDERATIONS

Consider the following prior to construction of the asphalt surface treatment:

1. Weather and Seasonal Limitations. Check compliance of the weather and seasonal limitations. Asphalt surface treatment is generally placed between March 15 and October 15 when temperature requirements are met. The treatment cannot be applied on a wet surface or when the temperature will fall below 60°F within 12 hours after placement.

2. Materials. Check the type of asphalt material for compliance (e.g., cut-back, emulsified, asphalt binder). Pay particular attention to the heating temperature requirements prior to spraying. Verify compliance of the types, properties and gradation of aggregate materials. Test procedure AASHTO T 96 will apply.

3. Equipment. Check that the distributor equipment meets specified criteria and is properly calibrated. Verify conformance and good working order of aggregate spreaders and steel-wheel tandem rollers.

4. Sampling and Testing. Review and understand the applicable criteria for the Quality Control Samples and Tests and the Independent Assurance Samples and Tests for asphalt and aggregate materials used for Asphalt Surface Treatment (see Section 106).

5. Surface Preparation. Ensure that the surface to be treated is clean and dry and that the base has been approved by the District Construction Engineer.

6. Application of Asphalt Prime Coat. When specified, check compliance of the application of asphalt prime coat. Where traffic is to be maintained, the operation should not allow traffic on the primed base without the use of an approved sand cover. The prime must be allowed to cure for 7 days prior to surfacing.

406.3 INSPECTION DURING CONSTRUCTION

406.3.1 Application of Asphalt Material

It is essential that the distributor be capable of distributing the asphalt uniformly over the surface to be treated. For optimum results, consider the following:

1. Spray Nozzles. Maintain uniform pressure on all spray nozzles. The fan of the spray from each nozzle must be uniform and set at the proper angle with the spray bar so that the spray fans do not interfere with each other.

2. Spray Bar. The spray bar must be maintained at the proper height above the surface to provide complete and uniform overlap of the spray fans.

3. Distributor Speed. The speed of the distributor truck must be uniform. Calibration using a test section and check of application rate is advisable.

4. Streaking. To avoid streaking, check the spread of the distributor spray bar. Valve action should be instantaneous, both in opening and cut-off. Check the spraying operation frequently to ensure that nozzles are the proper height from the surface and are fully operational.

5. Alignment. To obtain good alignment, verify that the Contractor places a stringline to guide the distributor operator. The stringline should be placed using points or stakes furnished by the Survey Party.

6. Spray Width. Do not assume that the correct width has been established on the spray bar. The width of the spray should be initially and subsequently checked at frequent intervals, especially when the width of surfacing changes.

7. Length of Application. The length of application of the asphalt material should be limited to an area that can be promptly covered with aggregate.

8. Temperature of Asphalt Material. Monitor the temperature of the asphalt material. It varies based on the type being sprayed and will be important in determining volumetric quantities.

9. Starting and Stopping. Ensure building paper is used properly at locations where the distributor starts and stops.

10. Excess and Overspray. Watch for excess deposits of asphalt material and ensure that it is removed. Ensure that overspray on structures is properly cleaned.

406.3.2 Spreading of Aggregate

An adequate supply of aggregate should be on hand to promptly cover the asphalt material. It is essential that asphalt binder and emulsion be covered quickly so that good wetting and binding of the aggregate is achieved. A simple rule of thumb is that when rapid-setting emulsions are used, the emulsion should break just after the first roller pass has been made.

406.3.3 Determining Rate of Spread

406.3.3.1 Asphalt Material

The application rate, in gallon per square yard, of asphalt material should be calculated for each distributor shot with the temperature of 60°F being used as the basis to determine the volumetric quantity of the asphalt material. Document these calculations and the rate of application in the Daily Work Report. Such documentation must be retained in the project files by the Resident Construction Engineer.

The distributor will be equipped with a volume measuring gauge or a calibrated tank with a measuring stick for determining the quantity in the tank. Usually the distributor is equipped with both devices. It is acceptable to use either device, provided they are accurate. The contents of the distributor tank should be determined while the tank is level. It is the responsibility of the Roadway Inspector to check the reading of the measuring device before and after the application of each shot. The accuracy of the volume measuring device should be checked against the volume of the material delivered by the asphalt tanker. A discrepancy of any significant magnitude should be investigated.

406.3.3.2 Aggregate Material

During the operation, regularly check the rate of spread of the aggregate material. When the haul trucks of aggregate are delivered with automatic weigh tickets, the spread can be easily determined by dividing the weight of material by the area, in square yards, of the treated surface. If this method is used, retain the original weigh tickets in the project files. However, trucks are often loaded from stockpiles with no readily available means of weighing. In this case, to determine the weight of aggregate in the truck, strike off the stone in the truck, calculate the volume occupied in cubic feet and multiply this volume by 100. This will yield the weight of aggregate in pounds, assuming an approximate density of 100 pounds per cubic foot. Once the weight in the truck is found, check the rate of spread. A quick method to check the rate spread is to place a square yard of building paper on the surface after the asphalt has been shot. Once the aggregate spreader has passed over the paper, remove and weigh the aggregate. This is also a good method to correlate visual appearance with rate of application. If this method is used, ensure that the area covered by paper is repaired.

406.3.4 Rolling and Dragging

The purpose of the rolling operation is to seat the aggregate into the asphalt material, which provides the bond necessary to resist traffic stresses. Rolling should begin immediately after distribution of the cover material and continue until the aggregate is properly seated in the asphalt material. If the aggregate turns over under rolling, the rolling (i.e., when emulsion is used) may be briefly delayed until the asphalt material will hold the aggregate. The steel-wheel roller should make only one or two passes over the aggregate, because excess rolling will crush the aggregate. Because a steel-wheel roller will tend to roll over high spots and bridge low spots, a pneumatic-tired roller should be used until the aggregate is properly seated. Verify that brooming and rolling continues until a smooth surface is provided with the aggregate being thoroughly keyed into the asphalt material. Rolling should be performed in the longitudinal direction beginning at the outer edges and working toward the center with overlap on each pass.

406.4 POST-CONSTRUCTION CONSIDERATIONS

Traffic will be permitted on the treated surface as soon as the aggregate is spread and rolled. Ensure that loose excess cover aggregate is removed. As needed, verify the proper use of seal stone prior to opening to traffic. Verify that the surface is maintained and that spotty or bleeding areas and deficiencies are repaired in accordance with the provisions of the Contract.

406.5 DOCUMENTATION AND PAYMENT CONSIDERATIONS

Document the area calculations (i.e. length x width) of the treated surface in the Daily Work Report. Measurement for payment will be based on the actual area of treatment accepted in place for the type specified in the Contract. Retain the weigh tickets, when available, in the project files. See Section 401.11 for information on documentation and payment.

Section 407
Asphalt Surface Treatment – Double Treatment

Section 406 presents preconstruction, construction and post-construction responsibilities that are applicable to the construction of asphalt surface treatment – single treatment, which are applicable to Section 407 of the *Standard Specification*s for asphalt surface treatment – double treatment. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 407 of the *Standard Specifications*, including applicable Supplemental Specifications and Special Provisions.

Section 408
Asphalt Surface Treatment – Triple Treatment

Section 406 presents preconstruction, construction and post-construction responsibilities that are applicable to the construction of asphalt surface treatment – single treatment, which are applicable to Section 408 of the *Standard Specification*s for asphalt surface treatment – triple treatment. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 408 of the *Standard Specifications*, including applicable Supplemental Specifications and Special Provisions.

Section 409
Open-Graded Friction Course

Section 401 presents preconstruction, construction and post-construction responsibilities of SCDOT and Contractor plant and roadway personnel that are applicable to the construction of Open-Graded Friction Courses. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 409 of the *Standard Specifications*, applicable Supplemental Specifications and the Special Provisions of the Contract.

Section 410
Hot-Mix Asphalt Thin-Lift Seal Course

Section 401 presents preconstruction, construction and post-construction responsibilities of SCDOT and Contractor plant and roadway personnel that are applicable to the construction of Hot-Mix Asphalt Thin-Lift Seal Courses. Prior to construction, review the materials, construction, sampling, testing, acceptance, documentation and payment requirements specified in Section 410 of the *Standard Specifications*, applicable Supplemental Specifications and the Special Provisions of the Contract.