

ITEM 9
HOTMIX ASPHALT PAVEMENT (HMA)
Stone Matrix Asphalt (SMA)

9.1 DESIGN INTENT

These specifications include general requirements applicable to all types of plant mixed hot mix asphalt (HMA). Also included are requirements for Stone Matrix Asphalt (SMA). Reference to HMA shall also mean SMA is Included. This work consists of one or more courses of asphalt mixture constructed on a prepared foundation in accordance with specifications. The design intent is to provide pavement with adequate thickness and quality to provide a serviceable life of at least 20 years. It is also the intent to provide construction in accordance with these specifications with a high standard of practice. This item shall include all labor, equipment, and materials to manufacture, place and compact asphaltic concrete for pavement purposes.

| TEST PROCEDURE DEFINITIONS | |
|-----------------------------------|--|
| CP-## | Colorado Department of Transportation: Field Materials Manual (Colorado Testing Procedures) |
| ASTM | American Society for Testing & Materials |
| AASHTO | American Association of State Highway & Transportation Officials |
| CP-L ##### | Colorado Department of Transportation: Laboratory Manual of Test Procedures (Lab Testing Procedures) |

When references to both an AASHTO and either a CP or CP-L and test procedure are given, The CP or CP-L shall be used, unless an Agency stipulated they will ONLY use and require AASHTO test procedures.

9.2 MATERIALS

The hot mix asphalt shall be composed of a mixture of aggregate, filler, hydrated lime and asphalt binder. Some mixes may require polymer modified asphalt binder. Some mixes may allow up to 25% reclaimed asphalt pavement (RAP) as approved by the **AGENCY**. All RAP introduced shall meet the requirements of section 9.2.5. Stone Mastic Asphalt (SMA) Mixtures are to be used in the top lift only.

NOTE: SMA specifications are adapted from the CDOT specification (2008) and incorporated throughout other sections of this specification.

9.2.1 Aggregate

Aggregates for HMA shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. Excess of fine material shall be wasted before crushing. The material shall not contain clay balls, vegetable matter, or other deleterious substances and shall meet the following requirements.

TABLE 9.2.1.1- AGGREGATE PROPERTIES

| Aggregate Test Property | Coarse: Retained on #4 | Fine: Passing the #4 |
|---|---|-------------------------|
| Fine Aggregate Angularity, CP-L 5113 Method A or AASHTO T 304 Note: Fine aggregate angularity does not apply to RAP aggregates | | 45% Min |
| Two Fractured Faces, CP-45 or ASTM D 5821 SG Mixtures Top and Middle Lifts Bottom Lifts SMA Mixtures | 90% Min. 80% Min. 70% Min. 100% required | |
| LA Abrasion, AASHTO T 96 | 45% Max. | |
| Flat and Elongated (Ratio 5:1) %, AASHTO M 283 | 10% Max. | |
| Adherent Coating (Dry Sieving) ASTM D 5711 | 0.5% Max. | |
| Sand Equivalent. AASHTO-T 176 | | 45% Min. |
| Micro Deval CP-L 4211 or AASHTO T 327 | 18% Max | |

Reclaimed Asphalt Pavement material (RAP) shall be used only where specifically allowed and shall be of uniform quality and gradation with a maximum size no greater than the nominal aggregate size of the mix. Mixes shall not contain more than 25 percent RAP.

The Proposed Design Job Mix Formula (PDJMF) gradation shall be wholly within the control point gradation range set forth in the following applicable Table 9.2.1.2 for dense graded mix designs or Table 9.2.1.3 for Stone Matrix Asphalt (SMA). The Allowable Job Mix Formula (AJMF) gradation for production shall be the PDJMF gradation with the tolerances of section 9.13.2 applied. The PDJMF and the final

AJMF gradation for production shall report all sieve sizes listed in the applicable Table 9.2.1.2 or Table 9.2.1.3.

Mineral filler for the Stone Matrix Asphalt pavement shall be limestone dust and shall meet the requirements of this subsection and have a maximum Plasticity Index (AASHTO T90) of 4%.

The **CONTRACTOR** shall submit hydrometer analysis (AASHTO T88) for the gradation of mineral filler used in the SMA mixture.

TABLE 9.2.1.2 – DENSE GRADED HMA GRADATION RANGE
(Percent by Weight Passing Square Mesh Sieves, CP-31, AASHTO T 11 & T 27)

| Mixture Grading | SX (1/2" nominal) | | S (3/4" nominal) | | SG (1" nominal) | |
|-----------------|-------------------|---------------|------------------|---------------|-----------------|---------------|
| Sieve Size | Control Points | Caution Zone* | Control Points | Caution Zone* | Control Points | Caution Zone* |
| 1 1/2" | | | | | 100 | |
| 1" | | | 100 | | 90-100 | |
| 3/4" | 100 | | 90-100 | | @ | |
| 1/2" | 90-100 | | @ | | @ | |
| 3/8" | @ | | @ | | @ | |
| #4 | @ | | @ | | @ | 39.5 |
| #8 | 28-58 | 39.1 | 23-49 | 34.6 | 19-45 | 26.8-30.8 |
| #16 | @ | 25.6-31.6 | @ | 22.3-28.3 | @ | 18.1-24.1 |
| #30 | @ | 19.1-23.1 | @ | 16.7-20.7 | @ | 13.6-17.6 |
| #50 | @ | 15.5 | @ | 13.7 | @ | 11.4 |
| #200** | 2.0-8.0 | | 2.0-7.0 | | 1.0-7.0 | |

* The caution zone is a guideline only. It is recommended that mix design gradations go above the caution zone boundaries, on the "fine" side.

** These limits shall include the required 1% of lime by weight.

@ These sieve sizes used only to determine the final Allowable Job Mix Formula (JMF) in accordance with 9.13.

TABLE 9.2.1.3- SMA AGGREGATE GRADATION RANGE PROPERTIES
(Percent by Weight Passing Square Mesh Sieves, CP-31, AASHTO T 11 & T 27)

(Ref: CDOT Table 703-5)

| Sieve Size | Stone Mastic Grading Designation (Percent by Weight Passing Square Mesh Sieves) | | | |
|------------|--|--------------|--------------|--------------|
| | #4 Nominal | 3/8" Nominal | 1/2" Nominal | 3/4" Nominal |
| 1" | | | | 100 |
| 3/4" | | | 100 | 90-100 |
| 1/2" | 100 | 100 | 90-100 | 50-88 |
| 3/8" | 100 | 90-100 | 50-80 | 25-60 |
| #4 | 90-100 | 26-60 | 20-35 | 20-28 |
| #8 | 28-65 | 20-28 | 16-24 | 16-24 |
| #16 | 22-36 | | | |
| #30 | 18-28 | 12-18 | 12-18 | 12-18 |
| #50 | 15-22 | 10-15 | | |
| #100 | | | | |
| #200 | 12-15 | 8-12 | 8-11 | 8-11 |

9.2.2 Performance Graded Asphalt Binders

The **CONTRACTOR** shall provide to the **AGENCY** acceptable 'Certifications of Compliance' of each applicable asphalt binder grade from the supplier. Upon non-conformance with the specifications, the asphalt binder may be rejected as directed by the **AGENCY**. When production begins, the **CONTRACTOR** shall, upon request, provide to the **AGENCY** a one quart can of each specified asphalt binder.

Additionally, when requested, the **CONTRACTOR** shall provide the refinery test results that pertain to the asphalt binders used during production.

Asphalt binder shall meet the requirements of the Superpave Performance-Graded Binders (PG) as presented in Table 9.2.2 below.

TABLE 9.2.2 -PROPERTIES OF PERFORMANCE GRADED BINDERS

| Usage for each Binder Grade | PG 58-28 | PG 64-22 | PG 76-28 |
|--|-------------------------------|--------------------------------|----------------------------|
| Traffic Loading, Total 18 kip ESALs Over Design Life (Usually 20 Years)*** | Low Volume (0-100,000) | 100,000 to <10.0 Million | 3.0 Million to <10 Million |
| Superpave Compactor Design gyrations Recommended (alternate) Usage | N _{design} = 50 (75) | N _{design} = 75 (100) | N _{design} = 100 |
| Property of Binder Grade | PG 58-28 | PG 64-22 | PG 76-28 |
| Flash Point Temperature, °C, AASHTO T 48 | 230 Min. | 230 Min. | 230 Min. |
| Viscosity at 135 °C, Pas, ASTM D 4402 | 3 Max. | 3 Max. | 3 Max. |
| Dynamic Shear, Temperature °C, where C'/Sin δ @ 10 rad/sec. ≥ 1.00 Kpa, AASHTO TP 5 | 58 ° C | 64 ° C | 76 ° C |
| Rolling Thin Film Oven Residue Properties, AASHTO T 240 | | | |
| Mass Loss, %, AASHTO T 240 | 1.00 Max. | 1.00 Max. | 1.00 Max. |
| Dynamic Shear, Temperature °C, where G'/Sin δ @ 10 rad/sec. ≥ 2.20 Kpa, AASHTO TP 5 | 58 ° C | 64 ° C | 76 ° C |
| Elastic Recovery ¹ , 25°C, % Min.* | N/A | N/A | 50 Min. |
| Pressure Aging Vessel Residue Properties, Aging Temperature 100 °C AASHTO PP1 | | | |
| Dynamic Shear, Temperature °C, where G'/Sin δ @ 10 rad/sec. ≤ 5,000 Kpa, AASHTO TP 5 | 19 ° C | 25 ° C | 28 ° C |
| Creep Stiffness, @ 60 sec. Test Temperature in °C, AASHTO TP 1 | -18 ° C | -12 ° C | -18 ° C |
| S, Mpa, AASHTO TP 1 | 300 Max. | 300 Max. | 300 Max. |
| m-value, AASHTO TP 1 | 0.300 Min. | 0.300 Min. | 0.300 Min. |
| **Direct Tension Temperature in °C, @ 1.0 mm/min., Where Failure Strain >1.0%, AASHTO TP 3 | -18 ° C | -12 ° C | -18 ° C |

* Elastic Recovery by Task Force 31, Appendix B Method

** Direct tension measurements are required when needed to show conformance to AASHTO MP.1

*** AGENCY is to determine PG Binder

9.2.3 Additives – Hydrated Lime

Lime shall be added at the rate of 1% by dry weight of the aggregate and shall be included in the amount of material passing the No. 200 sieve. Hydrated lime for aggregate pretreatment shall conform to the requirements of ASTM C 207, Type N. In addition, the residue retained on a 200-mesh sieve shall not exceed 10% when determined in accordance with ASTM C 110. Drying of the test residue in an atmosphere free from carbon dioxide will not be required.

9.2.4 Tack Coat

The emulsified asphalt, for Tack Coat shall be CSS-1h or SS-1h and conform to AASHTO M208 or M140, respectively.

9.2.5 Reclaimed Asphalt Pavement

Reclaimed Asphalt Pavement (RAP) may be allowed in the HMA mixture by the **AGENCY**. It shall be of uniform quality and gradation with a maximum size particle no greater than the maximum size allowed in the HMA mixture. HMA mixtures containing RAP shall meet the same gradation requirements as a virgin HMA mix. The AGENCY may allow mixtures with a maximum of 20% RAP may be allowed in the top lift of any asphalt pavement, and a maximum of 25% RAP may be allowed in layers below the top lift, RAP is not allowed in Stone Mastic Asphalt Mixtures, except by agreement by the **AGENCY**.

The reclaimed asphalt pavement shall meet all the requirements for HMA pavement, as contained herein. The **CONTRACTOR** shall have an approved mix design for the amount of RAP to be used prior to placement.

The **AGENCY** may require the **CONTRACTOR** to maintain separate stockpiles for each type of RAP material. All processed material shall be free of foreign materials and segregation shall be minimized. Any RAP material that cannot be readily broken down in the mixing process, and/or affects the paving operation, shall be processed prior to mixing with the virgin material.

Fine Aggregate Angularity requirements shall not apply to any RAP aggregate. The RAP will not contain clay balls, vegetable matter, or other deleterious substances.

Verification testing for asphalt content and gradation will be performed on RAP at the frequencies listed in section 9.5.2, below. The **AGENCY** may request

the mix supplier's testing results on RAP at any time. In addition, the mixture shall be tested for properties as listed in Table 9.15

When the use RAP is allowed, the following additional conditions shall apply:

9.2.5.1. The processed RAP must be 100 percent passing the 1¼" sieve. The aggregate obtained from the processed RAP shall be 100% passing the 1" sieve. The aggregate and binder obtained from the processed RAP shall be uniform in all the measured parameters in accordance with the following schedule:

Table 9.2.5.1 RAP AGGREGATE UNIFORMITY TOLERANCES

| <u>Element</u> | <u>Uniformity*</u> |
|----------------|--------------------|
| Binder Content | 0.5 |
| % Passing ¾" | 4.0 |
| % Passing ½" | 4.0 |
| % Passing 3/8" | 4.0 |
| % Passing #4 | 4.0 |
| % Passing #8 | 4.0 |
| % Passing #30 | 3.0 |
| % Passing #200 | 1.5 |

* Uniformity is the Maximum allowable Standard Deviation of test results of processed RAP.

9.2.5.2. The **CONTRACTOR** shall have an **approved RAP Quality Control (QC) Plan** that details how the RAP will be processed and controlled. The QC plan must address the following:

9.2.5.2. A. RAP Processing Techniques. This requires a schematic diagram and narrative that explains the processing (crushing, screening, and rejecting) and stockpile operation for normal plant operation or a specific project.

9.2.5.2. B. Control of RAP Asphalt Binder Content: - Minimum Testing Frequency: 1/1,000 tons of processed RAP material (minimum 3 tests) for recent production of the mix type.

9.2.5.2. C. Control of RAP Gradation (CP31 or AASHTO T-30):

Minimum Testing Frequency: 1/1,000 tons of processed RAP material (minimum 3 tests) for recent production of the mix type.

9.2.5.2. D. Process Control Charts shall be maintained for binder content and each screen listed, during addition of any RAP material to the stockpile. The **CONTRACTOR** shall maintain separate control charts for each RAP stockpile. The control charts shall be displayed and shall be made available to the **AGENCY** upon request.

9.2.5.3 Example of RAP QUALITY CONTROL PLAN

9.2.5.3. A Initial quality control of the reclaimed asphalt pavement shall be performed prior to and during crushing. Material for reclamation shall be separated by quality and source before being accepted for processing. Reclaimed asphalt must be free of concrete, dirt and organic materials... These stockpiles shall be built from the ground up, completely mixing all loads as they come in.

9.2.5.3. B Crushing of the reclaimed asphalt pavement shall be accomplished by means of a cone crusher and a screen deck. Oversize material shall be to be rejected on a ¾" scalping material, which reprocesses the material through the cone additional times. The processed material shall be stockpiled at the crushing facility and kept in separate piles and separate from other products to prevent intermingling of products, as well as the feed bins to prevent intermingling of the aggregates.

9.2.5.3. C The reclaimed asphalt pavement material shall be sampled during the crushing operations according to AASHTO T 2 at frequencies greater than 1/1000 tons and tested for gradation and asphalt content in accordance with AASHTO T 27 AND T11, and AASHTO T 308. Testing shall be done randomly on a daily basis to ensure conformance to specifications.

9.2.5.3. D The reclaimed asphalt pavement material at the asphalt plant shall be again sampled and tested according to the appropriate procedures to ensure that the asphalt content and gradation meet specifications and represent initial quality control data. Once data is collected, a statistical analysis shall be performed to determine the blend for the asphalt mixture design. This analysis shall be provided with the Asphalt Mixture Design submittal. The RAP will meet the Uniformity Specification of Table 9.2.5.1 above.

9.2.5.3. E The RAP system at the asphalt plant consists of a feed bin with a variable speed motor controlled by the plant computer, which ensures the proper quantity of RAP material called for by the mix design. Material is delivered to the asphalt-mixing chamber of the asphalt plant by means of conveyor belts. The RAP material falls from one conveyor to another through a shaker screen that serves to break up any RAP material that has recompacted. Any oversize material shall be rejected at the shaker screen. While in production, the front-end loader shall work the full face of the stockpile, to ensure a representative batch is being produced.

9.2.5.3. F Prior to starting a project and at any other time necessary, the RAP feed system shall be calibrated by placing an amount of RAP measured by certified external scales into the feed bin. That measured material is fed from the RAP bin across the belt scales. The weights are compared and, if outside of accepted tolerances for the blending system, adjustments are made by the plant-blending computer. This process is the same as for all other components of the mix design.

9.3 MIX DESIGN AND PLANT PRODUCED MIXTURE REQUIREMENTS

The mix design materials shall be those listed in Section 9.2 and used for the project. No substitutions are allowed during production, unless approved by the **AGENCY**.

The **AGENCY** shall indicate on MGPEC Form #9 the project specific criteria concerning mix design method, traffic level, asphalt binder type, mixture grading, and maximum amount of RAP allowed. This information shall be provided on MGPEC Form #9, "Requirements for Hot Mix Asphalt (HMA)", or other Contract bidding documents.

Grading SG (1-inch nominal aggregate) shall only be designed using the 150 mm Superpave molds. Hveem Stability and Lottman test are not required for Grading SG mixtures. Grading S and SX shall be designed using 100 mm Superpave molds.

9.3.1 Superpave Mixture Design Method

The **CONTRACTOR** shall submit a Proposed Design Job Mix Formula (PDJMF) for each mixture required by the Contract. The mixture design shall be determined using AASHTO T-312 or Colorado Procedure CP-L 5115 for the Superpave Method of Mixture Design. Guidance is provided in "Superpave Level 1 Mix Design" SP-2 published by the Asphalt Institute. Mixture design and field control testing shall meet the following requirements of Table 9.3.1a for Dense Graded HMA.

Mixture design and field control testing of SMA shall meet the following requirements of Table 9.3.1b.

TABLE 9.3.1a SUPERPAVE MIXTURE PROPERTIES FOR DENSE GRADED HMA

| Property or Test | Traffic Levels (ESALs) | | |
|--|--|--|---|
| | Low (0-100,000) | Medium (100,000 to <3.0 Million) | High (3.0 Million to <30 Million) |
| Traffic Loading, Total 18 kip ESALs Over Design Life (Usually 20 Years) | Low (0-100,000) | Medium (100,000 to <3.0 Million) | High (3.0 Million to <30 Million) |
| Design gyrations, N _{design} (Air Void: 3.5% to 4.5%) (See Note 1,2) | 50 | 75 | 100 |
| Air Voids in Total Mix (VTM) CPL 5115 or AASHTO T 312 | (See Note 1) | (See Note 1) | (See Note 1) |
| Hveem Stability CP-L 5106 or AASHTO T 246 (Grading S & SX only) (See Note 3) | N/A | 28 Min. | 30 Min. |
| Voids Filled with Asphalt (VFA), MS-2 | 70-80 | 65-78 | 65-75 |
| Lottman, Tensile Strength Ratio, % Retained, CP-L 5109 or AASHTO T 283, Method B | 80 Min. | 80 Min. | 80 Min. |
| Lottman, CP-L 5109 or AASHTO T 283 Dry Tensile Strength, psi | 30 Min. | 30 Min. | 30 Min. |
| VMA %. CP-48 or AASHTO PP 19 (See notes 2,3,4) | Minimum VMA criteria applies to the mix design only (Table 9.2.1.2). The minimum VMA criteria shall be linearly interpolated based on actual air voids. See 9.13 for production tolerances | | |

Note 1: Select the target Job Mix Optimum Binder Content for HMA gradings as close to 4.0% air voids as possible (3.5% to 4.5% air voids).

VTM is also referred to as Pax in CPL 5115, and %Gmmx in T 312

Note 2: Maximum Theoretical Specific Gravity of mix by CP-51 or AASHTO T 209.

Note 3: Refer to Section 9.13 for production tolerances.

Note 4: VMA shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (CP-L 5103 or AASHTO T 166) and Aggregate (AASHTO T 84 & T 85), and calculated according to CP-48 or AASHTO PP 19. All mixes shall meet the minimum VMA specified in Table 9.3.2, below.

Table 9.3.1b SUPERPAVE MIXTURE PROPERTIES FOR OPEN GRADED SMA

| Property | Test Method | Value for SMA |
|--|--|--|
| Lab compaction (Revolutions) N_{Design} | CPL 5115 or AASHTO T 312 | 100 |
| Air Voids, percent at: N_{Design} (See Note 1) | AASHTO T 312 | 3.0 – 4.0 |
| Hveem Stability | CP-L 5106 or AASHTO T 246 | 30 Min. |
| Accelerated Moisture Susceptibility, tensile strength Ratio, (Lottman) | CPL 5109 or AASHTO T 283, Method B | 80 Min. |
| Dry Split Tensile Strength, psi | CPL 5109 or AASHTO T 283, Method B | 30 Min. |
| Grade of Asphalt Binder | n/a | PG 76-28 |
| Voids in the Mineral Aggregate (VMA) %, minimum (see note 2) | CP 48 or AASHTO PP 19 | 17 |
| Draindown at Production Temperature | AASHTO T 305 | 0.3 maximum |
| % VCA_{MIX} (See Note 3) | AASHTO PP 41-02 | Less than VCA_{DRC} (See Note 4) |

General Note: Copies of AASHTO PP 41-02 and MP 8-02 (for designing SMA mixes) can be obtained from the CDOT Region Materials or the AGENCY

Note 1: Select the target Job Mix Optimum Binder Content for SMA grading at 3.0% to 4.0% air voids

Note 2: VMA shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (CP-L 5103 or AASHTO T-166) and Aggregate (AASHTO T 84 & T 85), and calculated according to CP-48 or AASHTO PP 19. All mixes shall meet the minimum VMA specified in Table 9.3.2, below

Note 3: VCA = Voids in the Coarse Aggregate

Note 4: DRC = Dry-Rodded Condition

TABLE 9.3.2 MINIMUM VOIDS IN MINERAL AGGREGATE (VMA) for Dense Graded HMA & Open Graded SMA, %

| Nominal Maximum* Particle Size | Air Voids ++ | | |
|-----------------------------------|--------------|------|------|
| | 3.5% | 4.0% | 4.5% |
| 1" | 12.2 | 12.7 | 13.2 |
| ¾" | 13.2 | 13.7 | 14.2 |
| ½" | 14.2 | 14.7 | 15.2 |
| SMA | 17.0 | 17.0 | 17.0 |

* Nominal Maximum Particle Size is defined as one sieve size larger than the first sieve to retain more than 10%, but shall not exceed the 100% passing size. The Nominal Maximum Particle Size can vary during mix production even when the 100% passing size is constant.

++ Minimum VMA criteria apply to the mix design only. The minimum VMA criteria shall be linearly interpolated based on actual air voids. See Section 9.13 for tolerances.

9.4 MIXTURE DESIGN SUBMITTALS

9.4.1 General Requirements

The **CONTRACTOR** shall submit all mixture designs, Certificates of Compliance, and laboratory data to the **AGENCY** for approval at least 7 calendar days before construction is to begin. The mix design (Proposed Design Job Mix) must be approved by the **AGENCY** prior to the start of construction.

Mixture designs shall be performed in a materials laboratory under the direct supervision of and shall be stamped and signed by a Professional Engineer licensed in the State of Colorado and practicing in this field. In addition, the **CONTRACTOR** shall submit, as part of the mixture design, laboratory data documents to verify the following:

1. Source of materials.
2. Gradation, specific gravity, source and description of individual aggregates and the final blend.
3. Aggregate physical properties.
4. Source and Grade of the Performance Graded Binder (PG Binder).
5. Proposed Design Job Mix: aggregate and additive blending, final gradation shown on 0.45 power graph, optimum asphalt content.
6. Mixing and compaction temperatures used.

7. Mixture properties determined at a minimum of four asphalt contents and interpolated at optimum and graphs showing mixture properties versus asphalt content.

AGENCY approval of any mix design for HMA or SMA must be given prior to placement,

The **AGENCY** reserves the right to verify the **CONTRACTOR's** mix design for each hot mix asphalt grading utilizing materials actually produced and stockpiled. If requested, the **CONTRACTOR** shall provide, at no cost, a sufficient quantity of each aggregate, mineral filler, RAP, and additive for the required laboratory tests, by the **AGENCY**. The **AGENCY** may request a Certificate of Conformance or Certificate of Compliance at any time on any material used. The **AGENCY** may request the mix supplier's testing results on RAP at any time.

9.4.2 Change in Source or Grade

Should a change in the source of Lime occur, or more than one temperature grade change on either the high or low end of Performance Graded Asphalt Binders - (PG Binder) occur, a one point verification test (at optimum asphalt content) of the mix must be performed to verify that the applicable criteria shown on 9.3.1a (Dense Graded HMA) or 9.3.1b (SMA), and Table 9.3.2 (VMA), is still met. If this testing shows noncompliance, a new Design Job Mix will be established and approved by the **AGENCY** before the new Performance Graded Asphalt Binders (PG Binder) or Lime source is used. Any change in aggregate type or source will require a new mix design. The one point verification test may be performed on lab mixed samples or on plant mixed samples

9.4.3 Mix Production Verification

Production verification shall occur prior to the start of the project. The production verification shall be performed by LABCAT Level C certified technicians with current Certification to verify the volumetric properties of the mix. If the mix has been produced for another project within the last 90 days, data from that project can be submitted for this verification. Volumetric properties of the mix verification testing shall be within the following tolerances compared to the Proposed Design Job Mix. The mix verification test reports shall be submitted to the **AGENCY** prior to mix placement.

TABLE 9.4.3 MIX DESIGN VERIFICATION TOLERANCES

| | |
|------------------------|--------------------|
| Air Voids | +/- 1.2% |
| VMA | +/- 1.2% |
| Asphalt Binder Content | +/-0.3% |
| Stability | Applicable minimum |

The tolerances in this table are for mix design verification only. See section 9.13 for production tolerances.

9.4.4 Pre-paving Meeting

AGENCY may require a pre-paving meeting of all parties involved in supply, haul, laydown inspection, quality control and quality acceptance of HMA. Areas of responsibility and contact names and numbers should be shared. A construction (joint) plan will be submitted at the pre-paving meeting, see section 9.9 for joint requirements. Form 9.1 provided at the end of this specification is an example of a pre-paving meeting agenda.

A minimum of two weeks prior to the proposed use of any Stone Matrix Asphalt pavement on the project, a pre-paving conference will be conducted. Prior to that time, the **CONTRACTOR** shall submit to the **AGENCY**, a mix design meeting the appropriate specification requirements for the items in Table 9.3.1b.

9.5 **EQUIPMENT**

9.5.1 Mixing Plant

The mixing plant shall be capable of producing a uniform material, have adequate capacity, and be maintained in good mechanical condition. Defective parts shall be replaced or repaired immediately if they adversely affect the proper functioning of the plant or plant units, or adversely affect the quality of the HMA.

Dust, smoke, or other contaminants shall be controlled at the plant site to meet all air quality requirements in the "Colorado Air Quality Control Act," Title 25, Article 7, CRS and regulations promulgated there under.

Acceptable safety equipment, approved by the **AGENCY**, shall be provided by the **CONTRACTOR** to accommodate sampling and testing.

9.5.2 Hauling Equipment

Trucks used for hauling HMA material shall have tight, clean, smooth beds, or functional and maintained conveyor belt bottom that is thinly coated with a minimum amount of paraffin oil, lime solution, or other approved release agent. Petroleum distillates such as kerosene or fuel oil will not be permitted. Each truck shall have a cover of canvas or other suitable material to protect the mixture from the weather and excessive temperature loss or cooled layers of mix in truck as covered in 9.6.3 Hauling, later in this specification.

9.5.3 Bituminous Pavers

Self-propelled pavers shall be provided for full lane width paving capable of spreading and finishing the HMA, material in full lane widths applicable to the typical section and thicknesses shown in the Contract and shall be equipped with:

1. anti-segregation devices,
2. A vibratory screed assembly capable of being heated.

Pavers used for shoulders, patching and similar construction, not requiring fine grade control, shall be capable of spreading and finishing courses of HMA material in widths shown in the Contract without segregation.

The paver's receiving hopper shall have sufficient capacity for a uniform spreading operation and shall have an automatic distribution system that will place and spread the mixture uniformly in front of the screed.

The paver shall be capable of operating at forward speeds consistent with uniform and continuous laying of the mixture. Stop and go operations of the paver shall be avoided. The screed or strike-off assembly shall produce the specified finished surface without tearing, shoving, or gouging the mixture. Self-propelled pavers shall be equipped with automatic screed controls with sensors capable of sensing grade from an outside reference line, and maintaining the screed at the specified longitudinal grade and transverse slope. The sensors may be contact or non-contact type devices. The sensor shall be constructed to operate from either or both sides of the paver and shall be capable of working with the following devices when they are required for the situation:

1. Grade control device at least 30 feet in length.

2. Joint matching device
3. Adequate length of control line and stakes, if no other type of geometric control is present
4. A straight edge at least 10 feet in length will be available to verify the crown on the screed, at the request of the **AGENCY**

The controls shall be capable of maintaining the screed at the specified transverse slope within plus or minus 0.1 percent. Automatic mode should be used where possible. If the automatic controls fail or malfunction, the equipment may be operated manually for the remainder of the normal working day, provided specified results are obtained.

If the **CONTRACTOR** fails to obtain and maintain the specified surface tolerances, the paving operations shall be suspended until satisfactory corrections, repairs, or equipment replacements are made.

Placement of HMA on a waterproofed bridge deck shall be accomplished with equipment that will not damage the membrane or protective covering.

9.6 MANUFACTURE

9.6.1 Preparation of Aggregates

Heating and drying of the aggregates shall be accomplished without damaging the aggregate. Hydrated lime shall be added to achieve complete and uniform coating of the aggregate, in accordance with one of the following methods:

- a) Lime Slurry Added to Aggregate: The hydrated lime shall be added to the aggregate in the form of slurry and then thoroughly mixed in an approved pugmill. The slurry shall contain a minimum of 70 percent water by weight.
- b) Dry Lime Added to Wet Aggregate: The dry hydrated lime shall be added to wet aggregate (a minimum of three percent above saturated surface dry) and then thoroughly mixed in an approved pug mill.

The lime-aggregate mixture may be fed directly into the hot plant after mixing or it may be stockpiled for not more than 90 days before introduction into the plant for mixing with the asphalt binder. The hydrated lime may be added to different sized aggregates and stockpiled by adding 75 percent of the lime to the aggregate passing the No.4 sieve and 25 percent to the aggregate retained on the No. 4 sieve.

A minimum of 1 percent hydrated lime by weight of the combined aggregate shall be added to the aggregate for all Dense Graded and Open Graded Stone Matrix Asphalt mixtures.

9.6.2 Mixing

The dried aggregates and asphalt binder shall be combined in the mixer in the quantities required to meet the design job mix. The materials shall be mixed until the aggregate is completely and uniformly coated, and the asphalt binder is uniformly distributed throughout the aggregate, Baghouse fines shall be fed back to the mixing plant in a uniform and continuous manner to maintain uniformity in the mixture. The Baghouse, fines feeder, auger, and related equipment, shall be in good working condition and operated in accordance with manufacturer's recommendation. If the **AGENCY** determines that non-uniform operation of the equipment is detrimental to the mixture, it may suspend all paving operations until the **CONTRACTOR** takes appropriate action.

The minimum temperature of the mixture when discharged from the mixer shall be as shown in the following table:

TABLE 9.6.2.1- MIXTURE DISCHARGE TEMPERATURES

| Asphalt Grade | Minimum Discharge Temperature | Maximum Discharge Temperature |
|---------------|-------------------------------|-------------------------------|
| PG 58-28 | 275° F | 310° F |
| PG 64-22 | 290° F | 325° F |
| PG 76-28* | 318° F | 326° F |

* Contractor or Binder supplier must supply production temperature as require by their product

The **CONTRACTOR** may provide refinery information that recommends revised discharge temperatures depending on the base binder grade or source being used. HMA mix shall be produced at the lowest temperature within the specified

temperature range that produces a workable mix and provides for uniform coating of aggregates (95 percent minimum in accordance with AASHTO T 195), and that allows the required compaction to be achieved.

HMA mix may be stored provided that any and all characteristics of the mixture are not altered by such storage. If storing or holding of the mixture causes segregation, excessive heat loss, or adversely affects the quality of the finished product, corrective action shall be taken. Unsuitable mixture shall be disposed of at the **CONTRACTOR's** expense.

When placing hot mix asphalt over bridge decks covered by waterproofing membrane, the minimum temperature of the mixture, when rolling operations begin, shall be 250 ° F. The job mix temperature may be increased up to 30 ° F to obtain this temperature.

The mineral filler for SMA shall be stored in a separate silo and added automatically in the correct proportion. The mineral filler addition equipment shall be electronically or mechanically interlocked to the aggregate feed sensors so that the proper amount of mineral filler is added whenever SMA is produced. The SMA mineral filler shall be added at the same point the asphalt binder is added to the aggregate.

9.6.3 Hauling

Each truck shall use full covers (tarps) to completely protect the mix during transport at all times. The **AGENCY** can reject any mix, which shows an excess or deficiency of asphalt cement, damage due to burning or overheating, an improper gradation, or thermal segregation with cold areas 10° F below the minimum discharge temperature.

9.7 TACK COAT

Prior to placement of HMA, a tack coat shall be applied to all existing concrete and asphalt surfaces. The material shall be in accordance with 9.2.4. The emulsified asphalt shall be diluted 1:1 with water and applied at 0.10 ± 0.01 gallons per square yard of diluted material. The **AGENCY** may direct other application rates to match the age of

condition of the surface. The surface prior to receiving the tack coat shall be dry and cleaned by sweeping, or other approved method, until dust, debris, and foreign matter are removed. The tack coat shall then be applied uniformly by squeegee, brooms, or distributor. Prior to paving, all water must have evaporated from the tack coat. Contaminated areas shall be cleaned and tack coat shall be reapplied.

Prior to placement of SMA, tack coat between the existing pavement and Stone Matrix Asphalt pavement shall be placed at a rate between 0.03 and 0.05 gallons per square yard

9.8 PLACEMENT

Hot mix asphalt shall be placed only on approved, properly constructed surfaces that are free from loose material, water, frost, snow or ice. The hot mix asphalt and tack coat shall be placed in accordance with the temperature limitations of Table 9.8 and only when weather conditions permit the pavement to be properly placed and finished as determined by the **AGENCY**. Placement temperature as stated shall be increased by 5° F for each 10 miles per hour wind velocity to a maximum increased minimum placement temperature of 70° F.

**TABLE 9.8 MINIMUM AIR and SURFACE TEMPERATURES
LIMITATIONS for MIX PLACEMENT (HMA)**

| Compaction Layer Thickness | Top Layer of Pavement* | | Lower Layers * | |
|-----------------------------|------------------------|----------|-------------------|----------|
| | PG 58-28 PG 64-22 | PG 76-28 | PG 58-28 PG 64-22 | PG 76-28 |
| <2 inches (not recommended) | 60° F | 75° F | N/A | N/A |
| 2 inches to <3 inches | 50° F | 65° F | 40° F | 50° F |
| > 3 inches | 50°F | 50° F | 40° F | 40° F |
| SG mix only | N/A | N/A | 38° F | 38° F |

*Air temperature is taken in the shade. Surface temperature is taken on the subgrade or base. The **AGENCY** may not waive the above temperature limitations for PG 76-28.

The mixture shall not be placed at a temperature lower than 245° F for mixes containing PG 58-28 or PG 64-22 asphalt, and 290 °F for mixes containing polymer modified

asphalt binder. Mix which is too cold or damaged by weather will be rejected.

The mixture shall be placed on an approved surface, spread and struck off to obtain the required grade and elevation after compaction. The minimum lift thickness shall be **at least three times (preferably four times) the nominal particle size**. The uncompacted mixture should be placed approximately 10-25 percent thicker than the existing surrounding mat to account for compaction based on the materials being placed. Raking is discouraged and will not be allowed except to correct major problems of grade and elevation. Casting or raking that causes any segregation will not be permitted.

On areas where the use of mechanical spreading and finishing equipment is impracticable, the mixture shall be carefully dumped, spread, raked, screeded, and luted by hand tools to the required compacted thickness plus approximately 25 percent based on the materials being placed. Carefully move or minimally work the HMA mix with the use of rakes, lutes, or shovels to avoid segregation. Mixtures made with modified asphalt binder require more rapid completion of handwork areas than for normal mixtures. Hauling and placement sequences shall be coordinated so that the paver is in constant motion. Excessive starting and stopping shall not be allowed. A construction joint shall be placed any time the paver stops, and the screed drops enough to cause a surface dip in violation of section 9.13.1, Surface Tolerances; or the mat temperature falls below that allowed in section 9.12, Compaction. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable. Echelon paving will be permitted.

9.8.1 SMA PLACEMENT & Compaction

A Roller Pass Study (RPS) for Density and 1000 foot demonstration control strip are required for placement of lifts less than or equal to 1.5 inch thick, optional for thicker lifts.

9.8.1.A For Thin Lift SMA less than or equal to 1.5 inch thick

In-place density shall be determined through the completion of a Roller Pass Study (RPS) to be conducted during placement of the required 1000-foot demonstration control strip. The RPS will determine the necessary roller compaction process needed to produce a minimum pavement density of 94 percent of theoretical maximum density (RICE). During the RPS, a minimum of three sets of three 4-inch diameter cores each shall be taken to measure SMA mat density for the various sections

of the RPS. All coring shall be completed by the **CONTRACTOR** and submitted to the **AGENCY**. The densities of the three cores will be averaged to produce the density for each RPS section tested.

Full production of the thin SMA shall not begin until density test results are determined and the project compaction process is established by the **CONTRACTOR** and approved by the **AGENCY**. The approved compaction process established from the RPS shall be used for the duration of the thin SMA paving. Changes to the thin SMA mixture will be reviewed and a new RPS may be required.

Using the same method for determining density during the RPS, density will be determined daily for each day of full production and tested to confirm pavement density. If a daily density check shows density below 92 percent of RICE, the **CONTRACTOR** shall stop production and the **CONTRACTOR** will again complete a RPS to establish the necessary compaction process. The **CONTRACTOR** will be allowed two daily density checks below 92 percent of RICE to be addressed in this manner during the project. All subsequent daily checks that identify locations having density below 92 percent of RICE shall be removed and replaced and a new RPS shall be completed and approved prior to again beginning production. Thin SMA density requirements will be enforced when the SMA mix design gradation and specified lift thickness are in accordance with or exceed the 3:1 requirements for the ratio of nominal maximum aggregate size to lift thickness.

The **CONTRACTOR** shall submit a plan for a Roller Pass Study (RPS) to the **AGENCY** for approval. Upon approval by the **AGENCY**, the **CONTRACTOR** shall perform a RPS. The plan for the RPS shall include, but is not limited to the following:

- Number, size, and type of rollers.
- Amplitude, frequency, size and speed of vibratory rollers.
- Temperature of mixture being compacted.
- Roller patterns.

The method of measuring density will be by roller passes. If a density

element is based on a RPS, the Pay Factor shall be as shown in section 9.14.3.

9.8.1.B For SMA lifts greater than 1.5 inch thick.

If in the opinion of the **AGENCY**, the roller pass study presented by the **CONTRACTOR** is inadequate, then the **CONTRACTOR** shall modify the compaction procedures as directed.

9.8.1.C Before Proceeding with SMA placement, the **CONTRACTOR** shall demonstrate the ability to produce and place a satisfactory mix.

The actual work may proceed when a full lane width demonstration control strip, having a minimum length of 1000 feet has been successfully placed. The **CONTRACTOR** shall determine properties (Superpave Air voids, VMA, in-place density, and Hveem Stability) of the project produced mix that is used in the demonstration control strip and provide the results to the **AGENCY**. No other SMA production or placement will be allowed until densities are determined. If the material in the demonstration control strip is not in close conformity with the specifications, the demonstration control strip will be removed and replaced at the **CONTRACTOR**'s expense. The **AGENCY** will designate the location of the control strip.

SMA mixture shall be transported and placed on the roadway without drain-down or flushing. All flushed areas behind the paver shall be removed immediately upon discovery. If more than 50 square feet of flushed SMA pavement is ordered removed and replaced in any continuous 500 linear feet of paver width laydown, operations shall be discontinued until the source of the flushing has been found and corrected. The **AGENCY** will designate the depth and area of all flushed areas requiring removal and replacement. All costs associated with the removal and replacement of the flushed areas shall be at the **CONTRACTOR**'s expense.

Stone Matrix Asphalt Pavement shall be placed and compacted in accordance with the temperatures listed in table 9.8 or as revised for the project.

The relative compaction for all SMA mixtures will be measured from roadway cores in accordance with CDOT-CP 44 or AASHTO T-166, Method B, unless the SMA mixture is being placed on a structure (bridge deck) in which case the **AGENCY** may specify that nuclear gauge measurements be used.

When cores are used, the **CONTRACTOR** shall provide all labor and equipment for the coring operation and filling the core holes. When nuclear density gauges are used, the tests will be performed in accordance with CDOT-CP 81 or ASTM D 2950 and CDOT-CP 82 or AASHTO T 230.

In-place density for SMA shall be 95 ± 2 percent of the SMA Mix maximum specific gravity as measured according to Maximum theoretical value (Rice) (CDOT-CP 51 or AASHTO T 209).

9.9 LONGITUDINAL JOINTS

The longitudinal joints in both a new pavement and an overlay pavement layer shall offset the joint in the layer immediately below by a minimum of 6 inches. The joints in any pavement layer shall not fall in a wheel track or path. The joints in the top layer of new pavement, not built on top of an existing pavement, shall be located on lane lines, or as shown on the plans. Longitudinal joints shall be minimized, where feasible, with wide paving pulls or echelon paving. Joints shall be parallel to the flow of traffic and shall not cross any centerline, lane line, or edge line unless approved by the **AGENCY**. The **CONTRACTOR** shall submit, prior to paving, a joint plan and pavement marking plan showing locations and the methods to establish a field control line. The **AGENCY** must approve such plans prior to paving. The **CONTRACTOR** shall use a continuous string line to delineate longitudinal joints during paving as shown on the joint plan. All string lines shall be removed at the end of each day's paving.

The free edge of the paved pass shall be laid as straight as possible, to the satisfaction of the **AGENCY**. This joint, if cold, shall be tack coated prior to placement of adjacent paving.

The new compacted mat shall overlap the previously placed mat no more than 1.5 inches. Excess overlap or thickness shall not be raked or cast onto the new mat, but shall be wasted by pulling back and removing. The hot edge shall be blocked or bumped in a smooth line consistent with the previous longitudinal edge. Minor raking will only be allowed to correct major grade problems or provide mix around manholes and meter covers. The longitudinal joint shall be rolled from the hot side and overlap the joint by approximately 6 inches on the cold side.

9.10 TRANSVERSE JOINTS

The **CONTRACTOR** shall submit, prior to paving, a joint plan showing locations and the methods to be used to construct transverse joints. The **AGENCY** must approve such plans prior to paving. Placing of the HMA shall be continuous with a minimum of transverse joints, and rollers shall not pass over the unprotected end of a freshly laid mixture. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. Tack coat material shall be applied to contact surfaces of all joints just before additional mixture is placed against the previously compacted material. The end of transverse joints shall be located so they will be constructed with a full head of mix in front of the screed. When butt joints are constructed, runoff boards shall be used to support the roller on the downstream side of the joint. All tapered sections, rounded edges and segregated areas shall be removed to achieve a vertical face at the butt joint before paving is restarted.

When a temporary tapered joint is required for temporary traffic access, the ramp shall be removed back to a full depth section before paving is restarted.

When restarting paving operations, the paver screed shall be placed on the starter block on the completed side of the transverse joint. The starter block should be approximately 25% greater than the thickness of the existing completed mat, so that adequate grade and compaction can be achieved on starting the paving operation. The screed should be nulled (angle removed) when on starting blocks and an up angle of attack set. Proper head of mix should be introduced into the paver prior to starting. The new compacted (downstream) side of the joint may be up to 3/16 inches higher than the old (upstream) side. Raking of this joint shall not be allowed except to correct major grade problems. The surface tolerance at the transverse joint must be verified by the **CONTRACTOR**

with a 10-foot straight edge before the paver is more than 100 feet from the joint. If the surface tolerance is not within the 3/16", the **CONTRACTOR** shall make corrections before proceeding

9.11 SEGREGATION

The asphalt mixture shall be transported and placed on the roadway without segregation. All segregated areas shall be removed immediately and replaced with specification material before the initial rolling. If more than 50 square feet of segregated pavement is removed and replaced in any continuous 500 linear feet of paver width laydown, operations shall be discontinued until the source of the segregation has been determined and corrected.

The **AGENCY** will visually determine areas that are segregated, and may also use density and gradation measures to help in this determination. The **AGENCY** will visually determine the extent of the segregation. The **CONTRACTOR** will not be allowed additional compensation for correction of segregated areas.

9.12 COMPACTION

The temperature of the mixture immediately behind the screed shall be sufficient to allow for proper compaction of the HMA layer and at least 245 °F for PG 58-28 or PG 64-22 binder and between 297°F and 305 °F for PG 76-28 binder. The breakdown compaction should be completed as quickly as possible after placement occurs.

The HMA shall be compacted by rolling. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density and surface texture while the mixture is in a workable condition. Compaction shall begin immediately after the mixture is placed and be continued until the required density is obtained. Final compaction shall be obtained using steel wheel rollers.

Pavement operations shall be suspended when density requirements are not met and the surface temperature falls below 185 °F, or there is obvious surface distress or breakage, the problem shall be resolved prior to continuing paving operations. The criteria for mixtures containing PG 76-28 asphalt cements shall be 235 °F. The minimum

compaction temperatures may be adjusted according to the asphalt binder supplier recommendations. Adjusted minimum compaction temperatures must be shown on the approved mix design or on other asphalt binder supplier documents, and be available on the job site. Pay Reduction criteria in Section 9.14 shall still apply in such cases.

All roller marks shall be removed with the finish rolling. Use of vibratory rollers with the vibrator on will not be permitted on bridge decks.

The **CONTRACTOR** shall establish a rolling pattern or procedure during the beginning of paving operations, which will achieve the required compaction and surface tolerances. This procedure may be re-evaluated by the **CONTRACTOR** and **AGENCY** throughout the paving operations.

All HMA paving shall be compacted to 94.0 ± 2 percent of Maximum Theoretical (RICE) Density, (CP-51 or AASHTO T-209: Maximum Specific Gravity of Bituminous Paving Mixtures) as determined by ASTM D 2950. RICE values shall be used in calculating Relative Compaction according to CP-44 or AASHTO T 166. The **CONTRACTOR** shall determine the proper RICE value to use for the initial day's placement. Subsequent day's RICE value(s) will be based on the current day's production. The **CONTRACTOR** shall provide the producer's RICE value, which shall be used for production until the actual day's RICE value is determined by the testing firm of record for the project as approved by the **AGENCY**.

All joints shall be compacted to 92.0 ± 2 percent of RICE, taken fully on each side of joint, every 200 Linear Feet. RICE values shall be used in calculating Relative Compaction according to AASHTO T 166, Cores if need will be used to verify compaction results.

The **CONTRACTOR** shall core the pavement, as required by the **AGENCY**, for field density tests in accordance with Colorado Procedure 44 or AASHTO T 230, Method B, or for field calibration of nuclear density equipment in accordance with the ASTM D 2950 or Appendix of Colorado Procedure 81. At a minimum, cores for nuclear density equipment calibration shall be taken at the beginning of placement of each pavement layer or change of mixture materials or gradation. Untested areas during placement will also require cores to be taken to verify compaction.

Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, shall be immediately removed and replaced with fresh hot mixture and compacted to conform to the surrounding area.

Compaction requirements for SMA are covered in section 9.8.1. Rollers shall not be used in a vibratory mode on SMA unless they are first used successfully in the demonstration control strip. Pneumatic wheel rollers shall not be used on SMA Mix.

9.13 PRODUCTION TOLERANCES

9.13.1 Top Lift Surface Tolerances

The surface variation between any two contacts shall not exceed 3/16 inch in 10 feet for full lane width paving. For patching surface tolerances, the variation shall not exceed 3/8 inch in 10 feet. Irregularities exceeding the specified tolerance shall be corrected at the **CONTRACTOR'S** expense. Transverse measurements for variations shall exclude breaks in the crown sections.

9.13.2 Job Mix Formula Tolerances

Production test results that deviate from the design job mix by more than shown in the following table are subject to Section 9.14:

TABLE 9.13.2 – JOB MIX FORMULA TOLERANCES

| Item | Tolerances |
|--------------------------------------|------------|
| Passing No. 3/8" and Larger (note 1) | ± 6% |
| Passing No. 4 and No.8 | ± 5% |
| Passing No. 30 to No. 50 | ± 4% |
| Passing No. 200 (note 2) | ± 2% |
| Air Voids | ± 1.2% |
| VMA (note 4) | ± 1.2% |
| Hveem Stability | (note 3) |
| Asphalt Content | ± 0.3% |

(Note 1) There is 1.0 percent tolerance for the maximum sieve size.

(Note 2) Mixes with passing No. 200 sieve material produced over 7.0 percent are allowed only when the above Air Voids and VMA tolerances are still met.

(Note 3) Hveem Stability must meet the minimum value specified in table 9.3.2.

(Note 4) When calculating VMA, use the most current aggregate specific gravity G_{sb} .

When disagreements concerning determination of specification compliance occur, only valid tests from both the **AGENCY** and **CONTRACTOR** will be considered. The **AGENCY** shall determine validity. Generally, valid tests are those in which sampling and testing have been performed according to referenced procedures and the results are within stated precision statements. When disagreements occur with asphalt content and gradation tests results, solvent extracted aggregate testing shall take precedence over burn off oven extracted aggregate, which shall take precedence over cold feed belt testing.

9.14 CONFORMITY WITH PLANS AND SPECIFICATION

9.14.1 General

All work performed and all materials furnished shall conform to the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown in the contract.

For those items of work where working tolerances are not specified, the

CONTRACTOR shall perform the work in a manner consistent with reasonable

and customary manufacturing and construction practices.

When the **AGENCY** finds that the materials furnished, the work performed, or the finished product does not conform with the contract, but that reasonably acceptable work has been produced, the **AGENCY** shall determine the extent of the work to be accepted and remain in place. Cost reduction, when allowed, shall be accomplished by adjusting pay quantities as indicated herein and applying contract unit prices to the reduced quantities. If the work is to be accepted, the **AGENCY** will:

- A. Document the basis for acceptance by "Cure Notice" which may provide for an appropriate adjustment in the payment quantity for such work or materials not otherwise provided for in this section.
- B. Notify the **CONTRACTOR** in writing that the payment may be adjusted in accordance with this section when "P" is 25 or less, or require appropriate remediation being performed.
- C. In lieu of cost (quantity) adjustment, permit correction or replacement of the finished product provided the correction or replacement does not adversely affect the work or the **AGENCY**.

When the **AGENCY** determines that the material furnished, work performed, or the finished product is not in conformity with the contract and has resulted in inferior or unsatisfactory product, the finished product or materials shall be removed and replaced or otherwise corrected by, and at the expense of, the **CONTRACTOR**.

Materials shall be sampled and tested by a qualified testing laboratory in accordance with the sampling, testing schedules, and procedures contained in the Section 9.15 Testing and Inspection. The approximate maximum quantity represented by each sample shall be as set forth in the testing schedule. An additional number of samples, in relation to the quantity of materials represented, may be selected and tested at the **AGENCY'S** discretion. The quantity represented by five consecutive random samples shall constitute a lot, whenever production schedules and material continuity permits. When it is necessary to represent short production runs, significant material changes, or other unusual characteristics of the work, the **AGENCY** may establish a lot consisting of the

quantity represented by any number of consecutive random samples from one to seven inclusive. Testing results that are determined to have sampling or testing errors, as determined by the **AGENCY**, shall not be used.

9.14.2 Pavement Thickness Deficiencies:

If the full depth cores indicate a thickness deficiency, additional cores will be taken by the **CONTRACTOR** to be given to the **AGENCY** so that price reductions can be determined per Lot. A Lot encompasses 250 lineal lane feet or the quantity between tests, and a price reduction shall be determined at the unit cost of the HMA.

9.14.2.1 Use of Cores to Determine Acceptable Asphalt Thickness

All cores shall be no more than 0.25-inch deficient than the required thickness shown on plans or pavement design report for full payment or acceptance. A minimum of 90% of all the pavement thickness cores must equal or exceed the required thickness shown on plans or pavement design report for full payment or acceptance. Any deficient pavement thickness shall be handled by 9.14.2.3 below.

9.14.2.2 Verification of Thickness and Remedial Action

When the **AGENCY** determines that deficient thickness exists, the **CONTRACTOR** may define the deficient section boundaries by any means, and then verify the boundaries to the satisfaction of the Agency at the boundary, or by direct measurement when cutting the pavement.

When the **AGENCY** determines that they do not want the top lift cored, they shall require the **CONTRACTOR** to use non-destructive survey techniques to determine top lift thickness. This shall be combined with core information taken from lower lifts to determine total pavement thickness.

The **CONTRACTOR** will be responsible for coring of the HMAP and notifying the **AGENCY** of the coring operations, so they may be present to observe. Duplicate cores will be required with the **CONTRACTOR** will retain one set and the **AGENCY** shall receive the other set for comparison testing.

9.14.2.3 Price Reductions on Thickness

There will be no Unit Price Reduction for Thickness deficiencies on projects to be accepted from developers. Remedial action is required of the **CONTRACTOR** to the satisfaction of the **AGENCY** to meet the design thickness requirements. Extended warranty will not be an acceptable alternate to remedial action.

For an **Agency's** Capital Project, the **AGENCY** may elect to apply a linear price reduction based on pavement thickness in lieu of remedial action using a base number from: 6% deficiency in thickness equates to an approximate 25% reduction traffic capacity over the design life.

9.14.3 Cost Reduction Formula

Materials or work shall only be evaluated for price adjustment when deviations from specifications occur on any of the individual tests for the lot. The several individual test values shall be averaged and the percentage of cost (quantity) reduction for the lot shall be determined by applicable formula. This shall apply only when a cost reduction factor "F" for the element is listed in Table 9.14.1.

9.14.3.1 When the Lot is represented by three through seven Tests

The formula in (a) and (b) below shall be used.

a) $P = (X_n + aR - Tu) * F$ Shall be used if a maximum limit only is specified or; when the average of the several test values is above the mid point of the specification band or above the job-mix formula value.

b) $P = (TL + aR - X_n) * F$ shall be used if the minimum limit only is specified or; when the average of the several test values is below the mid point of the specification band or below the job-mix formula value.

9.14.3.2 When the lot is represented by fewer than three tests

The materials shall be evaluated for cost (quantity) reduction by the following procedure:

Lots represented by two tests shall be divided into two separate lots represented by one test each, as determined by the **AGENCY**. Each lot that deviates from the specifications shall be cost adjusted by one of the following formulae.

c) $P = 0.76 * (T_o - T_u) * F$ When a maximum limit only is specified or the test value is above the maximum specified limit.

d) $P = 0.76 * (T_L - T_o) * F$ When a minimum limit only is specified or the test value is below the minimum specified limit.

Where:

P is the percentage of reduction in payment quantity.

X_n is the average of the several test values from samples taken from the lot, with “n” indicating the number of values.

a is a variable factor to be used if “n” changes according to the following:

| when “n” is | “a” equals |
|--------------|------------|
| 3 | 0.45 |
| 4 | 0.38 |
| 5 | 0.33 |
| 6 | 0.30 |
| 7 or greater | 0.28 |

R is the difference between the highest and lowest values in the group of several test results from the lot.

T_u is the upper or maximum tolerance limit permitted by the specifications.

T_L is the lower or minimum tolerance limit permitted by the specifications.

T_o is the test value of the test that deviates from the specifications.

F is the cost reduction factor to be applied for each element as shown in the following table:

TABLE 9.14.1

| TABLE OF PRICE REDUCTION FACTORS | |
|---|-------------------|
| ELEMENT | FACTOR "F" |
| 100 percent size sieve | 1 |
| 1/2 inch sieve and larger | 1 |
| 3/8 inch sieve, #4, #8, #30 sieves No. 100 | 3 |
| No. 200 sieve | 6 |
| Density of Hot Mix Asphalt | 8 |
| Asphaltic Cement Binder content (all asphalt-aggregate mixtures) | 20 |
| Total air voids | 30 |
| Voids in mineral aggregate | 20 |
| Stability | 5 |

If "**P**" is less than three (3) or a negative quantity, the material shall be accepted as being in conformity. In cases where one or more elements show a positive "**P**" value, such positive values shall be added and the resulting sum shall be used to determine whether the material is in conformity. If the total "**P**" value is between 3 and 25, the **AGENCY** may require correction or may accept the material at a reduced cost. If "**P**" is greater than 25, the **AGENCY** may:

- 1) Require complete removal and replacement with specification material at no additional cost to the **AGENCY**;
- 2) Require corrective action to bring the material into conformity at no additional cost to the **AGENCY**;
- 3) Where finished product is found to be capable of performing the intended purpose and the value of the finished product is not affected, permit the **CONTRACTOR** to leave the material in place with an appropriate cost adjustment to be based on the **AGENCY'S** evaluation but not less than that which would have occurred had an adjustment been made where "**P**" = 25.

If asphaltic binder content, aggregate sieve analysis, or compaction deviates from the specification requirements and the total "**P**" is three or greater, the

reduction shall apply to the contract cost (quantity) multiplied by 0.60 for aggregate base course and Hot Bituminous Pavement mixtures.

The **CONTRACTOR** shall not have the option of accepting a cost reduction in lieu of intentionally producing material not meeting specification. Continued production of non-specification material shall not be permitted. Material that is defective as identified by visual inspection shall be isolated and rejected without regard to sampling sequence or location within a lot.

9.15 TESTING AND INSPECTION

If any materials furnished or work performed by the **CONTRACTOR** fails to fulfill the specification requirements, such deficiencies shall be reported to the Project Manager and the **CONTRACTOR** immediately. Preliminary written field reports of all tests taken and observation results shall be given to the **CONTRACTOR** and **AGENCY, and DEVELOPER** within 1 business day after samples were obtained or density testing performed. Field reports shall be forwarded to the Project Manager no later than 1 week following the testing.

Reports of all tests taken, including failing tests, shall be reported to the **AGENCY**, to the **DEVELOPER** and to the **CONTRACTOR** no later than 1 week following the sampling. Density test results will be given in writing at the time the testing occurs.

Testing of Hot Mix Asphalt Pavement shall be performed in accordance with Table 9.15. The tests shall be performed under the general supervision of and signed by a **Professional Engineer** registered in the State of Colorado. Laboratories shall be inspected by either AASHTO or accredited A2LA or equivalent in the elements listed below. Technicians taking samples and conducting compaction tests must have a LABCAT Level A certification or equivalent. Technicians conducting tests of asphalt content and gradation must have a LABCAT Level B certification or equivalent. Technicians performing volumetric testing must have a LABCAT Level C certification or equivalent.

**TABLE 9.15.1
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING
FOR ITEM 9- HMA -PAVEMENT**

| Test | Standard* | Minimum Frequency |
|---|--|---|
| Sampling | AASHTO T 168, ASTM D 979 and ASTM D3665 | One test for each day |
| Density | AASHTO T 166, T 238, T 230 Or CP-44, CP-81, CP-82 | One test for each 250 lineal feet per Lane |
| Thickness (Core) | ASTM D 3549 | One test for each 1000 lineal feet per Lane, |
| Air Voids & VMA | AASHTO T 166 & AASHTO PP 19 or CP-48 | One test for each day (See note 4, Table 9.13.2) |
| Gradation | AASHTO T 27, T 11 or CP-31A, CP-31B | One test for each day |
| Hveem/Marshall Stability As Applicable | AASHTO T 245, AASHTO T 246 or CP-L 5106 | One test for each day |
| Asphalt (AC) Content | AASHTO T 164 or CP-L 5120 or other methods agreed upon between AGENCY and CONTRACTOR | One test for each day |
| Maximum Theoretical Specific Gravity (Rice) | AASHTO T 209 or CP-51 | One test for each day |
| Lottman Stripping, TSR & Dry Density | AASHTO T 283 or CP-L 5109, Method B | As requested by the AGENCY . |
| Micro Deval | AASHTO T 327 or CP-L 4211 | One per 5000 tons or 1 per project minimum |

* Agency may determine the method used (CP vs. AASHTO).

Inspectors shall be responsible for checking temperatures of mix in the truck and on pavement, segregation, rolling patterns and other construction means and methods that affect the performance of the pavement system. The **CONTRACTOR** shall provide assistance in sampling and testing at all facilities and at the job site.

The HMA or SMA mix design must be approved by the **AGENCY** before any pavement is placed on the project. In addition, the **CONTRACTOR** shall provide field control testing during production of the SMA mix and for the demonstration control strip. The **CONTRACTOR** shall perform the following tests and provide the results to the **AGENCY** during production:

If a SuperPave SMA mix design is used, the **CONTRACTOR** shall perform the following tests and provide the results to the **AGENCY** during production:

TABLE 9.15.2
SCHEDULE FOR MINIMUM MATERIALS SAMPLING AND TESTING
FOR ITEM 9- HMA/SMA PAVEMENT

| Superpave Mix Property | Frequency |
|--|---------------------------------|
| Draindown (AASHTO T 305) | 1/1000 tons or fraction thereof |
| Percent Voids in the total mix @ $N_{(design)}$ | 1/1000 tons or fraction thereof |
| VMA (Percent Voids in the Mineral Aggregate) @ $N_{(design)}$ | 1/1000 tons or fraction thereof |
| Lottman, CPL 5109 or AASHTO T 283, Method B | 1/5000 tons or fraction thereof |
| Dry Tensile Strength, CPL 5109 or AASHTO T 283 | 1/5000 tons or fraction thereof |
| Percent AC & Aggregate Gradation CP 5120 or AASHTO T 308 | 1/1000 tons or fraction thereof |

9.16 MEASUREMENT

HMA shall be measured based upon density, length X width and thickness to calculate tons Tack coat shall be measured gallons of bitumen without dilution.

Mix design, furnishing, hauling, preparing, and placing all materials, including aggregates, asphalt binder, limestone dust, hydrated lime, tack coat, and approved demonstration control strip; labor, equipment tools, setting of lines and guides where specified, and all other work necessary to complete the item will not be paid for separately but shall be included in the work.

9.17 PAYMENT

| Item | Description | Payment |
|-------|----------------------|---------------|
| 9.1 | HMA | \$ per Ton |
| 9.2* | Tack Coat | \$ per Gallon |
| 9.3** | Stone Matrix Asphalt | \$ per Ton |

* When the cost of the tack coat is a separate bid item.

** Stone Matrix Asphalt will be measured by the Ton of work completed and accepted.

HOT MIX ASPHALT PRE-PAVING CONFERENCE AGENDA

Form 9.1

The items in the following agenda are minimum requirements that should be covered during the conference. The agenda may be used as is or as a base to develop a customized agenda.

| | | | |
|-----------------------------|--|-----------------|--|
| Project Number: | | Owners Rep: | |
| Project Code (SA): | | Project AGENCY: | |
| Location: | | CONTRACTOR: | |
| Date: | | Superintendent: | |
| Time: | | Foreman: | |
| I. Attendance Roster | | | |
| Name: | | Office Number: | |
| Representing: | | Fax Number: | |
| Responsibilities: | | Cell Number: | |
| City, State, Zip: | | E-Mail Address: | |
| | | | |
| Name: | | Office Number: | |
| Representing: | | Fax Number: | |
| Street Address: | | Cell Number: | |
| City, State, Zip: | | E-Mail Address: | |
| | | | |
| Name: | | Office Number: | |
| Representing: | | Fax Number: | |
| Street Address: | | Cell Number: | |
| City, State, Zip: | | E-Mail Address: | |
| | | | |
| Name: | | Office Number: | |
| Representing: | | Fax Number: | |
| Street Address: | | Cell Number: | |
| City, State, Zip: | | E-Mail Address: | |

| | | | |
|---|--|-----------------|--|
| HOT MIX ASPHALT PRE-PAVING CONFERENCE AGENDA | | | |
| II. Project Organization and Status | | | |
| A. OWNER/AGENCY Personnel: | | | |
| 1. Personnel in Charge at Paving Site: | | | |
| Name/Title: | | Fax Number: | |
| Office Number: | | Home Number: | |
| Mobile Number: | | E-Mail Address: | |
| 2. Alternate Contact (when personnel identified in A.1 is not present): | | | |
| Name/Title: | | Fax Number: | |
| Office Number: | | Home Number: | |
| Mobile Number: | | E-Mail Address: | |
| 3. Quality Assurance Supervisor: | | | |
| Name/Title: | | Fax Number: | |
| Office Number: | | Home Number: | |
| Mobile Number: | | E-Mail Address: | |
| 4. Inspector/Duties: | | | |
| Name/Title: | | Fax Number: | |
| Office Number: | | Home Number: | |
| Mobile Number: | | E-Mail Address: | |
| Comments: | | | |

| | | | |
|---------------------------------------|--|-----------------|--|
| B. CONTRACTOR Personnel: | | | |
| 1. Quality Control Supervisor: | | | |
| Name/Title: | | Fax Number: | |
| Office Number: | | Home Number: | |
| Mobile Number: | | E-Mail Address: | |
| 2. Personnel to Notify at Paving Site | | | |
| Name/Title: | | Fax Number: | |
| Office Number: | | Home Number: | |
| Mobile Number: | | E-Mail Address: | |
| 3. Other: | | | |
| Name/Title: | | Fax Number: | |
| Office Number: | | Home Number: | |
| Mobile Number: | | E-Mail Address: | |
| Comments: | | | |

| | |
|--|--|
| HOT MIX ASPHALT PRE-PAVING CONFERENCE AGENDA | |
| II. Project Organization and Status | |
| C. Testing Information: (Compaction Test Results, acceptance tests to be performed, frequency) | |
| 1. Test locations determined by? | |
| 2. Frequency of tests to be performed? | |
| 3. Are Quality Assurance tests to be performed in addition to Quality control tests? ➤ If Yes how often and who will be responsible to schedule the QA tests? | |
| 4. Turn around time of test results? ➤ Preliminary? ➤ Final? | |
| 5. Is the mix design(s) approved by the Owner/Agency? | |

| HOT MIX ASPHALT PRE-PAVING CONFERENCE AGENDA | |
|---|--|
| III. Scheduling | |
| A. Materials: | |
| Materials will be available for sampling on: | |
| B. Asphalt Plant: | |
| The asphalt plant will be ready to be checked on: | |
| C. Paving Equipment: | |
| The paving equipment will be set up and ready to be checked on: | |
| D. Paving Sequence: | |
| 1. The CONTRACTOR will commence paving on: | |
| 2. Hot Bituminous Pavement will be delivered at: | |
| 3. The CONTRACTOR proposes to work the following hours: | |
| 4. How many days per week does the CONTRACTOR intend to work? | |
| 5. What paving sequence will the CONTRACTOR follow? | |
| E. A quality control plan shall provide information to control the quality of the following: | |
| 1. Segregation: | |
| 2. Longitudinal Joint Construction: | |
| 3. Transverse Joint Construction: | |
| 4. Smoothness: | |
| III. Scheduling | |
| 5. Other: | |
| F. Scales and Certified Weigher: | |
| 1. Scales shall be checked and sealed. Comments: | |
| 2. Weigh tickets shall contain information required by the owner. Comments: | |
| 3. Are truck weigh ticket required to be delivered on site? How will the weight tickets be collected? Comments: | |

| |
|--|
| IV. Preparation |
| A. Method of Approval Sub-Surface Materials? |
| Comments: |
| B. Has the Subsurface Been Approved for Paving? |
| ➤ Approved By Who? |
| C. Tack Coat: |
| 1. Material type, Application Rate? |

| |
|---|
| V. Production and Placement |
| A. Compaction Test Section: |
| <i>The following procedures should be observed and documented:</i> |
| 1. The CONTRACTOR must establish a roller pattern and carefully record the following information: |
| a. Type, size, amplitude, frequency, and speed of roller: |
| b. Tire pressure for rubber tire rollers and if the pass for vibratory rollers is vibratory or static: |
| c. Surface temperature of mixture behind the lay-down machine and subsequent temperatures and densities after each roller pass: |
| d. Sequence and distance from lay-down machine for each roller and total number of passes of each roller to obtain specified density: |

2. When the Compaction Test Section has been completed, the CONTRACTOR shall furnish a complete copy of this data to the person in charge (II.A.1) before continuing to pave. Comments:

HOT MIX ASPHALT PRE-PAVING CONFERENCE AGENDA

V. Production and Placement (continued)

3. When a successful Compaction Test Section has been completed, the CONTRACTOR is required to maintain the roller pattern established during the Compaction Test Section for the balance of the Hot Bituminous Pavement construction (i.e., the CONTRACTOR must use the same number and type of rollers and operate them at the same speed, frequency, and amplitude and in the same position, relative to the lay-down machine, as was performed during the Compaction Test Section). If the CONTRACTOR wants to change the roller pattern that was established during the Compaction Test Section, the CONTRACTOR must construct a new Compaction Test Section and demonstrate that the density can be obtained with the new roller pattern before proceeding with the paving operation.
Comments:

4. The CONTRACTOR is responsible for compaction testing of the Compaction Test Section. Comments:

5. Cores are required to calibrate the nuclear density gauge. The CONTRACTOR can continue to pave under the following conditions:
- The period that the CONTRACTOR continues to pave without test results from cores shall not exceed one working day.
- Construction proceeds at the's risk.
Comments:

6. A new Compaction Test Section will be required whenever there is a change in the compaction process.
Comments:

7. Striping plan: Sub CONTRACTOR or CONTRACTOR to do striping?
When will striping occur?
What material will be used?
Have Materials Data Sheets been submitted? Approved? If Not when?

A. Laydown Equipment:

1. Does the paving equipment meet the requirement detailed in the specifications? Comments:

VIII. Traffic Control

A. Method of Handling Traffic:

Has the Method of Handling Traffic been submitted for the Mix Asphalt Pavement placement operation?

If not, when will it be submitted?

Is the traffic control plan approved?

IX. Follow Up Items

Items discussed during the meeting, which will need follow up.

| Item for follow up | Who will follow up | Date of completion or response |
|--------------------|--------------------|--------------------------------|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |