

ROARING FORK & EAGLE VALLEY (RFEV)
SECTION 4
ASPHALT MIXTURE REQUIREMENTS

DEFINITION OF TERMS

Wherever the following abbreviations are used in the specifications or other Contract documents, the intent and meaning will be interpreted as shown below:

| | |
|------------|---|
| AASHTO | American Association of State Highway & Transportation Officials |
| ASTM | American Society for Testing & Materials |
| CP-## | Colorado Department of Transportation: Field Materials Manual (Colorado Testing Procedures) |
| CP-L ##### | Colorado Department of Transportation: Laboratory Manual of Test Procedures (Lab Testing Procedures) |
| HMA | Hot Mix Asphalt |
| RAP | Reclaimed Asphalt Pavement |
| WMA | Warm Mix Asphalt |

4.0 MIXTURE DESIGN SUBMITTALS (General Requirements)

All Asphaltic Mix Designs shall be performed by the Superpave Method. The Contractor shall submit all mix designs, Certificates of Compliance, and laboratory data to the Agency for approval before construction is to begin. The mix design (Proposed Design Job Mix) must be approved by the Agency prior to the start of construction.

Designs shall be developed and performed in a materials laboratory that meets the requirements set forth by AASHTO Materials Reference Laboratory (AMRL) for all required testing procedures and be under the direct supervision of and 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:

- Gradation, specific gravity, source and description of individual aggregates and the final blend.
- Aggregate physical properties.
- Source and Grade of the Performance Graded Binder
- Proposed Design Job Mix: aggregate and additive blending, final gradation shown on 0.45 power graph, optimum asphalt content.
- Mixing and compaction temperatures used.
- Mixture properties shall be determined with a minimum of four asphalt contents and interpolated at optimum and graphs showing mixture properties versus asphalt content.

Contractor shall obtain approval of the mix design intended for use on the project by the Agency prior to placement. The Project Manager reserves the right to verify the asphalt supplier's mix design for each grading utilizing materials actually produced and stockpiled. The asphalt supplier shall provide, at no cost, a sufficient quantity of each aggregate, mineral filler, RAP, and any additives used for the required laboratory tests, as well as all Certificates of Conformance / Compliance at any time on any material used. The Asphalt Supplier shall provide copies of quality control testing results during the

production of asphaltic mixtures used within one (1)-business day from the sampling date. Likewise, the owner / owner representative shall provide copies of acceptance tests to the contractor within one (1)-business day from the sampling date.

4.1 MATERIALS

Asphalt mixtures will consist of various aggregates, filler, and asphalt binder. Asphalt mixtures may also contain Reclaimed Asphalt Pavement (RAP), as well as a variety of additives.

Aggregate

Asphalt material aggregate shall be of uniform quality, composed of clean, hard, durable particles of crushed stone, crushed gravel, or crushed slag. The material shall not contain clay balls, vegetable matter, or other deleterious substances, and shall meet the following requirements:

**TABLE 4.1-1
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 (Does not apply to RAP or RAS aggregates) | | 45% Min |
| Two Fractured Faces, ASTM D 5821 All Lifts | 80% Min. | |
| LA Abrasion, AASHTO T 96 | 45% Max. | |
| Flat and Elongated (Ratio 5:1) %, AASHTO M 283 | 10% Max. | |
| Sand Equivalent. AASHTO-T 176 | | 45% Min. |
| Micro Deval AASHTO T 327 | 18% Max for individual materials 20% Max. for combined sample | |

**TABLE 4.1-2
Dense Graded Asphalt Material Gradation Range
(Percent by Weight Passing Square Mesh Sieves, AASHTO T 11 & T 27)**

| Mixture Grading | SX (1/2" nominal) |
|-------------------------------|---|
| Traffic Loading, ESALs | Low to Medium 0 to 300,000 All Lifts |
| Sieve Size** | Control Points |
| 3/4" | 100 |
| 1/2" | 90-100 |
| 3/8" | @ |
| #4 | @ |
| #8 | 28-58 |
| #16 | @ |
| #30 | @ |
| #50 | @ |
| #200 | 2.0-8.0 |

**These limits shall include the aggregate from the RAP and any other additive utilized in the mix.

@ These sieve sizes used only to determine the final Job Mix Formula (JMF) in accordance with Section 4.2.

Performance Graded Asphalt Binders

The Contractor shall provide to the Agency acceptable 'Certifications of Compliance' of each applicable asphalt binder grade from the supplier. When production begins, the Contractor shall, upon request, provide to the Agency a one quart can of each specified asphalt binder for analysis. Additionally, 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 4.1-3.

**TABLE 4.1-3
Properties of Performance Graded Binders**

| Usage for each Binder Grade | PG 58-28 | PG 64-22 |
|--|--------------------------|--------------------------|
| Binder Selection Based on Elevation | 6000 ft or Above | Below 6000 ft |
| Superpave Compactor Design gyrations Recommended Usage | $N_{\text{design}} = 75$ | $N_{\text{design}} = 75$ |
| Property of Binder Grade | PG 58-28 | PG 64-22 |
| Flash Point Temperature, °C, AASHTO T 48 | 230 Min. | 230 Min. |
| Viscosity at 135 °C, Pas, ASTM D 4402 | 3 Max. | 3 Max. |
| Dynamic Shear, Temperature °C, where $C^*/\sin \delta @ 10 \text{ rad/sec.} \geq 1.00$ Kpa, AASHTO TP 5 | 58 °C | 64 °C |
| Rolling Thin Film Oven Residue Properties, AASHTO T 240 | | |
| Mass Loss, %, AASHTO T 240 | 1.00 Max. | 1.00 Max. |
| Dynamic Shear, Temperature °C, where $G^*/\sin \delta @ 10 \text{ rad/sec.} \geq 2.20$ Kpa, AASHTO TP 5 | 58 °C | 64 °C |
| Elastic Recovery ¹ , 25°C, % Min.* | N/A | N/A |
| Pressure Aging Vessel Residue Properties, Aging Temperature 100 °C AASHTO PP1 | | |
| Dynamic Shear, Temperature °C, where $G^*/\sin \delta @ 10 \text{ rad/sec.} \leq 5,000$ Kpa, AASHTO TP 5 | 19 °C | 25 °C |
| Creep Stiffness, @ 60 sec. Test Temperature in °C, AASHTO TP 1 | -18 °C | -12 °C |
| S, Mpa, AASHTO TP 1 | 300 Max. | 300 Max. |
| m-value, AASHTO TP 1 | 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 |

* Elastic Recovery by Task Force 31, Appendix B Method

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

*** Any change in PG Binder other than what is shown in Table 4.1-3 shall be approved by the Agency's Engineer

Additives

Liquid Anti-stripping additives or Hydrated Lime may be used to meet the Lottman Tensile Strength requirements shown in Table 4.2-1. Liquid Anti stripping additives shall be added to the mix according to the manufacturer’s recommendations. Hydrated 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 No. 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. Use of any other additives used in the production of asphalt mixtures shall be approved by the Agency.

4.2 DESIGN REQUIREMENTS

The Agency shall indicate the “**Mixture Design Requirements for Hot Mix Asphalt Pavements**” binder type.

Superpave Mixture Design Method

A Job Mix Formula (JMF) design shall be submitted for approval for each mixture required, prior to construction. The JMF design shall be determined using AASHTO T-312 for the Superpave Method of Mixture Design. Mixture Design Gyration shall be 75 Design Gyration and shall meet the following of Table 4.2-1 for Dense Graded Asphalt Mixes.

**Table 4.2-1
Superpave Mixture Properties for Dense Graded Asphalt Mixtures**

| Property or Test | Criteria |
|--|-----------------|
| Design gyrations, N_{design} (Air Void: 3.5% to 4.5%) (See Note 1,2) | 75 |
| Air Voids in Total Mix (VTM) AASHTO T-312 (See Note 1) | 3.0-4.0 |
| Hveem Stability AASHTO T-246 (Grading S & SX only) (See Note 3) | 28 Min. |
| Voids Filled with Asphalt, MS-2 | 65-78 |
| Lottman, Tensile Strength Ratio, % Retained, AASHTO T-283, Method B | 80 Min. |
| AASHTO T-283 Dry Tensile Strength, psi | 30 Min. |

Note 1: Target Optimum asphalt binder content of mix: Choose target % as close to 3.5 air voids as possible (3.0% to 4.0% air voids).

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

Note2: Maximum Theoretical Specific Gravity of mix is to be determined by AASHTO T 209.

Note 3: Refer to Section 4.4 for production tolerances.

Note 4: VMA shall be based on tests of the Bulk Specific Gravity of the Compacted Mix (AASHTO T 166) and Aggregate (AASHTO T 84 & T 85), and calculated according to AASHTO PP 19. All mixes shall meet the minimum VMA specified in Table 4.4-2

The minimum Voids in Mineral Aggregate (VMA) % shall meet the requirements listed in Table 4.2-2.

TABLE 4.2-2
Minimum Voids in Mineral Aggregate (VMA) %

| Nominal Maximum* Particle Size | Air Voids ++ | | |
|-----------------------------------|--------------|------|------|
| | 3.0% | 3.5% | 4.0% |
| ½" | 13.0 | 13.5 | 14.0 |

*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 4.5 for tolerances.

Change in Source or Grade

Should a change in the source of any material used in the production of asphaltic pavement material (Aggregate, Mineral filler, Additives, or Performance Graded Asphalt 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 Table 4.2-1(Dense Graded Asphalt Mix), and Table 4.2-2 (VMA), is still met. If this testing shows noncompliance, the Contractor shall establish a new Job Mix Design and obtain approval by the Agency before the new Asphaltic Material is used.

4.3 RECLAIMED ASPHALT PAVEMENT (RAP)

RAP Material to be used in the asphalt mix shall be of uniform quality and gradation with a maximum size no greater than the nominal aggregate size of the mix. The average Asphalt Content (AC) of the RAP shall be determined using AASHTO T-164, Method A or B.

The total binder replacement by the binder in the RAP shall not exceed 23.0 percent as determined by the following equation:

$$\text{Total Binder Replacement} = (A \times B) \times 100/E$$

Where:

A = RAP % Binder Content*

B = RAP % in Mix*

E = Total Effective Binder Content*

*in decimal format (i.e. 2% is 0,02)

When RAP is used in the mix, the in-place properties of the binder will need to meet the required Performance-Graded Binder as tested using Dynamic Shear testing procedure TP 5. TP 5 shall be performed during the initial mix design and periodically throughout

the paving season, at a suggested rate of one test per bi-annually per production mix design.

RAP if allowed in the Asphalt mixture, shall be of uniform quality and gradation with a maximum size particle no greater than the maximum size allowed in the mixture. HMA mixtures containing RAP shall meet the same gradation requirements as a virgin HMA mix.

The reclaimed asphalt pavement shall meet all the requirements for Asphalt Pavements, as contained herein. The Contractor shall have an approved mix design for HMA with RAP prior to placement and shall include the asphaltic binder and virgin aggregate that are to be used to meet the requirements contained herein.

The Contractor shall 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 RAP aggregate. RAP shall 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 on Table 4.3-1, below. The Asphalt Supplier shall provide testing results on RAP mixtures daily.

When RAP is allowed for use in Asphalt mixtures, the following additional conditions shall apply:

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 to the mix design submitted in accordance with the following:

**TABLE 4.3-1
RAP Aggregate Uniformity Tolerances**

| Element | Uniformity* |
|----------------|--------------------|
| 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.

The Contractor shall supply the Agency with total binder grading tests from production samples collected when utilizing RAP.

4.4 WARM MIX ASPHALT (WMA)

The Contractor can utilize Warm Mix Asphalt (WMA) based on the following: Warm Mix Asphalt (WMA) is the generic term used to describe the reduction in production; paving and compaction temperatures achieved through the application of one of several WMA technologies. The producer shall submit a mix design for Warm Mix Asphalt production, or submit a statement that details production and testing items that require attention if the design is performed by standard HMA practice. All provisions for the production and placement of conventional hot mix asphalt (HMA) mixtures as stipulated in above sections except as noted below shall apply.

Mix Requirements

One or a combination of several technologies involving hot mix asphalt plant foaming processes and equipment, mineral additives, or chemicals that allows the reduction of mix production temperatures by as much as 100°F. A WMA mixture design shall identify the technology to be used. The producer shall comply with the manufacturer's recommendations for incorporating additives and WMA technologies into the mix. Comply with the manufacturer's recommendations regarding receiving, storage, and delivery of additives. Maintain supplier recommendations on file at the asphalt mixing plant, make available for reference while producing WMA, and be available to the Agency upon request.

Warm Mix Asphalt (Technologies)

WMA designs shall be developed using the specified additives or method. Each WMA design shall specify the production temperatures recommended by the WMA additive manufacturer to be used in production of Warm Mix Asphalt.

Chemical Modifiers to be considered shall be on the CDOT approved products list.

Foamed WMA technologies must be submitted to and approved by the Agency for use on a specific project or asphalt layer.

4.5 PRODUCTION REQUIREMENTS

There shall be no substitutions of materials allowed during production. All substitutions will require checkpoint verification if the checkpoint differs from the Job Mix Formula (JMF) a new mix design will be required. Upon request of the Agency, the binder grade may be changed by one available binder grade level without requiring a new mix design.

TABLE 4.5-1

Minimum Quality Control And Acceptance Sampling and Testing for Asphalt Mixtures

| | AASHTO | ASTM | COLORADO | Minimum Frequency of Tests |
|--|--|----------------------------|-------------------------|---|
| Sampling* | T 168 | D 979 D 3665 | CP-41 | One per 1,000 tons or fraction thereof (not less than one test per day) |
| In-place Mat Density | | D 1188 D 2950 | CP 81 | Minimum of three per project or one per 1,000 linear lane feet per |
| In-place Joint Density | T 230, Method B | | CP 44 | As Specified by the Agency / Owner |
| Asphalt content | T 164 T 269 TP 53 | D 2172 D 3203- PS 90 | CP-L 5120 CP 85 | One per 1,000 tons or fraction thereof (not less than one test per day) |
| Maximum Specific Gravity | T 209 | D 2041 | CP 51 | One per 1,000 tons or fraction thereof (not less than one test per day) |
| Air voids and VMA | T 269 | D 3203 | CP 44 CP-48 CP 51 | Only required for Mix Production Verification |
| Thickness | To be determined based on yield calculations or as specified by the Agency or Owner in the contract documents. | | | |
| Aggregate Gradation | T 27 | C 136 | CP-31 | One per 1,000 tons or fraction thereof (not less than one test per day) |
| Binder Performance-Graded, Dynamic Shear | TP 5 | | | One test Bi-Annually per production mixture. |

* Contractor shall provide plant split samples to the appropriate testing Agency.

Pre-paving Meeting

The Agency may require a pre-paving meeting of all parties that are directly involved in supply, haul, laydown, inspection, quality control, and quality assurance of asphalt pavement are required. Traffic control, haul, direction, sequence of paving and construction (joint) plan will be reviewed and discussed at the pre-paving meeting.

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.

Mix Production Verification

Production verification shall occur prior to the start of the project. Technicians that have current LabCAT Level C certification shall verify the volumetric properties of the mix. Certified technicians shall maintain current Certification to verify the volumetric properties of the mix. If the mix was produced for another project within the last 90 days, data from that project can be submitted for verification. Volumetric properties for 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.

Job Mix Formula Tolerances:

For production, test results must not deviate from the design job mix by more than shown in the following table:

**TABLE 4.5-2
Mix Design Verification Tolerances**

| Property | Criteria |
|------------------------|-----------------|
| Air Voids | +/- 1.2% |
| VMA | +/- 1.2% |
| Asphalt Binder Content | +/-0.3% |
| Stability | 28 minimum |

The tolerances in this table are for mix design verification only. See Section 4.2-1 for design requirements.

During Production

The minimum temperature of HMA mixtures when discharged from the mixer shall be as shown on Table 4.5-3 or according to refinery recommendations.

**TABLE 4.5-3
Mixture Discharge Temperatures**

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

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

Gradation and oil content tolerances shall be as defined by Table 4.5-4

**TABLE 4.5-4
Job Mix Formula Tolerances**

| Mixture Grading | SX (1/2" nominal) | |
|------------------------|--------------------------|------------------|
| Sieve Size | Control Points | Tolerance |
| 3/4" | 100 | + 1% |
| 1/2" | Design | ± 6% |
| 3/8" | Design | ± 6% |
| #4 | Design | ± 5% |
| #8 | Design | ± 5% |
| #16 | Design | ± 4% |
| #30 | Design | ± 4% |
| #50 | Design | ± 4% |
| #200 | Design | ± 2% |
| Asphalt Content | Design | ± 0. 3% |

In-place density requirements shall be as shown in Table 4.5-5

**Table 4.5-5
In-place Density Requirements**

| In-place Density | Percent of Theoretical Maximum Specific Gravity (CP 51)* |
|-------------------------|---|
| Mat | 92 to 96 |

*Colorado Department of Transportation: Field Materials Manual