

Colorado Procedure 52-21

Standard Practice for

Contractor Asphalt Mix Design Approval Procedures

1. SCOPE

- 1.1 This practice describes the procedures for asphalt mix design approval, the time required to perform the required tests, and the cost of the testing.

2. REFERENCED DOCUMENTS

2.1 *AASHTO Standards:*

- T 85 Specific Gravity & Absorption of Coarse Aggregate
- T 90 Determining the Plastic Limit & Plasticity Index of Soils
- T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- PP 78 Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in Asphalt Mixtures

2.2 *Colorado Procedures:*

- CP 10 Qualification of Testing Personnel and Laboratories
- CP 30 Sampling of Aggregates
- CP 31 Sieve Analysis of Aggregates
- CP 32 Reducing Field Samples of Soil and Aggregate to Testing Size
- CP 51 Determining the Maximum Specific Gravity of HMA

2.3 *Colorado Procedures – Laboratories:*

- CP-L 4102 Specific Gravity and Absorption of Fine Aggregate
- CP-L 4211 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
- CP-L 5106 Resistance to Deformation of Bituminous Mixtures by Means of Hveem Apparatus
- CP-L 5109 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
- CP-L 5115 Preparing & Determining the Density of Bituminous Mixture Test Specimens Compacted by the Superpave Gyratory Compactor
- CP-L 5117 Superpave Design for Hot Mix Asphalt
- CP-L 5120 **Determination of Asphalt Binder Content of Bituminous Mixtures by Ignition Method**
- CP-L 5145 Contractor Asphalt Mix Design Approval Procedures Utilizing RAP Millings from the Same Project

3. APPROVAL OF MIX DESIGNS

- 3.1 Asphalt mix designs shall be performed in conformance with CP-L 5115, CP-L 5106, CP-L 5109 and CP-L 5117 as well as other specified Colorado, AASHTO, and ASTM procedures. Mix designs for S, SX and ST mixes will be done using 4-inch molds. Mix designs for SG mixes will be done using 6-inch molds. A complete mix design will be required for all mixtures placed on the project.

3.2 The Contractor must submit to the Engineer three copies of the asphalt mix design on CDOT Form #429, which contains all the information detailed in Subsection 4.2, and the aggregate **samples (a Checklist is provided at the end of this procedure, to assist in organizing the required information). The Project Engineer will forward the Contractor's Asphalt Mix Design to the Regional Materials Engineer for review and approval, a minimum of 4 weeks prior to the anticipated paving start date. All asphalt mix designs shall be stamped by a registered Professional Engineer in the State of Colorado pursuant to Section 12-25-117 of the Colorado Revised Statutes.** Mix designs shall have an original manual ink signature. Copied or faxed mix designs will not be accepted. Scans of Wet-Stamped mix design submittals in pdf format are acceptable.

The cover letter describing the asphalt mix design, as a minimum, shall be stamped by a registered Professional Engineer in the State of Colorado. If the supporting documentation listed in Subsection 4.3 is not covered by the Engineer of Record, each supporting page shall be stamped by a registered Professional Engineer in the State of Colorado. The Region Materials Engineer (RME) must approve the Contractor's proposed asphalt mix design before paving may proceed. The Engineer may reject a mix design that appears to have errors. The Contractor shall use the latest version of the CDOT Form 429 which may be obtained through the RME or through the Flexible Pavement Unit of the Central Laboratory. Additionally, each mix design submitted for approval must be accompanied by a Microsoft® Excel® electronic version of the CDOT Form 429 specific to each mix.

3.2.1 To verify the asphalt mix design, the aggregates to be used in the mix design, shall be sampled by the contractor in accordance with CP 30 and split in accordance with CP 32 in the presence of the Engineer. The split aggregates shall be tested by the Contractor and CDOT Central Laboratory Concrete/Physical Properties Unit. The aggregates shall be tested for: Gradation (CP 31), Aggregate Specific Gravity and Absorption, (AASHTO T 85 & CP-L 4102) and Plastic Index (AASHTO T 90). The Engineer will coordinate with the Region Materials Engineer to determine the need to run the Micro-Deval (CP-L 4211) and/or the Los Angeles Abrasion (AASHTO T 96).

Note 1: If the combined aggregate specific gravity of the contractor's asphalt mix design is not within 0.020 of the test results for the combined aggregates derived from the CDOT Central Laboratory testing as specified in Subsection 3.2.1, the Contractor and CDOT Central Laboratory shall both recheck calculations, retest, and/or resample/retest as needed until the resulting mix combined aggregate specific gravities agree to within 0.020. The contractor's aggregate specific gravity values will then be used to calculate the HMA mixture volumetric properties. At the discretion of the Region Materials Engineer, the use of the aggregate test results from the CDOT Central Laboratory as listed in Subsection 3.2.1 may be allowed for mix development only if all other mix design criteria are met when using Central Laboratories test results. The mix design criteria that must be met includes minimum VMA and VFA criteria and dust to asphalt ratio, as required by the Contract.

3.2.2 The Reclaimed Asphalt Pavement (RAP) to be used shall be sampled by the contractor in accordance with CP 30, in the presence of the Engineer, and will be tested by the Flexible Pavement Unit of the CDOT Central Laboratory. **The RAP shall be tested for: Asphalt Binder Content (uncorrected) (CP-L 5120), and Gradation (uncorrected) (CP 31) and Effective Specific Gravity (CP 51, Method B).** Two individual samples are used to determine the average Asphalt Binder Content and Gradation.

- 3.3 The asphalt mix design cannot be approved when the laboratory trial, binder data, or aggregate data possess results from tests performed more than one year in the past.

If the Form #429 submitted is from a mix design developed more than 2 months' prior, the Region Materials Engineer may request additional aggregate data meeting the requirements of Subsection 4.3 (1) B and C be provided.

Based on the new data provided, the Region Materials Engineer may require additional testing.

If the average gradation for any material on any individual sieve varies by more than 5 percent from design gradation or 2 percent on the #200 sieve, or the combined gradation based on the averages varies by more than 3 percent on any sieve or 1 percent on the #200 sieve, a one-point verification, performed at the design optimum asphalt content, may be required using current production aggregate **at the Regional Materials Engineer's discretion.**

If CDOT Central Laboratory Concrete/Physical Properties Unit's gradation for any material on any individual sieve varies by more than 5 percent from design gradation or 2 percent on the #200 sieve, or the combined gradation based on CDOT's results varies by more than 3 percent on any sieve or 1 percent on the #200 sieve, a one-point verification, performed at the design optimum asphalt content, may be required using current production aggregate. As an alternative to a one-point verification, a new mix design may be required by the Region Materials Engineer. If one round of resampling and retesting in accordance with CP 30 does not resolve the gradation differences, the Region Materials Engineer may require a new HMA design.

The one-point verification may be performed at the Region Materials Engineer's discretion as an alternative to requesting a new mix design. Constituent materials used in the one-point verification shall be taken from the sampled stockpiles that CDOT Central Laboratory Concrete/Physical Properties Unit tested and shall not be modified for creation of the one-point verification sample.

The one-point may be performed by either CDOT or the Contractor at the direction of the Region Materials Engineer.

The results of the one-point verification shall meet the project design specifications. In addition, the results for air voids and voids in mineral aggregate shall be within 1 percent of design target. If the one point does not meet these criteria a new mix design may be required by the Region Materials Engineer.

- 3.4 If all tests conform to the specifications, a CDOT Form 43 (Job Mix Formula) will be executed.
- 3.5 All mix design properties must satisfy Table 403-1 from the Project Special Provisions. The CDOT Form #43 will establish construction targets for Asphalt Content and all mix properties at Air Voids up to 1.0% below the mix design optimum.
- 3.6 After an asphalt mix design is approved for use, binder changes shall be handled as follows:

3.6.1 If the Supplier remains the same, but the binder used changes, such that future binder supply to a project will come from a different refinery, different terminal, or be a different formulation that could potentially affect mix properties, a one-point check at the Form 43 target AC content shall be done by the Contractor to verify that asphalt mix design properties are still valid. The one-point check verification shall be reviewed and stamped by a registered Professional Engineer in the State of Colorado and shall be submitted to the Engineer. Production shall not commence until one-point verification is completed and is approved by the RME. A new mix design shall be required if the one-point check is not accepted by the RME. If the supplier is changing terminal location and both locations utilize the same formulation, the one-point check may be waived with concurrence from the RME.

3.6.2 If the Supplier or grade changes, a new asphalt mix design shall be submitted for approval.

4. MIX DESIGN REQUIREMENTS

4.1 Labs and personnel providing asphalt mix designs shall comply with the requirements listed in CP 10.

4.2 Cover Letter – A cover letter including the following:

- Laboratory name & address
- Supplier's name & address
- Supplier's unique mix design number
- Date(s) of trial batch testing
- Source of all mix design components
- Stamped & signed by a Professional Engineer registered in the State of Colorado

4.3 It is recommended that a complete mix design consisting of test results from three trial blends (in accordance with **Asphalt** Mix Design Methods MS-2) be conducted when the materials sources used in the mix design have not been verified on past CDOT projects. A complete mix design must contain all of the following:

(1) For each aggregate stockpile:

- A. Aggregate source
- B. Target gradation along with gradation results from at least the 10 most current samples taken during production. These samples shall have been sampled and tested within two months (**see Note 3**) of submitting the mix design.
- C. Coarse Aggregate Bulk specific gravity and fine aggregate bulk specific gravity from at least the 3 most current samples taken during production. These samples shall have been sampled and tested within two months (**see Note 4**) of submitting the Mix Design.
- D. Atterberg limits.
- E. Los Angeles Abrasion.
- F. Statistical data for the Apparent Specific Gravity and Bulk Specific Gravity.

(2) Reclaimed asphalt pavement (RAP) if used shall include the source and following statistical data from at least 10 samples tested within two months (**see Note 2, 3 & 4**) of mix design submittal:

- A. Percent RAP Binder Content - AASHTO T-164, Method A or B, or CP-L 5120 if correction established per Revision of 401 – Reclaimed Asphalt Pavement.
- B. RAP Aggregate Gradation – CP 31.
- C. Effective Specific Gravity.

D. Uniformity Calculations for the Processed RAP, to include Binder Content and Aggregate Gradation.

Note 2: The RAP aggregate bulk specific gravity will be back-calculated using an assumed average aggregate water absorption of 1.01%. The corresponding assumed aggregate asphalt absorption will be 0.61%.

- (3) Reclaimed asphalt shingles (RAS) if used, shall include the source and following statistical data from at least 10 samples tested within two months (see Note 2) of mix design submittal:
- A. Percent Asphalt – AASHTO T-164, Method A or B, or CP-L 5120 if correction established per Revision of 401 – Reclaimed Asphalt Shingles.
 - B. RAS Aggregate Gradation – AASHTO PP 53.
 - C. Effective Specific Gravity (in lieu of the RAS aggregate specific gravity – AASHTO PP 53.
 - D. Uniformity Calculations for the RAS to include gradation (on the processed RAS material), Asphalt Binder Content, and Percent Passing #200 Sieve (on the extracted RAS aggregate).
 - E. A copy of the RAS QC Plan from the contractor or RAS supplier per Section 401.

Note 3: If the material used in the mixture design submittal was crushed/stockpiled more than two months prior to submitting the design for approval, the required 10 gradation sample results shall be the 10 most recent to the submittal date.

Note 4: If the material used in the mixture design submittal was crushed/stockpiled more than two months prior to submitting the design for approval, the required 3 aggregate bulk specific gravities shall be the 3 most recent to the submittal date.

- (4) Combined Aggregate Properties:
- A. Percentage of each aggregate used,
 - B. Combined Aggregate Gradation and Virgin Aggregate Gradation.
 - C. Sand Equivalent.
 - D. Fine Aggregate Bulk Specific Gravity and Coarse Aggregate Bulk Specific Gravity on the virgin portion of the mix aggregates.
 - E. Fine Aggregate Angularity.
 - F. Combined Aggregate, Apparent and Bulk Specific Gravity.
 - G. Fractured Faces.
 - H. Micro-Deval according to CP-L 4211.
 - I. Effective Specific Gravity.
- (5) Source and grade of asphalt cement from a CDOT Certified Binder Supplier as listed on the CDOT APL. Use the actual specific gravity of the asphalt cement in calculations.
- (6) Hydrated Lime – Provide the Contractor's APL- Verification (AV).
- (7) Name and percentage of each additive.
- (8) For each asphalt content tested:
- A. Voids in Mineral Aggregate (VMA) @ N_{des} .
 - B. Dust to Asphalt ratio.
 - C. Percent Voids Filled with Asphalt (VFA) @ N_{des} .
 - D. Hveem Stability (@ N_{des}) for Grading S and Grading SX mixes only.
 - E. Maximum Theoretical Specific Gravity,

- F. Bulk specific gravity @ N_{des} .
 - G. Air voids, Voids in Total Mix (VTM) @ N_{des} .
- (9) Graphs of stability, Air Voids, VMA, VFA and **virgin effective AC content (RAS mixtures)** vs. total Asphalt content.
- (10) Lottman and wet/dry tensile strength at optimum asphalt content.
- (11) A 0.45 power plot of the proposed combined aggregate gradation, with maximum density line and control points included.
- (12) For SMA, submit the following additional aggregate information:
- A. Bulk Specific Gravity of the coarse-aggregate fraction.
 - B. Unit weight of the coarse aggregate fraction in the dry-rodded condition.
 - C. Drindown test results (at production temperature).
 - D. Mineral filler gradation (for limestone dust); or, plasticity index, hydrometer analysis, gradation, calcium oxide content, and modified Rigden Voids (if alternate mineral fillers are used).
- (13) For Warm Mix Asphalt, submit the following additional information.
- A. Contractor WMA Design Considerations:
 - i. A brief summary of mix design practices with WMA technology if different from HMA procedures.
 - ii. WMA deviations from CDOT design and acceptance criteria. All mix will be tested for acceptance in accordance with existing HMA procedures. Significant deviation from these criteria will require an experimental feature in accordance with PD 1401.1.
 - B. WMA Production Considerations:
 - i. Summary of equipment and plant requirements to control WMA production.
 - ii. For WMA mixtures provide data illustrating differences between mix design properties and the anticipated WMA production properties. WMA volumetric targets may be adjusted as approved by the RME. See CP-59 for details on the required data to be submitted.
 - iii. If the WMA produced on the project fails mixture verification, goes in to condition red, or if the asphalt plant fails to satisfy the WMA production controls outlined in the submittal for WMA approval, WMA production shall cease, written explanation shall be provided for the failures, and production may be required to revert to conventional HMA. WMA mix design submittals shall include a summary of contractor production plans should this occur during production.
 - C. WMA Contacts:
 - i. WMA product manufacturer representative name, email, and phone number.
 - ii. Name, email, and phone number of WMA product manufacturer representative who will be available during construction.

5. CONTRACTOR CHECKS

- 5.1 If a contractor wishes to check a test result with CDOT, they should make arrangements with the Flexible Pavement Unit or Physical Properties Unit of the CDOT Staff Materials Laboratory, depending upon the properties (mix or aggregate) that are to be tested. The Unit will work one-on-one with the contractor, as time permits, to improve inter-lab agreement. The testing will not be a part of the mix design process.

6. COST OF MIX DESIGN REVIEW

- 6.1 CDOT Regional Materials Engineer will review up to two HMA Mix Designs, for each specific mix type, per project (Note 5). The Contractor must pay \$1,100 for each subsequent mix design. The Project Engineer will pass on the appropriate charges through the Contractor.

Note 5: It should be anticipated that HMA Mix Designs, in excess of two, for a specific mix type, may take significantly longer to review and approve.

7. COST OF MIX AGGREGATE TESTING

- 7.1 CDOT Staff Materials Laboratory will conduct one complete set of mix aggregate tests at no cost to the Contractor upon receipt of a completed asphalt mix design submittal from the Contractor. (See Subsection 3.2.1) The Contractor must pay \$500 per aggregate for each subsequent set of mix aggregate tests performed by the CDOT Central Laboratory. The Project Engineer will document the additional tests performed and the appropriate charges will be passed through to the Contractor.

8. TIME REQUIRED FOR AGGREGATE TESTS

- 8.1 Reference the Laboratory Test Time table located in the Appendix of the Field Materials Manual.

9. RECORD

- 9.1 CDOT Form # 429 is used. It is available electronically from the Central Lab at 303-398-6576 or from the Region Materials Engineers. See Chapter 400 for an example and instructions on the use of this form.
- 9.2 All requests for mix design information shall be made under the Colorado Open Records Act and shall follow CDOT Procedural Directives 25.1.

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