

CONTRACTOR MIX DESIGN GUIDELINES

For

ASPHALT CONCRETE

OREGON DEPARTMENT OF TRANSPORTATION

January 2008

CONTRACTOR MIX DESIGN GUIDELINES for ASPHALT CONCRETE

These guidelines outline the procedures to be used in developing, testing, and submitting asphalt concrete mix designs for ODOT contracts and for projects with other agencies that using the version of Oregon Standard Specifications for Construction applicable to the contract (either 2002 or 2008 version). According to these specifications the contractor is responsible for developing the mix designs for all Hot Mixed Asphalt Concrete (HMAC) and Emulsified Asphalt Concrete (EAC). Stone Matrix Asphalt mix designs will be developed by ODOT.

The actual test procedures used to develop a mix design are available in a separate document described in Sections 1 & 2 of these guidelines.

If you have any questions about the information contained in these guidelines or any corrections to suggest, contact Karl Frick, Assistant Pavement Materials Engineer at (503) 986-6574 or Larry Ilg, Pavement Quality Engineer at (503)-986-3072.

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1.0 SCOPE

- 1.1 The Oregon Standard Specifications for Asphalt Concrete 00744.13, 00745.13(a) and 00735.13 require the Contractor to develop the mix designs for HMAC and Emulsified Asphalt Concrete (EAC). For projects under an ODOT contract, the proposed mix design is submitted to the ODOT Project Manager. The ODOT Project Manager forwards the mix design to the Pavement Materials Engineer to conduct a review of the design. The only exception is that SMA (Stone Matrix Asphalt) mix designs will be developed by ODOT.
- 1.2 This document, along with the Supplemental Test Procedures for HMAC and EAC, establishes the procedures for developing and submitting a new HMAC or EAC mixture design. It also describes procedures for submitting existing mix designs for use on a new contract. The guidelines cover Dense-Graded virgin and RAP mixtures and Open-Graded virgin mixtures. The design procedure for Dense-Graded Superpave mixes; Open-Graded HMAC and EAC, along with a few other procedures are in the ODOT "Supplemental Test Procedures for HMAC and EAC". See Section 2.0 "Applicable Documents" for a list of required procedures and their location.
- 1.3 Mix designs are reviewed by ODOT as described in Section 9 and if the design meets all requirements a Mix Design Review Report signed by the Pavement Materials Engineer is issued with a unique ODOT number. No report will be issued for designs that are incomplete or those not meeting specification requirements. However, the CMDT will be notified of the problem. ODOT may delay issuing a mix design review report until it has confirmed that the produced aggregate for the project meets the specifications. In most cases, aggregate product compliance testing must have been performed within the last twelve months on produced HMAC aggregate to meet these requirements. If the aggregate and RAP used to develop the mix design is determined to be unrepresentative of the materials produced for construction, all or part of the mix design may be rejected.
- 1.4 Existing mix designs developed or reviewed by ODOT for a project will be considered for transfer to other contracts with the written concurrence of the Pavement Materials Engineer. Mix designs that were originally developed prior to 2004 are not eligible for transfer. The timeline for mix design transfer reviews is the same as a "new" mix design. See Section 10 for the transfer policy.

2.0 APPLICABLE DOCUMENTS

Refer to the ODOT Manual of Field Test Procedures for the following test procedures. There may be modifications or special instructions relative to the AASHTO procedure.

AASHTO T84: Specific Gravity and Absorption of Fine Aggregate

AASHTO T85: Specific Gravity and Absorption of Coarse Aggregate

AASHTO T166: Bulk Specific Gravity of Compacted Bituminous Mixtures using SSD Specimens

AASHTO T209: Theoretical Maximum Specific Gravity and Density of Bituminous Mixtures

AASHTO T283: Resistance of Compacted Bituminous Mixture to Moisture-Induced Damage

ODOT TM 323: Determination of Calibration Factors for Determining the Asphalt Binder Content of Hot Mix Asphalt by the Ignition Method

Refer to AASHTO books for the following:

AASHTO T312: Preparing and Determining the Density of Hot-Mix Asphalt Specimens by Means of the Superpave Gyratory Compactor

AASHTO R30: Mixture Conditioning of Hot-Mix Asphalt

AASHTO TP63-03: Determining Rutting Susceptibility of Asphalt Paving Mixtures Using the Asphalt Pavement Analyzer (APA)

The following mix design procedures are in a separate document called "Supplemental Procedures for HMAC and EAC". This document is available from the ODOT Construction Section and is also found on the ODOT website at <http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/>.

ODOT TM 313: Compressive Strength of Emulsified Asphalt Mixtures

ODOT TM 316: Adding Anti-Strip Additives or Lime to Mix Design Samples

ODOT TM 318: Selection of Asphalt Content in Open-Graded Bituminous Mixtures by the Drain down Procedure

ODOT TM 319: Preparation and Characterization of RAP Materials for Mix Design

ODOT TM 330: Superpave Volumetric Design for Dense Graded HMAC

3.0 DENSE GRADED MIX DESIGNS

ODOT Special Provisions (SP00745) require that all Level 2, 3 and 4 mix designs be developed by the Superpave mix design procedure described in ODOT TM 330. For other agencies the Standard 00745 specifications allow Marshall mix designs for some mix levels according to MS-2 and ODOT TM 325.

- 3.1 Level 3 wearing course and all Level 4 mix designs require performance testing as described in Section 4 of these guidelines. Results of the performance test must be submitted with the mix design.
- 3.2 If the Ignition Oven (T 308) is selected or required for measuring the asphalt content on the project, fabricate and deliver a set of calibration samples per ODOT TM 323 for each mix design to the ODOT Region Quality Assurance Coordinator, a set to the ODOT Central Lab, and a set to the lab that will do the quality control testing.
- 3.3 Refer to Section 5 for information about reporting dense-graded mix designs to ODOT. Section 6 provides information about submitting mix design material to ODOT when requested.

4.0 PERFORMANCE TESTING OF DENSE GRADED MIXES

Test each Level 3 dense graded wearing course mix and all Level 4 dense graded mixes submitted for review per specification 00745.13 for rut resistance in an Asphalt Pavement Analyzer. Existing mix designs which are submitted for transfer to a new project must have been tested in the year 2006 or later.

The APA device must meet the requirements of AASHTO TP63-03 and must be equipped with an automatic rut measurement system. The APA device must be calibrated at least once per year according to the procedures in the test method. In addition, the load cell used for checking wheel loads shall be calibrated at least once per year.

Provide laboratory batched aggregate samples blended according to each JMF to be tested and samples of the appropriate grade and source of asphalt to an ODOT approved APA testing laboratory. Contact the APA testing laboratory to determine the required quantity of material.

The APA test lab shall fabricate samples according to the JMF being tested and shall perform the test according to AASHTO TP 63-03 at a test temperature of 64C for all mixes.

Submit APA test results in the format required by AASHTO TP 63-03 to the Engineer with the mix design. Identify each mix with a unique identification number, such as ODOT Lab Number or Suppliers Mix Number.

The maximum acceptable APA rut depths are as follows:

Level 3 with PG 64-22 or PG 64-28	6.0 mm rut depth
Level 3 with PG 70-22 or PG 70-28	5.0 mm rut depth
Level 4 with PG 64-22 or PG 64-28	5.0 mm rut depth
Level 4 with PG 70-22 or PG 70-28	4.0 mm rut depth

5.0 REPORTING DENSE GRADED MIX DESIGNS

5.1 Characterization of Constituent Materials and Material Properties

5.1.1 New Aggregate:

For new (“virgin”) aggregate, report the following:

- A) Source number,
- B) Product compliance information (current & passing) for each stockpile used,
- C) QL mean gradations for each new aggregate stockpile, and
- D) Bulk and apparent specific gravities (G_{sb} and G_{sa}) for each individual stockpile, as well as the individual weights from each aggregate gravity test (AASHTO T-84 and T-85).

5.1.2 RAP:

If RAP is used, establish and report the following:

- A) Mean gradations and asphalt binder contents as per ODOT TM 319,
- B) Individual and combined G_{sb} and G_{sa} values as per ODOT TM 319,
- C) Provide RAP burn data sheets, and
- D) Document the RAP source (e.g. stockpile or sampled from project).

5.1.3 Other Additives:

If other additives (e.g. lime) are used in the mix, first verify that the material is on the ODOT Qualified Products List, and report the following:

- A) Manufacturer’s mean gradation, and
- B) Manufacturer’s G_{sb} and G_{sa} .

5.1.4 Asphalt Binder:

Report the following information for the asphalt binder used in the mix:

- A) Binder supplier and PG binder grade,
- B) Binder gravity (G_b) at 60 F and 77 F (15.6 C and 25 C).
- C) Mixing and placement temperature ranges, and
- D) Liquid antistripping brand and percentage (if required).

5.2 Stage 1 Results:

5.2.1 Trial Blends:

For each trial blend provide the following information:

- A) Percent of each aggregate, lime, and/or RAP stockpile.
- B) Report the gradation of each trial blend, as the percent passing each sieve size, to the nearest 1% for the $\frac{3}{4}$ ", $\frac{1}{2}$ ", $\frac{3}{8}$ ", $\frac{1}{4}$ ", #4, #8, #16, #30, #50, and #100 sieves. Report the percent passing the #200 sieve to the nearest 0.1%.
- C) Combined G_{sb} and G_{sa} for each trial blend.

5.2.2 Measured Volumetrics:

Provide the following volumetric information for the samples fabricated for each trial blend:

- A) P_b , P_{ba} , P_{be} ,
- B) G_{mm} , G_{mb} , G_{se} ,
- C) V_a , VMA, VFA, and
- D) P_{200}/P_{be} .

5.2.3 Normalized Volumetrics:

Normalize the volumetrics to 4.0% V_a , and report the following:

- A) P_b and P_{be} ,
- B) V_a , VMA, and VFA,
- C) P_{200}/P_{be} .

5.2.4 JMF Blend Selection and Justification:

Document which trial blend was selected for the JMF and provide a brief justification as to why the selected blend was the most appropriate choice.

5.3 Stage 2 Results

5.3.1 Batch Gradation Verification:

Verify the accuracy of the blend gradation as per ODOT TM 330, Section 10.1.1 and report the results.

5.3.2 Measured Volumetrics:

Calculate the volumetrics for the mix at four different asphalt binder contents and report the following information for each binder content:

- A) P_b , P_{ba} , P_{be} ,
- B) Measured G_{mm} and G_{se} at two asphalt binder contents,
- C) Back-calculated G_{mm} for each of the four binder contents,
- D) Measured G_{mb} for each compacted sample,
- E) V_a , VMA, VFA, and
- F) $P200/P_{be}$.

5.3.3 JMF Properties:

Graph G_{mb} , G_{mm} , V_a , VFA, VMA, and $P200/P_{be}$ as a function of asphalt binder content. Through interpolation of the graphs of measured volumetrics, determine and report the following JMF properties for the mix at the optimum asphalt content:

- A) P_b , P_{ba} , P_{be} ,
- B) G_{mm} , G_{mb} ,
- C) V_a , VMA, VFA,
- D) $P200/P_{be}$, and
- E) Note whether or not the “dryback” method for G_{mm} determination was used in developing the mix design.

5.4 Stage 3 Results

If required, provide rut and moisture susceptibility test results for the JMF mix.

- A) APA rut test, and
- B) TSR test results.

5.5 Mix Design Submittal

Submit the mix design report, in the required format (example on Page 11), to the Project Manager. Sending a carbon copy of the submittal to the Pavement Materials Engineer may hasten the review process, but the submittal must be sent to the Project Manager. Include copies of the laboratory testing worksheets for G_{mb} , G_{mm} , TSR, and individual aggregate bulk specific gravity. Also provide RAP burn datasheets.

Provide a summary of the results of the mix design testing in the following format:

ODOT CONTRACTOR MIX DESIGN SUMMARY

PROJECT	
CONTRACT NO.	
MIX PRODUCER	
CMDT (print)	

MIX CLASS	
LEVEL (2,3,4)	
PROJECT MANAGER	
CMDT JMF MIX ID NO.	

AGGREGATE & OTHER CONSTITUENTS (RAP, BL. SAND, LIME, ETC.)

STOCKPILE SIZES							
SOURCE NUMBER							
STOCKPILE PERCENTAGE (Psp)							
Bulk Specific Gravity (Gsb)							
Apparent Specific Gravity (Gsa)							

Design developed with "dryback" Gmm (Y/N)?

JOB MIX FORMULA

Aggregate Gradation	
Sieve	
3/4" (19 mm)	
1/2" (12.5 mm)	
3/8" (9.5 mm)	
1/4" (6.3 mm)	
No. 4 (4.75 mm)	
No. 8 (2.36 mm)	
No. 16 (1.18 mm)	
No. 30 (0.60 mm)	
No. 50 (0.30 mm)	
No. 100 (0.150 mm)	
No. 200 (0.075 mm)	
Asphalt content, % (Pb)	
RAP AC, % (Pbr)	
Antistrip, %	
Asphalt Brand	
Asphalt Grade	
Mixing temp. range	
Placement temp. range	
Asphalt SpGr (Gb) 77 F	
Asphalt SpGr (Gb) 60 F	

MIXTURE AT DESIGN ASPHALT CONTENT

Maximum Specific Gravity (Gmm)	
Gyratory Bulk Gravity (Gmb)	
Air Voids, % (Va)	
VMA, %	
VFA, %	
Effective Asphalt Content, % (Pbe)	
P200 / Pbe Ratio	
Combined Aggregate (Gsb)	
Effective Specific Gravity (Gse)	
Combined Apparent Gravity (Gsa)	
Tensile Strength Ratio (TSR)	
TSR Compaction Blows	
VIR	
Absorbed Asphalt, % (Pba)	
APA Rut depth - mm	
Gmb Sample Weight @ JMF	
Number of Gyration	
Draindown % (open graded)	
Date	
CMDT Signature	

COMMENTS: BLEND CHOSEN? REASON? :

6.0 DENSE GRADED MIX DESIGN MATERIALS SUBMITTAL

- 6.1 Mix designs submitted for review **may** be verified at ODOT's discretion according to Section 9. If ODOT elects to verify a mix design, the ODOT Construction Section will notify the CMDT within 48 hours of receipt of a complete mix design submittal. **If requested**, for each JMF submitted, furnish representative samples (split from the materials used for the mixture design) and a completed Form 4000 for design verification to the Department's Materials Laboratory in Salem as follows:

<u>Material</u>	<u>Amount</u>
Aggregate	1 – 50 pound (minimum) bag from each stockpile used (untreated) Plus 300 pounds (minimum) of aggregate stockpiles in JMF blend percentages. Example: 25% ½" - #4 → deliver 75 pounds 25% #4 - #8 → deliver 75 pounds 50% #8 – 0 → deliver 150 pounds
Asphalt Cement	6 – quarts in 1 quart metal containers
Lime (If required)	1 – 2 lb. sample
Antistripping Additive (If used)	1 – 1 pint sample in a non-metal container
RAP (Recycled a/c pavement)	2 – 50 pound RAP samples

- 6.2 If the contract requires that a mix design be developed by ODOT, furnish representative samples to the Department's Material's Laboratory in Salem as follows:

<u>Material</u>	<u>Amount</u>
New Coarse Aggregate	16 – 50 lb. (1 bag)*
New Fine Aggregate	16 – 50 lb. (1 bag)*
RAP (if used)	4 – 50 lb. (1 bag) One bag from each of four locations (200 lbs. total)
Hydrated lime (if used)	1 – 2 lb.
Asphalt cement	18 – quarts in 1 quart metal containers
Antistripping additive (if used)	1 – pint in a non-metal container

- * If coarse or fine aggregate is in multiple stockpiles, divide the submittal evenly between stockpiles.

- 6.3 For Stone Matrix Asphalt (SMA) furnish all materials noted in 6.2 and 20 lbs. of mineral filler and 2 lbs. of fiber.

7.0 OPEN GRADED MIX DESIGN

- 7.1 The Open-Graded Mix Design procedures are found in the document “SUPPLEMENTAL TEST PROCEDURES FOR HMAC AND EAC”. Protocol and procedures for ½” (12.5 mm) and ¾” (19 mm) Open-Graded hot mixes, and ¾” (19 mm) Asphalt Treated Permeable Base (ATPB) are described in ODOT TM 318. The protocol and procedures for Emulsified Asphalt Concrete (EAC) cold mix are described in ODOT TM 313.

This document is available from the ODOT Construction Section and is also found on the ODOT website at <http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/>.

7.2 Open Graded Mix Design Report:

For Open-Graded HMAC use the same report format as used for dense-graded mixes (page 9) and provide the information required by ODOT TM 318. For EAC mixes provide the information required by ODOT TM 313 in a convenient format. Include the percent of oil distillate (cutter) in the emulsion used to develop the mix design. Note that for Open-Graded HMAC mix designs a Tensile Strength Ratio test result from a surrogate dense graded mix is required. See the test method for details.

8.0 OPEN GRADED MIX DESIGN MATERIALS SUBMITTAL

- 8.1 The ODOT Central Lab **may** verify mix designs according to Section 9. **If requested**, for each JMF submitted, furnish representative samples (split from the materials used for the mixture design) and a completed Form 4000 for design verification to the Department’s Materials Laboratory in Salem as follows:

<u>Material</u>	<u>Amount</u>
Aggregate	1 – 50 pound (minimum) bag from each stockpile used(untreated) Plus 300 pounds (minimum) of aggregate stockpiles in JMF blend percentages. Example: 25% ½” - #4 → deliver 75 pounds 25% #4 - #8 → deliver 75 pounds 50% #8 – 0 → deliver 150 pounds
Asphalt Binder	4 – quarts in 1 quart containers
Lime (if required)	1 – 2 lb. sample
Antistripping Additive (if required)	1 - pint in a non-metal container

9.0 REVIEW OF CONTRACTOR MIX DESIGNS

9.1 General

By specification ODOT retains the right to review all bituminous mix designs proposed for use on the State Transportation System. ODOT recognizes that the risk associated with each paving application varies. Therefore, the extent of each mix design review will be in accordance with these potential risks.

9.2 Dense Graded Mix Design Review

All dense graded mix designs will be reviewed for accuracy, completeness, reasonableness, compliance with specifications and compliance with the mix design guidelines. If the submittal is incomplete, the 10-day review period for the ODOT Construction Section does not start until the submittal materials are completed ODOT retains the right to perform one or more tests on submitted material to verify the design. These tests may include one or more of the following tests.

- Aggregate gradation
- Aggregate and RAP specific gravity
- Maximum specific gravity of mix
- Bulk specific gravity of mix
- Tensile Strength Ratio
- Optimum asphalt content

The type of tests performed, if any, will be determined by a risk assessment based on aggregate source, CMTD experience, and use of the mix.

9.3 Open Graded Mix Design Review

The standard process for reviewing open graded mix designs will include the following:

- Review of the mix design documents and calculations

The review process may include the following split sample testing:

- Fine and coarse aggregate G_{sb}
- Geometric G_{mb} , V_a , VMA, and VFA @ 4.5, 5.5, and 6.5% asphalt
- Drain down and G_{mm} at 4.5, 5.5, and 6.5% asphalt

9.4 Allowable Differences

The agency may request Mix Design Verification testing to validate some or all mix design information submitted. The results will be considered acceptable if the testing performed by the ODOT Central Lab falls within the tolerances identified below.

Test Procedure	Allowable Difference (\pm)
AASHTO T-84 Bulk Specific Gravity (dry)	0.066
AASHTO T-85 Bulk Specific Gravity (dry)	0.038
AASHTO T-166 Bulk Specific Gravity	0.030
AASHTO T-209 Specific Gravity	0.019
AASHTO T-283 Tensile Strength Ratio	10 units
ODOT Drain down (open graded)	5%
NCAT Drain down	0.05%
ODOT Film Coating (EAC)	5%
Batched Sample Weights (oven dried)	1%

- 9.4.1 If results do not fall within the allowable differences, the Pavement Materials Engineer will work with the CMDT to determine the cause of the difference. If there are significant differences between ODOT test results and contractor test results, the mix design may be returned to the CMDT for reevaluation and testing.

10.0 EXISTING MIX DESIGN GUIDELINES (TRANSFERS)

10.1 General

A mix design (dense-graded or open-graded) reviewed and accepted for a previous or current ODOT project may be proposed in writing for use on a new project. Acceptance of the mix design will be based on meeting the following requirements and is subject to final approval by the ODOT Pavement Materials Engineer.

10.2 All existing mix designs must meet the following to be considered for transfer:

- The proposed mix design is of the type and level required for the new project.
- The original mix design was developed in the year 2004 or later.
- Aggregate to be used for mix on the new project is from the same source and other materials are substantially the same as used in the original project. **If the original mix design is more than one year old, provide current aggregate and RAP specific gravities.**
- Aggregate has passed product compliance testing as required by the ODOT "Manual of Field Test Procedures"
- There were no pertinent restrictions placed on transferring the mix design when it was originally reviewed or previously transferred.
- Adjustments made to asphalt content or gradation targets during production are reflected in the proposed design.
- Materials placed under the original mix design are not currently under investigation for mix related premature distress

10.3 Dense-graded mix designs must also meet the following:

- The mix design was developed according to the Superpave mix design procedures outlined in ODOT TM 330 at the appropriate number of gyrations for the current contract.
- Mix produced following the design met the Mix Design Verification criteria shown in specification section 745.16 within the past 12 months.
- Blend percentages will not change by more than 10% from the original mix design, unless data is submitted to support the change.

- If the mix design is more than two years old, Stage 2 testing must be done to verify or re-establish the optimum binder content.

10.4 **Level 3 Dense-graded wearing course mix designs and all Level 4 Dense-graded mix designs must also meet the following:**

- The mix design meets APA rut depth criteria listed in Section 4.0 when tested according to AASHTO TP63-03 with the grade of asphalt required for the current contract. All mixes transferred under Section 10.4 must have passed the APA rut test in 2006 or more recently.

10.5 **Existing mix designs with changes to asphalt grade or source**

- Existing open-graded designs with changes to the asphalt grade or asphalt source are not acceptable. A new mix design must be developed.
- For dense-graded mix designs if the asphalt supplier has changed from the original design, a new Tensile Strength Ratio (TSR) test and a new APA rut test with the new asphalt must be performed and must meet criteria. If the aggregate comes from a commercial source with a satisfactory history of stripping resistance, the requirement for a new TSR test may be waived if requested.
- For dense-grade mix designs if the asphalt grade has changed, a new TSR test and a new APA rut test must be performed. If the aggregate comes from a commercial source with a satisfactory history of stripping resistance, the requirement for a new TSR test may be waived if requested.

10.6 **Submitting the Request to Use an Existing Mix Design**

- Submit a request to use an existing mix design in writing to the ODOT Project Manager with the following information:
- Identity of the mix design by ODOT Number.
- Note any adjustments made to the asphalt content, gradation or change in stockpile(s) from the original design during production of the mix.
- Confirm the source and grade of asphalt to be used on the new project.
- Provide summary of recent MDV test data for dense-graded mix designs.