

**INDIANA DEPARTMENT OF TRANSPORTATION  
OFFICE OF MATERIALS MANAGEMENT**

**HOT MIX ASPHALT MIX DESIGN LABORATORY REQUIREMENTS**

This guidance applies to all approved HMA mix design laboratories that design HMA mixtures for INDOT contracts. These procedures supersede all previous guidance. Section references are for the most recent Standard Specifications. Contract documents will have precedence over this guidance.

**APPROVAL**

The requirements to become an Approved HMA Mix Design Laboratory include the following:

1. Participation in the AMRL on-site inspection programs for:

Aggregate Equipment

Aggregate Demonstration Tests for:

- AASHTO T 11 -- Materials Finer than 75 $\mu$ m Sieve in Mineral Aggregates by Washing
- AASHTO T 84 -- Specific Gravity and Absorption of Fine Aggregate
- AASHTO T 85 -- Specific Gravity and Absorption of Coarse Aggregate
- AASHTO T 176 -- Plastic Fines in Graded Aggregates and Soils by use of the Sand Equivalent Test
- AASHTO T 304 -- Uncompacted Void Content of Fine Aggregate
- ASTM D 4791 -- Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

Asphalt Equipment

Asphalt Demonstration Tests for:

- AASHTO T 30 -- Mechanical Analysis of Extracted Aggregate
- AASHTO T 166 -- Bulk Specific Gravity of Compacted Bituminous Mixtures
- AASHTO T 209 -- Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
- AASHTO T 269 -- Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
- AASHTO T 283 -- Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
- AASHTO T 308 -- Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
- AASHTO T 312 -- Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyrotory Compactor
- AASHTO T 331 -- Bulk Specific Gravity and Density of Compacted Asphalt Mixtures using Automatic Vacuum Sealing Method

2. Submittal of the AMRL inspection report with comments addressing all footnotes (special emphasis on comments, especially repeat write-ups)

3. Participation in the AMRL Proficiency Sampling Program for HMA Ignition Oven and HMA Design Gyrotory samples
4. Submittal of the AMRL proficiency sample results with comments addressing all ratings of two or less

### **DESIGN MIX FORMULA**

The Design Mix Formula (DMF) shall represent the mix design, loose mixture, and compacted specimens prepared by the mix design laboratory. The materials used in the mix design shall be from an approved or certified source and be approved materials from that source, if applicable. Fines added to the mixture during the design to account for breakdown of material during production shall be included in the DMF and blended aggregate forms.

### **MIX DESIGN METHOD -- DENSE GRADED MIXTURE**

HMA dense graded mixture shall be designed in accordance with AASHTO R 35. This practice requires the air voids to be plotted against the binder content to develop a curve from which the optimum binder content at  $N_{des}$  may be determined. A mix design with an irregular plot or poorly conforming data may not be approved. The following are requirements for dense graded mixtures:

1. The compaction temperature for the specimens shall be  $300 \pm 9^{\circ}\text{F}$  ( $150 \pm 5^{\circ}\text{C}$ ).
2. The optimum binder content shall produce 4.0 % air voids at  $N_{des}$ .
3. The design shall have at least four points, including a minimum of two points above and one point below the optimum.

HMA 4.75 mm mixture shall have the following additional requirements:

1. Coarse aggregate angularity requirements do not apply.
2. Flat and elongated requirements do not apply.

QC/QA HMA and HMA may be produced by using a water-injection foaming device for all ESAL categories and mixture types.

The design gradation shall be less than or equal to the PCS control point for 9.5 mm category 3, 4, and 5 surface mixtures.

### **MIX DESIGN METHOD -- OPEN GRADED MIXTURE**

HMA open graded mixture shall be designed in accordance with AASHTO R 35, with the following exceptions:

1. The optimum binder content shall produce 15.0 % - 20.0 % air voids for 19.0 mm and 25.0 mm open graded mixtures.
2. The optimum binder content shall produce 10.0 % - 15.0 % air voids for 9.5 mm open graded mixtures.
3. A one point design may be used.
4. The compaction temperature shall be  $260^{\circ}\text{F}$  ( $125^{\circ}\text{C}$ ).

5. The bulk specific gravity of open graded specimens shall be determined in accordance with AASHTO T 331.
6. The moisture susceptibility requirements of AASHTO T 283 do not apply.
7. Fine aggregate angularity determination does not apply
8. The percent draindown shall not exceed 0.30 % as determined in accordance with AASHTO T 305.
9. Fibers may be incorporated into the mixture.

The binder for open graded mixtures containing fibers may be reduced by one temperature classification, 6°C, for the upper temperature classification. The fiber type and minimum dosage rate shall be in accordance with AASHTO M 325.

The binder for open graded mixtures containing recycled asphalt shingles may be reduced by one temperature classification, 6°C, for the upper temperature classification if a minimum of 3% by mass of mixture are used.

### **MIX DESIGN METHOD -- SMA MIXTURE**

SMA mixture shall be designed in accordance with AASHTO M 325 and R 46. The SMA mix design shall include the aggregate gradation as a percent passing by volume and by mass. The percent passing by volume is used to ensure a proper aggregate structure for the SMA and the percent passing by mass is used as the means for acceptance of mixture. The following requirements also apply to SMA mix designs:

1. The optimum binder content shall produce 4.0 % air voids.
2. Steel furnace slag or sandstone coarse aggregate may be used, as well as crushed dolomite, crushed gravel, and polish resistant aggregates when blended with steel furnace slag or sandstone. The coarse aggregate is required to be class AS in accordance with Section 904.03(a).
3. Suitability of an aggregate blend for use in SMA shall be determined by ITM 220.
4. The fine aggregate shall be limestone, dolomite, crushed gravel, steel furnace slag, or air-cooled blast furnace slag.
5. The fine aggregate portion of the aggregate blend shall be non-plastic as determined in accordance with AASHTO T 90.
6. Mineral filler shall consist of dust produced by stone, portland cement, or other inert mineral matter having similar characteristics. The material shall be in accordance with the gradation requirements of Section 904.02(h) for size No. 16 and the quality requirements of ITM 203 or be from an air-cooled blast furnace slag source. The sieve analysis shall be conducted in accordance with AASHTO T 37 except as noted in Section 904.06. The material shall be non-plastic in accordance with AASHTO T 90.

The percent draindown shall not exceed 0.30 % in accordance with AASHTO T 305.

### **CONDITIONING LABORATORY PRODUCED MIXTURE**

The mix design procedure requires mixtures to be conditioned in accordance with AASHTO R 30 prior to compaction of the mixture to  $N_{des}$  gyrations. Mixture conditioning is required in a force-draft oven for  $2 \text{ h} \pm 5 \text{ minutes}$  at a temperature of  $300 \pm 5^\circ\text{F}$  ( $150 \pm 3^\circ\text{C}$ ) for dense graded and SMA mixtures and  $260 \pm 5^\circ\text{F}$  ( $125 \pm 3^\circ\text{C}$ ) for open graded mixtures.

## **MOISTURE SUSCEPTIBILITY**

The moisture susceptibility of HMA dense graded mixtures and SMA mixtures shall be determined in accordance with AASHTO T 283 except as follows:

1. The loose mixture shall be conditioned for 2 h in accordance with AASHTO R 30.
2. The specimens shall be compacted in accordance with AASHTO T 312.

If anti-stripping additives are added to the mixture, the dosage rate shall be submitted with the DMF.

## **PG BINDER GRADE AND SOURCE CHANGE**

A PG binder grade or source change will not require a new mix design. If the upper temperature classification of the PG binder is lower than the original PG grade, a new TSR value is required. A new DMF shall be submitted for a binder grade change and shall reference the originating DMF/JMF number.

## **MAXIMUM SPECIFIC GRAVITY OF HMA**

The maximum specific gravity of HMA mixture shall be mass determined in water in accordance with AASHTO T 209. If the supplemental procedure for mixtures containing porous aggregates is required by AASHTO T 209, this procedure shall be designated on the DMF.

## **GYRATORY COMPACTOR**

The gyratory compactor is required to be of a make and model as shown on the approved list here: <http://www.in.gov/indot/div/mt/appmat/pubs/ap138.pdf>. The gyratory compactor is required to have the specimen molds tilted to an average internal angle of  $1.16 \pm 0.02^\circ$  ( $20.2 \pm 0.35$  mrad). The compactor shall be verified at least once per year in accordance with AASHTO T 344. Gyratory compactors shall provide the specified number of gyrations without additional compaction that may occur from “squaring of the specimen” or other compaction.

## **COOLING OF GYRATORY COMPACTED SPECIMENS**

The procedures contained in Directive 303 will be used by INDOT to cool dense graded, SMA, and open graded gyratory compacted specimens

## **BULK SPECIFIC GRAVITY OF COMPACTED DENSE GRADED HMA**

The bulk specific gravity of compacted dense graded HMA shall be determined in accordance with AASHTO T 166 Method A. AASHTO T 275 shall be used when the percent of water absorption exceeds 2.0 %.

## **BULK SPECIFIC GRAVITY OF COMPACTED OPEN GRADED HMA**

The bulk specific gravity of compacted open graded HMA shall be determined in accordance with AASHTO T 331.

## **BULK SPECIFIC GRAVITY OF AGGREGATES**

### **For contracts let after 10/1/13:**

The bulk specific gravity of aggregates to be used in all mix designs will be determined by INDOT and provided to the mix design labs. INDOT will determine the bulk specific gravity of fine aggregates by AASHTO T 84 and coarse aggregates by AASHTO T 85. A list of aggregate Gsb values along with instructions for use will be distributed annually, and addendums will be distributed as needed.

The bulk specific gravity of the combined aggregate blend shall be calculated in accordance with ITM 584.

Designs may be referenced from mix designs approved under the previous rules, with the new Gsb value as calculated above being substituted for the old. Affected properties such as VMA, VFA, and FAA shall be recalculated. If all recalculated values fall within specification limits, the design may be used. Otherwise, a new mix design is required.

### **For contracts let before 10/1/13:**

The above method may be used to determine aggregate bulk specific gravity, however, the following method is allowed:

The dry bulk specific gravity of fine aggregates shall be determined in accordance with AASHTO T 84 and the dry bulk specific gravity of coarse aggregates shall be determined in accordance with AASHTO T 85. These values shall be compared with the values published by INDOT annually. If there is a more recent District Testing value then that value shall be used for comparison. If the design values vary by more than the precision limits in the respective AASHTO test method of  $\pm 0.066$  for fine aggregates and  $\pm 0.038$  for coarse aggregates, an investigation will be made.

The specific gravity of mineral filler shall be determined in accordance with AASHTO T 133.

The bulk specific gravity of the combined aggregate blend with RAP shall be determined in accordance with ITM 584.

The bulk specific gravity of the combined aggregate blend reported on the DMF shall be based on the specific gravities noted above.

## **DUST/CALCULATED EFFECTIVE BINDER RATIO**

The dust to calculated effective binder ratio shall be determined in accordance with AASHTO R 35. This value shall be 0.6 to 1.2 when the aggregate gradation is above the Primary Control Sieve (PCS) control point, 0.8 to 1.6 when the aggregate gradation is less than or equal to the PCS control point, and 0.9 to 2.0 for 4.75 mm mixtures.

## **SURFACE AGGREGATES**

The coarse aggregate types used in HMA surface mixtures shall be in accordance with 904.02(d). Note 1 of Section 904.02 (d) designates the limits on the percentage of Approved Polish Resistant Aggregates or dolomite that may be blended with air-cooled blast furnace slag, sandstone, or steel furnace slag for surface mixtures used on contracts with ESAL's  $\geq$  10,000,000. The sources of Approved Polish Resistant Aggregates are listed in the INDOT Approved List.

Crushed stone or gravel that has been accepted for use by the procedures in ITM 221 may be used for ESALs greater than or equal to 3,000,000.

## **FINE AGGREGATE ANGULARITY**

The fine aggregate angularity shall be determined in accordance with AASHTO T 304 and shall include that portion of the coarse aggregate, fine aggregate and RAP aggregate retained on the specified sieves. A procedure has been written on how to prepare a blended aggregate sample and determine the Gsb. Crushed gravel for SMA shall have a minimum fine aggregate angularity value of 45. The material shall be representative of the selected aggregate blend. Open graded mixtures do not require fine aggregate angularity determination.

## **COARSE AGGREGATE ANGULARITY**

The coarse aggregate angularity shall be determined in accordance with ASTM D 5821 and shall include that portion of the coarse aggregate and RAP aggregate retained on the specified sieves. For SMA mixtures, the total blended aggregate shall be 100 % one face and 95 % two faced crushed. The material shall be representative of the selected aggregate blend. Coarse aggregate angularity of aggregates shall be determined based on mass.

## **FLAT AND ELONGATED PARTICLES**

The flat and elongated particles shall be determined in accordance with ASTM D 4791 and shall include that portion of the coarse aggregate and RAP aggregate retained on the specified sieves. The material shall be representative of the selected aggregate blend. Flat and elongated particles shall be determined based on mass for each sieve size equal to or larger than 9.5 mm. The percent of flat and elongated particles on each required sieve shall be reported.

## **BINDER CONTENT BY IGNITION**

The binder content by ignition shall be determined in accordance with ITM 586. At least four calibration samples and a calibration factor are required to be submitted for each DMF. A test temperature of 427 °C may be used for mixtures containing dolomite. The binder content shall be the value indicated on the computerized printout.

## **BINDER CONTENT BY EXTRACTION**

The binder content by extraction shall be determined in accordance with ITM 571. A request to use this test procedure is required to be submitted in writing to the District Testing Engineer. This procedure may be used, if approved, for aggregates that do not give accurate results in the ignition oven. Approval may be based on the results of the mix design laboratory and INDOT

calibration samples, the performance history of the aggregates, or the percentage of different aggregates in the blend.

### **Mixture Adjustment Factor**

The Mixture Adjustment Factor (MAF) reported on the DMF for dense graded and SMA mixtures is equal to the Gmm of the mix design divided by 2.465 for 9.5 mm mixtures or the Gmm of the mix design divided 2.500 for 12.5 mm, 19.0 mm, and 25.0 mm mixtures

If the MAF calculation results in a value of 0.980 to 1.020, then the MAF shall be considered to be 1.000. If the MAF is less than 0.980 or greater than 1.020, then the actual calculated MAF value shall have either 0.020 added or subtracted from the value.

The MAF does not apply to open graded mixtures.