Washington State
Department of Transportation

WSDOT SOP 731

Method for Determining Volumetric Properties of Hot Mix Asphalt Class Superpave

1. SCOPE

   This procedure covers the determination of volumetric properties of Asphalt Concrete Pavement Class Superpave i.e. Air Voids (Va), Voids in Mineral Aggregate (VMA), Voids Filled with Asphalt (VFA), and Dust to Binder Ratio ($P_{\#200}/P_{be}$).

2. REFERENCES

   a. T 329, WSDOT FOP for AASHTO Moisture content of Bituminous Mixtures by Oven

   b. T27/11, WSDOT FOP for WAQTC/AASHTO for Sieve Analysis of Fine and Coarse Aggregates

   c. T 166, WSDOT FOP for AASHTO for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

   d. T 168, WSDOT FOP for WAQTC/AASHTO for Sampling of Hot Mix Asphalt Paving Mixtur

   e. T 209, WSDOT FOP for AASHTO FOP for Maximum Specific Gravity of Hot Mix Asphalt Paving Mixtures “Rice Density”

   f. T 308, WSDOT FOP for AASHTO FOP for Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

   g. T 312, WSDOT FOP for AASHTO for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

   h. T 712, WSDOT Test Method for Standard Method of Reducing Hot Mix Asphalt Paving Mixtures

3. CALIBRATION OF COMPACTOR

   a. The gyratory compactor will be calibrated in accordance with WSDOT VP-58 and according to the manufacturer’s established calibration procedure. Anytime the gyratory compactor is moved to a new testing site a new calibration is required in accordance with WSDOT VP-58.

4. TEST SAMPLES

a. All test samples shall be obtained per WSDOT FOP for WAQTC/AASHTO T 168, and reduced in accordance with WSDOT Test Method No. 712. It is recommended that the gyratory test sample be the first sample acquired in order to minimize heat loss.

b. The size of the gyratory sample shall be such that it will produce a compacted specimen 115.0 ± 5.0 mm in height. Generally, the reference mix design verification report from the State materials Laboratory initial starting mass is adequate.

c. Place the gyratory sample in an oven set no more than 25°F above the compaction temperature (Note 1) as soon as possible to reduce sample cooling. The gyratory test is temperature sensitive. The sample should ~~only~~ be heated five degrees above ~~until it achieves~~ the compaction temperature as shown on the mix design verification report.

Note 1: ~~The compaction temperature for each mix design can be found on the mix design report.~~ Any change in compaction temperature must be confirmed by the temperature viscosity chart provided by the asphalt supplier, which can be obtained from the Paving Contractor.

5. PROCEDURE

a. Place a compaction mold, base plate, and top plate (if required), in an oven set at no more than 25°F above compaction temperature (Note 2) for a minimum of 60 minutes prior to the estimated beginning of compaction. Subsequent uses of a conditioned mold will require 5 minutes reheating.

Note 2: Never heat any gyratory compactor mold in excess of 350°F.

b. Place a thermometer into the center of the mix, do not stir the mixture. (Note 3) Compact the sample immediately upon achieving compaction temperature in accordance with step 4 (c).

Note 3: While the gyratory test sample is heating it is beneficial to prepare and/or run the other tests as times permits.

c. Perform the sample compaction in accordance with WSDOT FOP for AASHTO T312 Section 9.

d. Determine Rice Density per WSDOT FOP for AASHTO T 209.

e. Determine asphalt content and gradation per WSDOT FOP for AASHTO T 308 and WSDOT FOP for WAQTC/AASHTO T27/11.

f. Determine moisture content per WSDOT FOP for AASHTO T 329.

g. Allow the gyratory compacted specimen to cool at room temperature for 15 to 24 hours. Determine the Bulk Specific Gravity (Gmb) of the specimen in accordance with WSDOT FOP for AASHTO T 166 Method A.

Note 4: For repeatability between operators the challenge sample should be cooled for the same amount of time at room temperature as the original specimen. When sending challenge samples to the Region or State Laboratory, note the time the original sample was cooled at room temperature in the remarks section of the transmittal.

6. VOLUMETRIC CALCULATIONS

CALCULATIONS

a. Calculate $\%G_{mm}$ @N_{design} as follows:

$$\%G_{mm}@N_{design} = \frac{G_{mb}}{G_{mm}} \times 100$$

Example:

$$\%G_{mm}@N_{design} = \frac{2.383}{2.493} \times 100 = 95.6\%$$

Where:

$\%G_{mm}@N_{design}$ = % Theoretical Maximum Specific Gravity @ N_{design}
G_{mb} = bulk specific gravity of the compacted specimen
G_{mm} = maximum specific gravity of the paving mixture (Rice)
N_{design} = Number of design gyrations

b. Calculate $\%G_{mm}$ @N_{ini} as follows:

$$\%G_{mm}@N_{ini} = 100 \times \left(\frac{G_{mb} \times h_d}{G_{mm} \times h_i} \right)$$

Example:

$$\%G_{mm}@N_{ini} = 100 \times \left(\frac{2.383 \times 110.0}{2.493 \times 123.1} \right) = 85.4\%$$

Where:

$\%G_{mm}@N_{ini}$ = % Theoretical Maximum Specific Gravity @ $N_{initial}$
h_d = height of specimen at design gyration level
h_i = height of specimen at initial design gyration level
$N_{initial}$ = # of initial gyrations

c. Calculate Air Voids (V_a) as follow:

$$V_a = 100 \times \left(1 - \left(\frac{G_{mb}}{G_{mm}} \right) \right)$$

Example:

$$V_a = 100 \times \left(1 - \left(\frac{2.383}{2.493} \right) \right) = 4.4\%$$

Where:

V_a = percent air voids

d. Calculate Voids in Mineral Aggregate (VMA) as follows:

$$VMA = 100 - \left(\frac{G_{mb} \times P_s}{G_{sb}} \right)$$

Example:

$$VMA = 100 - \left(\frac{(2.383 \times 94.8)}{2.630} \right) = 14.1\%$$

Where:

P_s = percent of aggregate in the mix (use decimal form in calculation)
P_s = 100 - Pb

Example : 100% mix – 5.2% asphalt = 94.8% aggregate

G_{sb} = bulk specific gravity of the combined aggregate
VMA = Voids in Mineral Aggregate, percent

e. Calculate Voids Filled with Asphalt (VFA) as follows:

$$VFA = 100 \times \left(\frac{VMA - V_a}{VMA} \right)$$

Example:

$$VFA = 100 \times \left(\frac{14.1 - 4.4}{14.1} \right) = 68.8\%$$

Where:

VFA = Voids Filled with Asphalt, percent

f. Calculate Gravity Stone Effective (G_{se}) as follows:

$$G_{se} = \frac{100 - P_b}{\left(\frac{100}{G_{mm}} - \frac{P_b}{G_b} \right)}$$

Example:

$$G_{se} = \frac{100 - 5.2}{\left(\frac{100}{2.493} - \frac{5.2}{1.025} \right)} = 2.706$$

Where:

G_{se} = Gravity Stone Effective (specific gravity of aggregates, excluding voids permeable to asphalt)
P_b = The percent by mass of binder in the total mixture including binder and aggregate
G_b = Gravity Binder

Note 4: G_b is the specific gravity of the asphalt binder. It is imperative that current G_b is used in the volumetric calculations. Any changes in the binder specific gravity must be confirmed by the temperature viscosity curve provided by the asphalt supplier, which can be obtained from the paving Contractor.

g. Calculate Percent Binder Effective (P_{be}) as follows:

$$P_{be} = P_b - \left(\frac{(Ps \times Gb)(Gse - Gsb)}{(Gse \times Gsb)} \right)$$

Examples:

$$P_{be} = 5.2 - \left(\frac{(94.8 \times 1.025)(2.706 - 2.630)}{(2.706 \times 2.630)} \right)$$

Where:

P_{be} = percent binder effective, the percent by mass of effective asphalt content minus the quantity of binder lost by absorption into the aggregate particles.
P_s = percent aggregate in the mixture
G_b = Gravity binder
G_{se} = effective specific gravity of the aggregate
G_{sb} = bulk specific gravity of the combined aggregate
P_b = percent binder

h. Calculate dust-to-binder ratio (P_{200}/P_{be}) as follows:

$$P_{200}/P_{be} = P_{200} \div P_{be}$$

Example: $5.0 \div 3.6 = 1.4$

Where:

P_{200}/P_{be} = dust-to-binder ratio
P_{200} = percent of aggregate passing the No. 200 sieve

7. REPORT

Report asphalt content, gradation, and moisture content on WSDOT Form 350-560EF, and report volumetric properties on WSDOT Form 350-162 or other report approved by the State Materials Engineer.