

## **BULK SPECIFIC GRAVITY ( $G_{mb}$ ) OF COMPACTED HOT MIX ASPHALT (HMA) USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166**

### **Scope**

This procedure covers the determination of bulk specific gravity ( $G_{mb}$ ) of compacted hot mix asphalt (HMA) using three methods – A, B, and C – in accordance with AASHTO T 166-12. This FOP is for use on specimens not having open or interconnecting voids or absorbing more than 2.0 percent water by volume, or both. When specimens have open or interconnecting voids or absorbing more than 2.0 percent water by volume, or both, AASHTO T 275 or AASHTO T 331 should be performed.

### **Overview**

- Method A: Suspension
- Method B: Volumeter
- Method C: Rapid test for A or B

### **Test Specimens**

Test specimens may be either laboratory-molded or from HMA pavement. For specimens it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one and one half times the maximum size.

Test specimens from HMA pavement will be sampled according to WAQTC TM 11.

### **Terminology**

**Constant Mass:** The mass at which further drying at  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ) does not alter the mass by more than 0.05 percent. Samples shall initially be dried overnight and that mass determinations shall be made at 2-hour drying intervals. Recently molded laboratory samples that have not been exposed to moisture do not need drying.

### **Apparatus - Method A (Suspension)**

**Balance or scale:** 5 kg capacity, readable to 0.1 g, and fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water, conforming to AASHTO M 231.

- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale, and equipped with an overflow outlet for maintaining a constant water level.
- Towel: Damp cloth towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of  $110 \pm 5^{\circ}\text{C}$  ( $230 \pm 9^{\circ}\text{F}$ ) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of  $19$  to  $27^{\circ}\text{C}$  ( $66$  to  $80^{\circ}\text{F}$ ), graduated in  $0.1^{\circ}\text{C}$  ( $0.2^{\circ}\text{F}$ ) subdivisions.

### Procedure - Method A (Suspension)

1. Dry the specimen to constant mass, if required.  
*Note 1:* To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.
2. Cool the specimen in air to  $25 \pm 5^{\circ}\text{C}$  ( $77 \pm 9^{\circ}\text{F}$ ), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as “A”.
3. Fill the water bath to overflow level with water at  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 1.8^{\circ}\text{F}$ ) and allow the water to stabilize.
4. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath.
5. Immerse the specimen shaking to remove the air bubbles. Place the specimen on its side in the suspension apparatus. Leave it immersed for  $4 \pm 1$  minutes.
6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as “C”.
7. Remove the sample from the water and quickly surface dry with a damp cloth towel within 5 seconds.
8. Zero or tare the balance.
9. Immediately determine and record the mass of the SSD specimen to nearest 0.1 g. Designate this mass as “B”. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.

**Calculations - Method A (Suspension)**

$$G_{mb} = \frac{A}{B - C}$$

where:

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

C = Weight of specimen in water at  $25 \pm 1^\circ\text{C}$  ( $77 \pm 1.8^\circ\text{F}$ ), g

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B - C} \times 100$$

Example:

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} \times 100 = 0.4\%$$

**Apparatus - Method B (Volumeter)**

- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: Thermostatically controlled to  $25 \pm 0.5^\circ\text{C}$  ( $77 \pm 0.9^\circ\text{F}$ ).
- Thermometer: Range of  $19$  to  $27^\circ\text{C}$  ( $66$  to  $80^\circ\text{F}$ ), and graduated in  $0.1^\circ\text{C}$  ( $0.2^\circ\text{F}$ ) subdivisions.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of  $110 \pm 5^\circ\text{C}$  ( $230 \pm 9^\circ\text{F}$ ) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp cloth towel used for surface drying specimens.

**Procedure - Method B (Volumeter)**

1. Dry the specimen to constant mass, if required.  
*Note 1:* To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.
2. Cool the specimen in air to  $25 \pm 5^{\circ}\text{C}$  ( $77 \pm 9^{\circ}\text{F}$ ), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as “A”.
3. Immerse the specimen in the temperature-controlled water bath for at least 10 minutes.
4. Fill the volumeter with distilled water at  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 1.8^{\circ}\text{F}$ ) making sure some water escapes through the capillary bore of the tapered lid. Wipe the volumeter dry. Determine the mass of the volumeter to the nearest 0.1 g. Designate this mass as “D”.
5. At the end of the ten minute period, remove the specimen from the water bath and quickly surface dry with a damp cloth towel within 5 seconds.
6. Immediately determine and record the mass of the SSD specimen to the nearest 0.1 g.
7. Designate this mass as “B”. Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.
8. Place the specimen in the volumeter and let stand 60 seconds.
9. Bring the temperature of the water to  $25 \pm 1^{\circ}\text{C}$  ( $77 \pm 1.8^{\circ}\text{F}$ ) and cover the volumeter, making sure some water escapes through the capillary bore of the tapered lid.
10. Wipe the volumeter dry.
11. Determine and record the mass of the volumeter and specimen to the nearest 0.1 g. Designate this mass as “E”.

*Note 2:* Method B is not acceptable for use with specimens that have more than 6% air voids.

**Calculations - Method B (Volumeter)**

$$G_{mb} = \frac{A}{B + D - E}$$

where:

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at  $25 \pm 1^\circ\text{C}$  ( $77 \pm 1.8^\circ\text{F}$ ), g

E = Mass of volumeter filled with specimen and water, g

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B + D - E} \times 100$$

Example:

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} + 2924.4 \text{ g} - 5806.0 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} + 2944.4 \text{ g} - 5806.0 \text{ g}} \times 100 = 0.4\%$$

**Apparatus - Method C (Rapid Test for Method A or B)**

See Methods A or B.

**Note 3:** This procedure can be used for specimens that are not required to be saved and contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

**Procedure - Method C (Rapid Test for Method A or B)**

1. Determine which method to perform, A or B. Proceed with Method A or B, except that the dry mass, A, is determined last. In method A and B, start on Step 3 and complete that procedure, then continue as follows to determine mass "A".
2. Place the specimen on a large, flat-bottom pan of known mass.
3. Heat at a minimum of 105°C (221°F), until the specimen can be easily separated to the point where the fine aggregate particles are not larger than 6.3 mm (¼ in.). In no case should the Job Mix Formula mixing temperature be exceeded.
4. Dry to constant mass. Constant mass is defined as the mass at which further drying at the temperature in Step 3 does not change by more than 0.05% after an additional 2 hour drying time.
5. Cool in air to 25 ±5°C (77 ±9°F).
6. Determine and record the mass of the pan and specimen to the nearest 0.1 g.
7. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the pan from the mass determined in Step 6. Designate this mass as "A".

**Calculations - Method C (Rapid Test for Method A or B)**

Complete the calculations as outlined in Methods A or B, as appropriate.

**Report**

- Results on forms approved by the agency
- $G_{mb}$  to 3 decimal places
- Absorption to 2 decimal places
- Method performed.

**PERFORMANCE EXAM CHECKLIST**

**BULK SPECIFIC GRAVITY OF COMPACTED HOT MIX ASPHALT (HMA) USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166**

Participant Name \_\_\_\_\_ Exam Date \_\_\_\_\_

**Record the symbols “P” for passing or “F” for failing on each step of the checklist.**

<b>Procedure Element</b>	<b>Trial 1</b>	<b>Trial 2</b>
<b>Method A:</b>		
1. Mass of dry sample in air determined.		
a. Dried overnight at 52 ±3°C (125 ±5°F) and at successive 2-hour intervals to constant mass?	_____	_____
b. Cooled in air to 25 ±5°C (77 ±9°F)?	_____	_____
c. Dry mass determined to 0.1g?	_____	_____
2. Water at the overflow?	_____	_____
3. Balance zeroed?	_____	_____
4. Immersed weight determined.		
a. Water at 25 ±1°C (77 ±1.8°F)?	_____	_____
b. Immersed, shaken, on side, for 4 ±1 minutes?	_____	_____
c. Immersed weight determined to 0.1g?	_____	_____
5. Sample rapidly surface dried with damp towel(within 5 seconds)?	_____	_____
6. Saturated surface dry (SSD) mass determined to 0.1g?	_____	_____
7. G <sub>mb</sub> calculated to 0.001?	_____	_____
8. Absorption calculated to 0.01 percent	_____	_____
<b>Method B:</b>		
1. Specimen dried, cooled, and mass determined as in Method A?	_____	_____
2. Saturated surface dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at 25 ±1°C (77 ±1.8°F)?	_____	_____
b. Sample rapidly dried with damp towel?	_____	_____
c. Specimen mass determined to 0.1g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
3. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±1.8°F) determined?	_____	_____
4. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____

**OVER**

<b>Procedure Element</b>	<b>Trial 1</b>	<b>Trial 2</b>
5. Temperature of water brought to 25 ±1°C (77 ±1.8°F) and volumeter covered, allowing some water to escape through the capillary pore of the tapered lid?	_____	_____
6. Volumeter wiped dry, and mass of volumeter and contents determined?	_____	_____
7. G <sub>mb</sub> calculated to 0.001?	_____	_____
8. Absorption calculated to 0.01 percent?	_____	_____
<b>Method C/A:</b>		
1. Immersed weight determined.		
a. Water at 25 ±1°C (77 ±1.8°F)?	_____	_____
b. Immersed, shaken, on side, for 4 ±1 minutes?	_____	_____
c. Immersed weight determined to 0.1g?	_____	_____
2. Sample rapidly surface dried with damp cloth (within 5 seconds)?	_____	_____
3. Saturated surface dry mass determined to 0.1g?	_____	_____
4. Dry mass determined by:		
a. Heating in oven at a minimum of 105°C (221°F)?	_____	_____
b. Breaking down to 6.3 mm (1/4 in.) particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?	_____	_____
d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1g?	_____	_____
5. G <sub>mb</sub> calculated to 0.001?	_____	_____
6. Absorption calculated to 0.01?	_____	_____
<b>Method C/B:</b>		
1. Saturated surface dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at 25 ±1°C (77 ±1.8°F)?	_____	_____
b. Sample rapidly dried with damp towel (within 5 seconds)?	_____	_____
c. Specimen mass determined to 0.1g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
2. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±1.8°F) determined to 0.1g?	_____	_____
3. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
4. Temperature of water brought to 25 ±1°C (77 ±1.8°F) and volumeter covered, allowing some water to escape through the capillary pore of the tapered lid?	_____	_____
5. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1g?	_____	_____

**OVER**

**Procedure Element**

**Trial 1 Trial 2**

6. Dry mass determined by:

a. Warming in oven at a minimum of 105°C (221°F)?

\_\_\_\_\_

b. Breaking down to 6.3 mm (¼ in.) particles?

\_\_\_\_\_

c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?

\_\_\_\_\_

d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1g?

\_\_\_\_\_

7. G<sub>mb</sub> calculated to 0.001?

\_\_\_\_\_

8. Absorption calculated to 0.01 percent?

\_\_\_\_\_

Comments: First attempt: Pass \_\_\_\_\_ Fail \_\_\_\_\_ Second attempt: Pass \_\_\_\_\_ Fail \_\_\_\_\_

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Examiner Signature \_\_\_\_\_ WAQTC #: \_\_\_\_\_

