

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

### **Scope**

This procedure covers the determination of bulk specific gravity ( $G_{mb}$ ) of compacted asphalt mixtures using three methods – A, B, and C – in accordance with AASHTO T 166-16. This FOP is for use on specimens not having open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both. When specimens have open or interconnecting voids or absorbing more than 2.00 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 asphalt mixture 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 asphalt mixture pavement will be sampled according to AASHTO R 67.

### **Terminology**

*Constant Mass:* The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

### **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.
- Vacuum device: refer to AASHTO R 79 (optional)

### Procedure - Method A (Suspension)

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
  - a. Oven method
    - i. Initially dry overnight at  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ).
    - ii. Determine and record the mass of the specimen ( $M_p$ ).
    - iii. Return the specimen to the oven for at least 2 hours.
    - iv. Determine and record the mass of the specimen ( $M_n$ ).
    - v. Determine percent change by subtracting the new mass determination ( $M_n$ ) from the previous mass determination ( $M_p$ ) divide by the previous mass determination ( $M_p$ ) multiply by 100.
    - vi. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
    - vii. Constant mass has been achieved, sample is defined as dry.
  - b. Vacuum dry method
    - i. Perform vacuum drying procedure according to AASHTO R 79.
    - ii. Determine and record the mass of the specimen ( $M_p$ ).
    - iii. Perform a second vacuum drying procedure.

*Note 1:* To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

- iv. Determine and record the mass of the specimen ( $M_n$ ).
  - v. Determine percent change by subtracting the new mass determination ( $M_n$ ) from the previous mass determination ( $M_p$ ) divide by the previous mass determination ( $M_p$ ) multiply by 100.
  - vi. Continue drying until there is less than 0.05 percent change in specimen mass (constant mass).
  - vii. Constant mass has been achieved, sample is defined as dry.
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. Do not to exceed 15 seconds performing Steps 7 through 9.

**Calculations - Method A (Suspension)**

**Constant Mass:**

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

$M_p$  = previous mass measurement, g

$M_n$  = new mass measurement, g

**Bulk specific gravity ( $G_{mb}$ ) and percent water absorbed:**

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

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

where:

$G_{mb}$  = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

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

**Example:**

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

$$\% Water\ Absorbed\ (by\ volume) = \frac{4842.4\ g - 4833.6\ g}{4842.4\ g - 2881.3\ g} \times 100 = 0.45\%$$

**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.
- Vacuum device: AASHTO R 79 (optional)

**Procedure - Method B (Volumeter)**

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
  - a. Oven method:
    - i. Initially dry overnight at  $52 \pm 3^{\circ}\text{C}$  ( $125 \pm 5^{\circ}\text{F}$ ).
    - ii. Determine and record the mass of the specimen ( $M_p$ ).
    - iii. Return the specimen to the oven for at least 2 hours.
    - iv. Determine and record the mass of the specimen ( $M_n$ ).
    - v. Determine percent change by subtracting the new mass determination ( $M_n$ ) from the previous mass determination ( $M_p$ ) divide by the previous mass determination ( $M_p$ ) multiply by 100.
    - vi. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
    - vii. Constant mass has been achieved, sample is defined as dry.

*Note 1:* To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

b. Vacuum dry method

- i. Perform vacuum drying procedure according to AASHTO R 79.
  - ii. Determine and record the mass of the specimen ( $M_p$ ).
  - iii. Perform a second vacuum drying procedure.
  - iv. Determine and record the mass of the specimen ( $M_n$ ).
  - v. Determine percent change by subtracting the new mass determination ( $M_n$ ) from the previous mass determination ( $M_p$ ) divide by the previous mass determination ( $M_p$ ) multiply by 100.
  - vi. Continue drying until there is less than 0.05 percent change in specimen mass (constant mass).
  - vii. Constant mass has been achieved, sample is defined as dry.
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.
  5. Wipe the volumeter dry. Determine the mass of the volumeter to the nearest 0.1 g. Designate this mass as "D."
  6. 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.
  7. Immediately determine and record the mass of the SSD specimen to the 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.
  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 percent air voids.

**Calculations - Method B (Volumeter)**

**Constant Mass:**

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

$M_p$  = previous mass measurement, g

$M_n$  = new mass measurement, g

**Bulk specific gravity ( $G_{mb}$ ) and percent water absorbed:**

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

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

where:

$G_{mb}$  = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

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

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

**Example:**

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

$$\% Water\ Absorbed\ (by\ volume) = \frac{4842.4\ g - 4833.6\ g}{4842.4\ g + 2924.4\ g - 5806.0\ g} \times 100 = 0.45\%$$

**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. Start on Step 3 of Method A or B, and complete that procedure, then determine dry mass, "A," as follows.
2. Determine and record mass of a large, flat-bottom container.
3. Place the specimen in the container.
4. Place in an oven at a minimum of 105°C (221°F). Do not exceed the Job Mix Formula mixing temperature.
5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm (¼ in.).
6. Determine and record the mass of the specimen ( $M_p$ ).
7. Return the specimen to the oven for at least 2 hours.
8. Determine and record the mass of the specimen ( $M_n$ ).
9. Determine percent change by subtracting the new mass determination ( $M_n$ ) from the previous mass determination ( $M_p$ ) divide by the previous mass determination ( $M_p$ ) multiply by 100.
10. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
11. Constant mass has been achieved, sample is defined as dry.
12. Cool in air to 25 ±5°C (77 ±9°F).
13. Determine and record the mass of the container and dry specimen to the nearest 0.1 g.
14. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the container from the mass determined in Step 13. 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
- Sample ID
- $G_{mb}$  to 0.001
- Absorption to 0.01 percent
- Method performed.

