Standard Method of Test for

Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens

AASHTO Designation: T 166-13

AASHTO

1. SCOPE

1.1. This method of test covers the determination of bulk specific gravity (G_{mb}) of specimens of compacted hot mix asphalt (HMA).

1.2. This method should not be used with samples that contain open or interconnecting voids or absorb more than 2.0 percent of water by volume, as determined in Sections 7.2 or 10.2 herein. If the sample contains open or interconnecting voids or absorbs more than 2.0 percent of water by volume, then T 275 or T 331 should be used.

1.3. The bulk specific gravity (G_{mb}) of the compacted HMA may be used in calculating the unit mass of the mixture.

Note 1—The values for bulk specific gravity (G_{mb}) obtained from T 275 or T 331 may differ. Care should be exercised when comparing test results from T 275 and T 331.

1.4. The values stated in SI units are to be regarded as the standard.

1.5. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- T 275, Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
- T 331, Bulk Specific Gravity (G_{mb}) and Density of Compacted Hot Mix Asphalt (HMA) Using Automatic Vacuum Sealing Method

2.2. *ASTM Standards:*

- C670, Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
- D7227/D7227M, Standard Practice for Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus

3. TERMINOLOGY

3.1. *Definitions*:

3.1.1. *bulk specific gravity (of solids)* (G_{mb})—the ratio of the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the mass in air of equal density of an equal volume of gas-free distilled water at a stated temperature. The form of the expression shall be:

bulk specific gravity (G_{mb}) at x/y °C *(1)*

where:

x = temperature of the material; and

y = temperature of the water.

3.1.2. *constant mass*—shall be defined as the mass at which further drying does not alter the mass by more than 0.05 percent when weighed at 2-h intervals when using oven drying, or by more than 0.05 percent when weighed after at least two drying cycles of the vacuum-drying apparatus required in ASTM D7227/D7227M.

4. TEST SPECIMENS

4.1. Test specimens may be either laboratory-compacted HMA or sampled from HMA pavements.

4.2. *Size of Specimens*—It is recommended that: (1) the diameter of cylindrically compacted or cored specimens, or the length of the sides of sawed specimens, be at least equal to four times the maximum size of the aggregate; and (2) the thickness of specimens be at least one and one-half times the maximum size of the aggregate.

4.3. Specimens shall be taken from pavements with a core drill, diamond or carborundum saw, or by other suitable means.

4.4. Care shall be taken to avoid distortion, bending, or cracking of specimens during and after the removal from the pavement or mold. Specimens shall be stored in a safe, cool place.

4.5. Specimens shall be free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

4.6. If desired, specimens may be separated from other pavement layers by sawing or other suitable means. Care should be exercised to ensure sawing does not damage the specimens.

METHOD A

5. APPARATUS

5.1. *Weighing Device*—The weighing device shall have sufficient capacity, be readable to 0.1 percent of the sample mass or better, and conform to the requirements of M 231. The weighing device shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of the scale pan of the weighing device.

5.2. *Suspension Apparatus*—The wire suspending the container shall be the smallest practical size to minimize any possible effects of a variable immersed length. The suspension apparatus shall be constructed to enable the container to be immersed to a depth sufficient to cover it and the test sample during weighing. Care should be exercised to ensure no trapped air bubbles exist under the specimen.

5.3. *Water Bath*—For immersing the specimen in water while suspended under the weighing device, equipped with an overflow outlet for maintaining a constant water level.

6. PROCEDURE

6.1. Dry the specimen to a constant mass at a temperature of 52 ± 3°C (125 ± 5°F). Samples saturated with water shall initially be dried overnight and then weighed at 2-h drying intervals. Recently compacted laboratory samples, which have not been exposed to moisture, do not require drying. As an alternative to oven drying to constant mass, drying the sample according to ASTM D7227/D7227M may be used. When using ASTM D7227/D7227M to achieve constant mass, perform the drying procedure at least twice, with a mass determination after each drying cycle.

6.2. Cool the specimen to room temperature at 25 ± 5°C (77 ± 9°F), and record the dry mass as *A* (Note 2). Immerse each specimen in the water bath at 25 ± 1°C (77 ± 1.8°F) for 4 ± 1 min, and record the immersed mass as *C*. Remove the specimen from the water bath; damp-dry the specimen by blotting it with a damp towel, and determine the surface-dry mass as *B* as quickly as possible *(the entire operation is not to exceed 15 s)*. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen. Each specimen shall be immersed and weighed individually.

Note 2—If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass *C* can be taken, then the surface-dry mass *B*, and finally the dry mass *A*.

Note 3—Terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from the towel.

7. CALCULATION

7.1. Calculate the bulk specific gravity (G_{mb}) of the specimen as follows:

$$\text{bulk specific gravity} = \frac{A}{B - C} \qquad (2)$$

where:

A = mass of the specimen in air, g;
B = mass of the surface-dry specimen in air, g; and
C = mass of the specimen in water, g.

7.2. Calculate the percent of water absorbed by the specimen (on a volume basis) as follows:

$$\text{percent of water absorbed by volume} = \frac{B - A}{B - C} \times 100 \qquad (3)$$

7.3. If the percent of water absorbed by the specimen as calculated in Section 7.2 exceeds 2.0 percent, use either T 275 or T 331 to determine the bulk specific gravity (G_{mb}).

METHOD B

8. APPARATUS

8.1. *Weighing Device*—The weighing device shall have sufficient capacity, be readable to 0.1 percent of the sample mass or better, and conform to the requirements of M 231.

8.2. *Water Bath*—For immersing the specimen in water.

8.3. *Thermometer*—ASTM 17C (17F), having a range of 19 to 27°C (66 to 80°F), graduated in 0.1°C (0.2°F) subdivisions.

8.4. *Volumeter*[1]—Calibrated to 1200 mL, or an appropriate capacity depending on the size of the test sample. The volumeter shall have a tapered lid with a capillary bore.

9. PROCEDURE

9.1. Dry the specimen to a constant mass at a temperature of 52 ± 3°C (125 ± 5°F). Samples saturated with water shall initially be dried overnight and then weighed at 2-h drying intervals. Recently compacted laboratory samples, which have not been exposed to moisture, do not require drying. As an alternative to oven drying to constant mass, drying using ASTM D7227/D7227M may be used. When using ASTM D7227/D7227M to determine the constant mass, follow the drying procedure at least twice, with a mass determination after each drying procedure.

9.2. Cool the specimen to room temperature at 25 ± 5°C (77 ± 9°F), and record the dry mass as *A* (Note 2). Immerse the specimen in the water bath at 25 ± 1°C (77 ± 1.8°F), and let it saturate for at least 10 min. At the end of the 10-min period, fill a calibrated volumeter with distilled water at 25 ± 1°C (77 ± 1.8°F), and weigh the volumeter. Designate this mass as *D*. Remove the saturated specimen from the water bath and damp-dry the specimen by blotting with a damp towel (Note 3) as quickly as possible (not to exceed 5 s). Weigh the specimen, and record the surface-dry mass as *B*. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen.

9.3. Place the specimen into the volumeter, and let it stand for at least 60 s. Bring the temperature of the water to 25 ± 1°C (77 ± 1.8°F), and cover the volumeter, making certain that some water escapes through the capillary bore of the tapered lid. Wipe the outside of the volumeter dry with a dry, absorbent cloth, and weigh the volumeter and its contents (Note 4). Record this weight as *E*.

Note 4—If desired, the sequence of testing operations can be changed to expedite the test results. For example, first the mass of the saturated, damp-dry specimen *B* can be taken. Then the volumeter containing the saturated specimen and water *E* can be weighed. The dry mass of the specimen *A* can be determined last.

Note 5—Method B is not acceptable for specimens that have more than 6 percent air voids.

10. CALCULATIONS

10.1. Calculate the bulk specific gravity (G_{mb}) of the specimen as follows:

$$\text{bulk specific gravity} = \frac{A}{B + D - E} \qquad (4)$$

where:

A = mass of the dry specimen, g;

B = mass of the surface-dry specimen, g;

D = mass of the volumeter filled with water at 25 ± 1°C (77 ± 1.8°F), g; and

E = mass of the volumeter filled with the specimen and water at 25 ± 1°C (77 ± 1.8°F), g.

10.2. Calculate the percent of water absorbed by the specimen (on a volume basis) as follows:

$$\text{percent of water absorbed by volume} = \frac{B - A}{B + D - E} \times 100 \quad (5)$$

10.3. If the percent of water absorbed by the specimen as calculated in Section 10.2 exceeds 2.0 percent, use either T 275 or T 331 to determine the bulk specific gravity (G_{mb}).

METHOD C (RAPID TEST)

11. PROCEDURE

11.1. This procedure can be used for testing specimens that are not required to be saved and that contain a substantial amount of moisture. Specimens obtained by coring or sawing can be tested the same day by this method.

11.2. The testing procedure shall be the same as given in Section 6 or 9 except for the sequence of operations. The dry mass A of the specimen is determined last as follows:

11.2.1. Place the specimen in a large, flat-bottom drying pan of known mass. Place the pan and specimen in an oven at 110 ± 5°C (230 ± 9°F). Leave the specimen in the oven until it can be easily separated to the point where the particles of the fine aggregate-asphalt portion are not larger than 6.3 mm ($^1/_4$ in.). Place the separated specimen in an oven at 110 ± 5°C (230 ± 9°F), and dry to a constant mass.

11.2.2. Cool the pan and specimen to room temperature at 25 ± 5°C (77 ± 9°F). Determine the mass of the pan and specimen, subtract the mass of the pan, and record as the dry mass, A.

12. CALCULATIONS

12.1. Calculate the bulk specific gravity (G_{mb}) as given in Section 7.1 or 10.1.

13. REPORT

13.1. *The report shall include the following*:

13.1.1. The method used (A, B, or C).

13.1.2. Bulk specific gravity (G_{mb}) reported to the nearest thousandth.

13.1.3. Absorption reported to the nearest hundredth.

14. PRECISION

Table 1—Precision Estimates for T 166

Condition of Test	Standard Deviation (1s)[a]	Acceptable Range of Two Results (d2s)[a]
Single-operator precision	0.002	0.006
Multilaboratory precision	0.006	0.017

[a] These values represent the 1s and 2ds limits described in ASTM C670.

Note: Based on interlaboratory study described in NCHRP Research Report 9-26 Phase 2 involving 150-mm-diameter specimens, 20 laboratories, three materials (9.5-mm, 12.5-mm, and 19.0-mm mixtures), and two replicates.

[1] Suitable aluminum volumeters of different sizes are available from Pine Instrument Co., 101 Industrial Drive, Grove City, PA 16127; and Rainhart Co., 604 Williams St., Austin, TX 78765.