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Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method[1]

This standard is issued under the fixed designation D 6752; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of bulk specific gravity of compacted bituminous mixtures by the vacuum sealing method.

1.2 This method can be used for compacted cylindrical and cubical bituminous laboratory and field specimens.

1.3 The bulk specific gravity of the compacted bituminous mixtures may be used in calculating the unit weight of the mixture.

1.4 *This standard does not purport to address all of 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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[2]

D 979 Practice for Sampling Bituminous Paving Mixtures[3]

D 1461 Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures[3]

D 2726 Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures[3]

D 3203 Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures[3]

D 4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing [4]

3. Significance and Use

3.1 The results obtained from this method can be used to determine the unit weight of compacted bituminous mixtures and in conjunction with Test Method D 3203, to obtain percent air voids. These values in turn may be used in determining the relative degree of compaction.

3.2 Since specific gravity has no units, it must be converted to density in order to do calculations that require units. This conversion is made by multiplying the specific gravity at a given temperature by the density of water at the same temperature.

3.3 This method can be used for 100 mm and 150 mm diameter cylindrical as well as cubical asphalt specimens to correct for absorptive and open graded mixes. Mixes such as Stone Matrix Asphalt (SMA), porous friction coarse, and Superpave coarse graded mixes with significant surface texture and interconnected voids should be sealed for accurate bulk specific density results. Follow manufacturer recommendation for appropriate bag sizes to be utilized with cubical and abnormally shaped samples.[5]

4. Apparatus

4.1 *Balance*, with ample capacity, and with sufficient sensitivity to enable bulk specific gravity of specimens to be calculated to at least four significant figures, that is to at least three decimal places. It shall be equipped with a suitable apparatus to permit weighing the specimen while it is suspended in water. The balance shall conform to Guide D 4753 as a class GP2 balance.

NOTE 1—Since there are no more significant figures in the quotient (bulk specific gravity) than appear in either the dividend (the mass of the specimen in air) or in the divisor (the volume of the specimen, obtained from the difference in mass of the specimen in air and in water), this means that the balance must have a sensitivity capable of providing both mass and volume values to at least four figures. For example, a sensitivity of 0.1 g would provide four significant figures for the determination of a mass in the range from 130.0 to 999.9 g when the specific gravity is 2.300.

4.2 *Water Bath*, with minimum dimensions (Length × Width × Depth) of 610 × 460 × 460 mm (24 × 18 × 18 in.)

[1] This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.21 on Specific Gravity and Density of Bituminous Mixtures.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.

[3] *Annual Book of ASTM Standards*, Vol 04.03.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

[5] Bulk specific gravity determined by this method may be lower than the results obtained by Test Method D 2726. As a result, air voids determined from these bulk specific gravity values may be higher than the air voids values determined using Test Method D 2726. These differences may be more pronounced for coarse aggregate mixtures. Users of this method are cautioned to evaluate any alteration in percent asphalt content or aggregate gradations for mix designs with a known positive performance history.

or a large cylindrical container, for completely submerging the specimen in water while suspended, equipped with an overflow outlet for maintaining a constant water level.

NOTE 2—It is preferable to keep the water temperature constant by using a temperature controlled heater. Also, to reduce the chance for the bag to touch the sides of the water tank, it is preferable to elevate the water tank to a level at which the sample can be placed on the weighing mechanism while standing up, and the placement of the sample and the bag in the water tank can easily be inspected.

4.3 *Cushioned holder*, for water displacement of the sample, having no sharp edges.

NOTE 3—To avoid accidental puncture of the plastic bags in the water bath, plastic coated cushioned holders have been found to work well for this test method.

4.4 *Vacuum Chamber*, with a 0.93 kW (1.25 hp) pump capable of evacuating a sealed and enclosed chamber to 100 kPa vacuum (29.5 in. Hg vacuum) in less than 60 s, when at sea level. The chamber shall be large enough to seal samples of 150 mm wide by 350 mm long by 150 mm thick. The device shall automatically seal the plastic bag and exhaust air back into the chamber in a controlled manner to ensure proper conformance of the plastic to the asphalt specimen. The air exhaust and vacuum operation time should be calibrated at the factory prior to initial use. The air exhaust system should be calibrated to bring the chamber to atmospheric pressure in 80 to 120 s, after the completion of the vacuum operation. The vacuum system should be provided with a latch to control the chamber door opening.

4.5 *A Vacuum Measurement Gage*, independent of the vacuum sealing device that could be placed directly inside the chamber to verify vacuum performance and the chamber door sealing condition of the unit. The gage shall be capable of reading to 3 TORR (29.8 in. Hg) of vacuum.

4.6 *Plastic Bags*, used with the vacuum device shall be one of the two following sizes. The smaller bags shall have a minimum opening of 235 mm (9.25 in.) and maximum opening of 260 mm (10.25 in.) and the larger bags shall have a minimum of 375 mm (14.75 in.) and a maximum opening of 394 mm (15.5 in.). The bags shall be of plastic material that will not adhere to asphalt film, is puncture resistant, capable of withstanding sample temperatures of up to 70°C, is impermeable to water, containing no air channels for evacuation of air from the bag. The bags shall have a minimum thickness of 0.100 mm (0.004 in.) and maximum thickness of 0.152 mm (0.006 in.). The apparent specific gravity for the bags shall be provided by the manufacturer for each bag shipment. The apparent specific gravity provided for each size bag shall account for the different sample weights and bag weight used during testing.

4.7 *Specimen Sliding Plate*, used within the chamber for reduction of friction on the plastic bags.

4.8 *Bag Cutting Knife*, or scissors.

4.9 *Granite Standard Cylinder, 150 mm (6 in.) Diameter by 75 mm (3 in.)*, for verification of bag apparent density. This standard cylinder shall have a water absorption of 0.20 to 0.80 % by weight. Cylinders with lower absorption than 0.20 % might not seal tightly during vacuum operations.

5. Sampling

5.1 Test specimens may be molded from laboratory prepared samples or taken from bituminous pavement in the field. Field samples should be obtained in accordance with Practice D 979.

6. Test Specimens

6.1 It is recommended, (*1*) that the diameter of cylindrically molded 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*) that the thickness of specimens be at least one and one half times the maximum size of the aggregate. Pavement specimens are to be taken by such means as coring, sawing of blocks, and so forth.

6.2 Take care to avoid distortion, bending, or cracking of specimens during and after removal from pavement or mold. Store specimens in a safe, cool place.

6.3 Specimens shall be free of foreign materials, such as sealcoat, tack coat, foundation material, soil, paper, or foil. When any of these materials are visually evident, they shall be removed. Sealcoat or tackcoat, or both, may be removed by sawing the bottom or the top faces, or both, of the sample.

6.4 If desired, specimens may be separated from other pavement layers by sawing or other suitable means.

6.5 Use a brush or a soft sanding block to break sharp edges around the top and bottom corners of the sample.

7. Procedure

7.1 This procedure can be used for compacted field and laboratory specimens. Specifically, use this procedure, if the mix is absorptive as determined by Test Method D 2726 or if the mix is classified as an open graded mixture by the local mixture specifications. Follow the procedure outlined in this section for determination of bulk specific gravity.

7.2 *Mass of Unsealed Specimen*:

7.2.1 *Laboratory Prepared Specimens*—Determine the mass of the specimen after it has cooled to room temperature. Designate this mass as *A*.

7.2.2 *Cores and Specimens Containing Moisture*—Dry the specimen to constant mass. Designate this mass as *A*. Constant mass is defined as less than 0.05 % change in mass between consecutive 15 minute drying intervals.

7.3 *Mass of Sealed Specimen*:

7.3.1 Select an appropriate size bag. For all 100 mm (4 in.) diameter samples and samples with 150 mm (6 in.) diameter and less than 50 mm (2 in.) thickness, use the bag with smaller opening size as specified in 4.6. For 150 mm (6 in.) samples with greater than 50 mm (2 in.) thickness, use the larger opening size bags as specified in 4.6. For samples that weigh more than 5500 g or abnormally shaped samples, use manufacturer's recommendation for appropriate bag size and configuration.

NOTE 4—Protect the bag during storage. Rough handling, storing in proximity to sharp objects such as tools, aggregate, or inside drawers will damage the plastic bag. Refer to manufacturer's recommendation for handling and safe storage.

7.3.2 Inspect an appropriate size bag for holes or irregularities, record the bag weight and place a bag inside the vacuum chamber on top of the specimen sliding plate.

7.3.3 Gently open the bag and place the specimen in the plastic bag on top of the specimen sliding plate, being careful to handle the bag in such a manner that would prevent a puncture. Avoid dropping or impacting the bag, and follow manufacturer's recommendations for handling the specimens and the bags.

7.3.4 Allow the vacuum chamber to remove the air from the chamber and the plastic bag. The vacuum chamber shall automatically seal the bag once the air is removed.

7.3.5 Exhaust air into the chamber until the chamber door opens indicating atmospheric pressure within the chamber. The chamber door latch can be used to avoid automatic opening of the door after completion of the test.

7.3.6 Remove the sealed sample from the vacuum chamber. Handle the sealed sample with extreme care to prevent puncturing the bag. Gently pull on the bag and if the bag easily separates from the sample, the bag may be punctured; repeat the sealing process with a new bag.

7.3.7 Determine the mass of the sealed specimen in air by summing the weight in 7.2.2 and 7.3.2. Designate this mass as *B*.

7.3.8 Determine the mass of the sealed specimen in a water bath at 25°C (77°F). Designate this mass as *E*. Measure the temperature of the water and if it is different from 25 ± 1°C (77 ± 1.8°F), a correction to the bulk specific gravity to 25°C must be made in accordance with 8.3.

7.3.9 To ensure tight seal in the bag, remove the sample from water and cut the bag open. Remove the sample from the bag and determine its mass. Compare this mass with 7.2.1 (mass *A*). If the mass measured in this section is greater than mass *A* by 5 g, then dry and retest the sample.

8. Calculations

8.1 Calculate the bulk specific gravity of the sealed specimen as follows:

$$\text{Bulk Specific Gravity} = \frac{A}{B - E - \frac{B-A}{F_T}} \quad (1)$$

where:

A = mass of dry specimen in air, g,
B = mass of dry, sealed specimen, g,
E = mass of sealed specimen underwater, g, and
F_T = apparent specific gravity of plastic sealing material at 25°C (77°F), provided by the manufacturer.

8.2 Calculate the density of the specimen as follows:

$$\text{Density} = (\text{Bulk Specific Gravity})\ \gamma \quad (2)$$

where:

γ = density of water at 25°C (77°F) (997.0 kg/m^3, 0.997 g/cm^3 or 62.4 lb/ft^3).

8.3 *Correction for Water Bath Temperature Other Than 25°C (77°F)*:

8.3.1 For water temperature difference less than or equal to 3°C (5.4°F), determine the specific gravity as follows:

TABLE 1 Relative Density of Water and Conversion Factor *K* for Various Temperatures

Temperature, °C	Absolute Density of Water[A]	Correction Factor, *K*
10	0.999728	1.002661
11	0.999634	1.002567
12	0.999526	1.002458
13	0.999406	1.002338
14	0.999273	1.002204
15	0.999129	1.002060
16	0.998972	1.001903
17	0.998804	1.001734
18	0.998625	1.001555
19	0.998435	1.001364
20	0.998234	1.001162
21	0.998022	1.000950
22	0.997801	1.000728
23	0.997569	1.000495
24	0.997327	1.000253
25	0.997075	1.000000
26	0.996814	0.999738
27	0.996544	0.999467
28	0.996264	0.999187
29	0.995976	0.998898
30	0.995678	0.998599

[A] Data taken from Handbook of Chemistry and Physics, 55th ed., CRC Press, Inc.

$$\text{Bulk Specific Gravity at 25°C} = K\ (\text{Bulk at other temperature}) \quad (3)$$

where:

K = determined from Table 1.

8.3.2 For water temperature difference greater than 3°C (5.4°F), determine the correction based on the following equation:

$$\text{Correction} = \Delta T\, K_s \left(B - E - \frac{B-A}{F_T}\right) \quad (4)$$

where:

ΔT = 25°C minus the temperature of the water bath,
K_s = 6×10^{-5} ml/ml/°C average coefficient of cubical thermal expansion of bituminous concrete, and
$(B–E–(B–A)/F_T)$ = mass of the volume of water for the volume of the specimen at 25°C.

8.3.3 The mass of displaced water can be corrected for water temperatures difference greater than 3°C (5.4°F), by the following equation:

$$\text{Bulk Specific Gravity} = \frac{A}{\left(B - E - \frac{B-A}{F_T} + \text{Correction}\right)} \quad (5)$$

9. Verification

9.1 *System Verification*:

9.1.1 The vacuum settings of the device shall be verified once every three months, after major repairs, after each shipment or relocation.

9.1.2 Verification shall be performed with an absolute vacuum gage capable of being placed inside the chamber and reading the vacuum setting of the sealing device.

9.1.3 Place the gage inside the chamber and record the setting. The gage should indicate a reading of 10 TORR (29.5 in. Hg) or less. The unit should not be used if the gage reading is above 10 TORR.

9.1.4 Vacuum gage used for verification shall be calibrated or verified for accuracy once every three years.

NOTE 5—On line vacuum gages, while capable of indicating vacuum performance of the pump, are not suitable for use in enclosed vacuum chambers and can not accurately measure vacuum levels.

9.2 *Plastic Bag Verification*:

9.2.1 The plastic bag apparent specific gravity provided by the manufacturer shall be verified for each shipment.

9.2.2 Use a standard granite cylinder as specified in 4.9 to verify the bags.

9.2.3 Take 3 bags from each size and use the procedure in Section 7 to measure the density of the granite cylinder for each individual bag.

9.2.4 Average the three granite densities obtained for each bag.

9.2.5 The average bulk specific gravity calculated for the granite cylinder shall be within 10 kg/m^3(± 0.010 g/cm^3) of the bulk specific gravity provided by the manufacturer for the granite cylinder or the granite specific gravity as determined by Test Method D 2726.

9.2.6 Repeat this section for each bag size.

10. Report

10.1 Report the following information:

10.1.1 Apparent specific gravity of plastic bag to three decimal places.

10.1.2 Bulk specific gravity at 25° ± 1°C (77° ± 1.8°F) to four significant figures.

10.1.3 Density to four significant figures.

TABLE 2 Criteria for Judging Acceptability of Bulk Specific Gravity Test Results

Test and Type of Index[A]	Standard Deviation	Acceptable Range of Two Results (D2S)
Single operator precision	0.0124	0.035
Multi-laboratory precision	0.0135	0.038

[A] The precision estimates were obtained from FHWA pooled fund round robin study conducted by National Center for Asphalt Technology (NCAT). The precision limits were obtained using Practice C 670. A total of 18 laboratories participated in this study. Each laboratory tested 27 samples using this method. Samples were prepared and compacted by NCAT.

11. Precision and Bias [6]

11.1 *Precision*—Criteria for judging the acceptability of bulk specific gravity test results obtained by this test method are given in Table 2.

11.2 The figures given in column 2 are the standard deviations that have been found to be appropriate for the conditions of test described in column 1. The figures given in column 3 are the limits that should not be exceeded by the difference between results of two properly conducted tests.

11.3 The values in column 3 are the acceptable range for two tests. When more than two results are being evaluated, the range given in column 3 must be increased. Multiply the standard deviation(s) in column 2 by the multiplier given in Practice C 670, Table number 1, for the number of actual tests. For example: for three tests the value is 0.0124X 3.3=0.041. Additional guidance and background is given in Practice C 670.

11.4 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure for measuring density, no statement on the bias of this test method is being made.

12. Keywords

12.1 bituminous paving mixtures—compacted; bulk specific gravity; density

[6] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D04-1020.