Designation: D 1188 – 96 (Reapproved 2002)

Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples[1]

This standard is issued under the fixed designation D 1188; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of bulk specific gravity of specimens of Parafilm-coated, compacted bituminous mixtures as defined in Terminology E 12.

1.2 This method should be used with samples that contain open or interconnecting voids or absorb more than 2 % of water by volume, or both, as determined by Section 8.

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 limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 979 Practice for Sampling Bituminous Paving Mixtures[2]

D 1461 Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures[2]

D 2726 Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures[2]

D 3203 Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures[2]

D 4753 Specification for Evaluating, Selecting and Specifying Balances and Scales for Use in Testing Soil, Rock, and Related Construction Materials[3]

E 12 Terminology Relating to Density and Specific Gravity of Solids, Liquids, and Gases[4]

3. Significance and Use

3.1 This test method is useful in calculating percent air voids as given in Test Method D 3203. Since specific gravity has no units, it must be converted to density when this type of measurement is required. This conversion is made by multiplying the specific gravity at a given temperature by the density of water at the same temperature.

4. Apparatus

4.1 *Balance*, with ample capacity, and with sufficient sensitivity to enable bulk specific gravities to the 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 Specification D 4753 as a class GP2 balance.

4.1.1 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*, for immersing the specimen in water while suspended, equipped with either an overflow outlet for maintaining a constant water level or an electronic tare feature on the scale.

5. Materials

5.1 *Parafilm*—Is an elastomeric film obtainable from most scientific suppliers.

5.2 *Polyurethane Foam*—A foam mat of a minimum of 50 × 50 cm (20 × 20 in.) shall be used for the working surface by about 12.5 mm (0.5 in.) thick. Additionally, a minimum of one foam pad with a size approximately equal to the top surface dimensions of the sample shall be on hand.

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[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 04.03.

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

[4] *Annual Book of ASTM Standards*, Vol 15.05.

5.3 *Calibration Cylinder*—An approximately 100-mm (4-in.) diameter by 60-mm (2.5-in.) smooth-sided aluminum cylinder.

6. Test Specimens

6.1 Test specimens may be molded from laboratory-mixed field samples or be cut from bituminous pavement in the field. Field samples should be obtained in accordance with Practice D 979.

6.2 *Size of Specimens*—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.

6.3 Take pavement specimens from pavements with a core drill, diamond or Carborundum saw, or by other suitable means.

6.3.1 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.

6.3.2 Specimens shall be free of foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil. When any of these materials are visually evident, they shall be removed in accordance with 6.3.3.

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

7. Determine if Coating of Specimens is Needed

7.1 Determine the bulk specific gravity of the uncoated specimen according to Test Method D 2726.

7.2 Use the data collected in 7.1 to calculate the percent water absorbed by the specimen (on volume basis) as follows:

$$\% \text{ Water Absorbed by Vol.} = \frac{B - A}{B - C} 100 \quad (1)$$

where:
A = mass of the dry specimen in air, g
B = mass of the saturated surface-dry specimen in air, g
C = mass of specimen in water, g.

7.3 If the percent water absorbed by the specimen in Section 7.2 exceeds 2 %, continue with the procedures outlined in Section 8. If the percent water absorbed by the specimen does not exceed 2 %, report the bulk specific gravity of the uncoated specimen as determined in 7.1.

8. Procedure

8.1 *Mass of Uncoated Specimens*—After the sample has been dried under a fan until a constant mass has been achieved, determine the mass of the sample. Designate this as mass A.

8.2 *Mass of Coated Specimen*:

8.2.1 On a hard surface, cut two 100 × 100-mm (4 × 4-in.) and one 100 × 200-mm (4 × 8-in.) pieces of Parafilm from the roll with a sharp blade.

8.2.2 Peel the backing off of one of the 100 × 100-mm (4 × 4-in.) pieces.

8.2.3 Grasp opposite sides of the film and stretch. Repeat the stretching with the other two sides until the film has been stretched to an approximately 150 × 150-mm (6 × 6-in.) square. Take care not to create holes in the film.

8.2.4 Place the stretched film over one end of the specimen and press the sides of the film around the sample.

8.2.5 Turn the specimen over and place on the foam mat. Repeat 8.2.2-8.2.4 for the other end of the specimen.

8.2.6 After both ends have been wrapped (and working on the foam mat) place another piece of foam on top of the specimen that is approximately the same size and shape as the specimen. Use another specimen of the same size to press down on top of the foam. This will eliminate the air pockets from both surfaces.

8.2.7 Use a sharp knife to trim the excess film from the sides of the sample. Take care not to damage the sample. There should be a minimum of 15 mm (approximately 0.5 in.) of film remaining on the side of the specimen at each end.

8.2.8 Next, peel the backing off of the remaining piece of film. Grasp the film at the ends and stretch out to about 400 mm (16 in.).

8.2.9 Place one end of the stretched film on the side of the specimen and roll it over so that the film is stretched tightly over the surface.

8.2.10 Fold and press the edges around and over the edges of the specimen.

8.2.11 Determine the mass of the coated specimen in air. Designate this mass as D.

8.2.12 Determine the mass of the coated 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°C ± 1°C (77 ± 1.8°F), a correction to the bulk specific gravity to 25°C must be made in accordance with 10.3. If the temperature of the specimen differs from the temperature of the water bath by more than 2°C (3.6°F), the specimen shall be immersed in the water bath for 10 to 15 min.

8.3 *Apparent Specific Gravity of Parafilm*:

8.3.1 Determine the specific gravity of the aluminum calibration cylinder at 25°C (77°F) ± 1°C (1.8°F) first determining the mass in air and then under water. The specific gravity is:

$$G_{Al} = \frac{A_{Al}}{A_{Al} - B_{Al}} \quad (2)$$

where:
A_{al} = dry mass in air, g,
B_{al} = mass under water, g.

8.3.2 Dry and wrap aluminum cylinder as described in 8.2 and determine the dry, wrapped mass and the mass of the wrapped specimen under water.

8.3.3 Determine the specific gravity of the Parafilm at 25°C (77°F) ± 1°C (1.8°F):

$$F = \frac{D_{Al} - A_{Al}}{D_{Al} - E_{Al} - \frac{A_{Al}}{G_{Al}}} \quad (3)$$

where:
D_{Al} = dry mass of wrapped specimen, g,
E_{al} = mass of wrapped specimen under water, g.

9. Moisture Correction

9.1 In case the specimen has been obtained during construction or from a pavement and contains moisture, it is necessary to correct the masses determined in the following sections.

9.2 The moisture may be determined by one of two methods.

9.2.1 Determine the original mass of the sample. Then dry the uncoated sample to a constant mass in an oven maintained at a temperature of approximately 110°C (230°F). A constant mass is defined as less than a 0.05 % change in mass between consecutive 15 min drying intervals. Designate this oven-dry mass as E_{dry}. The mass of the moisture, E_{moist} is:

$$E_{moist} = E_{original} - E_{dry} \quad (4)$$

where:
$E_{original}$ = original mass of the specimen, g,
E_{dry} = oven dry mass, g.

9.2.2 Subtract E_{moist} from any further determinations of mass in subsequent sections.

9.2.3 Alternatively, determine the mass of moisture in the samples by using Test Method D 1461. This method should be used if the bituminous material in the mixture contains any distillates volatile at a temperature of 110°C (230°F). The mass of the moisture is then subtracted from any determination of mass in the following sections.

10. Calculations

10.1 Calculate the bulk specific gravity of the film-coated specimen as follows:

$$\text{Bulk Specific Gravity} = \frac{A}{D - E - \frac{D - A}{F}} \quad (5)$$

where:
A = mass of dry specimen in air, g,
D = mass of dry, coated specimen, g,
E = mass of coated specimen under water, g,
F = specific gravity of coating determined at 25°C (77°F).

10.2 Calculate the density of the specimen as follows:

$$\text{Density} = (\text{Bulk Specific Gravity})\,\gamma \quad (6)$$

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

10.3 *Correction for Water Bath Temperature Other than 25°C (77°F).*

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

$$\text{Bulk Specific Gravity at } 25°C = K\,(\text{Bulk at other temperature}) \quad (7)$$

where:
K = determined from Table 1.

10.3.2 For a difference of water temperature greater than 3°C (5.4°F), a correction to the mass of water displaced shall be made using the following equation:

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.

$$\text{Correction} = \Delta T\,K_s\left(D - E - \frac{D - A}{F}\right) \quad (8)$$

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,
$(D - E - (D - A) / F)$ = mass of the volume of water for the volume of the specimen at 25°C.

11. Report

11.1 *Report the following information*:
11.1.1 Percent water absorbed.
11.1.2 Specific gravity of Parafilm to three decimal places.
11.1.3 Moisture correction to four significant figures.
11.1.4 Bulk specific gravity at 25°C (77°F) ± 1°C (1.8°F) to four significant figures.
11.1.5 Density to four significant figures.

12. Precision and Bias

12.1 Criteria for judging the acceptability of bulk specific gravity test results obtained by this test method are given in the following table:

Test and Type Index	Standard Deviation	Acceptable Range of Two Test Results (D2S)
Single Operator	0.028	0.079
Multiple Laboratory	0.034	0.095

1: 10 laboratories, 2 materials, 3 replicates for 1 material and 2 replicates for the second

12.2 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.

13. Keywords

13.1 bituminous paving mixtures—compacted; bulk specific gravity/density