Designation: D 1074 – 02

Standard Test Method for Compressive Strength of Bituminous Mixtures[1]

This standard is issued under the fixed designation D 1074; 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 provides a method for measuring the compressive strength of compacted bituminous mixtures. It is for use with specimens weighed, batched, mixed, and fabricated in the laboratory, as well as for mixtures manufactured in a hot-mix plant.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.3 *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:*

C 136 Test Method for Sieve Analysis of Fine and Coarse Aggregate[2]

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

C 702 Practice for Reducing Samples of Aggregate to Testing Size[2]

D 75 Practice for Sampling Aggregates[3]

D 140 Practice for Sampling Bituminous Materials[3]

D 979 Practice for Sampling Bituminous Paving Mixtures[3]

D 1075 Test Method for Effect of Water on Compressive Strength of Compacted Bituminous Mixtures[3]

D 2041 Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures[3]

D 2170 Test Method for Kinematic Viscosity of Asphalts (Bitumens)[3]

D 2493 Viscosity-Temperature Chart for Asphalts[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 4402 Test Method for Viscosity Determinations of Unfilled Asphalts Using the Brookfield Thermoset Apparatus[4]

D 4753 Specification for Evaluating, Selecting and Specifying Balances and Scales for Use in Soil, Rock, and Construction Materials Testing[5]

E 4 Practices for Force Verification of Testing Machines[6]

2.2 *Federal Specification:*

Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects[7]

3. Significance and Use

3.1 The compressive strength of specimens prepared and tested by this test method along with density and voids properties are used for laboratory mix design of bituminous mixtures. One approach is described in ASTM STP 252.[8]

3.1.1 This test method also describes the methods for molding, curing, and testing of specimens being evaluated by Test Method D 1075.

3.1.2 When used in conjunction with other mixture physical properties, the compressive strength may contribute to the overall mixture characterization and is one factor determining its suitability for use under given loading conditions and environment as a highway paving material.

3.2 Typical values of minimum compressive strengths for design of bituminous mixtures by this test method for different traffic densities are given in Table 401-1 of the "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects."[7] Some state departments of transportation and federal agencies have specific requirements of their own based on their experience with this test method. The agencies should be consulted for their specific requirements if work is to meet their standards.

3.3 Reheated mixtures are permissible in this test method, but the resulting compressive strengths will be higher than for newly prepared mixtures due to the change in the binder viscosity, an element of the compressive strength as measured

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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 D04.20 on Mechanical Tests 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 04.04.

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

[6] *Annual Book of ASTM Standards*, Vol 03.01.

[7] "Asphaltic Concrete Mix Requirements," *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, 1996, Federal Highway Administration, Washington, DC 20590, p. 233.

[8] Goode, J. F., "Use of the Immersion-Compression Test in Evaluating and Designing Paving Mixtures." *ASTM STP 252*, 1959, pp. 113–129.

under these loading conditions and temperature.[9] See Note 1.

4. Apparatus

4.1 *Molds and Plungers*—The molds and plungers shall be in accordance with the following:

4.1.1 *Diameter Tolerances*—The mold shall have sufficient height to allow fabrication of a 101.6 by 101.6 mm (4 by 4 in.) specimen. It shall have an inside diameter of 101.60 to 101.73 mm (4.000 to 4.005 in.) and a nominal thickness of 6.4 mm. (¼ in.).

4.1.2 The plungers shall pass through the mold freely and shall have a diameter within 1.27 mm (0.050 in.) of the mold inside diameter. The plungers may be solid, hollow, or other structure so long as the ends are at least 12.7 mm (½ in.) thick and are at a right angle to the mold wall. The bottom plunger shall be 50± 4 mm (2 ± ⅛ in.) high but the top plunger may be any suitable height.

4.1.3 *Specimens Other than 101.6 by 101.6 mm (4 by 4 in.)*—Molds and plungers for fabricating these size specimens are allowed in accordance with Section 6.

4.2 *Supports*—Temporary supports for specimen molds shall consist of two steel bars, 25.4 ± 3.1 mm (1 ± ⅛ in.) square and a minimum length of 76.2 mm (3 in.).

4.3 *Testing Machine*—The testing machine must be of any type of sufficient capacity that will provide a range of accurately controllable rates of vertical deformation. Since the rate of vertical deformation for the compression test is specified as 0.05 mm/min·mm (0.05 in./min·in.) of specimen height, and it may be necessary to test specimens ranging in size from 50.8 by 50.8 mm (2 by 2 in.) to perhaps 203.2 by 203.2 mm (8 by 8 in.) in order to maintain the specified minimum ratio of specimen diameter to particle size, the testing machine should have a range of controlled speeds covering at least 2.5 mm (0.1 in.)/min for 50.8-mm (2-in.) specimens to 10.2 mm (0.4 in.)/min for 203.2-mm (8-in.) specimens. The testing machine shall conform to the requirements of Practices E 4. The testing machine shall be equipped with two steel bearing blocks with hardened faces, one of which is spherically seated and the other plain. The spherically seated block shall be mounted to bear on the upper surface of the test specimen and the plain block shall rest on the platen of the testing machine to form a seat for the specimen. The bearing faces of the plates shall have a diameter slightly greater than that of the largest specimens to be tested. The bearing faces, when new, shall not depart from a true plane by more than 0.0127 mm (0.0005 in.) at any point and shall be maintained within a permissible variation limit of 0.025 mm (0.001 in.). In the spherically seated block, the center of the sphere shall coincide with the center of the bearing face. The movable portion of this block shall be held closely in the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilted through small angles in any direction.

4.4 *Oven*—The oven used in the preparation of materials or reheating of mixtures shall be controllable within ±3°C (±5°F) of any specified temperature above ambient up to 200°C (392°F).

4.5 *Hot Plate*—A small hot plate equipped with a rheostat shall be provided for supplying sufficient heat under the mixing bowl to maintain the aggregate and bituminous material at the desired temperature during mixing.

4.6 *Hot Water Bath or Oven*—A water bath or oven sufficiently large to hold three sets of 101.6-mm (4-in.) molds and plungers. If the water bath does not have an internal temperature control, a hot plate of sufficient capacity with a control to maintain the water bath at a temperature just under the boiling point will be required. The oven shall be capable of maintaining a temperature of between 93.3 to 135°C (200 to 275°F).

4.7 *Air Bath*—The air bath shall be capable of either manual or automatic control for storing the specimens at 25 ± 0.5°C (77 ± 1.0°F) immediately prior to making the compression test.

4.8 *Balance*—Balances or scales and weights meeting the requirements of Specification D 4753 shall be provided as appropriate for the sample or ingredient mass.

4.9 *Mixing Machine*—Mechanical mixing is preferable over handmixing. Any type of mixer may be used, provided it can be maintained at the required mixing temperature and will produce a well-coated, homogeneous mixture of the required size in two minutes or less, and further provided that it is of such design that fouling of the blades will be minimized and each individual batch can be retrieved in essentially its entirety including asphalt and fines. Handmixing is allowable, if necessary, but for hot mixtures the time required to obtain satisfactory coating is often excessive and generally the test results are less uniform than when machine mixing is employed.

4.10 *Spatulas*—A flexible spatula for scraping the mixing bowl and a stiff spatula for spading the specimen in the mold.

5. Preparation of Test Mixtures

5.1 Limit the size of the individual batches to the amount required for one test specimen.

5.2 Mix an initial batch for the purpose of "buttering" the mixing bowl and stirrers. Empty this batch after mixing and clean the sides of the bowl and stirrers of mixture residue by scraping with a small limber spatula. Do not wipe with cloth or wash clean with solvent, except when a change is to be made in the binder or at the end of a run.

5.3 Mold a trial specimen in order to determine the correct weight of materials to produce a specimen of the desired height. Use the initial or "buttering" batch for this purpose, if desired.

5.4 Aggregate ingredient samples shall be obtained in accordance with Practice D 75 and reduced to the appropriate size by Practice C 702. When preparing aggregates for batching, each reduced ingredient sample shall be separated into the desired size fractions in accordance with Test Method C 136. Agency practice will specify which of the following sieves should be used to derive the desired fractions: 50.0 mm, 37.5 mm, 25.0 mm, 19.0 mm, 12.5 mm, 9.5 mm, 4.75 mm, 2.36 mm, and 2.00 mm (2 in., 1½ in., 1 in., ¾ in., ½ in., ⅜ in., No. 4, No. 8, and No. 10). The mixture design, job mix formula, or other control shall be used to combine the appropriate mass of

[9] Welborn, J. Y., Halstead, W. J., and Olsen, R. E., "Relation of Absolute Viscosity of Asphalt Binders to Stability of Asphalt Mixtures," *Public Roads*, Vol. 32, No. 6, February 1963, FHWA, Washington, DC. (Also "Symposium on Fundamental Viscosity of Bituminous Materials" *ASTM STP No. 328.*

each size from each ingredient aggregate to obtain the appropriate gradation and batch mass, and to determine the appropriate mass of bitumen to use for each specimen. A representative sample of bitumen shall be obtained in accordance with Practice D 140 from a representative stock of material. The temperature versus kinematic viscosity relationship for the bitumen involved dictates the temperature to be used for preparing the asphalt concrete test specimens. Mixing temperature is the temperature that yields a viscosity of 170 ± 20 mm^2/s (170 ± 20 cSt). Compacting temperature is the temperature that yields a viscosity of 280 ± 30 mm^2/s (280 ± 30 cSt). Aggregate is heated no hotter than 28°C (50°F) above the mixing temperature to allow for dry mixing prior to adding the asphalt cement. The mixing and compacting temperatures are normally available from the bitumen supplier; however, it may be determined by testing the asphalt cement for kinematic viscosity in accordance with Test Method D 2170 or Rotational Viscosity in accordance with Test Method D 4402 at two temperatures and plotting a graph showing the temperature and corresponding viscosity for each of the two points. Temperatures of 135°C (275°F) and 163°C (325°F) are convenient for many asphalt grades; however, other temperatures may be more appropriate for some asphalt grades. The temperature-viscosity chart used to plot the graph shall be as described in Charts D 2493. Greater precision is derived by selecting ranges that cover a wide range of temperatures.

NOTE 1—Modified asphalt binders may not adhere to the equi-viscous ranges noted in 5.4. The user should refer to the asphalt binder manufacturer to establish appropriate mixing and compaction temperature ranges. In no case should the mixing temperature exceed 175°C.

5.5 Preheat the bowl and batch of aggregate in an oven meeting the requirements of 4.4 to a temperature that complies with the aggregate temperature in 5.4. This will result in an acceptable temperature after dry mixing. With the bowl of aggregate resting on a balance, quickly pour the prescribed mass of hot asphalt cement onto the hot aggregate and immediately mix the asphalt cement into the aggregate with minimal "fanning action." This can be done with a large spoon by rolling the material from perimeter toward the center to maximize aggregate and asphalt contact and minimize asphalt contact with the bowl. The mixing shall be completed within 90 to 120 s, during which time the temperature should have dropped to about 3 to 5°C (5 to 9°F) above the compacting temperature. If the counter top is metal, an insulator such as paper may be used to reduce the rate of cooling. If the material has cooled too fast, a hot plate, oven, or similar device shall be used to slightly reheat the mixture. Caution should be exercised to avoid excessive heating of the material so as to prevent causing an increase in the viscosity of the thin film of asphalt cement coating the aggregate.

5.6 Bituminous paving mixtures shall be sampled in accordance with Practice D 979 and reduced to slightly more than needed to fabricate the specimen. The size reduction shall be in accordance with Practice C 702, Method B. Then the mass of the reduced sample will be adjusted to the required mass by removing and discarding a small amount of mixture. Care must be exercised to discard both fine and coarse particles to maintain proper gradations. Place the weighed mixture into an appropriate container and heat in an oven to the mixing temperature provided in 5.4 for the asphalt represented in the mixture. Thoroughly mix the mixture until the temperature is 3 to 5°C (5 to 9°F) above the compacting temperature. This will result in the mixture being at the compacting temperature when compacting begins. Compacting may commence immediately; or the material may be placed into an oven for a short time to allow more efficient handling of multiple samples; however, a sample shall not remain in the oven more than 1 h.

6. Test Specimens

6.1 Generally, the test specimens shall be cylinders 101.6 mm (4.0 in.) in diameter and 101.6 ± 2.5 mm (4.0 ± 0.1 in.) in height. It is recognized that the size of test specimens has an influence on the results of the compressive strength test. Cylindrical specimens of dimensions other than 101.6 mm (4.0 in.) are allowable, provided that:

6.1.1 The height shall be equal to the diameter within± 2.5 %,

6.1.2 The diameter shall be not less than four times the nominal diameter of the largest aggregate particles,

6.1.3 The diameter shall be not less than 50.8 mm (2 in.), and

6.1.4 The unit rate of deformation shall be kept constant during the compression test (Section 8).

7. Molding and Curing Test Specimens

7.1 Wipe the molds and plungers with a clean cloth that has a few drops of oil on it. The thoroughly mixed material, maintained at a temperature slightly above (3 to 5°C or 5 to 9°F) compacting temperature, is now ready for transfer into the mold for compacting. As soon as the material has been thoroughly mixed and has reached a temperature within the specified range, place approximately ½ of the mixture in the molding cylinder which, together with the top and bottom plunger, has been preheated for at least 1 h in the water bath maintained at a temperature just under the boiling point or preheated for at least 2 h in an oven maintained at a temperature between 93.3 and 135°C (200 and 275°F). With the bottom plunger in place and the molding cylinder supported temporarily on the two steel support bars, spade the mixture vigorously 25 times with a heated spatula with 15 of the blows being delivered around the perimeter of the mold to reduce honeycombing, and the remaining ten at random over the mixture.

NOTE 2—Laboratory samples prepared according to this test method may produce different test results, such as compressive strength values and percent air voids, when compared to results obtained from reheated field samples due to the effect of additional cure time on the absorption of bituminous material by the aggregate in the field sample.

7.2 Quickly transfer the remaining half of the mixture to the molding cylinder and repeat a similar spading action. Penetrate the mixture with the spatula as deeply as possible. A spatula having a slightly curved cross section has been used to advantage by some laboratories. The top of the mixture must be slightly rounded or cone-shaped to aid in firm seating of the upper plunger.

7.3 Compress the mixture between the top and bottom plungers under an initial load of about 1 MPa (150 psi) to set the mixture against the sides of the mold. Remove the support bars to permit full double–plunger action and apply the entire molding load of 20.7 MPa (3000 psi) for 2 min. When specimens are to be tested in accordance with Test Method D 1075 for loss of strength resulting from the action of water, the standard molding load of 20.7 MPa (3000 psi) may be increased or decreased to achieve a target air void percentage or percent density.

7.4 Remove the specimen from the mold with an ejection device that provides a smooth, uniform rate of travel for the ejection head.

7.5 After removal from the mold, oven-cure specimens 24 h at 60°C (140°F). In case specimens are to be stored dry for more than 24 h from completion of oven curing to compression testing, protect them from exposure to the air by sealing them in closely fitting, airtight containers.

8. Procedure

8.1 Allow the test specimens to cool at room temperature for at least 2 h after removal from the curing oven; then determine the bulk specific gravity of each specimen in accordance with the procedure and calculations of paragraph numbers 9.2 and 10.1, respectively, of Test Method D 2726.

8.2 Bring the test specimens to the test temperature 25 ± 1°C (77 ± 1.8°F), by storing them in an air bath maintained at the test temperature for not less than 4 h.

8.3 Test the specimens in axial compression without lateral support at a uniform rate of vertical deformation of 0.05 mm/min·mm (or 0.05 in./min·in.) of height. For specimens 101.6 mm (4 in.) in height, use a rate of 5.08 mm/min (0.2 in./min).

8.4 The theoretical specific gravity and density shall be determined by Test Method D 2041, or by any other method deemed appropriate by the agency involved. If Test Method D 2041 is used, a sample of the mixture prepared but not molded and compacted may be used.

8.5 Calculate the percent air voids in each specimen in accordance with Test Method D 3203.

9. Report

9.1 Report the following information:

9.1.1 The bulk specific gravity, theoretical maximum specific gravity, density, and percent air voids of the specimens,

9.1.2 The compressive strength in kilopascals (lb/in.^{2}), determined by dividing the maximum vertical load obtained during deformation at the rate specified in Section 8, by the original cross-sectional area of the test specimen. Not less than three specimens shall be prepared for each asphalt increment and the average of the three shall be reported as the compressive strength, and

9.1.3 The nominal height and diameter of the test specimens.

10. Precision and Bias

10.1 *Single-Operator Precision*—The single-operator standard deviation of a single test result (where a test result is, as defined in this test method, the average of a minimum of three separate compressive strengths) has been found to be 145 kPa (21 psi) (see Note 3). Therefore, results of two properly conducted tests (each consisting of the average of a minimum of three individual compressive strengths) in the same laboratory on the same material by the same operator should not differ by more than 407 kPa (59 psi) and the range (difference between highest and lowest) of the individual measurements used in calculating the average should not exceed 841 kPa (122 psi) (see Note 4).

NOTE 3—These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C 670.

NOTE 4—Calculated as described in Practice C 670.

10.2 *Multilaboratory Precision*—The multilaboratory standard deviation of a single test result (where the test result is, as defined in this test method, the average of a minimum of three separate compressive strengths) has been found to be 372 kPa (54 psi) (see Note 3). Therefore, results of two properly conducted tests (each consisting of the average of a minimum of three individual compressive strengths) in different laboratories on the same material should not differ by more than 1055 kPa (153 psi).

10.3 This test method has no bias because the compressive strength of bituminous mixtures is defined only in terms of the test method.

11. Keywords

11.1 bituminous paving mixtures; compression testing; compressive strength