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100 Barr Harbor Dr., West Conshohocken, PA 19428
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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.

1.2 *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.*

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

2. Referenced Documents

2.1 *ASTM Standards:*

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

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

D 2726 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens[3]

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

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.[5]

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 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." [6] Some state Departments of Transportation and Federal agencies have specific requirements of their own based on their experience with this method. The agencies should be consulted for their specific requirements if work is to meet their standards.

3.3 Reheated mixtures may be used 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 under these loading conditions and temperature.[7] See also Note 1.

4. Apparatus [8]

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

4.1.1 *Diameter Tolerances*—The maximum difference between the inside diameter of the mold and the diameter of the plungers shall be 1.27 mm (0.050 in.). There is no minimum difference specified, but it shall be such that the plungers move through the mold without binding.

4.1.2 For specimens 101.6 mm (4 in.) in diameter by 101.6 mm (4 in.) in height, molding cylinders shall be of suitable height with a nominal wall thickness of 6.4 mm (¼in.) and an inside diameter of 101.6 mm (4 in.) or greater. Both the top and the bottom plungers shall have a diameter, or a plunger face, of less than 101.6 mm (4 in.). The bottom plunger shall be 50.8 ± 3.2 mm (2 ± ⅛ in.) in height. The top plunger shall be of suitable height. Plungers may be of various designs. Plungers of solid construction, hollow cylinders with solid caps of not less than 12.7 mm (½ in.) thickness on each end, or a plunger design which allows the attachment of a plunger face of no less than 12.7 mm (½ in.) in thickness are all acceptable.

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[1] This test method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.20 on Mechanical Tests of Bituminous Mixes.

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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 03.01.

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

[6] "Asphaltic Concrete Mix Requirements," *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects*, 1985, Federal Highway Administration, Washington, DC 20590, p. 196.

[7] 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*.

[8] These requirements for apparatus are considered to be appropriate for central research and control laboratories. It is realized that, in field laboratories, less elaborate equipment will be available and that the testing machine, especially, is likely to be of much simpler type than that specified in this test method.

4.1.3 For specimens other than 101.6 mm (4 in.) by 101.6 mm (4 in.), molds and plungers to produce specimens of sizes other than 101.6 mm (4 in.) in diameter and 101.6 mm (4 in.) in height may be used in accordance with the requirements of Section 6.

4.2 *Supports*—Temporary supports for specimen molds shall consist of two steel bars, 25.4 mm (1 in.) square and 76.2 mm (3 in.) long.

4.3 *Testing Machine*—The testing machine may 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. For central control laboratory installations, 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 for the preparation of hot mixtures shall be capable of being set to maintain any desired temperature from room temperature to 163°C (325°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. For the water bath, a hot plate of sufficient capacity to maintain the water bath at a temperature just under the boiling point will be required. The hot plate shall be furnished with a rheostat to permit suitable control. 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*—A balance having a capacity of 2000 g or more and a sensitivity of 0.1 g for weighing the ingredients of the mixture shall be provided.

4.9 *Mixing Machine*—The mixture should preferably be prepared in a mechanical mixer. Any type of mixer may be used, provided it can be maintained at the required mixing temperature and will produce a well-coated, homogenous mixture of the required size in 2 min 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. Hand mixing may be used, 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.

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 but 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 In preparing aggregates for making mixtures, make a sieve analysis on each aggregate involved. Separate all coarse aggregates individually and recombine in the necessary quantities with the fine aggregates to meet the formula under study. Thoroughly mix dry the weighed aggregate fractions for each batch and then bring to a temperature of 163 ± 2.8°C (325 ± 5°F) for wet mixing. Heat just sufficient bituminous material for the batch in a separate container to 163 ± 2.8°C (325 ± 5°F) in the case of asphalts and 107 ± 2.8°C (225 ± 5°F) in the case of road tars. Do not let the container come in direct contact with a flame or an unshielded hot plate. Stir the bituminous material constantly while being heated. As an alternative method of preheating the bitumen, use a paraffin dispenser to hold not more than one day's supply at the required temperature throughout a working day. Discard any residual amount left over at the end of the day.

5.5 Bring the bituminous material to the desired temperature, charge the mixing bowl, which shall have been preheated to approximately the temperature of the aggregate, with the preheated and dry mixed aggregate, weigh the preheated bituminous material into the aggregate, and start wet mixing, continue for not less than 90 s nor more than 2 min. Excessive loss of heat during mixing may be offset by the use of a small hot plate, sand bath, or infrared lamp under the mixing bowl. Do not allow the mixing bowl to be in direct contact with a hot plate if used.

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.) may be used, however, 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 Allow laboratory prepared mixtures to cool to molding temperature as quickly as possible after mixing. Bring mixtures from field projects to molding temperature by careful, uniform heating immediately prior to molding (Note 1). Molding temperatures shall be 124 ± 2.8°C (255 ± 5°F) for hot mixtures containing asphalt, and 104 ± 2.8°C (220 ± 5°F) for those containing road tar. As soon as the materials have been thoroughly mixed and have reached a temperature within the specified range, place approximately one half 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 to 135°C (200 to 275° F). Wipe the molds and plungers with a clean cloth that has a few drops of oil on it. With the bottom plunger in place and the molding cylinder supported temporarily on the two steel bars, spade the mixture vigorously 25 times with a heated spatula with 15 of the blows being delivered around the inside of the mold to reduce honeycomb, and the remaining ten at random over the mixture. 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 should be slightly rounded or cone-shaped to aid in firm seating of the upper plunger. 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.

NOTE 1—Laboratory samples prepared according to this 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 Remove the specimen from the mold with an ejection device that provides a smooth, uniform rate of travel for the ejection head.

7.3 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 Sections 9.3 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).

9. Report

9.1 Report the following information:

9.1.1 The bulk specific gravity of the specimens,

9.1.2 The compressive strength in pounds per square inch, 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 2). Therefore, results of two properly conducted tests (each consisting of the average of a minimum of three individual compressive strengths) 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 3).

NOTE 2—These numbers represent, respectively, the (1s) and (d2s) limits as described in Practice C 670.

NOTE 3—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 method, the average of a minimum of three separate compressive strengths) has been found to be 372 kPa (54 psi) (see Note 2). 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 The procedure in this test method for measuring compressive strength has no bias because the value of compressive strength can be defined only in terms of a test method.

11. Keywords

11.1 bituminous paving mixtures; compression testing; compressive strength