Designation: D 1633 – 00

Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders[1]

This standard is issued under the fixed designation D 1633; 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 the compressive strength of soil-cement using molded cylinders as test specimens.

1.2 Two alternative procedures are provided as follows:

1.2.1 *Method A*—This procedure uses a test specimen 4.0 in. (101.6 mm) in diameter and 4.584 in. (116.4 mm) in height. Height to diameter ratio equals 1.15. This test method made be used only on materials with 30 % or less retained on the ¾-in. (19.0-mm) sieve. See Note 3.

1.2.2 *Method B*—This procedure uses a test specimen 2.8 in. (71.1 mm) in diameter and 5.6 in. (142.2 mm) in height. Height to diameter ratio equals 2.00. This test method is applicable to those materials that pass the No. 4 (4.75-mm) sieve.

1.3 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026.

1.4 The values stated in inch-pound units are to be regarded as standard, except as noted in 1.4.1-1.4.3. The values given in parentheses are mathematical conversions to SI units, and are provided for information only and are not considered standard.

1.4.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.4.2 The slug unit of mass is almost never used in commercial practice (density, scales, balances, etc.). Therefore, the standard unit for mass in this standard is either kilogram (kg) or gram (g), or both. Also, the equivalent inch-pound unit (slug) is not given.

1.4.3 It is common practice in the engineering/construction profession in the United States to use concurrently pounds to represent both a unit of mass (lbm) and of force (lbf). This use combines two separate system of units, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. As stated in 1.4.2, this standard uses the gravitational system and does not present the slug unit for mass. However, the use of scales or balances recording pounds of mass (lbm) or the recording of density in lbm/ft^3 shall not be regarded as nonconformance with this standard.

1.5 *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 42 Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete[2]

D 559 Test Methods for Wetting-and-Drying Tests of Compacted Soil-Cement Mixtures[3]

D 560 Test Methods for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures[3]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

D 1632 Practice for Making and Curing Soil-Cement Compression and Flexure Test Specimens in the Laboratory[3]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass[3]

D 3740 Practice for the Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock Used in Engineering Design and Construction[3]

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

D 6026 Practice for Using Significant Digits in Calculating and Reporting Geotechnical Test Data[4]

E 4 Practices for Load Verification of Testing Machines[5]

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology D 653.

4. Significance and Use

4.1 Method A makes use of the same compaction equipment

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.15 on Stabilization with Admixtures.

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[2] *Annual Book of ASTM Standards*, Vol 04.02.
[3] *Annual Book of ASTM Standards*, Vol 04.08.
[4] *Annual Book of ASTM Standards*, Vol 04.09.
[5] *Annual Book of ASTM Standards*, Vol 03.01.

***A Summary of Changes section appears at the end of this standard.**

and molds commonly available in soil laboratories and used for other soil-cement tests. It is considered that Method A gives a relative measure of strength rather than a rigorous determination of compressive strength. Because of the lesser height to diameter ratio (1.15) of the cylinders, the compressive strength determined by Method A will normally be greater than that for Method B.

4.2 Method B, because of the greater height to diameter ratio (2.00), gives a better measure of compressive strength from a technical viewpoint since it reduces complex stress conditions that may occur during the shearing of Method A specimens.

4.3 In practice, Method A has been more commonly used than Method B. As a result, it has been customary to evaluate or specify compressive strength values as determined by Method A. A factor for converting compressive strength values based on height to diameter ratio is given in Section 8.[6]

NOTE 1—The agency performing this test method can be evaluated in accordance with Practice D 3740. Not withstanding statements on precision and bias contained in this test method: the precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not, in itself, ensure reliable testing. Reliable testing depends on many factors; Practice D 3740 provides a means of evaluating some of these factors.

5. Apparatus

5.1 *Compression Testing Machine*—This machine may be of any type having sufficient capacity and control to provide the rate of loading prescribed in 7.2. It shall conform to the requirements of Section 15 of Practices E 4. The testing machine shall be equipped with two steel bearing blocks with hardened faces (Note 2), one of which is a spherically seated head block that normally will bear on the upper surface of the specimen, and the other a plain rigid block on which the specimen will rest. The bearing faces shall be at least as large, and preferably slightly larger, than the surface of the specimen to which the load is applied. The bearing faces, when new, shall not depart from a plane by more than 0.0005 in. (0.013 mm) at any point, and they shall be maintained within a permissible variation limit of 0.001 in. (0.02 mm). In the spherically seated block, the diameter of the sphere shall not greatly exceed the diameter of the specimen and 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.

NOTE 2—It is desirable that the bearing faces of blocks used for compression testing of soil-cement have a hardness of not less than 60 HRC.

5.2 *Molds and Compaction Equipment*, in accordance with Test Methods D 559 or D 560 for Method A; Practice D 1632 for Method B.

6. Test Specimens

6.1 Mold the test specimens as follows:

6.1.1 *Method A*—Specimens are 4.0 in. (101.6 mm) in diameter and 4.584 in. (116.4 mm) in height and are molded in accordance with Test Methods D 559 or D 560.

6.1.2 *Method B*—Specimens are 2.8 in. (71.1 mm) in diameter and 5.6 in. (142.2 mm) in height and are molded in accordance with Practice D 1632.

NOTE 3—These methods may be used for testing specimens of other sizes. If the soil sample includes material retained on the 4.75-mm (No. 4) sieve, it is recommended that Method A be used, or that larger test specimens, 4.0 in. (101.6 mm) in diameter and 8.0 in. (203.2 mm) in height, be molded in a manner similar to Method B.

6.2 Moist cure the specimens in accordance with Practice D 1632.

6.3 At the end of the moist-cure period, immerse the specimens in water for 4 h.

6.4 Remove the specimens from the water and make compression tests as soon as practicable, keeping specimens moist by a wet burlap or blanket covering.

NOTE 4—Other conditioning procedures, such as air or oven drying, alternate wetting and drying, or alternate freezing and thawing may be specified after an initial moist curing period. Curing and conditioning procedures shall be given in detail in the report.

6.5 Check the smoothness of the faces with a straightedge. If necessary, cap the faces to meet the requirements of the section on Capping Specimens of Practice D 1632.

7. Procedure

7.1 Place the lower bearing block on the table or platen of the testing machine directly under the spherically seated (upper) bearing block. Place the specimen on the lower bearing block, making certain that the vertical axis of the specimen is aligned with the center of thrust of the spherically seated block. As this block is brought to bear on the specimen, rotate its movable portion gently by hand so that uniform seating is obtained.

7.2 Apply the load continuously and without shock. A screw power testing machine, with the moving head operating at approximately 0.05 in. (1 mm)/min when the machine is running idle, may be used. With hydraulic machines, adjust the loading to a constant rate within the limits of 20 $\pm$ 10 psi (140 $\pm$ 70 kPa)/s, depending upon the strength of the specimen. Record the total load at failure of the test specimen to the nearest 10 lbf (40 N).

8. Calculation

8.1 Calculate the unit compressive strength of the specimen by dividing the maximum load by the cross-sectional area.

NOTE 5—If desired, make allowance for the ratio of height to diameter (h/d) by multiplying the compressive strength of Method B specimens by the factor 1.10. This converts the strength for an h/d ratio of 2.00 to that for the h/d ratio of 1.15 commonly used in routine testing of soil-cement (see Section 4). This conversion is based on that given in Method C 42, which has been found applicable for soil-cement.

9. Report

9.1 The report shall include the following:

[6] For additional discussion on the significance and use of compressive strength results, see the *Soil-Cement Laboratory Handbook*, Chapter 4, Portland Cement Association, Skokie, IL, 1971, pp 31 and 32.

9.1.1 Specimen identification number,

9.1.2 Diameter and height, in. (mm),

9.1.3 Cross-sectional areas, in.^{2} (mm^2),

9.1.4 Maximum load, to the nearest 10 lbf (40 N),

9.1.5 Conversion factor for height to diameter ratio (see Note 4), if used,

9.1.6 Compressive strength, calculated to the nearest 5 psi (35 kPa),

9.1.7 Age of specimen, and

9.1.8 Details of curing and conditioning periods, and water content in accordance with Test Method D 2216 at the time of test.

10. Precision and Bias

10.1 The precision and bias of this test method have not been established by an interlaboratory test program. However, based on the test data that are available, the following may serve as a guide as to the variability of compressive strength test results.

10.1.1 Tests were performed in a single lab on 122 sets of duplicate specimens molded from 21 different soil materials. The average difference in strength on duplicate specimens was 8.1 % and the median difference was 6.2 %. These values are expressed as the percent of the average strength of the two specimens as follows:

$$\% \text{ Difference} = \frac{(\text{high value} - \text{low value})}{(\text{high value} + \text{low value})/2} \times 100 \quad (1)$$

The distribution of the variation is shown in Fig. 1. The data[7,8] cover a wide range of cement contents and compressive strengths.

11. Keywords

11.1 compressive strength; soil-cement; soil stabilization

[7] Packard, R. G., "Alternate Measures for Measuring Freeze-Thaw and Wet-Dry Resistance of Soil-Cement Mixtures," *Highway Research Bulletin*, 353, Transportation Research Board, 1962, pp 8–41.

[8] Packard, R. G., and Chapman, G. A., "Developments in Durability Testing of Soil-Cement Mixtures," Highway Research Record No. 36, Transportation Research Board, 1963, pp 97–122.

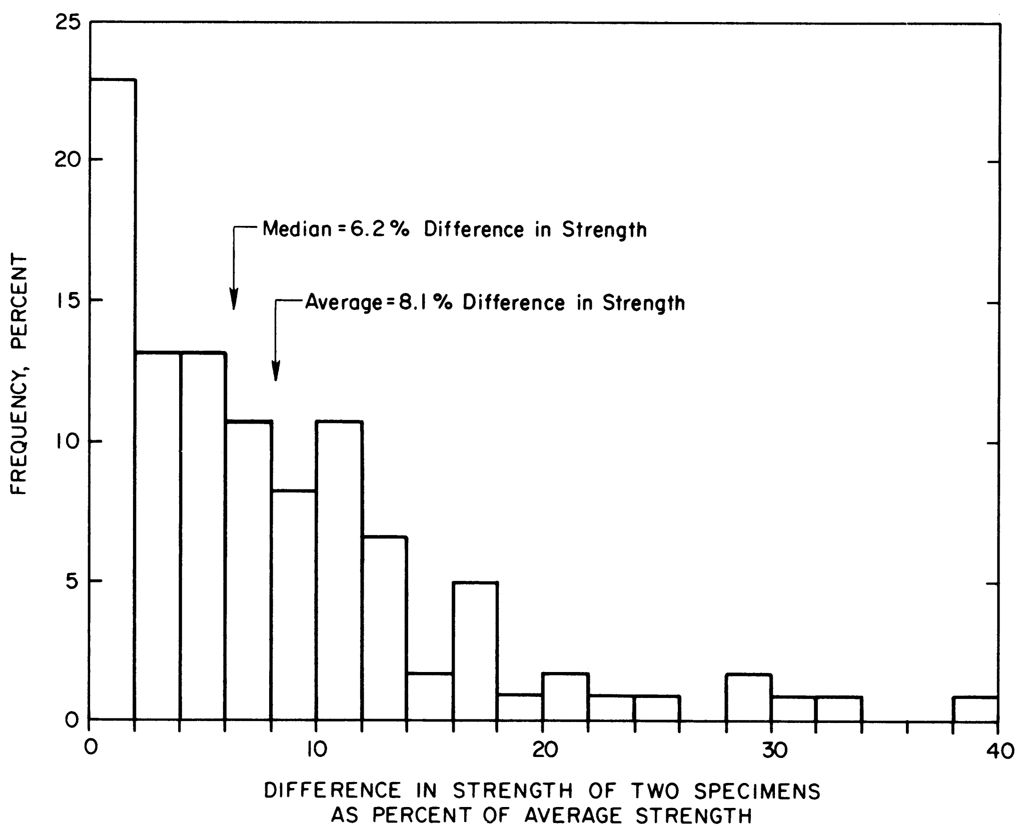

FIG. 1 Distribution of Variation of Test Results for 122 Sets of Duplicate Specimens

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1996) that may impact the use of this standard.

(*1*) Changed title to clarify that two methods are presented.
(*2*) Added new sentence at the end of 1.2.1 to identify applicable materials.
(*3*) Added a new sentence at the end of 1.2.2 to identify applicable materials.
(*4*) Added new 1.3 to reference Practice D 6026.
(*5*) Revised 1.4 to clarify units used in the test method.
(*6*) Added Terminology D 653, Test Method D 2216, Specification D 4753, and Practice D 6026 to Section 2, Referenced Documents.
(*7*) Added new footnote 4 to reference *Annual Book of ASTM Standards*, Vol 04.09 and renumbered the remaining footnotes.
(*8*) Added new Section 3 on Terminology. Renumbered remaining sections.
(*9*) Added reference to Test Method D 2216 in 9.1.8.
(*10*) Changed "crushing" to "shearing" in 4.2.
(*11*) Changed "moisture" to "water" in 9.1.8.
(*12*) Prepared new Summary of Changes.