INTERNATIONAL

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Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils[1]

This standard is issued under the fixed designation D2850; 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 determination of the strength and stress-strain relationships of a cylindrical specimen of either intact, compacted, or remolded cohesive soil. Specimens are subjected to a confining fluid pressure in a triaxial chamber. No drainage of the specimen is permitted during the application of the confining fluid pressure or during the compression phase of the test. The specimen is axially loaded at a constant rate of axial deformation (strain controlled).

1.2 This test method provides data for determining undrained strength properties and stress-strain relations for soils. This test method provides for the measurement of the total stresses applied to the specimen, that is, the stresses are not corrected for pore-water pressure.

NOTE 1—The determination of the unconfined compressive strength of cohesive soils is covered by Test Method D2166/D2166M.

NOTE 2—The determination of the consolidated, undrained strength of cohesive soils with pore pressure measurement is covered by Test Method D4767.

1.3 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.3.1 The procedures used to specify how data are collected/recorded or calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering design.

1.4 *Units*—The values stated in SI units are to be regarded as the standard. The values given in parentheses are mathematical conversions to inch-pound units, which are provided for information only and are not considered standard. Reporting of test results in units other than SI shall not be regarded as nonconformance with this test method.

1.4.1 The converted inch-pound units use the gravitational system of units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs. The slug unit is not given, unless dynamic (F = ma) calculations are involved.

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:*[2]

D422 Test Method for Particle-Size Analysis of Soils
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D2166/D2166M Test Method for Unconfined Compressive Strength of Cohesive Soil
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4220/D4220M Practices for Preserving and Transporting Soil Samples

[1] This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Strength and Compressibility of Soils.

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[2] For referenced ASTM Standards, visit the ASTM website, www.astm.org, or contact Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing

D4767 Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

D6026 Practice for Using Significant Digits in Geotechnical Data

D6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions*—For definitions of common technical terms in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *failure*—a stress condition selected to represent the maximum stress supported by a test specimen.

3.2.1.1 *Discussion*—Failure is often taken to correspond to the maximum principal stress difference (deviator stress) attained or the principal stress difference (deviator stress) at 15 % axial strain, whichever is obtained first during the performance of a test.

3.2.2 *unconsolidated-undrained compressive strength*—the value of the principal stress difference (deviator stress) at failure.

3.2.3 *unconsolidated-undrained shear strength*—the value of the principal stress difference (deviator stress) at failure divided by two.

4. Significance and Use

4.1 In this test method, the compressive strength of a soil is determined in terms of the total stress, therefore, the resulting strength depends on the pressure developed in the pore fluid during loading. In this test method, fluid flow is not permitted from or into the soil specimen as the load is applied, therefore the resulting pore pressure, and hence strength, differs from that developed in the case where drainage can occur.

4.2 If the test specimens is 100 % saturated, consolidation cannot occur when the confining pressure is applied nor during the shear portion of the test since drainage is not permitted. Therefore, if several specimens of the same material are tested, and if they are all at approximately the same water content and void ratio when they are tested, they will have approximately the same unconsolidated-undrained shear strength.

4.3 If the test specimens are partially saturated, or compacted/reconstituted specimens, where the degree of saturation is less than 100 %, consolidation may occur when the confining pressure is applied and during application of axial load, even though drainage is not permitted. Therefore, if several partially saturated specimens of the same material are tested at different confining stresses, they will not have the same unconsolidated-undrained shear strength.

4.4 Mohr failure envelopes may be plotted from a series of unconsolidated undrained triaxial tests. The Mohr's circles at failure based on total stresses are constructed by plotting a half circle with a radius of half the principal stress difference (deviator stress) beginning at the axial stress (major principal stress) and ending at the confining stress (minor principal stress) on a graph with principal stresses as the abscissa and shear stress as the ordinate and equal scale in both directions. The failure envelopes will usually be a horizontal line for saturated specimens and a curved line for partially saturated specimens.

4.5 The unconsolidated-undrained shear strength is applicable to situations where the loads are assumed to take place so rapidly that there is insufficient time for the induced pore-water pressure to dissipate and for consolidation to occur during the loading period (that is, drainage does not occur).

4.6 Compressive strengths determined using this procedure may not apply in cases where the loading conditions in the field differ significantly from those used in this test method.

NOTE 3—The quality of the results produced by this standard 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 D3740 are generally considered capable of competent testing. Users of this test method are cautioned that compliance with Practice D3740 does not ensure reliable results. Reliable results depend on several factors; Practice D3740 provides a means of evaluating some of those factors.

5. Apparatus

5.1 *Axial Loading Device*—The axial loading device shall be screw jack driven by an electric motor through a geared transmission, a hydraulic loading device, or any other compression device with sufficient capacity and control to provide the rate of loading prescribed in 7.5. The rate of advance of the loading device shall not deviate by more than ±5 % from the selected value. Vibrations due to the operation of the loading device shall be sufficiently small to not cause dimensional changes in the specimen.

NOTE 4—A loading device may be said to provide sufficiently small vibrations if there are no visible ripples in a glass of water placed on the loading platen when the device is operating at the speed at which the test is performed.

5.2 *Axial Load-Measuring Device*—The axial load-measuring device shall be capable of measuring the axial load to at least three significant digits (readability); have a full scale accuracy not to exceed 0.25 %; and a capacity that is not greater than four times the axial load at failure. Commonly, an electronic load cell is used and may be integrated with the axial loading device.

5.3 *Triaxial Compression Chamber*—The triaxial chamber shall consist of a top plate and a baseplate separated by a cylinder. The cylinder shall be constructed of any material capable of withstanding the applied pressure. It is desirable to use a transparent material or have a cylinder provided with viewing ports so the behavior of the specimen may be observed. The top plate shall have a vent valve such that air can be forced out of the chamber as it is filled. The base plate shall have an inlet to fill the chamber.

5.4 *Axial Load Piston*—The piston passing through the top of the chamber and its seal must be designed so the variation in axial load due to friction does not exceed 0.1 % of the axial load at failure as measured in 8.6 and so there is negligible lateral bending of the piston during loading.

NOTE 5—The use of two linear ball bushings to guide the piston is recommended to reduce the friction and maintain alignment.

NOTE 6—A minimum piston diameter of one sixth the specimen diameter has been used successfully in many laboratories to minimize lateral bending.

5.5 *Pressure-maintaining and Measurement Devices*—The pressure-maintaining and measurement devices shall be capable of applying, controlling, and measuring the chamber pressure to within ±2 kPa (0.3 psi) for pressures less than 200 kPa (29 psi) and to within ±1 % for pressures greater than 200 kPa (29 psi).

5.5.1 A pressure transducer measuring the applied chamber pressure shall have an accuracy not to exceed ±0.25 % of full range, a capacity in excess of the applied chamber pressure, and a readability equivalent to at least three significant digits at the maximum applied chamber pressure. This device commonly consists of a reservoir connected to the triaxial chamber and partially filled with the chamber fluid (usually water), with the upper part of the reservoir connected to a compressed gas supply; the gas pressure being controlled by a pressure regulator and measured by an electronic pressure transducer.

5.6 *Specimen Cap and Base*—An impermeable rigid cap and base shall be used to prevent drainage of the specimen. The specimen cap and base shall be constructed of a noncorrosive impermeable material, and each shall have a circular plane surface of contact with the specimen and a circular cross section. The mass of the specimen cap shall produce an axial stress on the specimen of less than 1 kPa (0.1 psi). The diameter of the cap and base shall be equal to the initial diameter of the specimen. The specimen base shall be connected to the triaxial compression chamber to prevent lateral motion or tilting, and the specimen cap shall be designed such that eccentricity of the piston-to-cap contact relative to the vertical axis of the specimen does not exceed 1.3 mm (0.05 in.). The end of the piston and specimen cap contact area shall be designed so that tilting of the specimen cap during the test is minimal. The cylindrical surface of the specimen base and cap that contacts the membrane to form a seal shall be smooth and free of scratches.

NOTE 7—To determine the axial stress from the top cap, measure the mass of the top cap in grams and area of the top cap in cm^2. The stress from the top cap, in kN/m^2 (= kPa), is equal to the mass in grams times the acceleration due to gravity (9.8087 m/sec^2) divided by the area in cm^2 times 10,000 cm^2/m^2 divided by 1000 N/kN and 1000 g/kg.

5.7 *Deformation Indicator*—The vertical deformation of the specimen is usually determined from the travel of the piston acting on the top of the specimen. The piston travel shall be measured using a deformation indicator with a range of at least 20 % of the initial height of the specimen and an accuracy not to exceed 0.25 % of the initial specimen height. The deformation indicator is commonly a linear variable differential transformer (LVDT) or other measuring device meeting the requirements for accuracy and range.

5.8 *Rubber Membrane*—The rubber membrane used to encase the specimen shall provide reliable protection against leakage. Membranes shall be carefully inspected prior to use, and if any flaws or pinholes are evident, the membrane shall be discarded. To offer minimum restraint to the specimen, the unstretched membrane diameter shall be between 90 and 95 % of that of the specimen. The membrane thickness shall not exceed 1 % of the diameter of the specimen. The membrane shall be sealed to the specimen base and cap with rubber O-rings for which the unstressed inside diameter is between 75 and 85 % of the diameter of the cap and base, or by any method that will produce a positive seal. An equation for correcting the principal stress difference (deviator stress) for the effect of the strength of the membrane is given in 8.8.

5.9 *Sample Extruder*—The sample extruder shall be capable of extruding the soil core from the sampling tube in the same direction of travel in which the sample entered the tube and with minimum disturbance of the sample. If the soil core is not extruded vertically, care should be taken to avoid bending stresses on the core due to gravity. Conditions at the time of sample removal may dictate the direction of removal, but the principal concern is to keep the degree of disturbance minimal.

5.10 *Specimen-Size Measurement Devices*—Devices used to measure the height and diameter of the specimen to three or more significant digits (readability) with an accuracy not to exceed 0.25 % of its full range. The devices shall be constructed such that during use the specimen is not disturbed or deformed.

NOTE 8—Circumferential measuring tapes are recommended over calipers for measuring the diameter.

5.11 *Timer*—A timing device indicating the elapsed testing time to the nearest 1 s shall be used for establishing the rate of strain application prescribed in 7.5 and recording the time during specimen compression as required in 7.6.

5.12 *Balances*—A balance or scale conforming to the requirements of Specification D4753 readable (with no estimation) to 0.1 % of the test mass, or better.

5.13 *Miscellaneous Apparatus*—Specimen trimming and carving tools including a wire saw, steel straightedge, miter box and vertical trimming lathe, apparatus for preparing remolded specimens, membrane and O-ring expander, water content containers, and data sheets shall be provided as required.

6. Test Specimens

6.1 *Specimen Size*—Specimens shall be cylindrical and have a minimum diameter of 33 mm (1.3 in.). The average height-to-average diameter ratio shall be between 2 and 2.5. The largest particle size shall be smaller than one sixth the specimen diameter. If, after completion of a test, it is found based on visual observation that oversize particles are present, indicate this information in the report of test data (see 9.2.14).

NOTE 9—If oversize particles are found in the specimen after testing, a particle-size analysis may be performed in accordance with Test Method D422 or D6913 to confirm the visual observation and the results provided with the test report (see 9.2.4).

6.2 *Intact Specimens*—Prepare intact specimens from large intact samples or from samples secured in accordance with Practice D1587 or other acceptable intact tube sampling