This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D7181 – 20

Standard Test Method for Consolidated Drained Triaxial Compression Test for Soils[1]

This standard is issued under the fixed designation D7181; 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 the determination of strength and stress-strain relationships of a cylindrical specimen of either intact or reconstituted soil. Specimens are consolidated and sheared in compression with drainage at a constant rate of axial deformation (strain controlled).

1.2 This test method provides for the calculation of principal stresses and axial compression by measurement of axial load, axial deformation, and volumetric changes.

1.3 This test method provides data useful in determining strength and deformation properties such as Mohr strength envelopes. Generally, three specimens are tested at different effective consolidation stresses to define a strength envelope. The stresses should be specified by the engineer requesting the test. A test on a new specimen is required for each consolidation stress.

1.4 If this test method is used on cohesive soil, a test may take weeks to complete.

1.5 The determination of strength envelopes and the development of relationships to aid in interpreting and evaluating test results are beyond the scope of this test method and must be performed by a qualified, experienced professional.

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

1.6.1 The procedures used to specify how data are collected, calculated, or recorded 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 variations, purpose for obtaining the data, special purpose studies or any consideration for the user's objectives; and it is common practice to increase or reduce the significant digits of the reported data to be commensurate with these considerations. It is beyond the scope of this test standard to consider significant digits used in analysis methods for engineering design.

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

1.7.1 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. The slug unit is not given, unless dynamic (F = ma) calculations are involved.

1.7.2 It is common practice in the engineering/construction profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two separate systems of units: that is, 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, this standard includes the gravitational system of inch-pound units and does not use/present the slug unit for mass. However, the use of balances or scales recording pounds of mass (lbm) or recording density in lbm/ft^3 shall not be regarded as non-conformance with this standard.

1.7.3 The terms density and unit weight are often used interchangeably. Density is mass per unit volume whereas unit weight is force per unit volume. In this standard density is given only in SI units. After the density has been determined, the unit weight is calculated in SI or inch-pound units, or both.

1.8 *This standard may involve hazardous materials, operations, and equipment. 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[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.

Current edition approved Jan. 1, 2020. Published February 2020. Originally approved in 2011. Last previous edition approved in 2011 as D7181 - 11. DOI: 10.1520/D7181-20.

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. United States

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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 Fine-Grained Soils for Geotechnical Purposes
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2435 Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
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 Practices for Preserving and Transporting Soil Samples
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
D7263 Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens
D7928 Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *back pressure, n*—a pressure applied to the specimen pore-water to cause air in the pore space to compress and to pass into solution in the pore-water thereby increasing the percent saturation of the specimen.

3.2.2 *effective consolidation stress, n*—the difference between the cell pressure and the pore-water pressure prior to shearing the specimen.

3.2.3 *effective consolidation stresses, n—for anisotropic (9.4)*, the vertical and lateral stress applied magnitudes are not equal by design, with lateral stress equal to the cell pressure minus pore-water pressure, and the vertical stress equal to the desired total vertical stress (9.4.2) minus the pore pressure.

3.2.4 *failure, n*—a maximum-stress condition or stress at a defined strain for a test specimen.

3.2.4.1 *Discussion*—Failure is often taken to correspond to the maximum principal stress difference (maximum deviator stress) attained or the principal stress difference (deviator stress) at 15 % axial strain, whichever is obtained first during the performance of a test. Depending on soil behavior and field application, other suitable failure criteria may be defined, such as maximum effective stress obliquity, σ_1'/σ_{3max}', or the principal stress difference (deviator stress) at a selected axial strain other than 15 %.

4. Summary of Test Method

4.1 The test specimen, either intact or reconstituted, is mounted in the testing apparatus using either a dry or wet mounting procedure. The test specimen is cylindrical in shape and dimensions are measured prior to mounting. The test specimen is then back pressure saturated. After saturation, the specimen is isotropically or anisotropically consolidated. The test specimen is then axially loading at a constant rate and with the drainage lines open to allow the sample to drain.

5. Significance and Use

5.1 The shear strength of a saturated soil in triaxial compression depends on the stresses applied, time of consolidation, strain rate, and the stress history experienced by the soil.

5.2 In this test method, the shear characteristics are measured under drained conditions and are applicable to field conditions where soils have been fully consolidated under the existing normal stresses and the normal stress changes under drained conditions similar to those in the test method.

5.3 The shear strength determined from this test method can be expressed in terms of effective stress because a strain rate or load application rate slow enough to allow pore pressure dissipation during shear is used to result in negligible excess pore pressure conditions. The shear strength may be applied to field conditions where full drainage can occur (drained conditions), and the field stress conditions are similar to those in the test method.

5.4 The shear strength determined from the test can be used in embankment stability analyses, earth pressure calculations, and foundation design.

NOTE 1—The quality of the result 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 and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 The requirements for equipment needed to perform satisfactory tests are given in the following sections. See Fig. 1

6.2 *Axial Loading Device*—The axial loading device may be a 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

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM 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.

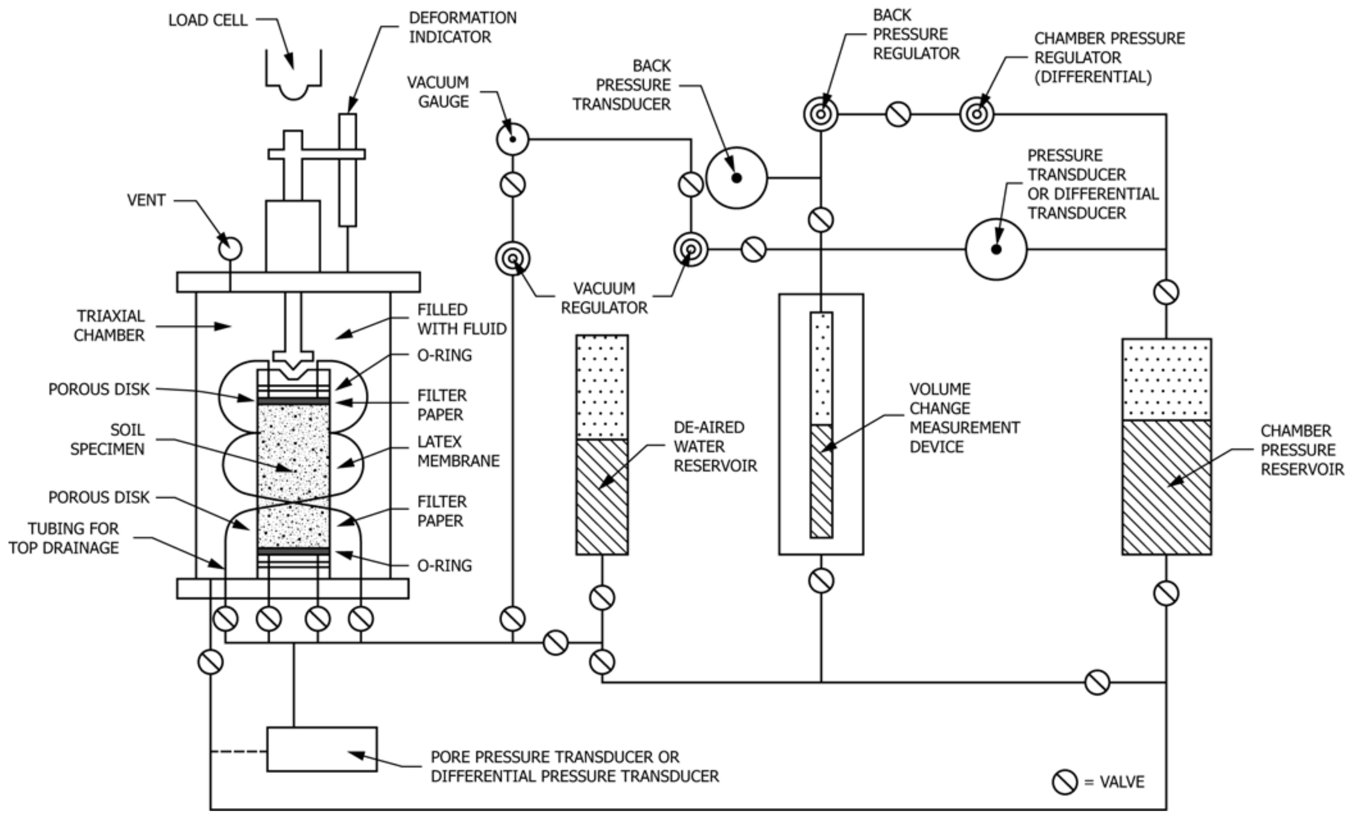

FIG. 1 Schematic Diagram of a Typical Consolidated Drained Triaxial Apparatus

the rate of axial strain (loading) prescribed in 9.5.2. The rate of advance of the loading device should not deviate by more than ±1 % from the selected value. Vibration due to the operation of the loading device shall be sufficiently small to not cause dimensional changes in the specimen.

NOTE 2—A loading device may be judged to produce sufficiently small vibrations if there are no visible ripples in a glass of water placed on the loading platform when the device is operating at the speed at which the test is performed.

6.3 *Axial Load-Measuring Device*—The axial load-measuring device shall be an electronic load cell, hydraulic load cell, or any other load-measuring device capable of the accuracy prescribed in this paragraph and may be a part of the axial loading device. The axial load-measuring device shall be capable of measuring the axial load to an accuracy of within 1 % of the axial load at failure. If the load-measuring device is located inside the triaxial compression chamber, it shall be insensitive to horizontal forces and to the magnitude of the chamber pressure.

6.4 *Triaxial Compression Chamber*—The triaxial chamber shall have a working chamber pressure capable of sustaining the sum of the effective consolidation stress and the back pressure. It shall consist of a top plate and a base plate separated by a cylinder. The cylinder may be constructed of any material capable of withstanding the applied pressures. 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 through which the pressure liquid is supplied to the chamber and inlets leading to the specimen base and provide for connection to the cap to allow saturation and drainage of the specimen when needed.

6.5 *Axial Load Piston*—The piston passing through the top of the chamber and its seal must be designed so the axial load due to friction does not exceed 0.5 % of the load on piston at failure and so there is negligible lateral bending of the piston during loading. For triaxial cell with internal load, cell piston friction is not as important.

NOTE 3—The use of two linear ball bushings to guide the piston is recommended to reduce friction and maintain alignment.

NOTE 4—A minimum piston diameter of ⅙ the specimen diameter has been used successfully in many laboratories to reduce lateral bending.

6.6 *Pressure and Vacuum-Control Devices*—The chamber pressure and back pressure control devices shall be (a) capable of applying and controlling pressures to within ±2 kPa (0.25 lbf/in.^{2}) for effective consolidation pressures less than 200 kPa (28 lbf/in.^{2}) and to within ±1 % for effective consolidation pressures greater than 200 kPa, and (b) able to maintain the effective consolidation stress within 2 % of the desired value (Note 5). The vacuum-control device shall be capable of applying and controlling partial vacuums to within ±2 kPa. The devices may consist of pneumatic-pressure regulators, combination pneumatic pressure and vacuum regulators, or any other device capable of applying and controlling pressures or partial vacuums to the necessary tolerances. These tests can have a duration of several days, therefore, an external air/water interface is recommended for both the chamber-pressure or back-pressure systems.

NOTE 5—Many laboratories use differential pressure regulators and