Designation: D 4767 – 95

Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils[1]

This standard is issued under the fixed designation D 4767; 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 an undisturbed or remolded saturated cohesive soil. Specimens are isotropically consolidated and sheared in compression without drainage at a constant rate of axial deformation (strain controlled).

1.2 This test method provides for the calculation of total and effective stresses, and axial compression by measurement of axial load, axial deformation, and pore-water pressure.

1.3 This test method provides data useful in determining strength and deformation properties of cohesive soils such as Mohr strength envelopes and Young's modulus. Generally, three specimens are tested at different effective consolidation stresses to define a strength envelope.

1.4 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.

1.5 The values stated in SI units shall be regarded as the standard. The values stated in inch-pound units are approximate.

1.6 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 422 Method for Particle-Size Analysis of Soils[2]
D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]
D 854 Test Method for Specific Gravity of Soils[2]
D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]
D 2166 Test Method for Unconfined Compressive Strength of Cohesive Soil[2]
D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]
D 2435 Test Method for One-Dimensional Consolidation Properties of Soils[2]
D 2487 Test Method for Classification of Soils for Engineering Purposes[2]
D 2850 Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression[2]
D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction[2]
D 4220 Practices for Preserving and Transporting Soil Samples[2]
D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[2]
D 4753 Specification for Evaluating, Selecting, and Specifying Balances and Scales for Use in Soil and Rock Testing[2]

3. Terminology

3.1 *Definitions*—The definitions of terms used in this test method shall be in accordance with Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *back pressure*—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*—the difference between the cell pressure and the pore-water pressure prior to shearing the specimen.

3.2.3 *failure*—the stress condition at failure for a test specimen. 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

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.05 on Strength and Compressibility of Soils.

Current edition approved Dec. 10, 1995. Published April 1996. Originally published as D 4767 – 88 $^{\epsilon 1}$. Last previous edition D 4767 – 88 $^{\epsilon 1}$.

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

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

effective stress obliquity, $\sigma'1/\sigma'3$, or the principal stress difference (deviator stress) at a selected axial strain other than 15 %.

4. Significance and Use

4.1 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.

4.2 In this test method, the shear characteristics are measured under undrained conditions and is applicable to field conditions where soils that have been fully consolidated under one set of stresses are subjected to a change in stress without time for further consolidation to take place (undrained condition), and the field stress conditions are similar to those in the test method.

NOTE 1—If the strength is required for the case where the soil is not consolidated during testing prior to shear, refer to Test Method D 2850 or Test Method D 2166.

4.3 Using the pore-water pressure measured during the test, the shear strength determined from this test method can be expressed in terms of effective stress. This shear strength may be applied to field conditions where full drainage can occur (drained conditions) or where pore pressures induced by loading can be estimated, and the field stress conditions are similar to those in the test method.

4.4 The shear strength determined from the test expressed in terms of total stresses (undrained conditions) or effective stresses (drained conditions) is commonly used in embankment stability analyses, earth pressure calculations, and foundation design.

NOTE 2—Notwithstanding the 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 which meet the criteria of Practice D 3740 are generally considered capable of competent testing. Users of this test method are cautioned that compliance with Practice D 3740 does not ensure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means of evaluating some of those factors.

5. Apparatus

5.1 The requirements for equipment needed to perform satisfactory tests are given in the following sections.

5.2 *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 the rate of axial strain (loading) prescribed in 8.4.2. 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 or to produce changes in pore-water pressure when the drainage valves are closed.

NOTE 3—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.

5.3 *Axial Load-Measuring Device*—The axial load-measuring device shall be a load ring, 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.

5.4 *Triaxial Compression Chamber*—The triaxial chamber shall have a working chamber pressure equal to 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 baseplate 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 required.

5.5 *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 and so there is negligible lateral bending of the piston during loading.

NOTE 4—The use of two linear ball bushings to guide the piston is recommended to minimize friction and maintain alignment.

NOTE 5—A minimum piston diameter of ⅙the specimen diameter has been used successfully in many laboratories to minimize lateral bending.

5.6 *Pressure and Vacuum-Control Devices*—The chamber pressure and back pressure control devices shall be capable of applying and controlling pressures to within ± 2 kPa (0.25 lb/in.^{2}) for effective consolidation pressures less than 200 kPa (28 lb/in.^{2}) and to within ± 1 % for effective consolidation pressures greater than 200 kPa. The vacuum-control device shall be capable of applying and controlling partial vacuums to within ± 2 kPa. The devices may consist of self-compensating mercury pots, pneumatic pressure regulators, combination pneumatic pressure and vacuum regulators, or any other device capable of applying and controlling pressures or partial vacuums to the required tolerances. These tests can require a test duration of several days, therefore, an air/water interface is not recommended for either the chamber pressure or back pressure systems.

5.7 *Pressure- and Vacuum-Measurement Devices*—The chamber pressure-, back pressure-, and vacuum-measuring devices shall be capable of measuring pressures or partial vacuums to the tolerances given in 5.6. They may consist of Bourdon gages, pressure manometers, electronic pressure transducers, or any other device capable of measuring pressures, or partial vacuums to the stated tolerances. If separate devices are used to measure the chamber pressure and back pressure, the devices must be calibrated simultaneously and against the same pressure source. Since the chamber and back pressure are the pressures taken at the mid-height of the specimen, it may be necessary to adjust the calibration of the devices to reflect the hydraulic head of fluids in the chamber