Designation: D2850 – 15

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 procedures. Samples shall be preserved and transported in accordance with the practices for Group C samples in Practices D4220/D4220M. Specimens obtained by tube sampling may be tested without trimming except for cutting the end surfaces plane and perpendicular to the longitudinal axis of the specimen, provided soil characteristics are such that no significant disturbance results from sampling. Handle specimens carefully to minimize disturbance, changes in cross section, or change in water content. If compression or any type of noticeable disturbance would be caused by the extrusion device, split the sample tube lengthwise or cut the tube in suitable sections to facilitate removal of the specimen with minimum disturbance. Prepare trimmed specimens, in an environment such as a controlled high-humidity room where soil water content change is minimized. Where removal of pebbles or crumbling resulting from trimming causes voids on the surface of the specimen, carefully fill the voids with remolded soil obtained from the trimmings. When the sample condition permits, a vertical trimming lathe may be used to reduce the specimen to the required diameter. After obtaining the required diameter, place the specimen in a miter box and cut the specimen to the final height with a wire saw or other suitable device. Trim the surfaces with the steel straightedge. Perform one or more water content determinations on material trimmed from the specimen in accordance with Test Method D2216. Determine the mass and dimensions of the specimen consistent with 5.12 and 5.10. A minimum of three height measurements (120° apart) and at least three diameter measurements at the quarter points of the height shall be made to determine the average height and diameter of the specimen.

6.3 *Compacted/Reconstituted Specimens*—Soil required for compacted/reconstituted specimens shall be thoroughly mixed with sufficient water to produce the desired water content. If water is added to the soil, store the material in a covered container for at least 16 h prior to compaction. Compacted/reconstituted specimens may be prepared by compacting material in at least six layers using a split mold of circular cross section having dimensions meeting the requirements enumerated in 6.1. Specimens may be compacted/reconstituted to the desired density by either: (*1*) kneading or tamping each layer until the accumulative mass of the soil placed in the mold is compacted/reconstituted to a known volume; or (*2*) by adjusting the number of layers, the number of tamps per layer, and the force per tamp. The top of each layer shall be scarified prior to the addition of material for the next layer. The tamper used to compact the material shall have a diameter equal to or less than one half the diameter of the mold. After a specimen is formed, with the ends perpendicular to the longitudinal axis, remove the mold and determine the mass and dimensions of the specimen using the devices described in 5.12 and 5.10. Perform one or more water content determinations on excess material used to prepare the specimen in accordance with Test Method D2216.

6.4 *Remolded Specimens*—Specimens may be prepared either from a failed intact specimen or from a disturbed sample, providing it is representative of the failed intact specimen. In the case of failed intact specimens, wrap the material in a thin rubber membrane and work the material thoroughly with the finger to ensure complete remolding. Avoid entrapping air in the specimen. Exercise care to obtain a uniform density, to remold to the same void ratio as the intact specimen, and to preserve the water content of the soil. Form the disturbed material into a mold of circular cross section having dimensions meeting the requirements of 6.1. After removal from the mold, determine the mass and dimensions of the test specimen consistent with 5.12 and 5.10. A minimum of three height measurements (120° apart) and at least three diameter measurements at the quarter points of the height shall be made to determine the average height and diameter of the specimen.

NOTE 10—It is common for the unit weight of the specimen after removal from the mold to be less than the value based on the volume of the mold. This occurs as a result of the specimen swelling after removal of the lateral confinement due to the mold.

7. Procedure

7.1 Place the membrane on the membrane expander or, if it is to be rolled onto the specimen, roll the membrane onto the impermeable rigid cap or base. Place the specimen on the base. Place the rubber membrane around the specimen and seal it at the cap and base with O-rings or other positive seals at each end. A thin coating of silicon grease on the vertical surfaces of the cap or base will aid in sealing the membrane.

7.2 With the specimen encased in the rubber membrane, which is sealed to the specimen cap and base and positioned in the chamber, assemble the triaxial chamber. Bring the axial load piston into contact with the specimen cap several times to permit proper seating and alignment of the piston with the cap. When the piston is brought into contact the final time, record the reading on the deformation indicator to three significant digits. During this procedure, take care not to apply an axial stress to the specimen exceeding approximately 0.5 % of the estimated compressive strength. Lock the piston in place above the specimen cap after checking the seating and alignment and keep locked until application of the chamber pressure.

7.3 Place the chamber in position in the axial loading device. Be careful to align the axial loading device, the axial load-measuring device, and the triaxial chamber to prevent the application of a lateral force to the piston during testing. Attach the pressure-maintaining and measurement device and fill the chamber with the chamber fluid. Lock the piston or hold in place by axial loading device before applying the chamber pressure. Adjust the pressure-maintaining and measurement device to the desired chamber pressure and apply the pressure to the chamber fluid. Wait approximately ten minutes after the application of chamber pressure to allow the specimen to stabilize under the chamber pressure prior to application of the axial load.

NOTE 11—In some cases the chamber will be filled and the chamber pressure applied before placement in the axial loading device.

NOTE 12—The waiting period may need to be increased for soft or partially saturated soils.

7.4 Unlock the piston. If the axial load-measuring device is located outside of the triaxial chamber, the chamber pressure will produce an upward force on the piston that will react against the axial loading device. In this case, start the test with the piston slightly above the specimen cap, and before the piston comes in contact with the specimen cap, either: (*1*) measure and record the initial piston friction to three significant digits and upward thrust of the piston produced by the chamber pressure and later correct the measured axial load, or (*2*) adjust the axial load-measuring device to compensate for the friction and thrust. If the axial load-measuring device is located inside the chamber, it will not be necessary to correct or compensate for the uplift force acting on the axial loading device or for piston friction. In both cases record the initial reading on the deformation indicator when the piston contacts the specimen cap. Measure the chamber pressure and adjust if necessary. Record the chamber pressure in accordance with 5.5.

7.5 Select a strain rate between 0.3 to 1 %/min. The rate of strain shall be chosen so that the time to failure does not exceed about 15 minutes.

NOTE 13—Softer or plastic materials will exhibit larger deformation at failure and should be tested at a rate of strain in the higher range. Conversely, stiff or brittle materials will exhibit small deformations at failure (less than 6 % axial strain) and should be tested at a rate of strain in the lower range.

7.6 Record load and deformation values to three significant digits and time to the nearest second. If desired, chamber pressure readings may be obtained at each reading and will negate the requirement for an initial and final chamber reading. Take sufficient readings to define the stress-strain curve; hence, more frequent readings may be required in the early stages of the test and as failure is approached. Typically, readings at about 0.1, 0.2, 0.3, 0.4, and 0.5 % strain; then at increments of about 0.5 % strain to 3 %; and, thereafter at every 1 % define the curve adequately.

7.7 Continue the loading to 15 % axial strain, or when the principal stress difference (deviator stress) has peaked then dropped by more than 20 %, or the axial strain has reached at least 5 % beyond the strain at which the peak in principal stress difference (deviator stress) occurred.

7.8 If chamber pressure readings were not recorded during compression testing, record the chamber pressure at the end of the test.

7.9 After completion of the test, remove the test specimen from the chamber. Determine the water content of the test specimen in accordance with Test Method D2216 using the entire specimen, if possible.

7.10 Prior to placing the specimen (or portion thereof) in the oven to dry, sketch a picture or take a photograph of the specimen showing the mode of failure (shear plane, bulging, etc.).

8. Calculation

8.1 Calculations as shown are based on the use of SI units. Other units are permissible, provided the appropriate conversion factors are used to maintain consistency of units throughout the calculations. See 1.4.1 for additional comments on the use of inch-pound units.

8.2 Equations are presented using a single and dimensionally consistent set of units. Each equation makes use of the most convenient unit for each variable in the calculation. The multiplier unit conversion factors are not provided in the equations for simplicity and may be required to provide dimensional consistency between equations. Other units may be used and still be in conformance with these test methods.

8.3 Measurements and calculations shall contain three significant digits. More significant digits can be used in accordance with the criteria established by Practice D6026.

8.4 Calculate the axial strain for a given applied axial load, as follows:

$$\varepsilon = \frac{\Delta H}{H_0} \tag{1}$$

where:

ε = axial strain for the given axial load (expressed as a decimal),
ΔH = change in height of specimen during loading as read from deformation indicator, mm, and
H_0 = initial height of test specimen minus any change in length prior to loading, mm.

8.5 Calculate the average cross-sectional area for a given applied axial load as follows:

$$A = \frac{A_0}{(1 - \varepsilon)} \tag{2}$$

where:

A = average cross-sectional area, m^2 and
A_o = initial average cross-sectional area of the specimen, m^2.

NOTE 14—In the event that the application of the chamber pressure results in a change in the specimen length, A_o, should be corrected to reflect this change in volume. Frequently, this is done by assuming that lateral strains are equal to vertical strains. The diameter after volume change would be given by $D = D_o (1 - \Delta H/H)$.

8.6 Calculate the measured principal stress difference (deviator stress), for a given applied axial load as follows:

$$\sigma_1 - \sigma_3 = \frac{P}{A} \tag{3}$$

where:

$\sigma_1 - \sigma_3$ = measured principal stress difference (deviator stress), kN/m^2 = kPa
P = measured applied axial load (corrected for uplift and piston friction, if required as obtained in 7.4), kN, and
A = corresponding average cross-sectional area, m^2.

8.7 *Stress-Strain Curve*—Prepare a graph showing the relationship between principal stress difference (deviator stress) and axial strain, plotting deviator stress as ordinate and axial strain (in percent) as abscissa. Select the unconsolidated-undrained compressive strength and axial strain at failure in accordance with the definitions in 3.2.1 and 3.2.2.

8.8 *Correction for Rubber Membrane*—The following equation shall be used to correct the principal stress difference (deviator stress) for the effect of the rubber membrane if the error in principal stress difference (deviator stress) due to the strength of the membrane exceeds 5 %:

$$\Delta(\sigma_1 - \sigma_3)_m = \frac{4E_m t_m \varepsilon_1}{D} \tag{4}$$

where:

$\Delta(\sigma_1 - \sigma_3)_m$ = membrane correction to be subtracted from the measured principal stress difference,
D = $\sqrt{4A/\pi}$ diameter of specimen, m,
E_m = Young's modulus for the membrane material, $kN/m^2 = kPa$,
t_m = thickness of the membrane, m, and
ε_1 = axial strain (decimal format).

8.8.1 The Young's modulus of the rubber membrane (E_m) may be determined by hanging a 15.0 mm (0.6 in.) circumferential strip of membrane over a thin rod, placing another rod through the bottom of the hanging membrane, and measuring the force per unit strain obtained by stretching the membrane. The modulus value may be computed using the following equation:

$$E_m = \frac{\left(\frac{F}{A_m}\right)}{\left(\frac{\Delta L}{L}\right)} \tag{5}$$

where:

E_m = Young's modulus of the membrane material, kN/m^2 = kPa,
F = force applied to stretch the membrane, kg mass times $9.8087\ m/s^2 = N$,
L = unstretched length of the membrane, m,
ΔL = change in length of the membrane due to applied force (F), m,
A_m = area of the membrane = $2t_mW_s$, m^2, and
W_s = width of circumferential strip of membrane, 15 mm (0.6 in.).

A typical value of E_m for latex membrane is 1400 kPa (203 $lbf/in.^2$).

NOTE 15—The effect of the stiffness of the membrane on the lateral stress is usually assumed to be negligible.

NOTE 16—The correction for rubber membranes is based on simplified assumptions concerning their behavior during shear. Their actual behavior is complex, and there is not a consensus on more exact corrections.

8.9 Calculate the major and minor principal total stresses and unconsolidated-undrained compressive strength at failure as follows:

σ_{1C} = major principal total stress corrected = deviator stress at failure minus the membrane correction plus chamber pressure, and

σ_3 = minor principal total stress = chamber pressure.

Unconsolidated-Undrained Compressive Strength at Failure

$$= \sigma_{1C} - \sigma_3 \tag{6}$$

8.10 Calculate the initial degree of saturation of the test specimen using the initial mass, dimensions, and water content.

NOTE 17—The specific gravity determined in accordance with Test Methods D854 is required for calculation of the saturation. An assumed specific gravity may be used provided it is noted in the test report that an assumed value was used.

9. Report: Test Data Sheet(s)/Form(s)

9.1 The methodology used to specify how data are recorded on the data sheet(s)/form(s, as given below, is covered in 1.3 and Practice D6026.

9.2 Record as a minimum the following general information (data):

9.2.1 Identification data and visual description (Practice D2488 or, if the information is available, Practice D2487) of specimen including soil classification and whether the specimen is intact, compacted/reconstituted, remolded, or otherwise prepared,

9.2.2 Values of plastic limit and liquid limit, if determined, in accordance with Test Methods D4318,

9.2.3 Value of specific gravity of solids and notation if the value was determined in accordance with Test Methods D854 or assumed,

9.2.4 Particle-size analysis, if determined, in accordance with Test Method D422 or D6913,

9.2.5 Average initial height and diameter of the specimen.

9.2.6 Initial specimen dry unit weight, void ratio, water content, and saturation. (Specify if the water content was obtained from cuttings, excess material, or the entire specimen.),

9.2.7 Tabulation of readings of load, deformation, and chamber pressure, if recorded at each reading.

9.2.8 Initial and final measurements of chamber pressure if not recorded at each reading.

9.2.9 Rate of axial strain, percent per minute,

9.2.10 Axial strain at failure, percent,

9.2.11 The value of the compressive strength and the values of the minor and major principal stresses at failure, (Indicate when values have been corrected for membrane effects),

9.2.12 Stress-strain curve as described in 8.7,

9.2.13 Failure sketch or photograph of the specimen, and

9.2.14 Remarks and notations regarding any unusual conditions such as slickensides, stratification, shells, pebbles, roots, etc., or other information necessary to properly interpret the results obtained including any departures from the procedure outlined.

10. Precision and Bias

10.1 *Precision*—Test data on precision is not presented due to the nature of the soil materials tested by this test method. It is either not feasible or too costly at this time to have ten or more laboratories participate in a round-robin testing program. Also, it is either not feasible or too costly to produce multiple specimens that have uniform physical properties. Any variation observed in the data is just as likely to be due to specimen variation as to operator or laboratory testing variation.

10.1.1 Subcommittee D18.05 is seeking any data from users of this test method that might be used to make a limited statement on precision.

10.2 *Bias*—There is no accepted reference value for this test method; therefore, bias cannot be determined.

11. Keywords

11.1 cohesive soil; lateral confinement; strain-controlled loading; stress-strain relationships; total stresses; unconsolidated undrained strength

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (2003 (Reapproved 2007)) that may impact the use of this standard. (November 1, 2015)

(1) Changed "undisturbed" to "intact."
(2) Added more information regarding Mohr failure envelopes.
(3) Revised the apparatus requirements with an emphasis on requirements rather than pieces of equipmen that could be used to meet the requirements.
(4) Removed the option for using compacted/reconstituted specimens; and replaced with an option to test remolded specimens.
(5) Clarified the procedure.
(6) Measurement of chamber pressure was required.
(7) Added units and significant digit requirements.