Designation: D7181 – 11

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.

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 methods 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 of the end use. It is beyond the scope of this test method 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 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

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[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 July 1, 2011. Published August 2011. DOI: 10.1520/D7181-11.

[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.

D2166 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
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)
D2850 Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
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
D7263 Test Methods for Laboratory Determination of Density (Unit Weight) of Soil Specimens

3. Terminology

3.1 *Definitions*—Refer to Terminology D653 for standard definitions of common technical terms.

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 *failure, n*—a maximum-stress condition or stress at a defined strain 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 effective stress obliquity, $\sigma_1/\sigma_{3\max}$, 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 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.

4.3 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 minimize 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.

4.4 The shear strength determined from the test is commonly used in embankment stability analyses, earth pressure calculations, and foundation design.

NOTE 1—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 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 testing. Reliable testing depends on several factors; Practice D3740 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. See Fig. 1

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.

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.

5.3 *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.

5.4 *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

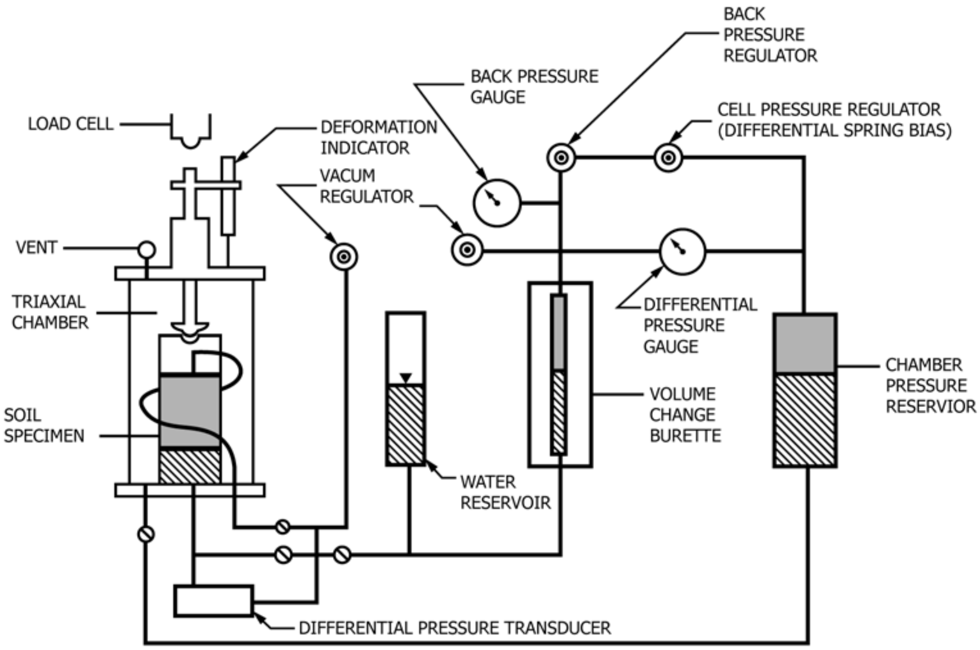

FIG. 1 Schematic Diagram of a Typical Consolidated Undrained Triaxial Apparatus

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 required.

5.5 *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 0.1 % of the axial load at failure and so there is negligible lateral bending of the piston during loading.

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

NOTE 4—A minimum piston diameter of ⅙ the 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 (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 required tolerances. These tests can require 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 transducers to achieve the requirements for small differences between chamber and back pressure.

5.7 *Pressure- and Vacuum-Measurement Devices*—The chamber pressure-, back pressure-, and vacuum-measuring devices shall be capable of measuring the ranges of pressures or partial vacuums to the tolerances given in 5.6. They may consist of 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 normalized simultaneously and against the same pressure source. Since the chamber and back pressure are the pressures taken at the midheight of the specimen, it may be necessary to adjust the zero-offset of the devices to reflect the hydraulic head of fluids in the chamber and back pressure control systems.

5.8 *Volume Change Measurement Device*—The volume of water entering or leaving the specimen shall be measured with an accuracy of within ±0.05 % of the total volume of the specimen. The volume-measuring device is usually a burette connected to the back pressure but may be any other device meeting the accuracy requirement. The device must be able to withstand the maximum back pressure and of sufficient capacity for the performance of the test. Volume changes during shear are often on the order of ±20 % or more of the specimen volume. Either allowing for resetting of the system during shear or having a total capacity capable of measuring the entire change may meet the required capacity.

5.9 *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 with an accuracy of at least 0.25 % of the initial specimen height. The deformation indicator shall have a range of at least 20 % of the initial height of the specimen and may be a dial indicator, linear variable differential transformer (LVDT), extensometer, or other measuring device meeting the requirements for accuracy and range.

5.10 *Specimen Cap and Base*—The specimen cap and base shall be designed to provide drainage from both ends of the specimen. They shall be constructed of a rigid, noncorrosive, impermeable material, and each shall, except for the drainage provision, have a circular plane surface of contact with the porous disks and a circular cross section. It is desirable for the mass of the specimen cap and top porous disk to be as minimal as possible. However, the mass may be as much as 10 % of the axial load at failure. If the mass is greater than 0.5 % of the applied axial load at failure and greater than 50 g (0.1 lb), the axial load must be corrected for the mass of the specimen cap and top porous disk. 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.

5.11 *Porous Disks*—A rigid porous disk shall be used to provide drainage at each end of the specimen. The coefficient of permeability of the disks shall be at most equal to that of fine sand (1×10^{-4} cm/s (4×10^{-5} in./s)). The disks shall be regularly cleaned by ultrasonic or boiling and brushing and checked to determine whether they have become clogged.

5.12 *Filter-Paper Strips and Disk*—Filter-paper strips are used by many laboratories to decrease the time required for testing. Filter-paper disks of a diameter equal to that of the specimen may be placed between the porous disks and specimen to avoid clogging of the porous disks. If filter strips or disks are used, they shall be of a type that does not dissolve in water. The coefficient of permeability of the filter paper shall not be less than 1×10^{-5} cm/s (4×10^{-6} in./s) for a normal pressure of 550 kPa (80 lbf/in.^{2}). To avoid hoop tension, filter strips should cover no more than 50 % of the specimen periphery. Many laboratories have successfully used filter strip cages. An equation for correcting the principal stress difference (deviator stress) for the effect of the strength of vertical filter strips is given in 10.3.3.1.

NOTE 6—Grade No. 54 Filter Paper has been found to meet the permeability and durability requirements.

5.13 *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 cap and base 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 other means that will provide a positive seal. An equation for correcting the principal stress difference (deviator stress) for the effect of the stiffness of the membrane is given in 10.3.3.2.

5.14 *Valves*—Changes in volume due to opening and closing valves may result in inaccurate volume change and pore-water pressure measurements. For this reason, valves in the specimen drainage system shall be of the type that produces minimum volume changes due to their operation. A valve may be assumed to produce minimum volume change if opening or closing the valve in a closed, saturated pore-water pressure system does not induce a pressure change of greater than 0.7 kPa (±0.1 lbf/in.^{2}). All valves must be capable of withstanding applied pressures without leakage.

NOTE 7—Ball valves have been found to provide minimum volume-change characteristics; however, any other type of valve having suitable volume-change characteristics may be used.

5.15 *Specimen-Size Measurement Devices*—Devices used to determine the height and diameter of the specimen shall measure the respective dimensions to four significant digits and shall be constructed such that their use will not disturb/deform the specimen.

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

5.16 *Data Acquisition*—Specimen behavior may be recorded manually or by electronic digital or analog recorders. If electronic data acquisition is used, it shall be necessary to calibrate the measuring devices through the recording device using known input standards.

5.17 *Timer*—A timing device indicating the elapsed testing time to the nearest 1 s shall be used to obtain consolidation data (8.3.3).

5.18 *Balance*—A balance or scale conforming to the requirements of Specification D4753 readable to four significant digits.

5.19 *Water Deaeration Device*—The amount of dissolved gas (air) in the water used to saturate the specimen shall be decreased by boiling, by heating and spraying into a vacuum, or by any other method that will satisfy the requirement for saturating the specimen within the limits imposed by the available maximum back pressure and time to perform the test.

5.20 *Testing Environment*—The consolidation and shear portion of the test shall be performed in an environment where temperature fluctuations are less than ±4 °C (±7.2 °F) and there is no direct exposure with sunlight.

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

6. Test Specimen Preparation

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. An individual measurement of height or diameter shall not vary from average by more than 2 %. The largest particle size shall be smaller than ⅙ 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 (11.1.4).

NOTE 9—If oversize particles are found in the specimen after testing, a particle-size analysis may be performed on the tested specimen in accordance with Test Method D422 to confirm the visual observation and the results provided with the test report (11.1.4).

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. 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. If the sample can be trimmed with minimal disturbance, 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 using the devices described in 5.16 and 5.20. 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 *Reconstituted Specimens*—Reconstituted specimens shall be prepared at the conditions specified for the test. Soil required for 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. 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 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 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 ½ 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 5.14 and 5.17. 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. Perform one or more water content determinations on excess material used to prepare the specimen in accordance with Test Method D2216.

NOTE 10—It is common for the density or 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.

6.4 *Reconstituted Specimens*—Prepare reconstituted specimens in the manner specified by the requesting agency. Common methods include:

6.4.1 *Pluviation Through Water Method*—For this specimen preparation method, a granular soil is saturated initially in a container, poured through water into a water-filled membrane placed on a forming mold, and then densified to the required density by vibration; refer to reference by Chaney and Mullis.[3]

NOTE 11—A specimen may be vibrated either on the side of the mold or the base of the cell using a variety of apparatus. These include the following: tapping with an implement of some type such as a spoon or metal rod, pneumatic vibrator, or electric engraving tool.

6.4.2 *Dry Screening Method*—For this method a tube with a screen attached to one end is placed inside a membrane stretched over a forming mold. A dry uniform sand is then poured into the tube. The tube is then slowly withdrawn from this membrane/mold allowing the sand to pass through the screen forming a specimen. If a greater density of the sand is desired the mold may be vibrated.

6.4.3 *Dry or Moist Vibration Method*—In this procedure compact oven-dried, or moist granular material in layers (typically six to seven layers) in a membrane-lined split mold attached to the bottom platen of the triaxial cell. Compact the weighed material for each lift by vibration to the dry unit weight required to obtain the prescribed density. Scarify the soil surface between lifts. It should be noted that to obtain uniform density, the bottom layers have to be slightly under compacted, since compaction of each succeeding layer increases the density of sand in layers below it. After the final layer is partially compacted, put the top cap in place and continue vibration until the desired dry unit weight is obtained.

6.4.4 *Tamping Method*—For this procedure tamp air dry or moist granular or cohesive soil in layers into a mold. The only difference between the tamping method and the vibration method is that each layer is compacted by hand tamping with a compaction foot instead of with a vibrator, refer to reference by Ladd, R.S.[4]

6.4.5 After the specimen has been formed, place the specimen cap in place and seal the specimen with O-rings or rubber bands after placing the membrane ends over the cap and base. Then apply a partial vacuum of 35 kPa (5 lbf/in.^{2}) to the specimen and remove the forming jacket. If the test confining-pressure is greater than 103 kPa (14.7 lbf/in.^{2}), a full vacuum may be applied to the specimen in stages prior to removing the jacket.

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[3] Chaney, R., and Mulilis, J., "Wet Sample Preparation Techniques," *Geotechnical Testing Journal*, ASTM, 1978, pp. 107-108.

[4] Ladd, R.S., "Preparing Test Specimens Using Under-Compaction," *Geotechnical Testing Journal*, ASTM, Vol. 1, No. 1, March, 1978, pp. 16-23.

7. Mounting Specimen

7.1 *Preparations*—Before mounting the specimen in the triaxial chamber, make the following preparations:

7.1.1 Inspect the rubber membrane for flaws, pinholes, and leaks.

7.1.2 Place the membrane on the membrane expander or, if it is to be rolled onto the specimen, roll the membrane on the cap or base.

7.1.3 Check that the porous disks and specimen drainage tubes are not obstructed by passing air or water through the appropriate lines.

7.1.4 Attach the pressure-control and volume-measurement system and a pore-pressure measurement device to the chamber base.

7.2 Depending on whether the saturation portion of the test will be initiated with either a wet or dry drainage system, mount the specimen using the appropriate method, as follows in either 7.2.1 or 7.2.2. The dry mounting method is strongly recommended for specimens with initial saturation less than 90 %. The dry mounting method removes air prior to adding backpressure and lowers the backpressure needed to attain an adequate percent saturation.

NOTE 12—It is recommended that the dry mounting method be used for specimens of soils that swell appreciably when in contact with water. If the wet mounting method is used for such soils, it will be necessary to obtain the specimen dimensions after the specimen has been mounted. In such cases, it will be necessary to determine the double thickness of the membrane, the double thickness of the wet filter paper strips (if used), and the combined height of the cap, base, and porous disks (including the thickness of filter disks if they are used) so that the appropriate values may be subtracted from the measurements.

7.2.1 *Wet Mounting Method:*

7.2.1.1 Fill the specimen drainage lines and the pore-water pressure measurement device with deaired water.

7.2.1.2 Saturate the porous disks by boiling them in water for at least 10 min and allow to cool to room temperature.

7.2.1.3 Place a saturated porous disk on the specimen base and after wiping away all free water on the disk, place the specimen on the disk. Next, place another porous disk and the specimen cap on top of the specimen. Check that the specimen cap, specimen, and porous disks are centered on the specimen base.

NOTE 13—If filter-paper disks are to be placed between the porous disks and specimen, they should be dipped in water prior to placement.

7.2.1.4 If filter-paper strips or a filter-paper cage are to be used, saturate the paper with water prior to placing it on the specimen. To avoid hoop tension, do not cover more than 50 % of the specimen periphery with vertical strips of filter paper. The filter paper should extend to porous disks on top and bottom of sample.

7.2.1.5 Proceed with 7.3.

7.2.2 *Dry Mounting Method:*

7.2.2.1 Dry the specimen drainage system. This may be accomplished by allowing dry air to flow through the system prior to mounting the specimen.

7.2.2.2 Dry the porous disks in an oven and then place the disks in a desiccator to cool to room temperature prior to mounting the specimen.

7.2.2.3 Place a dry porous disk on the specimen base and place the specimen on the disk. Next, place a dry porous disk and the specimen cap on the specimen. Check that the specimen cap, porous disks, and specimen are centered on the specimen base.

NOTE 14—If desired, dry filter-paper disks may be placed between the porous disks and specimen.

7.2.2.4 If filter-paper strips or a filter paper cage are to be used, the cage or strips may be held in place by small pieces of tape at the top and bottom.

7.3 Place the rubber membrane around the specimen and seal it at the cap and base with two rubber O-rings or other positive seal at each end. A thin coating of silicon grease on the vertical surfaces of the cap and base will aid in sealing the membrane. If filter-paper strips or a filter-paper cage are used, do not apply grease to surfaces in contact with the filter paper.

7.4 Attach the top drainage line and check the alignment of the specimen and the specimen cap. If the dry mounting method has been used, apply a partial vacuum of approximately 35 kPa (5 lbf/in.^{2}) (not to exceed the consolidation stress) to the specimen through the top drainage line prior to checking the alignment. If there is any eccentricity, release the partial vacuum, realign the specimen and cap, and then reapply the partial vacuum. If the wet mounting method has been used, the alignment of the specimen and the specimen cap may be checked and adjusted without the use of a partial vacuum.

8. Procedure

8.1 *Prior to Saturation*—After assembling the triaxial chamber, perform the following operations:

8.1.1 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. During this procedure, take care not to apply an axial load to the specimen exceeding 0.5 % of the estimated axial load at failure. When the piston is brought into contact, record the reading of the deformation indicator.

8.1.2 Fill the chamber with the chamber liquid, being careful to avoid trapping air or leaving an air space in the chamber.

8.2 *Saturation*—The objective of the saturation phase of the test is to fill all voids in the specimen with water without undesirable prestressing of the specimen, allowing the specimen to swell, or causing migration of fines. Saturation is usually accomplished by applying back pressure to the specimen pore water to drive air into solution after saturating the system by either: (1) applying vacuum to the specimen and dry drainage system (lines, porous disks, pore-pressure device, filter-strips or cage, and disks) and then allowing deaired water to flow through the system and specimen while maintaining the vacuum; or (2) saturating the drainage system by boiling the porous disks in water and allowing water to flow through the system prior to mounting the specimen. It should be noted that placing the air into solution is a function of both time and pressure. Accordingly, removing as much air as possible prior to applying back pressure will decrease the amount of air that will have to be placed into solution and will also decrease the