



Designation: D4186 – 06

Standard Test Method for One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading¹

This standard is issued under the fixed designation D4186; 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 is for the determination of the magnitude and rate-of-consolidation of saturated cohesive soils using continuous controlled-strain axial compression. The specimen is restrained laterally and drained axially to one surface. The axial force and base excess pressure are measured during the deformation process. Controlled strain compression is typically referred to as constant rate-of-strain (CRS) testing.

1.2 This test method provides for the calculation of total and effective axial stresses, and axial strain from the measurement of axial force, axial deformation, and base excess pressure. The effective stress is computed using steady state equations.

1.3 This test method provides for the calculation of the coefficient of consolidation and the hydraulic conductivity throughout the loading process. These values are also based on steady state equations.

1.4 This test method makes use of steady state equations resulting from a theory formulated under particular assumptions. Section 5.4 presents these assumptions.

1.5 The behavior of cohesive soils is strain rate dependent and hence the results of a CRS test are sensitive to the imposed rate of strain. This test method imposes limits on the strain rate to provide comparable results to the incremental consolidation test.

1.6 The determination of the rate and magnitude of consolidation of soil when it is subjected to incremental loading is covered by Test Method D2435.

1.7 This test method applies to intact (Group C and Group D of Practice D4220), remolded, or laboratory reconstituted samples or specimens.

1.8 This test method is most often used for materials of relatively low hydraulic conductivity that generate measurable excess base pressures. It may be used to measure the compression

behavior of essentially free draining soils but will not provide a measure of the hydraulic conductivity or coefficient of consolidation.

1.9 All recorded and calculated values shall conform to the guide for significant digits and rounding established in Practice D6026.

1.9.1 The procedures used to specify how data are collected/recorded and calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that should generally 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.

1.9.2 Measurements made to more significant digits or better sensitivity than specified in this standard shall not be regarded a non-conformance with this standard.

1.10 This standard is written using SI units. Inch-pound units are provided for convenience. The values stated in inch-pound units may not be exact equivalents; therefore, they shall be used independently of the SI system. Combining values from the two systems may result in non-conformance with this standard.

1.10.1 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 rationalized slug unit is not given, unless dynamic ($F = ma$) calculations are involved.

1.10.2 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/ft³ shall not be regarded as non-conformance with this standard.

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

1.11 *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

- 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
- 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)
- D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
- D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of 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
- D4452 Practice for X-Ray Radiography of Soil Samples
- D4753 Guide for Evaluating, Selecting, and Specifying Balances and Standard Masses for Use in Soil, Rock, and Construction Materials Testing
- D6026 Practice for Using Significant Digits in Geotechnical Data
- D6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler
- D6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis
- D7015 Practices for Obtaining Intact Block (Cubical and Cylindrical) Samples of Soils

3. Terminology

3.1 Definitions:

3.1.1 For definitions of other terms used in this Test Method, see Terminology D653.

3.2 Definitions of Terms:

3.2.1 *back pressure*, (u_b (FL^{-2}))—a fluid pressure in excess of atmospheric pressure that is applied to the drainage boundary of a test specimen.

3.2.1.1 *Discussion*—Typically, the back pressure is applied to cause air in the pore spaces to pass into solution, thus saturating the specimen.

3.2.2 *consolidometer*—an apparatus containing a specimen under conditions of no lateral deformation while allowing one-dimensional axial deformation and one directional axial flow.

3.2.3 *excess pore-water pressure*, Δu (FL^{-2})—in *effective stress testing*, the pressure that exists in the pore fluid relative to (above or below) the back pressure.

3.2.4 *total axial stress*, σ_a (FL^{-2})—in *effective stress testing*, the total stress applied to the free draining surface of the specimen in excess of the back pressure.

3.3 Definitions of Terms Specific to This Standard:

3.3.1 *axial displacement reading*, *AD* (volts)—readings taken during the test of the axial displacement transducer.

3.3.2 *axial force reading*, *AF* (volts)—readings taken during the test of the axial force transducer.

3.3.3 *average effective axial stress*, σ'_a (FL^{-2})—the effective stress calculated using either the linear or nonlinear theory equations to represent the average value during constant strain rate conditions.

3.3.4 *base excess pressure*, Δu_m (FL^{-2})—the fluid pressure in excess of the back pressure that is measured at the impervious boundary of the specimen under conditions of one way drainage.

3.3.5 *base pressure*, u_m (FL^{-2})—the fluid pressure measured at the impervious boundary (usually at the base of the consolidometer) of the specimen under conditions of one way drainage.

3.3.6 *base pressure reading*, *BP* (volts)—readings taken during the test of the base pressure transducer.

3.3.7 *chamber pressure*, σ_c (FL^{-2})—the fluid pressure inside the consolidometer. In most CRS consolidometers, the chamber fluid is in direct contact with the specimen. For these devices (and this test method), the chamber pressure will be equal to the back pressure.

3.3.8 *chamber pressure reading*, *CP* (volts)—readings taken during the test of the chamber pressure transducer.

3.3.9 *constant rate-of-strain*, *CRS*—a method of consolidating a specimen in which the surface is deformed at a uniform rate while measuring the axial deformation, axial reaction force, and induced base excess pressure.

3.3.10 *dissipation*—change over time of an excess initial condition to a time independent condition.

3.3.11 *equilibrated water*—potable water that has come to equilibrium with the current room conditions including temperature, chemistry, dissolved air, and stress state.

3.3.12 *linear theory (calculation method)*—a set of equations derived based on the assumption that the coefficient of volume compressibility (m_v) is constant.

3.3.13 *monofilament nylon screen*—thin porous synthetic woven filter fabric made of single untwisted filament nylon.

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.

3.3.14 *nonlinear theory (calculation method)*— a set of equations derived based on the assumption that the compression index (C_c) is constant.

3.3.15 *pore-water pressure factor, F (D)*—a dimensionless number equal to the change in total axial stress minus the base excess pressure divided by the change in total axial stress.

3.3.16 *pore-water pressure ratio, R_u (D)* —the base excess pressure divided by the total axial stress.

3.3.17 *steady state condition—in CRS testing* , a time independent strain distribution within the specimen that changes in average value as loading proceeds.

3.3.18 *transient condition—in CRS testing*, a time dependent variation in the strain distribution within the specimen that is created at the start of a CRS loading or unloading phase or when the strain rate changes and then decays with time to a steady state strain distribution.

4. Summary of Test Method

4.1 In this test method the specimen is constrained axially between two parallel, rigid platens and laterally such that the cross sectional area remains constant. Drainage is provided along one boundary (typically the top) and the fluid pressure is measured at the other sealed boundary (typically the base).

4.2 A back pressure is applied to saturate both the specimen and the base pressure measurement system.

4.3 The specimen is deformed axially at a constant rate while measuring the time, axial deformation, reaction force, and base pressure. A standard test includes one loading phase, one constant load phase, and one unloading phase. The constant load phase allows the base excess pressure to return to zero prior to unloading. More extensive tests can be performed by including more phases to obtain unload-reload cycle(s).

4.4 The rate of deformation is selected to produce a pore pressure ratio that is between 3 % and 15 % at the end of the loading phase.

4.5 During loading and unloading, the measurements are first evaluated in order to be sure transient effects are small. Steady state equations are then used to compute the one-dimensional stress versus strain relationship. During the loading phase, when base excess pressures are significant, the measurements are used to compute both the coefficient of consolidation and hydraulic conductivity throughout the test.

5. Significance and Use

5.1 Information concerning magnitude of compression and rate-of-consolidation of soil is essential in the design of earth structures and earth supported structures. The results of this test method may be used to analyze or estimate one-dimensional settlements, rates of settlement associated with the dissipation of excess pore-water pressure, and rates of fluid transport due to hydraulic gradients.

5.2 Strain Rate Effects:

5.2.1 It is recognized that the stress-strain results of consolidation tests are strain rate dependent. Strain rates are limited in this test method by specification of the pore-water pressure ratio. This specification provides comparable results

to the 100 % consolidation compression behavior obtained using Test Method [D2435](#).

5.2.2 Field strain rates vary greatly with time, depth below the loaded area, and radial distance from the loaded area. Field strain rates during consolidation processes are generally much slower than laboratory strain rates and cannot be accurately determined or predicted. For these reasons, it is not practical to replicate the field strain rates with the laboratory test strain rate.

5.3 This test method may not be used to measure the properties of partially saturated soils because the method requires the material to be back pressure saturated prior to consolidation.

5.4 *Test Interpretation Assumptions*— The equations used in this test method are based on the following assumptions:

5.4.1 The soil is saturated.

5.4.2 The soil is homogeneous.

5.4.3 The compressibility of the soil particles and water is negligible.

5.4.4 Flow of pore water occurs only in the vertical direction.

5.4.5 Darcy's law for flow through porous media applies.

5.4.6 The ratio of soil hydraulic conductivity to compressibility is constant throughout the specimen during the time interval between individual readings.

5.4.7 The compressibility of the base excess pressure measurement system is negligible compared to that of the soil.

5.5 Theoretical Solutions:

5.5.1 Solutions for constant rate of strain consolidation are available for both linear and nonlinear soil models.

5.5.1.1 The linear model assumes that the soil has a constant coefficient of volume compressibility (m_v). These equations are presented in [13.4](#).

5.5.1.2 The nonlinear model assumes that the soil has a constant compression index (C_c). These equations are presented in [Appendix X1](#).

NOTE 1—The base excess pressure measured at the boundary of the specimen is assumed equal to the maximum excess pore-water pressure in the specimen. The distribution of excess pore-water pressure throughout specimen is unknown. Each model predicts a different distribution. As the magnitude of the base excess pressure increases, the difference between the two model predictions increases.

5.5.2 The equations for the linear case are used for this test method. This test method limits the maximum time interval between readings and the maximum pore-water pressure ratio to values that yield similar results when using either theory. However, it is more precise to use the model that most closely matches the shape to the compression curve.

5.5.3 The nonlinear equations are presented in [Appendix X1](#) and their use is not considered a non-conformance with this test method.

5.5.4 The equations used in this test method apply only to steady state conditions. The transient strain distribution at the start of the test is insignificant after the pore-water pressure factor (F) exceeds 0.4. Data corresponding to lower pore-water pressure factors are not used in this test method.

5.6 This test method may be used to measure the compression behavior of free draining soils. For such materials, the base excess pressure will be zero and it will not be possible to compute the coefficient of consolidation or the hydraulic conductivity. In this case, the average effective axial stress is equal to the total stress and the results are independent of model.

5.7 The procedures presented in this test method assume a high permeability porous disk is used in the base pressure measurement system. Use of a low permeability porous disk or high-air entry (> 1 bar) disk will require modification of the equipment specifications and procedures. These modifications are beyond the scope of this test method and are not considered a non-conformance.

NOTE 2—The quality of the results produced by application of this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities. 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 in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Electronics*—This test method requires the use of electronic transducers along with the necessary apparatus to energize (power supply) and read (digital voltmeter) these transducers. In addition, automatic data acquisition will be necessary to achieve the required reading frequency.

6.1.1 Transducers are required to measure the base pressure (or base excess pressure), the back pressure, the axial deformation, and the axial force. Each transducer must meet the accuracy and capacity requirement specified for the particular measurement. The capacity of the force and pressure transducers will depend on the stiffness of the soil and magnitude of the back pressure.

6.1.2 A power supply is required to energize each transducer. The specific type of power supply will depend on the details of the individual transducers. Ideally, all the transducers will operate using the same power supply. Some data acquisition systems provide transducer power.

6.1.3 *Recording Devices:*

6.1.3.1 A digital voltmeter is useful in setting up tests and obtaining zero readings but the actual test requires far too many readings to be collected manually.

6.1.3.2 A data acquisition system is required to collect and store data during the test. The specifications (bit precision and voltage range) of the data acquisition system must be matched to the individual transducers in order to obtain the capacity necessary for the individual test and readability requirement for each device. These requirements will depend on the stiffness of the soil, the magnitude of the back pressure and the specific transducers.

6.1.3.3 A reading set must contain a measurement of base pressure (or base excess pressure), back pressure, axial force, axial deformation, excitation voltage, and elapsed time (or time). Time must be recorded to three significant digits of the reading interval. The reading set must be completed within 0.1 s if the measurements are made sequentially.

6.2 *Axial Loading Device*—This device may be a screw jack driven by an electric motor through a geared transmission, a hydraulic or pneumatic loading device, or any other compression device with sufficient force and deformation capacity. It must be able to apply a constant rate of deformation as well as maintain a constant force. During a single loading or unloading phase of the test, the deformation rate should be monotonic and should not vary by more than a factor of 5. The rate can gradually change due to the system stiffness but should not have more than $\pm 10\%$ cyclic variation. During a constant load phase of the test, the load must be maintained to $\pm 2\%$ of the target value. Vibration due to the operation of the loading device shall be considered sufficiently small when there are no visible ripples in a glass of water placed on the loading platform when the device is operating at the typical test speed.

6.3 *Axial Load Measuring Device*—This device may be a load ring, strain-gage 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 0.1 % of full range and a readability of at least 5 significant digits at the maximum load applied to the specimen.

6.3.1 For a constant rate-of-deformation to be transmitted from the axial loading device through the load-measuring device, it is important that the load-measuring device be relatively stiff. Most electronic load cells are sufficiently stiff, while load rings are typically not stiff (that is, they are compressible).

6.4 *Back Pressure Maintaining Device*— A device capable of applying and controlling the back pressure to within $\pm 2\%$ of the target back pressure throughout the test. This device may consist of a single unit or separate units connected to the top and bottom of the specimen. The device may be a pressurized hydraulic system or a partially filled reservoir with a gas/water interface. The bottom drainage lines shall be connected to the bottom drainage valve and shall be designed to minimize dead space in the lines. This valve, when open, shall permit the application of back pressure to the base of the specimen; when closed, it shall prevent the leakage of water from the specimen base and base pressure measuring device. However, if high air entry stones are used, then different means will be required to keep the system saturated.

6.4.1 A pressurized hydraulic system may be activated by deadweight acting on a piston, a gear driven piston with feedback control, a hydraulic regulator, or any other pressure-maintaining device capable of applying and controlling the back pressure within the specifications stated above. The system should be filled with equilibrated potable water.

6.4.2 A pressure reservoir partially filled with potable water and having a gas/water interface may be controlled by a precision pressure regulator. As much as practicable, the device should minimize the air diffusion into the back pressure water. All gas/water interfaces should be small in area relative to the area of the specimen and should be in reservoirs connected to the consolidometer by a length of small diameter tubing. Any water remaining in the reservoir should be flushed out after each test and replenished with equilibrated water.

6.4.3 The bottom drainage 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 3—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.

6.5 *Back Pressure Measuring Device*— A pressure transducer arranged to measure the applied back pressure shall have an accuracy of ± 0.25 % of full range, a capacity in excess of the applied back pressure, and a readability of at least 5 significant digits at the maximum applied axial stress.

6.6 *Base Pressure Measuring Device*— This device can be a differential pressure transducer referenced to the back pressure or a separate pressure transducer measuring pressure at the base of the specimen. If a separate pressure transducer is used, then its zero value must be adjusted to give the same pressure reading as the back pressure transducer at the end of back pressure saturation and with the bottom drainage valve open. The device shall be constructed and located such that the water pressure at the base of the specimen can be measured with negligible drainage from the specimen due to changes in pore-water pressure. To achieve this requirement, a very stiff electronic pressure transducer must be used. The compliance of all the assembled parts of the base pressure measurement system relative to the total volume of the specimen shall satisfy the following requirement:

$$(\Delta V/V)/\Delta u_m < 3.2 \times 10^{-6} \text{ m}^2/\text{kN} \quad (2.2 \times 10^{-5} \text{ in.}^2/\text{lbf}) \quad (1)$$

where:

ΔV = change in volume of the base measurement system due to a pressure change, mm³ (in.³),

V_{total} = total volume of the specimen, mm³ (in.³), and

Δu_m = change in base excess pressure, kPa (lbf/in.²).

NOTE 4—To meet this compressibility requirement, tubing between the specimen and the measuring device should be short and thick-walled with small bores. Thermoplastic, copper, and stainless steel tubing have been used successfully.

6.6.1 A differential pressure transducer shall have an accuracy of ± 0.25 % of full range, a capacity of at least 50 % of the maximum applied axial stress, a burst pressure that exceeds the applied back pressure plus 50 % of the maximum applied axial stress, and a readability of at least 5 significant digits at the maximum applied axial stress.

6.6.2 A separate pressure transducer shall have an accuracy of ± 0.25 % of full range, a capacity of at least the applied back pressure plus 50 % of the maximum applied axial stress, and a readability of at least 5 significant digits at the maximum applied axial stress.

NOTE 5—Typically, pressure transducers with a capacity of 1500 kPa (200 lbf/in.²) will meet these requirements.

6.7 *Deformation Measuring Device*—The axial deformation of the specimen is usually determined from the travel of the piston acting on the top platen of the specimen. The deformation measuring device may be a linear variable differential transformer (LVDT), extensometer, or other electronic measur-

ing device and shall have a range of at least 50 % of the initial height of the specimen. The device shall have an accuracy of at least 0.25 % of full range and a readability of at least 5 significant digits at the initial specimen height.

6.8 *Consolidometer*—This device must hold the specimen in a confinement ring to a rigid base, with porous disks on each face of the specimen and apply a back pressure to the specimen. A high air entry stone can be used in place of the porous disk on the bottom of the specimen provided that the high air entry stone is always kept saturated. The top platen should be rigid enough to uniformly distribute the load to the top stone. Any potentially submerged parts of the consolidometer shall be made of a material that is noncorrosive in relation to the soil or other parts of the consolidometer. The bottom of the confinement ring shall form a leak proof seal with the rigid base capable of withstanding internal pressures of 1500 kPa (200 lbf/in.²). The consolidometer shall be constructed such that placement of the confinement ring (with specimen) into the consolidometer will not entrap air at the base of the specimen. The axial loading device and back pressure maintaining device may be an integral part of the consolidometer. A schematic drawing of a typical CRS consolidometer is shown in Fig. 1.

6.8.1 The axial load piston seal must be designed so the variation in axial load due to friction does not exceed 0.05 % of the maximum axial load applied to the specimen.

NOTE 6—The use of two linear ball bushings to guide the piston is recommended to minimize friction and maintain alignment.

6.8.2 The confinement ring shall be made of a material that is noncorrosive in relation to the soil and pore fluid. The inner surface shall be polished and coated with a low-friction material (silicone/vacuum grease). The ring shall be stiff enough to prevent significant lateral deformation of the specimen throughout the test.

6.8.2.1 The thickness of the ring (for metallic rings) shall be no less than 3.2 mm ($\frac{1}{8}$ in.) for stresses up to 3000 kPa (400 lbf/in.²) or 6.4 mm ($\frac{1}{4}$ in.) for stresses up to 6000 kPa (800 lbf/in.²).

6.8.3 The test specimen dimensions shall conform to the following specifications.

6.8.3.1 The minimum diameter shall be about 50 mm (2.0 in.).

6.8.3.2 The minimum height shall be about 20 mm (0.75 in.), but shall not be less than 10 times the maximum particle diameter as determined in accordance with Test Method D6913. If, after completion of a test, it is found based on visual observation that oversize (> 2 mm; 0.075 in.) particles are present, indicate this information in the report of test data.

6.8.3.3 The maximum height-to-diameter ratio shall be 0.5.

6.9 *Porous Disks*—The porous disks at the top and bottom of the specimen shall be made of silicon carbide, aluminum oxide, or other material of similar stiffness that is not corroded by the specimen or pore fluid. The disks shall have plane and smooth surfaces and be free of cracks, chips, and nonuniformities. They shall be checked regularly to ensure that they are not clogged. For fine-grained soils, fine-grade porous disks shall be used. The disks shall be fine enough that the soil will not penetrate into their pores, but have sufficient hydraulic

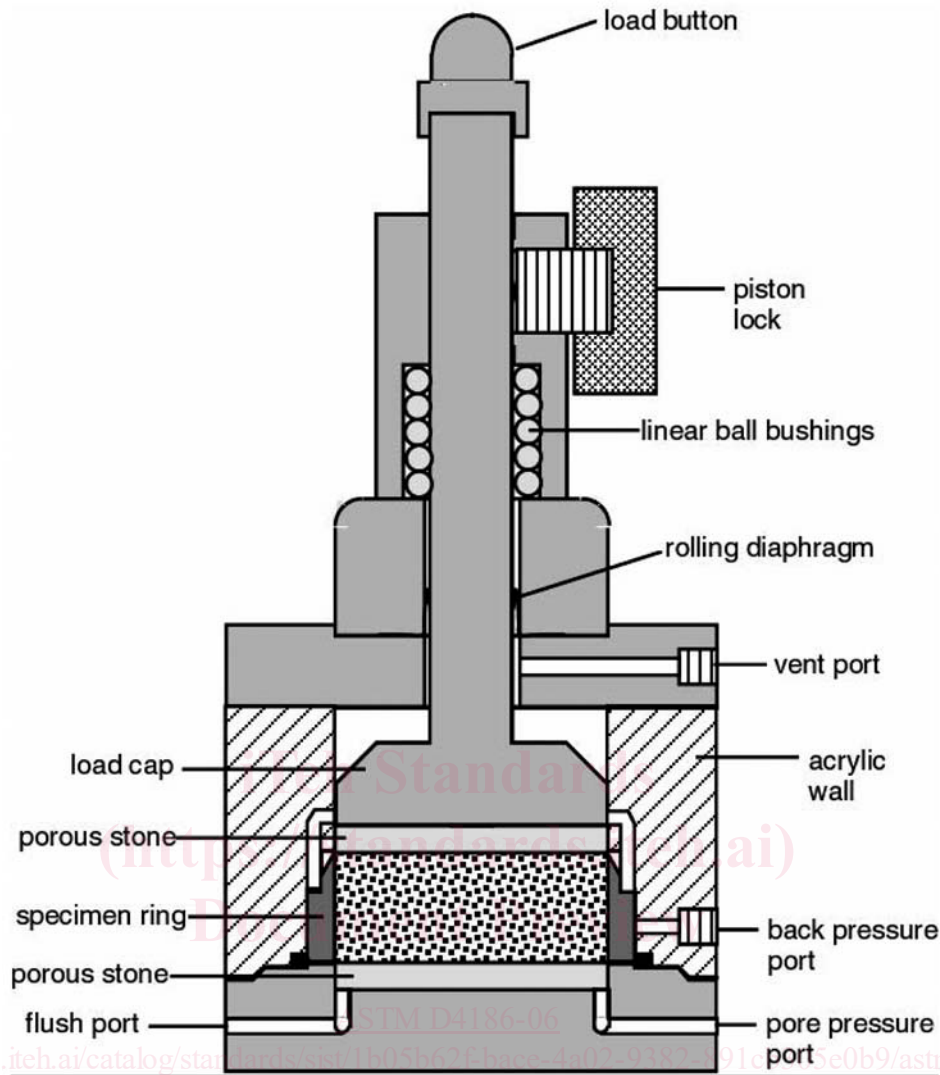


FIG. 1 Example of a CRS Consolidometer

conductivity so as not to impede the flow of water from the specimen. (Exact criteria have not been established but the disc should be at least 10 times more permeable than the soil.)

6.9.1 The diameter of the top disk shall be 0.2 to 0.5 mm (0.01 to 0.02 in.) less than the inside diameter of the confinement ring.

6.9.2 The surfaces of the disks, as well as the bearing surfaces in contact with them, shall be flat and rigid enough to prevent breakage of these disks.

6.9.3 The disks shall be regularly cleaned by ultrasonification or boiling and brushing and checked routinely for signs of clogging. Disks will last longer if stored in water between testing.

6.10 *Filter Screen*—To prevent intrusion of material into the pores of the porous disk, a filter screen must be placed between the top porous disk and the specimen. The screen shall have negligibly small hydraulic impedance. A monofilament-nylon filter screen or Whatman No. 54 filter paper may be used for the top of the specimen.

NOTE 7—Filters should be cut to approximately the same shape as the cross section of the test specimen. Soak the filter paper, if used, in a container of water to allow it to equilibrate before testing.

6.11 *Balances*—The balance shall be suitable for determining the mass of the specimen and shall be selected as discussed in Specification D4753. The mass of specimens shall be determined to at least four significant digits.

6.12 *Sample Extruder*—When the material being tested is contained in a sampling tube, the soil shall be removed from the sampling tube with an extruder. The sample extruder shall be capable of extruding the soil from the sampling tube in the same direction of travel that the soil entered the tube and with minimum disturbance of the soil. If the soil is not extruded vertically, care should be taken to avoid bending stresses on the soil due to gravity. Conditions at the time of soil extrusion may dictate the direction of removal, but the principle concern is to avoid causing further sample disturbance.

NOTE 8—Removing the soil from a short section of the tube will reduce the amount of force required to extrude the sample and hence cause less