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# Standard Test Method for ~~Measuring the Soil-Geotextile System Clogging Potential by the Gradient Ratio~~Measuring the Filtration Compatibility of Soil-Geotextile Systems[1]

This standard is issued under the fixed designation D5101; 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

~~1.1This test method covers a performance test applicable for determining the soil-geotextile system permeability and clogging behavior for cohesionless soils under unidirectional flow conditions.~~

~~1.2The values stated in SI units are to be regarded as standard. The values in parentheses are for information only.~~

~~1.3~~

1.1 This test method covers performance tests applicable for determining the compatibility of geotextiles with various types of water-saturated soils under unidirectional flow conditions.

1.2 Two evaluation methods may be used to investigate soil – geotextile filtration behavior, depending on the soil type:

1.2.1 For soils with a plasticity index lower than 5, the systems compatibility shall be evaluated per this standard.

1.2.2 For soils with a plasticity index of 5 or more, it is recommended to use ASTM D5567 ('HCR', Hydraulic Conductivity Ratio) instead of this test method.

1.2.3 If the plasticity index of the soil is close to 5, the involved parties shall agree on the selection of the appropriate method prior to conducting the test. This task may require comparison of the permeability of the soil-geotextile system to the detection limits of the HCR and Gradient Ratio Test (GRT) test apparatus being used.



1.3 The values stated in SI units are to be regarded as standard. The values in parentheses are for information only.

1.4 *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]



D123 Terminology Relating to Textiles
D422 Test Method for Particle-Size Analysis of Soils
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$(600 kN-m/m$^3$))
D737 Test Method for Air Permeability of Textile Fabrics
D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer
D1587 Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D4220 Practices for Preserving and Transporting Soil Samples
D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D4354 Practice for Sampling of Geosynthetics and Rolled Erosion Control Products(RECPs) for Testing
D4439 ~~Terminology for Geosynthetics~~ Terminology for Geosynthetics
D4491 Test Methods for Water Permeability of Geotextiles by Permittivity
D4647 Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test

[1] This test method is under the jurisdiction of ASTM Committee D35 on Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

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[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.

D4751 Test Methods for Determining Apparent Opening Size of a Geotextile
D5084 Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
D5101 Test Method for Measuring the Filtration Compatibility of Soil-Geotextile Systems
D5567 Test Method for Hydraulic Conductivity Ratio (HCR) Testing of Soil/Geotextile Systems

## 3. Terminology

3.1 *Definitions:*

3.1.1 *clogging potential*clogging, *n—in geotextiles*, the tendency for a given fabric to lose permeability due to soil particles that have either lodged in the fabric openings or have built up a restrictive layer on the surface of the fabric. , the tendency for a given geotextile to lose permeability due to soil particles that have either become embedded in the fabric openings or have built up on the geotextile surface to form a layer with lower permeability than that of the bulk soil specimen.

3.1.2 *geotextile*piping, *n*—a permeable geosynthetic comprised solely of textiles. —the tendency of the geotextile to let a quantity of soil pass through its plane that may potentially lead to stability concerns in the soil or internal clogging of the geotextile.

3.1.3 *gradient ratio*, *n—in geotextiles*, the ratio of the hydraulic gradient throughacross a soil-geotextile systeminterface to the hydraulic gradient through the soil alone.

3.1.4 *hydraulic gradient, i, s (D)*—the loss of hydraulic head per unit distance of flow, dH/dL.

3.1.5 For definitions of other textile terms, refer to Terminology D123. For definitions of other terms related to geotextiles, refer to Terminology D4439 and Terminology D653.

3.2 *Symbols and Acronyms:*

3.2.1 $CO_2$—the chemical formula for carbon dioxide gas.

3.2.2*CHD*—the acronym for constant head device.

3.2.2 *GRT*—the acronym for Gradient Ratio Test

3.2.3 *HCR*—the acronym for Hydraulic Conductivity Ratio

## 4. Summary of Test Method

4.1This test method requires setting up a cylindrical, clear plastic permeameter (see Fig. 1 and Fig. 2) with a geotextile and soil, and passing water through this system by applying various differential heads. Measurements of differential heads and flow rates are taken at different time intervals to determine hydraulic gradients. The following test procedure describes equipment needed, the testing procedures, and calculations.

4.1 This method is intended for use in the observation of change in the permeability of a soil-geotextile interface over time under a range of applied hydraulic gradients. At the end of the test, the weight of soil passing through the geotextile is measured. The distribution of hydraulic gradients in the vicinity of the soil-geotextile interface is also observed.



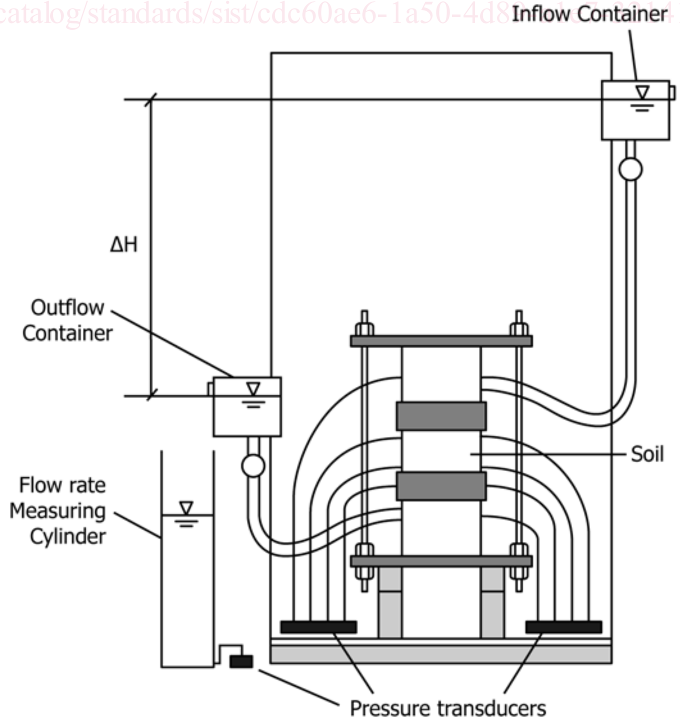


**FIG. 1 Gradient Ratio Test Setup**

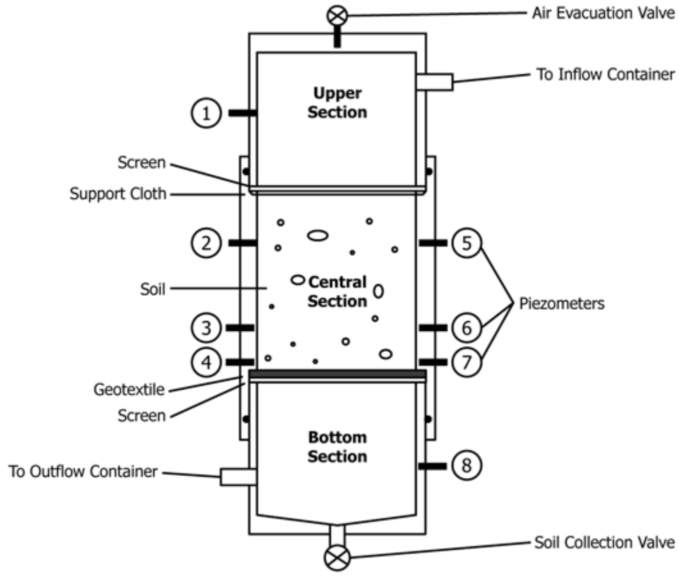


FIG. 2 Permeameter Section

## 5. Significance and Use

~~5.1This test method is recommended for evaluating the performance of various soil-geotextile systems under controlled test conditions. Gradient ratio values obtained may be plotted and used as an indication of the soil-geotextile system clogging potential and permeability. This test method is not appropriate for initial comparison or acceptance testing of various geotextiles. The test method is intended to evaluate geotextile performance with specific on-site soils. It is improper to utilize the test results for job specifications or manufacturers' certifications.~~

~~5.2It is important to note the changes in gradient ratio values with time versus the different system hydraulic gradients, and the changes in the rate of flow through the system (see Section 11 and Annex A1.).~~

5.1 This test method is recommended for the evaluation of the performance of water-saturated soil-geotextile systems under unidirectional flow conditions. The results obtained may be used as an indication of the compatibility of the soil-geotextile system with respect to both particle retention and flow capacity.

5.2 This test method is intended to evaluate the performance of specific on-site soils and geotextiles at the design stage of a project, or to provide qualitative data that may help identify causes of failure (that is, clogging, particle loss). It is not appropriate for acceptance testing of geotextiles. It is also improper to utilize the results from this test for job specifications or manufacturers' certifications.

5.3 This test method is intended for site-specific investigation therefore is not an index property of the geotextile, and thus is not intended to be requested of the manufacturer or supplier of the geotextile.



## 6. Apparatus and Supplies

6.1 *Soil-Geotextile Permeameter*~~—(three-piece unit) equipped with support stand, soil-geotextile support screen, piping barriers (caulk), clamping brackets, and plastic tubing (see~~ —A typical permeameter will consist of three units, shown in Fig. 1, set-up on a frame incorporating the other components such as the structure shown in Fig. 2~~). Both 100-mm (4-in.) and 150-mm (6-in.) diameter permeameters are described.~~ . The lower unit will contain a soil-geotextile support screen and an outflow reservoir that permits collection of the particles passing through the geotextile during different stages of the test. The middle unit will hold the soil specimen and should be equipped with a piping barrier (i.e., caulk) along the interface between the geotextile and the permeameter walls. The geotextile support screen opening size shall be greater than ten times the measured AOS of the geotextile. The upper unit will permit application of a constant head boundary condition to the top of the specimen. The permeameter should also be equipped with a support stand, clamping brackets, and plastic tubing to connect with an external pressure head monitoring system.

NOTE 1—the diameter of the permeameter shall be at least 10 x d100, where d100 is the largest particle of soil placed in the permeameter. In the case soils with particles larger than 16 mm (mesh #5/8") were to be evaluated, only the fraction smaller than 16 mm shall be used for testing.

NOTE 2—Some permeameters allow application of a normal load on the soil-geotextile interface. If so, the loading system shall be designed in such a way that it will not influence the system's hydraulic behavior.

6.2 *Two Constant Water Head Devices*, one mounted on a jack stand (adjustable) and one stationary (Fig. 3).

6.3 *Soil Leveling Device* (Fig. 4).

6.4 *Manometer Board*, of parallel glass tubes and measuring rulers.

6.5 *Two Soil Support Screens*, of approximately 5 mm (No. 4) mesh.

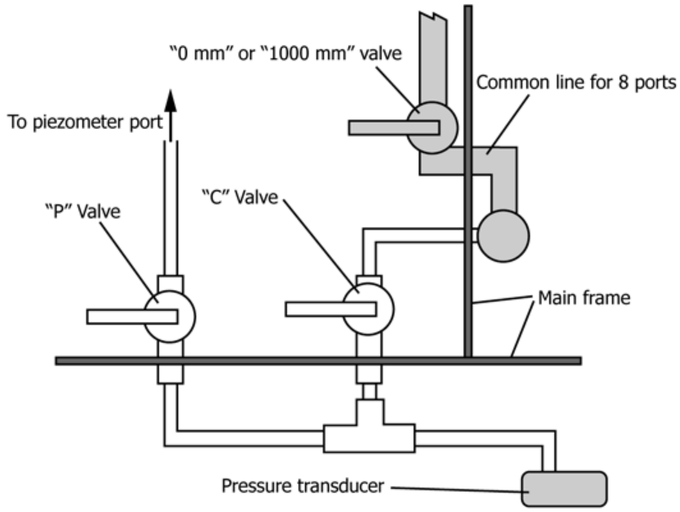


FIG. 3 Individual Setup of Calibration System for Each Pressure Transducer

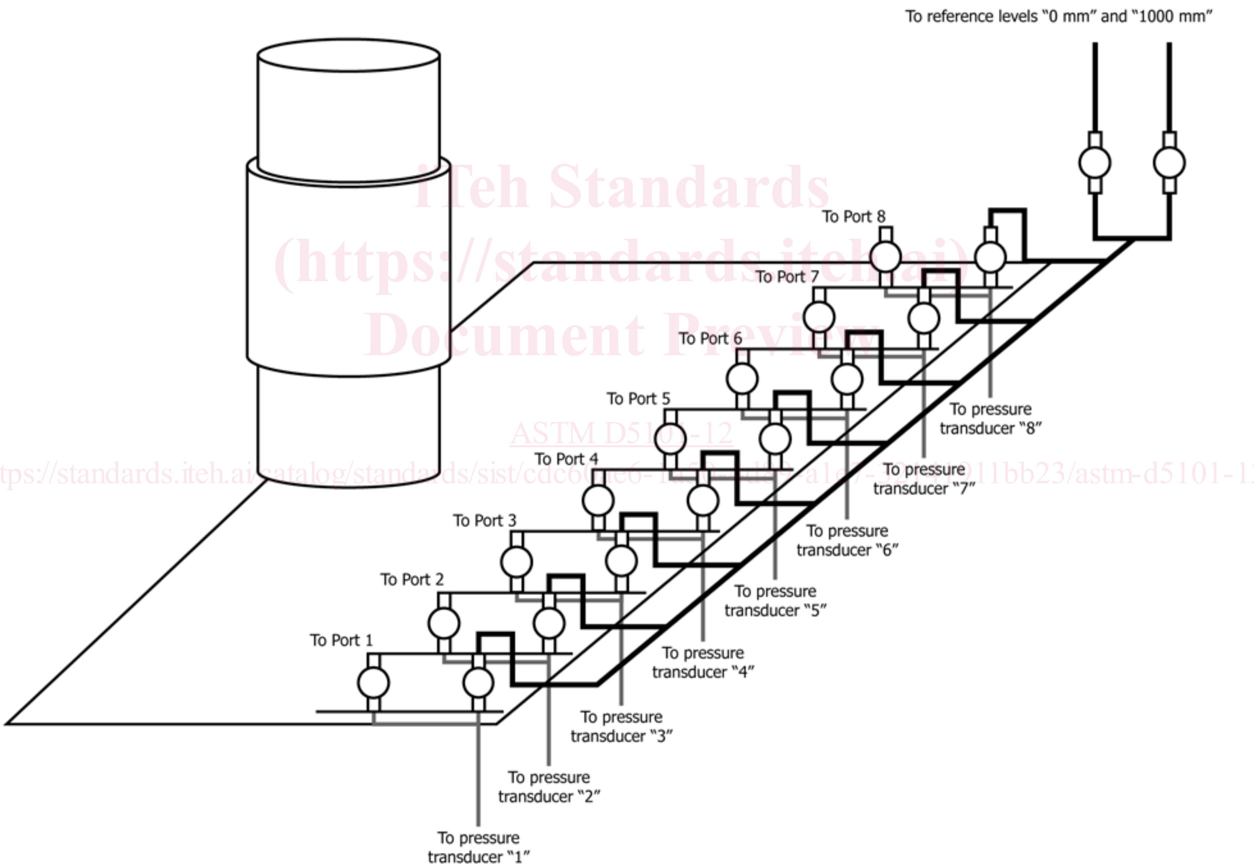




FIG. 4 General Setup of Calibration Board

6.6 *Soil Support Cloth*, of 150 µm (No. 100) mesh, or equivalent geotextile.
6.7 *Thermometer* (0 to 50 ± 1°C).
6.8 *Graduated Cylinder*, 100 ± 1 $cm^3$ capacity.
6.9 *Stopwatch*.
6.10 *Balance*, or scale of at least 2-kg capacity and accurate to ±1 g.
6.11 *Carbon Dioxide*, ($CO_2$), gas supply and regulator.
6.12 *Geotextile*.
6.13 *Water Recirculation System*.
6.14 *Water Dearing System*~~, with a capacity of approximately 1700 L/day (500 gal/day).~~ , with a sufficient capacity to avoid

recirculation of water in the test, which may replace fine particles that have washed out of the specimen. Typical capacity: 1700 L/day (500 gal/day).

6.15 *Algae Inhibitor*, or micro screen.

6.16 ~~*150-μm Mesh Screen, (No. 100)*, or equivalent geotextile for manometer ports.~~ Computer, with data acquisition card.

6.17 ~~*Soil Sample Splitter (optional)*.~~ Pressure Transducers. with a precision of at least 1 mm of water head, used for measurements of the head distribution in the specimen during water flow. Fig. 3 describes the plumbing connections for each individual pressure transducer.

6.18 ~~*Pan*, for drying soil.~~ Pressure Transducer Calibration System, allowing the pressure transducers to be connected either to the permeameter ports or to one or two independent containers adjustable to different water levels. It should be installed as close as possible to the permeameter. This system can consist of a set of 18 ball valves, two (2) reference water reservoirs (that is, large open tubes), and adequate tubing for connections, as shown in Fig. 4.

~~6.19 *Mortar and Pestle*, for pulverizing soil.~~

~~6.20*Wooden rod*, 20-mm (¾ – in.) diameter by 150 mm (6in.) long.~~ Funnel, with a internal diameter of about 6mm or as needed to facilitate soil placement in the apparatus.

## 7. Sampling and Test Specimens

7.1 *Lot Sample and Laboratory Sample*~~—Take~~—Obtain a lot sample and laboratory samples as directed in Practice D4354~~. For laboratory samples, take a full width swatch of geotextile from each roll of material in the lot sample at least 1 m (3 ft) long cut from the end of the roll after discarding the first metre of material from the outside of the roll.~~ .

7.2 ~~*Test Specimen*—Cut one circular specimen from each swatch in the laboratory sample with the specimen having a diameter of 110 mm (4.33 in.) or 165 mm (6.50 in.). Take the specimen from the center of the swatch.~~ Soil to be tested for gradient ratio—Select approximately 6 to 8 liters of representative soil, with a maximum particle size of 10 mm. If the natural soil to be tested contains large gravel- or boulder-size particles, these particles should be removed from the specimen using a 10 mm (3/8 in.) or 16 mm (5/8 in.) sieve, depending on the diameter of the cell used (100 or 150 mm).

## 8. Conditioning

8.1 *Test Water Preparation*:

~~8.1.1Test water should be maintained at room temperature about 16 to 27°C (60 to 80°F), and deaired to a dissolved oxygen content of 6 ppm or less before introducing it to permeameter system. This will reduce or eliminate the problems associated with air bubbles forming within the test apparatus.~~

8.1.1 Test water should be maintained between 16 and 27°C (60 to 80°F) and deaired to a dissolved oxygen content of 2 ppm before being introduced into the apparatus. In addition, the deaired water shall be stored at a temperature within ± 2°C of the tested soil/geotextile system.

NOTE 3—Use of deaired water is essential to reduce or eliminate problems associated with air bubbles forming within the test apparatus or in the soil. The dissolved air content will be lower, and chances to observe air clogging will be decreased

8.1.2 An algae inhibitor or micro screen should be used to eliminate any algae buildup in the system.

~~8.2*Specimen Conditions*:~~

~~8.2.1Condition the specimen by soaking it in a container of deaired water for a period of 2 h. Dry the surface of the specimen by blotting prior to inserting in the permeameter.~~

## 9. Procedure

9.1 ~~*Preparation of Apparatus*~~Preparation of the test:

~~9.1.1Thoroughly clean and dry permeameter sections.~~

~~9.1.2Close all valves and cover the inside openings of all manometer ports with fine wire mesh or lightweight nonwoven fabric (the equivalent of No. 100 mesh).~~

~~9.1.3Lubricate all O-ring gaskets.~~

9.1.1 *Determination of the soils properties*:

9.1.1.1 Measure the following properties of the soil under investigation:

Particle size distribution per Method D422

Plasticity index per Test Method D4318D4318, when applicable

9.1.1.2 For silty soils with plasticity indices in the vicinity of 5, estimate the permeability of the soil that is, using the particle size distribution determined in 9.1.1.1) and compare this value to the detection limit of the apparatus. If the detection limit of the apparatus is close to the soils permeability, additional investigations shall be considered to determine whether GRT or HCR shall be used.

9.1.1.3 The soil installation technique is determined as follows:

For silty soils, with permeabilities less than 10-3 cm/s, use of the 'slurry' deposition technique is preferred as discussed in Section 9.4.2;

For sandy soils, with permeabilities greater than 10-3 cm/s, use of the 'water pluviation' technique is preferred as discussed in Section 9.4.3.

For well graded soils or unstable soils that easily segregate, the dry method presented in section 9.4.4 is preferred.

9.1.2 *Preparation of the Apparatus*:

9.1.2.1 Thoroughly clean and dry all permeameter sections.

9.1.2.2 Close all valves and cover the inside openings of all manometer ports with fine wire mesh or lightweight nonwoven fabric (having an equivalent percent open area to that of a No. 100 mesh sieve).

9.1.2.3 Lubricate all O-ring gaskets.

9.2 *Permeameter Preassembly*:

~~9.2.1Stand center section of the permeameter on end and place a soil support cloth 110 mm (4.33 in.) or 165 mm (6.5 in.) in diameter on recessed permeameter flanges.~~

~~9.2.2Insert the support screen 110 mm (4.33 in.) or 165 mm (6.5 in.) in diameter on top of the support cloth with the mesh side against the cloth.~~

~~9.2.3Align and insert top section of the permeameter into center section and press until there is a tight fit to secure the support cloth and screen in place. Ensure that all gasket edges secure against the support cloth, support bracket, and between the center and top permeameter sections.~~

~~9.2.4Invert and place permeameter into holding stand.~~

9.2.1 Stand center section of the permeameter on its bottom end and place the geotextile specimen on the recessed permeameter flanges.

9.2.2 Insert the support screen on top of the geotextile with the mesh side down.

9.2.3 Align and insert the bottom section of the permeameter onto the center section and press until there is a tight fit that secures the geotextile and support screen in place. Ensure that all gasket edges are secure against the geotextile, support bracket, and the interface between the center and top permeameter sections.

9.2.4 Place permeameter into holding stand.

9.3 *Process Soil*:

~~The test is to be performed on −10 mm (−⅜ in.) material. The material passing the 10 mm (⅜ in.) and retained on the No. 10 sieve is subject to a second round of grinding to ensure that the sample has been broken down into individual grains.~~

~~9.3.1Thoroughly air dry the soil sample as received from the field. This shall be done for a minimum of three days. Grind the sample in a mortar with a rubber-tipped pestle (or in some other way that does not cause breakdown of individual grains), to reduce the particle size to a maximum of 10 mm (⅜ in.). Select a representative sample of the amount required, approximately 1350 g (or 3000 g for the 150-mm (6-in.) diameter), to perform the test by the method of quartering or by the use of a soil splitter.~~

~~9.3.2Select that portion of the air-dried sample selected for purpose of tests and record the mass as the mass of the total test sample uncorrected for hygroscopic moisture. Separate the test sample by sieving with a 2-mm (No. 10) sieve. Grind that fraction retained on the 2-mm (No. 10) sieve in a mortar with a rubber-covered pestle until the aggregations of soil particles are broken up into the separate grains.~~

~~9.3.3Mix the fractions passing the 2-mm (No. 10) sieve along with the portion that was retained on the 2-mm (No. 10) sieve to form the test soil. All particles larger than 10 mm (⅜ in.) should be eliminated.~~



The test is to be performed on a soil specimen having particle sizes which are <10 mm (<⅜ in.) in size. The material passing the 10 mm (⅜ in.) and retained on the No. 10 sieve is subject to a second round of grinding. However, this second grinding shall be done gently to ensure that agglomerates of particles will be maintained, as they reflect the field condition.

Select a representative sample of the amount required, approximately 1500 g, to perform the test by the method of quartering or by the use of a soil splitter.

9.4 *Soil Placement*~~—The following procedures offer two options to the user. The first is a "standard" placement while the second is a "field condition" placement. The placement procedure is a critical aspect of the test and may significantly influence the test results.~~

~~9.4.1*Standard Placement Method*:~~

~~9.4.1.1Weigh out approximately 1350 g of air–dried processed soil (or 3000 g for the 150-mm (6-in.) diameter).~~

~~9.4.1.2Place air-dried processed soil above the support cloth to a depth of 103 mm (4.12 in.). The final depth of soil after settlement will be approximately 100 mm (4 in.). The soil should be placed in 25-mm (1-in.) to 40-mm (1½-in.) layers, making sure that no voids exist along the permeameter walls at manometer ports, or the caulk piping barriers. The soil shall be placed carefully into the permeameter with a scoop or appropriate tool with a maximum drop of the soil no greater than 25mm (1 in.). Consolidation of each layer shall consist of tapping the side of the permeameter six times with a wooden rod, 20 mm (¾ in.) by 150 mm (6 in.) in diameter.~~

~~9.4.1.3When the level of the soil in the permeameter reaches a depth of 100 mm (4 in.), insert the soil leveling device (Fig. 4), with the notch down, on the top edges of the permeameter. Continue placing soil and rotating the leveling device until the total soil height of 103 mm (4.12 in.) is reached.~~

~~9.4.1.4Remove the soil leveler and any excess soil. Determine the mass of the soil in the permeameter for unit weight calculations.~~

~~NOTE1—The standard soil placement procedure results in a relatively loose soil condition and is conservative for many applications. If a density approximating actual field soil conditions is desirable, the field condition procedure should be used. It should be recognized, however, that predicting field~~