Designation: D5101 − 12 (Reapproved 2017)

Standard Test Method for 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

1.1 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 Test Method 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D422 Test Method for Particle-Size Analysis of Soils (Withdrawn 2016)[3]

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

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

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, n—in geotextiles*, 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

[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.

[3] The last approved version of this historical standard is referenced on www.astm.org.

on the geotextile surface to form a layer with lower permeability than that of the bulk soil specimen.

3.1.2 *piping, n*—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*, ratio of the hydraulic gradient across a soil-geotextile interface 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 *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

4.1 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.

5. Significance and Use

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 (for example, 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*—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. 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 (for example, 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.

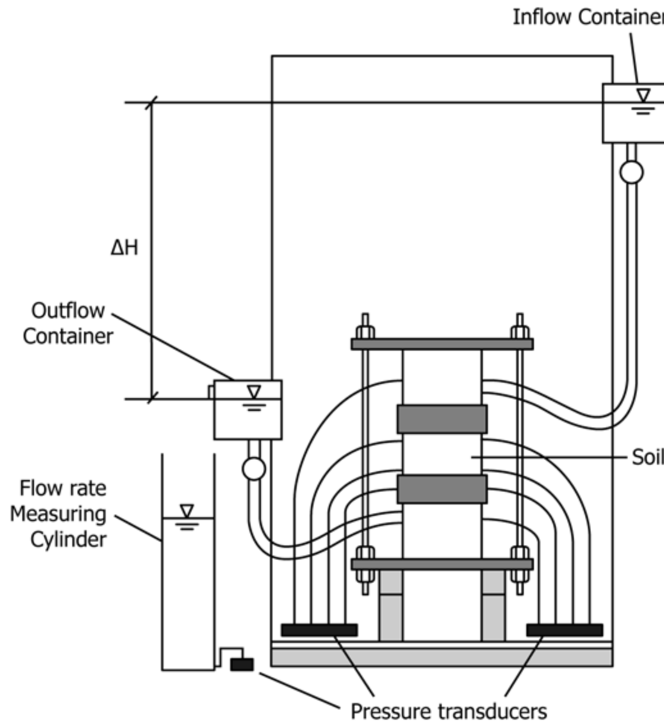

FIG. 1 Gradient Ratio Test Setup

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 #⅝ in.) 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.

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.

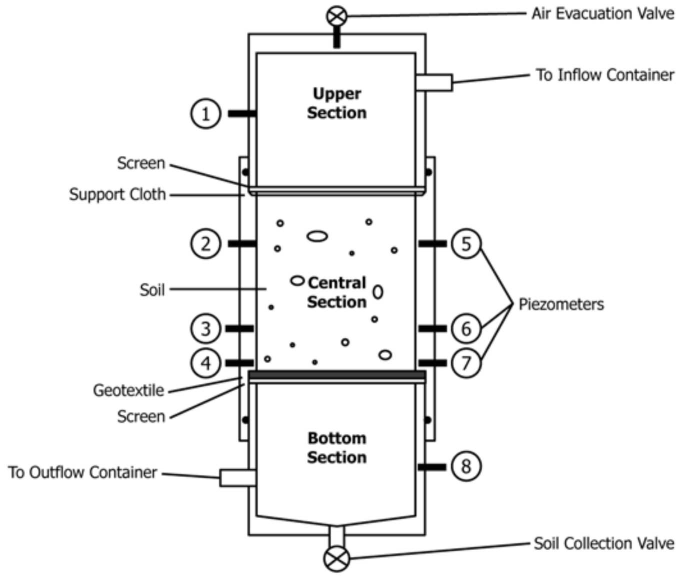

FIG. 2 Permeameter Section

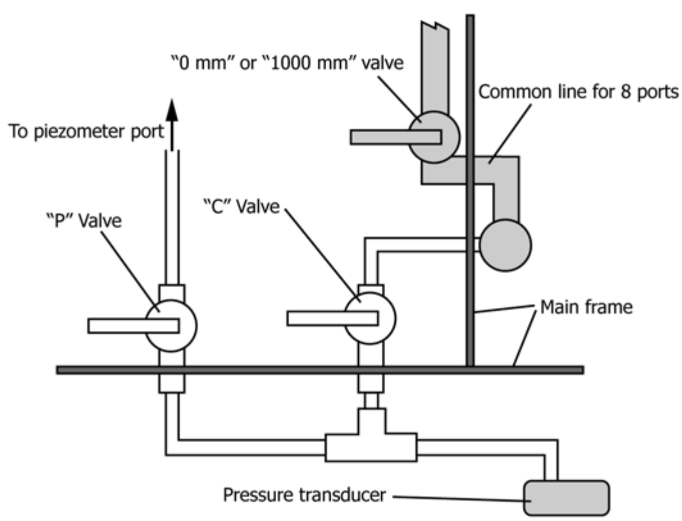

FIG. 3 Individual Setup of Calibration System for Each Pressure Transducer

6.12 *Geotextile.*

6.13 *Water Recirculation System.*

6.14 *Water Deairing System,* 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 *Computer,* with data acquisition card.

6.17 *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 *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 *Funnel,* with a internal diameter of about 6 mm or as needed to facilitate soil placement in the apparatus.

7. Sampling and Test Specimens

7.1 *Lot Sample and Laboratory Sample*—Obtain a lot sample and laboratory samples as directed in Practice D4354.

7.2 *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 (⅜-in.) or 16-mm (⅝-in.) sieve, depending on the diameter of the cell used (100 or 150 mm).

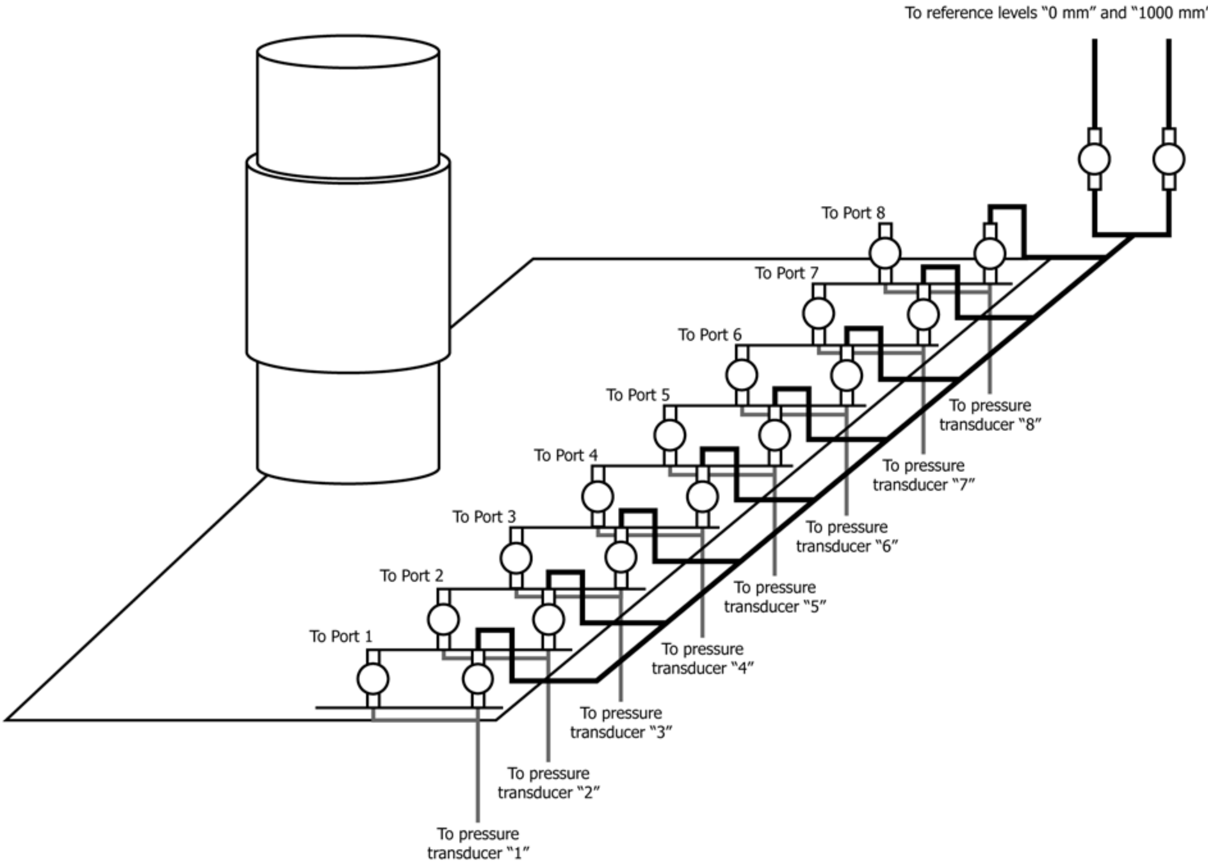

FIG. 4 General Setup of Calibration Board

8. Conditioning

8.1 *Test Water Preparation:*

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.

9. Procedure

9.1 *Preparation of the Test:*

9.1.1 *Determination of the Soil's Properties:*

9.1.1.1 Measure the following properties of the soil under investigation:

(1) Particle size distribution per Test Method D422.

(2) Plasticity index per Test Method D4318, 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 soil's 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:

(1) For silty soils, with permeabilities less than 10^{-3} cm/s, use of the 'slurry' deposition technique is preferred as discussed in 9.4.3.

(2) For sandy soils, with permeabilities greater than 10^{-3} cm⁄s, use of the 'water pluviation' technique is preferred as discussed in 9.4.2.

(3) For well-graded soils or unstable soils that easily segregate, the dry method presented in 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:*

9.2.1 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 a soil specimen having particle sizes which are <10 mm (<3⁄8 in.) in size. The material passing the 10 mm (3⁄8 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*—Soil placement shall be conducted keeping in mind that the following goals have to be achieved:

(1) Uniformity of the soil from the top to the bottom of the test specimen at the beginning of the test. Particular attention shall be given to the soil located at the interface.

(2) Saturation of the system at the beginning of the test.

9.4.1 The placement procedure is a critical aspect of the test and may significantly influence the test results. Judgment shall be used to determine the appropriate placement technique given the field conditions to be reproduced. The following procedures are proposed for informational purposes only. The first two procedures are wet methods and the third procedure is a dry method. Saturation of the device is related to the specific method as detailed in the procedures. Any other procedure can be considered, although it shall be detailed in the test report.

9.4.2 *Soil Placement by Water Pluviation Technique*—This method is to be used for soils having permeability values greater than 10^{-3} cm/s (that is, sandy soils, easily wetted). For finer soils, use the slurry deposition technique described in 9.4.3.

In this method, the piezometer lines are plugged before soil placement, and the apparatus is flooded as shown in Fig. 5. See comments on Fig. 5. Also, the geotextile to be tested is installed first and the soil is poured on top of it.

9.4.2.1 Weigh out approximately 1500 g of oven-dried processed soil in a pan.

9.4.2.2 Use the funnel described in 6.19 to pour the soil in the permeameter, in 25 mm-thick lifts. The water level shall be periodically verified to ensure that the soil particles will always fall into 5 to 10 mm of water. The bottom of the funnel should remain close to the water surface during soil deposition, to avoid air segregation of the soil (see Fig. 5).

9.4.2.3 When the soil level is about 2 mm below a piezometer port, use this port to add some water in the permeameter. Stop filling with this port when the water has reached a level of 5 to 10 mm over the port itself.

9.4.2.4 After each lift of 25 mm of soil poured into the permeameter, gently tap on the permeameter wall with a pestle to level the soil until reaching the desired lift thickness.

9.4.2.5 When the soil level has exceeded the support cloth level after the last soil lift, gently use a vacuum to remove the excessive soil until the upper surface is even with the upper flange. During this task, the water level shall be increased so that the soil always remains submerged.

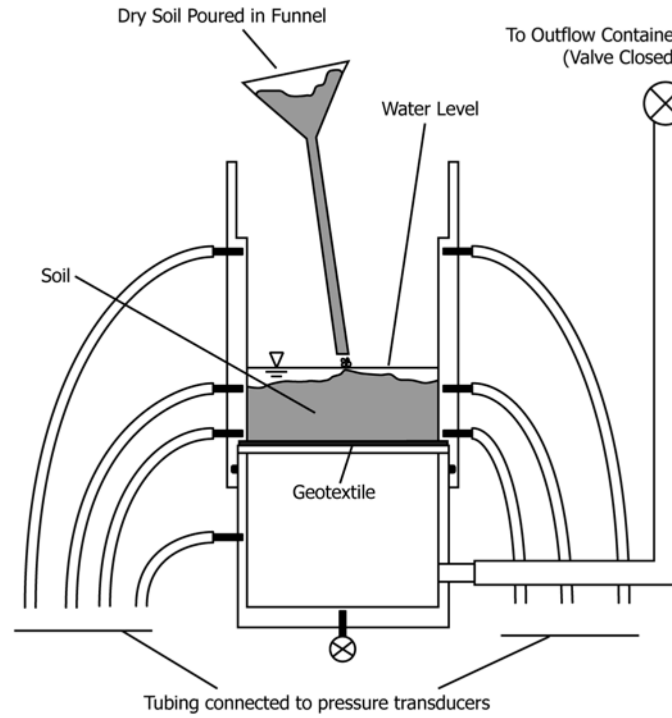

FIG. 5 Water Pluviation Technique

9.4.3 *Soil Placement by Slurry Deposition Technique*—This method is to be used for silty or low permeability soils (that is, nonplastic with permeability up to 10^{-3} cm/s). As with 9.4.2, the apparatus is flooded to the level shown in Fig. 6 before placing the soil on top of the geotextile.

9.4.3.1 Place approximately 1500 g of soil in a pan. Add the minimum quantity of water required to reach a slurry-like consistency (see Note 4). Let the soil rest in a large plate

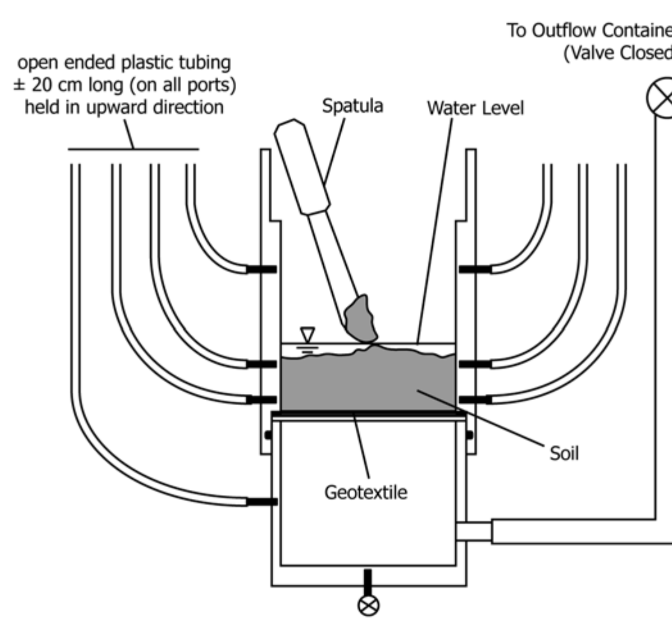

FIG. 6 Slurry Deposition Technique

covered with plastic for 24 hours to permit settling and hydration of any clay minerals. After settling, the thickness of the sedimented slurry shall be in the range of 15 to 25 mm.

9.4.3.2 Disconnect the piezometer lines from the permeameter ports, and plug a 20-cm long tube of the same inside diameter as the piezometer lines into each port.

9.4.3.3 After permitting 24 hours for settlement of the slurry in the first soil lift, add small quantities of slurry into the permeameter using a spatula without leveling the soil surface. Ensure that at least 2 to 5 mm of water remains on top of the soil slurry at all times to avoid desiccation (Fig. 6). The slurry present in the pan shall also be protected from desiccation in the same manner.

9.4.3.4 Repeat step 9.4.3.3 by placing the slurry in four (4) successive lifts with thicknesses of 25 to 30 mm, permitting a rest period of two hours between placement of each lift.

NOTE 4—It is recommended to that the heights of the soil lifts correspond with the locations of the ports at 25 and 75 mm.

(1) After installation of the fourth lift of soil, let it rest for two hours and remove any excess soil using a vacuum (always maintain at least 2 to 5 mm of water on top of the soils surface).

9.4.4 *Soil Placement by Dry Method*—This method is to be used for well graded soil, especially if the soil contains gravel, is unstable and can easily segregate, or both. In this case, the soil is installed on a support cloth in the apparatus reversed upside down in dry conditions. The geotextile is then installed on top of the dry soil, and the apparatus reversed upside down before proceeding with the saturation and the test.

9.4.4.1 Weigh out a sufficient quantity (typically ±1350 g) of air-dried processed soil.

9.4.4.2 Place 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 25 mm (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.) in diameter by 150 mm (6 in.) in length.

9.4.4.3 When 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.

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

9.4.5 *Saturating the Soil-Geotextile System:*

9.4.5.1 Open the top vent valve, and close off the permeameter water outlet hose.

9.4.5.2 Backfill permeameter with water through the outflow CHD until the water level is approximately 10 mm (⅜ in.) below the open manometer port 6. Stop waterflow into the permeameter by clamping off the hose between outflow CHD and permeameter.

9.4.5.3 Expel oxygen and other gases in the permeameter and soil system by (*1*) attaching a carbon dioxide (CO_2) line to manometer port 6, and (*2*) regulating the gas flow at 2 L/min and purging the system for 5 min.

9.4.5.4 After 5 min of gas saturation, seal off (plug) the open end of each manometer tube (1 through 5) and continue to purge the system with CO_2 for an additional 5 min with only the top vent valve open.

9.4.5.5 Remove the CO_2 gas line and replace the No. 6 manometer hose. Remove the seals (plugs or clamps) from all manometer tubes (1 through 5).

9.4.5.6 Loosen the hose clamp between the outflow CHD and permeameter, and fill the soil section of the permeameter with water. Filling is accomplished by adding water to and raising the level on outflow CHD slowly. Start with outflow CHD at 25 mm (1 in.) above the geotextile level and raise 25 mm (1 in.) every 30 min until water level is 50 mm (2 in.) above the top support screen bracket. This slow saturating process is necessary to prevent air pockets or internal soil movement during loading.

9.4.5.7 Clamp the hose between outflow CHD and permeameter to prevent flow. Continue to raise the water level in the permeameter by filling from the top inlet through the inflow CHD. The outflow CHD should be clamped so that no flow occurs through the system. The water level should be raised until water flows from the top vent valve. Position outflow CHD so that its overflow outlet is approximately 25 mm (1 in.) above the permeameter soil level. The system should be in no-flow condition and the manometers should all read the same.

9.4.5.8 Close off the top vent valve and allow the system to stand overnight in a static condition. This should ensure complete saturation of the system with water. The system should be in a no-flow condition overnight.

9.4.5.9 Check for and remove air bubbles found in the tubes or manometers by light vibration or tapping. It may be necessary to disconnect tubing from the manometer board and slowly lower the tubing, allowing water and entrapped air to run out.

9.4.5.10 Place a thermometer into the inflow CHD to monitor the temperature of water flowing into the permeameter.

9.5 *Permeameter Final Assembly and Setup:*

9.5.1 Clean the inner flange of the center section of the permeameter and insert the support screen, previously soaked in deaired water. Maintain 10 to 20 mm of water above the geotextile.

9.5.2 Insert support screen on top of geotextile.

9.5.3 Align and insert the top section of the permeameter into the center section, and press tightly to secure the geotextile and support screen. Check the O-ring gaskets to assure contact is made between the permeameter sections, support screen, and geotextile.

9.5.4 Fill the upper section of the permeameter with water, connect the inlet channel, and saturate the inflow tubing setup.

9.5.5 Secure the permeameter sections together with brackets and tighten bolts on bracket rods evenly.

9.5.6 Set the water inlet and outlet container to the same height, approximately 200 mm above the soil's upper surface.

9.5.7 Once the system is completely set-up, connect all the piezometer ports to the outflow weir by opening all the 'P' and 'C' valves (Fig. 4) in order to reach equilibrium in the system. Let the system rest at least 16 hours under 200 mm water head.

9.6 *Calibration:*

9.6.1 Follow the data acquisition system's manufacture recommendations to calibrate the piezometer readings. It is encouraged to use an installation similar to the one presented on Fig. 4 as it allows to conduct calibration and verification of the permeameter system without applying any unwanted water head directly on the soil while keeping the piezometers attached to the outflow tubes as well as to verify the accuracy of the readings during the test.

9.7 *Running the Test:*

9.7.1 After calibration and verification of the piezometers and permitting 16 hours of rest, all of the water pressure levels should indicate the same value as measured by the data acquisition system. This value should correspond with the levels of the water in the inlet and outlet containers, prior to the initiation of the test.

9.7.2 Place the thermometer in the inflow container.

9.7.3 Close the inlet valve, and adjust the inflow container to a level so that the first requested hydraulic gradient is obtained (see 9.7.9).

9.7.4 Prepare the data acquisition system to record piezometric levels and outflow rate.

9.7.5 Open the inflow valve and start data acquisition simultaneously.

9.7.6 Record the following data periodically (such as every 30 seconds for the first 30 minutes, and then every 15 minutes):

9.7.6.1 Date and time;

9.7.6.2 Flow rate;

9.7.6.3 Temperature (°C) of the water in the system;

9.7.6.4 Water heads from the individual pressure transducers connected to the permeameter.

9.7.7 After the final reading when system stabilization has again been achieved, raise the inflow CHD to obtain $i = 7.5$. Record time. After ½ h, record all data.

9.7.8 When equilibrium is reached (that is, when both the gradient ratio and permeability are considered to be constant) or after a predetermined test duration has been reached, rise the inflow container to obtain the second requested system hydraulic gradient (i).

9.7.9 Repeat measurements as in 9.7.4 for all the hydraulic gradients and test durations requested. Without particular requirements, the following testing schedule shall be used:

i=1.0 for a maximum of 48 hours or until stabilization (that is, constant outflow rate)

i=2.5 for a maximum of 2 hours or until stabilization;

i=5.0 for a maximum of 46 hours or until stabilization;

i=7.5 for a maximum of 2 hours or until stabilization;

i=10.0 for a maximum of 46 hours or until stabilization.

9.7.10 The test must be run continuously until steady-state conditions are obtained under each of the applied hydraulic gradients. Once the test has been started, it shall not be stopped and then resumed.

9.8 *Collection of the Soil Piped Through the Geotextile:*

9.8.1 At the end of the test, the weight of soil passing through the permeameter shall be collected using the valve located at the bottom section of the permeameter (see Fig. 2). It should then be dried and weighed for further calculations.

NOTE 5—With some apparatus, it is theoretically possible to collect the soil piped through the geotextile during the test, such as after installation, and periodically. However, attention shall be paid not to influence the test while doing so, such as by disturbing the outflow rate and water pressure in the vicinity of the geotextile interface.

9.8.2 While dismantling the test, the soil remaining on top of the geotextile should be collected and dried to determine the dry density (adding the weight of soil piped if relevant). This will correspond with the density of the soil in the filter cake.

10. Calculation

10.1 *Hydraulic Gradient*—Calculate the hydraulic gradients for the system *i*, using Eq 1.

$$i_{m-n} = \frac{h_m - h_n}{l_{n-m}} \tag{1}$$

where:

h_m = water head measured on piezometer 'm' (or average from all piezometers located at the same distance from the geotextile), and

l_{n-m} = length or thickness of soil between manometers being analyzed, cm.

10.2 *System Permeability*—Calculate the system permeability at the temperature of the test and corrected to 20 °C using Eq 2:

$$k_T = \frac{V}{i\,At} * \frac{1}{100} * \frac{\mu_T}{\mu_{20}} \tag{2}$$

where:

k_{20} = system permeability at 20°C, m/s,
V = quantity of flow measured, cm^3,
i = hydraulic gradient,
A = cross-sectional area of the specimen, cm^2,
T = time needed to collect a volume of water '*V*,' *s*,
μ_T = water viscosity at temperature of the test, and
μ_{20} = water viscosity at 20 °C.

10.3 *Gradient Ratio*—For each hydraulic gradient, report the gradient ratio, *GR*, for the system using Eq 3 and data for the final time interval used. Fig. 5 shows the meaning of the values in the equation schematically.

$$GR = \frac{i_{0-25}}{i_{25-75}} = \frac{h_{25} - h_0}{25} * \frac{50}{h_{75} - h_{25}} \tag{3}$$

where:

$i_{0–25}$ = hydraulic gradient measured between the outflow weir and the piezometer located at 25 mm above the geotextile,

$i_{25–75}$ = hydraulic gradient measured between the piezometer located at 25 and 75 mm above the geotextile,

h_0 = water head measured in the outflow weir,

h_{25} = water head measured in the piezometer located at 25 mm above the geotextile,

h_{75} = water head measured in the piezometer located at 75 mm above the geotextile,
25 = 25 mm, distance between the geotextile and the piezometer located at 25 mm above the geotextile, and
50 = 50 mm, distance between the piezometers located at 25 and 75 mm above the geotextile.

Calculate values from two sets of manometers, as previously shown, to detect any changes in pressure from one side to the other. If a significant difference exists between manometers, the system should be investigated for air bubbles, algae buildup, plugged manometer tube, or a plugged port.

11. Report

11.1 State that the specimen was tested in accordance with Test Method D5101. Describe the material or product tested and the method of sampling used.

11.2 Report the following information:

11.2.1 Unit weight of dry soil in the permeameter,

11.2.2 Permeameter diameter,

11.2.3 All instrument time series, such as flow volume, outflow rate, temperature, and manometer readings,

11.2.4 System permeability corrected to 20 °C (K_T),

11.2.5 A plot of the gradient ratio (to the nearest 0.1 units) against time for each hydraulic gradient tested,

11.2.6 A plot of the permeability and flow rate to three significant digits against time,

11.2.7 A plot of the gradient ratio versus the system hydraulic gradient,

11.2.8 Mass of soil passing through the geotextile,

11.2.9 Soil installation technique.

12. Precision and Bias

12.1 *Precision*—Precision of this test method cannot be established as this is a performance test.

12.2 *Bias*—The procedure in Test Method D5101 for measuring the soil-geotextile system permeability and clogging potential has no bias because the value of the gradient ratio and permeability can be defined only in terms of a test method.

13. Keywords

13.1 clogging potential; gradient ratio; soil-geotextile system

ANNEX

(Mandatory Information)

A1. INTERPRETATION OF RESULTS

A1.1 The gradient ratio test is best suited for evaluating the movement of finer solid particles in coarse grained or gap graded materials where internal stability from differential hydraulic gradients may be a problem. The important aspect of the gradient ratio values obtained during the testing is not so much the number itself, but whether or not positive flow and permeability is maintained and there is the establishment of some recognizable equilibrium or stabilization of the system.

A1.2 A gradient ratio of one or slightly less is preferred. A value less than one is an indication that some soil particles have moved through the system and a more open filter bridge has developed in the soil adjacent to the geotextile. A continued decrease in gradient ratio indicates piping and may require quantitative evaluation to determine filter effectiveness. Although gradient ratio values of higher than one mean that some system clogging and flow restriction has occurred, if system equilibrium is present, the resulting flow may well satisfy design requirements.

A1.3 The allowable gradient ratio values and related flow rates for various soil-geotextile systems will be dependent on the specific site application. It is the responsibility of the design professional to establish these allowable values on a case-by-case basis.