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D422 Test Method for Particle-Size Analysis of Soils (Withdrawn 2016)[3]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

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[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.

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 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.~~device

3.2.2 *GRT*—the acronym for ~~Gradient Ratio Test~~gradient ratio test

3.2.3 *HCR*—the acronym for ~~Hydraulic Conductivity Ratio~~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 ~~(that is,~~(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 ~~(i.e.,~~ (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.

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")~~#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.

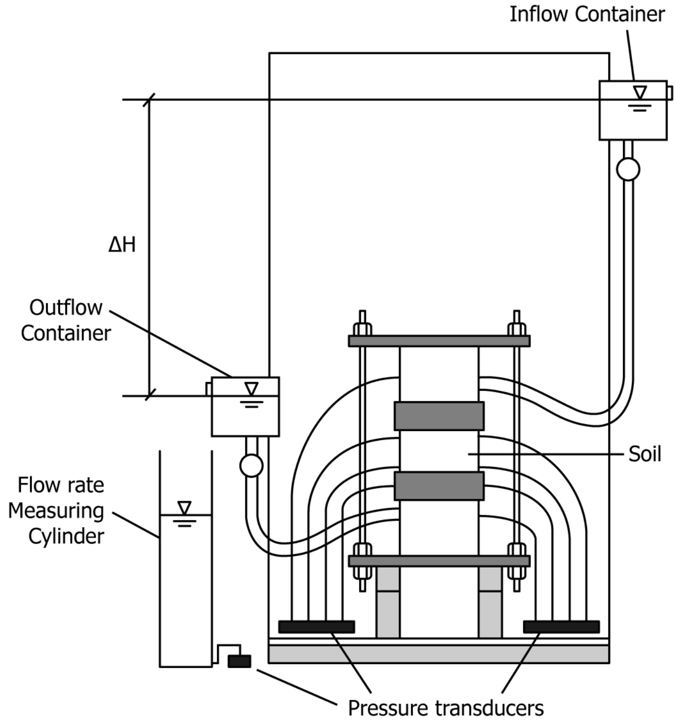

FIG. 1 Gradient Ratio Test Setup

6.6 *Soil Support Cloth,* of 150 µm (No. 100) mesh, or equivalent geotextile.

6.7 *Thermometer* (0 to 50 ± ~~1°C).~~1 °C).

6.8 *Graduated Cylinder,* 100 ± ~~1 cm~~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 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.~~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 ~~6mm~~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~~Tested for ~~gradient ratio—~~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~~10-mm (⅜ ~~(3/8 in.) or 16 mm~~-in.) or 16-mm (⅝ ~~(5/8 in.)~~ -in.) sieve, depending on the diameter of the cell used (100 or 150 mm).

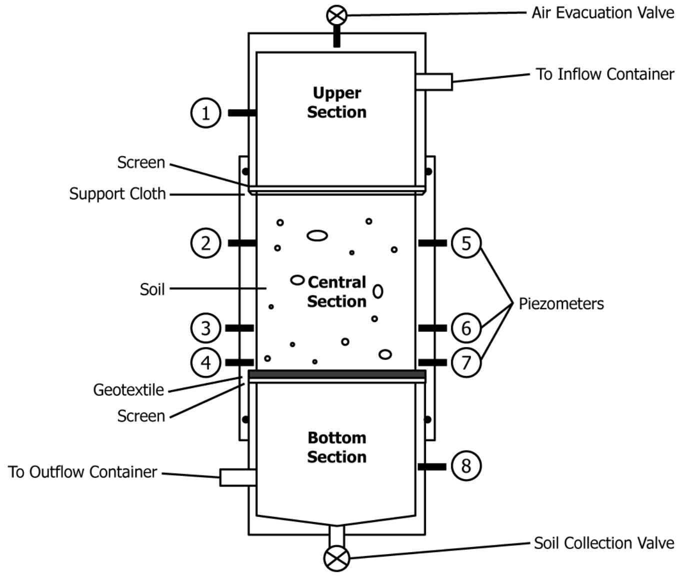

FIG. 2 Permeameter Section

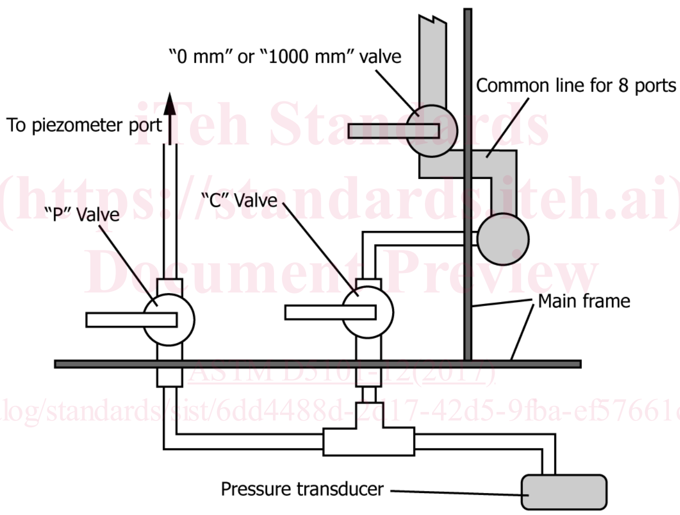

FIG. 3 Individual Setup of Calibration System for Each Pressure Transducer

8. Conditioning

8.1 *Test Water Preparation:*

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

9.1.1 *Determination of the ~~soils properties:~~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~~D4318,~~, when ~~applicable~~applicable.

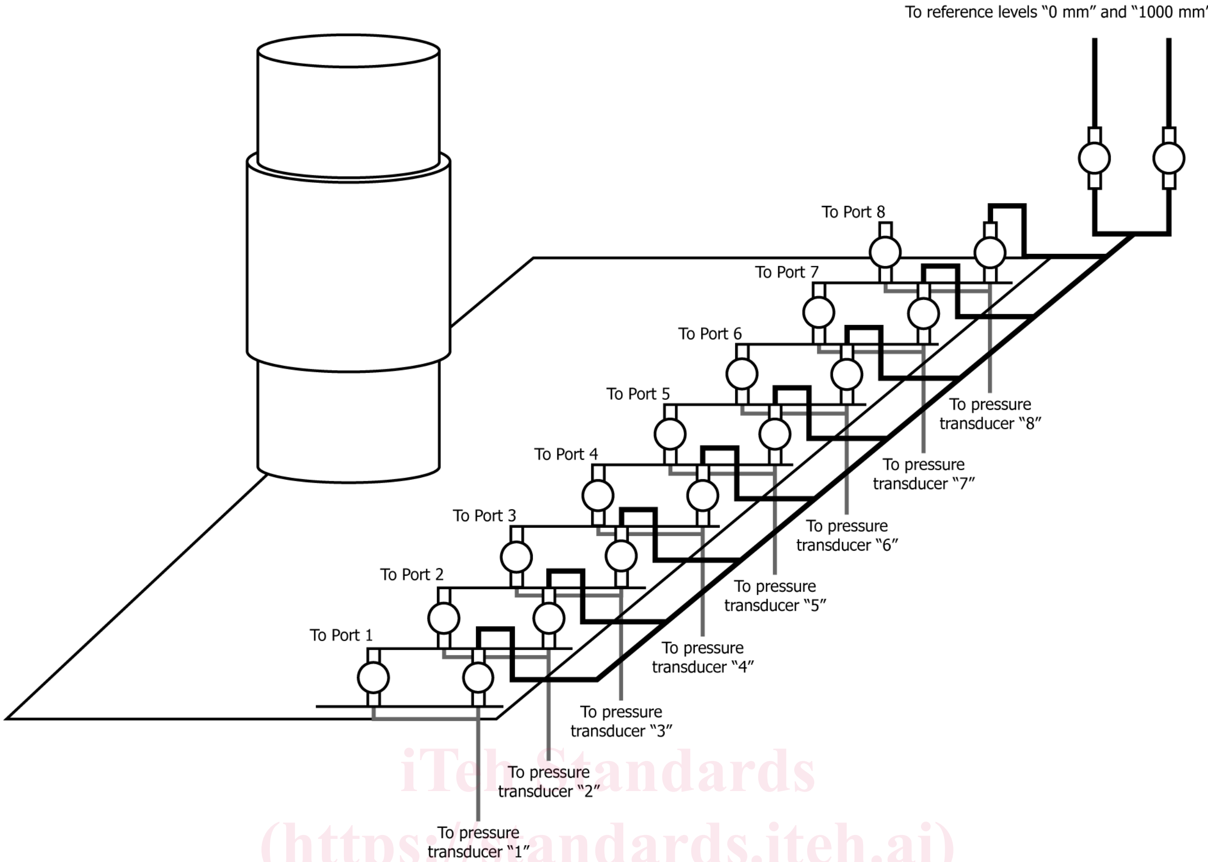

FIG. 4 General Setup of Calibration Board

9.1.1.2 For silty soils with plasticity indices in the vicinity of 5, estimate the permeability of the soil ~~that~~(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~~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~~10^{-3} cm/s, use of the 'slurry' deposition technique is preferred as discussed in 9.4.3~~Section 9.4.2;~~.

(2) For sandy soils, with permeabilities greater than ~~10-3~~10^{-3} cm ~~cm/s, /~~s, use of the 'water pluviation' technique is preferred as discussed in 9.4.2~~Section 9.4.3.~~.

(3) For ~~well graded~~ well-graded soils or unstable soils that easily segregate, the dry method presented in ~~section~~9.4.4 ~~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:~~ Soil—*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*—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:~~ 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~~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~~ oven-dried processed soil in a pan.

9.4.2.2 Use the funnel described in ~~6.19~~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~~ 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.

9.4.3 *Soil Placement by Slurry Deposition Technique*—This method is to be used for silty or low permeability soils (that is, ~~non plastic~~ nonplastic with permeability up to 10^{-3} cm/s). As with 9.4.2~~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 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.

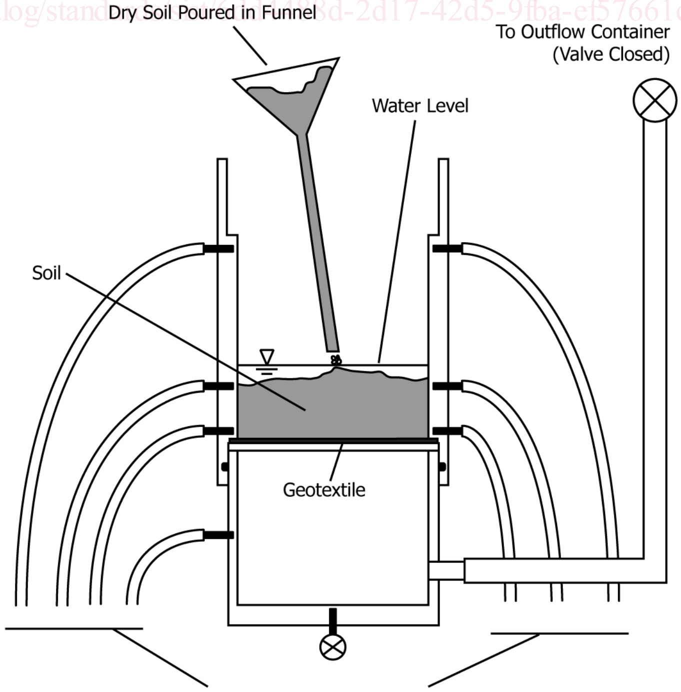

FIG. 5 Water ~~pluviation technique~~Pluviation Technique