
Standard Method of Test for Permeability of Granular Soils (Constant Head)

AASHTO Designation: T 215-23

Technically Revised: 2023

Editorially Revised: 2023

Technical Subcommittee: 1a, Soil and Unbound Recycled Materials



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1. SCOPE

- 1.1. This method describes a procedure for the determination of the permeability of water through granular (cohesionless) soils in a steady-state condition.
- 1.2. The determination of the coefficient of permeability, k , as defined in this method, was developed under the assumptions of the validity of Darcy's Law, which states that the coefficient of permeability is the ratio of the flow rate to the hydraulic gradient.
- 1.3. This test procedure is intended for use with disturbed granular soils containing not more than 10 percent passing the 75- μm (No. 200) sieve. Soil materials with significant amounts of material passing the 75- μm (No. 200) sieve may be subject to consolidation effects that may influence the outcome of the test results. Permeability of soils not meeting the above criteria should be performed by use of a flexible wall permeameter test procedure, such as ASTM D5084.
- Note 1**—Soils containing less than 14 percent passing the 75- μm (No. 200) sieve may be tested if it is determined that the liquid limit does not exceed 25 and plasticity index does not exceed 5, and the hydrometer analysis from AASHTO T 88 reveals the majority of the 75- μm (No. 200) particles are silt. The height of the sample after the permeability test should be obtained to ensure no consolidation effects have occurred during testing. A moisture content using T 265 should be performed from the sample after the permeability test to ensure it has been adequately saturated with a Degree of Saturation in the range of 98 percent to 100 percent.
- 1.4. Two methods of test, Method A and Method B, are provided. The method used is dependent on the permeameter used to complete testing.
- 1.5. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

- 2.1. AASHTO Standards:
- < M 231, Weighing Devices Used in the Testing of Materials
 - < R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
 - < R 61, Establishing Requirements for Equipment Calibrations, Standardizations, and Checks

- < T 88, Particle Size Analysis of Soils
- < T 89, Determining the Liquid Limit of Soils
- < T 90, Determining the Plastic Limit and Plasticity Index of Soils
- < T 99, Moisture–Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
- < T 180, Moisture–Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- < T 265, Laboratory Determination of Moisture Content of Soils

2.2. *ASTM Standards:*

- < D5084, Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
- < E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- < E77, Standard Test Method for Inspection and Verification of Thermometers
- < E563, Standard Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature
- < E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- < E2251, Standard Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

3. SIGNIFICANCE AND USE

- 3.1. Soil foundations with inadequate drainage capabilities can result in excess pore water pressures that may ultimately lead to pumping distress when subjected to loading. Pumping distress, which is the forceful ejection of waterborne soil subgrade, can occur when freestanding water accumulates between a pavement surface and the subgrade of concrete pavement. Pumping distress is particularly common on high-volume roadways sustaining heavy axle loads.

4. SUMMARY OF TEST METHOD

- 4.1. Loose soil material is compacted into a rigid-wall permeameter. A vacuum is applied to the test sample to evacuate air from the sample. While remaining under vacuum, the specimen is slowly saturated with water from the bottom upward. Finally, the flow of water is induced through the sample. Once a stable head condition is reached, time, head, and flow measurements are taken and recorded. These measurements are used to calculate the coefficient of permeability of the soil. It is recommended that measurements be repeated at increasing heads in order to determine the region of laminar flow.

5. APPARATUS

- 5.1. *Apparatus Required for Method A:*

- 5.1.1. *Permeameter*—As shown in Figure 1 and equipped with the following:

- 5.1.1.1. *Specimen Cylinder*—A rigid glass, plastic, or metal. The diameter of the cylinder required is dependent on the maximum particle size of the sample to be tested, and shall conform to the minimum requirements described in Table 1.

Table 1—Minimum Cylinder Diameter Based on Maximum Particle Size

Maximum Particle Size Lies Between Sieve Openings	Minimum Cylinder Diameter			
	Less than 35% of Total Soil Retained on Sieve Opening		More than 35% of Total Soil Retained on Sieve Opening	
	2.00-mm (No. 10)	9.5-mm (³ / ₈ in.)	2.00-mm (No. 10)	9.5-mm (³ / ₈ in.)
2.00-mm (No. 10) and 9.5-mm (³ / ₈ in.)	76 mm (3 in.) Methods A and B	—	114 mm (4.5 in.) Methods A and B	—
9.5-mm (³ / ₈ in.) and 19.0-mm (³ / ₄ in.)	—	152 mm (6 in.) Methods A and B	—	229 mm (9 in.) Methods A and B

- 5.1.1.2. *Porous Disks*—The bottom and top of the specimen shall be covered with a porous disk constructed of silicon carbide, aluminum oxide, or similar noncorrosive material. The porosity of the disks shall be fine enough to prevent intrusion of soil particles into the pores. The permeability of the disks must be at least one order of magnitude higher than that of the soil to be tested. The disks shall be of sufficient thickness and construction so that they do not bend, compress, or otherwise deform during regular use. The top porous disk shall be supplied with a suitable spring or similar device for applying a light pressure of 22 to 45 N (5 to 10 lbf) when the top plate of the permeameter is in place as shown in Figure 1.

Note 2—The spring, or other suitable device, is used to maintain the density and volume of the soil without significant effects on the saturation and permeability of the specimen.

- 5.1.1.3. *Manometer Tubes*—With metric scales, for measuring loss of head across the specimen during testing. The minimum length of the tubes is equivalent to the diameter of the permeameter cylinder.
- 5.1.1.4. *Constant-Head Filter Tank*—Supplied with metric scale on its side, for measuring loss of head across the specimen during testing. The minimum length of the tubes is equivalent to the diameter of the permeameter cylinder.
- 5.1.1.5. *Graduated Cylinder*—With a capacity of 250 mL.

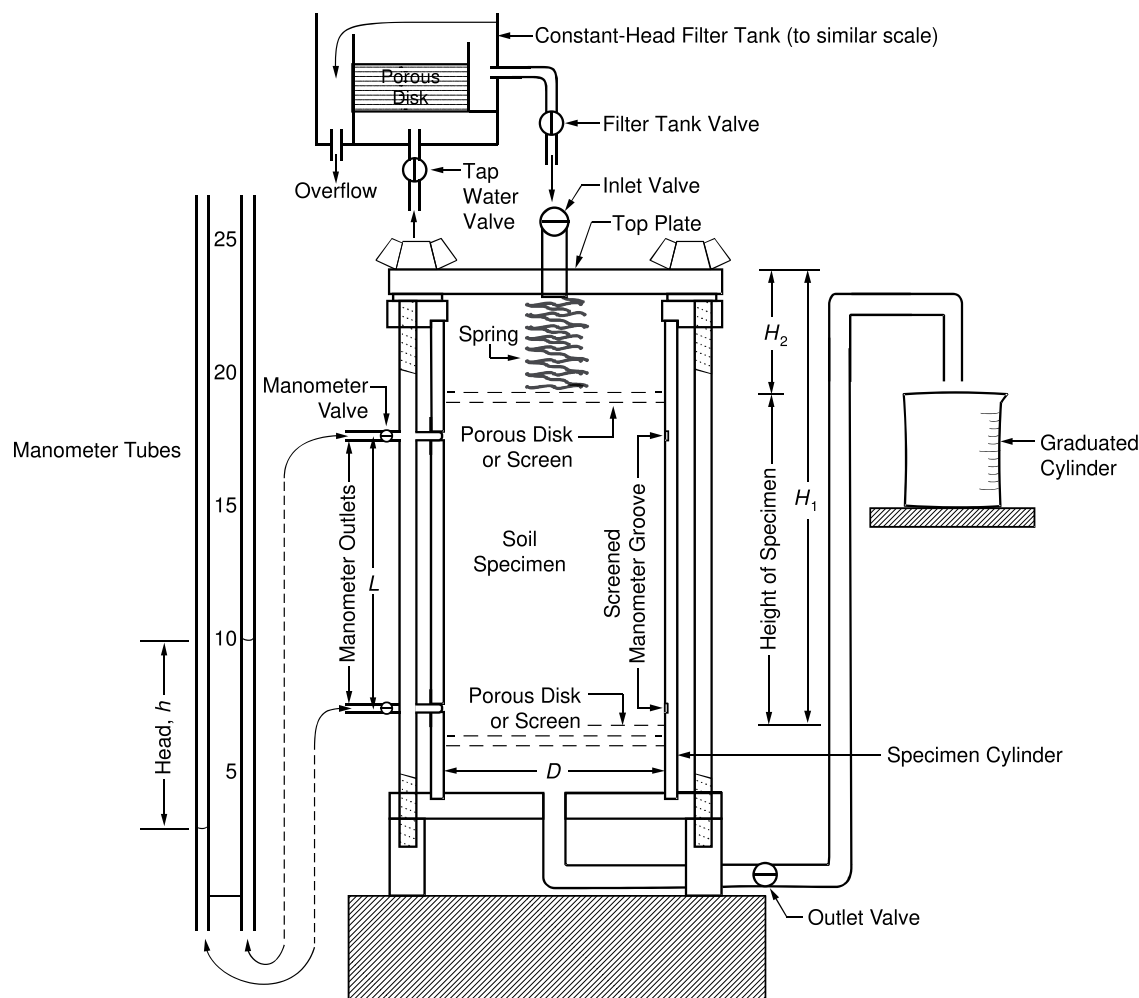


Figure 1—Constant-Head Permeameter for Use with Method A

5.2. *Apparatus Required for Method B:*

5.2.1. *Permeameter*—As shown in Figure 2 and equipped with the following:

5.2.1.1. *Tailwater Receptacle*—A receptacle that is used to maintain a constant tailwater level. The permeameter shall be placed in the tailwater receptacle during testing. When in use, water shall flow from the reservoir tube, through the specimen, out of the bottom drain holes, and into the tailwater receptacle. The rim of the tailwater receptacle shall be located above the top of the test specimen by a minimum of 2 in. The receptacle shall have a volume of no less than 5 gal.

Note 3—A 5-gal bucket, commonly found at hardware supply stores, has been found to be satisfactory for use as a tailwater receptacle.

5.2.1.2. *Bubble Tube*—A rigid glass or plastic tube used to maintain a constant head on the test specimen. The tube shall have an outer diameter of 19 mm. The tube shall be attached to the top of the reservoir with a lock nut and shall have the ability to be adjusted vertically to be able to adjust the gradient used during the test.

5.2.1.3. *Reservoir Tube*—A rigid glass or plastic tube that stores the water used for the test. The reservoir tube shall be 76 mm, 101.6 mm, or 152 mm in diameter depending on the material size as