EXPERIMENT 10

PERMEABILITY (HYDRAULIC CONDUCTIVITY) TEST

CONSTANT HEAD METHOD

Purpose:

The purpose of this test is to determine the permeability (hydraulic conductivity) of a sandy soil by the constant head test method. There are two general types of permeability test methods that are routinely performed in the laboratory: (1) the constant head test method, and (2) the falling head test method. The constant head test method is used for permeable soils ($k>10^{-4}$ cm/s) and the falling head test is mainly used for less permeable soils ($k<10^{-4}$ cm/s).

Standard Reference:

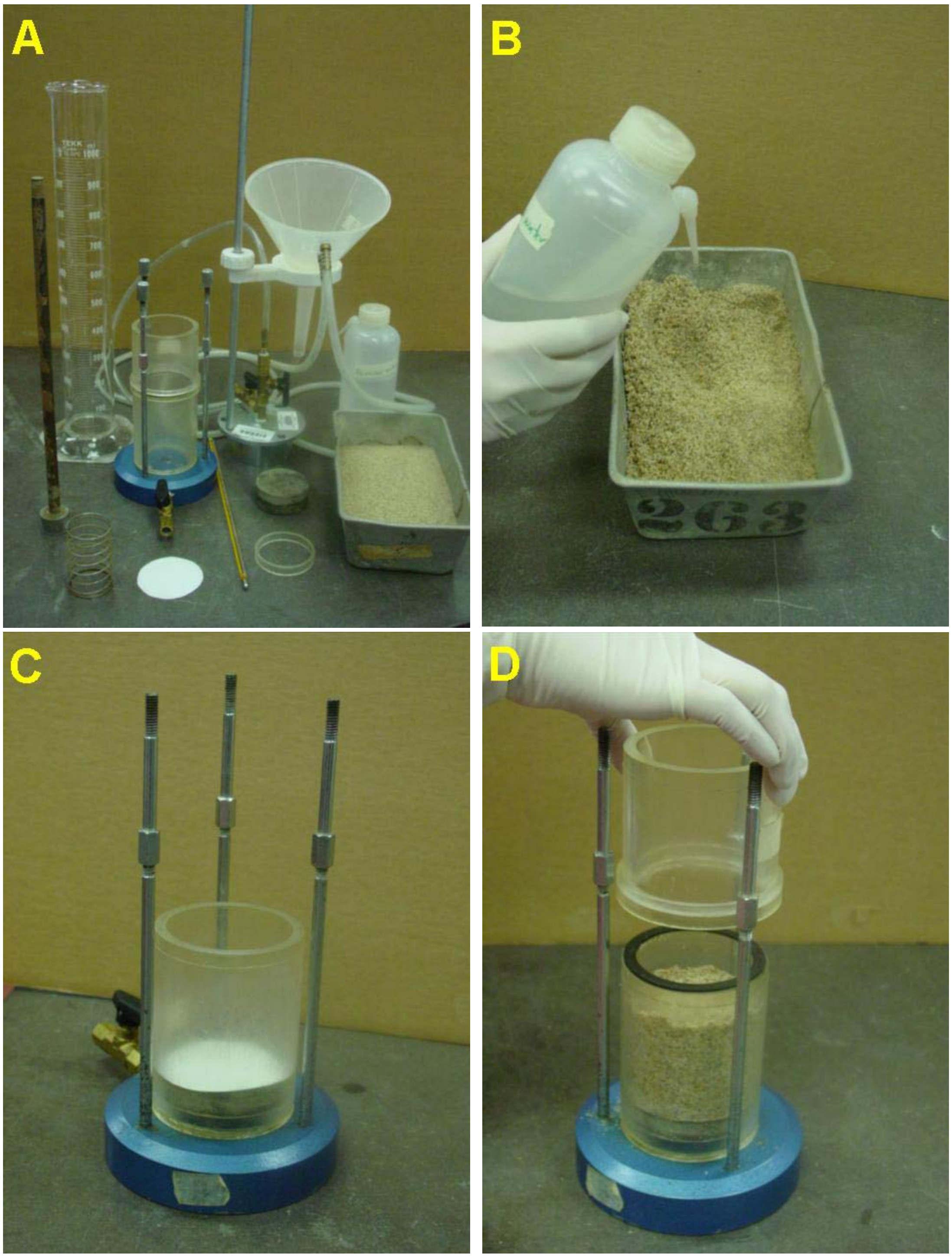
ASTM D 2434 - Standard Test Method for Permeability of Granular Soils (Constant Head) (Note: The Falling Head Test Method is not standardized)

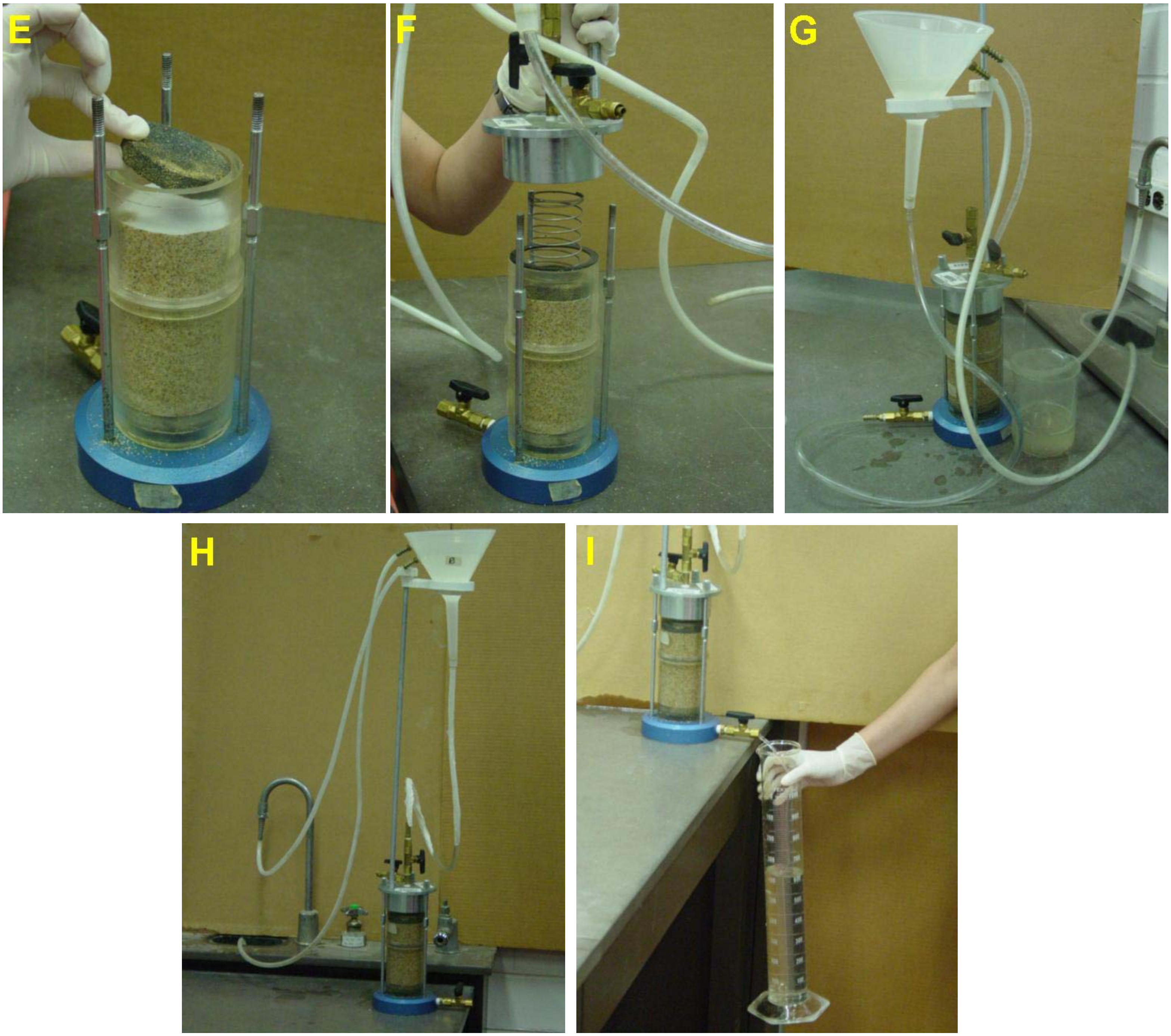
Significance:

Permeability (or hydraulic conductivity) refers to the ease with which water can flow through a soil. This property is necessary for the calculation of seepage through earth dams or under sheet pile walls, the calculation of the seepage rate from waste storage facilities (landfills, ponds, etc.), and the calculation of the rate of settlement of clayey soil deposits.

Equipment:

Permeameter, Tamper, Balance, Scoop, 1000 mL Graduated cylinders, Watch (or Stopwatch), Thermometer, Filter paper.




E
F
G
H
I

Test Procedure:

(1) Measure the initial mass of the pan along with the dry soil (M_1).

(2) Remove the cap and upper chamber of the permeameter by unscrewing the knurled cap nuts and lifting them off the tie rods. Measure the inside diameter of upper and lower chambers. Calculate the average inside diameter of the permeameter (D).

(3) Place one porous stone on the inner support ring in the base of the chamber then place a filter paper on top of the porous stone (see Photo C).

(4) Mix the soil with a sufficient quantity of distilled water to prevent the segregation of particle sizes during placement into the permeameter. Enough water should be added so that the mixture may flow freely (see Photo B).

(5) Using a scoop, pour the prepared soil into the lower chamber using a circular motion to fill it to a depth of 1.5 cm. A uniform layer should be formed.

(6) Use the tamping device to compact the layer of soil. Use approximately ten rams of the tamper per layer and provide uniform coverage of the soil surface. Repeat the compaction procedure until the soil is within 2 cm. of the top of the lower chamber section (see Photo D).

(7) Replace the upper chamber section, and don't forget the rubber gasket that goes between the chamber sections. Be careful not to disturb the soil that has already been compacted. Continue the placement operation until the level of the soil is about 2 cm. below the rim of the upper chamber. Level the top surface of the soil and place a filter paper and then the upper porous stone on it (see Photo E).

(8) Place the compression spring on the porous stone and replace the chamber cap and its sealing gasket. Secure the cap firmly with the cap nuts (see Photo F).

(9) Measure the sample length at four locations around the circumference of the permeameter and compute the average length. Record it as the sample length.

(10) Keep the pan with remaining soil in the drying oven.

(11) Adjust the level of the funnel to allow the constant water level in it to remain a few inches above the top of the soil.

(12) Connect the flexible tube from the tail of the funnel to the bottom outlet of the permeameter and keep the valves on the top of the permeameter open (see Photo G).

(13) Place tubing from the top outlet to the sink to collect any water that may come out (see Photo G).

(14) Open the bottom valve and allow the water to flow into the permeameter.

(15) As soon as the water begins to flow out of the top control (deairing) valve, close the control valve, letting water flow out of the outlet for some time.

(16) Close the bottom outlet valve and disconnect the tubing at the bottom. Connect the funnel tubing to the top side port (see Photo H).

(17) Open the bottom outlet valve and raise the funnel to a convenient height to get a reasonable steady flow of water.

(18) Allow adequate time for the flow pattern to stabilize (see Photo I).

(19) Measure the time it takes to fill a volume of 750 - 1000 mL using the graduated cylinder, and then measure the temperature of the water. Repeat this process three times and compute the average time, average volume, and average temperature. Record the values as t, Q, and T, respectively (see Photo I).

(20) Measure the vertical distance between the funnel head level and the chamber outflow level, and record the distance as h.

(21) Repeat step 17 and 18 with different vertical distances.

(22) Remove the pan from the drying oven and measure the final mass of the pan along with the dry soil (M_2).

Analysis:

(1) Calculate the permeability, using the following equation:

$$K_T = \frac{QL}{Ath}$$

Where:

K_T = coefficient of permeability at temperature T, cm/sec.

L = length of specimen in centimeters

t = time for discharge in seconds

Q = volume of discharge in cm^3 (assume 1 mL = 1 cm^3)

A = cross-sectional area of permeameter (= $\frac{\pi}{4}D^2$, D= inside diameter of the permeameter)

h = hydraulic head difference across length L, in cm of water; or it is equal to the vertical distance between the constant funnel head level and the chamber overflow level.

(2) The viscosity of the water changes with temperature. As temperature increases viscosity decreases and the permeability increases. The coefficient of permeability is standardized at 20°C, and the permeability at any temperature T is related to K_{20} by the following ratio:

$$K_{20} = K_T \frac{\eta_T}{\eta_{20}}$$

Where:

η_T and η_{20} are the viscosities at the temperature T of the test and at 20°C, respectively. From Table 1 obtain the viscosities and compute K_{20}.

(3) Compute the volume of soil used from: $V = LA$.

(4) Compute the mass of dry soil used in permeameter (M) = initial mass - final mass:

$$M = M_1 - M_2$$

(5) Compute the dry density (ρ_d) of soil

$$\rho_d = \frac{M}{V}$$

Table 1. Properties of Distilled Water (η = absolute)

Temperature $^{\circ}C$	Density (g/cm^3)	Viscosity (Poise*)
4	1.00000	0.01567
16	0.99897	0.01111
17	0.99880	0.01083
18	0.99862	0.01056
19	0.99844	0.01030
20	0.99823	0.01005
21	0.99802	0.00981
22	0.99780	0.00958
23	0.99757	0.00936
24	0.99733	0.00914
25	0.99708	0.00894
26	0.99682	0.00874
27	0.99655	0.00855
28	0.99627	0.00836
29	0. 99598	0.00818
30	0. 99568	0.00801

$$\text{*Poise} = \frac{\text{dyne}\cdot\text{s}}{\text{cm}^2} = \frac{\text{g}}{\text{cm}\cdot\text{s}}$$

EXAMPLE DATA

HYDRAULIC CONDUCTIVITY TEST
CONSTANT HEAD METHOD
DATA SHEET

Date Tested: October 10, 2002

Tested By: CEMM315 Class, Group A

Project Name: CEMM315 Lab

Sample Number: B-1, ST-10, 8'-10'

Visual Classification: Brown medium to fine sand, poorly graded, subrounded, dry.

Initial Dry Mass of Soil + Pan (M_1) = 1675.0 g
Length of Soil Specimen, L = 17 cm
Diameter of the Soil Specimen (Permeameter), D = 6.4 cm
Final Dry Mass of Soil + Pan (M_2) = 865.6 g
Dry Mass of Soil Specimen (M) = 809.4 g
Volume of Soil Specimen (V) = 846.9 cm^3
Dry Density of Soil (ρ_d) = 1.48 g/cm^3

Trial Number	Constant Head, h (cm)	Elapsed Time, t (seconds)	Outflow Volume, Q (cm^3)	Water Temp., T (°C)	K_T cm/sec	K_{20} cm/sec
1	30	84	750	22	0.157	0.149
2	50	55	750	22	0.144	0.137
3	60	48	750	22	0.137	0.130
4	70	38	750	22	0.149	0.142

Average K_{20}= 0.139 cm/sec

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HYDRAULIC CONDUCTIVITY TEST
CONSTANT HEAD METHOD
DATA SHEET

Date Tested:
Tested By:
Project Name:
Sample Number:
Visual Classification:

Initial Dry Mass of Soil + Pan (M_1) = ___________________ g
Length of Soil Specimen, L = __________________ cm
Diameter of the Soil Specimen (Permeameter), D = ______________ cm
Final Dry Mass of Soil + Pan (M_2) = __________________ g
Dry Mass of Soil Specimen (M) = ______________________ g
Volume of Soil Specimen (V) = ____________________ cm^3
Dry Density of Soil (ρ_d) = ___________________ g/cm^3

Trial Number	Constant Head, h (cm)	Elapsed Time, t (seconds)	Outflow Volume, Q (cm^3)	Water Temp., T (°C)	K_T	K_{20}
1						
2						
3						
4						

Average K_{20}= _______________________ cm/sec