PERMEABILITY TEST

1. Objective

The rate of flow of water, under laminar flow conditions, through a unit cross sectional are of soil mass, under unit hydraulic gradient, is defined as coefficient of permeability. Permeability of the soil governs the magnitude of excess pore water pressure built-up in the embankment or cuttings, during consolidation process or when the embankment is ponded by water. The excess pore water pressure in-turn significantly influences the stability of the embankments and indicate the need, or otherwise, of need for special measures (e.g. sandwich construction) to prevent/quickly dissipate excess pore water pressure. Coefficient of permeability is used to assess drainage characteristics of soil, rate of consolidation and to predict rate of settlement of soil bed. The coefficient of permeability is generally determined by two procedures (i.e. Constant Head Method and Falling Head Method).

2. Apparatus

2.1 The mould assemble (including drainage base and drainage cap) conforming to IS: 11209-1985.
2.2 The compaction rammer conforming to IS: 9198-1979.
2.3 Set of Stand Pipes - A suitable water reservoir capable or suppling water to the permeameter under constant head for constant head test arrangement.
2.4 Constant Head Tank – A suitable water reservoir capable or suppling water to the permeameter under constant head for constant head test arrangement.
2.5 Vacuum Pump
2.6 Miscellaneous Apparatus – Such as IS sieves, mixing pan, graduated cylinder, metre scale, stop watch, 75-micron wire gauge, thermometer, and a source of de-aired water.

3. Reference

IS-2720(Part 17):1986(Reaffirmed-2021)"Methods of test for soils: Laboratory determination of permeability".

4. Preparation of Test Specimen

4.1 Disturbed Soil Sample

4.1.1. Take 2.5 kg sample from a thoroughly mixed air-dried or oven dried material, obtained in accordance with IS: 2720 (Part-1).
4.1.2 Determine the moisture content of the sample. Place the sample in an air-tight container. Compute the quantity of water required to give the desired moisture content and ad this water evenly over the sample and mix it thoroughly. Place the sample in storage container. Moisture content of the sample shall be determined again to ensure that is within 0.5 percent of that desired.
4.1.3 Weigh the empty mould, grease it lightly inside, clamp it between the compaction base plate and extension collar and keep the assembly on a solid base.
4.1.4 The dry density for remoulding of samples shall be either the field density or maximum dry density estimated by compaction tests or any other density at which the

permeability is desired. The moisture content used for compaction should be the optimum moisture content or the field moisture as the case may be. The compactive effort may be varied to simulate field conditions. Static compaction may also be used where necessary.
4.1.5 After completion of compaction, remove the extension collar and trim the excess soil from the top of mould. Detach the mould and weigh the mould with compacted specimen.
4.1.6 Assemble the mould, with specimen inside, to the drainage base and cap having porous discs. The porous discs shall be saturated before assembling the mould.

4.2 Undisturbed Soil Sample

Trim the undisturbed specimen in the form of a cylinder not larger than about 85 mm in diameter and having a height equal to that of mould. To provide sealing between the soil specimen and the mould against the leakage from sides, fill the annular space between the mould and the specimen with cement slurry or a mixture of 10 percent dry powdered bentonite and 90 percent fine sand. Compact the mixture using a small tamping rod and then fix the drainage cap over the top of the mould.

4.3 Saturation

For soils of medium to high permeability, the specimen shall be subjected to sufficient head, flow or immersion to obtain full saturation.
Soils of low permeability require flow under a high head for a period ranging from a day to a week, depending upon the permeability and the head. Alternatively, the specimen shall be subjected to a gradually increasing vacuum with bottom outlet closed. The vacuum shall be increased to atleast 70 cm of mercury and maintained for 15 minutes or more depending upon the soil type. Follow this by a very slow saturation of the specimen with de-aired water from the bottom upwards under full vacuum. Close both top and bottom outlet, when the specimen is saturated.

5. Constant Head Test

5.1 Connect the specimen through top inlet to the constant head reservoir. Open the bottom outlet and when the steady state of flow is established, collect the quantity of flow for a convenient time interval and weight or measure it. Alternatively, the inlet may be at the bottom and collect water from outlet at the top. The collection of water flow for the same time interval shall be repeated thrice.
5.2 The hydraulic gradient in the test should be preferably include the hydraulic gradient likely to occur in the field.
5.3 The linearity (of Darcy’s law) between the hydraulic gradient and the average velocity of flow the soil under test should be established by performing the test over a range of hydraulic gradients. Any deviation from linearity observed should be noted.

5.4 Record of Observations:

Diameter of specimen (D)	=	cm
Length of specimen (L)	=	cm
Area of specimen (A) = $\pi/4 \times D^2$	=	cm^2
Volume of specimen (V) = A x L	=	cm^3
Head Loss (h) = $H_1 - H_2$	=	cm
Hydraulic Gradient (i) = h/L	=	

Experiment No.	**1**	**2**	**3**
Quantity of Flow: Q (cm^3)			
Time: t (Seconds)			
$K_T = Q / (A \times i \times T)$ (cm/sec)			
Remarks: At Dry Density of Void Ratio of Degree of Saturation of	Average (K_T) = cm/sec		

Temperature of Water (T)	=	^{0} C
Weight of wet soil specimen, after test (W_t)	=	g
Weight of dry soil specimen (W_s)	=	g
Dry unit weight (γ) = W_s/V	=	g/cm^3
Water Content (W) = $(W_t - W_s)/W_s \times 100$	=	%
Specific Gravity of specimen (G_S)	=	
Void ratio (e) = $(VG_S - W_S)\ W_S$	=	
Degree of Saturation (S) = $G_S \times W / e$	=	%

Permeability at 27°C, $K_{27} = k_T \times (\mu_T / \mu_{27})$

Where, K27 = Permeability at 27°C

KT = Permeability at T°C

μ27 = Coefficient of Viscosity at 27°C

μT = Coefficient of Viscosity at T°C

5.5 Presentation of Results: The values of permeability at T^0C and 27^0C are reported. Also reported are corresponding void ration, degree of saturation and water content.

6. Falling Head Test

6.1 The specimen shall be connected through the top inlet to the selected stand pipe. The bottom outlet shall be opened and the time interval required for the water level to fall from a known initial head to know final head, as measured above centre of the outlet, shall be recorded.
6.2 The stand-pipe shall be re-filled with the water and the test repeated till three

successive observations give nearly same time interval.

6.3 Record of Observations:

Diameter of specimen (D)	=	cm
Length of specimen (L)	=	cm
Area of specimen (A) = $\pi/4 \times D^2$	=	cm^2
Volume of specimen (V) = A x L	=	cm^3
Area of Stand-pipe (a)	=	cm^2

$$K_T = 2.303 \times [(aL/A) / (t_f - t_i)] \times \log_{10} (h_1/h_2)$$

Experiment No.	1	2	3
Initial Time: t_1 (Seconds)			
Final Time: t_f (Seconds)			
Initial Head: h_1 (cm)			
Initial Head: h_2 (cm)			
h_1 / h_2			
K_T (cm / sec)			
Remarks: At Dry Density of Void Ratio of Degree of Saturation of	Average (K_T) = cm/sec		

Temperature of Water, T	=	^{0} C
Weight of soil specimen after the test (W_t)	=	g
Weight of dry soil specimen (W_S)	=	g
Water content, W = $(W_t - W_S)/W_S \times 100$	=	%
Specific Gravity of specimen (G_S)	=	
Void ratio (e) = $(VG_S - W_S)/W_S$	=	
Degree of Saturation, S = $G_S \times W / e$	=	%

Permeability at 27°C, $K_{27} = k_T \times (\mu_T / \mu_{27})$ =

Where, K27 = Permeability at 27°C

KT = Permeability at T°C

μ27 = Coefficient of Viscosity at 27°C

μT = Coefficient of Viscosity at T°C

6.4 Presentation of Results : The permeability values are reported at T^0C and 27^0C. The state of sample is also reported in terms of water content, void ration and degree of saturation.

7. Video

- Constant Head Permeability Test
- Falling Head Permeability Test

8. Download

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