METHODS OF COMPUTING COEFFICIENT OF PERMEABILITY:

Water moves through ground by means of mechanical energy. In this case, the difference in pressure is the driving force in groundwater: water flows from a higher pressure zone to a lower one.

Two Standard Laboratory Tests that are used to Determine the Coefficient of Permeability:

Constant Head Test

- The constant head permeability test is a laboratory experiment conducted to determine the permeability of soil. The soils that are suitable for tests are sand and gravels. Soils with silt content cannot be tested with this method. The test can be employed to test granular soils either reconstituted or disturbed.
- In this type of laboratory setup, the water supply at the inlet is adjusted in such a way that the difference of head between the inlet and the outlet remains constant during the test period. After a constant flow rate is established, water is collected in a graduated flask for a known duration.
-This test is based on the assumption of laminar flow where ***k*** is independent of ***i.***

Calculation of Constant Head Test:

1. Determine the unit weight.
2. Calculate the void ratio of the compacted specimen.
3. Calculate:

$$k = \frac{qL}{Ah} = \frac{QL}{Aht}$$

Where:

Q = volume of water collected (mm cm, and m)

A = area of cross section of the soil specimen (mm^2, cm^2 and m^2)

T = duration of water collection (sec, hour, and day)

h = constant head difference (mm, cm, and m)

L = length of soil specimen (mm, cm, and m)

k = coefficient of permeability (mm/sec, cm/sec, and mm/sec)

Coefficient of Permeability (k) is defined as the rate of flow of water under laminar flow conditions through a porous medium area of unit cross section under unit hydraulic gradient.

Constant-Head Hydraulic Conductivity Test Apparatus

Laboratory Procedures of Constant Head Test:

1. Prepare the following apparatus needed:
   a. Stop watch
   b. Filter paper.
   c. Thermometer
   d. Constant head collecting chamber
   e. Permeameter mould,
      Internal diameter = 100mm, effective height =127.3 mm, capacity = 1000ml.
   f. Detachable collar, 100mm diameter, 60mm height
   g. Dummy plate, 108 mm diameter, 12mm thick,
   h. Drainage base, having porous disc
   i. Drainage cap having porous disc with a spring attached to the top.

j. Static compaction equipment.

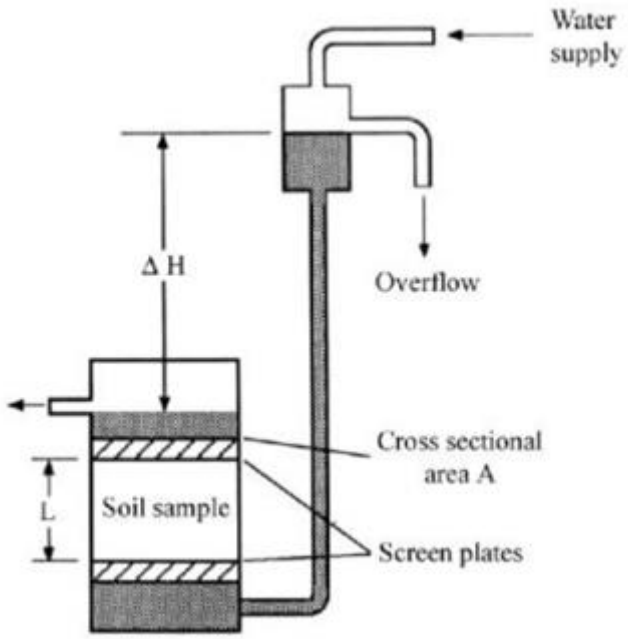
k. Constant head water supply reservoir

l. Vacuum pump

m. Large funnel

n. Weighing balance accuracy 0.1g

2. Prepare the specimens needed:
   a. Remove the collar of the mould. Measure the internal dimensions of the mould. Weigh the mould with dummy plate to the nearest gram.
   b. Apply a little grease on the inside to the mould. Clamp the mould between the base plate and the extension collar and place the assembly on a solid base.
   c. Take about 2.5kg of the soil sample, from a thoroughly mixed wet soil, in the mould. Compact the soil at the required dry density using a suitable compacting device.
   d. Take a small specimen of the soil in a container for the water content determination.
   e. Remove the collar and base plate. Trim the excess soil level with the top of the mould.
   f. Clean the outside of the mould and the dummy plate. Find the mass of the soil in the mould.
   g. The mould with the sample is now placed over the permeameter. This will have drainage and cap discs properly saturated
3. Lastly execute the test procedures:
   a. Through the top inlet of the constant head reservoir, the specimen is connected.
   b. The bottom outlet is opened and a steady flow is established
   c. For a particular time interval, the quantity of flow can be collected.
   d. Measure the difference of head (h) in levels between the constant head reservoir and the outlet in the base.
   e. For the same interval, this is repeated three times.



Constant Head Test

Observations and Computation in Constant Head Pemeameter:
The data that is obtained directly from the tests are:

1. Length (L) in cm

2. Area (A) in cm^2

3. Constant Head (H) in cm

4. Discharge (q) cm^3/sec

Table.1: Observations and Calculations

Sl. No.	Observations	Determination No.		
		1	2	3
	Observations			
1	Mass of empty mould with base plate			
2	Mass of mould, soil and base plate			
3	Hydraulic head (h)			
4	Time interval (t)			
5	Quantity of flow (Q)			
	(a) First time in period t			
	(b) Second time in period t			
	(c) Third time in period t			
	Average Q			
	Calculations			
6	Mass of soil = (2) – (1)			
7	Bulk Density $\rho = \frac{Mass}{Volume}$			
8	Water content w			
9	Dry density $\rho_d = \frac{\rho}{1+w}$			
10	Void ratio $e = \frac{\rho_w G}{\rho_d} - 1$			

11	Coefficient of permeability $k = \frac{qL}{Ah} = \frac{QL}{Aht}$ Where q= dischargeQ=total volume of watert=time periodh=head causing flow L= length of specimen A= cross-sectional area.			

Note: The dry density and void ratio have to be reported along with the test results.

As a Result:

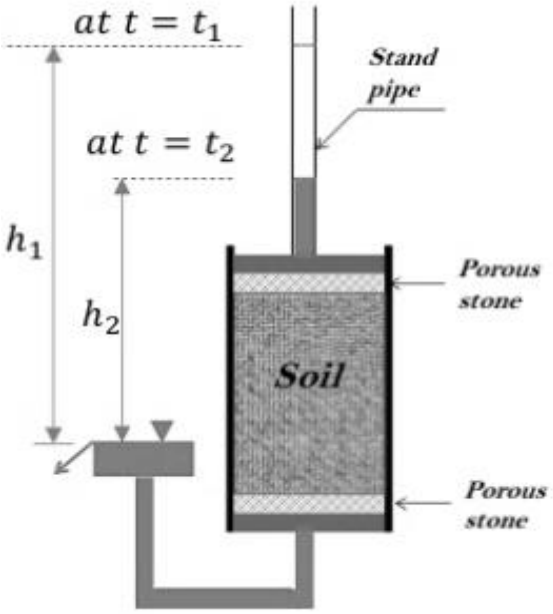
The coefficient of permeability of given soil, k = _____ mm/sec

The dry density = _____

The void Ratio = _____

Falling Head Test

-It is a laboratory testing method used to determine the permeability of fine grained soils with intermediate and low permeability such as silts and clays.
-This testing method can be applied to an undisturbed sample.



The water from a standpipe flows through the soil. The initial head difference *h1* at time *t*= 0 is recorded, and water is allowed to flow through the soil specimen such that the final head difference at time t=t2 is h2.

Calculation of Falling Head Test:

1. Calculate the velocity of fall in the rate of flow of the water through the specimen at any time t can be given by:

$$q = k\frac{h}{L}A = -a\frac{dh}{dt}$$

Where: q = flow rate (mm^3/sec, cm^3/sec, and m^3/sec)

a = cross-sectional area of the standpipe (mm^2, cm^2 and m^2)

A = cross-sectional area of the soil specimen (mm^2, cm^2 and m^2)

h = constant head difference (mm, cm, and m)

L = length of soil specimen (mm, cm, and m)

k = coefficient of permeability (mm/sec, cm/sec, and mm/sec)

2. Rearrange the formulas: $$dt = \frac{aL}{Ak}\left(-\frac{dh}{h}\right)$$

3. Integrate of the left side of: $$dt = \frac{aL}{Ak}\left(-\frac{dh}{h}\right)$$

with limits of time from 0 to t and the right side with limits of head difference from h1 to h2 gives:

$$t = \frac{aL}{Ak}\log_e \frac{h_1}{h_2}$$ or $$k = \frac{aL}{At}\log_{10}\frac{h_1}{h_2}$$

Where:

k = coefficient of permeability (mm/sec, cm/sec, and mm/sec)

A = area of cross section of the soil specimen (mm^2, cm^2 and m^2)

a = inside cross sectional area of the water tank (mm^2, cm^2 and m^2)

t = duration of water collection (sec, hour, and day)

h1 = distance of bottom of the beaker before the test (mm, cm, and m)

h2 = distance of bottom of the beaker after the test (mm, cm, and m)

L= length of soil specimen (mm, cm, and m)

Falling-Head Hydraulic Conductivity Test Apparatus

Laboratory Description of Falling Head Test:

1. The falling head permeability test involves flow of water through a relatively short soil sample connected to a standpipe which provides the water head and also allows measuring the volume of water passing through the sample.

2. The diameter of the standpipe depends on the permeability of the tested soil. The test can be carried out in a Falling Head permeability cell or in an odometer cell.

3. Before starting the flow measurements, the soil sample is saturated and the standpipes are filled with de-aired water to a given level.

4. The test then starts by allowing water to flow through the sample until the water in the standpipe reaches a given lower limit. The time required for the water in the standpipe to drop from the upper to the lower level is recorded.

5. Often, the standpipe is refilled and the test is repeated for couple of times. The recorded time should be the same for each tests within an allowable variation of about 10% otherwise the test is failed.

Apparatus: Constant Head Test Apparatus