GEOTECHNICAL & SOILS LABORATORY
PERMEABILITY TEST : CONSTANT HEAD & FALLING HEAD

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CONSTANT HEAD PERMEAMETER

Introduction

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.

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). ASTM D 2434 - Standard Test Method for Permeability of Granular Soils (Constant Head) will be used throughout this experiment.

Theory

Permeability is defined as a capacity of soil to allow water passes through it i.e. quantity of flowing for a unit of soil surface under a pressure of 1 unit hydraulic gradient. Permeability is also known as hydraulic conductivity. Coefficient of permeability (k) is the flow velocity produced by hydraulic gradient of unity using the following formula which is known as Darcy's Law:

$$v = ki$$

where:

a) v = flow velocity
b) k = coefficient of permeability
c) i = hydraulic gradient = Δh/ ΔL
d) Δh = difference in total head over a flow path length of ΔL

Objective

To determine the coefficient of permeability of a soil using constant head method.

Results

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
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:

$$K_{20} = K_T \frac{n_T}{n_{20}}$$

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 (ρd) of soil

Calculation of Data

Specimen height,	L	=	93.6×10^{-3}	m
Specimen diameter,	D	=	75.38×10^{-3}	m
Cross-sectional areas,	A	=	……..	
		=	……..	m^2
Specimen volume,	V	=	……..	
		=	……..	m^3
Mass of mould,		=	1.52	kg
Mass of mould + wet specimen,		=	2.48	kg
Specimen mass,	M	=	1.23	kg
Specimen bulk unit weight,	γ_b	=	$\frac{W}{V}$	
		=	……..	
		=	……..	kN/m^3
Internal diameter of tube,		=	6×10^{-3}	m
Tube cross-sectional area,	a	=	……..	
		=	……..	m^2

Table

Test No.	Time, t (second)	Volume, V (ml)	q = V/t (m^3/s)	h (m)	i = h/L	v = q/A (m/s)
1						
2						
3						
4						

FALLING HEAD PERMEAMETER

Introduction

Pore spaces between soil particles are interconnected to ease the flow of water where the water flows from higher pore pressure to lower pore pressure zone.

Theory

Permeability is defined as a capacity of soil to allow water passes through it i.e. quantity of flowing for a unit of soil surface under a pressure of 1 unit hydraulic gradient. Permeability is also known as hydraulic conductivity. Coefficient of permeability (k) is the flow velocity produced by hydraulic gradient of unity using the following formula which is known as Darcy's Law:

$$v = ki$$

where:

e) v = flow velocity
f) k = coefficient of permeability
g) i = hydraulic gradient = $\Delta h / \Delta L$
h) Δh = difference in total head over a flow path length of ΔL

Objective

To determine the coefficient of permeability of a soil using constant head method.

Procedures

1. Prepare the soil sample
2. Determine the bulk density and moisture content of the soil
3. Place the sample in perspex cylinder with wire mesh and gravel filter above and below
4. Place the cylinder in an overflowed water reservoir
5. Connect the top of cylinder to a glass standpipe using a rubber tube
6. Fill in distilled water from the top of the glass standpipe
7. Record the height of water in the glass standpipe at several time intervals
8. Repeat the test using standpipes of different diameter for at least 2 tests
9. Determine the average of k from the results

Calculation of Data

Specimen height,	L	=	127×10^{-3}	m
Specimen diameter,	D	=	102×10^{-3}	m
Cross-sectional areas,	A	=	……..	
		=	……..	m^2
Specimen volume,	V	=	……..	
		=	……..	m^3
Mass of mould,		=	1.04	kg
Mass of mould + wet specimen,		=	2.90	kg
Specimen mass,	M	=	1.86	kg
Specimen bulk unit weight,	γ_b	=	$\frac{W}{V}$	
		=	……..	
		=	……..	kN/m^3
Internal diameter of tube,		=	5.8×10^{-3}	m
Tube cross-sectional area,	a	=	……..	
		=	……..	m^2

Results

Test No.	Time, t (second)	h_1	h_2	$k = 2.3026 \frac{aL}{At} \log 10 \frac{h_1}{h_2} (mm/s)$
1				
2				
3				
4				
Average				

Conclusion

Compare the results with the values of **k** and then determine the type of soil that has been tested.

Question

A falling head permeameter mould of 75 mm diameter and 150 mm height is filled with soil. The internal diameter of the burette tube is 5 mm. Determine the time (in seconds) required for the hydraulic head to fall from 1300 mm to 50 mm if the coefficient of permeability of the soil in the mould is 0.0215 mm/s?