BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Civil Engineering Department

Soil Lab

ENCE311

Experiment #9 :

" Constant Head Permeability test and Falling Head permeability test "

Instructors :

Dr. Saheem Murshid

Eng. Maha Jarrar

Done by Group A :

Mohammad Al-Swaity	1181136
Wajih Sammour	1180956
Samer Maali	1180360
Thaljea Shaabna	1182216
Mohammad Marbou	1180126
Baseel Abd Elrazaq	1170032

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Contents :

Introduction :

The constant head permeability test involves flow of water through a column of cylindrical soil sample under the constant pressure difference. The test is carried out in the permeability cell, or permeameter, which can vary in size depending on the grain size of the tested material. The soil sample has a cylindrical form with its diameter being large enough in order to be representative of the tested soil. As a rule of thumb, the ratio of the cell diameter to the largest grain size diameter should be higher than 12 (Head 1982). The usual size of the cell often used for testing common sands is 75 mm diamater and 260 mm height between perforated plates. The testing apparatus is equipped with a adjustable constant head reservoir and an outlet reservoir which allows maintaining a constant head during the test. Water used for testing is de-aired water at constant temperature. The permeability cell is also equipped with a loading piston that can be used to apply constant axial stress to the sample during the test. Before starting the flow measurements, however, the soil sample is saturated. During the test, the amount of water flowing through the soil column is measured for given time intervals.

Knowing the height of the soil sample column L, the sample cross section A, and the constant pressure difference Δh, the volume of passing water Q, and the time interval ΔT, one can calculate the permeability of the sample as

$$K = \frac{QL}{A.\Delta h.\Delta t}$$

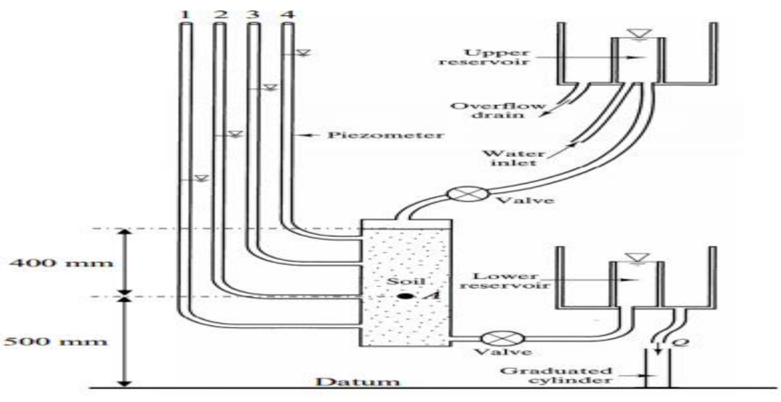


Figure 1 Constant head permeability test.

An introduction about the Falling Head permeability test :

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. 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 oedometer cell.

Before starting the flow measurements, the soil sample is saturated and the standpipes are filled with de-aired water to a given level. 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 to drop from the upper to the lower level is recorded. Often, the standpipe is refilled and the test is repeated for couple of times. The recorded time should be the same for each test within an allowable variation of about 10% (Head 1982) otherwise the test is failed .

On the basis of the test results, the permeability of the sample can be calculated as

$$K =[\ 2.3\ \frac{a.L}{A.\Delta t}\ ]\ .\ Log(\ \frac{h\_U}{h\_L}\ )$$

Where :

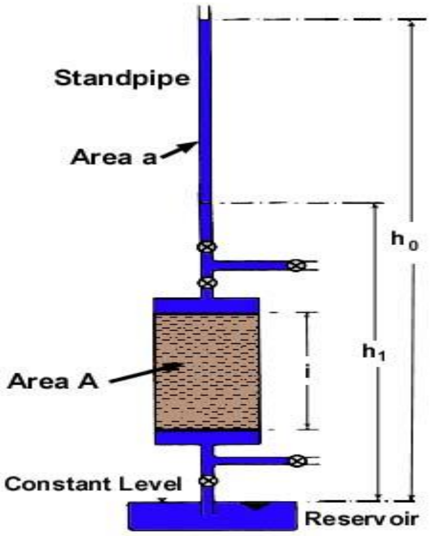
L: the height of the soil sample column

A: the sample cross section

a: the cross section of the standpipe

Δt : the recorded time for the water column to flow though the sample

h_U and h_L : the upper and lower water level in the standpipe measured using the same water



Purpose of the Constant Head Permeability test :

to determine the coefficient of permeability for sand in the laboratory via the Constant Head test for permeability. This test is an easy, cost effective way to determine permeability in a laboratory setting

Materials and Equipment's :

Look at the **" Table 1 "** that show the equipment we used in this experiment :

Equipment	The name of it :	Equipment	The name of it :
 Figure 1	**Coarse Soil sample**	 Figure 2	**Fine Soil sample**
 Figure 3	**Water supplier**	 Figure 4	**Graduated Cylinder**
 Figure 5	**Falling head perimeter**	 Figure 6	**Constant head perimeter**
 Figure 7	**Straight part of steel**	 Figure 8	**Stop Watch**

Table 1

Procedure :

- The sample was put in the device.
- The water was allowed to move to causing a flow and the soil was saturated with water.
- The water went out from another side of the device.
- After a little time, the steady state flow case was arrived.
- After that, a graduated cylinder was taken.
- The graduated cylinder was put under the exit of water.
- Then, the reading of graduated cylinder was taken after 10 sec
- Step 7 was repeated 3 times.
- The steps above was repeated for another 2 samples, but the time of take the reading was different.

Data and Calculations :

$$K = \frac{V\,L}{t\,\Delta h\,A}$$

D = 7.5 cm → A = 44.15625 cm^2

Length between manometers (cm)		
A&B	B&C	A&C
6.5	7	13.5

Volume (cm^3)	Time (sec)	Manometer (cm)			Difference in head (cm)			Coeff. Of permeability (cm/sec)		
---	---	A	B	C	A&B	B&C	A&C	K_1	K_2	K_3
140	10	93.5	86.6	78.2	6.9	8.4	15.3	0.299	0.264	0.280
260	20	93.5	86.6	78.2	6.9	8.4	15.3	0.277	0.245	0.260
385	30	93.5	86.6	78.2	6.9	8.4	15.3	0.274	0.242	0.256
								K_{avg} = 0.283	K_{avg} = 0.250	K_{avg} = 0.265
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90	5	90.5	80.3	68.8	10.2	11.5	21.7	0.260	0.248	0.254
160	10	90.5	80.3	68.8	10.2	11.5	21.7	0.231	0.221	0.225
265	15	90.5	80.3	68.8	10.2	11.5	21.7	0.255	0.244	0.249
								K_{avg} = 0.249	K_{avg} = 0.238	K_{avg} = 0.243
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125	5	82.5	69	53	13.5	16	29.5	0.273	0.248	0.259
235	10	82.5	69	53	13.5	16	29.5	0.256	0.233	0.244
350	15	82.5	69	53	13.5	16	29.5	0.254	0.231	0.242
								K_{avg} = 0.261	K_{avg} = 0.237	K_{avg} = 0.248

Results and Conclusion :

We can conclude that the soil that tested in constant head is coarse sand since the coefficient of permeability is lies between 0.1 and 0.01cm/sec .
We can conclude the relationship between void ratio and particle size distribution where (K α e) and also $(K \, \alpha \, grain\ size\ distribution)$.
And when the temperature increases, the viscosity of water decreases and the coefficient of permeability increases, the flow rate increase.

Sources of errors :

- If the sample wasn't saturated it may affect the result
- The measurement of sample diameter and height is imprecise
- The volume of water measured during a given time is inaccurate

References :

- Soil lab manual
- https://elementaryengineeringlibrary.com/civil-engineering/soil-mechanics/falling-head-variable-head-permeability-method
- http://www.geotechdata.info/geotest/falling-head-permeability-test