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CONSTANT HEAD PERMEABILITY TEST

# Purpose of the Test

The main purpose of the constant head permeability test is to investigate the hydraulic conductivity of a coarse grained soil sample. Furthermore, boiling which is also named quick condition is observed in this laboratory session; even though, it is not a part of the standard test.

# Equipment

* A rubber ring – sealed cylinder of soil with inlets/outlets at the top, bottom, and optionally two more at different levels along the length. (using a modified 4” Proctor mold is a common practice)
* porous stones and filter papers of the same diameter.
* constant head reservoir
* 2 piezometer tubes with a height scale.
* flexible tubing, valves, etc.
* beakers (a graduated cylinder also helps)
* chronometer
* thermometer
* a large water container or sink (so that the lab floor doesn’t get too wet)

**Sand specimen**

**Porous disk**

**Measuring cylindering**

**Outlet pipe**

**Water tank**

**Stand pipe**

Figure 2: Constant Head Test Aparature (It is a figure that describes the general idea of the test)

# General Rules

* This test has rubber ring seals. The solid surfaces contacting rubber ring seals must be clean, flat; free of particles, hair, dents, and scratches. The rubber rings must be flexible and without cracks. Rings must be greased before placement.
* Taking the volume measurements by weighing water is a more precise measurement than reading the marks of a graduated cylinder, but the graduated cylinder is ok for this session.
* This test assumes steady-state. Flow measurements taken after steady-state is reached are the only values that can be used in the calculations correctly. Steady-state is verified by successive flow volume measurements for equal time increments – two, preferably three of them should be equal at steady state. For finer soils, reaching the steady state takes longer.
* When you assemble the setup, it is better to do it such that flow is upwards inside the mold. Therefore, “inlet” is through the lower plate, “outlet” is through the upper plate.

# Calibration

* Measure the dimensions of the mold and temperature of water.
* If the setup does not have side outlets for piezometers, then a separate calibration run is done without soil, to measure head losses in the equipment as a function of flow rate. Our setup has piezometric tubes attached to the mold at two different levels, so a calibration run won’t be necessary.

# Specimen Preparation

Because of the time limitations, the following processes copied from the word document of the experiment are done by assistant before the laboratory session.

* Place the soil homogeneously into the mold, at the desired density or void ratio.
* Remove excess soil with a straight-edge. Always cut outwards.
* Weigh the entire test container (mold + lower plate) with the specimen. Obtain the weight of the specimen by subtracting weight of the equipment.
* If the material is moist, determine its water content (use the excess soil).
* Place a filter paper, then upper porous stone on the soil.
* Clean the top of the rim of the mold and place a greased rubber ring seal on it.
* Put the upper plate on top, and tighten the nuts and bolts.

In addition to the above points, the connection of the reservoir to the bottom plate with a closed valve is done before the experiment. Moreover, the side outlets to the piezometer tubes are connected, and the top outlet to a pipe that ends in a large container is connected.

* **That is, the setup is completed before the laboratory session. It is not seen how to set up because of the time constraints, however, the assistant informs the student in detail about the formation of the set up.**

The valve should open, and allow the water to flow for a while. At this point, the total flowing volume of the water should be equal to the volume of the specimen.

# Procedure

* Vary the head difference by adjusting the valve from the reservoir. (This is specific to our lab’s huge constant-head reservoir. In many setups, either the elevation of the setup is varied relative to the reservoir head, or the setup stays on the table and a small constant-head reservoir is moved up and down.)
* For each head difference, do steps a-b-c.
* Measure flow of volume for a measured time interval. (a minimum of 1 mL water must be collected – but to reduce the relative error, greater volume should be collected)
* Wait for a while (duration depends on the permeability of the specimen)
* Repeat steps a and b until two consecutive flow rates are equal.
* Stop water flow.
* Disconnect the pipes from the mold.
* Press on the piston rod lightly.
* Measure the height of the piston rod from the upper plate of the cylinder.

# Boiling Demonstration

In addition to the test, we have prepared a second setup to observe this phenomenon.

* Let the water flow in, fill the pores, and spill out from the top.
* Place metal object tied to a rope on the soil surface.
* Gradually increase the upwards hydraulic gradient until quick condition is reached.
* In this condition, the soil expands in volume, and loses all strength (the metal object sinks into the soil)
* Measure the minimum head difference that causes boiling.
* Calculate the critical hydraulic gradient.

# Calculations

Dry mass of sand, volume of the solid particles, and the area of the sample are calculated and written in red, in the **Table-1**.

Table 1: Colored writings are calculated, the others are the data taken in the laboratory session

|  |  |  |
| --- | --- | --- |
| **Mass of Sand, M** | 500 | g |
| **Initial Water Content, w** | 4 | % |
| **Dry Mass of Sand MD=M/(1+w)** | 480.77 | g |
| **Specific Gravity of Sand, Gs** | 2.65 |  |
| **Volume of Solid Particles Vs=MD/GS** | 181.42 | ml |
| **Internal Diameter of Permeameter** | 7.4 | cm |
| **Area of Sample, A** | 43.01 | cm2 |
| **Temperature of Water** | 24 | °C |
| **Length of Permeameter, L** | 19.5 | cm |
| **Difference Between Two Piezometers, y** | 7 | cm |

The measured flow rates for each head difference are calculated and tabulated in **Table-2.** Furthermore, the conversion of the flow rates into flux and head difference values to gradients are also tabulated in **Table-2.**

Table 2: Colored writings are calculated, the others are the data taken in the laboratory session

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Time t (sec)** | **V in Graduated Bowl (Vb) (cm3)** | **Discharge Q=Vb/t (ml/t)** | **Flux q=Q/A (cm/s)** | **Head Difference Δh (cm)** | **Hydraulic Gradient i=Δh/(y)** | **Hydraulic Conductivity k=q/t (cm/s)** | **k20=k\*μ/μ20 (cm/s)** |
|
|
|
| 9 | 22 | 2.444444444 | 0.05683644 | 13 | 1.85714286 | 0.00631516 | 0.005733089 |
| 15 | 29 | 1.933333333 | 0.04495246 | 10 | 1.42857143 | 0.00299683 | 0.002720611 |
| 19 | 43 | 2.263157895 | 0.0526213 | 14 | 2 | 0.002769542 | 0.002514272 |

q vs i. graph is plotted **(see Figure-1)** and a best line fixed at the origin (q=ki) which has a slope of k.

Figure 1: q vs i. Graph & the best line fixed at the origin (q=ki)

The corrected value of the hydraulic conductivity (k) is shown in **Table-2.** Viscosity of the water at 20 °C and 24 °C are given in **Table-3**.

Table 3: Viscosity of the Water at Different Temperatures

|  |  |  |
| --- | --- | --- |
| **Viscosity (mPa.s)** | | |
| μ | 0.916 | @ 24 °C |
| μ20 | 1.009 | @ 20 °C |

# Discussıon of Results

Our theoretical icr and experimental i cr are different from each other. That can be happened because our experimental values can be wrong. For example; we could not read exact height of soil in permeameter..

We assume the temperature is 20 0 C but it could be different. In addition of that; aim of the experiment is to determine k from A\*k\*I and observe the ‘boiling’. When there are differences between bottom of soil and top of soil, there will be seepage. Water slip among soil particles and because of friction of these particles it could not slip well. When this friction is zero, boiling is occurred. This experiment enable us to determine permeability of soil. However; we should do this experiment very carefully. The values are so significantly so we read properties truly such as height, time.