Constant Head Permeability Test in Sand

Lecture Note # 8
Principles of Permeability through Soils

Darcy’s law \((v = k \ i)\) is valid i.e. flow through soils is assumed laminar.

![Figure 1. Zones of laminar and turbulent flows (After Taylor, 1948)](image)

Table 1. Coefficient of permeability in different soils

<table>
<thead>
<tr>
<th>Classification of soils according to their coefficients of permeability (after Kulhawy and Mayne, 1990; and Terzaghi and Peck, 1967)</th>
<th>Coefficient of permeability (k) (cm/s)</th>
<th>Degree of permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>Over (10^{-1})</td>
<td>High</td>
</tr>
<tr>
<td>Sandy gravel, clean sand, fine sand</td>
<td>(10^{-1}) to (10^{-3})</td>
<td>Medium</td>
</tr>
<tr>
<td>Sand, dirty sand, silty sand</td>
<td>(10^{-3}) to (10^{-5})</td>
<td>Low</td>
</tr>
<tr>
<td>Silt, silty clay</td>
<td>(10^{-5}) to (10^{-7})</td>
<td>Very low</td>
</tr>
<tr>
<td>Clay</td>
<td>Less than (10^{-7})</td>
<td>Practically impermeable</td>
</tr>
</tbody>
</table>
Definitions, Objectives and Applications (class notes)

Objective

To determine the Coefficient of Permeability \((k)\) of coarse sand by constant head method.

Significance

- Permeability is the ease with which the water flows through a soil medium.
- Two types of tests are routinely performed on soils (1) Constant Head test (2) Falling Head test.
- Constant Head Permeability Test is performed on sands as the pore openings are large and hence high permeability \((k >10^{-4} \text{ cm/s})\)
- Falling head Permeability Test is performed on clays as the pore openings are small and hence low permeability \((k <10^{-4} \text{ cm/s})\)

Applications

**Constant Head Permeability**

- Calculation of seepage through earth dams, embankments of canals, under sheet pile walls.
- Estimate settlements in foundations and slope stability analysis.

**Falling Head Permeability**

- Settlements in structures
- Methods for lowering the ground water table during construction
- Design grouting pressures and quantities for soil stabilization
- Freeze Thaw movements in soils *(Note that coefficient of permeability \(( k)\) varies with temperature as the viscosity of the fluids changes with temperature)*
- Design of recharge pits
Equipment

- Constant head permeameter
- Graduated flask
- Sensitive balance
- Stop watch

\(^a\) For this test, the equipment has been prepared prior to the class.
Test procedure

1. The sand has been filled and the permeameter is all set prior to the class (refer to http://geotech.uta.edu/lab/Main/index.htm, permeability test for details).

2. Allow water to flow through the funnel until the water level in the funnel is constant

3. Open the bottom outlet, run water through the permeameter until the sand is saturated and no air bubbles appear to flow out of the discharge pipe (steady flow), see picture 1.

4. Measure the head of water (h), distance between the water surface in the funnel and the bottom outlet of the permeameter (fill in column 4 of the table).

5. Run the water with the bottom outlet open for some time to achieve steady state (no air bubbles flowing through the pipe) at that particular height.

6. Weigh an empty conical flask, W₁ (g), see picture 2.
7. Start the stop watch and collect the discharge water in the conical flask for a particular period (say 60 seconds), record the time of collection (column 3 of the table).

8. Weigh the flask with water, W2 (g), see picture 3.

9. Calculate the volume of water, \( V = \frac{W_2 - W_1}{\text{unit weight of water, } 1 \times 10^{-3} \text{ kg/cm}^3} \).

10. Change the head by adjusting the funnel at a different height, see picture 4.

11. Repeat steps 4 to 10 three times and calculate the average k (cm/s)
### Calculations

Length of the specimen, L (cm)..........................
Diameter of the specimen, D (cm) .....................

Area of the specimen, A (cm$^2$).....................

<table>
<thead>
<tr>
<th>Test No</th>
<th>Discharge volume, Q (cm$^3$)</th>
<th>Time of collection, t (s)</th>
<th>Head difference, h (cm)</th>
<th>$k = \frac{QL}{Aht}$ (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
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Average permeability, $k$ (cm/s) = ____________________________

NOTE:

- IN YOUR REPORT, INCLUDE THE GRAPH SHOWING THE VARIATION OF DISCHARGE VELOCITY ($v = \frac{Q}{A}$) WITH HYDRAULIC GRADIENT ($i = \frac{L}{h}$).

- Compute the coefficient of permeability from the above graph and compare with the experimental value (average permeability).

- State all important conclusions
Schematic showing constant head permeability setup