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Lab report N°1

Soil Permeability - Constant Head Permeameters

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A lab report for the practical work of soil mechanics 2
for the degree of 3 Licence in Civil Engineering

2024/2025

Contents

1 Soil Permeability - Constant Head Permeameters

1.1 Introduction

Soil permeability varies from one type of soil to another. Water fills the spaces, or voids, between the soil particles, and this water can be removed either by evaporation (from high temperatures) or by applying an external load. When an external load is applied, it causes the soil to compress over time in a process called consolidation settlement.

1.2 Objective of the Test

The purpose of this test is to determine the soil's **permeability coefficient "k"**

1.3 The use of the Test in Civil Engineering

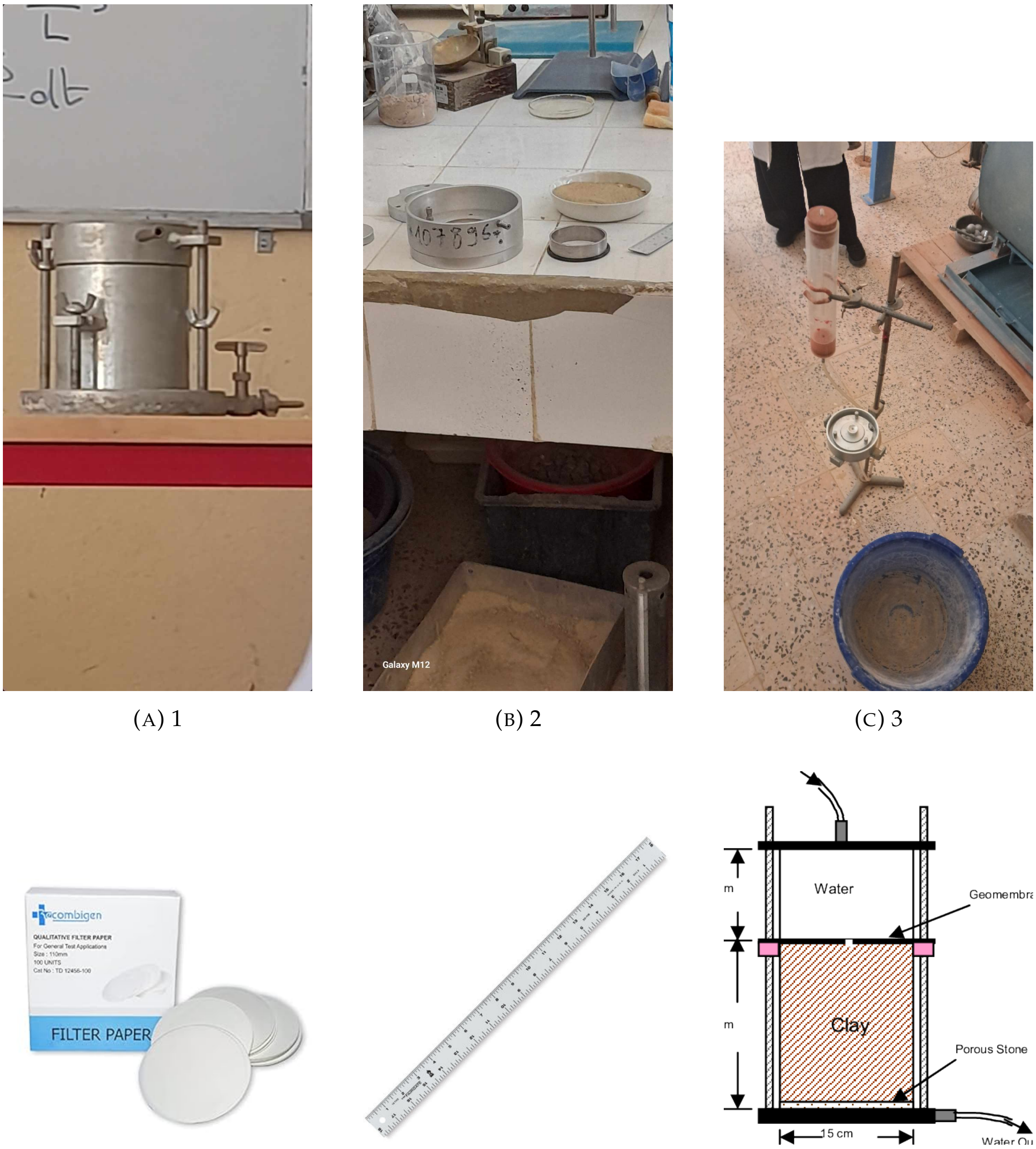
Permeability testing helps civil engineers understand how water moves through soil, which is key for designing safe structures. Main uses include:

- **Foundations and Dams:** Helps prevent water seepage that could weaken foundations or cause dam failures.
- **Drainage Design:** Guides drainage plans for tunnels and basements to avoid water buildup and pressure.
- **Environmental Safety:** Used in landfills to keep waste liquids from leaking into groundwater.
- **Slope Stability:** Supports slope designs by controlling water flow to prevent erosion and landslides.

1.4 Materials Used

- **Compaction Permeameter with Accessories:** A glass tube closed at the bottom with a valve, and equipped with additional tubes.
- **Piezometric tube panel** at different levels.
- **Permeameter stand with accessories.**
- **Chronometer:** to measure flow time.
- **Soil sample.**
- **Water reservoir.**

- **Graduated cylinder.**
- **Filter paper**
- **Straightedge**



(A) 1 (B) 2 (C) 3

(D) 4 (E) 5 (F) 6

FIGURE 1.1: Materials Used

1.5 Operating Procedure :

In this test, the sample is subjected to a load gradient due to the difference in water height between the upstream and downstream reservoirs, with the upstream reservoir level kept constant.

- Supply water to the upstream reservoir and set the desired level.
- Open the valves on the panel and the permeameter. Start the stopwatch immediately.

- Wait for a stabilization period (about 2 minutes).
- Record the time t_1, the height h_1, and measure the volume V_1 of the water that has passed through the sample using the graduated cylinder.
- Repeat the operation several times, changing the water level in the upstream reservoir.
- Record the new measurements $t_2, t_3, \ldots h_2, h_3$ and measure the volumes $V_2, V_3, \ldots$.

1.6 Expression of results

A constant head loss Δh causes water to flow through the soil sample. The water flow rate q is measured by collecting a volume of water V over a time t. Knowing the length of the sample L and the cross-sectional area S through which the water flows, we can calculate the coefficient of permeability k (Darcy's equation):

$$k \cdot i \cdot S = q \quad \Rightarrow \quad k = \frac{q}{i \cdot S} \quad \text{where} \quad q = \frac{V_{\text{water}}}{t}$$

$$\text{We obtain :} \quad k = \frac{V_{\text{water}}}{i \cdot S \cdot t} = \frac{V_{\text{water}} \cdot L}{\Delta h \cdot S \cdot t}$$

Where:

- k is the coefficient of permeability.
- V_{water} is the volume of water.
- t is the time.
- Δh is the head loss.
- L is the length of the soil sample.
- S is the cross-sectional area.

Given Calculations:

1. **Calculate V_{eau}:**

$$V_{\text{eau}} = A \times h = \left(\frac{\pi \times 5^2}{4} \right) \times 2 = 60.38\,\text{cm}^3$$

Where:

- A is the cross-sectional area of the tube.

2. **Calculate S:**

$$S = \frac{\pi \times 6.2^2}{4} = 30.19\,\text{cm}^2$$

Individual Permeability Coefficients:

Using different values of t for each test:

- **Test 1** ($t = 8.26s$):

$$K_1 = \frac{60.38 \times 1.4}{30.19 \times 28 \times 8.26} = 12.1 \times 10^{-3}\,\text{cm/s}$$

- **Test 2** ($t = 7.14s$):

$$K_2 = 14 \times 10^{-3} \,\text{cm/s}$$

- **Test 3** ($t = 7.19s$):

$$K_3 = 13.9 \times 10^{-3} \,\text{cm/s}$$

Average Permeability Coefficient:

$$K = \frac{K_1 + K_2 + K_3}{3} = 13.33 \times 10^{-3} \,\text{cm/s}$$

Table 01: Permeability Coefficient (k)

Type	Range of k (cm/s)	Permeability Level
Medium and coarse gravel	10^{-1} to 10^{-3}	Very high
Small gravel, coarse sand	10^{-3} to 10^{-5}	Fairly high
Fine sand, silty sand, loess	10^{-5} to 10^{-7}	Low
Compact silt, siliceous clay	10^{-7} to 10^{-9}	Very low
Clay	10^{-9} to 10^{-12}	Impermeable

Conclusion:

- Classification of this soil: small gravel, coarse sand
- Permeability level: Fairly high

1.7 Conclusion

Permeability (or hydraulic conductivity) refers to the ease with which water can pass through soil. This characteristic is essential for calculating leakage through earthen embankments or beneath pile walls, estimating the leakage rate from waste storage facilities (landfills, ponds, etc.), and assessing sedimentation rates in clayey soils.