Lesson 04

Title of the Experiment: Determination of soil density and its compaction or porosity
(Activity number of the GCE Advanced Level practical Guide - 04)

Name and affiliation of the author:
Dr W A P J Premaratne
Department of Chemistry, University of Kelaniya

Introduction:

The particle density of a soil measures the mass of a soil sample in a given volume of particles (mass divided by volume). Particle density focuses on just the soil particles and not the total volume that the soil particles and pore spaces occupy in the soil. Particle density differs from bulk density because bulk density includes the volume of the solid (mineral and organic) portion of the soil along with the spaces where air and water are found. The density of soil particles is a result of the chemical composition and structure of the minerals in the soil.

Bulk density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles. Bulk density is typically expressed in g/cm^3. Bulk density reflects the soil's ability to function for structural support, water and solute movement, and soil aeration

Learning outcomes:

At the end of the experiment, students will be able to

- develop skills to obtain accurate readings
- use correct instruments and calculations
- determine the particle density and bulk density of a soil sample
- determine the compaction or porosity of a soil sample

Materials/Equipment:

a) To measure the particle density of soil

Soil sample

Galvanized tube of 10 cm height

A piece of wood

Crucible

Hammer

Oven

Electronic balance

Sharpen blade

Desiccator

b) To measure the bulk density of soil

Density bottle

Mortar and pestle

2 mm sieve

Electronic balance

Methodology/Procedure:

a) Measuring the particle density of soil

1. Measure the weight and the diameter of the galvanized tube.
2. Sharpen one edge of the galvanized tube.
3. Keep the sharpened edge of the cylinder on the ground and leave a piece of wood on the other edge. Then tap on it by a hammer.
4. Take the cylinder out when it is filled with soil and remove any excess soil on the outside of the cylinder.
5. Cover the cylinder containing the soil sample by a piece of polythene and rubber bands and bring it to the laboratory.
6. Remove the polythene cover and determine the mass of the soil and the cylinder.
7. Obtain an empty crucible and determine the mass and record. (W_1 g)
8. Add the soil sample to the crucible. Heat the sample in the crucible at 105 °C until a constant weight is obtained. (W_2 g)

b) Measuring the bulk density of soil

1. Obtain a soil sample.
2. Remove all other rough particles and take 100 g of soil and leave for air drying.
3. Break this into small pieces by using the mortar and pestle.
4. Measure the mass of a density bottle. (m_1 g).
5. Fill soil to the density bottle to the top and heat slowly in a soil bath to remove any air bubbles in the bottle and cool. Measure the mass. (m_2 g)
6. Add distilled water to the top of the density bottle when it is cooled. Measure the mass. (m_3 g)
7. Remove the soil in the density bottle, clean and fill it again with water. Measure the mass. (m_4 g)

Calculations:

a) Measuring the particle density of soil

Particle density of soil $= \frac{Mass\ of\ the\ solid\ particles\ in\ the\ soil\ (Mass\ of\ the\ dry\ soil)}{total\ volume}$

Mass of the crucible = W_1 g

Mass of the crucible + dried soil = W_2 g

Volume of the soil = $\pi r^2 h$

Particle density (ρ_b) $= \frac{w_2 - w_1}{\pi r^2 h}$

(h=10 cm as the height of the cylinder is 10 cm)

b) Measuring the bulk density of soil

Bulk density of soil $= \frac{Mass\ of\ the\ dry\ soil}{Volume\ of\ water\ equal\ to\ the\ volume\ of\ solid\ particles\ in\ the\ soil}$

Mass of the dry soil = $(m_2\text{-}m_1)$ g

True density (ρ_p) $= \frac{(m_2 - m_1)}{(m_4 - m_1) - (m_3 - m_2)}$

c) Determine the compaction (Porosity) of the soil sample (p_1) by the particle density and the bulk density

$$p_1 = \left[1 - \frac{\rho_b}{\rho_p}\right] \times 100$$

Discussions:

a) Measuring the particle density of soil

1. Measure the mass of the soil after drying in an oven and leaving to cool in a desiccator.
2. Assume the volume of the galvanized tube is equal to the volume of soil as the tube is completely filled with soil.
3. The particle density of soil varies with the way of obtaining the soil sample, type of soil, amount of organic matter in soil and hardness of soil.

b) Measuring the bulk density of soil.

1. Generally, the bulk density of soil varies from 2.3 to 3.8 g/cm^3.
2. Bulk density changes with the soil texture.

References:

Soil Sampling and Methods of Analysis *(Second Edition)* 2006, Edited by M.R. Carter and E.G. Gregorich, Canadian Society of Soil Science, Taylor & Francis Group