Lab 3

Soil Density

Density of Solids (Particle Density or Real Density) ρs

Particle density may be defined as the mass of soil solid (Ms) per unit volume of soil solid (Vs).

$$\rho s = Ms / Vs$$

$$(g.cm^{-3}), (kg.m^{-3}), (Mg.m^{-3})$$

$$1\ g.cm^{-3} = 1\ Mg.m^{-3} \qquad 1\ kg.m^{-3} = 1/1000\ g.cm^{-3}$$

The particle density of mineral soils with small percentage of organic matter (<1%) is about 2.65 $g.cm^{-3}$.

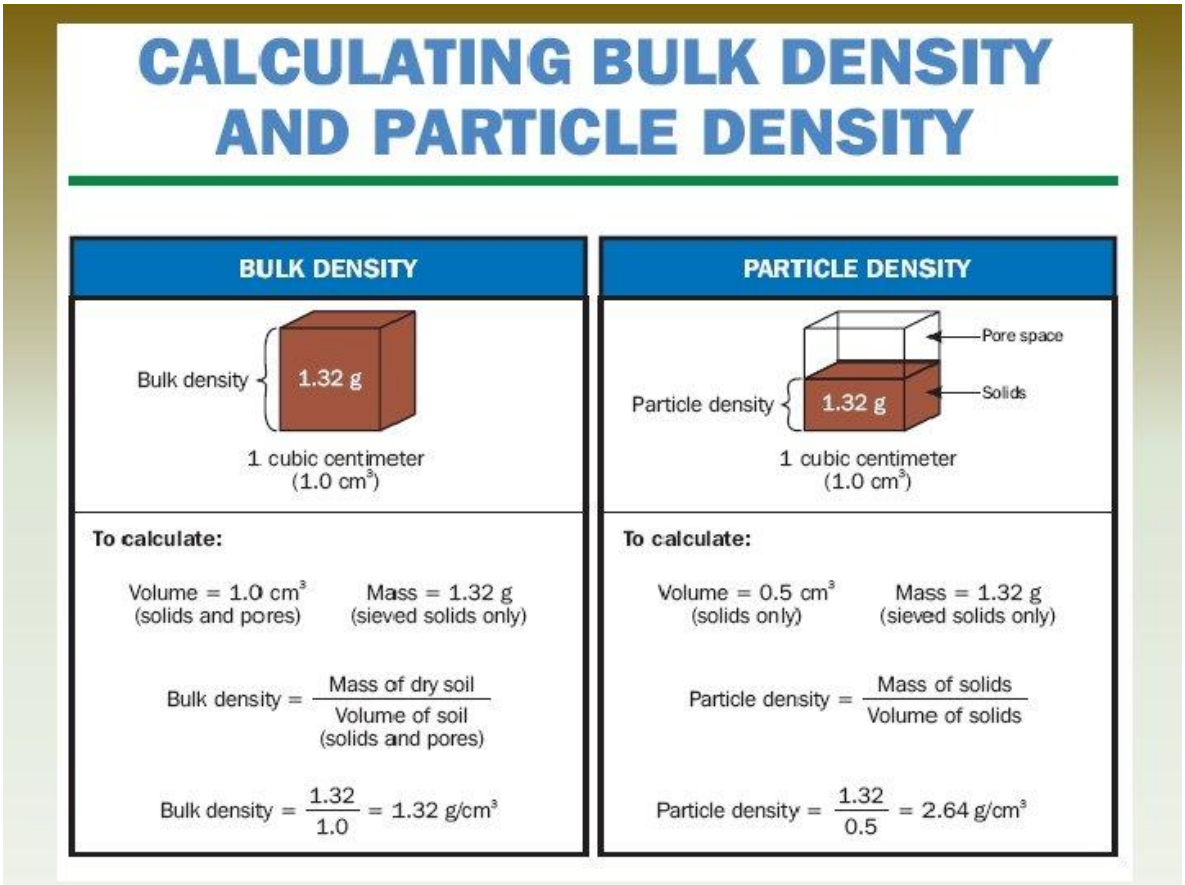
Bulk Density (ρb)

Is defined as the mass of soil solid (Ms) per unit volume of soil (Vt).

$$\rho b = Ms / Vt$$

The bulk volume of soil is the sum of the volume occupied by the soil solids (Vs) and the volume occupied by voids (Vv).

The bulk density value of an ideal soil is generally 1.33 $g.cm^{-3}$. While the **ρb** for sandy soil may be as high as 1.6 $g.cm^{-3}$, and in aggregated loams and in clayey soils it may be as low as 1.1 $g.m^{-3}$.



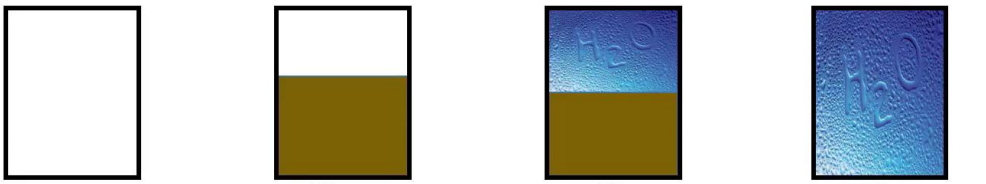
Measurement of Particle Density by pycnometer

Equipment

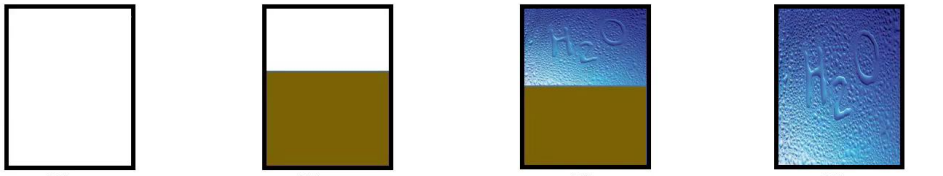
1- Pycnometer 2- Heater 3- Electronic balance 4- Distill water

Procedure :

- Series of observation involved in all density bottle, pycnometer and flask is same.
  - Empty weight of pycnometer $\boldsymbol{w_1}$.
  - Oven dry sample of soil + pycnometer $\boldsymbol{w_2}$.
  - Empty volume of pycnometer is filled with water in multiple stages simultaneous removal of air present in soil either by constant stirring or by use of vacuum at the top of pycnometer.
  - Pycnometer is being again weight after filling the empty volume with water $\boldsymbol{w_3}$.
  - Pycnometer is then completely emptied and again filled with water after cleaning properly $\boldsymbol{w_4}$.



w_1 Empty, Dry | w_2 Dry soil | w_3 Soil + water | w_4 Filled with water



w_1 Empty, Dry **(a)** | w_2 Dry soil **(b)** | w_3 Soil + water **(c)** | w_4 Filled with water **(d)**

$$G = \frac{Dry\ weight\ of\ soil\ (w_d)}{weight\ of\ water\ of\ equal\ volume\ (w_w)}$$

Weight of solid (w_d) $= w_2 - w_1$

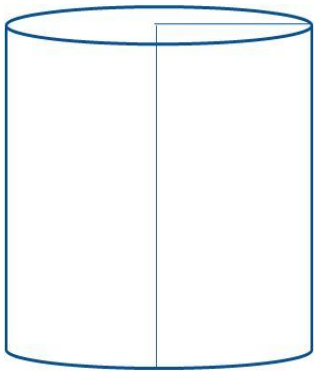
Weight of water in (c) $= w_3 - w_2$

Weight of water in (d) $= w_4 - w_1$

$$w_w = (w_4 - w_1) - (w_3 - w_2)$$

$$G = \frac{w_d}{w_w} = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)}$$

Measurement of Bulk Density by core method



Procedure:

Label the core and weight it empty (M_1).

Record the diameter and height of the core.

$$V = \pi r^2 h \quad (Vt)$$

1. Remove the plant residue and level the land.
2. Drive the core gently into the soil completely with a minimum disturbance via a core sampler or by a piece of leveled wood and hammer.
3. Excavate the soil surrounding the core to pull it easily.
4. Trim the samples with a piece of seem (wire) or knife.
5. Protect the sample from loss of moisture by pouring melted paraffin over the ends/or cover it with the cover.
6. Obtain the mass of the moist soil with core (M_2).
7. Oven dry the sample at 105^0C overnight (24 hrs).
8. Obtain the dry mass of the soil with core (M_3).

$$\text{Bulk density}(\rho b) = \frac{M_3 - M_1}{V_t}$$

Example 1

A soil is sampled by a core measuring 7.6 cm in diameter and 7.6 cm deep. The core weighs 300 g. The total core plus wet soil weight is 1000 g, on oven drying at 105° C the core plus dry soil weighed 860 g. Calculate wet and dry bulk densities and gravimetric moisture contents.

Solution

Total volume of core = $\pi r^2 h$ = 3.14 (3.8 cm^2) *7.6 cm=345 cm^3

Core weight = 300 g

Weight of wet soil = 1000 g − 300 g = 700 g

Weight of dry soil = 860 g − 300 g = 560 g

bulk density (Ms / Vt) = 560 g / 345 cm^3 =1.62 g/cm^3

Gravimetric moisture content (w) = Mw / Ms= (1000 g − 860 g) / 560 g

= 140 g / 560 g = 0.25 or 25%

Example2:

1. Calculate particle density of a soil from the following data:
Weight of empty pycnometer w_1 = 50 g
Weight of the dry soil + pycnometer w_2 = 270g
Weight of soil and water + Pycnometer w_3 =352 g
Weight of pycnometer filled with water w_4 = 215 g

Solution:

ρs = Ms / Vs $\qquad \boldsymbol{\rho s} = \dfrac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$

Ms = (w_2 – w_1) = (270-50) = 220 g
Vs = Volume of displaced water
Weight of displaced water = (w_4 –w_1) – (w_3– w_2)
= (215-50) – (352 – 270)
= (165) – (82)
83 gm

ρs = 220/83 = 2.65$gm.cm^{-3}$