Chapter - 3

Index properties of Soil

3.1 Water content

3.2 Specific gravity

3.3 Particle size distribution; sieve analysis, wet mechanical analysis, particle size distribution and its uses.

3.4 Consistency of soils, Atterberg's limits, plasticity index, consistency index, Liquidity index.

3.1 Water Content :-

- This is the first test to be conducted after taking a soil sample because the water content will changes during transportation and storage also.
- water content of soil is an important soil parameter which influences the soil behaviour, particularly of cohesive soil.
- It can be measured accurately because it is based upon mass only (i.e mass can be measured accurately than vol).

$$w = \frac{W_w}{W_s}$$

- It is important parameters used to classify the soil; to find out dry unit wt, also for consistency limits etc,

methods

(1) Oven drying method
(2) Torsion balance method
(3) Pycnometer method
(4) Sand bath method
(5) Calcium carbide method.

Oven Drying Method

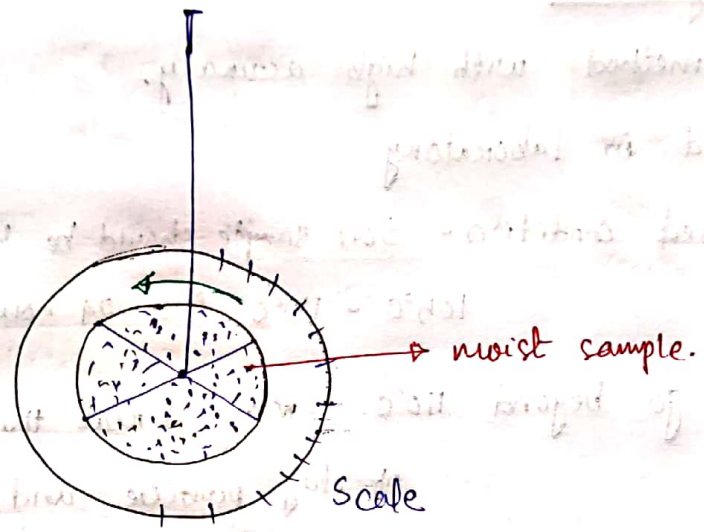
- ✓ Easiest method with high accuracy.
- ✓ Performed in laboratory
- ✓ Pre-defined condition - Soil sample should be heated in an oven upto 105°C - 110°C for 24 hours.
- ✓ If we go beyond 110°C - may break the crystalline structure of clay particle and result in loss of chemically-bound water of crystalisation.
- ✓ For organic soil sample - temp 60°C - 80°C.
  If we go beyond 80°C - organic matter may get oxidised.
  (So we need to take care of these things).
- ✓ Readings - W_1 – weight of container
  W_2 – weight of container + weight of moist sample.
  W_3 – weight of container + dry sample after oven drying.

$$w = \frac{W_w}{W_s}$$

$$\boxed{w = \frac{W_2 - W_3}{W_3 - W_1} \times 100}$$

Torsion Balance Method :

- ✓ Device used – Torsion balance Moisture meter for quick determination of moisture content.
  - Infraced lamp having greater penetration of heat to heat up the sample.

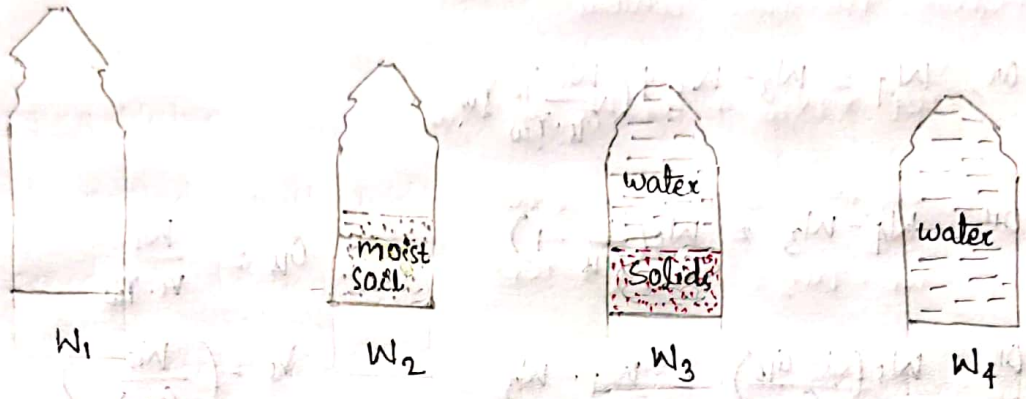


- ✓ First give rotation (torsion) accurately to an extent equal to 100 percent of scale reading. Due to moist sample rotation will stop. Then heat up the sample - moisture loss will take place. Then again torsion balance will rotate back. From the scale we can know the moisture content.

Pycnometer Method :-

- ✓ Quick laboratory method compared to other two method.
- ✓ If we know the specific gravity (G_s) of soil we use this method. more suitable for cohesionless soil.

- Pycnometer - approximately 900 ml capacity glass bottle, conical top.
  - Conical cap provided with a 6 mm dia hole at the top.
  - Rubber washer provided - to avoid leakage of water.



W_1 - empty pycnometer reading.

W_2 - weight bottle plus moist sample

W_3 - weight of bottle + soil + water (air should be removed completely by shaking / by using vacuume)

W_4 - weight of bottle + water.

as we know, $w = \frac{W_w}{W_s} \times 100$

$W_w = W_2 - W_1 - W_s$; where W_s = weight of dry sample.

So, $w = \frac{W_2 - W_1 - W_s}{W_s} \times 100$

$$w = \left(\frac{W_2 - W_1}{W_s} - 1 \right) \times 100$$

from W_3 the weight of solids W_s could be removed and replaced by the weight of an equ. vol of water, the W_4 would be obtained

$$W_4 = W_3 - W_s + (V_s \cdot \gamma_w)$$

$$\text{or, } W_4 = W_3 - W_s + \left(\frac{W_s}{G_s \cdot \gamma_w}\right) \cdot \gamma_w$$

$$\text{or, } W_4 - W_3 = W_s\left(\frac{1}{G_s} - 1\right) \qquad G_s = \frac{W_s}{V_s \cdot \gamma_w}$$

$$\text{or, } W_s\left(\frac{1-G_s}{G_s}\right) = W_4 - W_3 \qquad V_s = \left(\frac{W_s}{G_s \cdot \gamma_w}\right)$$

$$\text{or, } W_s = (W_4 - W_3)\left(\frac{G_s}{1-G_s}\right)$$

$$\text{or, } W_s = (W_3 - W_4) \cdot \frac{G_s}{G_s - 1}$$

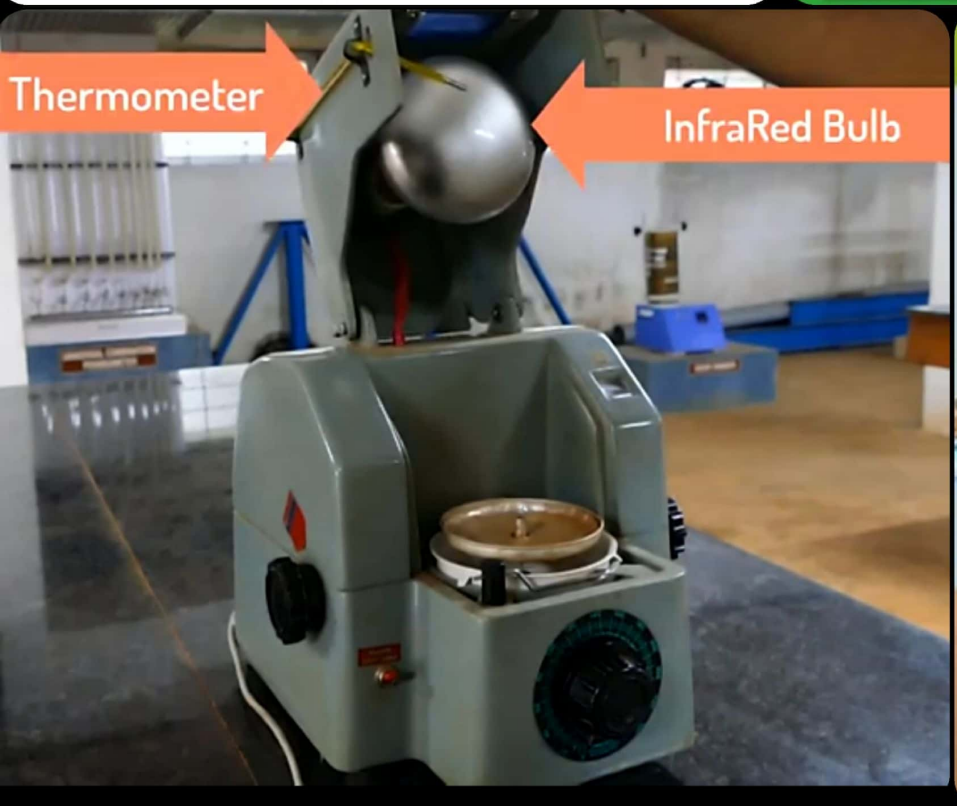
$$\text{So } w = \left[\frac{W_2 - W_1}{(W_3 - W_4)\frac{G_s}{G_s - 1}} - 1\right] \times 100$$

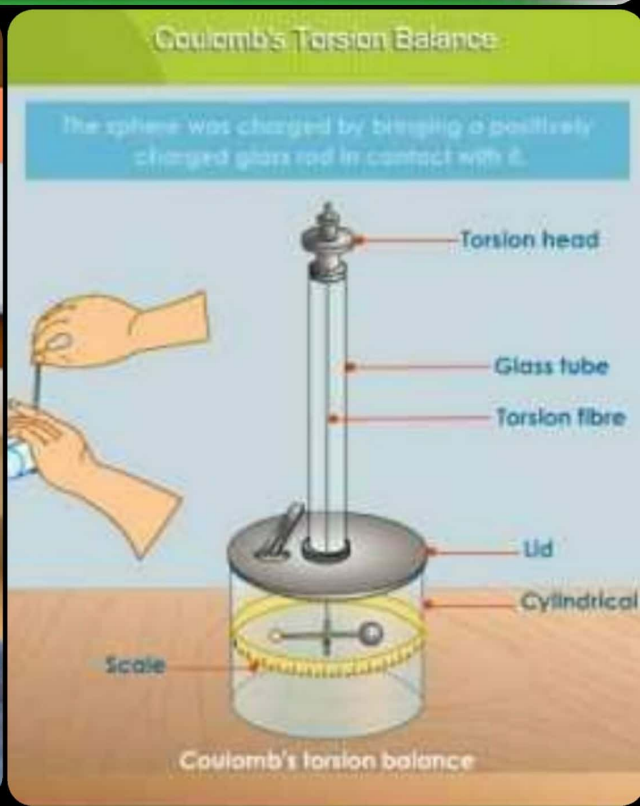
$$\boxed{w = \left[\frac{(W_2 - W_i)}{(W_3 - W_4)} \times \left(\frac{G_s - 1}{G_s}\right) - 1\right] \times 100} \quad \text{V. imp}$$

Sand Bath Method:

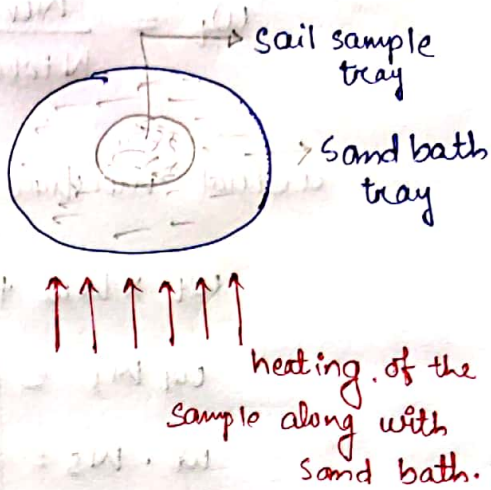
- Quick field method
- material required - Sand bath, container, heating equipment, spatula, small tools.

Pycnometer Bottles





- Sand bath - just a container which is filled with 3cm of sand to supply uniform heating.



- To avoid the over heating put a white paper on the soil sample. If the paper is turning to brown colour, the sample is over heated.
- heating 20 min - 60 min
- moisture content $w = \frac{W_{initial} - W_{dry\ sample}^{final}}{W_{final} - W_{tray}}$

Calcium carbide method

- Field method
- Instrument used Rapid moisture meter, which works on the principle of "calcium carbide, introduced in the weighed quantity of sample (5g) reacts with the free moisture in the sample and releases acetylene gas. The amount of gas released depends upon the amount of free moisture in contact with reagent."
- have to measure the pressure of the gas on the container.

$$CaCO_2 + 2H_2O \longrightarrow \underset{\text{acetylene}}{C_2H_2\uparrow} + Ca(OH)_2$$

- It is calibrated in such a way that pressure reading will directly gives the moisture content.

- This moisture content is the bulk moisture content.

$$\omega_t = \frac{W_{cv}}{W_{total}} = \frac{W_w}{W_w + W_s}$$

actual moisture content.

$$\omega_t \times W_w + \omega_t W_s = W_w$$

$$\omega_t W_s = W_w - \omega_t W_s$$

$$\omega_t \cdot W_s = W_w (1 - \omega_t)$$

$$\frac{W_w}{W_s} = \frac{\omega_t}{1 - \omega_t}$$

OR, $\boxed{\omega_{actual} = \frac{\omega_t}{1 - \omega_t}}$