Soil Mechanics (Solids & water are assumed to be incompressible)

- Father of Soil Mechanics : Karl Terzaghi

opics :

- Origin of Soil & Soil water relationship
1. Classification of Soil
3. Clay minerals
4. Soil compaction
5. Effective stress & seepage through soils
6. Vertical stress
7. Consolidation
8. Shear strength of soil
9. Earth Pressure theories
10. Stability of slopes
11. Foundation.
    a) Shallow foundation
    b) Deep foundation.
12. Soil exploration
13. Expansive Soils

1. Origin of soil & Soil water relationship

∴ Rock + Organic matter = Soil

→ Soil is composed of particles found from the disintegration of rocks. The void spaces between the particles may contain air, water, (or) both.

→ The soil particles may contains organic matter.

→ Formation of soil particles takes place by 2 processes
  a) Physical weathering
  b) Chemical weathering

a) Physical weathering :-

→ Physical weathering processes are,
  i) Errosion of rock by wind, water, glaciers etc & penetration of plant roots
  ii) Disintegration of rocks due to alternate freezing, thawing ~~cycles~~.

→ Soils so formed retain the minerals, that were present in the parent rock.

→ Soils so formed are coarse grained soil, ex:- sand & gravel

→ The shape may be angular, subangular, subrounded (or) rounded.

→ Soils so formed does not have bond between the particles and hence they are said to have single grained structure.

b) Chemical weathering :-

→ It occurs due to chemical action of acids & Alkalis present in water, Air & Glaciers.

→ Chemical action leads to formation of crystalline particles of small size (<2μ), known as "Clay minerals".

→ The identity of these minerals are different from that of the parent rock

→ Clay minerals have plate like structure having large specific surface (Specific surface area is, $\frac{\text{Surface area}}{\text{unit mass (or) unit volume}}$).

→ Thus surface bonding forces are more predominant in these soils.

→ Presence of water in the soil is so formed influences their engineering properties significantly.

→ Residual & Transported Soils :-

→ Soils that remain at the location of its formation are called "Residual soils". While soils that are transported from its place of origin by wind, water, (or) glaciers are called "Transported Soils".

Note :-

→ Residual soils have better engineering properties as compare to the Transported soils.

→ According to the transporting Agency, the soils are classified as follows

i) Alluvial Deposit → deposited by rivers

ii) Lacustrine Deposit → deposited by still water of lakes

iii) Marine Deposit → deposited by sea water

iv) Aeolian Deposit → deposited by wind (these deposits has large permeability)
ex:- Loess → Pores & friable (easily crushable).

v) Glacial Deposit → deposited by glaciers
ex:- drift, till, (or) Outwash

vi) Colluvial Deposit → Transported by gravity
ex:- Talus → found at foot of hills.

⇒ Various types of soils :-

. Bentonite clay :-

→ Bentonite has high percentage of clay minerals called "mont morillonite".

→ This soil is highly plastic, high water absorption property, high swelling & shrinkage potential.

› It is formed due to decomposition of Volcanic Ash.

› It is used as drilling mud.

:. Black Cotton soil :-

› This soil also contains high percentage of mont morillonite minerals and has high swelling and shrinkage potential.

→ It is has very low bearing capacity.

→ It is formed from the chemical weathering of Basalt (or) trap [Igneous rock].

› It is generally dark in colour and cotton grows on this soil easily.

Hence the name "Black cotton soil".

: Loam :-

→ It is the mixture of sand, silt and clay and it is also called "Garden soil".

∴ Indurated clays :-

→ The hardening of clay due to heat & pressure

Note:-

ithification :-

→ It is the process of conversion of unconsolidated deposits into hard rocky mass by compaction and cementation.

5. Organic soils :- (or Organic clays)

→ The other mode of soil formation is decomposition by Bacteria etc, of the vegetable matter, plants etc. These leads to the formation of organic soil (or) clay.

→ These soils have a characteristic odour and colour. It is also called "Cumulose soils".

Ex:- Muck, Peat & Humus

a) Muck → Inorganic + organic matter

b) Peat → full decomposed organic matter. It is fabrious and highly compressible.

c) Humus → top soil, it contains partly decomposed organic matter.

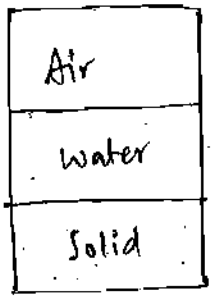
Note:-

→ Organic soils have poor engineering properties.

⇒ Soil Water relationship :-

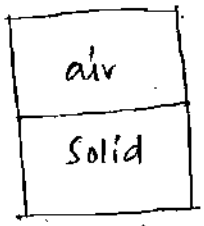
→ Phase System :-

a) Three Phase System :-

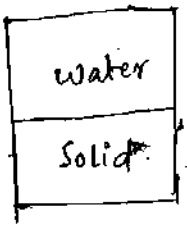


* Partially saturated condition.

b) Two Phase System :-



* Dry condition



* Saturated condition

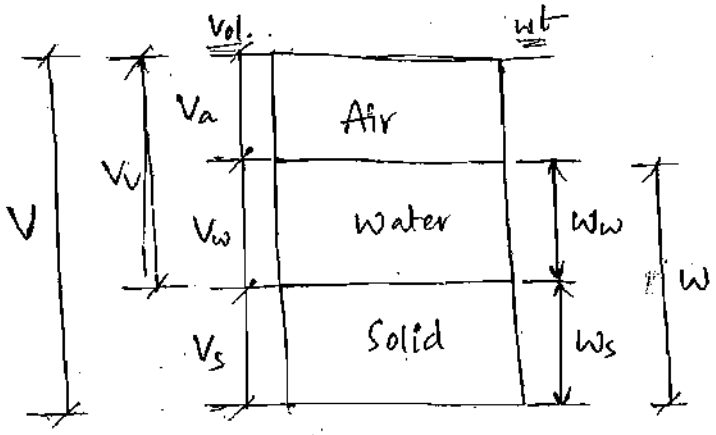
→ Soil mass is generally a three phase system composed of soil solids, water & air.

→ Thus soil can be completely dry (or) completely saturated, in that condition soil is represented by Two phase system.

Note:-

→ A frozen soil = Solids + Ice + water + air has 4 phases.

→ Simple Definitions :-



Where, $W_s \rightarrow$ wt. of solids

$W_w \rightarrow$ wt. of water

$W \rightarrow$ Total wt. of soil

$W = W_s + W_w$

$V_s \rightarrow$ Volume of solids

$V_w \rightarrow$ Volume of water

$V_a \rightarrow$ Volume of air

$V_v \rightarrow$ Vol. of voids

$V_v = V_w + V_a$

$V \rightarrow$ Total volume of soil.

$V = V_v + V_s = V_a + V_w + V_s$

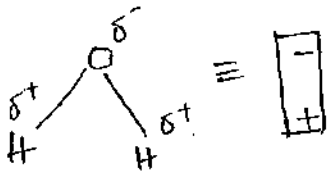
1) Water content (w) :-

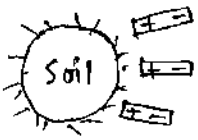
$$\boxed{w = \frac{W_w}{W_s} \times 100} \quad (\%) \quad \& (w \geq 0)$$

$\therefore w \geq 0 \rightarrow$ minimum value of water content is "0" & there is no upper limit.

→ water content of fine grained is more than that of coarse grained soil

→ clay particles has negative charge on its surface, to this -ve charge water dipole gets attach, thus the retension capacity of water is more in fine grained soil.





ii) Void ratio (e) :-

$$e = \frac{V_v}{V_s} \quad \& (e > 0)$$

→ $e > 0$ → Since soil has to contain some voids but there can be no upper limit to void volume.

→ The individual void sizes are larger in coarse grained soil, but the void ratio of fine grained soil is generally larger than that in the coarse-grained soil.

$$\left.\begin{array}{l} e \text{ of clay} > 0.8 \\ 0.5 < e \text{ of sand} < 0.7 \end{array}\right\} \text{generally.}$$

iii) Porosity (n) (or) %age voids :-

$$n = \frac{V_v}{V} \quad \& \ (0 < n < 1)$$

iv) Degree of saturation (S) :-

$$S = \frac{V_w}{V_v} \quad \& \ (0 \leq S \leq 1)$$

$S = 0$ in dry condition

$S = 1$ in saturated condition.

i) Air content (a_c) :-

$$\boxed{a_c = \frac{V_a}{V_v}} \quad \& \; (0 \le a_c \le 1)$$

$$\rightarrow \boxed{a_c = 1 - S}$$

i) % age air voids (n_a) :-

$$\boxed{n_a = \frac{V_a}{V}} \quad \& \; (0 \le n_a < 1)$$

$\rightarrow$ $n_a = 0$ in saturated condition.

$\rightarrow$ $\boxed{n_a = a_c n}$.

ii) Bulk unit wt. (γ_t) :-

$$\boxed{\gamma_t = \frac{W}{V} = \frac{\text{wt. of soil}}{\text{Vol. of soil}}}$$

iii) Unit wt. of water (γ_w) :-

$$\boxed{\gamma_w = \frac{W_w}{V_w}}$$

$\rightarrow$ $\gamma_w = 9.81\ KN/m^3$ for $g = 9.81\ m/sec^2$

$\rightarrow$ $\gamma_w = 10\ KN/m^3$ for $g = 10\ m/sec^2$

iv) Unit wt. of solids (γ_s) :-

$$\boxed{\gamma_s = \frac{W_s}{V_s} = \frac{\text{wt. of solids}}{\text{Vol. of solids}}}$$

v) Dry unit wt. (γ_d) :-

$$\boxed{\gamma_d = \frac{W_s}{V} = \frac{\text{wt. of solids}}{\text{Vol. of soil}}}$$