

SOIL ENGINEERING



By- JASPAL SINGH
Ex-IES

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SOIL MECHANICS & FOUNDATION ENGINEERING

- The Process of formation of Soil is termed as 'PEDOGENESIS'.
- Soil is formed due to the weathering of Rocks.
 - ↳ Erosion/wear & Tear
- Weathering of the Soil Can Occur either Physically ^{↳ Mechanical} or Chemically ^{↳ Disintegration}.
- Weathering of Rocks can be done by —
 - a. Physical**
 - Prepack or Grinding of Water, air, Ice or Wind.
 - Splitting action of ice.
 - Gravitational force.
 - Plants and Animals.
 - b. Chemical**
 - Oxidation
 - Reduction
 - Carbonation
 - Hydration
 - Leaching by Organic acid and H₂O.



Note :- Leaching is the process of extracting a Substance from a Solid material, i.e. dissolved in a liquid.

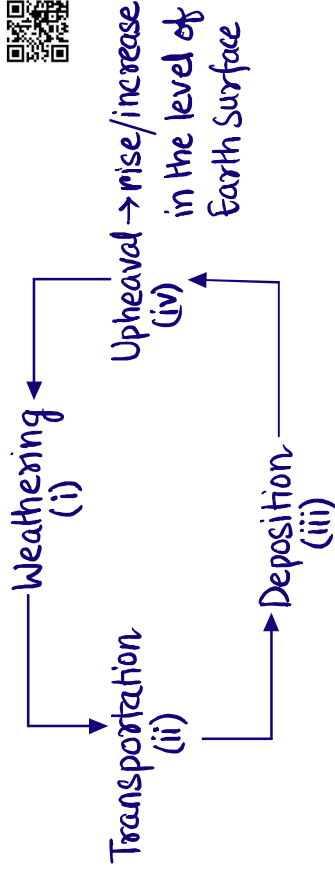
- If the Soil is formed by physical weathering, there is no change in mineral Content of the Soil but if its formed by Chemical Weathering mineral Content of Soil differs from that of rock.
- If the weathered material retains over the Parent rock, it is termed as residual Soil & if it is transported it is termed as transported Soil.
- The characteristics of the Soil • Size of Particle, Shape & Soundness, Surface texture, degree of Sortness depends upon mode / agency of transportation.

Solid Particles → ◻
Angular → ☼



Properties	Water	Air	Ice	Gravity	Organism
-Size	Reduction	Considerable Reduction	Considerable grinding and Impact	Considerable Impact	Minor Abrasion
-Shape & Roundness	Rounding off Sand & Gravel	High degree of Rounding	Angular Solid Particles	Angular, Non-Spherical Particle	—
-Surface Texture	Smooth, Silty, Polished	Impact Produces Frosting Surface	Striated Surface	Striated Surface	—
-Sorting	Considerable Sorting	Considerable	Very little Sorting	No Sorting	Limited Sorting

— General Cycle involved in the formation of Soil,



•• Types of Soil :

— On the basis of mode of transportation.

a. Alluvial Soil: It is the Soil which is deposited from Suspension in Running Water.

— Transported Soil (Water)

— Weathering is Physical.

— Found Along the bank of river.

b. Lacustrine Soil: It is the Soil which is deposited from Suspension in fresh Still water of Lake.

c. Marine Soil: It is the Soil which is deposited from Sea water.

d. Aeolian Soil/Sand dunes: It is the Soil which is transported by blowing wind.


e. Glacial Soil: It is the Soil which is transported by Ice.

f. Colluvial/Talus Soil: It is formed due to transportation  by Gravity.

g. Loess Soil: It is Uniformly graded wind blown Silt, Silty highly Cemented by Calcium Compound or Montmorillonite. It is also termed as Collapsible Soil.

h. Marl Soil: It is finely grained Calcium Carbonate Soil of Marine Origin which is formed due to the decomposition of plants & bones of Aquatic Animals.

i. Tuff Soil: A fine grained Slightly Cemented Volcanic ash transported by wind or water.

j. Bentonite Soil: It is Chemically weathered volcanic ash. It consist of high % of Montmorillonite. It is residual Soil.  It is highly plastic posses high shrinkage and Swelling prop. & low Shear Strength. -It is used as lubricants drilling Operations.

k. Black Cotton Soil: It is residual Soil formed from Basalt & have excess of Montmorillonite in it. It is dark in Colour & is Suitable for growing Cotton.

l. Laterite Soil: It is the type of Soil formed due to leaching (Washing out of Silicious Compound & deposition of Fe_2O_3 & Al_2O_3). It is found in hilly Areas.

m. Muck Soil: It is a mixture of fine Particle inorganic Soil & Black decomposed Organic matter. -It is found in Marshy/Swampy/after the Overflow of river.

n. Peat Soil: It is highly Organic Soil which almost entirely consist of black decomposed Vegetative matter in different Stages. It is highly fibrous, Compressible.

Note: Muck Soil + Peat Soil \longrightarrow Cumulose Soil Found Near the river. 

o. Loam Soil: It is a mixture of Clay, Sand & Silt.

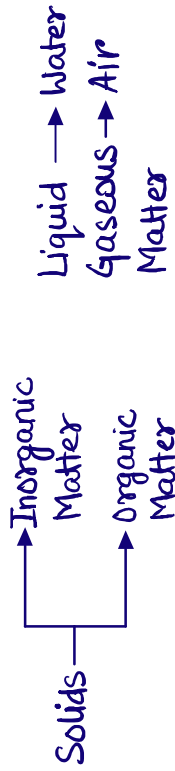
p. Gumbo Soil: It is a black Coloured, Sticky, highly Plastic Soil. -It Can be formed either by Physical weathering or

by Chemical Weathering.



•• PROPERTIES OF SOIL

— Soil is a 3-Phase System which consists of Solid, liquid and gaseous matter that do not occupy separate spaces but are blended with each other in definite proportion, which in turn governs the property of soil.



$\Rightarrow V = V_v + V_s$
 $V = (V_a + V_w) + V_s$
 $W = W_v + W_s$
 $W = (W_a + W_w) + W_s$

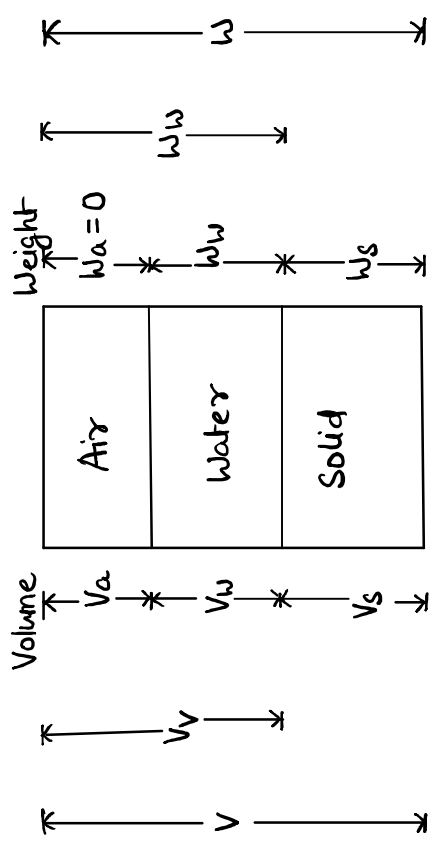
$\rho_{air} \approx 1.2 \text{ Kg/m}^3$
 $\rho_{water} \approx 1000 \text{ Kg/m}^3$
 $\rho_{solids} \approx 2600 \text{ Kg/m}^3$

$W_{air} \ll W_w \text{ or } W_s$
 Hence, it can be neglected
 $V_{air} \ll V_w \text{ or } V_s \rightarrow$ but
 Volume of air cannot be neglected.



$W_{soil} = W_w + W_s$
 but,
 $V_{soil} = V_w + V_s$

→ In some limiting case, it can be represented as a 2-phase system also.



•• PROPERTIES OF SOIL

1. Water Content (w): It is defined as the weight of water to the weight of solids present in the given soil mass.

$w = \frac{W_w}{W_s} \times 100$

— Water content can be equal to zero but it has no upper limit.

$$w = \frac{W_s}{W_w} \Rightarrow w+1 = \frac{W_s}{W_w} + 1$$

$$\Rightarrow w+1 = \frac{W_w + W_s}{W_s} = \frac{w'}{w_s} \quad **$$

$$w_s = \frac{w'}{1+w} \quad **$$

w' → weight of Soil.

— Water Content can also be Reported in terms of the total weight of the Soil.

$$w'' = \frac{\text{Weight of Water}}{\text{Weight of Soil}} = \frac{W_w}{w'} \times 100$$

— w'' can be equal to zero but cannot be equal to 100 %.

$$0 \leq w'' < 100 \%$$

$$w'' = \frac{W_w}{w'} = \frac{W_w}{W_w + W_s} = \frac{w_w/w_w}{w_w/w_w + w_s/w_w}$$

$$w'' = \frac{1}{1 + 1/w} = \frac{w}{1+w}$$

$$w'' = \frac{w}{1+w} \quad **$$

$$w = \frac{w''}{1-w''} \quad **$$



Note: Weight of Solid is comparatively stable in comparison to weight of Soil as it does not change with change in water, hence engineering significance of ' w' ' is more than ' w'' '.

2. Void Ratio (e): It is defined as the ratio of Volume of Voids to Volume of Solids in given Soil mass.



$$e = \frac{V_v}{V_s} \quad ** \quad e > 0$$

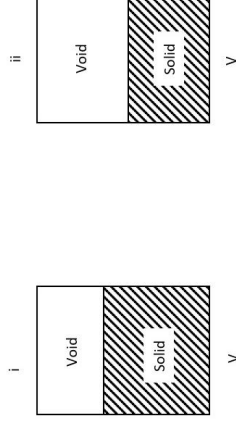
— Volume of Void cannot be zero for Soil as it is a 2-phase system, however it can be zero for Rocks.

$$e = \frac{V_v}{V_s} \Rightarrow e+1 = \frac{V_v}{V_s} + 1$$

$$\Rightarrow e+1 = \frac{V_v + V_s}{V_s} = \frac{V}{V_s}$$

$$V_s = \frac{V}{1+e} \rightarrow \text{Volume of Soil.}$$

— Void ratio can also be used to represent degree of denseness of Soil.



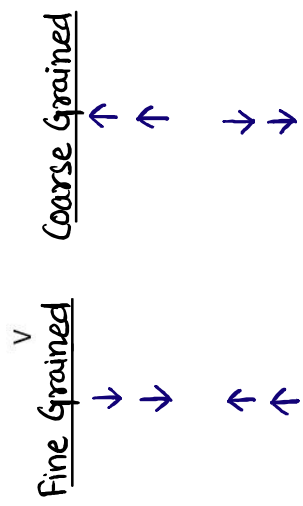
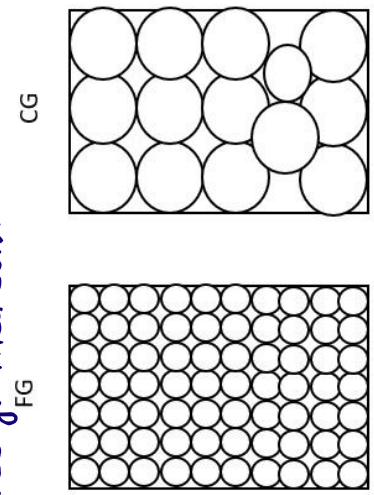
- $e_2 > e_1$
- $V_{v2} > V_{v1}$
- $V_{s2} < V_{s1}$

$$(Denseness)_2 < (Denseness)_1$$

**

$$e \propto \frac{1}{Denseness}$$

- Though Volume of one void is more for coarse grained but total Volume of Voids is more for fine grained Soil, hence Void ratio & water Content of fine grained Soil is more than Coarse grained soil.



- When 2 or more Soil Samples are added or mixed, Quantity (Vol. & wt.) of Solids will not Change.

$$A + B \longrightarrow C$$

$$V_{SA} \quad V_{SB} \quad V_{SC}$$

$$W_{SA} \quad W_{SB} \quad W_{SC}$$



- Quantity (wt. & Volume) of Solids remains same if Soil is displaced from one to another location.

Q.1)

<u>Soil A</u>	<u>Soil B</u>
W 1 Kg	1 Kg
W 100 %	50 %

Find Water Content of Soil 'C' if A+B → C

Ans: $W_{SA} = \frac{1}{1+1} = 0.5 \text{ Kg} = \frac{2}{3} \text{ Kg}$

$W_{SB} = \frac{10}{15} = \frac{2}{3} \text{ Kg}$

$$W_{SC} = W_{SA} + W_{SB} = 0.5 + 0.67 = 1.17 \text{ Kg}$$

$$1.17 = \frac{2}{1+W}$$

$$1+W = 1.709$$

$$W = 0.709 = 70.9 \%$$

Q.2) Soil A + Soil B = Soil C

V	1 m ³	1 m ³	?
e	1	2	?



Find e_c ?

Ans: $V_{SA} = \frac{1}{1+1}$

$$\frac{V_c}{1+e_c} = \frac{V_A}{1+e_A} + \frac{V_B}{1+e_B}$$

$$1+e_c = \frac{6}{5}$$

$$\Rightarrow e_c = \frac{6}{5} - 1$$

$$e_c = 0.2$$

3. Porosity (n): It is defined as the ratio of Volume of Voids to the Volume of Soil present in the given Soil mass.

$$n = \frac{V_v}{V} \times 100 \quad ** \quad 0 < n < 100\% \quad **$$

$$n = \frac{V_v}{V} = \frac{V_v}{V_v + V_s} = \frac{V_v/V_v}{V_v/V_v + V_s/V_v} = \frac{1}{1+1/e} = \frac{e}{1+e}$$