Soil Mechanics

Chapter # 1

INTRODUCTION TO SOIL MECHANICS AND ITS TYPES

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Chapter Outlines

- Introduction to Soil Mechanics , Soil and its Constituents
- Weathering of Rocks
- Soil and its Types

Soil Mechanics (Definitions)

- Soil Mechanics is defined as the branch of engineering science which enables an engineer to know theoretically or experimentally the behavior of soil under the action of;
  1. Loads (static or dynamic),
  2. Gravitational forces,
  3. Water and,
  4. Temperature.

- Simply speaking it is the knowledge of engineering science , which deals with properties, behavior and performance of soil as a construction material or foundation support.

Soil Mechanics (Definitions)

- Terzaghi, a famous scientist defines soil mechanics as follows, Soil Mechanics is the application of **Laws of Hydraulics** and **Mechanics** to engineering problem dealing with sediments and other unconsolidated accumulations of solid particles produced by Mechanical and Chemical Disintegration of rocks.

Soil Mechanics (Explanation)

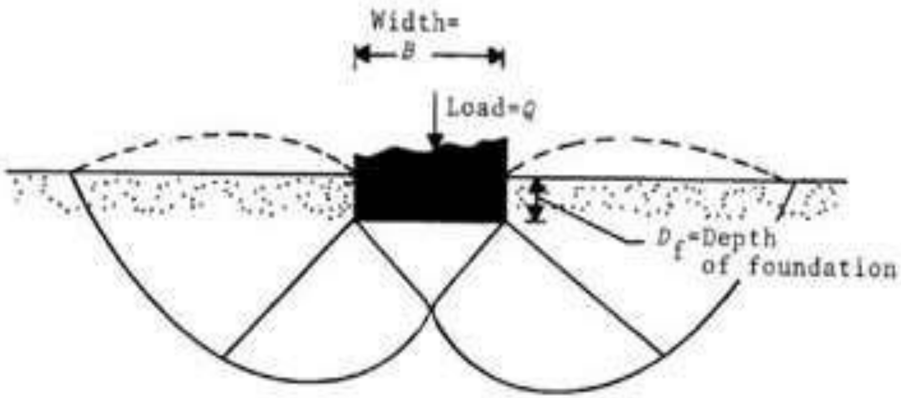
- With the recent advances in the science of Engineering, the design and execution of large projects, which at times were considered beyond imagination and control, have now become quite common. Sky scrapers, subways, maritime and off shore structures, dams and bridges spanning the sea are some examples of large projects.
- For the design and construction of almost all such projects the engineers have to deal with both soil and rock, either as construction material or as a foundation support.

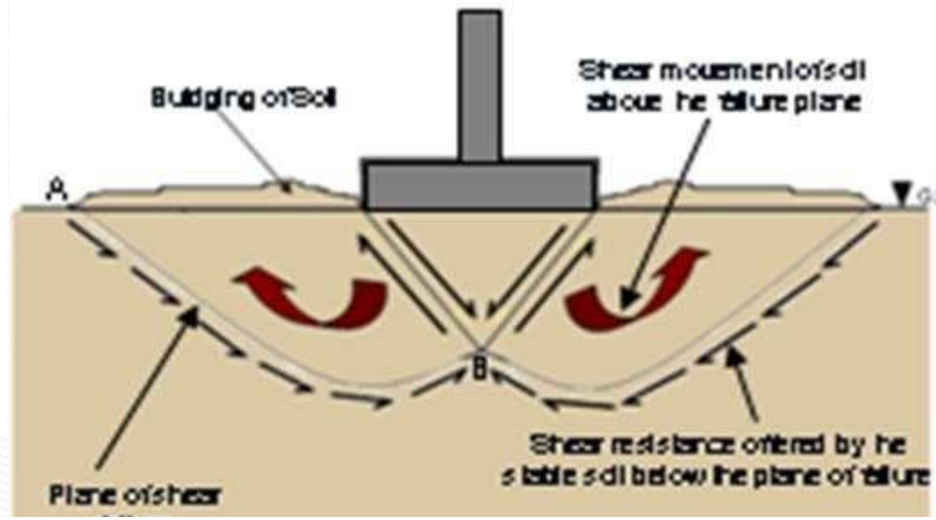
Why we study Soil Mechanics?

- Various reasons to study the properties of Soil:
  1. Foundation to support Structures and Embankments
     - Effects of static loading on soil mass
       - Shear failure of the foundation soil
       - Settlement of structures
     - Stability criteria (Solution)
       - There should be no shear failure of the foundation soil.
       - The settlement should remain within permissible limits.

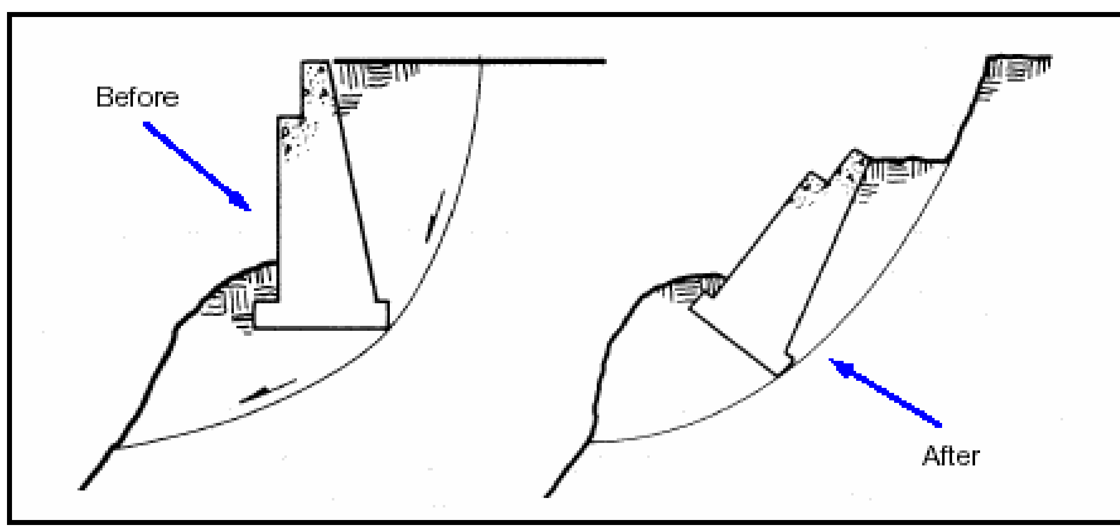
     - Firm Soil -> Spread Footing (Spread Foundation)
     - Soft Soil -> Pile Foundation (Vertical members transferring load of structure to ground i.e. rock)

Why we study Soil Mechanics?





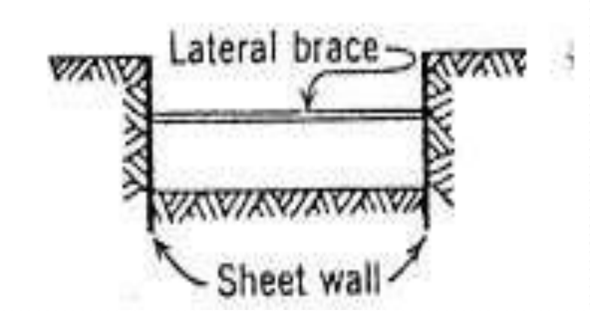
Examples:
Shear Failure of Soil



Why we study Soil Mechanics?

- Various reasons to study the properties of Soil:

1. Slopes and Landslides
   - Major cause is the moisture variation resulting in;
     - Reduction of shear strength
     - Increase of moisture
     - Increase in unit weight
   - Excavation of trenches for buildings require braced excavation.



Why we study Soil Mechanics?

- Various reasons to study the properties of Soil:
  2. Earth Retaining Structures
     - Earth retaining structure (e.g., Retaining walls) are constructed to retains (holds back) any material (usually earth) and prevents it from sliding or eroding away.

Why we study Soil Mechanics?

- Various reasons to study the properties of Soil:

3. Special Problems

   i. Effects of river water on soil mass

      a) Scouring

Causes:

- Increased flow velocity due to obstruction
- Fineness of river bed material

Stability criteria:

- The foundation of pier must be below the scour depth

   ii. Land Erosion

Why we study Soil Mechanics?

- Various reasons to study the properties of Soil:

5. Special Problems

iii. Effects of frost action on soil mass

- Reduction Of Shear Strength
- Settlement Of Structure In Summer
- Lifting Up Of Structure In Winter

Causes:

- Heaving (due to formation of ice lenses)
- Increase of moisture due to thawing (MELTING)

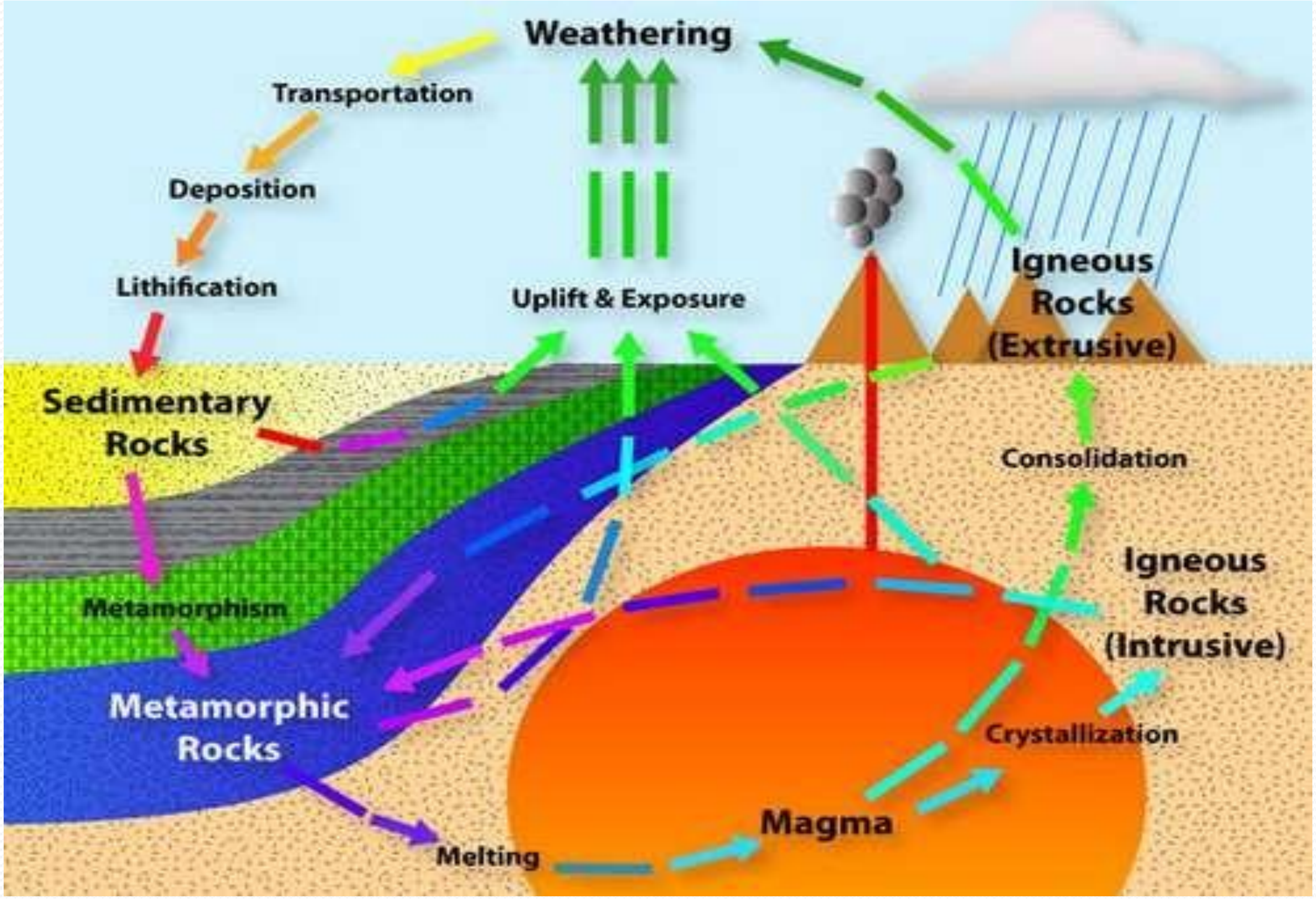
Objectives of Soil Mechanics

- Perform Engineering Soil Surveys
- Develop suitable Soil Sampling Devices and Methods
- Develop suitable Soil Testing Devices and Methods
- Determine Physical Properties of Soil
- Evaluation and Interpretation of Test results and their application to the use of soil as foundation support
- Behavior of Soil under Loads and Forces
- Adopt suitable Soil Conservation Techniques
- Sedimentation Control of Dam Reservoirs
- Select site for disposal of solid waste (i.e land fills) and to deal with their Design, Operation and Post Completion Problems of Landfills

Weathering of Rocks

- Physical Weathering
- Chemical Weathering
- Rock Cycle

Weathering of Rocks



Weathering of Rocks

- Weathering is the process of breaking down rocks by physical and chemical process into smaller particles.

- There are two main types of weathering processes:
  - Physical (or mechanical) Weathering
  - Chemical Weathering

- Biological weathering is caused by activities of living organisms - for example, the growth of roots or the burrowing of animals. Tree roots are probably the most occurring, but can often be by animals!

Physical Weathering

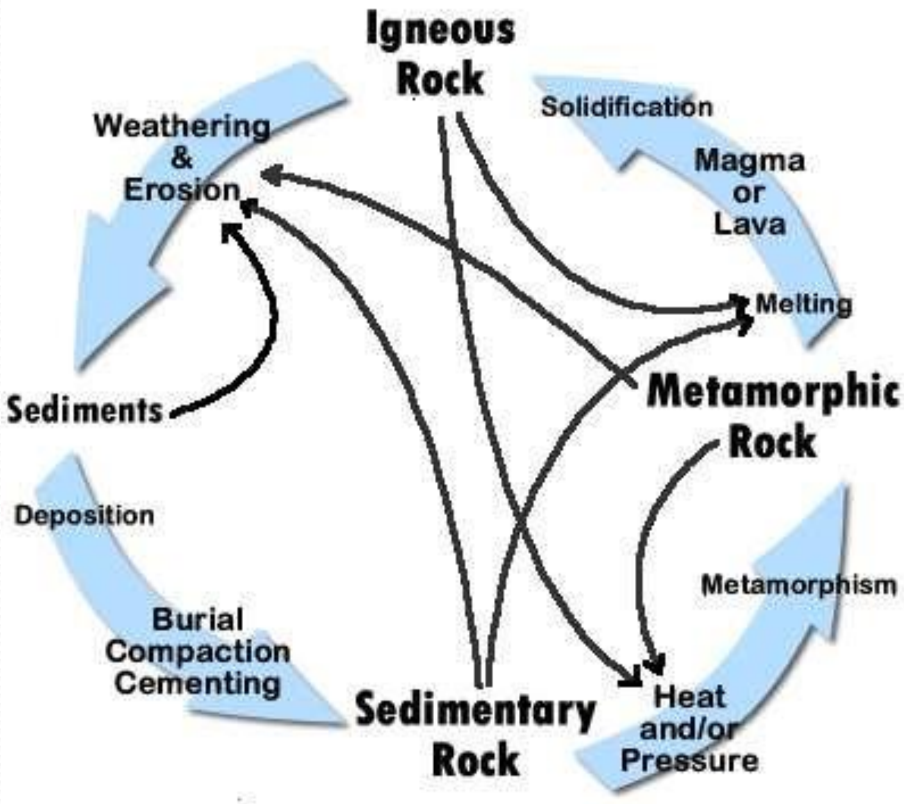
- Physical (or mechanical) Weathering is the disintegration of rocks into smaller particles through physical processes, including:
  - The erosive action of water, ice and wind.
  - Opening of cracks as a result of unloading due to erosion of overlying soil and rock.
  - Loosening through the percolation and subsequent freezing (and expansion) of water.
  - Thermal Expansion and contraction from day to day and season to season.
  - Landslides and rockfalls.
  - Abrasion from the downhill movement of nearby rock and soil.

Chemical Weathering

- Chemical Weathering is the disintegration of rock through chemical reactions between the minerals in the rocks, water, and oxygen in theatmosphere.

Rock Cycle

All rock at or near Earth's surface is being modified by the processes of metamorphism, melting, crystallization, lithification and weathering. These processes move rock material through the states of metamorphic rock, igneous rock, sedimentary rock, melts and sediment. The natural and continuous cycling of rock materials through these states is known as the Rock Cycle.



Soil and its Types

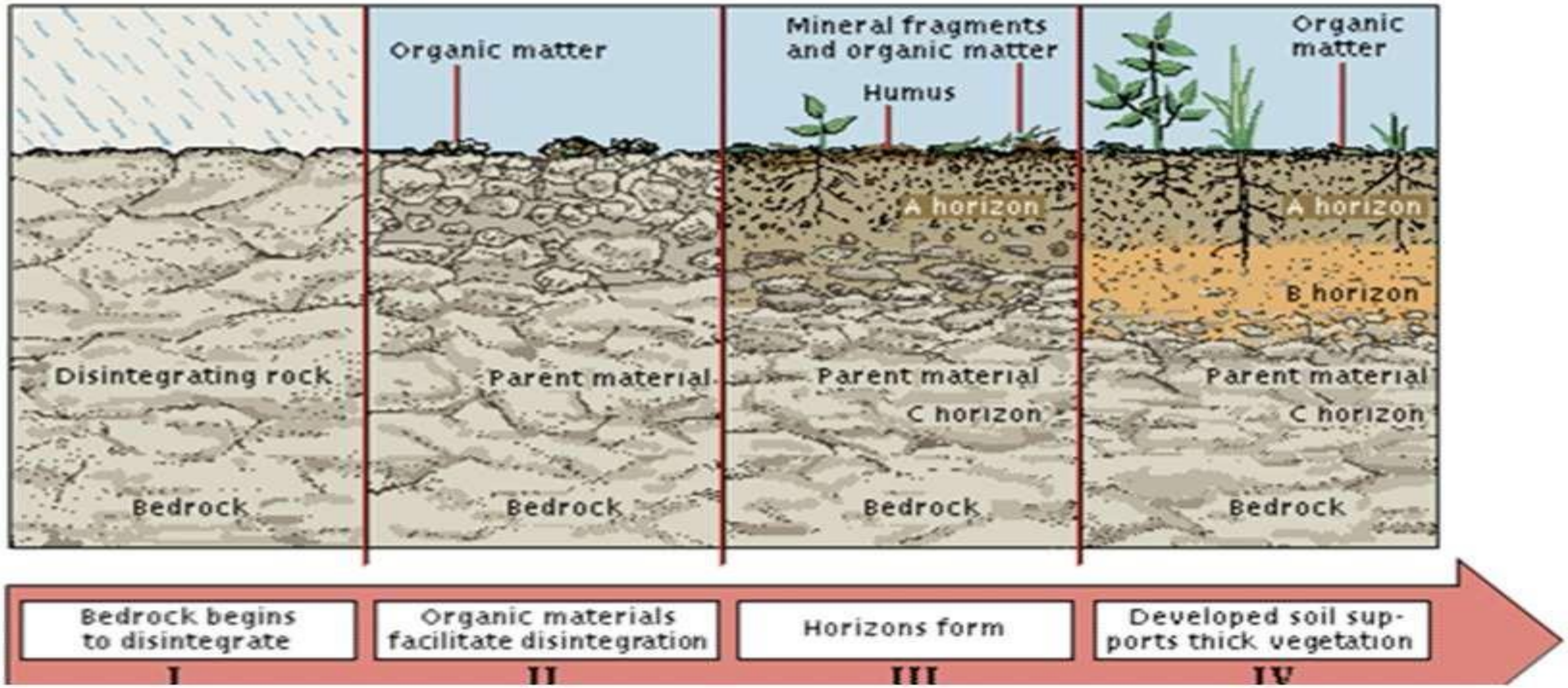
- What is Soil?
- Formation of Soil
- Types of Soil
    - Geological Consideration
    - Engineering Consideration

What is Soil? (Definition)

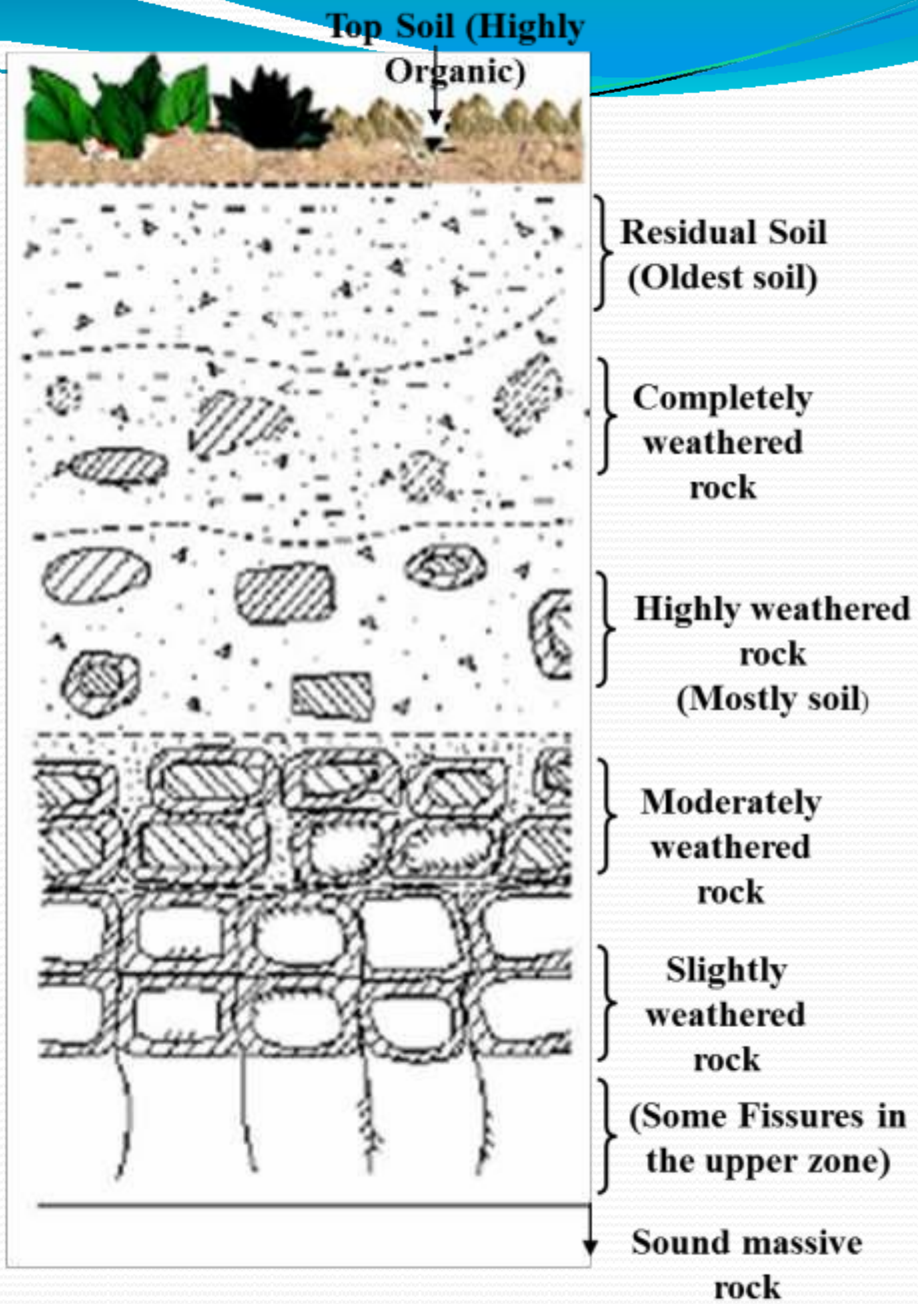
- The term soil according to engineering point of view is defined as the material, by means of which and upon which engineers build their structures. The term soil includes entire thickness of the earth's crust (from ground surface to bed rock), which is accessible and feasible for practical utilization as foundation support or construction material. It is composed of loosely bound mineral particles of various sizes and shapes formed due to weathering of rocks.

Formation of Soil

- Soil is generally formed by disintegration and decomposition (weathering) of rocks through the action of physical (or mechanical) and chemical agents which break them into smaller and smaller particles.



Different stages of weathering of rocks and formation of soil.



Types of Soil

- Soil types, based on geological and engineering view points, are separately discussed below:

1. Geological consideration:

   The history of formation of a soil deposit, greatly influence its properties and behaviour. The properties of soil highly depend on the process through which the soil deposits have been developed. Following are the types of soil based on the geological agents or the processes through which the soil deposits have been developed.

   i. **Glacial Soil:** This type of soil is developed, transported and deposited by the actions of glaciers. These deposits consists of rocks fragments, boulders, gravels, sand, silt and clay in various proportions (i.e., a heterogeneous mixture of all sizes of particles).

Types of Soil

ii. **Residual Soil:** This type of soil is found on nearly flat rock surfaces were the weathering action has produced a soil with a little or no tendency to move. Residual soil also occurs when the rate of weathering is higher than the rate of removal.

iii. **Alluvial Soil:** The soil transported and deposited by water is called alluvial soil. As flowing water (stream or river) looses velocity, it tends to deposit some of particles that it was carrying in suspension or by rolling, sliding or skipping along the river bed. Coarser or heavier particles are dropped first. Hence on the higher reaches of a river, gravel and sand are found. However on the lower parts, silt and clay dominate where the flow velocity is almost zero or very small.

Types of Soil

iv. **Wind blown Soil or Aeolian Soil:** The soil transported by the geological agent ‘wind’ and subsequently deposited is known as wind blown soil or Aeolian Soil. Aeolian soil as two main types namely Dune sand and Loess.

a) **Dune or Dune Sand**: In arid parts of the world, wind is continually forming sand deposits in the form of dunes characterized by low hill and ridge formation. They generally occur in deserts and comprise of sand particles, which are fairly rounded and uniform in size. The particles of the dune sand are coarser than the particles of loess. Dune material is generally, a good source of sand for construction purposes.

Sand dunes fill this view of the desert in Qatar.

Types of Soil

b) **Loess**: Accumulations of wind blown dust (mainly siliceous silt or silty clay) laid down in a loose condition is known as loess. Silt soil in arid regions have no moisture to bond the particles together and are very susceptible to the effects of wind and therefore can be carried great distances by wind storms. An important engneering property of loess is its low density and high permeability. Saturated loess is very weak and always causes foundation problems e.g., liquefaction.

v. **Colluvial Soil:** The accumulation formed by the rock fragments and soil material resulting from the mechanical weathering of rocks is known as colluvial soil. This type of soil is formed more or less in situ or as a result of trasport by gravity over a short distance.

Types of Soil

2. Engineering consideration :

The types of soil based on engineering consideration depend on the particle size. Since the engineering properties of soil markedly change with the change of particle size, different names are assigned to particular ranges of particle sizes. The soil types based on MIT classification are as follows:

i. **Clay: (< .002mm):** It is composed of very fine particles, less than .002 mm in size. They are flaky in shape and therefore have considerable surface area. These surfaces carry electrical charge, which helps in understanding the engineering properties of clay soils. In moist condition, clay becomes sticky and can be rolled into threads. Due to electrical charge, clay shows high inter-particle attraction and thus exhibits sufficient cohesion. It has high dry strength, low erosion, low permeability, good workability under moist condition, and can be readily compacted. Also susceptible to shrinkage and swelling. Clay soils commonly have brown colour.

Types of Soil

ii. **Silt: (.002mm < Size < .06mm)**

It is composed of very fine particles ranging in size between .002 and .06mm. It has high capillarity, no plasticity and very low dry strength. It possesses properties of both clay and sand, i.e. it shows slight cohesion and also friction. The colour of silty soil is mostly brown.

iii. **Sand: (.06mm < Size < 2mm)**

It consists of particles ranging in size from .06 and 2mm. It has a grey colour. These particles may be rounded to angular in shape. It shows no plasticity, high strength in a confined state and has considerable frictional resistance. It has high permeability and low capillarity. Sand is the most wanted construction material. Abundant quantities of sand are available in deserts and riverbeds.

Types of Soil

iv. **Gravels: (2mm < Size < 60mm)**

They consists of particles varying in size from 2mm to 60mm. They form a good foundation material. They show high frictional resistance. The frictional resistance depends upon the particle size and shape. The gravels produced by crushing of rocks are angular in shape, while those taken from river beds are sub-rounded to rounded. They show very high permeability. When sand and silt are mixed with gravels their bearing capacity is further increased but permeability may be decreased.

v. **Cobbles and Boulders**:

Particles larger than gravels are commonly known as cobbles and boulders. Cobbles generally range in size from 60mm to 200mm. The material larger than 200mm is designated as boulders.

Types of Soil

vi. **Organic Matter:**

The main source of organic matter is the plants or animal remains that are added to the soil when these organism die. Plants decompose at a slower rate than the animal remains. Commonly about 12” of the soil from top surface has a major concentration of organic matter. It undergoes large volume changes under loads and contains high natural moisture content. The strength of soil is very much reduced when the concentration of organic matter is more than 2% and the soil is considered unsuitable for foundation support.

The soil types based on the grain size limits according to ASTM and AASHTO are given in the following table.

Types of Soil

The nomenclature for the materials assigned to the grain-size limits adopted by the ASTM (American Society for Testing and Materials) as given in the Table above, has been used in the unified soil classification system. The AASHTO soil classification system however, follows the nomenclature established by the AASHTO (American Association of State Highway and Transportation Officials) for the classification of soils.

Soil Mechanics

Chapter # 2

Physical properties of soils

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TOPICS TO BE COVERED

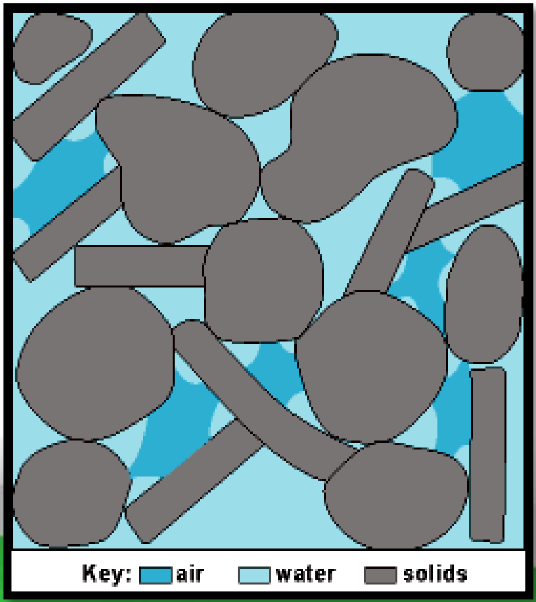
1. Phase diagram
2. Basic terms and definition
3. Functional relationships
4. Determination of index properties
5. Relative density

PHASE DIAGRAMS

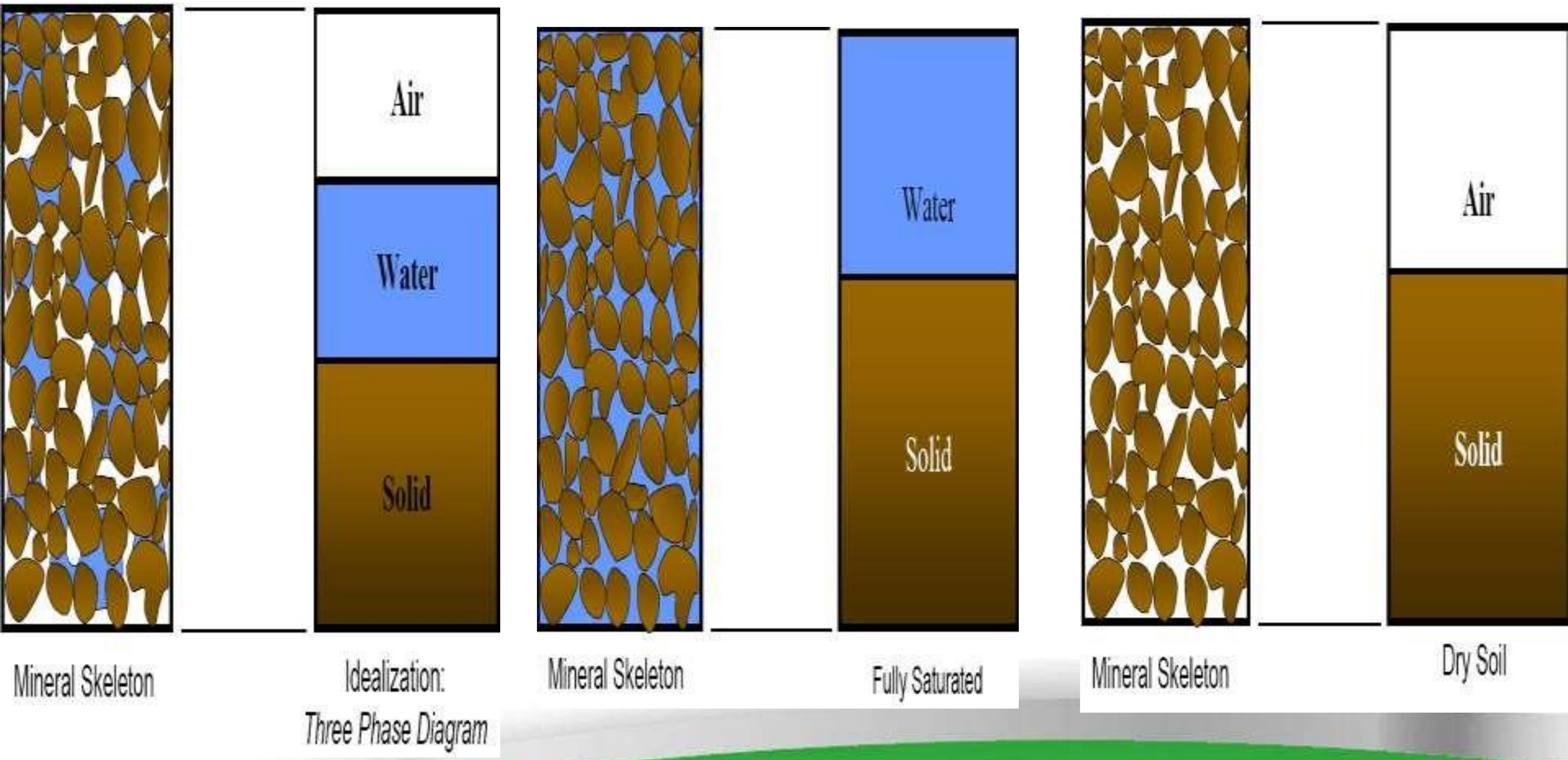
Soil mass consist of solid particles, water, air. In soil mass volume of solid particles is highest. The voids may be filled of water or air.

SOME ASSUMPTIONS ARE MADE

- Mass of air in soil is zero.
- All soil particles are of same size.
- Moisture is uniformly distributed.



PHASE DIAGRAMS



THREE PHASE DIAGRAM

In this case soil is partially dry and partially saturated. Here,

V_a=volume of air

V_w=volume of water

V_s=volume of solids

V_t=total volume of soil

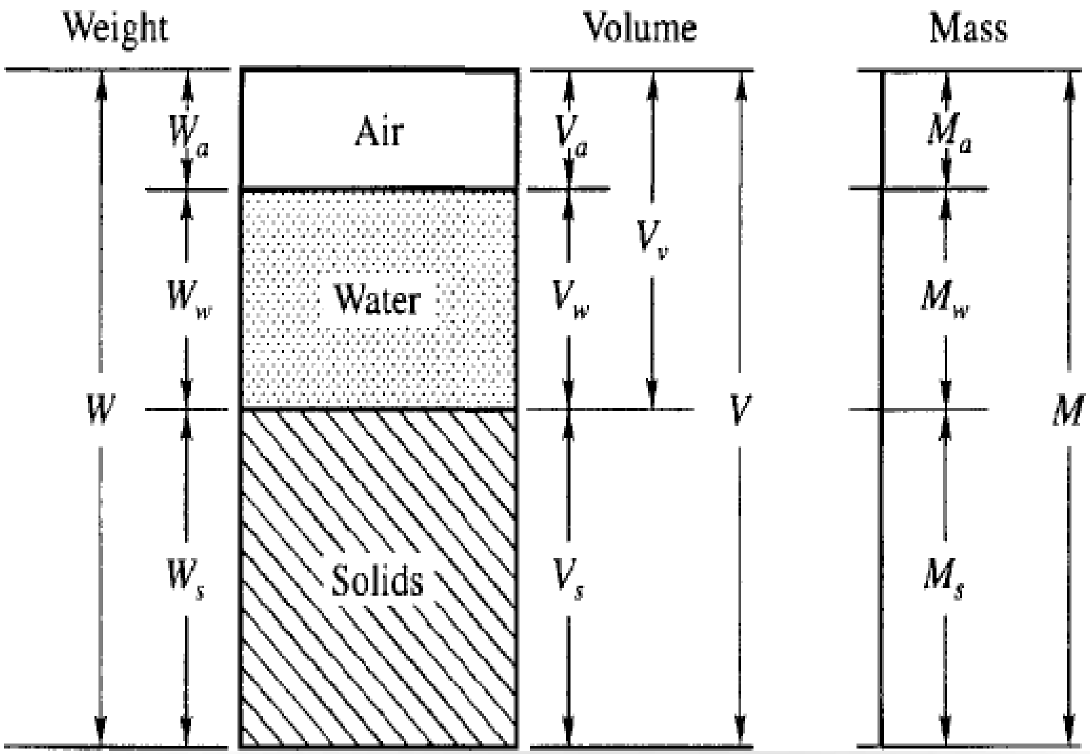
From fig;

$V_t=V_s+V_w+V_a$

Similarly;

$M_t=M_s+M_w+M_a$ (but $M_a=0$)

$M_t=M_s+M_w$



TWO PHASE DIAGRAM FOR FULLY DRY SOIL

In this case ,two phases ,solids and air are present. Water is absent and void are filled with the air.

From, fig;

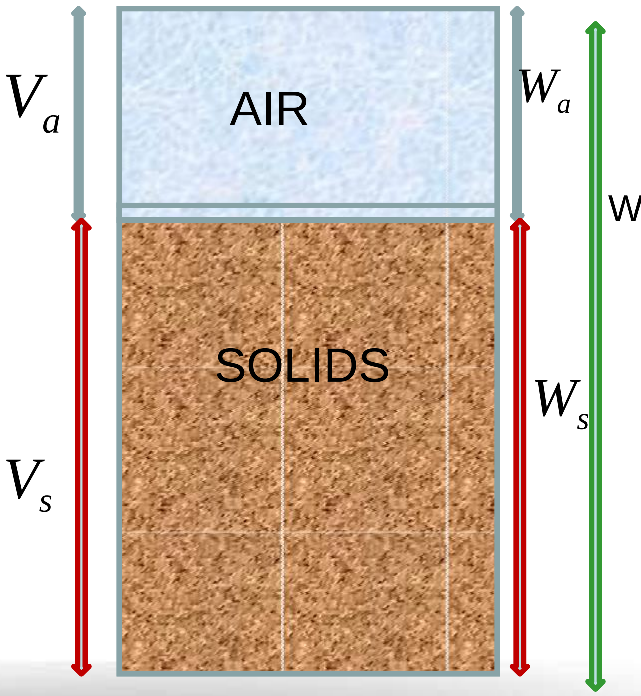
V=Vs+Va

Now,

$W=W_v+W_s$

$\therefore W = W_a + W_s \qquad \text{but;} W_a = 0$

$\therefore W = W_s$



TWO PHASE DIAGRAM FOR FULLY SAURATED SOIL

In this case two phases , solid , water are present. Air is absent. Voids are filled with water only.

$$V = V_v + V_s$$

$$but, \; V_v = V_w$$

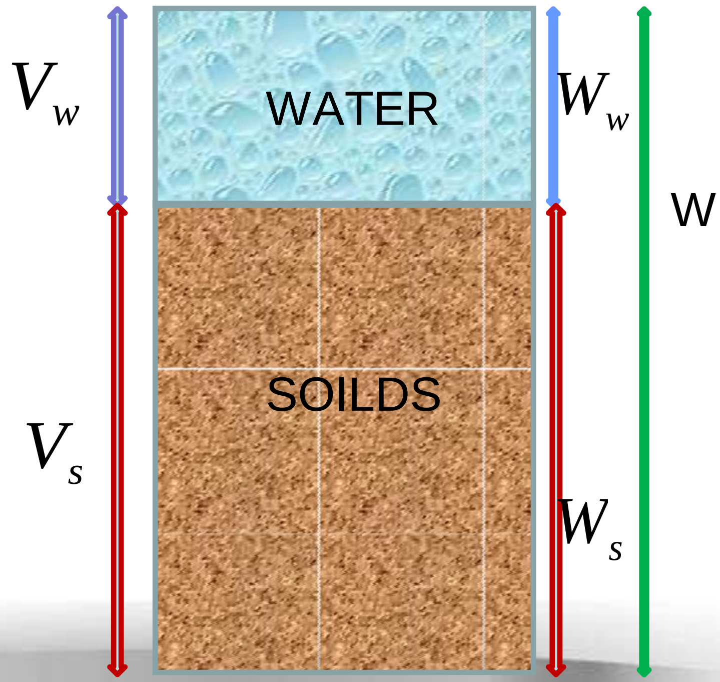
$$\therefore V = V_w + V_s$$

Similarly,

$$W = W_v + W_s$$

$$but, \; W_v = W_w$$

$$\therefore W = W_w + W_s$$



FUNDAMENTAL DEFINATION

1. WATER CONTENT OR MOISTURE CONTENT

- The water content is defined as the ratio of mass of water to the mass of soils.

- Water content=(weight of water / weight of dry soil)*100%

$$w = \frac{M_w}{M_s} * 100\%$$

or

$$\mathrm{w} = \frac{\mathrm{M_w}}{\mathrm{M_d}} * 100\%$$

2. BULK UNIT WEIGHT (γ_b)

- Bulk unit weight is defined as the total weight of soil mass per unit of total volume.
- Bulk unit weight = (total weight of soil mass / total volume of soil mass) * 100 %

$$\gamma_b = \frac{W}{V} \quad \ldots \mathrm{N/m^3} \quad \text{or} \quad \mathrm{kN/m^3}$$

3. DRY UNIT WEIGHT (γ_d)

Dry unit weight is defined as the weight of soil solids per unit of total volume of the soil mass.

Dry unit weight = (total weight of soil solids / total volume of soil mass) * 100%

$$\gamma_d = \frac{W_d}{V} \quad \ldots \mathrm{kN/m^3}$$

4. SATURATED UNIT WEIGHT (γ_{SAT})

- When soil mass is saturated, its bulk unit weight is called the saturated unit weight.
- Saturated unit weight = (total weight of saturated soil mass / total volume of soil mass)
- $\gamma_{sat} = (W_{sat} / V)$… k N/m^3

5. UNIT WEIGHT OF SOLIDS(γ_s)

•Unit weight of solids is the ratio of weight of solids to the volume of solids.

$$\gamma_s = \frac{W_s}{V_s}$$

6. SUBMERGED UNIT WEIGHT (γ_{sub} OR γ)

- Submerged unit weight is defined as the ratio of submerged weight of soil solids to the total volume of the soil mass.
- Submerged unit weight = (submerged weight of soil solids / total volume of soil mass)

$$\gamma_{sub} = \frac{(W_d)_{sub}}{V} \quad \cdots \mathrm{kN/m^3}$$

- When dry soil is submerged in water, it displaces an equal volume of water. Thus the net weight of soil is reduced.

$$\gamma_{sub} = \gamma_{sat} - \gamma_w = \gamma'$$

where,

$$\gamma_w = \text{unit weight of water} = 10\,\mathrm{kN/m^3}$$

7. SPECIFIC GRAVITY (G)

- Specific gravity is defined as the ratio of the weight of a given volume of soil solids to the weight of an equal volume of distilled water.
- Specific gravity = (weight of a given volume of soil solid / weight of an equal volume of distilled water)

$$G = \frac{W_s}{W_w} = \frac{\gamma_s}{\gamma_w} \quad \text{no unit}$$

SPECIFIC GRAVITY

• GRAVEL	2.65 - 2.68
• SAND	2.65 - 2.68
• SILTY SAND	2.66 - 2.70
• SILTS	2.66 - 2.70
• INORGANIC CLAYS	2.70 – 2.80
• ORGANIC SOILS	VARIABLE, MAY FALL BELOW 2.0
• SOILS HIGH IN MICA, IRON	2.75 - 2.85

8. VOID RATIO (e)

- It is defined as the ratio of the volume of voids to the volume of solids.

∴ Void ratio = (volume of voids / volume of solids)

- $e = V_v/V_s$.

9. POROSITY(n)

- It is defined as the ratio of volume of voids to the total volume.
- Porosity = (volume of voids/ total volume)

  $n = (V_v/V)$

10. DEGREE OF SATURATION(S_r)

- It is defined as the ratio of the volume of water to the volume of voids.

$\therefore$ Degree of saturation = (volume of water / volume of voids)

- $S_r = (V_w/V_v)$
- In case of fully saturated soil, voids are completely filled with water. There is no air.

$\therefore V_w = V_v$

$\therefore S_r = 1$

- In case of fully dry soil, voids are completely filled with air. There is no water.

$\therefore V_w = 0$

$\therefore S_r = 0.$

11. AIR CONTENT(a_c)

- It is defined as the ratio of the volume of air to the volume of voids.
- Air content = (volume of air/ volume of voids)

$\therefore a_c = (V_a/V_v)$

12. PERCENTAGE AIR VOIDS(n_a)

•It is defined as the ratio of the volume of air to the total volume.

•Percentage air voids = (volume of air/ total volume)

$\therefore n_a = (V_a/V)$

It is represented as a percentage.

13. DENSITY INDEX OR RELATIVE DENSITY

- The density index is defined as,

$I_D = (e_{max} – e / e_{max} – e_{min})$

Where,

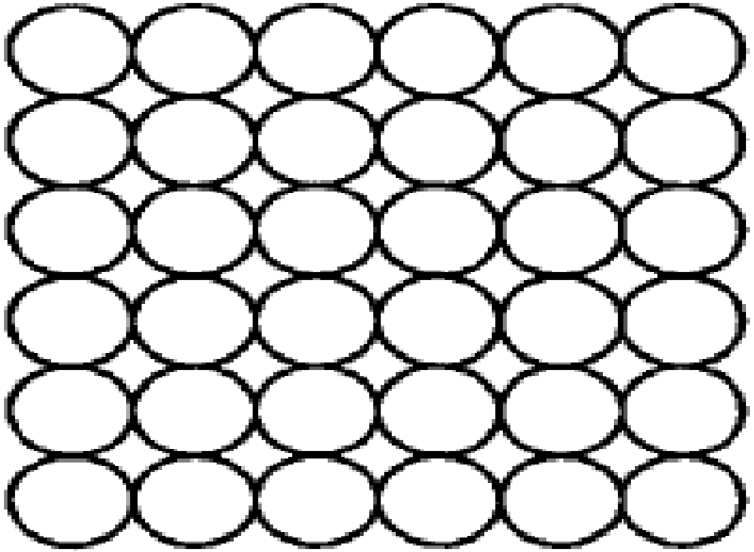
e_{max} = void ratio in the loosest state

e_{min} = void ratio in the densest state

e = natural void ratio of the deposit

- This term is used for cohesion less soils only.
- When the natural state of the cohesionless soil is in the loosest form,

e_{max}= e.


(a) Loosest state

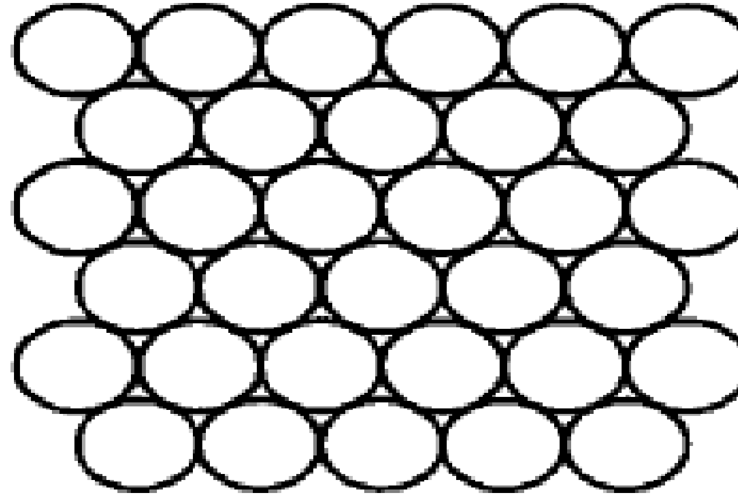

(b) Densest state

Figure 3.8 Packing of grains of uniform size

Table 3.8 Classification of sandy soils

Relative density, D_r, %	Type of soil
0–15	Very loose
15–50	Loose
50–70	Medium dense
70–85	Dense
85–100	Very dense

VOLUME - MASS RELATIONSHIP

1) BULK DENSITY (ρ_b)

The bulk density is defined as the total mass per unit volume.

$$\therefore \rho_b = \rho = (m/v)$$

- It is expressed as kg/m^3.
- $1cm^3 = 1ml$

2) DRY DENSITY (ρ_d)

The dry density is defined as the mass of solids per unit total volume.

$\therefore \rho_d = (m_d /v) = (m_s /v)$….. Kg/m^3

3.SATURATED DENSITY

- The saturated density is the bulk density of soil when it is fully saturated.

$\therefore \rho_{sat} = (M_{sat} / V)$ ….. Kg/m^3

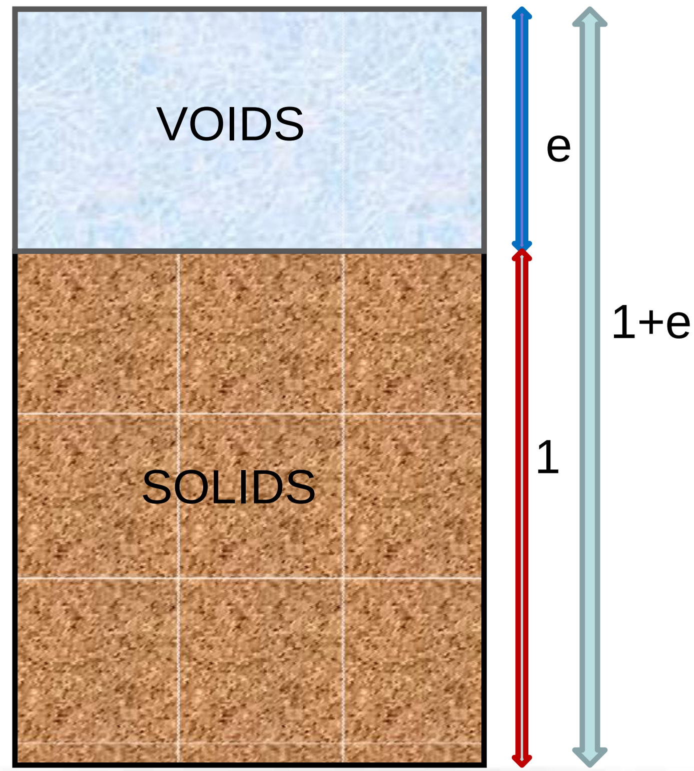
4.SUBMERGED DENSITY

- When the soil exist below water , it is in a submerged condition. When a volume v of soil is submerged in water, it displaces an equal volume of water. Thus the net mass of soil when submerged is reduced.
- The submerged density of the soil is defined as the submerged mass per unit total volume.
- $\rho_{sub} = \rho' = (m_{sub} / v) = (\rho_{sat} - \rho_w)$

FUNCTIONAL RELATIONSHIPS

If volume of void is taken as "e", the volume of solids by definition of porosity will be "1" and total volume is "1+e".

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



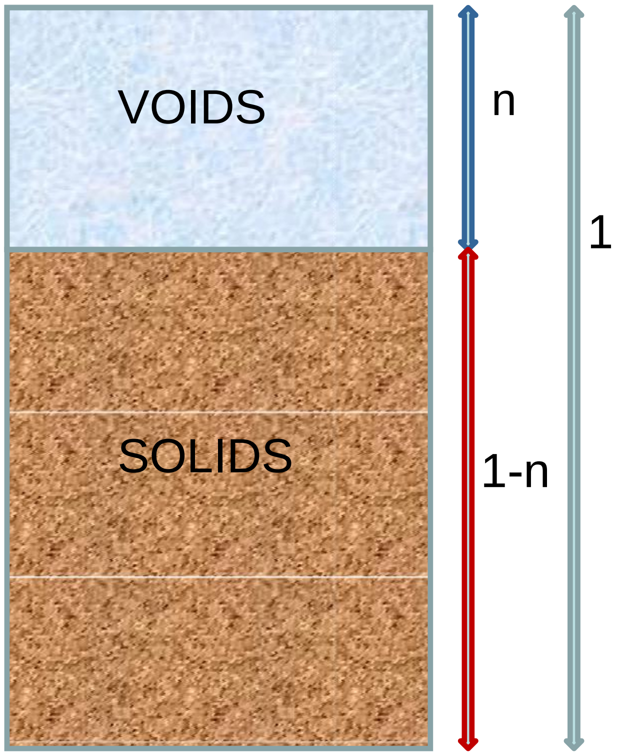
If volume of voids is taken as "n", the volume of solids, by definition of void ratio will be "1-n" and total volume equal to "1".

$$\therefore e = \frac{V_v}{V_s} = \frac{n}{1-n}$$

combining theabove twoeqution weget,

$$n = \frac{e}{1+e} = e(1 - n) \qquad (\because n = \frac{e}{1+e})$$

$$\therefore (1-n) = \frac{1}{1+e}$$



RELATION BETWEEN e,G,w& S_r

Fig shows the soil element.

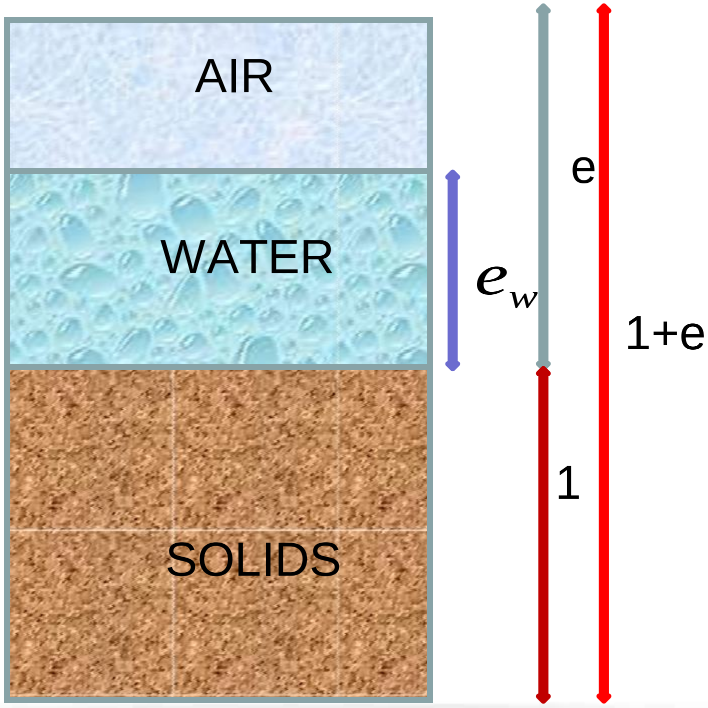
Where, e_w = water void ratio

e = void ratio

Vs=1= volume of solids

We, know

$$w = \frac{M_w}{M_s} = \frac{\rho_w . V_w}{\rho_s . V_s} \quad \text{-----} \quad (A)$$



Now,

$$S = \frac{V_w}{V_v} \quad \& \quad G = \frac{\rho_s}{\rho_w} \quad \therefore \rho_s = G\,\rho_w$$

(1) ______ (2) ________

putting the value of equ. (1) & (2) in equ. (A)

$$\therefore w = \frac{\rho_w . S V_v}{\rho_w . G V_s} = \frac{S V_v}{G V_s} = \frac{S}{G} e$$

$$\therefore Se = wG$$

In case of fully saturated soil S=1. So, e=w G

DERIVE : $\rho_b = \dfrac{(G + e.S_r)\gamma_w}{1+e}$

We know that,

$$\gamma_b = \frac{W}{V} = \frac{W_s + W_w}{V}$$

$$\therefore \ \gamma_b = \frac{\gamma_s.V_s + \gamma_w.V_w}{V} \qquad (\because \gamma_s = \frac{W_s}{V_s} \ \& \ \gamma_w = \frac{W_w}{V_w})$$

$$\therefore \gamma_b = \frac{\gamma_s.1 + \gamma_w.e_w}{1+e} \qquad \cdots \text{from fig } V_s = 1, V_w = e_w, V = 1+e$$

Now,

$$\gamma_{\mathrm{b}} = \frac{G.\gamma_w + e_w.\gamma_w}{1+e} \qquad (\because \mathrm{G} = \frac{\gamma_{\mathrm{s}}}{\gamma_w} \;\&\; \mathrm{e_w} = \mathrm{e.S_r})$$

$$\gamma_{\mathrm{b}} = \frac{(G+e_w)\gamma_w}{1+e}$$

$$\therefore \gamma_b = \frac{(G+e.S_r)\gamma_w}{1+e}$$

- If soil is fully dry, $\mathrm{S_r} = 0$ and $\gamma_{\mathrm{b}} = \gamma_d$

$$\therefore \gamma_d = \frac{G.\gamma_w}{1+e}$$

- If soil is fully saturated, $\mathrm{S_r} = 1$ and $\gamma_{\mathrm{b}} = \gamma_{sat}$

$$\therefore \gamma_{sat} = \frac{(G+e)\gamma_w}{1+e}$$

DERIVE : $\rho_{dry} = \dfrac{\rho_b}{1+w}$

We know that,

$$\rho_b = \frac{M_t}{V} = \frac{M_s + M_w}{V}$$

$$\therefore \rho_b = \frac{M_s + wM_s}{V} \qquad (\because w = \frac{M_w}{M_s})$$

$$\therefore \rho_b = \frac{M_s(1+w)}{V} \qquad \text{But, } \rho_{dry} = \frac{M_s}{V}$$

$$\therefore \rho_b = \rho_{dry}.(1+w)$$

$$\therefore \rho_{dry} = \frac{\rho_b}{(1+w)}$$

Table 3.1 Various Forms of Relationships for γ, γ_d, and γ_{sat}

Moist unit weight (γ)		**Dry unit weight (γ_d)**		**Saturated unit weight (γ_{sat})**	
Given	**Relationship**	**Given**	**Relationship**	**Given**	**Relationship**
w, G_s, e	$\dfrac{(1+w)G_s\gamma_w}{1+e}$	γ, w	$\dfrac{\gamma}{1+w}$	G_s, e	$\dfrac{(G_s+e)\gamma_w}{1+e}$
S, G_s, e	$\dfrac{(G_s+Se)\gamma_w}{1+e}$	G_s, e	$\dfrac{G_s\gamma_w}{1+e}$	G_s, n	$[(1-n)G_s+n]\gamma_w$
w, G_s, S	$\dfrac{(1+w)G_s\gamma_w}{1+\dfrac{wG_s}{S}}$	G_s, n	$G_s\gamma_w(1-n)$	G_s, w_{sat}	$\left(\dfrac{1+w_{sat}}{1+w_{sat}G_s}\right)G_s\gamma_w$
w, G_s, n	$G_s\gamma_w(1-n)(1+w)$	G_s, w, S	$\dfrac{G_s\gamma_w}{1+\left(\dfrac{wG_s}{S}\right)}$	e, w_{sat}	$\left(\dfrac{e}{w_{sat}}\right)\left(\dfrac{1+w_{sat}}{1+e}\right)\gamma_w$
S, G_s, n	$G_s\gamma_w(1-n)+nS\gamma_w$	e, w, S	$\dfrac{eS\gamma_w}{(1+e)w}$	n, w_{sat}	$n\left(\dfrac{1+w_{sat}}{w_{sat}}\right)\gamma_w$
		γ_{sat}, e	$\gamma_{sat}-\dfrac{e\gamma_w}{1+e}$	γ_d, e	$\gamma_d+\left(\dfrac{e}{1+e}\right)\gamma_w$
		γ_{sat}, n	$\gamma_{sat}-n\gamma_w$	γ_d, n	$\gamma_d+n\gamma_w$
		γ_{sat}, G_s	$\dfrac{(\gamma_{sat}-\gamma_w)G_s}{(G_s-1)}$	γ_d, S	$\left(1-\dfrac{1}{G_s}\right)\gamma_d+\gamma_w$
				γ_d, w_{sat}	$\gamma_d(1+w_{sat})$

DETERMINATION OF INDEX PROPERTIES OF SOIL

Those properties of soil which are used in the identification and classification of soil are known as INDEX PROPERTIES.

- Various index properties of soils are:-

a. Water content
b. In-situ density
c. Specific gravity
d. Particle size
e. Consistency
f. Density index

METHODS OF WATER CONTENT DETERMINATION

The water content can be determined by any of the given methods:-

a) Oven drying method
b) Sand bath method
c) Alcohol method
d) Calcium carbide method
e) Nuclear probe method
f) Pycnometer method
g) Infra-red method