INTRODUCTION TO SOIL, ROCK AND THEIR FORMATION

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Books Details

- **Primary Books**

1. R. Whitlow, “Basic Soil Mechanics” -Longman Pub Group
2. Prof. Dr. Shaukat Ali Khan, “Soil Mechanics”
3. T. William Lambe Robert V. Whitman”Soil Mechanics” (Wiley Series in Geotechnical Engineering).

- **Secondary Books**

1. Braja M. Das, Khaled Sobhan, “Principles of Geotechnical Engineering”, 8th SI edition-Cengage Learning (2013).
2. Donald P. Coduto, “Geotechnical Engineering” (Principles and practices)

Course Outline

- Significance. Soil, rock and their types and formation. Physical properties of soil: water content, voids ratio, porosity, degree of saturation, specific gravity, unit weight and their determination, mass-volume relationships.
- Soil Classification: Principle properties of soil (natural moisture content, density, specific gravity, void ratio, porosity, degree of saturation). Volumetric and volume weight relationships. Index properties of soil (Grain size distribution, consistency limits). Purpose of soil classification, engineering soil classification systems (ASTM or USCS, AASHTO).
- Geotechnical Investigation: Scope and objective, exploration methods, field tests (SPT,CPT, Plate load Test, Pressure meter, Dilatometer Test)
- Permeability and Seepage: Darcy's law, factors affecting permeability, laboratory and field determination of permeability, capillary and its effects.

- Seepage force. Introduction to flow net, Estimation of seepage quantity. Quick sand condition. Sand boiling Filters.
- Stresses in Soil: Geostatic stresses, total and effective stresses, stress from surface loads. Lateral stress, Stress influence charts/diagrams and their uses
- Compaction: Fundamentals, moisture density relationship, compaction standards, factors affecting compaction, field control and measurements of insitu density. Field compaction equipment.
- Consolidation: Definitions, consolidation, consolidation test and data reduction, naturally consolidated clayey and partially consolidated clayey soils, settlement and rate of settlement. Shear strength of soil, Coulomb‟s law, shear strength parameters (c & fi), cohesive and non- cohesive soils. Laboratory and field evaluation of (c & fi). Utility of shear strength parameters

Marks Distribution

For Theory

Assignments----------05

Quiz---------- ----------10

Class Participation/Attendance----05

Midterm----------30

Final----------50

Total----------100

Soil

- Material by means of which and upon which Engineers build their structures.
- The term soil includes entire thickness of earth of crust
- It is composed of loosely bound mineral particles of various sizes and shapes formed due to weathering of rocks
- It also has organic matters, water and air in it

Factors affecting Behavior of Soil

- The behavior of soil as a foundation support or as a construction material is influenced by:

a) Moisture content present in soil pores
b) The fluctuation of ground water table
c) Freezing and thawing phenomena
d) The presence of organic matter
e) History of formation of soil
f) Seismicity of the area

- Soil is a particulate mixture, which means that a soil mass consists of an accumulation of individual particles that are bonded together by mechanical or attractive forces
- The top soil which usually extend to a depth of 2 feet contains organic matter and generally consider unsuitable for Civil Engineering use

Origin of soil

- All soil originates directly or indirectly , from solid rocks and these are classified according to their mode of formation

a) Igneous Rock
b) Metamorphic Rock
c) Sedimentary Rock

- **Igneous Rock**
- Formed due to the cooling of hot molten material (Magma) within or on the surface of earth crust
- **Examples**
- Granite, Basalt, Dolerite, Gabbro. Etc.
- **Metamorphic Rock**
- Formed due to alteration of existing rock by:
- **Extreme Heat:** Marble, Quartzite
- **Extreme Pressure:** Slate, Schist

- **Sedimentary Rock**
- Formed in layers from sediments settling in bodies of water, such as seas and lakes
- **Examples:** Limestone, Sandstone, Mudstone, Shale
- The process that convert solid rock in to soil take place near the earth crust, and although they are complex

Factors Affecting the Conversion of Rock in to Soil

a) Nature and composition of parent rock
b) Climatic conditions
c) Topography
d) Interference by other activity, Earthquake, storms, action of man
e) Mode and condition of transport

Mineral Composition of soil

- The large majority of soil consists of mixtures of inorganic minerals particles, together with some water and air.
- So it is convenient to think of a soil model which has three phases. As shown in Figure 1

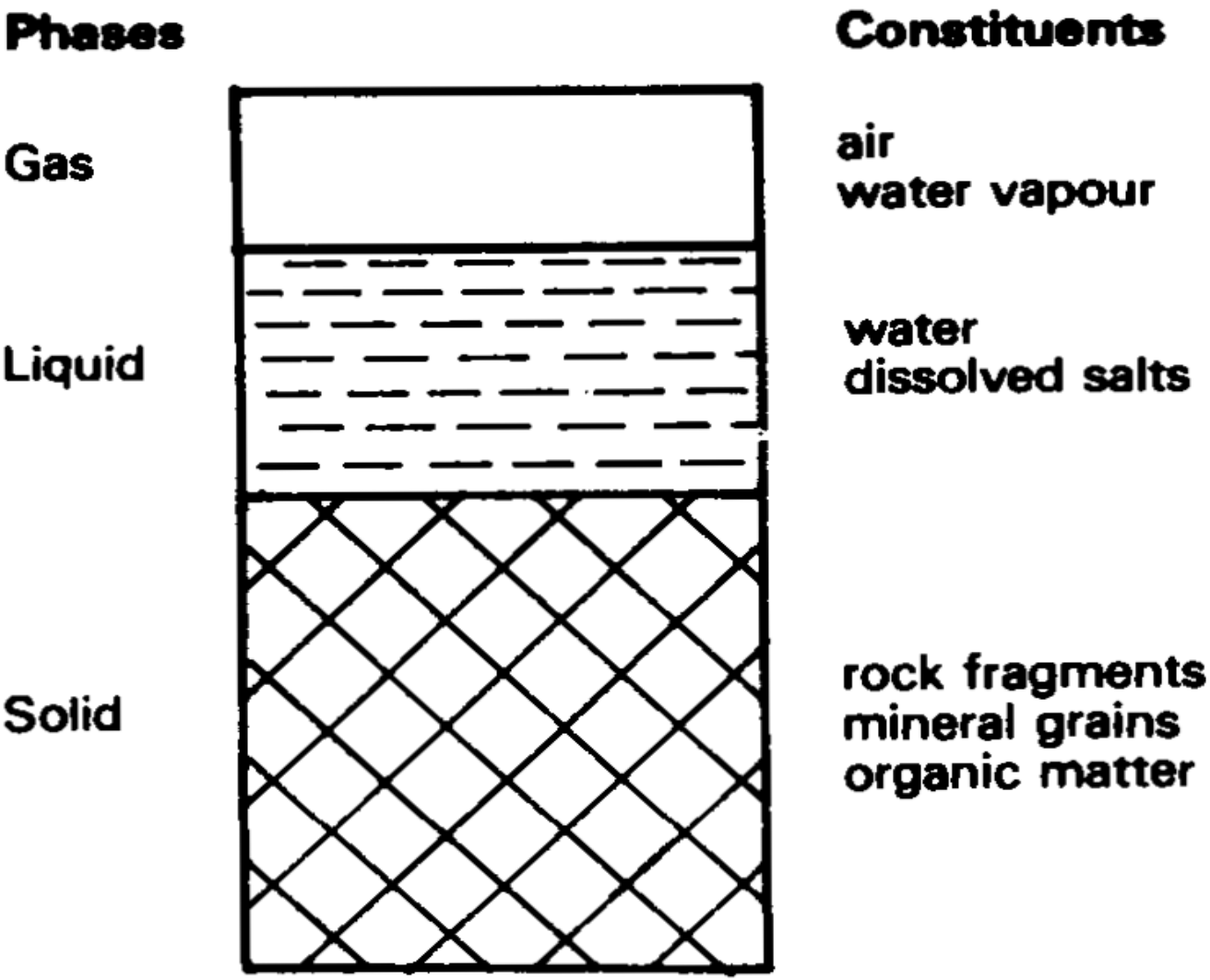

Figure 1: Three phase Soil model

Formation of Soil

- As we discussed earlier that soil is generally formed by disintegration of rock at or near the earth crust through the action of many natural, physical, chemical and mechanical changes which break them in to smaller and smaller particles
- The disintegration of rock is the result of freezing of water in the pores of rock. Because water expands on freezing.
- Water, wind and gravity are transporting agents that works on the products of weathered rocks to produce soil.
- Geological time is another factor in the formation of soil.
- Over the thousands year beating action of rain, the grinding action of waves and tides of sea are responsible for the formation of soil

Types of soil

- A geologist has a different point of view about the types of soil to an Engineer.
- According to geologist, types of soil are named on the bases of particular geological agent, due to which soil has been formed.
- The name of soil so given an idea about the properties and behavior.
- According to Engineer the soil types are solely based on the particle size of within the soil mass.
- Since the soil properties very much dependent on the particle size, so name given to the soil give an idea about the properties and behavior of the soil.
- So soil classified on the following two basis

a) Geological Consideration

b) Engineering Consideration

Geological Consideration

- The history of formation of a soil deposit, greatly influence its properties and behavior.
- Following are types of soil based on the geological agents or process of formation.

a) Glacial Soil
b) Residual Soil
c) Alluvial Soil
d) Aeolian Soil (It has two Types (1) Dune or Sand Dune (2) Loess)
e) Colluvial Soil

- **Glacial Soil**
- This type of soil is developed, transported and deposited by the action of glaciers.
- These deposit consists of rock fragments, boulders, Gravels, Sand, Silt and clay in various proportion.
- **Residual Soil**
- formed in situ by rock decay and left as a residue after the leaching out of the more soluble products. This type of soil is found on nearly flat rock surfaces where the weathering action has produced a soil with a little or no tendency to move.
- The residual soil also occurs when the rate of weathering is higher than the rate of removal.
- **Alluvial Soil**
- The soil transported and deposit by water is called Alluvial soil.
- As flowing water loses velocity, it tends to deposit some of the particles that it was carrying in suspension or by rolling, sliding or skipping along the river bed.
- Coarser and heavier particles are dropped first, Hence on higher reaches of the river Gravel and sand is found.
- However on the lower parts, Silt and Clay dominant, where the flow velocity is almost zero or very small.

- **Aeolian Soil**
- The soil transported by geological agent “Wind” and subsequently deposited is known as wind blown or Aeolian Soil.
- Wind can move small particles of soil by rolling or by carrying them and may pile up in the form of dunes.
- The wind may bring dunes storm in the arid regions, removing the soil, which is necessary to the plant life.
- Aeolian soil has two main types.

a) Dune or Sand dunes

- In arid part of the world, wind is continually forming sand deposit in the form of dunes characterized by low hill and ridge formation.
- They usually occur in desert and comprises of sand particle which are fairly rounded and uniform in size

b) Loess

- Accumulations of wind blown dust (mainly siliceous or silty-clay) laid down in loose condition is known as loess.
- The dust is originally derived from desert areas or from vegetation free areas.

- Silt soil in arid regions have no moisture to bond the particles together and are very susceptible to the effects of wind.
- **Colluvial Soil**
- The accumulation formed by the rock fragments and soil materials resulting from mechanical weathering (any of the various weathering processes that cause physical disintegration of exposed rock without any change in the chemical composition of the rock: Collision between rock surfaces can cause mechanical weathering) of rock is known as Colluvial soil.
- This type of soil is formed more or less in situ or as a result of transport by gravity over a short distance.
- Colluvial soil usually exist near the foot of cliffs and steep slopes in the form of heaps of coarse debris.
- The Slope adopts the angle of repose for the material, usually 25-35°

Engineering Consideration

- The type of soil based on Engineering consideration solely depend on the particle size

a) Clay (< 0.002 mm)
b) Silt (0.002-0.06 mm)
c) Sand (0.06-2 mm)
d) Gravels (2-60 mm)
e) Cobbles (60-200 mm)
f) Boulders (>200 mm)
g) Organic Matter

- **Clay**
- It is composed of very fine particles, less than 0.002 mm.
- They are Flaky in Shape, and therefore have considerable surface area.
- These surface electrical charge, which helps in understanding the engineering properties of clay soil.
- In a moist condition clay becomes very sticky and can be rolled into threads.
- Due to electrical charges, clay shows high inter-particle attraction and thus exhibits sufficient cohesion.
- It has very high dry strength, low erosion good workability under moist condition, and therefore subjected to slide at high moisture content.
- It also susceptible to shrinkage and swelling.
- It has very low permeability.
- Clay soil commonly have “Brown” color

- **Silt**
- It is composed of particles ranges in size between 0.002 and 0.06 mm.
- It has high capillarity
- It has no plasticity
- It has very low dry strength

- It has particle size intermediate between clay and sand. Therefore it possesses properties of both clay and sand, i.e. it shows slight cohesion and also friction.
- The color of silty soil is mostly Brown.

- **Sand**
- It consists of particle ranging in size from 0.06 mm to 2 mm.
- It has Grey color.
- These particles may be rounded to angular shape
- It has no plasticity, has high strength in confined state and has considerable frictional resistance. The frictional resistance depend upon particle shape. Angular particles has high frictional resistance as compared to the rounded ones.
- It has high permeability and low capillarity

- **Gravels**
- The consists of particles varying in size from 2 mm to 60 mm.
- They form a good foundation material
- They show high frictional resistance

- The gravels produced by crushing of rocks are angular in shape, while those taken from river bed are sub rounded to rounded.
- Therefore gravel from crusher are used in upper layer of pavement, where wheel load stress is high.
- They show very high permeability.
- When sand and silt are mixed with gravel their bearing capacity further increased but permeability may be decreased.
- **Cobbles**
- Particles larger than Gravel are commonly known as cobbles or boulders.
- They usually ranges in size from 60 mm to 200 mm.
- **Boulder**
- The materials larger than 200 mm is designated as boulder.

- **Organic matter**
- The main source of organic matter is plant and animals remains
- Plant decompose at a slower rate as compared to the animals remains
- Commonly about 1 feet of the soil from the top surface has a major concentration of organic matter
- 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 civil engineering purpose i.e. for foundation support.

Soil Types According to ASTM and AASHTO

Soil Type	ASTM (American Society for Testing and Materials)	(American Association of State Highway & Transportation Officials)
Gravel	75 mm to 4.75 mm 3 In Sieve to No. 4 Sieve	Less than 2 mm
Coarse Sand	4.75 mm to 2 mm No. 4 Sieve to No. 10 Sieve	2 mm to 0.425 mm
Medium Sand	2 mm to 0.425 mm No. 10 Sieve to No. 40 Sieve	----------
Fine Sand	0.425 mm to 0.075 mm No. 40 Sieve to No. 200 Sieve	0.425 mm to 0.075 mm
Silt	0.075 mm to 0.005 mm No. 200 Sieve to No. 0.005 mm	0.075 mm to 0.002 mm
Clay	Smaller 0.005 mm	Smaller 0.002 mm
Collides	Smaller than 0.001 mm	Smaller than 0.001 mm

THANK YOU!