Soil Mechanics Class Notes

Origin and Characteristics of Soil Deposits

Rock - Harder, consolidated material (Parent material for all soil)

Soil - Unconsolidated deposits of particulate material

Engineering Applications:

Hard materials are considered soils if they can be excavated by conventional construction equipment.

Rock is usually considered suitable for a foundation material and is used in rock fills for embankments.

Soil must be evaluated to determine its in situ condition to determine if it is suitable for a foundation.

Types of Rock

1. Igneous Rock - from molten rock that has hardened during cooling

    a. Intrusive - formed slowly under high pressure, large crystals

    b. Extrusive - formed rapidly or under low pressure small crystals

2. Sedimentary Rock - Deposits of soil particles, precipitate or organisms that are cemented together

    a. Sandstone - quartz or rock fragments

    b. Shale - composed of very fine grained material

    c. Limestone - crystalline calcium carbonate

    d. Dolestone - harder types of limestone

3. Metamorphic Rock - Igneous or sedimentary rock that is changed chemically by both high pressure and heat.

   a. Limestone to marble

   b. Sandstone to quartzite

   c. Shale to slate or schist

   d. Coal to diamond

Engineering Applications:

Rock that weathers rapidly such as shale, claystone or slate may be a problem for foundations or rock fills.

Weak rock can pose problems in rock cuts and tunnels.

Highly porous or highly fractured rock can cause a problem as foundations for water retention structures.

Some limestone is dissolved forming cavities in the subsurface.

Decomposition of Rock to Soil

1. Igneous rocks

   a. Intrusive rocks (acidic) - decompose to coarse grained soils, sand and gravel

   b. Extrusive rocks (basic) - decompose to fine grained soils, clay and silt

2. Sedimentary rocks

   a. sandstone to sand and gravel

   b. shale to silts and clay

   c. limestone to silt and clay

3. Metamorphic rocks
   - decompose to the soil that the parent rock would decompose to

Soil Types According to Geologic Origin

1. Residual Soils - soil that originates from weathered rock and remains at its original site.

   A profile of the subsurface will consist of a preponderance of soil near the ground surface changing to more rock with depth until unweathered rock is encountered.

2. Transported Soils

   a. Gravity - material moves down sides of hills

   b. Wind Blown Deposits

      1) Sand - blown relatively short distances into dunes or ridges

      2) Silts (Loess) - blown large distances (hundreds of miles) to form large accumulations

         Example - Mississippi river valley consisting of near vertical bluffs

   c. Glacial Deposits - soil transported either directly or indirectly by glaciers.

      Glaciation - large continental glaciers of up to thousands of feet thickness transported soil and advanced over it compressing it. During the time of glaciation the mean sea level was lowered by as much as 400 to 500 feet causing coastal deposits to become dried out (desiccated).

      1) Till - heterogeneous mixture of soil that was directly deposited by the glacier (moraines).

      2) Glacial Drift - material that was transported out as the glaciers melted and receded (glacial outwash). The action of the water very often sorted the soil particles out by size.

d. River Deposits (alluvial deposits) - soils carried by flowing water

Sedimentation - occurs as the soil settles out. Settling rate is dependent on the velocity. The particle size of the soil being deposited is dependent on velocity. Therefore, larger particles settle first and then smaller sizes after the fluid velocity decreases. This causes settling out of particles according to particle size, or sorting out by size.

1) Alluvial Fans - rivers or streams will 'fan out' if there is an abrupt change of slope. Coarse soil particles are deposited in the fans.

2) Flood Plain Deposits - as rivers flood from their banks and the flood waters spread out, coarse particles are first deposited out forming natural levees. The finer particles are deposited further from the river.

3) Meanders - natural tendency is for rivers and streams to form many bends or meanders. As the water meanders, the velocity on the outside of the bend is larger than on the inside. Therefore the meander will progress by erosion outward and deposition of coarse particles on the inside of the meander.

4) Lake Deltas - velocity suddenly decreases causing deposition of coarse particles.

e. Lake Deposits - Sand and gravel deposited along edges forming beaches due to wave action. Fine size particles are deposited in the center. The fines are generally soft, compressible deposits referred to as lacustrine deposits.

f. Marine Sediments - silt and clay combined with organisms to form weak deposits of clay. These occur along many coastlines.

g. Beach Deposits - coarse materials deposited because of currents wave action.

h. Swamp and Marsh Deposits - contain large amounts of organics and silts and clay. Usually black and has an odor. Will usually be soft and compressible and is not suited for engineering purposes.

Engineering Applications:

Weak or compressible soils are problem soils for foundations.

Organic soils are problem soils for engineering purposes.

Silts are frost susceptible soils which is a problem for roadway subgrades.

Clays soils with a high fraction of particular mineral types will undergo large changes in volume with change in water content.

Soils that have a mixture of different soil sizes and rock, such as residual soils and till, generally are difficult to work with and may be sensitive to changes in water content.

Other problem soils include collapsible soils, erodible soils and laterites.

Coarse soils that are well sorted are good sources for construction materials for fills and concrete.

Fine soils are used for hydraulic barriers to contain liquids.

Plate Tectonics

Refers to the movement or drift of continental plates. Large continental plates are floating on the inner core of molten, geologic material. As the plates separate, molten material is forced upward along rifts, which contributes to the spreading.

Geologic Faulting

Refers to the activity along the intersections of continental plates that are not spreading.

1. Subduction Zones - downwarping of one plate under another. Forms deep sea trenches in the ocean.

2. Transform Faults - occurs when one plate is moving up over another such as along the western coast of the U.S.

3. Folding - Occurs where two plates are compressed forming folded rock or anticline – syncline features, such as along the eastern U.S.

Engineering Applications:

Earthquakes that occur along fault zones can cause foundation and embankment failures.

Soil liquefaction can also occur during earthquakes leading to many types of failures.

Faulting causes rock to dip which can lead to failures, particularly along the interface of rock layers.

Recommendation for further reading:

McCarthy, D. F., *Essentials of Soil Mechanics and Foundations: Basic Geotechnics*, 6th ed., New Jersey: Prentice Hall, 2002.