Module 1

Introduction

1.1. Definitions:

Rock is a natural aggregate of mineral particles bonded by strong and permanent cohesive forces. They require blasting, drilling and wedging for its removal from the earth's surface as it is an extremely hard material. Rocks are usually made of one or more minerals; for example, granite rock is made of 3 minerals: quartz, feldspar and biotite. Rocks are broadly classified under 3 categories: igneous, sedimentary and metamorphic.

Soil is the loose, unconsolidated and inorganic material produced by disintegration of rocks on the earth's crust. It is composed of solid particles and the void spaces in between these particles contain air or water or both. It lies on top of hard rock and may or may not contain organic matter. Soil includes widely different materials like boulders, clays, gravels, sands, silts etc. and may vary in particle size from a fraction of a micron to a few meters in diameters.

Origin and Formation of Soil: Soil is a complex material produced by the weathering of the solid rock. The formation of soil is as a result of the geological cycle continually taking place on the face of the earth. The cycle consists of weathering or denudation, transportation, deposition and upheaval, again followed by weathering, and so on. Weathering is caused by the physical agencies such as periodical temperature changes, impact and splitting action of flowing water, ice and wind, and splitting actions of plants and animals. Cohesionless soils are formed due to physical disintegration of rocks. Chemical weathering may be caused due to oxidation, hydration, carbonation and leaching by organic acids and water. Clay minerals are produced by chemical weathering. Soil obtained due to weathering may be residual or transported. *Residual soils*, which remain in places directly over the parent rock, are relatively shallow in depth. The deposits of the *transported soils* may be greater in depth and their homogeneity and heterogeneity depends upon the manner of their transportation and deposition. The various agencies of transporting and redepositing soils are: water, ice, wind and gravity. Water-formed transported soils are termed as alluvial, marine or lacustrine. All the material, picked up, mixed, disintegrated, transported and redeposited by glaciers either by ice or by water issuing from melting of glaciers, is termed as *glacial drifts* or *simple drift*.

The glacial deposits in general consists of a heterogeneous mixture of rock fragments and soils of varying sizes and proportions and, except the stratified depth deposited by glacial streams, are without any normal stratification. Dune sand and loess are the windblown (aeoline) deposits. *Loess* is the wind-blown silt or silty clay having little or no stratification. Soils transported by gravitational forces are termed as *colluvial soils*, such as *talus*. The accommodation of decaying and chemically deposited vegetable matter under conditions of excessive moisture results in the formation of *cumulose* soils, such as *peat* and *muck*.

Soil mechanics is a branch of soil physics and engineering mechanics that describes the behaviour of soils. It differs from fluid mechanics and solid mechanics in the sense that soils consist of a heterogeneous mixture of fluids (usually air and water) and particles (usually clay, silt, sand and gravel) but soil may also contain organic solids and other matter. Soil mechanics is used to analyze the deformations of and flow of fluids within natural and man-made structures that are supported on or made of soil, or structures that are buried in soils. It is applicable in building and bridge foundations, retaining walls, dams and buried pipeline systems. Principles of soil mechanics are also applied in related disciplines such as engineering geology, geophysical engineering, hydrology etc.

Rock mechanics is a theoretical and applied science of the mechanical behaviour of rock and rock masses. It is the branch of mechanics concerned with the response of rock and rock masses to the force fields of their physical environment. Rock mechanics, as applied in engineering geology, mining, petroleum and civil engineering practices, is concerned with the application of engineering mechanics to the design of the rock structures generated by mining, drilling, reservoir production or civil construction activity such as tunnels, mining shafts, underground excavations, open pit mines, oil and gas wells, road cuts, waste repositories and other structures built in or of rock. It also includes the design of reinforcement systems, such as rock bolting patterns.

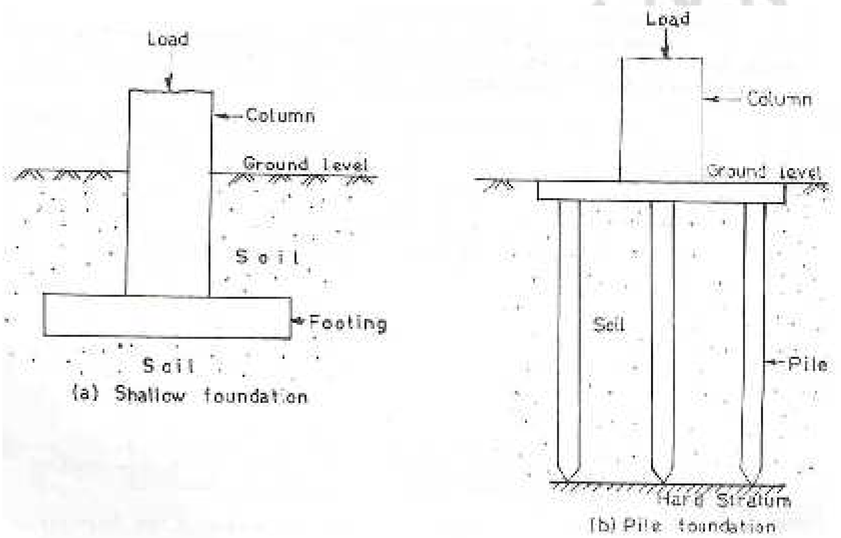
Soil engineering is an applied science dealing with the applications of principles of soil mechanics to practical problems. It deals with site investigation and analysis of a site for soil characteristics, its composition and drainage conditions. Soil engineering predicts whether a building will settle or shift over time based on the bearing capacity of the soil below. Soil engineering calculations are necessary both in designing a foundation as well as designing the structure itself. It involves taking borings and soil samples and investigation of soil composition and grade among other factors.

Geotechnical engineering is a broader term which includes soil engineering, rock mechanics and geology.

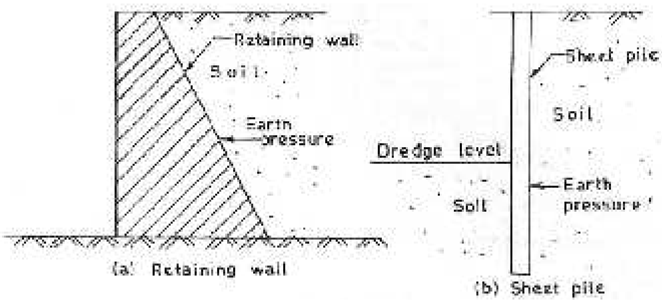
1.2. Scope of Geotechnical Engineering:

Geotechnical engineering has great scope in the field of various civil engineering works. Some of the important applications are as under:

i. Foundations: Every civil engineering structure, whether it is a building, a bridge or a dam, is founded on or below the surface of the earth. Foundations are required to transmit the load of the structure to soil safely and efficiently. A foundation is termed as a shallow foundation when it transmits the load to the upper strata of earth. A foundation is called deep foundation when the load is transmitted to strata at considerable depth below the ground surface. Pile foundation is a type of deep foundation. Foundation engineering is an important branch of civil engineering.



ii. Retaining Structures: When sufficient space is not available for a mass of soil to spread and form a safe slope, a structure is required to retain the soil. An earth retaining structure is also required to keep the soil at different levels on its either sides. The retaining structure may be a rigid retaining wall or a sheet pile which is relatively flexible. Geotechnical engineering gives the theories of earth pressure on retaining structures.



iii. *<u>Stability of Slopes</u>:* If soil surface is not horizontal, there is a component of the weight of the soil which tends to move it downward and thus causes instability of slope. The slopes may be natural or man-made. Soil engineering provides the methods for checking the stability of slopes.

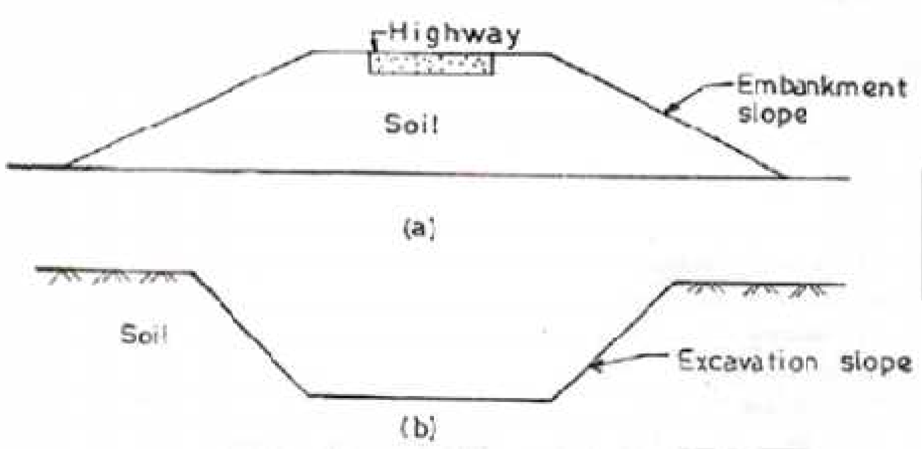
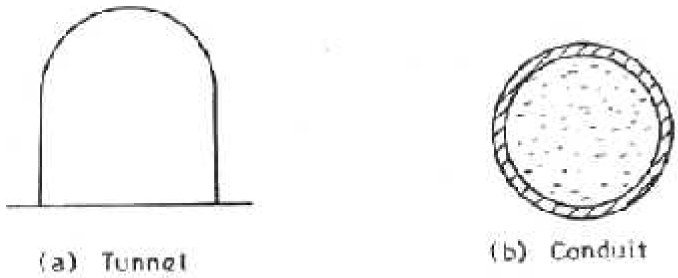
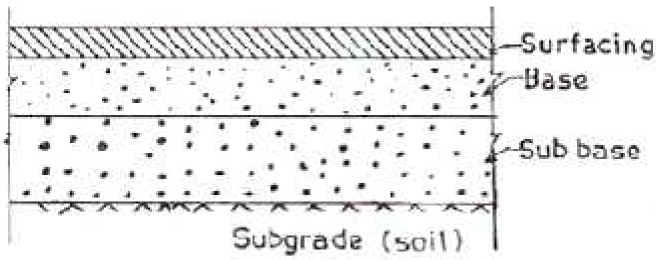


Fig: Slopes in (a) filling and (b) cutting

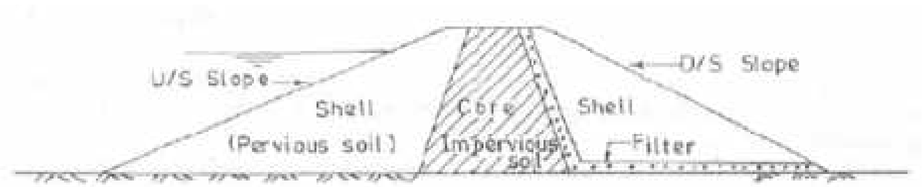
iv. *<u>Underground Structures</u>*: The design and construction of underground structures, such as tunnels, shafts and conduits require evaluation of forces exerted by the soil on these structures. These forces are discussed in geotechnical engineering.



v. *<u>Pavement Design</u>*: A pavement is a hard crust placed on soil (subgrade) for the purpose of providing a smooth strong surface on which vehicles can move. The pavement consists of surfacing, such as bitumen layer, base and sub base. The behaviour of subgrade under various conditions of loading and environmental changes is studied in geotechnical engineering.



vi. *<u>Earthen Dams</u>*: Earthen dams are huge structures in which soil is used as a construction material. They are built for creating water reservoirs. Since the failure of a dam may cause widespread catastrophe, extreme care is taken in its design and construction. It requires a thorough knowledge of geotechnical engineering.



vii. *<u>Miscellaneous Soil Problems</u>*: Geotechnical engineers have to sometime tackle miscellaneous soil problems, such as soil heave, soil subsidence, frost heave, shrinkage and swelling of soils. Geotechnical engineering provides an in-depth study of such problems.