CBCS Scheme **15CV35**

Third Semester B.E. Degree Examination, Dec. 2017/Jan. 2018

ENGINEERING GEOLOGY

Module 1

1. **a. What is Engineering Geology? Discuss its role in Civil Engineering.**

ENGINEERING GEOLOGY: The principles and methods of geology is adopted for the purpose of civil engineering operations. Broadly speaking, engineering geology has two divisions:

(1) The study of raw materials

(2) The study of the geological characteristics of the area where engineering operations are to be carried out such as Groundwater characteristics; the load bearing capacity of rocks; the stability of slopes; excavation; rock mechanics etc for civil engineer.

SCOPE OF GEOLOGY:

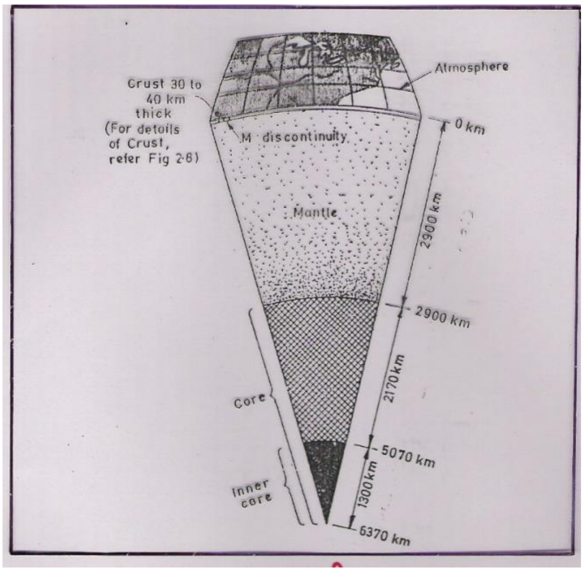
In Civil Engineering

- Geology provides necessary information about the construction materials at the site used in the construction of buildings, dams, tunnels, tanks, reservoirs, highways and bridges.
- Geological information is most important in planning stage, design phase and construction phase of an engineering project.
- Geology is useful to know the method of mining of rock and mineral deposits on earth's surface and subsurface.
- Geology is useful for supply, storage and filling up of reservoirs with water.

IMPORTANCE OF GEOLOGY FROM CIVIL ENGINEERING POINT OF VIEW

- Before constructing roads, bridges, tunnels, tanks, reservoirs and buildings, selection of site is important from the point of stability of foundation.
- Geology provides a systematic knowledge of construction materials and their properties.
- The knowledge about the nature of the rocks in tunnelling and construction of roads.
- The foundation problems of dams, bridges and buildings are directly related with geology of the area where they are to be built.
- The knowledge of ground water is necessary in connection with excavation works, water supply, irrigation and many other purposes.
- The knowledge of Erosion, Transportation and Deposition (ETD) by surface water helps in soil conservation, river control.
- Geological maps and sections help considerably in planning many engineering projects.

b. With a neat sketch, explain the structure and composition of the Earth.



The Crust:- Is the top most shell of the earth, which has a thickness of 30-40 km in the continents and 5-6km in the oceans. There is a striking variation in the materials or rocks, as they are called, composing the crust over the continents and ocean floors. The oceanic crust is made up of heavier and darker rocks called basalts compared to light- colored and light-density, granitic rocks of the continental crust. When considered as a part of the total structure of the earth, crust makes only an insignificant part represented by a thin layer similar to the skin of an apple. As regards the chemical composition of the crust, analyses made by Clarke and Gold Schmith, using rocks from different geographic regions of the crust have all shown that when expressed in terms of oxides, volume in the oceanic crust and above62% in the continental crust. Alumina is the next important oxide, varying between13-16% followed by Iron Oxides (8%), Lime (6%), Sodium (4%), Magnesium (4%), Potassium (2.5%) &Titanium (2%). The crust itself shows a complicated structure both in make-up and compositional variations.

The Mantle:- At the base of the crust materials of the earth become greatly different in many properties from those overlying the mine the crust. These materials appear to form a nearly homogeneous zone till a depth of 2900km is reached. This zone of materials lying between crust and a depth of 2900km is known a MANTLE. It is made up of extremely basic materials, called ultra basic rocks, which are believed to be very rich in iron and magnesium but quite poor in silica. Such rock names as Periodotites, Dunite. This One is characterized with a high density, increasing steadily with depth further; the mantle material is believed to be highly plastic in nature. Many of the most important geological process such as earthquakes and formation of mountains are believed to have their origin in this zone.

The Core:- It is the third and the innermost structures hell of the earth, which is clearly marked by the seismic evidence. It starts at adepthof2900 km below the surface andextends right upto the center of the earth at 6370km. The material making the core isfound to be from seismic studies only strikingly different from that making the other two shells in one major aspect, in elastic properties. The material has no shear resistance,which makes it nearer to liquid than to a solid body. It has a very high density, above 10gms/cubic centimeter, at the mantle–core boundary Nothing can be said about the composition of the core. According to one, widely favoured view, the core is made up of Iron and Nickel alloy material.

OR

2. <u>a. Explain briefly i) Rock forming mineral ii) Economic mineral</u>

Rock forming minerals:

The six minerals olivine, quartz, feldspar, mica, pyroxene and amphibole are the commonest rock-forming minerals and are used as important tools in classifying rocks, particularly igneous rocks. Except for quartz, all the minerals listed are actually mineral groups. However, instead of trying to separate all the minerals which make up a group, which is often not possible in the field, they are dealt with here as a single mineral with common characteristics.

Economic mineral:

Earth materials that can be used for economic and/or industrial purposes. These materials include precious and base metals, nonmetallic minerals, construction-grade stone, petroleum minerals, coal, and water.

b. Name the physical properties which are helpful to identify the mineral. Explain luster and fracture of a mineral with suitable examples.

Properties of Minerals

The following physical properties of minerals can be easily used to identify a mineral:

1. Color
2. Streak
3. Hardness
4. Cleavage or Fracture
5. Crystalline Structure
6. Diaphaneity or Amount of Transparency
7. Tenacity
8. Magnetism
9. Luster
10. Odor
11. Taste
12. Specific Gravity

Luster

Luster is the property of minerals that indicates how much the surface of a mineral reflects light. The luster of a mineral is affected by the brilliance of the light used to observe the mineral surface.

Fracture

Fracture describes the quality of the cleavage surface. Most minerals display either uneven or grainy fracture, conchoidal (curved, shell-like lines) fracture, or hackly (rough, jagged) fracture.

Module 2

3. a) What are igneous rocks? Explain the classification of Igneous rocks with suitable examples.

Igneous rocks are those, which are formed by direct solidification of liquid rock or magma. They are thus called primary rocks. Magma is a got viscous silicate melt with gases occur in the deeper part of the Earth. This magma during its upward journey tries to penetrate to thin crust. During this process magma sometimes successful in coming out and sometime they arrest themselves within the crust.

Lava: The magma which is successful in coming out on the Earth's surface, it is erupted out with a great force and spreads out on the surface of the Earth is called Lava.

Classification of Igneous rocks: They are classified on the basis of 'silica' content in the magma and 'mode' of occurrence.

1. Based on silica content:

a) Acidic Igneous rocks: It is rich in silica content (>65%ofSiO_2) Ex: Granite, Pegmatite.
b) Intermediate Igneous rocks: Silica percentage is 55-65% Ex: Syenite, Diorite.
c) Basic Igneous rocks: Silica content is 45-55% Ex: Dolerite, Gabbro.
d) Ultra-basic Igneous rocks: Silica content is <45% Ex: Dunite.

2. Based on mode of origin:

a) Plutonic rocks: These are deep seated rocks formed under slow cooling and great pressure conditions. They exhibit equi-granular texture because the magma has cooled slowly under uniform pressure. Ex: Granite, Syenite, Diorite, Gabbro.
b) Hypabyssal rocks: They are formed by the solidification of magma nearer to the surface of the Earth's crust. They show porphyritic texture because of rapid cooling of magma. Ex: Pegmatite, Porphyry, Dolerite.
c)Volcanic rocks: These are formed on the surface of the crust by the consolidation of the lava. Here, the minerals cannot be distinguished with naked eye because of very small grain size and is due to rapid cooling and chilling. Ex: Basalt.

b) What is Rock Quality Designation? How is RQD used for the rock mass classification?

Rock-quality designation (RQD) is a rough measure of the degree of jointing or fracture in a rock mass, measured as a percentage of the drill core in lengths of 10 cm or more. High-quality rock has an RQD of more than 75%, low quality of less than 50%. Rock quality designation (RQD) has several definitions. The most widely used definition was developed in 1964 by D. U. Deere. It is the borehole core recovery percentage incorporating only pieces of solid core that are longer than 100 mm in length measured along the centerline of the core. In this respect pieces of core that are not hard and sound should not be counted though they are 100 mm in length. RQD was originally introduced for use with core diameters of 54.7 mm (NX-size core). RQD has considerable value in estimating support of rock tunnels.

RQD is defined as the quotient:

"RQD = (Sumof10)/Itot * 100%"
Where (Sumof10) = Sum of length of core sticks longer than 10 cm
Itot = Total length of core run

Classification table

From the RQD index the rock mass can be classified as follows:

RQD	Rock mass quality
<25%	completely weathered rock
25-50%	weathered rock
51-75%	moderately weathered rock
76-90%	Hard rock
91-100%	Fresh rock

OR

4. a) <u>With a neat sketch, explain the development of folds, joints, faults and unconformities in rocks.</u>

Fold:

Axial line or Axis:- The median line about which folding has taken place. The axis may be horizontal, inclined or vertical

Axial plane:-An imaginary plane that divides a fold into two more or less symmetrical halves. The axial plane may be vertical inclined or horizontal

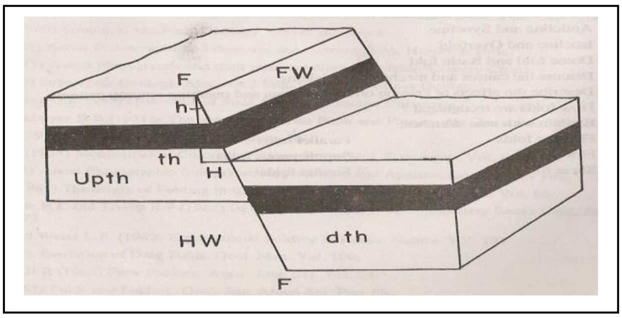
Limbs: -The two sides of a folds the left limb and right limb **Crest:**-Highest position of fold, it is always curving or angular **Crestline**: -The two sides of crest point are referred as crest line If the fold axis is inclined then it referred as Plunge of fold.

FAULT:

A fault is a fracture or fracture zone in rocks along which there has been displacement of the two sides relative to one another parallel to the fracture.

A fault is aruptured formation produced either by tensional or compressive force and maybe local or regional like famous San Andreas system of faults of North America.

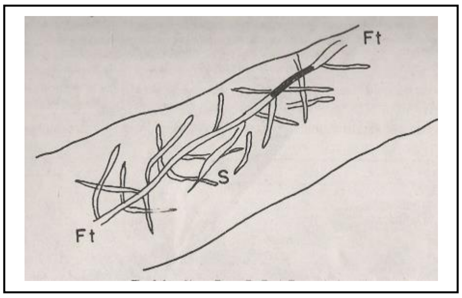
PARTSOF FAULT: -



<u>Faultplane(FF)</u>:- The planar fracture surface along which the break and dislocation of rock beds have taken place.

In elevation and plan, i.e. the vertical and horizontal sections the fault plane appears as line along which the dislocated beds remain almost in contact with each other.

The fault plane may be simple, clean cut smooth or slicken sided open fracture or an irregular zone of a number or smaller inter section fracture making a small angle with the main fault called a shear zone often filled with crushed rock and flour.



Shear zones range in width from less than a meter to several meters.

Fault plane may be vertical, but commonly it is steeply inclined. The attitude of the fault plane is specified by its dip and strike parameters. The intersection of fault plane with the surface is called the fault out crop, fault line, fault strike or commonly fault trace. The fault trace in most cases of high angle faults is straight or slightly sinuous. When the dip of the fault plane is low and the ground relief high it may be very irregular.

The direction of the trend of the fault trace with reference to the north-south line is the strike of the fault.

The lower wall of an inclined fault plane is called the **footwall** and the upper wall the

hanging wall.

<u>Throw</u>:-The vertical component of fault movement

The side of fault plane or trace, which appears to have moved down, is the fault block above an inclined fault plane is called down, throw side.

The side that appears to have moved up relative to the down throw side is called the up throw side.

The amount of throw varies from a few centimetres to thousand of meters.

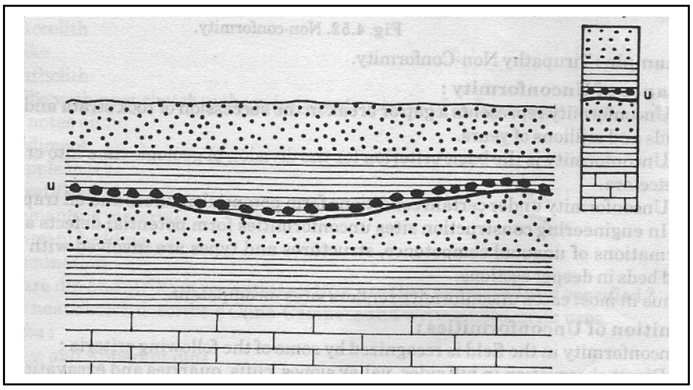
<u>Heave</u>: -The horizontal component of the fault movement, the shift in measured at right angles to the strike movement.

<u>Hade</u>: -The angle between the inclined fault plane and the vertical. Hade is thecompliment of the dip of the fault plane expressed in degrees.

UNCONFORMITY:

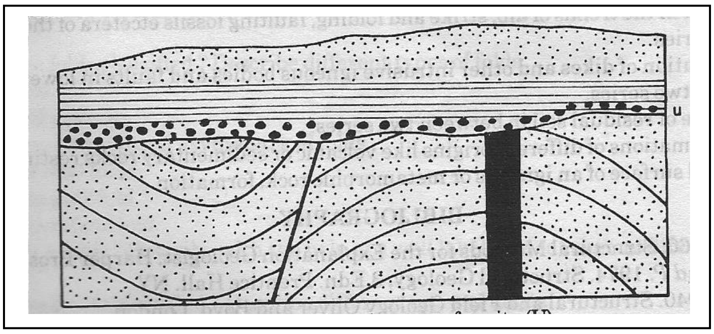
Unconformity is of three kinds.

PARALLELUNCONFORMITY OR DISCONFORMITY



An erosion surface with an uneven relief between two parallel (conformable)series.

ANGULAR UNCONFORMITY



An unconformity in which a younger parallel series deposited on an erosion surface of a lower deformed (tilted, folded and or faulted) older series with an angular discordance.

NON-CONFORMITY

An unconformity between two series of rock of different origins like an upper younger stratified formation and an older non-stratified or massive igneous or metamorphic rock.

b) Mention the Engineering consideration of folds, joints, faults and unconformities.

IMPORTANCEOF UNCONFORMITY

- Unconformity represents a gap or break in the succession of rock strata and a time gap of thousands of millions of years.
- Unconformity is the basic criterion for the division of geologic time into era, periods and epoch etc.
- Unconformity traps.
- In engineeringconstructionsitesunconformitiesformpotentialdefectsastwoseriesof rock formations of unequal competence, structure and types are involved with deformed and strained beds deeper sections.

IMPORTANCEOF FAULT:-

- Faults form a major defect in rocks and therefore a potential hazard in engineering and mining works.
- Fault movement trigger earthquake and landslides.
- Fault zones are most undesirable features in dam and reservoir sites.
- Faults provide passages for percolation of water and mineralizing solutions
- Fault zones form sites of mineralization
- Fault are responsible for lakes, swamps and spring heads
- Fault zones often form potential oil traps

IMPORTANCEOF FOLDS: -

Folded strata is greatly strained broken and incompetent, therefore form weak and unsafe zones in construction areas especially excavation, tunnelling, hillside, cutting and dam, bridge site.

Anticline and other up folds form potential oil traps while synclines and other down fold form potential aquifer for ground water. In some instances down folds like sync lines when filled with ground water artesian conditions undergoing pressure affecting the stability of the ground above and therefore the stability of structure constructed in such ground.

Module 3

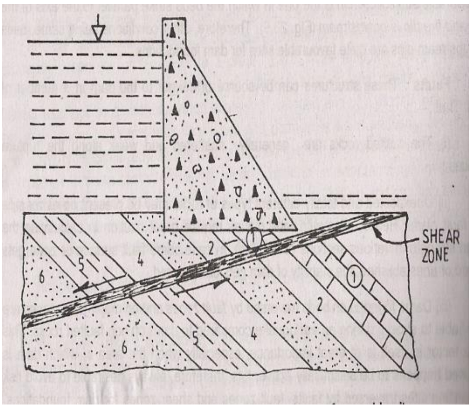
5. <u>Discuss briefly the geo-morphological aspect in the selection of the site for Dam construction.</u>

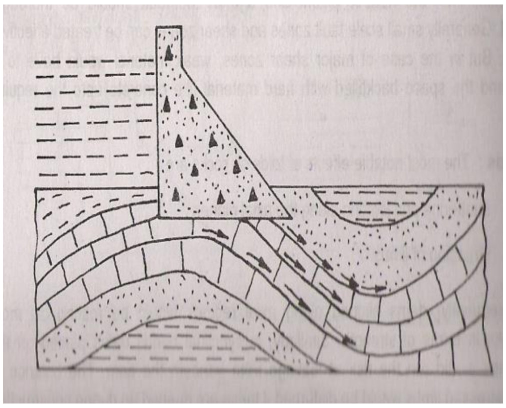
Thick and well-cemented beds of sandstones, grit, conglomerate and breccias are generally strong and impervious. However, the weak zones in such rocks may allow excessive per collation under the dam and these openings should therefore, be properly sealed by means of grouting. Massive and strong sedimentary rocks with calcareous matrix may become weak in course of time, due to removal of a portion of the cementing material in solution such foundation and abutment rocks, at dam sites should be studied and carefully protected. Limestone’s, Dolomite marbles and other carbon at rocks are usually strong enough to support the weight of the dam These soluble rocks, however contain enough of joints and solution cavities of variable dimensions, which act as suitable avenues for percolation too much of water below the dam. At the dam sites therefore the exposures of carbonater rocks should examined carefully to ascertain the extent to which they are likely to allow leakage of water underneath rocks like shale, clay stone, mud stone etc., are rather weak in nature especially when they are moist.

Sandstones are frequently interred bedded with shale. These layers of shale may constitute potential sliding surfaces. Sometimes such inter bedding causes the undesirable properties of shale by permitting excess of water to shale, sandstone. Contact seepage may weaker shale surfaces and cause slider, which dip away from abutments and spillways cuts.

Unlike the massive igneous and metamorphic rocks the sedimentary rocks are characterized by the presence of bedding planes. In case of dams lying in sedimentary rocks, therefore, the bearing capacity and water tightness of the foundation are dependent to some extent, on the orientation of the bedding planes in space. Horizontal beds are most capable of supporting the weight of dam since, in such cases; the load acts at right angles to the bedding planes. The weight of the dam, however, is not the only force acting on the foundation. The other force in play are the thrust of the water in the reservoir and this tends to push the dam horizontally towards the down streamside of the reservoir. The resultant of these too mutually perpendicular forces is obviously inclined downstream. The exact amount of inclination of this resultant is however, dependent on the magnitude of forces.

Leaving aside the aforesaid ideal condition sedimentary beds at dam sites may have any other orientation.





Many factors are causing a mass of material to slide or flow. Some of them play a direct role and are easily understand whereas others are indirectly responsible for the instability of the landmass. All such factors that facilities land sliding in one way or the another is generally grouped in tow headings.

1) Internal Factors

2) External Factors

Internal Factors:-These include such causes, which tend to reduce the shearing of the rock, further it is classified into, 1) The nature of slope, 2) Water content, 3) Composition and compaction of the mass, 4)geological structures

- **The nature of slope:-**Some slopes are very stable even when very steep whereas other are unstable, even at very gentle slope. But a great majority of failure are confined to slopes only, indicating that slopes are directly responsible for mass failure.

- **Water content:-**Much Importance is attached to the role of water is causing mass movements. It may act in a number of ways to reduce the shearing strength of the rock or soil mass. Even presence of water in the pores paces of rocks has been found to affect all the strength properties adversely. When water within the mass is also capable of flow around the grains. Similarly, when water happens to move along a plane of weakness within the mass, that plane gets lubricated and may turn into an effective plane of shear failure. In sliding type of failure this lubricating action is of great importance.

- **Composition and compaction of the mass :** Some materials are stable in a given set of conditions of slopes and water content whereas others may be practically unstable under those very conditions. This clearly suggests that compaction plays an important part in defining the stability of the masses. Sandstone exhibits a great variation in chemical composition. Siliceous Sandstones would be highly stable even during intensive rain sand at steep slopes whereas clayey or calcareous may suffer repeated failure under same conditions. Along with composition, the texture of rocks plays an important part-It indicates the degree and manner of packing of grains or crystals. Porosity and permeability of are the two important factors influencing the percolation of water through the mass.

- **Geological structures:-**Of all the geological structure the inclination (dip),joints, faults zones of the strata, presence or deposition of shear, fault zone, joints and other planes of weakness are important in defining their stability.

External Factors:-Earthquakes and blasting around mines due to this vibration is librated from this mass failure may take place.