Engineering geology

Unit 1 module 1

INTRODUCTION

- Geology is the science of the earth
- (geo = earth, logos = study or science).
- It deals with different aspects of the earth as a whole such as
- (i) Origin, age, interior structure and history of the earth,

- (ii) Evolution and modification of various surface features like rivers, mountains and lakes along with their causes, and
- (iii) Materials making up the earth.

- The vast subject of geology has been subdivided into the following branches for the sake of systematic study

Main Branches :	Physical Geology	**Allied Branches :**
	Mineralogy	Engineering Geology
	Petrology	Mining Geology
	Structural geology	Geophysics
	Historical geology (Stratigraphy)	Geohydrology
	Palaeontology	Geochemistry
	Economic geology	

IMPORTANCE OF GEOLOGY IN CIVIL ENGINEERING

- The Civil Engineers aim at safety, stability, economy and life of the structures that they construct.
- Civil engineering constructions like dams and bridges will have their foundations on geological formations of the earth's surface. Therefore, their stability and safety depend on the competence of the in situ rocks of the sites concerned.
- Also, to be economical, such competent foundation rocks should be at a shallow depth.
- Further, for huge constructions like dams, building materials are required in very large quantities near the site. Otherwise, the cost of construction will increase

- These critical details of civil engineering importance, i.e., durability and competence of foundation rocks, their depth of occurrence, availability of building material near project sites, can be reliably obtained from geological and geophysical studies.

Let us see some case histories

- *Case histories of failure of some civil engineering Constructions due to geological drawbacks*
- The significance of geology with reference to civil engineering will be better appreciated if the consequences of ignoring geological studies are also quotes.
- Few specific examples of failures of different kinds of important civil constructions due to geological cases are :

1. St. Francis Dam (California, 1928)

- This dam was a curved concrete gravity dam constructed between 1924 and 1926 in order to provide a storage reservoir for the Los Angeles Aqueduct system.
- The dam was failed in 1928, only twelve hours after its last inspection by Mulholland, who was a ‘self – taught’ engineer and orchestrated the design and construction of the Los Angeles – Owens River Aqueduct, the longest water conveyance system at that time

- The cause of dam failure is, When the plan for the dam construction is finalized and after construction began, the height of the dam was raised by ten feet on two separate occasions in order to provide additional reservoir storage needed to sustain the growing community surrounding the dam.
- Although these modifications increased the dam's height by twenty feet, no changes were made to its base width. As a result, the intended safety margin for this structural stability decreases significantly.
- At the time of failure, leaking cracks were observed within the main dam and at its abutments which were dismissed as conditions typical of the dam type.

- Finally, after the investigation of the failure, it was clearly proposed St. Francis Dam design was not reviewed by any independent party and the dam was designed to prevent small foundation stresses only and not accommodate full uplift.
- And the ultimate failure mode to weakening of the left abutment foundation rock due to the saturated condition created by the reservoir which essentially re-activated a large landslide that combined with a destabilizing uplift force on the main dam caused failure to initiate at the dam's left end.
- At the left end, the maximum height section tilted and rotated which destabilized the right end of the main dam causing catastrophic failure at the right end as well.

View Looking Upstream of St. Francis Dam prior to failure

Aerial view of St. Francis Dam site after failure.

- Geological Studies at the dam site will also suggest which design will be suitable for a given geological context.
- For example, gravity dams need very strong and competent foundation rocks; for Buttress dams, relatively less strong foundation rocks are enough;
- Arch dams need very strong and stable abutment rocks; for Earth dams, even weak foundation rocks met the requirements.

With Reference to Reservoirs

- The Jerome reservoir of Idaho and the Hondo reservoir of New Mexico are two examples of failures due to geological reasons

- As in the case of dam sites, selection of suitable sites for locating reservoirs needs geological studies to make them successful. Unfavourable geological conditions lead to quick silting of reservoirs, thereby decreasing its life, and profuse leakage of stored water.

- Intense weathering in the rocks upstream causes silting problems. Porosity and Permeability of rocks, occurrence of faults, joints and other weak planes cause leakage problems. Thus proper studies of geological conditions at any proposed reservoir site will forewarn an engineer of the problems, if any.

With Reference to Tunnels:

- Ramganga diversion tunnel (Himalayas), Umiam – Barapani stage I tunnel
- (Meghalaya) are some examples where geological conditions posed serious problems.
- Competence of the rocks, associated geological structures like bedding, faults, joints, porosity and permeability of rocks, and ground water conditions are the geological conditions which need to be thoroughly studied to solve such problems.

With Reference to Bridges:

- The failure of a bridge near Cornwall(Canada) and difficulties faced in the
- construction of the Georges rives bridge illustrate the consequences of improper or incomplete study of geological condition of the sites concerned.
- Strong and stable rocks are needed for foundations and abutments. Adverse geological structures should not occur at the site.

- **This is one of the most common causes of dam failures and has do with the geology of the dam site. Includes with the following considerations .**
- **1. Failure due to earthquake**
- **2. Failure due to landslide**
- **3. Failure due to chemical weathering of foundation rocks (Effect Of Alkali-Silica Reaction , Sulfate & Chloride On Concrete)**
- **4. Failure due to physical weathering (temperature variations, or by heavy rain, or by physical breaking)**
- **5. Failure due to increase of fractures in geological structures (fault, folds & unconformities)**

- **1. Kaila Dam, Gujarat, India**
- The Kaila Dam in Kachch, Gujarat, India was constructed during 1952 - 55 as an earth fill dam with a height of 23.08 m above the river bed and a crest length of 213.36 m. The storage of full reservoir level was 13.98 million m 3. The foundation was made of shale. The spillway was of ogee shaped and ungated. The depth of cutoff was 3.21 m below the river bed. Inspite of a freeboard allowance of 1.83 m at the normal reservoir level and 3.96 m at the maximum reservoir level the energy dissipation devices first failed and later the embankment collapsed
- due to the weak foundation bed in 1959.

2. Kodaganar Dam, Tamil Nadu, India

- **This dam in the India, was constructed in 1977 on a tributary of Cauvery River as an earthen dam with regulators, with five vertical lift shutters each 3.05 m wide. The dam was 15.75 m high above the deepest foundation, having a 11.45 m of height above the river bed. The storage at full reservoir level was 12.3 million m 3, while the flood capacity was 1275 m3/s. A 2.5 m free board above the maximum water level was provided. The dam failed due to overtopping by flood waters which flowed over the downstream slopes Hydraulics Prof. B.S. Thandaveswara Indian Institute of Technology Madras of the embankment and breached the dam along various reaches. There was an earthquake registered during the period of failure although the foundation was strong. Water gushed over the rear slopes, as a cascade of water was eroding the slopes. Breaches of length 20 m to 200 m were observed. It appeared as if the entire dam was overtopped and breached**

SCOPE OF GEOLOGY

- Engineering Geology: A well established interdisciplinary branch of Science and Engineering has a scope in different fields as outlined below:
- a)In Civil Engineering: Geology provides necessary information about the site of construction materials 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.
- b)In Mining Engineering: Geology is useful to know the method of mining of rock and mineral deposits on earth's surface and subsurface.
- c)In Ground Water: Resources development geology is applied in various aspects of resources and supply, storage, filling up of reservoirs, pollution disposal and contaminated water disposal

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 viewpoint of stability of foundation and availability of construction materials. Geology of area is important and rock-forming region, their physical nature, permeability, faults, joints, etc. Thus, geology is related to civil engineering in construction jobs with economy and success.**

- **The role of geology in civil engineering may be briefly outlined as follows:**
- **1. Geology provides a systematic knowledge of construction materials, their structure and properties.**

- **2. The knowledge of Erosion, Transportation and Deposition (ETD) by surface water helps insoil conservation, river control, coastal andharborworks.**

- **3. The knowledge about the nature of the rocks is very necessary in tunneling, constructing roads and in determining the stability of cuts and slopes. Thus, geology helps in civil engineering.**

- **4. The foundation problems of dams, bridges and buildings are directly related with geology ofthe area where they are to be built.**
- **5. The knowledge of ground water is necessary in connection with excavation works, water supply, irrigation and many other purposes.**
- **6. Geological maps andsections help considerably in planning many engineering projects.**
- **7. If the geological features like faults, joints, beds, folds, solution channels are found, they haveto be suitably treated. Hence, the stability of the structure is greatly increased.**
- **8. Pre-geological survey of the area concerned reduces the cost of engineering work.**

IMPORTANCE OF SOME MAIN & ALLIED BRANCHES OF GEOLOGY

- 1. ***PHYSICAL GEOLOGY/DYNAMIC GEOLOGY/GEOMORPHOLOGY.***
- It is concerned with the work of natural processes which bring about changes upon the earth's surface.
- As the name suggests it deals with :
- (i) Different physical features of the earth, such as mountains, plateaus, valleys, rivers, lakes, glaciers, and volcanoes in terms of their origin and development,
- (ii) The different changes occurring on the earth's surface, like marine
- transgression, marine regression, formation or disappearance of rivers, springs and lakes,
- (iii) Geological work of wind, glaciers, rivers, oceans, ground water, and their role in constantly moulding the earth's surface features, and
- (iv) Natural phenomena like landslides, earthquakes, and weathering.

- The main cause for surface changes is weathering. This is a natural phenomenon resulting directly or indirectly due to changes in the atmosphere. It disintegrates and decomposes rocks.

- This weathering is of special importance from the civil engineering point of view, because colour, appearance, strength and durability of rocks are adversely affected by weathering.

- Thus even granite which is considered ideal for most of the civil engineering works becomes weak and friable on thorough weathering, rendering it useless.

2. PETROLOGY(Petro = rock, Logos = Study)

- Petrology deals with the study of rocks. It deals with mode of formation, structure, texture, composition, occurrence, types of rocks.
- (i) The earth's crust, also called lithosphere, is made up of different types of rocks.
- (ii) The composition and textural characters of rocks primarily contribute to their inherent strength and durability.
- (iii) Rocks based on their suitability can be used as foundation for dams, for tunnelling and as materials of construction.

3. STRUCTURAL GEOLOGY

- This branch of geology deals with the study of structures of rocks in the earth's crust.
- (i) The rocks which form the earth's crust undergo various deformations, dislocations and disturbances under the influence of tectonic forces.
- (ii) The result is occurrence of different geological structures like folds, faults, joints and unconformities in rocks.
- (iii)The details of mode of formation, causes, types, classification, importance, etc., of these geological structures from structural geology.
- *From the Civil engineering point of view, it is as important as Petrology because these geological structures modify the inherent physical characters of rocks rendering them more suitable or unsuitable for civil engineering purposes.*

4. MINERALOGY

- This deals with the study of Minerals. This deals with the mode of formation, mcomposition, occurrence, types, association, properties, uses, etc., of minerals form the subject Mineralogy.
- Minerals are basic units with which different rocks and ores of the earth are made up of.
- For example, sometimes quartzite and marble resembles one another in shine, colour and appearance.
- But quartzite by virtue of its mineral composition is very hard, tough, strong and durable, while marble disintegrates and decomposes in a shorter period because of its mineral composition and properties.

5. HISTORICAL GEOLOGY/ STRATIGRAPHY

- It is the science of the description, correlation and classification of strata in sedimentary rocks including the interpretation of the depositionalenvironments of those strata.

- The study of the earth's history through the sedimentary rocks is called historical geology. It is also called as Stratigraphy (Strata = a set of sedimentary rocks; Graphy= description) because this subject deals with details and description of sedimentary rock sequences.

6. PALAEONTOLOGY

- It is the science of fossils of ancient life forms and their evolution.

7. ECONOMIC GEOLOGY

- The economic geology deals with the study of minerals, ores and fossil fuels of economic importance.

- 8. ENGINEERING GEOLOGY
- This deals with the application of geological knowledge in the field of civil engineering, for execution of safe, stable and economic constructions like dams, bridges and tunnels.

- 9. MINING GEOLOGY
- This branch of geology is concerned with the study of application of geology to mining engineering.
- 10. GEOPHYSICS
- The study of physical properties like density and magnetism of the earth or its parts, to know its interior, forms the subject matter of geophysics.

11. GEOHYDROLOGY

- This is also called as Hydrogeology.
- It deals with occurrence, movement andnature (i.e., quality and quantity) of ground water in an area.
- This branch is closely related to geology because the very existence, movement of ground water, etc., are directly related to porosity, permeability, structure, texture andcomposition of the surface and underground rocks.
- Dykes may control the occurrence and movement of ground water.

12. GEOCHEMISTRY

- This branch is relatively more recent and deals with the occurrence,distribution, abundance, mobility etc., of different elements in the earth’s crust.