Engineering Geology [3rd year B.Tech C.E (1-sem)]

Unit-I

Introduction

Geology is the science of the earth. [Geo = Earth, loges = study].

It deals with different aspects of the earth. Such as (i) Origin
(ii) Age
(iii) Interior
(iv) History.
(v) Evolution of Earth.

→ It is a recent Subject.

→ Geophysics, Geochemistry, Geohydrology, Glaciology, seismology, Oceanography, Mineralogy, Petrology, Structural Geology, Stratigraphy, Paleontology, etc... are the braches of Geology. Engineering Geology, mining Geology, are the applied branches of Geology.

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 etc....

(i) 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 of geological formations of the earth's surface.

→ Their stability and safety depend on the competence of the in situ rocks of the site concerned.

→ Economical point of view Competent foundations rocks should be at a shallow depth.

→ For huge constructions like dams, building materials are required in very large quantities near the site.

→ 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.

→ The significance of geology with reference to civil engineering will be better appreciated if the consequences of ignoring geological studies are also quoted.

→ Geological knowledge can also be utilized when necessary in dealing with huge buildings, runways, terrain evolution for military operations and defence purposes.

(ii) Failure of C.E. Constructions due to Geological drawbacks:-

A few specific examples of failures of different kinds of important civil constructions are listed now.

Dams:- The following are the few examples of failures of dams. These failures have occured only due to adverse geological conditions and not due to technical lapes.

(i) St. Francis dam of California.
(ii) Lafayette dam of California.
(iii) Austin dam of Texas.

In addition to these failures, there are also a number of examples where the cost of construction became very high in order to overcome the associated geological

→ Hales bar dam (on Tennessee river)
→ Camarassa dam (Spain)
→ Dokan dam (Iraq)
→ Chickmauga dam (USA)
→ Vallgalling dam (Italy) etc....

Geological studies at the damsite will also suggest which will be suitable for a given geological context.

Reservoirs:— The Jerome reservoir of Idaho and the Hondo reservoir of New Mexico are two exemples of failures due to geological reasons.

→ Selection of suitable sites for locating reservoirs nee -ds geological studies to make them successful.
→ Unfavarable geological conditions lead to quick silting of reservoirs, leakage of water.
→ Intense weathering in the rocks upstream causes silting problems.
→ Thus proper studies of geological conditions at any proposed reservoir site will forewarn an engineer of the problems. if any.

Tunnels:— → Ramganga diversion tunnel (Himalayas)
→ Umiam - Barapani stage I tunnel (Meghalaya)
→ Koyna III stage tail race tunnel.
→ Bassein creek tunnel (Bombay) are

Some examples of 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 studied to solve such problems.

Bridges:- Failure of bridge near Cornwall (Canada) and difficulties faced in the construction of the Georges river bridge illustrate the consequences of improper or incomplete study of geological conditions at the sites concerned.

→ Strong & stable rocks are needed for foundations and abutments. Adverse geological structures should not occur at the site.

Roads and Railways:- The erstwhile problem of frequent boulderfalls along some sections of Bor Ghat on the Bombay – Pune line is one of the examples that may be quoted to highlight the importance of geological studies at the site.

Thus, to ensure safety, stability, success and economy in all major civil engineering constructions, geological studies are very important.

Failures of various earlier structures due to different geological causes have now made it mandatory to have geological clearance before taking up major construction. N.G.R.I & G.S.I are needfaul in this regard.

Importance of physical Geology, Petrology & structral Geology

physical Geology: — This is also described as dynamic-geology, geomorphology etc. 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 occuring on the earth's surface.

iii) Geological work of physical factors constantly molding the earth's surface features.

iv) Natural phenomena like landslides, earthquakes, & weathering.

Disintegrates & decomposes of rocks is directly or indirectly resulting due to the changes of atmosphere. This aspect is of special importance from the civil engineering point of view. because physical properties of rocks can be adversely affected by weathering.

Civil engineers deal with structures like dams. Dams are the artificial barriers to the natural flow of water/river. Proper understanding of the geological work of a river and its features will lead to their better utilization for engineering applications.

Importance of petrology :- Petrology deals with the study of rocks. The earth's crust, also called lithosphere (litho = rocks), is made up of different kinds of rocks.

The composition and textural characters of rocks primarily contribute to their inherent strength & durability. Rocks based on their suitability can be used as foundation for dams, for tunnelling and as construction materials. Hence this is the most important branch of geology from civil engineering point of view.

Structural geology :- It is important in the civil engineering point of view because it deals with the geological structure like - folds, faults, joints and unconformities of rocks. ~~Are the modifying the inherent physical characters of rocks.~~

Ex :- At a dam site Sedimentary rocks with upstream dip provide a desirable geological set-up, while the same rocks with down stream dip make the geological set-up most un desirable.

Weathering of Rocks

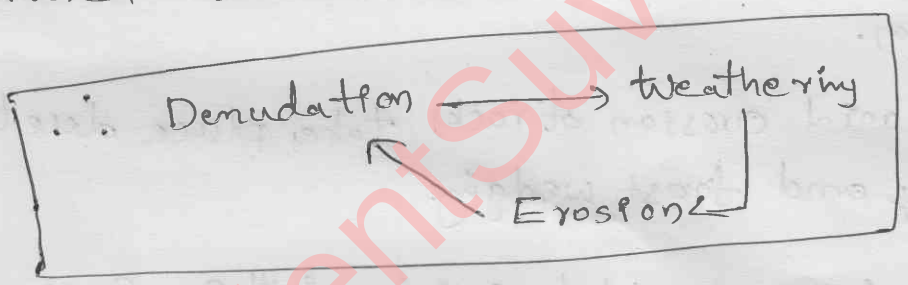
Weathering :- The process of mere chemical decay and mechanical disintegration of rocks is called weathering.

→ Due to weathering the effected rock become weak, less cohesive and fractured.

Erosion :- The process of removal of weathered material from the place of its formation is called erosion.

→ Erosion leads to degradation in that region.

Denudation :- The process of exposing fresh country rocks to the surface due to the removal of their overlying weathered material is called denudation.



'3' ← Interrelated processes

The weathering process :-

Factor :- Physical, chemical & Biological factors of nature.

Effects :- Due to weathering rocks become smaller. They are reduced in size.

(i) Physical factor
(ii) Chemical " .
(iii) Biological " . are...

(i) physical factors :- Wind, rivers, glaciers, dashing waves and tides, gravity, exfoliation, frost wedging, frost heaving and miscellaneous.

(a) Wind :- Wind is a relatively weak natural force because of the medium that is Air.

→ Abrasion, Deflation are the phenomenon caused by wind.

(b) River :- The importance of a river as an exogenous geological agent and its mode of causing erosion.

→ abrasion, attrition, hydraulic action & solutes are erosional processes.

(c) Glaciers :- The slow moving ice body can only cause disintegration.

→ The glacial erosion of rocks takes place due to abrasion, quarring and frost wedging

(d) Tides of Sea :- Coastal erosion is the consequence of dashing tides and waves of the sea.

(e) Hydraulic action :- It is the most powerfull marine erosion,

(f) Gravity :- The earth's gravitational attraction imparts enormous energy to falling bodies.

(g) Exfoliation :- It is a type of mechanical disintegration of rocks that takes place due to frequent intense temperature changes. [Exfoliation → Ex = pre-existing and folio = layers]

Chemical Factors :- Water directly affects rocks by way of dissolution (complete disappearence of rocks) leaching (making porous), hydration and hydrolysis.

Dissolution :- This happens in case of Carbonate rocks, particularly limestones.

$$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$$

(Limestone) (Calcium bicarbonate)

Leaching :- Water is the most powerful corroding and leaching agent. Minerals affected by water.

→ Laterite is typical example.

Hydration :- Hydration is the process wherein water or hydroxyl molecules are injected into the molecular structures of minerals, thereby bringing about the decomposition of these minerals.

$$K_2Al_2O_3 6SiO_3 + H_2O + CO_2 \longrightarrow K_2CO_3 + Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O + 4SiO_2$$

(Orthoclase) (Hydration) (Kaolin) (Sand)

Hydrolysis :-

$$KAlSi_3O_8 \longrightarrow H^+ \longrightarrow HAlSi_3O_8 + K^+$$

(Feldspar) (Hydrogen ions from water) (Silicic acid-like structure)

Atmospheric gases like CO_2, O_2 N_2 are the other factors of chemical weathering.

Biological factors:- plants, animals, Man and bacteria help in disintegration and decomposition of rocks.

Trees & plants :- The developing roots of growing trees and plants, sometimes penetrate into the cracks, widen them and ultimately the rocks disintegrate.

Animals :- Animals make burrows underground and help in the weathering of rocks.

Bacteria :- These help in decay of organic material and produce humic, carbonic and other acids.

Man :- Man ranks top in the list of various factor responsible for forced, unnatural weathering of rocks.

→ By quarrying, blasting of rocks
→ Mining - opencast & underground mining.

Importance of Weathering :-

Some useful effects of weathering are :-

→ Weathering produces soil which is vital for agriculture and for the production of different crops.

→ Weathering makes rocks porous and permeable. This is very important from ground water occurrence point of view in the case of hard rocks like granites and gneisses.

→ These acquire acquifer characteristic because of weathering.

→ Cheap building stones like laterites develop due to weathering.

→ Oxidation & Supergene enrichment are important phenomena in the formation of Sulphides.

→ Occurrence of a few economically important placer deposits too is indirectly related to weathering.

But civil engineering point of view weathering is not a welcome process, because it reduces the strength, durability and good appearance of rocks.

→ Weathered rocks unfit to be at the site of foundation of civil structures like dams and bridges.

- to make that sites fit, remove weathered zone increase the cost.

→ Weathered rocks lose characters of strength, durability and good appearance so they become unfit to be used as construction material.

(2) ... building stones, railway ballast, road material.

→ Weathering due to sea waves results in coastal erosion which poses a difficult problem for civil engineers.

→ Weathered rocks being weak are unsuitable for tunnelling.

→ Enormous loose soils (formed out of weathering) along steep slopes may turn out to be landslides, a civil engineering hazard.

→ Weathered zone in the upstream side creates silting problems in the case of reservoirs.

→ Rapid silting reduces the capacity of the reservoir, (or) the life of the reservoir

Thus, weathering poses many problems for civil engineers.

Granite is one of the most abundant rock on the earth surface. Therefore, it will be appropriate to critically analyse the process of weathering in granite.

Mineralogically, ordinary granite contain feldspar (orthoclase and plagioclase) and quartz as essential minerals, and muscovite, biotite and hornblende as common accessory minerals.

The effect of weathering mineral-wise is as follows,

→ Hornblende responds to weathering in a manner similar to biotite, as it is also a ferromagnesium mineral.

Thus due to decomposition, granite produces different kinds of material, which may be grouped as follows.

(a) Unaltered minerals :-

Quartz → Sand grains.
Muscovite → Mica flakes.

(b) Insoluble residues :-

Clays → Hydrous aluminium silicates
Iron oxides are the colouring matter of rocks.

(c) Soluble substances :-

These are the salts formed from substances such as potassium, Sodium, Calcium, magnesium, iron and silica.

The soluble material enters the rivers and is carried to the sea, contributing to the dissolved salts of the ocean.

The decomposition of basic rocks proceeds on the same general lines as those of granite.

→ They produce more soluble material and iron oxiding and less free silica than granites because they are rich in ferromagnesium.

This is the weathering of granite.

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