

UNIT-I

Introduction:

Engineering Geology is the application of geology to engineering study for the purpose of assuring that the geological factors regarding the location, design, construction, operation and maintenance of engineering works are recognised and accounted for. Engineering geologists provide geological and geotechnical recommendations, analysis, and design associated with human development and various types of structures.

The practice of engineering geology is also very closely related to the practice of geological engineering and geotechnical engineering. If there is a difference in the content of the disciplines, it mainly lies in the training or experience of the practitioner.

Importance of geology from civil Engineering point of view.

Every civil engineering works involve earth and its features. Geological information are necessary in every stage of the project be it planning, designing or construction phase of the project.

The importance of geology in civil engineering may be briefly outlined as follows:

1. Geology provides a systematic study of the structure and properties of construction materials and their occurrence. The civil engineers need to know the properties of rocks accurately to enable them to consider different rocks for any required

that is as a foundation rock, as road metal, as concrete aggregate, as building stones, as the roofing material for decorative purpose.

2. The selection of a site is important from the viewpoint of stability of foundation and availability of construction materials. Geology provides knowledge about the site used in the construction of buildings, dams, tunnels, tanks, reservoirs, highways and bridges.
3. Geology helps to identify area susceptible to failures due to geological hazards such as earthquake, landslides, weathering effects, etc.
4. The knowledge about the nature of the rocks is very necessary for tunnelling, constructing roads and in determining the stability of cuts and slopes.
5. The foundation problems of dams, bridges and buildings are directly related to the geology of the area where they are to be built.
6. The knowledge of groundwater is necessary for connection with excavation works, water supply, irrigation and many other works.
7. Geological maps help in planning civil engineering projects. It provides information about the structural deposition of rock types in the proposed area.
8. Geology helps in determining the earthquake-prone areas. If any geological features like faults, folds, etc. are found.
9. A Geological survey of a site before starting project

will reduce the overall cost.

Brief study of case histories of failures of 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 quoted.

With Reference to Dams:

The following are few examples of failures of dams.

1. St. Francis dam of California.

2. Lafayette dam of California.

3. Austin dam of Texas.

Geological studies at the dam site will also suggest which design will be suitable for given geological context.

For example, gravity dam need very strong and competent foundation rocks; For buttress dam, relatively less strong foundation rocks are enough; Arch dams need very strong and stable abutment rocks; For earth dams, even weak foundation rocks meet 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.

With Reference to Tunnels:

Ramganga diversion tunnel (Himalayas), Omiam-Barapani stage I tunnel (Meghalaya), Koyna III stage tail race tunnel, and Bassein creek tunnel (Bombay)

are some of the examples where geological conditions posed serious problems.

With Reference to Bridges:

The failure of a 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 of the sites concerned.

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

With Reference to 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 sites.

Occurrences of landslides, earthquakes, land subsidences, high snowfall, waterlogging, type of natural forces like rivers, etc....

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

Importance of Physical Geology, Petrology, and Structural Geology.

Physical Geology is the branch of geology that deals with geologic events and materials occurring at the present time, or in the very near past.

Physical geologists study current processes, like volcanoes, earthquakes, erosion, weathering, and glaciers. They use their understanding of historical geological process to understand what might be causing current geological processes to take place, as well as utilizing new technologies and techniques.

Importance of Petrology:

Petrology plays an important role in ascertaining the physical and chemical composition of rocks and the different conditions that influence their formation. Modern petrology rely on knowledge in mineralogy to help in mapping and sampling of rocks. Since most rocks constitute various minerals, it becomes easier to study and understand them with background knowledge in mineralogy.

Petrological research is also crucial in helping us understand the nature of the earth's crust and mantle. Over many years, the earth's tectonic processes have shaped the nature of rocks and the topography of earth's surface. These geological processes are vital in determining the suitability of certain areas for agriculture, industrial or commercial use.

Importance of Structural Geology:

The study of structural geology has a primary importance in economic geology both petroleum geology and mining geology. The main target of structural geology is to use measurements to understand the stress field that resulted in the observed strain and geometries. We can also understand the structural evolution of a particular area

due to plate tectonics.

An essential importance of structural geology is to know areas that contain folds and faults because they can form traps in which the accumulation and concentration of fluids such as oil and natural gas occur.

WEATHERING OF ROCKS:

The deteriorating effect of weather, climate, or atmospheric agencies on rocks may be described as weathering of rocks.

The different kinds of rocks which are formed under different conditions undergo disintegration, lose their strength and decay when exposed to earth's surface.

The Weathering Process:

The weathering of rocks is due to processes of mechanical disintegration and chemical decomposition.

This happens due to different Physical, chemical and biological factors of nature.

Physical factors:

Out of the two types of weathering, i.e., disintegration and decomposition, the disintegration process is accomplished in nature by a greater variety of natural agencies like wind, rivers, glaciers, dashing waves and tides, gravity, etc..

Wind:

Wind is a relatively weak natural force because of medium, i.e., air. In spite of this it can cause disintegration or create conditions favourable for weathering. Its action is more pronounced on sea shores and desert regions.

Wind causes disintegration by means of abrasion and attrition.

River:

The importance of a river as an exogenous geological agent, and its mode of causing erosion are dealt with along with the influencing factors.

Glaciers:

These slow-moving bodies of ice can cause only the disintegration. Decomposition of rocks cannot take place due to the extremely cold environment. The glacial erosion or disintegration of rocks takes place due to abrasion, quarrying and frost wedging.

Dashing waves & tides of the sea:

Coastal erosion is the consequence of dashing tides and waves of the sea. The wind, when it blows over shallow parts of the sea, creates waves. The marine erosion is both by means of mechanical disintegration and chemical decomposition.

Abrasion:

The sea waves armed with rock fragments cause abrasion of coastal rocks. The sharp fragments cause powerful impact and also scouring effects.

Attrition:

Since abrasion is always accompanied by attrition, here too, attrition is the consequence of abrasion.

Hydraulic action:

Among different kinds of marine erosion this is the most powerful. The waves and currents of the sea break down the rocks along the coast by their forceful impact. The effect is so severe that even the hard rocks are shattered.

Miscellaneous:

The endogenous geological agents also contribute to the physical breakdown of rocks. These are irregular in their functioning and their action lasts for very brief periods.

Volcanic eruptions and earthquake occurrences illustrate this phenomenon.

Chemical Factors:

This is a relatively slow process but very effective in the weathering of rocks. This process weakens the rocks to the extent of offering no resistance to natural forces to break them down.

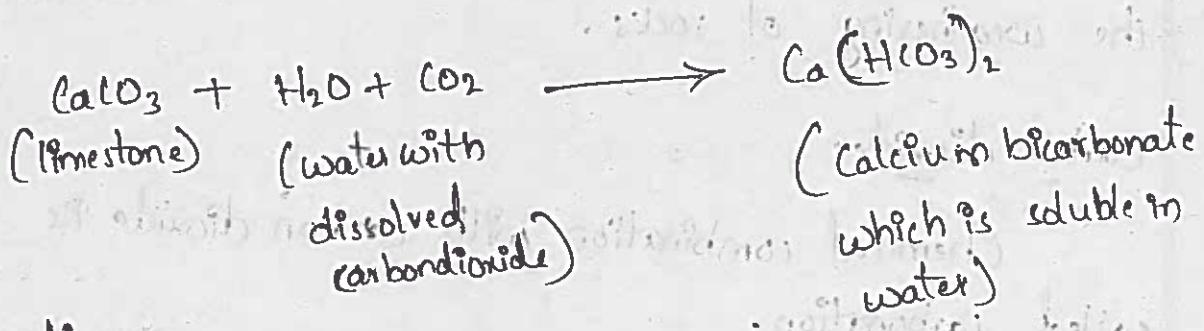
Water:

Water in the form of river, glacier, frost & sea is very active in bringing about the disintegration of rocks. It plays a leading role in the decomposition of the rocks too. As an agent of decomposition water acts directly & indirectly in different ways.

Dissolution:

This happens in the case of carbonate rocks; particularly limestones. Carbon dioxide of the atmosphere has natural tendency to dissolve in water. The extent to which it dissolves depends on the temperature, pressure and chemical environment.

The chemical reaction that explains this phenomenon as follows:



Leaching:

Water among different liquids, is the most powerful corroding and leaching agent. Only very few materials are totally unaffected by water.

Under a tropical climate rocks are thoroughly leached and made porous.

Laterite is a typical example.

Hydration:

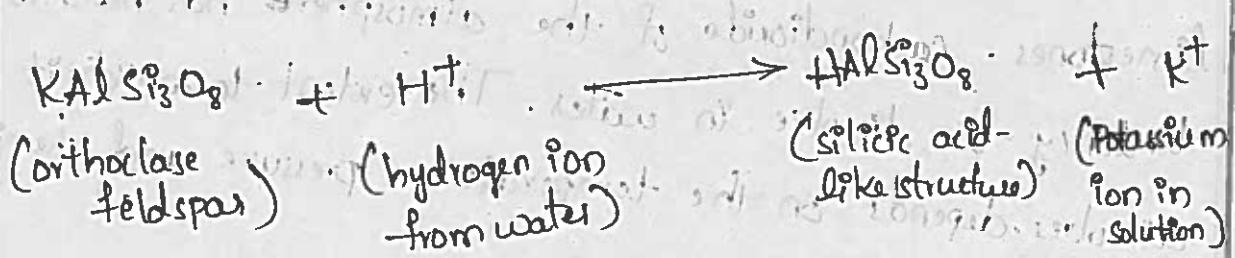
It is the process wherein water or hydroxyl molecules are injected into molecular structures of minerals, thereby bringing about the decomposition of these minerals.

This phenomenon is extremely important because it affects more than 80% of the minerals of an avg. rock.

Hydrolysis:

In some cases of decomposition which lead to the weakening of rocks, instead of water molecule, only the hydrogen part of water enters into the mineral structure.

This is called hydrolysis. The following eqⁿ is example



Atmospheric gases: CO₂, Oxygen & Nitrogen are some atmospheric gases which take part in the weathering of rocks.

Carbon dioxide:

Chemical combination with carbon dioxide is called carbonation.

Oxygen:

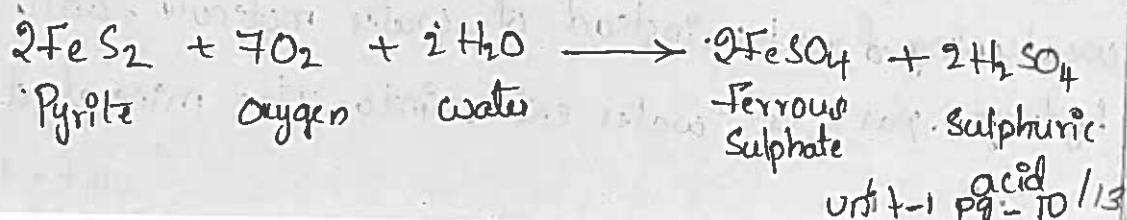
Chemical combination with oxygen is called oxidation. Ferruginous minerals show conspicuous colour changes due to oxidation.

Reduction is another similar process of chemical weathering. It takes place in the zones where the soil is rich in decaying vegetation.

Pyrite:

This is a very common accessory mineral in many rocks. It is very harmful for rocks because it creates favourable conditions for weathering.

This mineral gets oxidised in iron sulphate with the liberation of sulphuric acid which may chemically attack the other composition of rock.



Biological factors:

plants, animals, man & even bacteria help in disintegration and decomposition of rocks.

Trees and Plants:

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

Animals: Some animals make burrows underground & help in the weathering of rocks. The major contribution towards weathering from animals and plants is that when they die their soft parts decay and decompose, releasing toxic products which are highly potent in causing decomposition of rocks, particularly reduction.

Bark Bacteria:

Some bacteria also take part in the decomposition of rocks. These help in decay of organic material and produce humic, carbonic and other acids.

Man:

Man ranks top in the list of various factors responsible for forced unnatural weathering of rocks. He is all powerful and to satisfy his various requirements he undertakes large-scale construction of buildings, dams, bridges, roads, etc.,

Importance of Weathering:

Some useful effects of weathering:

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

→ cheap building stones like laterites develop due to weathering.

- Economic mineral deposits like bauxite are formed due to weathering.
- Occurrence of a few economically important placer deposits too is indirectly related to weathering.
- However, from the civil engineering point of view, weathering is not a welcome process, because it reduces the strength, durability and good appearance of rocks.
- Weathering due to sea waves results in coastal erosion, which poses a difficult problem for civil engineers.
- Weathered rocks being weak are unsuitable for weathering.
- Enormous loose soils along steep slopes may turn out to be landslides, a civil engineering hazard.

Response of Granite to Weathering:

The weathering phenomenon has been discussed at length from various angles. Yet, by considering what actually happens when a particular rock undergoes weathering, a clear concept of weathering can be achieved.

Among different rocks which occur on the earth's surface, granite is one of the most abundant. Therefore, it will be appropriate to critically analyse the process of weathering in granite.

The table shows the chemical composition undergoes changes during weathering.

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

- a) Unaltered minerals: Quartz forms sand grains. & muscovite produces mica flakes.
- b) Insoluble residues: The resulting hydrous aluminium silicates are the fundamental constituents of clays; iron oxides are the colouring matter of rocks.

S.no.	Mineral	Chemical Composition	Weathering Effect	Products of Weathering
1.	Feldspars			
	A. Orthoclase (or microcline)	K_2O Al_2O_3 $6SiO_2$	goes into solution as carbonate, chloride, etc., hydrated to form hydrous aluminium silicate, with the liberation of soluble	soluble material clay, soluble material
	B. Oligoclase (plagioclase)	$3Na_2O$ CaO $4Al_2O_3$ $20SiO_2$	goes into solution as carbonate, chloride, etc.,, decomposes as in orthoclase	soluble material clay
2.	Quartz	SiO_2	Remains undecomposed	sand grains
3.	Muscovite (white mica)	$2H_2O$ K_2O $3Al_2O_3$ $6SiO_2$	Remains undecomposed	mica flakes
4.	Biotite (black mica)	H_2O K_2O $Si(Mg, Fe)O$ Al_2O_3 $3SiO_2$	goes into solution as carbonate or chloride goes into sol ⁿ as carbonate or chloride; iron carbonate oxidizes to hematite or limonite forms hydrous aluminium silicate and soluble silica	water soluble material soluble material & colouring material clay, soluble material

Table : Decomposition in granite.