

# Unit 1

## Module 2

# WEATHERING OF ROCKS :

- Weathering is a natural phenomenon resulting directly or indirectly due to changes in the atmosphere.
- It disintegrates and decomposes rocks.
- This aspect 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

- Any rock, however hard and strong it may be, when exposed to the atmosphere, decays and disintegrates, ultimately making the rock unfit to be at the site of the foundation or to be used as construction material.
- The earth's surface has been dynamic and therefore, subject to various kinds of changes like Transgressions and regressions of the sea, appearance of new mountains, rivers, glaciers, volcanoes, lakes, springs, waterfalls, etc., and disappearance of old or earlier features of similar kind are just a few such changes.
- The natural forces like rivers, glaciers, wind, volcanoes, earthquakes, tectonic forces, etc., which are part and parcel of earth's crust are responsible for all these changes.

- **GEOLOGICAL AGENTS** : The natural forces which are responsible for the visible changes on the earth's surface are called geological agents.
- Based on their origin these natural forces can be grouped into “Exogenous or epigene” geological agents and “Endogenous or hypogene” geological agents.
- These two groups differ not only in their origin but also in their nature of work and results produced, etc.

Exogenous Geological Agents	Endogenous Geological Agents
<ul style="list-style-type: none"> <li>✓ These agents originate on the earth's surface, work slowly but steadily and erase topographic irregularities, i.e., ups and downs on the surface.</li> <li>✓ Their geological work in a way is systematic, i.e., commences with erosion and is followed by transportation and deposition.</li> </ul>	<ul style="list-style-type: none"> <li>✓ The nature, origin and functions of endogenous geological agents are in principle opposite to those of exogenous geological agents.</li> <li>✓ The latter originate below the earth's surface, work suddenly and create topographic irregularities.</li> <li>✓ Volcanoes, Earthquakes, Ground</li> </ul>

<ul style="list-style-type: none"> <li>✓ The erosion process causes disappearance of protruding land masses like hills, while the deposition process causes the disappearance of depressed land masses like pits, lakes and seas. Thus plain land surface is made to evolve.</li> <li>✓ Examples of Exogenous geological agents are Rivers, Wind, Glaciers, Tides and Waves of the sea, etc.,</li> <li>✓ The work of these forces appears to be too slow, because visible changes are not noticed even in decades or</li> </ul>	<p>water and tectonic forces are typical examples of the group of endogenous geological agents. Their action not only obliterates the results of exogenous geological agents but also creates great topographic heights and depths.</p> <ul style="list-style-type: none"> <li>✓ Volcanoes are generally hill like structures with trenched tops. They undergo periodical eruptions and out of accumulations of resulting lava flows and ash, volcanic mountains develop.</li> </ul>
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centuries.

- ✓ The distinctive characters of exogenous geological agents are : (i) Slow but methodical work involving erosion, transportation and deposition, (ii) Removal of irregularities such as elevations (like hills and highlands)) and depressions (like lakes and seas) leading to the development of plain ground on the earth's surface and (iii) Their origin on the surface.

- ✓ Earthquakes, which are often associated with geological faulting phenomena, result in steep fault scarps or ridges or highlands. Faults and folds of geological strata occur due to tectonic forces which are internal and inherent in the earth. They are combinedly responsible for all great mountain ranges of the world.
- ✓ Ground water is responsible for the occurrence of "Karst topography", Known for its rugged surface and irregularities.

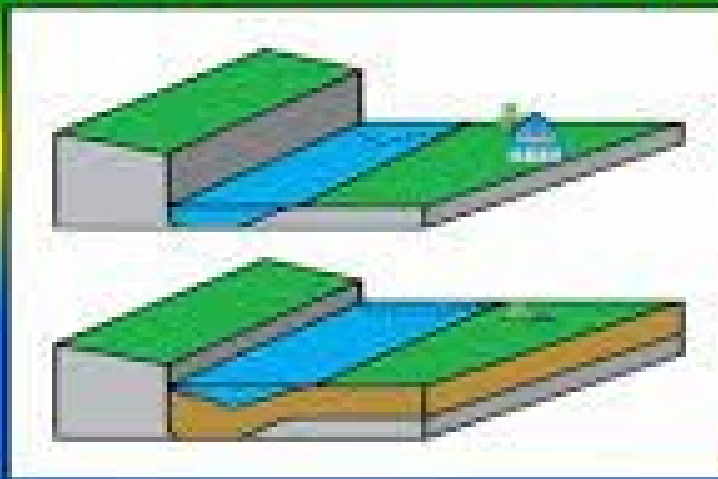
- Thus, the different natural forces of the earth can be grouped into two categories, i.e.,
- Exogenous and Endogenous. Since they are inherent in the earth and permanent in existence, their effects too are always present and thus, make the earth's surface a scene of constant dynamic changes.
- **DEGRADATION :** The continuous removal of topographic irregularities from hills, mountains or highlands reduces their height bit by bit and ultimately their topographic level becomes equal to their surroundings. This phenomenon of lowering the elevation or altitude of high lands may be described as "Degradation."



- **AGGRADATION :**
- The exogenous geological agents dump their load in places favourable for deposition.
- Due to continuous deposition in the low lying tracts, basins, lakes, seas, etc., which are topographic depressions, these are gradually filled up, thereby decreasing their depths slowly bit by bit.
- Finally, their topographic level becomes equal to their surroundings. This phenomenon of the rising of the sea or lake bottom or their depth reducing may be described as “Aggradation

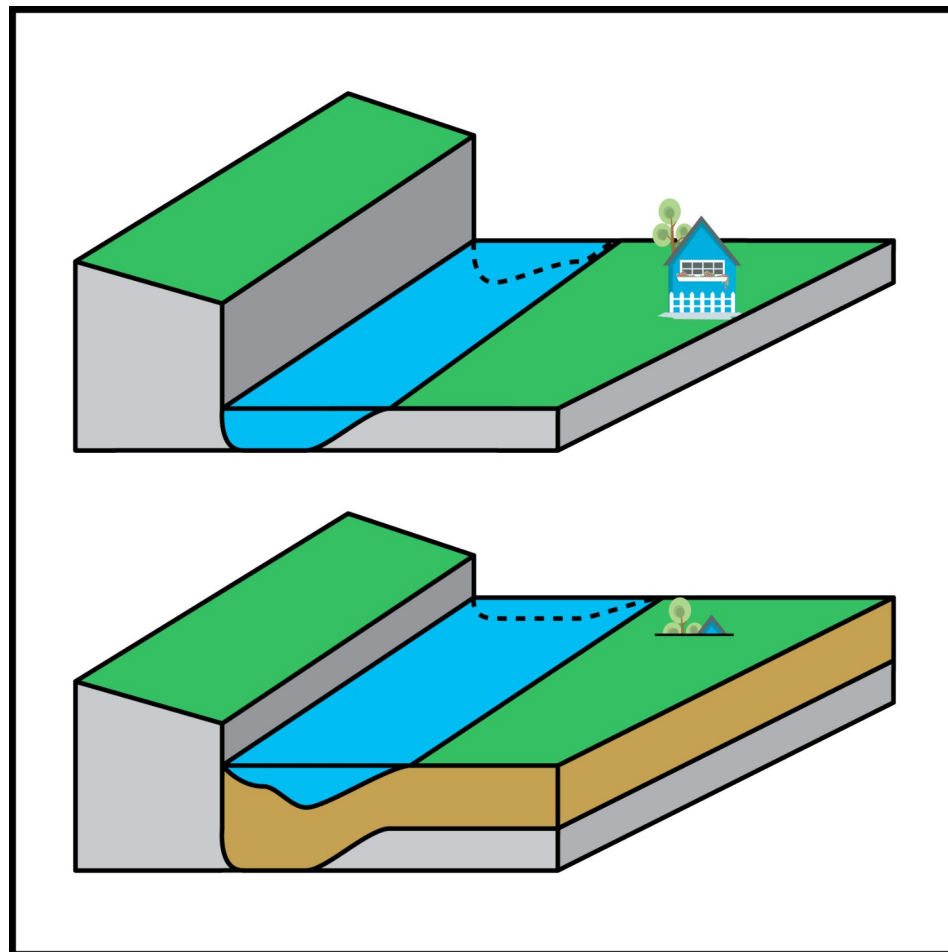
# Difference Between

## Aggradation



## Degradation





# Aggradation vs Degradation

Factor	Aggradation	Degradation
Effect on base level	Increases the base level	Decreases the base level
Sedimentary environment	Happens in sediment-choked rivers	Happens more often in sediment-starved rivers
Associated processes	Associated with deposition	Associated with erosion
River energy	Associated with decreasing kinetic energy	Associated with increasing kinetic energy

- **GRADATION:** Due to degradation (i.e., lowering of highlands) and aggradation (i.e., concomitant elevation of lowlands) processes,
- the topographic elevations and depressions disappear, leading to the development of plain ground or land masses of a very gentle slope.
- This is called “Gradation.
- **What is the root cause of the gradation???**
- The tough and hard rocks of giant size subjected to natural breakdown in the hills and rocks are reduced in size due to physical, chemical and biological factors of nature.
- They may act together or independently. When physical factors influence, the rocks are just mechanically broken down.

- When chemical factors influence, the rocks are decayed, decomposed and weakened.
- When biological factors influence, the rocks are disintegrated as well as decomposed.
- This disintegration and decomposition process which is instrumental in the breakdown or reduction of size of rocks is called “Weathering”.
- *Thus, Weathering is the root cause for gradation.*

- Weathering is the breaking down of rocks, soils and minerals as well as artificial materials through contact with the Earth's atmosphere, biota and waters.
- Weathering occurs in situ, or "with no movement", and thus should not be confused with erosion, which involves the movement of rocks and minerals by agents such as water, ice, wind, and gravity.
- **Two important classifications of weathering processes exist**
  - 1) physical weathering.**
  - 2) chemical weathering.**

- **1. Physical weathering:-**

- a) Thermal stress
- b) Frost weathering
- c) Pressure Release
- d) Hydraulic action
- e) Salt-crystal growth
- f) Biological weathering



- **2. Chemical weathering.**
- a) Dissolution / Carbonation
- b) Hydration
- c) Hydrolysis on silicates and carbonates
- d) Oxidation
- e) Biological weathering

- Mechanical or physical weathering involves the breakdown of rocks and soils through direct contact with atmospheric conditions, such as heat, water, ice and pressure.
- Chemical weathering, involves the direct effect of atmospheric chemicals or biologically produced chemicals in the breakdown of rocks, soils and minerals.

## **IMPORTANCE OF WEATHERING WITH REFERENCE TO DAMS, RESERVOIRS AND TUNNELS**

- **Weathering transports rocky material after the process of weathering has broken bedrock down into smaller, moveable pieces. Through erosion the surface of the earth is constantly being sculptured into new forms.**
- **The shapes of continents are continuously changing, as waves and tides cut into old land while silt from rivers builds up new land. Weathering initiates the erosion of rock, causing alterations in the surface layers.**
- **Weathering is a process that applies major role of engineering mechanics, e.g. kinematics, dynamics, fluid mechanics, and mechanics of material, to predict the mechanical behavior of erosion.**
- **Rock mechanics & weathering process are plays a theoretical and the mechanical behaviour of rock and rock masses; it is useful in the branch of mechanics concerned with the response of rock and rock masses to the force fields of their physical environment.**

- **The fundamental processes are all related to the behaviour of erosions. Together, soil and rock mechanics are the basis for solving many engineering geologic problems with references to damreservoirand tunnels.**

- Role of Atmosphere in Weathering: Along with the gravity effect, the atmosphere is directly or indirectly responsible for the weathering phenomenon.
- Since the earth is enveloped by atmosphere(air) everywhere, all rocks exposed on the surface are invariably affected by weathering. The atmosphere is essentially a mixture of various gases like N<sub>2</sub>, O<sub>2</sub> and CO<sub>2</sub> and water vapour.
- Wind is nothing but the moving air. Wind is capable of forming considerable physical disintegration under favourable condition. The water vapour or moisture content of the atmosphere is responsible for rainfall and snowfall which cause formation of rivers, glaciers, seas, etc. these dynamic forces play a major role in causing disintegration and decomposition of rocks.
- The atmosphere also transmits heat and thereby influences effects of temperature changes.

- The atmospheric carbon dioxide, oxygen, etc., cause carbonation, oxidation, reduction, etc., in the mineral constituents of rocks and thereby decompose the rocks.
- The inert nitrogen content of the atmosphere, at times under the influence of lightning and bacteria, changes into chemically potential nitric acid and aids in the decay of the rocks.

- **EROSION:** It is a process of breakdown of rocks into smaller and smaller pieces and their subsequent removal from their places of original occurrence. i.e.,
- Erosion reduces the sizes of rocks to such an extent that they are easily transported by the exogenous geological agents.
- **DENUDATION :**
- When erosion takes place, fresh underlying surfaces of country rocks are exposed for weathering attack.
- This process of exposing fresh rocks to the surface due to the removal of their overlying weathered material is called Denudation.
- In any area denudation leads to weathering, weathering leads to erosion and erosion leads to denudation. Thus these processes are interrelated and go on.

## Natural Disintegration Process in Rocks

- During disintegration, the rocks are broken down without chemical changes by temperature, frost, water or air.
- Disintegration occurs mainly in the drier, higher and colder regions of the earth's surface.
- In desert and mountainous regions the great variations in temperature cause strains to be set up in the surface layers of rocks by which fragments are scaled off.
- The rocks may be split into numerous thin pieces by this action.
- The freezing of water in cracks may break rocks into angular fragments, and much of the weathering in high mountainous takes place in this way.



- Glaciers may pluck and tear boulders from their beds and by their slow movement grind the material they carry against the sides and floors of the valleys, with the formation of sand and mud.
- Many streams which are formed from glaciers are heavily loaded with material derived from this action.
- The disintegration process usually occurs under conditions which preclude chemical activity upon the rocks. The products of disintegration are frequently quite fresh or comparatively unaltered rock fragments.

- **Decomposition of Rocks :** This process is more active in moist, warm and low lying areas.
- *The main factors of decomposition are water and air.*
- When rain falls through the atmosphere it dissolves a certain proportion of the carbon dioxide, oxygen and other gases. This oxygenated and carbonated water is particularly active in attacking the minerals.
- It is strengthened by ground water, which has already attacked the rocks, and is therefore poorer in oxygen and carbon dioxide, but richer in dissolved substances which may exert a very active influence in further attack upon the rock constituents.

- Important processes of decomposition are solution, oxidation, hydration and carbonation.
- Oxidation involves the alteration of minerals with the products of oxides. It is particularly more active with iron – bearing minerals forming the iron oxides hematite and limonite, which are the chief colouring matter in rocks and produce the red, brown and yellow colours that are so common on weathered surfaces.
- The process of hydration alters minerals into substances rich in combined water.
- In carbonation the minerals are altered with the formation of carbonates.
- In this way, the effect of decomposition is to produce certain soluble substances such as carbonates, sulphates and chlorides and to leave behind an insoluble residue consisting of hydrated oxides and silicates, mixed with minerals such as quartz and muscovite which have suffered negligible attack by the agents of weathering.

- **REGOLITH:** The resulting product of Disintegration is the mantle of broken and decomposed material of varying compositions and thickness, called the Regolith, which covers the whole surface of the earth except in areas in which it is removed as fast as it is formed.
- The regolith may remain in the same place for a long period or may be quickly transported by natural forces to find its ultimate resting place in the sea.

# Regolith



# Importance of Weathering :

- Some useful effects of weathering are.
- 1. Weathering produces soil which is vital for agriculture and for the production of, different crops.
- 2. 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 aquifer characteristics because of weathering. Of course, the presence of joints, faults, shear zones in them also contributes to this phenomenon.
- 3. Cheap building stones like laterites develop due to weathering.

- 4. Economic mineral deposits like bauxites are formed due to weathering.
- 5. Oxidation and supergene enrichment are important phenomena in the formation of some ore deposits, particularly sulphides.
- 6. 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.
- Therefore, all thoroughly weathered rocks, irrespective of their original competence, become unfit to be at the site of foundation of important civil structures like dams and bridges. To make such sites fit, either intensive grouting or digging the weathered zone and refilling with concrete are resorted to. These increase the cost.
- Since weathered rocks lose characters of strength, durability and good appearance, they also become unfit to be used as construction material, either in the form of building stones, or railway ballast or road metal or concrete aggregate.



- ❑ 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.
- ❑ Occurrence of a thoroughly weathered zone in the upstream side creates silting problems in case of reservoirs. Rapid silting reduces the capacity of the reservoir, in other words, the life of the reservoir.
- ❑ Thus, weathering poses many problems for civil engineers.

