VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELGAUM

ENGINEERING GEOLOGY

(Subject Code: BCV303)

LECTURE NOTES

(MODULE-3)

III-SEMESTER

Ms. Pooja D

Assistant Professor

AJIET

AJIET

A J INSTITUTE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF INFORMATION SCIENCE AND ENGINEERING

(A unit of Laxmi Memorial Education Trust. (R))

NH - 66, KottaraChowki, Kodical Cross - 575 006

Surface investigation for Civil Engineering projects

Weathering, type, causes, soil insitu, drifted soil, soil profile, soil mineralogy , structure, types of soil,

Black cotton soil v/s Lateritic soil; effects of weathering on monumental rocks, River morphology and basin investigation for engineering Projects like earthen dam, gravity dam, arch dam, features of

river erosion, deposition and their influences on river valley projects, morphometric analysis of river

basin, selection of site for artificial recharge,, interlinking of river basins, coastal process and landforms, sedimentation /siltation, erosion

ROCK AS CONSTRUCTION MATERIAL

Rock is a solid cumulative of minerals located in the earth's lithosphere. They have been used by mankind through history as a basic construction material. There are huge variation within each type of rocks, depending on their engineering properties rocks have been used in various construction works. Rocks are using for making bricks, fire places and kitchen counter of our homes, dams, buildings, railway ballast, pavement material, road metal, concrete aggregates etc. Rocks are extremely important in terms of their stability and strength as a geological material on which construction foundation are made.

Rocks are used as Construction Materials in Following:

Concrete Aggregate: Aggregates are used in concrete for very specific purposes. The use of coarse and fine aggregates in concrete provides significant economic benefits for the final cost of concrete in place. Aggregates typically make up about 60 to 75 percent of the volume of a concrete mixture, and as they are the least expensive of the materials used in concrete, the economic impact is measurable. Rocks in Concrete aggregate Concrete is made by mixing fine aggregate, coarse aggregate, cement and water. The raw material for making cement is also obtained by rocks.

Railway Ballast : used in railway ballast to a) To provide firm and level bed for the sleepers to rest on b) To allow for maintaining correct track level without disturbing the rail road bed c) To drain off the water quickly and to keep the sleepers in dry conditions d) To discourage the growth of vegetation e) To protect the surface of formation and to form an elastic bed f) To hold the sleepers in position during the passage of trains g) To transmit and distribute the loads from the sleepers to the formation h) To provide lateral stability to the track as a whole

The stone to be used as railway ballast should be hard, tough nonporous and should not decompose when exposed to air and light. Igneous rocks like quartzite and granite forms the excellent ballast materials. Railway Ballast is the foundation of railway track and provide just below the sleepers. The loads from the wheels of trains ultimately come on the ballast through rails and sleepers.

Roofing and Flooring: Slate is a foliated metamorphic rock that forms from the metamorphism of shale it is popular for a wide variety of uses such as roofing, flooring. Slate is useful for roofing, pool tables and floor tile. Flooring and Roofing Shale, Marble, mudstone, slate and well packed sandstone are all examples of impermeable rocks which are extensively used for flooring and roofing material. Stone are available in plenty across the entire stretch of the country. Many of these are suitable for providing floors in residential construction. Stones suited for the purpose should be strong and able to resist abrasion and impact besides giving a pleasing appearance. Some of the stones which is used for floor construction are given below. (a) Kota stone (b) Granite (c) Sand stone

Foundation: Rock foundations are always prefered because rocks offer a number of advantages compare with soil in terms of stability and durability. Even the weakest rock is better in strength and reliability compared to good soils. Rocks such as limestone, granite, sandstone, shale and hard solid chalk have a high bearing capacity which are extensively used for foundation

Engineering Properties of Rock

Structure: The structure of the stone may be stratified (layered) or unstratified. Structured stones should be easily dressed and suitable for super structure. Unstratified stones are hard and difficult to dress. They are preferred for the foundation works.

Texture: Fine grained stones with homogeneous distribution look attractive and hence they are used for carving. Such stones are usually strong and durable.

Density: Denser stones are stronger. Light weight stones are weak. Hence stones with specific gravity less than 2.4 are considered unsuitable for buildings.

Appearance: A stone with uniform and attractive colour is durable, if grains are compact. Marble and granite get very good appearance, when polished. Hence they are used for face works.

Strength: Strength is an important property to be looked into before selecting stone as building block. Indian standard code recommends a minimum crushing strength of 3.5 N/mm^2 for any building block. Due to non-uniformity of the material, usually a factor of safety of 10 is used to find the permissible stress in a stone. Hence even laterite can be used safely for a single storey building, because in such structures expected load can hardly give a stress of 0.15 N/mm2. However in stone masonry buildings care should be taken to check the stresses when the beams (Concentrated Loads) are placed on laterite wall.

Hardness: It is an important property to be considered when stone is used for flooring and pavement

Weathering: Rain and wind cause loss of good appearance of stones. Hence stones with good weather resistance should be used for face works.

Toughness: The resistance to impact is called toughness. It is determined by impact test Stones with toughness index more than 20 are preferred for road works. Toughness indexes 13 to 19 are considered as medium tough and stones with toughness index less than 13 are poor stones.

WEATHERING

It is a process that causes the breakdown of rocks, either to form new minerals that are stable on the surface of the earth, or to break the rock down into smaller particles. Weathering is the result of the interactions of air, water, and temperature on exposed rock surfaces and prepares the rock for erosion.

Erosion is the movement of the particles by ice, wind, or water. The particles are then transported by that agent until they are deposited to form sedimentary deposits, which can be later eroded again or transformed into sedimentary rocks. Weathering is generally along, slow process that is continuously active at the earth's surface.

There are two kinds of weathering:

1. mechanical
2. chemical.

Mechanical weathering: It is the process by which rocks are broken down into smaller pieces by external conditions.

Processes of Mechanical Weathering

A single block is broken gradually into numerous small irregular fragments and then into smaller fragments. further it is classified into block disintegration and granular disintegration.

Block disintegration:-This is because of regular arrangement of atoms in a rock, due to this individual blocks are obtain.

Granular Disintegration: -This is because of irregular arrangement of atoms in a rock, due to this small grains are obtain.

Thermal or Heat Effect:- The effect of change of temperature on rocks is of considerable importance in arid and semi-arid regions where difference between day time and night time temperature is very high. expansion on heating followed by contraction on cooling, repeated expansion and of the same rock body gradually breaks into smaller pieces due to stress developing by this process.

Frost Action: It results due to freezing of water which are trapped in the cracks of the rocks widen sand deepens the cracks, breaking of f pieces and slabs.

Plant and Animal activities:- Plant roots can extend into fractures and grow, causing expansion of the fracture and eventually can break rock. Animals burrowing or moving through cracks can break rock. Plants can penetrate into the ground just a few meters where as micro organisms can penetrate to a depth of 10-25 mts.

Weathering Rinds- a rock may show an outer weathered zone and an inner unweathered zone in the initial stages of weathering. The outer zone is known as a weathering rind

Exfoliation –Concentrated shells of weathering may form on the outside of a rock and may become separated from the rock. these thin shells of weathered rocks are separated by stresses that result from changes in volume of the minerals that occur as a result of the formation of new minerals.

Spheroidal Weathering -If joints and fractures in rock beneath the surface form a 3-dimensional network, the rock will be broken into cube like pieces separated by the fracture. Water can penetrate more easily along this fracture and each of the cube- like pieces will begin to weather inward. The rate of weathering will be greatest along the corners of each cube, followed by the edges, and finally the faces of the cubes. As a result the cube will weather into a spherical shape with unweathered rock in the center and weathered rock towards outside. such progress of weathering is referred as Spheroidal Weathering.

Chemical weathering: it is a process where chemical alteration or decomposition of rock sand minerals takes due to rain water and other atmospheric agents. chemical weathering weakens the bonds in rock and makes them more vulnerable to decomposition and erosion.

Process of Chemical Weathering

The chemical weathering of rocks involves reactions that are interrelated that may occur simultaneously, and that utilize water, oxygen, carbon dioxide, and organic acids. These processes include hydrolysis, oxidation, carbonation, solution, hydration, and chemical changes induced by the growth of plants.

Hydrolysis:-Hydrolysis is a chemical reaction between a mineral and water. It involves a reaction between the H+ or OH" ions in the water and relatively active metallic ions such as sodium, calcium, potassium and magnesium. Hydrolysis is particularly important in causing the decomposition of silicate minerals. Although it may occur in the presence of pure water, in nature hydrolysis nearly always involves carbon dioxide. To illustrate, small quantities of carbon dioxide from the atmosphere or soil are dissolved in water to form carbonic acid.

The potassium ions released from the feldspar may be carried away in solution, utilized by plants, or become incorporated into clay minerals. A small part of the silica is removed in solution, although the greater part remains in the clay-rich weathering residue.

Carbonation:- As implied by the term, carbonation involves the chemical addition of carbon dioxide to earth materials. Carbon dioxide in the atmosphere (and in the air trapped within soils) is readily absorbed to water to form carbonic acid. Although relatively weak, carbonic acid nevertheless has a pervasive cumulative effect in the chemical weathering of a variety of different kinds of rocks. It is involved in the dissolution of common silicate minerals and is particularly effective in dissolving limestones and dolostones. The reaction for limestone is indicated below

$$H_20 + C0_2 = H_2C0_3$$

Water carbon dioxide carbonic acid

$$H_2C0_3 + CaC0_3 > Ca(HCCy_2)$$

carbonic acid calcite soluble calcium (in limestone) bicarbonate

In order for carbonation to occur, water must be readily available. For this reason carbonation is most vigorous in most climates.

In the weathering of silicate minerals, carbonation and hydrolysis work together as the earth's most important processes for achieving decomposition of rocks. The hydrolysis component provides clay minerals and takes silica into solution, while simultaneously carbonation removes metallic elements as ions in solution.

Oxidation:-Oxidation, the addition of oxygen to a compound, is one of the main kinds of changes produced in rocks by chemical weathering. Oxygen has a strong affinity for iron, which may be present in such silicate minerals as hornblende, and olivine, as well as sulphides such as pyrite (FeS).

The oxidation of the iron (essentially what we call rusting) takes place chiefly in the presence of atmospheric moisture and results in the range of red and brown colourations we see in soils, and weathered rocks. In the oxidation process, oxygen gas dissolved in water reacts with iron to from hematite (Fe_20_3) or limonite (Fe_20_3 H_2O). The process is illustrated by the illustrated by the following formula,

$$4Fe + 30_2 + nH_2O \text{ -> } 2(Fe_20_3)\ nH_20$$

iron oxygen water "limonite" iron hydroxide or "rust"

(n means a variable amount)

Hydration:- Hydration is a process whereby water is absorbed by a mineral and incorporated into the weathering product. For example the mineral anhydrite ($CaS0_4$) may take in water to become alabaster gypsum ($CaS0_4$ nH_2O), or hematite (Fe_20_3) may be converted to limonite (Fe_20_3 nH_20). Hydration is an important process in the development of clay and accounts for the presence of water within many clay minerals. Another aspect of hydration is that the hydrated mineral, because of the water it has taken up, larger than the parent mineral. The increase in volume causes growing hydrated crystals to exert pressure on the walls of the spaces they occupy, and such pressure may contribute to rock disintegration.

SOIL

Soil is an important natural resource, they represent the interface between the lithosphere and the biosphere. As soil provides nutrients to plants, soils consists of weathered rock plus organic material that comes from decaying plants and animals.

Engineers define soil as any unconsolidated material that may be excavated without blasting. Soil contains mostly quartz and clay particles of varying sizes. The quartz sand grains help keep the soil porous, and the clay particles hold water and nutrients for plant growth.

Sand – composed of sand grains mostly without clay

Loam – Mixture of sand and clay

Clay– The finest material, mostly kaoline without sand

Importances of soils are:

1) Natural resource(for agriculture, for construction material)
2) Soil erosion
3) As a sediment source(via erosion)
4) As a water filter(for water infiltrating the ground)
5) As a contaminant sink
6) As a bearing material (for building on)

Soil Profile: When a soil develops on a rock, a soil profile develops as shown below. These different layers are not the same as beds formed by sedimentation, instead each of the horizons forms and grows in place by weathering and the addition of organic material from decaying plants and plant roots. Vertical sequence of A, B, C and D horizon is the soil profile which is as follows.

Selection of Site for Dams and Reservoirs

A **dam** may be defined as a solid barrier constructed at a suitable location across a river valley. The principle uses are to provide stream regulation and storage for communities or industrial water supply, power, irrigation, flood control. A dam that serves more than 1 such purpose is known as multipurpose dam.

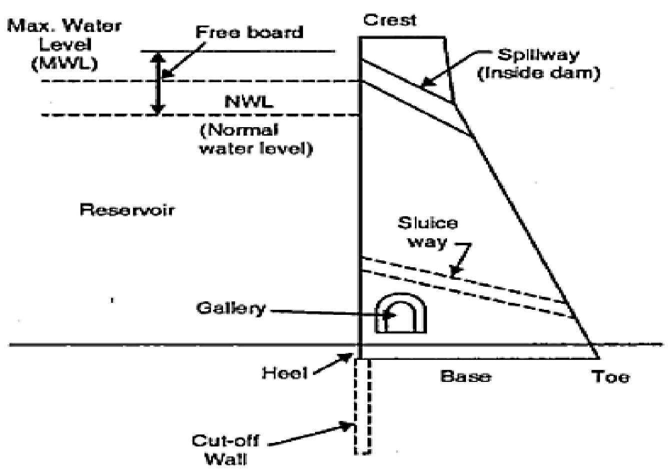


Fig- Schematic Cross Section of Dam

Structure of Dam: Generally Dam consists of following parts

Heel : It is the part where the dam comes in contact with the ground on the upstream side.
Toe : It is the part where the dam comes in contact with the ground on the downstream side.
Abutments : These are the sides of the valley on which the dam structure rests.
Free board: It is the difference in level between the top of the dam wall and the highest storage level.
Galleries : These are small rooms left within the dam for checking operations
Diversion tunnels : These are the tunnels which are constructed beforehand for diverting the river water. This helps in keeping the river bed dry at the dam site and facilitates dam construction.
Spill way : It is the arrangement made in a dam near the top to let off excess water of the reservoir to the downstream side.
Sluice way : It is an opening in the dam near the ground level. It is useful in clearing the silt of the reservoir.
Cut-off wall : It is an underground well-like structure of concrete in the heel portion. It is useful in preventing leakage under the foundation and thereby avoiding undercutting of the heel as well as the uplift pressure (or upward thrust) on the dam, which are harmful to dam stability.

1. Gravity Dam
2. Buttress Dam
3. Arch Dam
4. Earth dam

1. **Gravity Dam** :- A gravity dam is a solid masonry or concrete structure generally of a Triangular in cross section. solid gravity dam drive their stability from weight of the materials comprising the structure. Axis may be straight line it is designed that it can with hold a percolated volume of water by its weight. All the applied forces on such a dam is due to water and weight of the dam itself are assumed to be directly transmitted to the foundation rock.

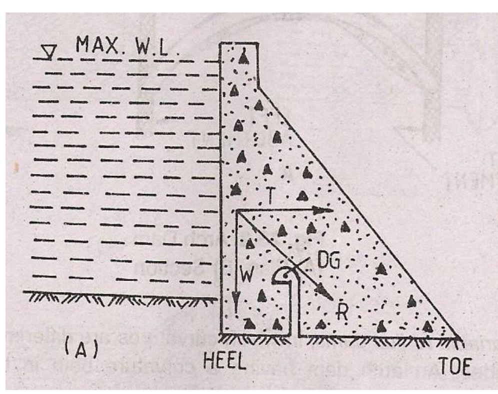


Fig: A Typical Cross Section of Gravity Dam

1. **Buttress Dam**: - A buttress dam or hollow dam is a dam with a solid, water-tight upstream side that is supported at intervals on the downstream side by a series of buttresses or supports. The dam wall may be flat or curved. Most buttress dams are made of reinforced concrete and are heavy, pushing the dam into the ground. Water pushes against the dam, but the buttresses are inflexible and prevent the dam from falling over.

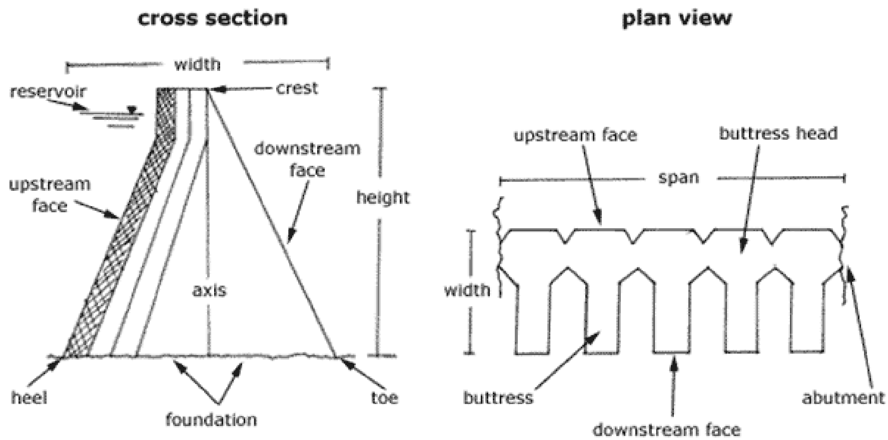


Fig: Buttress Dam Cross Section and Plan

2. **Arch Dam**: - An arch dam is an impermeable concrete shell shaped an arch in plan when curved in vertical section it forms a dome shape. Many gravity dams are arched in plan. But he characteristic of an arch dam is that it's cross section. Arch dam are thin, they require the least volume of construction materials of all designs yet their shape makes them strongest of all.

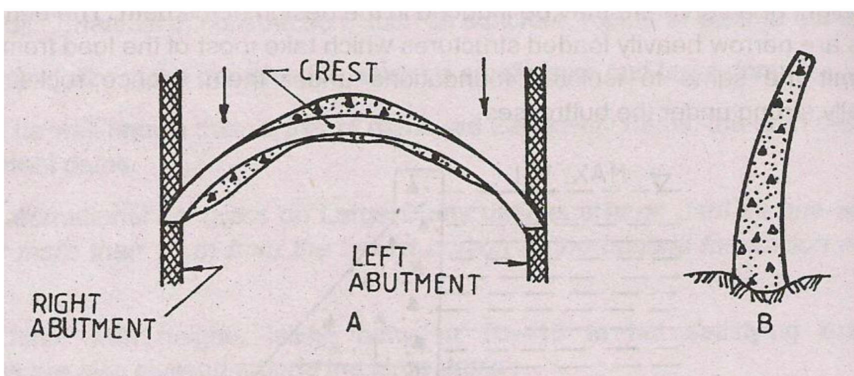


Fig: Arch Dam

3. **Earth dam**: - These consists essentially core of impermeable material, such as clay or concreted, supported by permeable boulders of earth and rockfill, when a clay are used it is normally flanked by filters of permeable material such as sand to protect the core from erosion by the seepage of reservoir water through dam. Embankment dams, by virtue of the slopes required for their stability. Earth fill and rock fill dam are terms used to described suitable sedimentary materials such a clay, sand and rock blocks that can be placed to forming safe embankment.

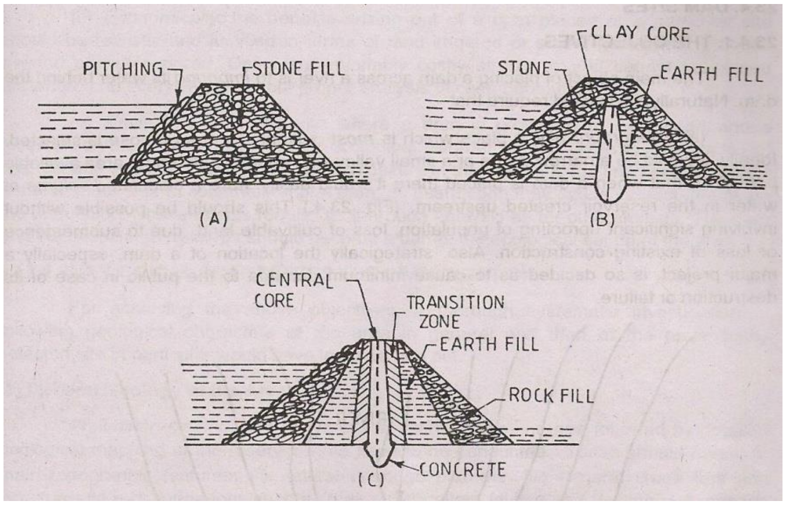


Fig: Earth Dam

Geological Considerations in the Selection of Dam Site

The important geological environment requirements that should be considered in the selection of a dam site are as followed

1. Narrow River Valley.
2. Occurrence of the bedrock at a shallow depth.
3. Competent rocks to offer a stable foundation.
4. Proper geological structures.

1. **Narrow River Valley**

i) If the proposed site contains a narrow river valley, only a small dam is required, which means the cost of the dam construction is also will be less. On the other hand if the valley is wider, construction cost will be very high and maintenance of the dam will also be high. Yet if the valley is narrow, following considerations should be taken in to account.

ii) Deceptive narrowing of a valley due to the occurrence of thick superficial deposits such as residual soil and talus in recently glaciated regions, moraine, boulder clay, sand, gravel and river alluvium.

iii) Narrow valley due to deceptive rock outcrops which are the result of land slip, rock creep and rock fracturing

iv) The occurrence of buried river channels crossing the site, either below the bed or adjacent to it

2. **Occurrence of the bedrock at a shallow depth**

i) If the dam rest on very strong and stable rocks, the stability and safety of the dam will be very high. This also reduces the cost of the dam. On the other hand the dam cost will be high and the work of excavation will be overburden. This also requires heavy concrete refilling.
ii) In the case of deposition along the river valley depends on the stage of river. If the river is in young stage, the erosion might have exposed the strong bed rocks that may occur at the surface this would be competent for the dam construction.
iii) The hilly terrain which occurs in these stages may not provide a suitable topography for the occurrence of a large reservoir basin and the flow of water itself may not be high in such developing rivers for obvious reasons. In older stage, the deposition will be resulting in overburden. This means that suitable bedrock may lie at a considerable depth and hence proves uneconomical.
iv) The general occurrence of material like clay, silt, sand and gravel along the river bed, naturally makes it difficult to assess the thickness of loose overburden by mere surficial studies. Therefore, to know the bedrock profile in the river valley along the axis of the proposed dam, geophysical investigations such as “electrical resistivity studies” or seismic refraction studies” are carried out carefully.
v) In certain places particularly in glaciated regions, the occurrence of buried river valleys, a buried river valley may occur in the river bed that is generally deep, and is composed of loose drift which is a highly porous and permeable material. This poses problems of weakness and leakage which are dangerous for the success of the dam.

Competent Rocks for Safe Dam: The suitability of the site for the dam construction can be estimated by the following factors:
1. The existing rock type at the dam.
2. The extent of weathering it has undergone.
3. The occurrence of intrusions.
4. The extent of fracturing.
5. The occurrence of geological structures.
6. The mode and number of rock types.

Suitability of igneous rocks

These are the most desirable rocks at the dam site. Because these are strong and durable due to their dense character, interlocking texture, hard silicate mineral composition, occurrence of negligible porosity and permeability, absence of any inherent weak planes, resistance to weathering and their tendency to occur over wide areas. Yet it should be checked that the selected rocks are not affected by weathering or fracturing or dykes or any geological structures like shearing, faulting and jointing. Thus, all plutonic rocks like granites, syenites, diorites and gabbors are very competent and desirable rocks for the foundation at the dam site. Yet another consideration should be taken in to account, i.e. volcanic rocks, which are generally vesicular or amygdaloidal, are not desirable since they will be permeable and contribute to porosity and hollowness, in turn contributing to weakness of rocks. The case of massive basalts, which are very fine grained, are one of the toughest rocks in the nature. Yet they can be adversely effected when they are vesicular and permeable.

Suitability of sedimentary rocks:

In the case of sedimentary rocks following factors affect the construction of dam.

1. The bedding and its orientation.
2. Thickness of beds.
3. Nature and extent of compaction and cementation.
4. Grain size.
5. Leaching of soluble matter.
6. Porosity and permeability.
7. Associated geological structures and
8. Composition of constituents.

Sedimentary rocks those are undesirable:

1. Shales are the most undesirable at the dam site, as they form slippery bases.
2. Laterites and conglomerates are undesirable, because of their porosity and permeability.
3. Lime stones are competent if they are massive, i.e, unaffected by the solution phenomenon, but are liable to become dangerously porous for the same reason at any time in future.
4. Alternating soft and hard rocks for small thickness are undesirable.

Suitability of Metamorphic rocks:

Among the metamorphic rocks,

1. “Gneisses” are most competent rocks like granites, unless they possess a very high degree of foliation and are richly accompanied by mica-like minerals.

2. “Schists” are undesirable because

a. Their constituent minerals are soft and possess a very well developed cleavage.

b. The schistose structure results because of the foliation of minerals present in the rock.

3. Quartzites are very hard and highly resistant to weathering. They are neither porous nor permeable.

4. Marbles, like quartzites, are compact, bear a granulose structure, are not porous, not permeable and reasonably strong too. But by virtue of their chemical composition and mineral composition they are unsuitable at dam sites.

5. Slates bear a typical slaty cleavage (due to the presence of minute flakes of mica). Hence this rock is soft and weak, and undesirable at the dam site.

6. Khondalites, which are feldspar-rich, are to some extent heterogeneous in terms of their mineral compostion. They often contain soft graphite, hard granet, etc. in addition to other minerals. They are highly weathered and hence unsuitable at dam site.

TUNNELS

Tunnels are the underground passages or routes through hills, mountains or earth crust used for different purposes. These passages are made by excavating rocks below the surface or through the hills, mountains.

Tunnels are basically made to serve some specific purposes. For instance:

1. **Transportation tunnels**: tunnels made across hills or high lands to lay roads or railway tracks for regular traffic and transportation purpose.
2. **Traffic tunnels**: Tunnels laid to reduce the distance between places of interest across natural obstacles like hills, to save time and provide convenience are called traffic tunnels. These have the advantage of leaving the ground surface undisturbed so that it can be used as desired.
3. **Diversion tunnels**: The tunnels layed for diverting normal flow of river water to keep the dam site dry are called diversion tunnels.
4. **Pressure tunnels**: these are also called as hydropower tunnels. These are used to allow water to pass through them under force, used for power generation.
5. **Discharge tunnels**: These are meant for conveying water from one point to another under gravity force, like across hill.
6. **Public utility tunnels**: These are the tunnels layed for public supplies like drinking water supply, cables laying, sewage discharge or oil supply etc.

Geological Considerations of tunnel sites

1) Lining of tunnels:

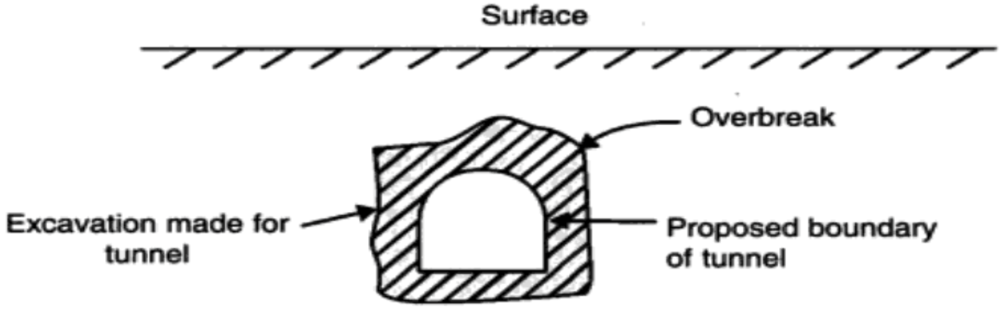
i) When tunnels are made through weak or loose or unconsolidated formations, they are provided with suitable lining for safety and stability. Lining refers to the support porvided to tunnel. Lining may be in the form of steel structures or concrete.

ii) The main purposes of lining are to resist the pressures from the surroundings and to protect the shape of tunnel. It takes care of the weaknesses of the ground. It also helps in checking leakage of ground water into tunnel.

iii) The thickness of concrete lining dependes on the extent of protection required, and the degree of weakness of the ground. Lining is provided to support weak parts of the tunnel. Lining is also provided in such places where the seepage of water into the tunnel occurs and creating problems. In the case of very weak rocks with unfavorable geological structures, lining may be necessary through out the length of the tunnel. The zones of faulting or shearing also need suitable lining to impart strength to them.

2) **Overbreak**

During tunneling the excavations normally involve the removal of extra rocks or matter around the tunnel. The quantity of rock broken and removed, in excess of what is required by the perimeter of the proposed tunnel, is known as overbreak.



Factors governing the amout of overbreak:

1) The nature of the rocks.
2) The orientation and spacing of joints or weak zones in them.
3) In the case of sedimentary rocks, the orientation of the bedding planes
4) Thickness of the beds with respec to the alignment of the tunnel.

Geological factors influencing the overbreak:

1.) Massive and soft rocks of a homogenous nature cause less overbreak than harder rocks with well developed joints or weak zones.

2.) In sedimentary rocks, thin formations and those with alternating hard and soft strata produce more overbreak. This is because, during excavation, softer rocks yield more than the hard rocks.

3.) In metamorphic rocks, foliated and soft formations like slats and schists produce more overbreak if the tunnel lies parallel to them and less overbreak if they are mutually across.

4.) Tunnels that pass through a single thick homogenous formation without structural defects produce little overbreak, whereas tunnels which pass through a variety of rocks with structural defects like fault zones or which are less thickness of strata or alignment cutting across different strata along the dip direction, produces more overbreak.

Site Selection for Bridge

A **bridge** is a structure built to across physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle.

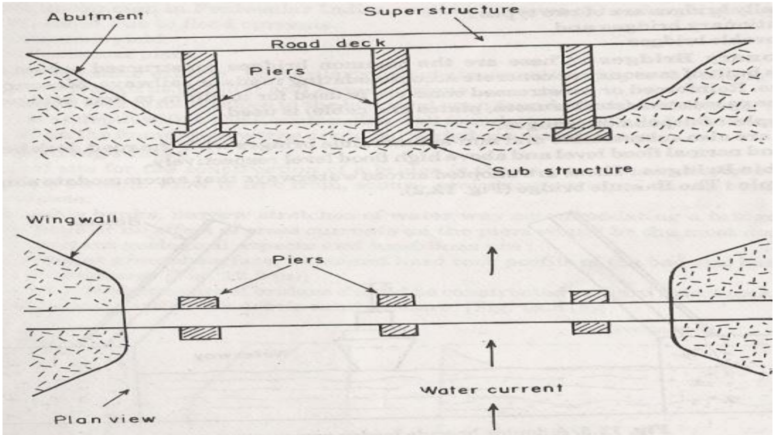


Fig: Cross Section of Bridge

Parts of Bridges

Bed:-Surface of firm ledge or bed rock providing a stable foundation for bridge piers.

Abutment: -The end supports of a bridge to withstand thrust

Wing wall: - A masonry or concrete wall that guides a river into a bridge.

Pier:- A rectangular, oval or circular masonry or RCC column that supports the super structures of a bridge erected from a firm bearing bed for stability.

Components of Bridge

1. Sub Structure:- constructions on the banks, piers, wing walls and foundations.
2. Super Structure: - comprises of construction that res on the piers and the abutments including girders and beams.

Bridge Types: -It is classified into

I). **Stationary bridges: -** these are common bridges constructed across valley and depression built of masonry or concrete accommodating roads or railways. masonry is used for arch bridges, reinforced of prestressed concrete used for medium to long bridges.

II). **Movable bridges: -** These are adopted across water ways that accommodate shipping. These are consists of one or two movable steel sections or spans-single or double bascules. These are lifted up at either end to allow ships to pass through and then lowered back to position providing normal road or railway

The important bridge problems that lead to the failure are

1. Erosion of the piers and wing walls
2. Deep scouring and collapse of bridges
3. Wash out due to flood currents
4. Settlement of piers

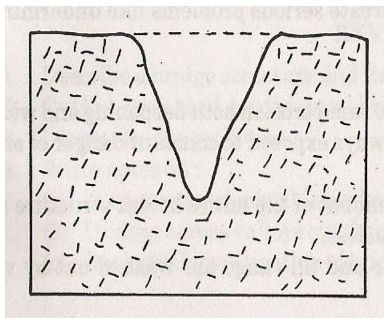
5. Earthquake effects

Geology of Bridge Sites

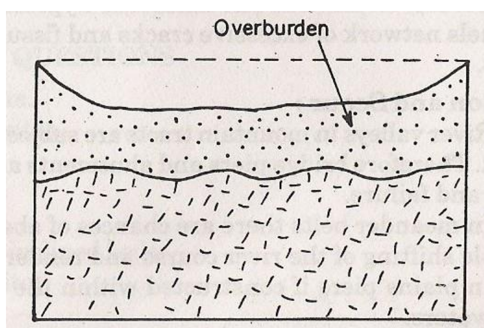
An ideal site for the construction of a bridge is the one across a valley cut in sound rock and where the stream flow is free from scour, provoking currents due to bends and other causes. A high stable bank, narrow stretches of water accommodating a bridge of minimum length with little or no effect.

The important geological aspects and conditions are:-

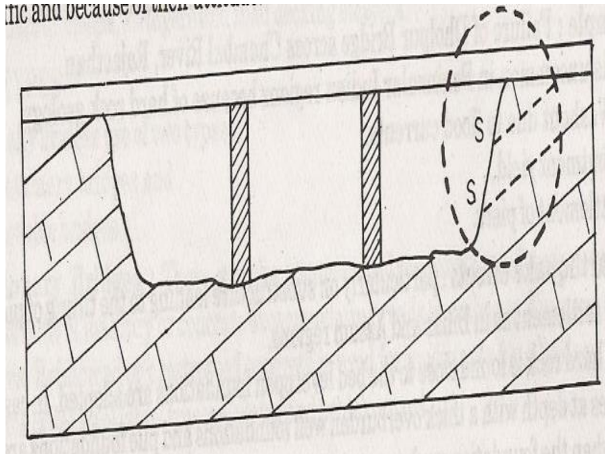
1. Bed rock at round surface i.e. sound hard rock profile of the bed and banks of valleys, canals and depressions.



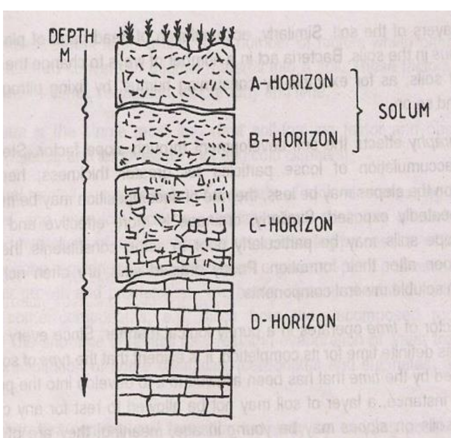
2. The piers and abutments of bridges should be constructed on hard intact rocks only and not on over burden such as fill, rock debris, sand etc.



3. Rock formation should be intact, strong and tough without defects and weak planes.
4. Intact intrusive igneous rocks like granite, compact basalt, Sedimentary like hard Sand stone free from excessive joints and metamorphic like massive gneiss, quartzite provide excellent foundation abutment and bearing materials.
5. Bedded and Jointed formations especially those dipping into the river at lesser angle than the slope of the natural banks always dangerous as they tend to slide at any movement it is shown in figure.



6. Faulting brings rocks of diverse character strength together along the fault line. Any further displacement at the fault contact may adversely affect the piers like displacement, tilting. Therefore it is very essential to treat the fault one well and substructure suitability designed.
7. soluble formation like lime stone, gypsum rocks are enlarged with elongated joints solution channels networks of excessive cracks create serious problems like understanding of banks.



A- Horizon: Top soil, organic layer

B- Horizon: Rich in mineral matter, zone of Accumulation of clays. Colloids, iron and Aluminum oxides. The horizon A and B is Combined is called Solum which is a true Soil zone.

C- Weathered material

D- Horizon: Solid rock (fresh parent rock)

SOIL CLASSIFICATION

Soils are basically divided into two main groups:

1. **Residual and**
2. **Transported soils**

1. **Residual Soils**:- A soil that is formed by weathering of the parent rock and still Occupies the position of the formed, which it has been formed, is called a residual soil.

The important types of residual soils are:

1. Red Soils

2. Black Soils
3. Lateritic Soils

1. **Red Soil**: - These are residual soils derived mainly from the disintegration and decomposition of ancient granites and geneisses and contain coarse grains of quartz and mica and fines mainly kaolinite. Red Soils are generally heavily stained red with iron oxides grading into brown, yellow gray and even black. These are fairly rich in potash, porous and contain no salts and free carbonate and moderately fertile. Red Soils occur extensively in peninsular India covering the states of Bihar, West Bengal, Orissa, Parts of Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu.

2. **Black Soil:-** These are residual soils mainly from the alteration of basalts. Black soils are typically highly clay. Black soils are fine grained, porous, sticky and swell when wet and contracts on drying with the development of a network of deep cracks. These highly fertile and excellent for cotton cultivation, hence called black cotton soil locally. In India black soils are derived from the alteration of Deccan Basalts and occur over a very wide area of over 200,000 sq miles in western and central parts covering the states of Gujarat, Maharashtra, parts of M.P , Orissa, A.P and Karnataka.

3. **Laterites**: - Laterites are residual soils formed in tropical regions. Laterites are very soft when freshly cut but become hard after long exposure. Hardness is due to cementing action of iron oxide and aluminium oxide that are most resistant to leaching. Valuable metals like aluminum, copper, silver, gold, nickel and iron are concentrated in literates. These soils are also called lateritic soils.

2. **Transported Soil**:- Any soil that has been transported from place of origin by wind, water & glaciers and redeposit in another place. This type formation is known as transported soil.

Formational Processes:- The origin of transported soils involve three important process, they are Erosion, Transportation and Deposition.

Erosion: Erosion is a process where natural forces like water, wind, ice, and gravity wear away rocks and soil. It is a geological process, and part of the rock cycle. Erosion occurs at the Earth's surface, and has no effect on the Earth's mantle and core.
Transportation:- The soils formed at a place may be transported to other places by agents of transportation, such as water, ice, wind and gravity.
Deposition: - Deposition is the geological process in which sediments, soil and rocks are added to a landform or land mass. Wind, ice, water & gravity transport previously weathered surface material which at the loss of enough kinetic energy in the fluid is deposited building up layers of sediment.

Soils are further classified according to the transporting agency and method of deposition,
Alluvial deposits:-Soils deposited from suspension in running water
Lacustrine soil: -Soils deposited from suspension in quiet fresh water lakes
Marine soil;- soil deposited from suspension in sea water
Aeolian soil: -Soils transported by wind
Glacial soils: -Soils transported by thick mass ice

Drainage System

In geomorphology, drainage systems, also known as river systems, are the patterns formed by the streams, rivers, and lakes in a particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. Geomorphologists and hydrologists often view streams as being part of drainage basins. A drainage basin is the topographic region from which a stream receives runoff, through flow, and groundwater flow.
According to the configuration of the channels, drainage systems can fall into one of several categories known as drainage patterns. Drainage patterns depend on the topography and geology of the land.

1. **Dendritic Drainage Pattern** :- Dendritic drainage systems are the most common form of

drainage system. In a dendritic system, there are many contributing streams (analogous to the twigs of a tree), which are then joined together into the tributaries of the main river (the branches and the trunk of the tree, respectively). They develop where the river channel follows the slope of the terrain. Dendritic systems form in V-shaped valleys; as a result, the rock types must be impervious and non-porous.

2. **Parallel Drainage Pattern** : A parallel drainage system is a pattern of rivers caused by steep slopes with some relief. Because of the steep slopes, the streams are swift and straight, with very few tributaries, and all flow in the same direction. This system forms on uniformly sloping surfaces. A parallel pattern also develops in regions of parallel, elongate landforms like outcropping resistant rock bands. Tributary streams tend to stretch out in a parallel-like fashion following the slope of the surface. A parallel pattern sometimes indicates the presence of a major fault that cuts across an area of steeply folded bedrock.

3. **Trellis drainage pattern**: The geometry of a trellis drainage system is similar to that of a common garden trellis used to grow vines. As the river flows along a strike valley, smaller tributaries feed into it from the steep slopes on the sides of mountains. These tributaries enter the main river at approximately 90 degree angle, causing a trellis-like appearance of the drainage system. Trellis drainage is characteristic of folded mountains.

4. **Rectangular drainage pattern:** Rectangular drainage develops on rocks that are of approximately uniform resistance to erosion, but which have two directions of joining at approximately right angles. The joints are usually less resistant to erosion than the bulk rock so erosion tends to preferentially open the joints and streams eventually develop along the joints. The result is a stream system in which streams consist mainly of straight line segments with right angle bends and tributaries join larger streams at right angles.

5. **Radial drainage pattern** : In a radial drainage system, the streams radiate outwards from a central high point. Volcanoes usually display excellent radial drainage. Other geological features on which radial drainage commonly develops are domes and laccoliths. On these features the drainage may exhibit a combination of radial patterns.

6. **Annular drainage pattern** : In an annular drainage pattern streams follow a roughly circular or concentric path along a belt of weak rock, resembling in plan a ring like pattern. It is best displayed by streams draining a maturely dissected structural dome or basin where erosion has exposed rimming sedimentary strata of greatly varying degrees of hardness.

<u>Site Selection for Artificial Recharging of Groundwater</u>

Although most recharge is supplied directly by rain fill, this intense demand for water in some areas has led to artificial recharge of the ground. One example is the practice of water spreading in dry parts of the American West. A common way to spread water for recharge is to build a low dam across a stream valley. This holds water bank that would otherwise flow away and allows it to seep downward and recharge aquifers beneath the stream be. The water thereby, stored underground is withdrawn through wells as needed.

In some regions an aquifers may be recharged with used water. This practice has increased as air-conditioning, which requires a large volume of water, has become commonplace in hot, dry regions. Some cities have laws requiring that water used for air conditioning be returned to the ground, where it successfully builds up the water table. This illustrates the basic principles of groundwater conservation. Where groundwater with drawl exceeds the rate of recharge, the lowering of the water table can lead to subsidence of the ground.

Recharge and Discharge Areas

Water enters the groundwater system as precipitation falling on recharges areas, which are areas where water is added to the saturated zone.

It means through the system to discharge areas, which are areas where subsurface water is discharged to streams or to a bodies of surface water. The aerial extent of recharge areas is invariably larger than that of discharge area. In humid regions, recharge areas encompass nearly all areas except stream and their adjacent floodplains. In more arid regions, recharge occurs mainly in mountains and in the alluvial fans.

From the figure streams that flow from mountains having substantial rainfall into much drier regions in which the water table lies deep beneath the surface. Water from these rivers leaks downwards and recharges the groundwater below.

Interlinking of river basins

It is the water transfer from the water surplus rivers to water deficit rivers or regions. It will increase water supply, irrigation potential, mitigate floods, and droughts and reduce regional imbalance in the availability of water.

River Interlinking Projects - Need

- **Reducing Regional Imbalance: India is dependent on erratic and regionally imbalanced monsoon rains. River interconnection will reduce the amount of excess rain and river water that flows into the sea.**
- **Irrigation for Agriculture:** Interlinking can provide a solution to India's rain-fed irrigation problems by transferring surplus water to deficit regions.
- **Reducing Water Stress:** To some extent, this can help to mitigate the effects of drought and flooding.
- Other advantages include hydropower generation, year-round navigation, job creation, and environmental benefits as dried-up forests and lands are replenished.

River Interlinking Projects - Significance

- The interlinking river is a method of transferring excess water from high-rainfall areas to drought-prone areas. It can thus control both floods and droughts.
- This will also aid in the resolution of the country's water crisis in many areas.
- The project will also aid in the generation of hydropower. This project calls for the construction of numerous dams and reservoirs. If the entire project is completed, it will generate approximately **34000 MW of electricity.**
- The project will aid in the enhancement of dry weather flow. That is, during a dry season, excess water stored in reservoirs can be released. This will allow for the least amount of water flow in the rivers.

- This will greatly aid in **pollution control, navigation, forests, fisheries, wildlife protection,** and so on.
- **Indian agriculture** is primarily dependent on the monsoon. When the monsoons behave unexpectedly, this causes problems in agricultural output. When irrigation facilities improve, this problem will be solved. The project will provide irrigation services in water-stressed areas.
- The project will also benefit the economy by improving the inland waterways transportation system. Furthermore, rural areas will have an alternate source of income in the form of fish farming, among other things.
- The project will also strengthen the country's defense and security by providing additional waterline defense.

COASTAL PROCESS AND LANDFORM

The landforms that develop and persist along the coast are the result of a combination of processes acting upon the sediments and rocks present in the coastal zone. The most prominent of these processes involves waves and the currents that they generate, along with tides.

The earth's surface isn't even all the way around. Some areas are flat, while others are mountainous. Landforms come in a variety of shapes and sizes. The varied physical features present on the Earth’s surface like mountains, plains, valleys, plateaus etc. are called landforms.

The different types of landforms are :

1. Mountains
2. Plateaus
3. Valleys
4. Plains

Sedimentation /siltation, erosion

The total sediment is volume of sediment particles in motion per unit time. This includes the sediment transported by bed load motion and by suspensions as well as the wash load. Siltation is the accumulation of silt (fine particles of sand, mud, and other materi- als) in the reservoir.

QUESTION BANK

1. What are the geological aspects to be considered in site selection of dam?
2. What are the geological aspects to be considered in site selection of tunnel?
3. What are the geological aspects to be considered in site Selection of Bridge?
4. Explain weathering and its Classification
5. List and explain types of soil