ENGINEERING GEOLOGY – 18CV36 -2021

1a. Discuss in brief different branches of geology, which are relate to civil engineering

This are the following branches which are relate to civil engineering:

- Study of science which deals with minerals is known as mineralogy
- Study of science which deals with rocks is known as petrology
- Study of science which deals with crystals and crystal growth is known as crystallography
- Study of science which deals with the surfacial features of earth is known as geomorphology
- The branch of science which deals with the order & relative position or strata and their relationship to the geological time is called stratigraphy
- study of science which deals with surface and subsurface water is known as hydrology
- Study of science which deals with physical properties of earth (gravity, magnetic and resistivity etc.) is known as geophysics.
- Study of science which deals with Fossils, paleoclimates etc. is known as palaeontology.
- Study of science which deals with dynamic process (earthquakes, plate tectonic , continental drift theory etc) which makes earth as active planet is known as geodynamics
- Study of science which deals with Earth structures & deformation of rocks is known as structural geology
- Exploration and survey carried out by the help of maps, toposheets & imageries and the study of this science is known as Geomatics/Geodesy
- Study of science which deals with chemical composition of earth is known as geochemistry

1b. Briefly explain the Internal structure of the earth based on different unconformities and add a note on its composition

The interior structure and composition of the earth cannot be directly studied because as we go deeper inside the earth, the temperature and pressure goes on increasing. The drillings also fail in this regard since using the present day technology we can drill only 10 to 15kms, which is negligible as compared to the depth of the earth, which is about 6378kms. The direct observations of the internal crustal layer of the earth are also possible to record from the petroleum and natural gas oil wells from onshore and offshore basins in addition, heat of the earth's interior can be known during the volcanic eruptions and other surface processes.

The shape of the earth is that of a geoid or oblate spheroid and it is bulged in the Equatorial region and flattened at the Polar Regions. The mean equatorial radius is about 6378kms and the mean polar radius is about 6357kms. Hence the difference comes about 25kms. this indicates clearly that earth is not circular.

The earth is chemically layered, broken into a series of concentric layers of different compositions (for your reference: similar to egg which consists of top white shell inside white fluid further inside it consists of yellow albumin). The layers are distinguished by seismic wave velocity and density. They are as follows:

- The outermost rocky layer is the crust.

- The intermediate layer is the mantle
- The bottom most layer is the core

These divisions are based on the seismic data interpretations of the earth's interior.

Crust:

The earth's crust is the outermost layer of rocks. The crust is subdivided into 2 layers based on its composition and density.

- Continental crust
- Oceanic crust

Continental crust:

It consists of 0.374% of the earth's mass; depth average 35km and locally it varies 60 – 70kms. It is the outermost part of the earth composed mainly crystalline Felsic rocks. These are low density minerals composed mainly quartz (sio_2) and feldspars (granites, synites and andisites). The crust is the coldest part of our planet. Because cold rocks are deforms slowly, this layer can be easily travelled by primary (P) and secondary (S) waves at velocity 5.8 km/sec. It mainly composed of silicon and aluminium known as SIAL. Its density varies from 2.2 to 2.9 kg/ m^3

Oceanic crust:

It consists 0.099% of earth's mass; thickness or depth at which lies is 0 – 10kms. It is mainly composed of mafic rocks, it consists of silicon and magnesium known as SIMA. The majority of earth's crust was made through volcanic activity of the mid oceanic ridge system. A 40,000 km network of volcanoes generates new oceanic crust at the rate of 17 km^3 per year, covering the ocean floor with basalt. Eg. of accumulation of basalts are the Hawaii and Iceland's. P wave velocity is 6.4km.

The 'mohorovicic discontinuity', named after the Yugoslavian seismologist who discovered it, which separates the crust and the mantle and this boundary marks the variation in rock composition from crust to mantle. There is a marked difference in P wave velocity across the boundary from 6.5 km/s for the crust to 8 km/s for the mantle. Its density varies from 2.9 to 3.2 kg/ m^3

The continental crust regions are thicker and less dense where as oceanic regions are thinner and higher in density.

Mantle:

The second major internal region which extends from the base of the crust to the top of the core, forming the majority of the earth's volume.

The mantle region is the source of internal heat known as geothermal energy. This region is also the source energy for all major geodynamic processes like sea floor spreading, plate tectonics, orogeny (mountain building activity), major earthquakes and continental drift.

The mantle is subdivided into the following major categories based on seismic wave characteristics:

- Upper mantle
- Transition zone
- Lower mantle

1. **c. Explain role of Geology in the Field of Civil Engineering:**

In any civil engineering construction geology plays a vital role. Because every civil engineering structure constructed on or in the ground. In this regard a civil engineer should understand and analyse a detailed investigation should be carried out by using geology as a tool. They are as follows:

Foundation Problem: The foundation problems of dams , bridges and buildings are directly related with geology of the area where they are built.

Construction material: Geology provides a systematic knowledge of construction material there structures , stability quality and properties of stones.

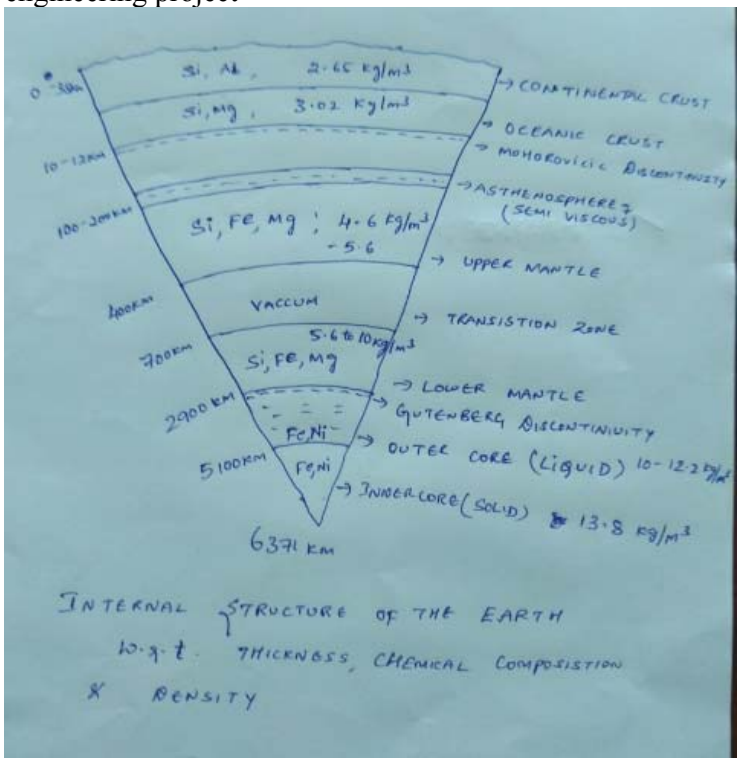
Infrastructure Engineering: In tunnelling, construction roads and bridges and in determining the stability of cuts and slopes , the knowledge about the nature of rock is very necessary.

Water resource engineering:
The knowledge of ground water is necessary in connection with excavation works, source an quality of water, desilting of reservoir, water supply, irrigation, navigation channels etc.

Geological map and Section helps considerably in planning man engineering projects. In geological mapping rock deformation such as faults, folds, joints etc has to be treated for assuring the stability of structures .

Pre geological Survey of the area concerned reduces the cost of engineering projects.

Thus in civil engineering geology provides necessary information about the site , construction materials for buildings, dams, tanks, reservoirs, highways and bridges. It is most important in Planning phase, Design phase and construction phase o a civil engineering project



Upper mantle:

10.3% of earth's mass; depth of 10 – 400km in oceanic crust and 35 – 400km in continental crust side. The upper mantle is mainly consists of ultramafic rocks like peridotite, pyroxenite, and dunnite etc. part of the upper mantle called Asthenosphere which is partly molten or semi solid in nature and is responsible for plate tectonism. It lies around 150 – 200km in upper mantle. Seismic velocities are not uniform in the mantle region as they vary with depth. This is because of the increasing density. There is a sudden increase in P w
ave velocity at a depth of 410km and is known as 410km discontinuity. There is a decrease in the P wave velocity at depths of 100 – 200km which extends upto 300 to 400km and this decreases is due to partial melting of the material and the layer is called the Asthenosphere. This is responsible for the plate tectonics. Its density varies from 3.4 to 4.4 kg/ m^3

Transition zone:

7.5% of the earth mass; depth of 400 – 650km. This region is also called the mesosphere. Here it consists of mantle crust mass and is the source of basaltic magmas. It also contains calcium, aluminium and garnet, which is a complex aluminium bearing silicate mineral. There is a sudden increase in P wave velocity at a depth of 660km and this is called the 660km discontinuity. Composition is same throughout the mantle zone, only velocity varies due to depth.

Lower mantle:

49.2% of the earth mass; depth of 650km – 2890km. The lower mantle contains 72.9% of the mantle-crust mass and is probably composed of silicon, magnesium and oxygen. It also contains some iron, calcium, and aluminium. Its density varies from 3.4 to 5.6 kg/ m^3

Core:

The inner most layer of the earth which got separated from mantle by Guttenberg – Weichert discontinuity. There is an increase in density from 5,500 kg/ m^3 to 9,900 kg/ m^3 across the boundary. It is again subdivided into two as the

- Outer core
- Inner core

Outer core:

30.8% of the earth's mass; depth of 2890km – 5150km. The outer core is a hot, electrically conductive liquid within which convective motion occurs. This conductive layer combines with the earth's rotation to create dynamo effect that maintains a system of electrical currents known as the earth's magnetic field. It also composed of sulphur and /or oxygen.

In the core mantle boundary there is a marked changes of seismic wave velocity. P wave velocity at the base of the mantle is about 13.7km/s. In the outer core it is 8km/s. Whereas shear wave or S wave drops from 7.3km/s to zero indicating that the outer portion of the core is fluid. Its density varies from 5.6 to 12.2 kg/ m^3

Inner core:

1.7% of the earth's mass, depth of 5150km – 6370km. The inner core is solid and unattached to the mantle, suspended in the molten outer core. It is belived to have solidified as a result of pressure freezing which happens to most liquids when temperature decreases or pressure increases. The innermost 1,200km of the core are solid, as indicated by increase in P wave velocity and non – zero S wave velocity and probably, composed of pure iron. In the high pressure at that depth, dense solids are favoured over less dense liquids. Its density

varies from 12.2 to 13.1 kg/ m^3

3. a . What are folds

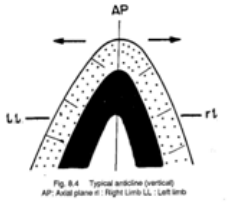
An undulation is obtained in rock strata produced by compressive forces in plastic strata similar to buckling of an overload column.

Folded strata is greatly strained broken and incompetent, therefore form weak and unsafe zones in construction areas especially excavation tunneling, hillside, cutting and dam, bridge site.

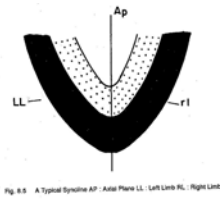
Anticline and other up folds form potential oil traps while synclines and other down fold form potential aquifer for groundwater. In some instances down folds like synclines when filled with groundwater artesian conditions undergoing pressure affecting the stability of the ground above and therefore the stability of structure constructed in such ground.

Folds are classified depending on the upward and downward bending of rocks beds as below

Anticline: A simple up fold in which older beds lie inside and the limbs dip away from each other equally or unequally like the sides of a gable roof of a house. When the limbs dip equally the fold is called a symmetrical anticline when dip unequally, it is called asymmetrical anticline.

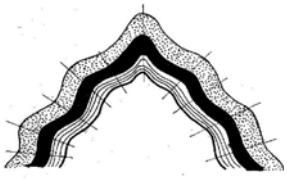


Syncline: a Simple down fold in which younger beds lie inside and the limbs dip towards each other. When the limb dip equally the fold is called symmetrical synclines, when dip unequally an asymmetrical syncline.



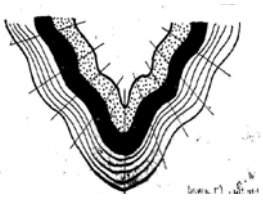
Anticlorium

A large Anticline with secondary folds smaller size developed on it



Synclorium

A large Syncline with secondary folds smaller size developed on it

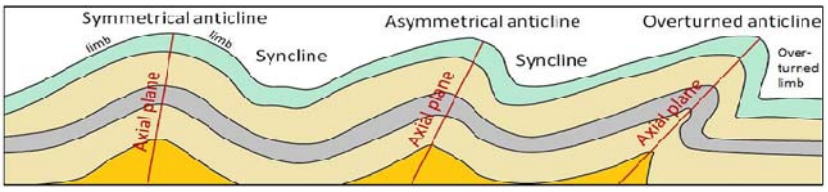


Folds are classified depending on the position of axial plane as below

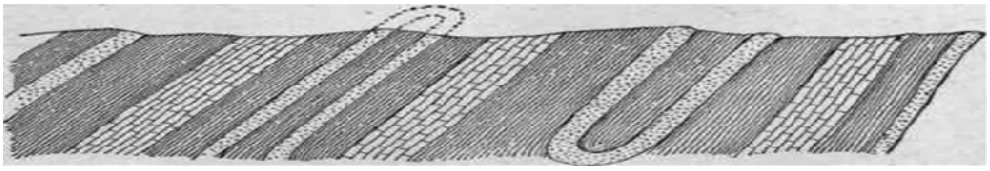
Symmetrical Folds:
When the axial plane divides a fold into two equal halves in such a way that one half is the mirror image, then the fold is called as symmetrical fold.

Asymmetrical Folds :
When the axial plane divides a fold not of the in such a way that not having same magnitude (Inclined), asymmetrical folds are formed.

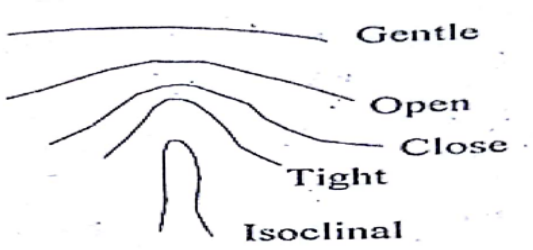
Overturned Folds :
Both limbs dip in same direction but one limb will be beyond vertical . The beds dip in the same direction on both sides of the axial plane because one of those limbs being rotated through an angle of at least 90º



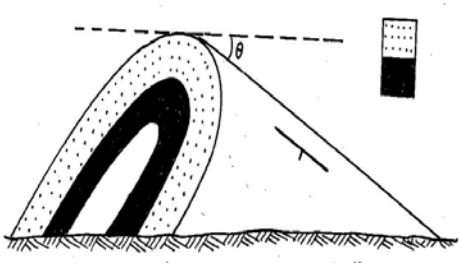
Isoclinal Fold: - A fold in which the limbs dip at equal angle in the same direction i.e limbs are parallel to each other. The axial plane may be vertical inclined or horizontal. When the axial plane is horizontal it is called as recumbent fold.



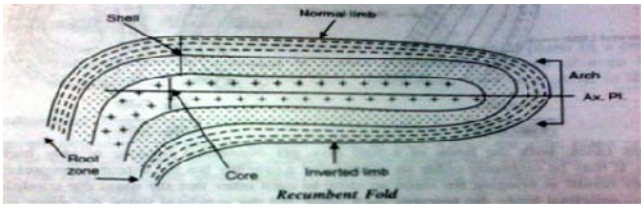
The angle between two limbs is 180 ° Homocline fold
The angle between two limbs is 170° – 180 ° Gental fold
The angle between two limbs is 90° – 170 ° Open fold
The angle between two limbs is 10 ° - 90 ° Tight fold
The angle between two limbs is 0 ° - 10 ° Isoclinal fold



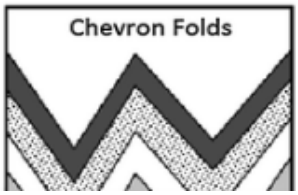
Plunge Fold: - A folds whose axis is inclined from the horizontal. It is also called a pitching fold. The angle of inclination of the axis from the horizontal in called the plunge or the pitch. It is expressed in degree.



Recumbent fold:
These may be described as extreme types of overturned fold in which the axial plane is almost horizontal . In such a fold one limb comes to lie exactly under the other limb.



Chevron folds are regular folded beds with straight limbs and sharp hinges. Well developed, these folds produce a set of v-shaped beds



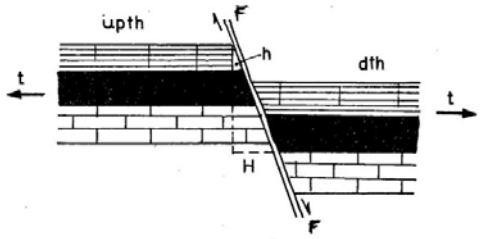
Open Fold : If the thickness of beds is uniform throughout the folds, it is called an open fold.

Closed Fold: If the beds are thinner in the limb portions and thicker at crest and trough, are called as closed fold.

Artificial recharge of ground water:

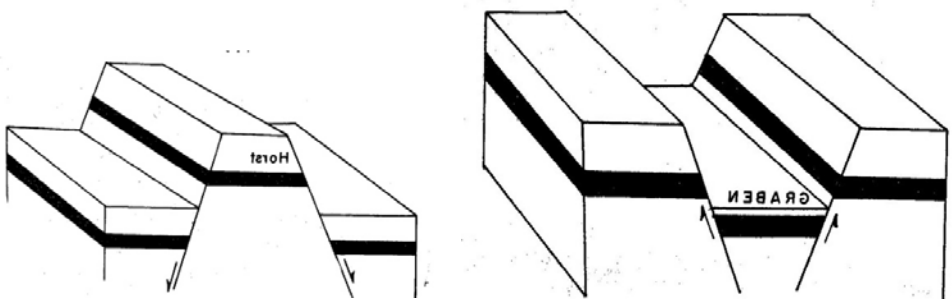
A fault is a fracture or fracture zone in rocks along which there has been displacement of the two sides relative to one another parallel to the fracture. A fault is defined as a displacement of rock strata, due to relative movement of adjacent blocks has taken place.

Normal Fault: A normal fault is a high angle dip-slip fault in which the fault plane is inclined steeply with hade10 deg -20 deg or less. The vertical component of the movement ie the throw is generally large. The hanging wall moves downwards relative to the foot wall and caused by extensional tectonic forces. This kind of faulting will cause the faulted section of rock to lengthen.



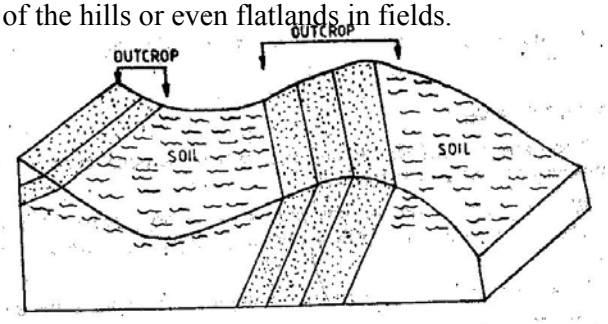
Horst Fault: A fault system consisting of a pair of normal faults whose fault planes are inclined away from each other with a common up throw side in between. The up throw side of a ridge fault system forms a conspicuous inverted wedge shaped ridge parallel to the fault planes, generally long compared to its width called ridge or a horst.

Graben Fault: A fault system consisting of a pair of normal faults whose fault planes are inclined towards each other with a common down throw side in between. The down throw side of a troughs fault system forms a long trench or depression parallel to the fault planes, general long compared to its width called fault basin or graben of a rift valley.



5.a what is an out crop? Describe the terms strike, dip with a neat sketck
Outcrop

An outcrop is the exposure of a solid rock on the surface of the earth. Everywhere on the surface; a thin or thick layer of alluvium or soil often covers it. In certain regions alluvium or soil may be spread for thousands of square kilometer and the bed may not be visible anywhere. In other areas, however, exposures of rocks may be easily seen forming sides of valleys or caps of the hills or even flatlands in fields.



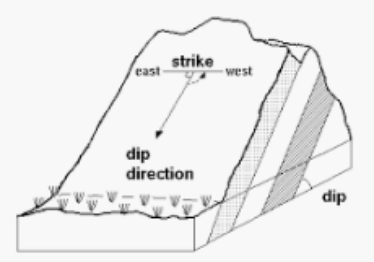
Dip and Strike

These are two definite quantities by which the position or attitude of a body of rock, especially stratified, is expressed.

Dip: It is defined as the maximum angle of slope of a bed or layer of rock with the horizontal. It is expressed both in terms of degree of inclination and direction of inclination.

The amount of dip is the angle between the bedding plane and a horizontal plane.

Strike: It is a horizontal line on a surface of rock beds. It is a geographic direction of extension of the layers of rocks and may be explained as the direction of intersection of the bedding plane with a horizontal plane. It's defined as the direction of a line formed by the intersection of a bedding plane and a horizontal plane. It's always at right angle with the true dip direction.



5.b Explain flood and its control

Flood is overflow of excess water that submerges land and inflow of tide onto land. Floods can form where there is no stream, as for example when abnormally heavy precipitation falls on flat terrain at such a rate that the soil cannot absorb the water or the water cannot run off as fast as it falls.

Floods are caused not only by rain but also by human interference to the surface of the earth. Farming, deforestation, and urbanization increase the runoff from rains; thus storms that previously would have caused no flooding today inundate vast areas.

Some of the major causes are:

- Heavy rainfall
- Heavy siltation of the river bed reduces the water carrying capacity of the rivers/stream.
- Blockage in the drains lead to flooding of the area.
- Landslides blocking the flow of the stream.
- In areas prone to cyclone, strong winds accompanied by heavy down pour along with storm surge leads to flooding

Prevention methods for effective Control of Flood

- Mapping of the flood prone areas

  Historical records give the indication of the flood inundation areas and the period of occurrence and the extent of the coverage. Warning can be issued looking into the earlier marked heights of the water levels in case of potential threat. In the coastal areas the tide

levels and the land characteristics will determine the submergence areas. Flood hazard mapping will give the proper indication of water flow during floods.

- Land use control

  In areas where people already have built their settlements, measures should be taken to relocate to better sites so as to reduce vulnerability.

  No major development should be permitted in the areas which are subjected to high flooding. Important facilities like hospitals, schools should be built in safe areas.

  In urban areas, water holding areas can be created like ponds, lakes or low-lying areas.

- Construction of engineered structures

  Construction of Engineering structures like Embankments , Dams & reservoirs, Channel improvement ,Drainage improvement , Diversion of flood rivers to withstand flood forces and seepage.

  The buildings should be constructed on an elevated area. If necessary build on stilts or platform.

- Flood Control , Detention, Flood proof , Channelization

  Flood Control aims to reduce flood damage. This can be done by decreasing the amount of runoff with the help of reforestation, protection of vegetation, clearing of debris from streams and other water holding areas, conservation of ponds and lakes etc.

  Detention facilities, such as dams, store flood waters and release them at lower rates, thus reducing or eliminating the need for major downstream flood control facilities, the construction of which would disrupt the developed areas.

  Flood Proofing reduces the risk of damage. Measures include use of sand bags to keep flood water away, blocking or sealing of doors and windows of houses etc. Houses may be elevated by building on raised land.

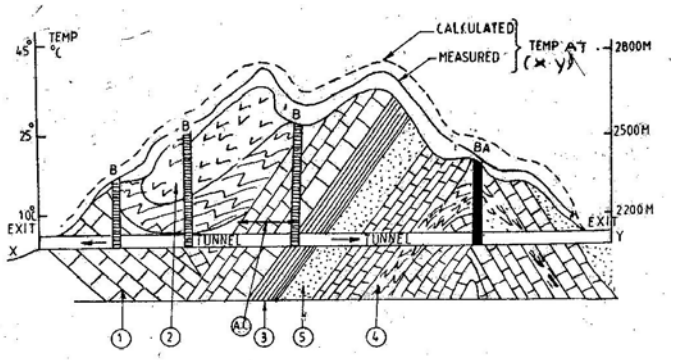
  The construction of open channels is a commonly used method of reducing the size of a floodplain or floodway. To prevent erosion, channels can be lined with grass, wire-enclosed rock, concrete, riprap or cobblestones placed a few layers deep. Open channels allow water to enter them at almost any point, thus compensating for inadequate tributary collection systems.

- Flood Management

Flood plain zoning ,Flood preparedness ,Flood forecasting ,Afforestation ,Public relief

5 c. write a note on Tunnelling through the fold axis of an antidine

Tunnels are passages underneath the earth's surface, which are always constructed with some specific purpose. Along roads and railways, tunnels are driven through hills with a view to providing a short and convenient route across the natural obstacle. Tunnels can be driven through a rock or earth mass by methods used in mining including blasting.



A Typical Geological Profile

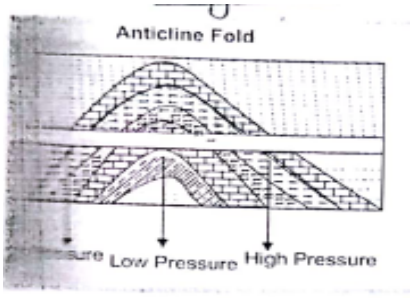
1= Limestone, 2= Volcanic, 3= Clay, 4= Quartzite, 5= Sandstone, BA= Dyke, AC= Artesian Condition, B= Boreholes

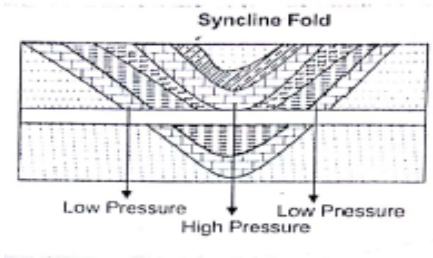
In view of the fact that the construction of a tunnel involves penetration through rocks of various types, it is apparent that the convenience, cost and stability of tunneling operation is dependent primarily on the geological characteristics of the country rocks along the alignment of the proposed tunnel. The geologic factors, which govern the extent to which tunneling conditions may be favorable or adverse and thus determine the cost and stability of tunnels.

The nature of the country-rocks occurring along the alignment of the tunnel.
The geological structure of the region.
The position of the water table within the country-rocks and the
Prevailing ground water condition along the length of the Tunnel.
Effects of Structural Features:

Folds signify beds and curvatures and a lot of strain energy stored in the rocks. Their influence on design and construction of tunnels is important . Folding of rocks introduces considerable variation and uncertainty in a sequence of rocks, so that entirely unexpected rocks might be encountered along any given direction. This situation becomes especially serious when folding is not recognized properly in preliminary or detailed surveys due either to its being localized or to misinterpretation.

Folding of rock introduces peculiar rock pressures. In anticline folds, loads of rocks at the crest are transferred by arch action to a great extent on to the limbs, which may be highly strained,





- A. Anticlinal – low pressure in middle region B.Synclinal- high pressure

7.a Explain the electrical resistivity method for exploration of ground water.

Ground water exploration is a typical task of hydrologist or an engineer. Identifying the location of its availability more techniques have been developed . Among this geophysical methods are conducted on the surface of the earth observing some physical parameters like density , velocity, conductivity, resistivity, magnetic, electromagnetic and radio active phenomena.

Electrical resistivity method: All geological formations have a property called electrical resistivity which determines the ease with which electric current flows through them. This resistivity is expressed in the units of "Ω" ohms meter and is indicated by the symbol ρ.

The electrical resistivity of a rock formation limits the amount of current passing through the formation when an electrical potential is applied.

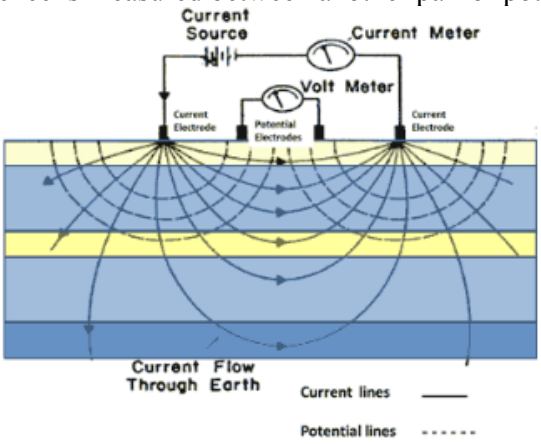
$\rho = R (A/L)$

ρ- Resistivity of a material

L-Length of the wire

A-Cross sectional area of wire

When current is introduced into the ground through a pair of current electrodes , the resulting potential difference is measured between another pair of potential electrodes.



In this type , 4 electrode are placed in a line on the surface , two for energizing the earth and other two for measuring the resultant voltage. This arrangements is categorized in to Wenner and Schlumberger method

7.b Explain how the quality of ground water can be determined by SAR, RSC, GTH

Sodium Adsorption Ratio (SAR):

SAR is an important parameter for determining of the suitability of water quality Sodium hazard is also usually expressed in terms of SAR . Sodium concentration is the important factor for water quality to express reactions with the soil and know reduction in its permeability. Therefore, sodium absorption ratio is considered as a better measure of sodium(alkali) hazard in irrigation as SAR of water is directly related to the adsorption of sodium by soil and is a valuable criterion for determining the suitability of the water for irrigation. This index quantifies the proportion of sodium(Na+) to calcium(Ca2+) and magnesium(Mg2+) ions in a sample. The sodium ad-sorption ratio values for each water sample were calculated by using following equation where all ionic concentrations are expressed in milli equivalents per liter.

SAR = Na / (√Ca + Mg / 2)
Groundwater could be also classified based on Sodium Adsorption ratio (SAR) as
Excellent -10 ,
Good 10-18 ,
Doubtful 18-26
Unsuitable > 26

The residual sodium carbonate (RSC) index is used to indicate the relative proportion of carbonates and bicarbonates in relation to calcium and magnesium in water .
RSC of irrigation water or soil water is used to indicate the alkalinity hazard for soil. The RSC index is used to find the suitability of the water for irrigation in clay soils which have a high cation exchange capacity. When dissolved sodium in comparison with dissolved calcium and magnesium is high in water, clay soil swells or undergoes dispersion which drastically reduces its infiltration capacity.

RSC is expressed in meq/l units. RSC should not be higher than 1 and preferably less than +0.5 for considering the water use for irrigation. The formula for calculating RSC index is:

RSC index = $[HCO_3 + CO_3] - [Ca + Mg]$

RSC < 1.25 me/l : Good
1.25 -2.5 :Fair
> 2.5 me/l : Bad

Total Hardness (TH): Total hardness (TH) is caused primarily by the presence of cations such as calcium and magnesium and anions such as carbonate, bicarbonate, chloride and sulphate in water.

< 75	Soft
75- 100	Moderately hard
150 – 3000	Hard
> 3000	Very hard

7.c Explain how Artificial recharge of ground water can be made

Artificial recharge is the process of induced replenishment of the groundwater reservoir by human activities.

Need for artificial Recharge:

- Improvement quality of existing groundwater
- Conservation and storage of excess water for future use
- To enhance yield in areas where aquifer has depleted
- To remove bacteriological and other impurities from waste water

The following studies are needed for the implementation of any artificial recharge project
Areas for recharge
Source water availability
Hydrological studies

Geophysical studies

Techniques

Direct methods

a. Surface Method
   Percolation tank
   Ditch and furrow system
   Contour bund
b. Sub Surface method
   Recharge wells
   Dug wells
   Pits and shafts

Percolation tank

Series of dams are constructed on suitable sites for storing of adequate quantity of water.
Tank area should be selected in such a way that significant amount of water infiltrates through the bed of the tank and reaches the ground water table
Size of the tank depends upon percolation capacity of strata

Stream augmentation- Seepage from natural stream or river is artificially increased by putting some series of check dams across the river or stream .

Ditch and Furrow system

A system of closely spaced flat bottomed ditch or furrow is used to carry water from the source and spacing of the ditches depends on permeability of soil.

Contour bund: Contour bund is a small embankment constructed along the contour in hilly region to retain the surface runoff for longer time. This scheme is adopted form low rainfall area where internal subsurface drainage is good.

Recharge well: used to recharge water directly to the aquifer. Recharge wells re similar to pumping wells.

Wells and spring

Wells are land excavated holes on the earth surface usually drilled up to the aquifer levels or more at particular site. Wells are vary greatly in depth, water volume, water quality.

These wells are of three types

Dug wells- formed on soft ground using Pick and Shovel. These wells drilled in the places where water table is shallow. After drilling , casing are carried out by stones bricks and other hard rock to prevent caving

Driven wells: built by inserting pipe into soft soil formation . The pipes used in the driven wells are equipped with a filter at the bottom to filter out sand and other particles .

Drilled wells- These are the modern wells and are drilled using drilling machines . These wells are drilled up to the deep aquifer levels. Wells can be drilled in any type of soft or hard soil and any rock types .

Springs :

A spring is a place or point on the earth surface where water flows out naturally from the ground. Springs are created when water is filtered through permeable rock or soil in the ground. The presence of a spring at any site depends on the nature and relationship of permeable and impermeable rock or soil formation and on the position of water table and land topography of that particular site.

9. a what is earth quake Describe the tectonic causes of earthquake and its effects

Earthquake

An earthquake is a sudden and rapid shaking of the ground due to passage of vibrations beneath the earth surface of rocks. An earthquake is the vibration of the earth produced by the rapid release of energy.

Tectonic Movements

- The surface of the earth consists of some plates, comprising of the upper mantle. These plates are always moving, thus effecting earth's crust.
- Constructive is when two plates move away from each other, they correspond to mild earthquakes.
- When two plates move towards each other and collide, this is known as destructive plate boundaries. This is very destructive.
- Conservative corresponds to passing by of plates of crust. Earthquakes of this type have varying intensities.
- A geological fault is known as the displacement of plates of their original plane. The plane can be horizontal or vertical. These planes are not formed suddenly but slowly develop over a long period.
- The movement of rocks along these planes brings about tectonic earthquakes. These faults occur due to the impact of geological forces. The displacement of plates creates the fracturing of rocks, which releases a lot of energy. This type of earthquake can be disastrous.

Effects of Earthquake

1. Ground Vibration/ shaking

Vibration Shaking of the ground caused by the passage of seismic waves , especially surface waves near the epicenter of the earthquake are responsible for the most damage during an earthquake.

The intensity of ground shaking depends on:

- Nature of Rocks , Structure of Rock, Rock Deformation features (Cleavage, Joints,Fracture)
- Duration and intensity
- Distance: the distance from the epicentre drops off so the intensity of the shaking decreases.

2.Faulting and Ground Rupture

Due to earthquake numerous faults and rupture of ground rupture takes place

3. Landslides and ground subsidence

Avalanches, landslides, slumps and rock slides are triggered by ground vibration. These landslides are often more destructive than the earthquakes.

4. Damage to man-made structures

Damage to man-made structures, such as roads, bridges, dams and buildings from ground motion depends on the type of construction, concrete and masonry structures that are brittle and therefore more susceptible to damage and collapse compare to the damage to wood and steel structures is far less because of its flexibility.

5. Fires

Fires, often associated with broken electrical and gas lines, is one of the common side effects of earthquakes.

6. Tsunamis

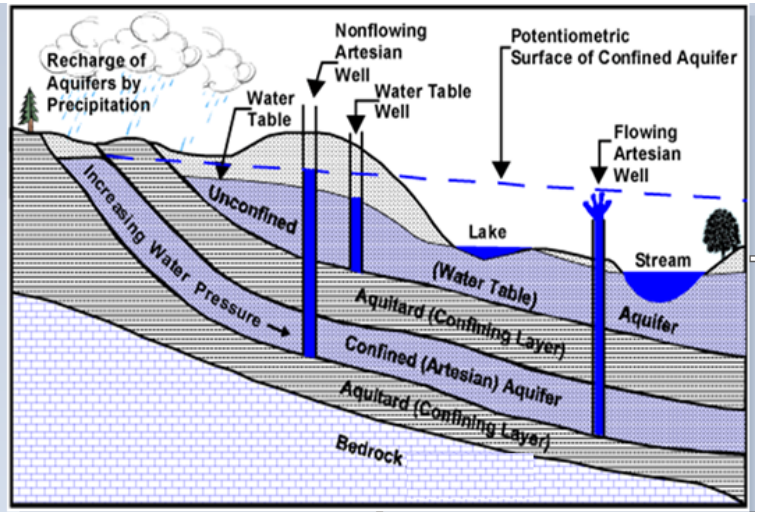
The most dangerous effects of an earthquake is a Tsunami. Tsunamis are giant waves that can cause floods. These deadly waves strike a great distance from the epicentre.

9.b Explain aquifer and its type

Groundwater is an important natural resource. The precipitation infiltrates into the ground and travels down until it reaches the impervious stratum where it is stored as groundwater. It is stored in the pores present in the geological formations such as soil, rock, sand, etc.

1. Aquifer

An aquifer is a saturated formation of the earth. It not only stores the water but also yields it in adequate quantity. Aquifers are highly permeable formations and hence they are considered as main sources of groundwater applications. Unconsolidated deposits of sand and gravel are examples of an aquifer.



Aquifers are classified into two types based on their occurrence which are as follows :

- Unconfined aquifer
- Confined Aquifer

Unconfined aquifer

An unconfined aquifer is an aquifer which has free water surface – which means the water table exists for this type of aquifer. This is also called as water table aquifer or free aquifer or phreatic aquifer. Unconfined aquifers are recharged by the infiltration of precipitation from the ground surface.

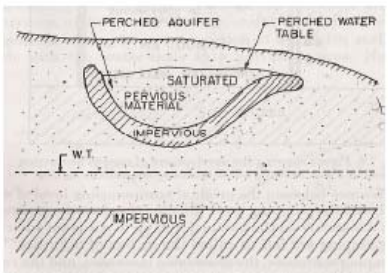
Unconfined aquifers are those into which water seeps from the ground surface directly above the aquifer.

Confined Aquifer

A confined aquifer is an aquifer confined between two impermeable beds such as aquifuge, aquiclude, etc. The water in the confined aquifer will be under greater pressure which is greater than atmospheric pressure. Hence, the water level shown by piezometer is always higher than the top level of the confined aquifer. The recharge of confined aquifer occurs at a place where it exposes to the ground surface.

Perched Aquifers: -

Perched aquifer is a special case, which is sometimes found to occur within an unconfined aquifer. A perched aquifer is separated from another water-bearing stratum by an impermeable layer. Since this type of aquifer occurs above the regional (original) water table, in the unsaturated zone, the aquifer is called a perched aquifer.



9.c Write a note on specific yield and specific retention

Specific yield

Specific yield is the water removed from unit volume of aquifer by pumping or drained and is expressed as percentage volume of aquifer. Specific yield depends up on grain size, Shape and distribution of pores and compaction of the formation .

Specific yield = $\frac{\text{Volume of water drained}}{\text{Total volume of Rock Aquifer}}$

Specific Retention

Specific Retention is the percentage of total volume of Saturated Aquifer which will be held/retained in a unit volume of saturated Aquifer by molecular and surface tension forces against the gravity.

Specific Retention = $\frac{\text{Volume of Retained water}}{\text{Total volume of Rock Aquifer}}$