II/IV B.Tech Regular Degree Examination

November 2016 Civil Engineering

Third Semester

Engineering Geology (14CE306)

Scheme of Valuation

Question No:1 **(1×12=12Marks)**

a. What is Dendudation?

Denudation is the long-term sum of processes that cause the wearing away of the Earth's surface by moving water, ice, wind and waves, leading to a reduction in elevation and relief of landforms and landscapes.

b. What is Physical 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.

c. Name any two ore forming Minerals?

Basalt, a common igneous rock, consists largely of the minerals olivine and pyroxene (both magnesium-iron silicates), feldspar (calcium-aluminum silicate), and ilmenite (iron-titanium oxide).

d. What is the value of Calcite on Moh's Scale of Hardness?

Calcite in Moh's Scale of Hardness is "3".

e. Name any intrusive igneous rock?

Intrusive, or plutonic, igneous rocks form when magma cools slowly below the Earth's surface. Most intrusive rocks have large, well-formed crystals. Examples include **granite, gabbro, diorite and dunite.**

f. Define Strike and Dip?

Strike is defined as the direction of the line formed by the intersection of a fault, bed or other planar feature and a horizontal plane. Dip is the angle at which a planar feature is inclined to the horizontal plane; it is measured in a vertical plane perpendicular to the strike of the feature.

g. Define focus of an Earthquake?

The focus of an earthquake is the point where the rocks start to fracture. It is the origin of the earthquake.

h. What is the purpose of Spillway in a dam?

Spillway is a structure used to provide the controlled release of flows from a dam or levee into a downstream area.

i. What are the main components of a gravity dam?

Heel: contact with the ground on the upstream side

Toe: contact on the downstream side

Abutment: Sides of the valley on which the structure of the dam rest

Spillways: It is the arrangement near the top to release the excess water of the reservoir to downstream side

Sluice way: An opening in the dam near the ground level, which is used to clear the silt accumulation in the reservoir side.

j. What is meant by overbreak?

Rock excavated in excess of the neat lines of a tunnel or cutting. Also, known as backbreak or over break.

k. What are the different types of Joints?

Nonsystematic joints, Systematic joints

l. What is Frost Wedging?

Frost wedging is a form of physical weathering that involves the repeated freezing and thawing of water in areas with extremely cold weather. When water freezes, it expands.

Unit-I

2.a) Explain in detail about weathering of rocks and its engineering Properties

Weathering: the process of more chemical delay and mechanical disintegration of rocks is called weathering.

THE WEATHERING PROCESS:

Factors: physical, chemical & biology factors of nature.

Effects: due to weathering of rocks become smaller .they are reduced in size.

(1) Physical factors
(2) Chemical factors

(1) **Physical factors:** wind, rivers, glaciers, dashing waves and tides, gravity, exfoliation, frost wedging, frost heaving and miscellaneous.

- **Wind**: wind is a relatively weak natural force because of the medium that's air.
- **River**: the importance of a river as an exogenous geological agent and its mode of causing erosion.
- **Glaciers**: the slow moving ice body can only cause disintegration.
- **Tides of sea**: coastal erosion is the consequence of clashing tides and waves of the sea.
- **Hydraulic action**: it is the most powerful marine erosion.
- **Gravity**: the earth's gravitation attraction imparts enormous energy to falling bodies.
- **Exfoliation**: is a type of mechanical disintegration of rocks that place due to frequent intense temperature changes. [Exfoliation $\longrightarrow$ ex = pre-existing and folio = layers]

Chemical factors:

Water directly affects rocks by way of dissolution [complete disappearance of rocks] leaching (making porous), hydration and hydrolysis.

- **Dissolution**: this happens in case of carbonate rocks, particularly lime stones.

  $CaCo_3$(lime stone) + H_2O+CO_2 $\longrightarrow$ $Ca(HCO_3)_2$(calcium bicarbonate)

- **Leaching**: water is the most powerful corroding and leaching agent. minerals effected by water.

  $\rightarrow$laterite is the typical example.

- **Hydration**: hydration is the process where in waste water in hydrology molecules are injected into the molecular structures of minerals, bare by bringing about the decomposition if these minerals.

  $K_2Al_2O_36SiO_3$(orthoclase)+H_2O+CO_2(hydration) $\longrightarrow$ K_2CO_3(kaolin) + $Al_2O_3.2SiO_2.2H_2O$+$4SiO_2$ (sand)

- **Hydrolysis**:

  $KAlSi_3O_8$(feldspar) $\longrightarrow$ H^+ (hydrogen from water) $\longrightarrow$ $HALSI_3O_8 + K^+$

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

Importance of Weathering:

Some useful effects of weathering are:

- Weathering produces soil which is vital for agriculture and for the production of different crops.
- Weathering makes rocks porous and permeable .this is very important from ground water occurrence point of view in the case of hard rocks like granites and gneisses.
- These acquire aquifer characteristic because of weathering.
- Cheap building stones like lateries develop due to weathering.
- Oxidation & supergenic enrichment are important phenomenon is the information of sulphides.

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

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

2b) What is Mass Wasting? Explain the important methods to be adopted in mitigation of landslides.

Mass wasting, also known as slope movement or mass movement, is the geomorphic process by which soil, sand, regolith, and rockmove downslope typically as a mass, largely under the force of gravity, but frequently affected by water and water content as in submarine environments and mudflows.

Landslides

A landslide, also called a landslip, is a rapid movement of a large mass of earth and rocks down a hill or a mountainside. Little or no flowage of the materials occurs on a given slope until heavy rain and resultant lubrication by the same rainwater facilitate the movement of the materials, causing a landslide to occur. The common forms of landslides are slump, debris slide, rock slide, rock fall, debris fall and avalanche.

Landslide mitigation refers to construction and other man-made activities on slopes with the goal of lessening the effect of landslides. Landslides can be triggered by many, sometimes concomitant causes. In addition to shallow erosion or reduction of shear strength caused by seasonal rainfall, landslides may be triggered by anthropic activities, such as adding excessive weight above the slope, digging at mid-slope or at the foot of the slope. Therefore, landslide hazard mitigation measures are not generally classified according to the phenomena that might cause a landslide. Instead, they are classified by the sort of slope stabilization method used:

- Geometric methods, in which the geometry of the hillside is changed (in general the slope);
- Hydro geological methods, in which an attempt is made to lower the groundwater level or to reduce the water content of the material
- Chemical and mechanical methods, in which attempts are made to increase the shear strength of the unstable mass or to introduce active external forces (e.g. anchors, rock or ground nailing) or passive (e.g. structural wells, piles or reinforced ground) to counteract the destabilizing forces.

3a) Briefly explain the branches of Geology.

ENGINEERING GEOLOGY: This deals with the application geological knowledge in the field of civil engineering for execution of safe, stable and economic constructions like dams, bridges and tunnels etc.

DIFFERENT BRANCHES OF GEOLOGY

For studying the earth in detail, the subject of Geology has been divided into various branches as follows:

Physical Geology	Mining Geology
Mineralogy	
Petrology	Hydrology
Structural Geology	Palaeontology

Historical Geology Stratigraphy

(i) **Physical Geology**

As a branch of geology, it deals with the "various processes of physical agents such as wind, water, glaciers and sea waves", run on these agents go on modifying the surface of the earth continuously.

Physical geology includes the study of Erosion, Transportation and Deposition (ETD).

The study of physical geology plays a vital role in civil engineering thus:

(a) It reveals constructive and destructive processes of physical agents at a particular site.

(b) It helps in selecting a suitable site for different types of project to be under taken after studying the effects of physical agents which go on modifying the surface of the earth physically, chemically and mechanically.

(iii) **Mineralogy**

As a branch of geology, it deals with 'the study of minerals'. A mineral may be defined as a naturally occurring, homogeneous solid, inorganically formed, having a definite chemical composition and ordered atomic arrangement. The study of mineralogy is most important.

(a) For a civil engineering student to identify the rocks.

(b) In industries such as cement, iron and steel, fertilizers, glass industry and so on.

(c) In the production of atomic energy.

(iv) **Petrology**

As a branch of geology it deals with 'the study of rocks'. A rock is defined as "the aggregation of minerals found in the earth's crust".

The study of petrology is most important for a civil engineer, in the selection of suitable rocks for building stones, road metals, etc.

(v) **Structural Geology**

As a branch of geology, it deals with 'the study of structures found in rocks'. It is also known as tectonic geology or simply tectonics. Structural geology is an arrangement of rocks and plays an important role in civil engineering in the selection of suitable sites for all types of projects such as dams, tunnels, multistoried buildings, etc.

(vi) **Stratigraphy**

As a branch of geology it deals with 'the study of stratified rocks and their correlation'.

(vii) **Paleontology**

As a branch of geology, it deals with 'the study of fossils' and the ancient remains of plants and animals are referred to as fossils. Fossils are useful in the study of evolution and migration of animals and plants through ages, ancient geography and climate of an area.

(viii) **Historical Geology**

As a branch of geology, it includes "the study of both stratigraphy and paleontology". Its use in civil engineering is to know about the land and seas, the climate and the life of early times upon the earth.

(x) **Mining Geology**

As a branch of geology, it deals with "the study of application of geology to mining engineering in such a way that the selection of suitable sites for quarrying and mines can be determined".

(xii) **Hydrology**

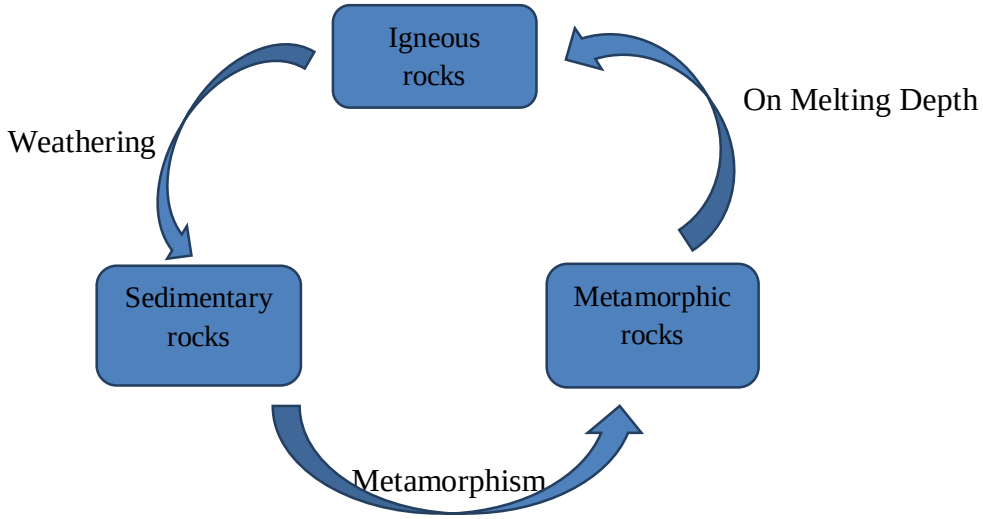
As a branch of geology, it deals with "the studies of both quality and quantity of water that are present in the rocks in different states" (Conditions). Moreover, it includes:
(a) Atmospheric water,
(b) Surface water, and
(c) Underground water.

3b).Explain in detail about the importance of geology in civil engineering

Importance of Geology In Civil Engineering:

- The civil engineers aim at safety, stability and life of the structures that they construct.
- Civil engineering constructs like dams and bridges will have their foundations of geological formations of the earth's surface.
- Their stability and safety depend on the competence of the insitu rocks of the sites concerned.
- Economic point of view competent foundation rocks should beat a shallow depth.
- For huge constructions like dams, building materials are required in very large quantities near the site.
- These critical details of civil engineering importance i.e, durability and competence of foundation rocks, their depth of occurrence, availability of building materials of new project sites, can be reliably obtained from geology and geographical studies.
- The significance of the geology with reference reference to civil engineering will be better appreciated if the consequences of ignoring geological studies are also quoted.
- Geological knowledge can also be utilized when necessary in dealing with huge buildings, runways, terrain evolution for military operations and purposes.

4a) Describe rock cycle with a neat diagram.



The three group of rock, i.e., Igneous, Sedimentary and metamorphic, which occurs in nature give place to one another as explained below • Igneous rocks, as a consequence of weathering, give rise to sedimentary rocks, further under the influence of metamorphism they also give rise to Ortho-metamorphic rocks. • Sedimentary rocks, when buried to great depths, form magma on melting and subsequently solidify to form igneous rocks and, under the influence of metamorphism, change over to para-metamorphic rocks. • The metamorphic rocks, like the igneous rocks, on weathering, give rise to sediments which form sedimentary rock later. The metamorphic rocks, like the sedimentary rocks, when buried to great depths due to tectonic activity will melt and give to magma, from which igneous rocks are formed. • Thus one group of rocks give rise to another in nature due to geological reasons and this phenomenon is called "Rock Cycle"

4b). Describe the structure and textures of igneous rocks.

Igneous Structures and Textures:-

Textures: - texture means the size, shape and arrangement of mineral grains in a rock.

The grain size of an igneous rock depends on the rate of cooling of magma.

Slower is the rate of cooling ---- coarser the grain

In the study of texture four points are considered. Those are;

i. Degree of crystallization
ii. Size of grains
iii. Shape of crystals
iv. Mutual relationship between mineral grains

Degree of crystallization:

On the basis of degree of crystallization, textures of igneous rocks can be divide into

a) ***Holocrystalline texture***: when a rock is made up entirely of crystals its texture is described as holocrystalline.
b) ***Holohyaline texture:*** When a rock is composed entirely of glassy material its texture is called holohyaline
c) ***Mero crystalline texture***: when a rock is composed partly of crystals and partly of glass the texture is called mero crystalline.

Size of grains:-

The size of grains in an igneous rock varies considerably grains are,

If, slowly cooling – 5mm → phaneric, Rapid cooling – glassy texture → aphanitic

Phaneric further subdivided as

i. Coarse grained texture = > 5mm
ii. Medium grained texture = 1-5mm
iii. Fine grained texture = < 1mm
iv. Micro crystalline texture - under microscope only
v. Cryptocrystalline - very small not even seen in microscope

Shape of crystals:-

The grains of an igneous rocks are called

"*Euhedral*" – if they show well developed crystal face

"*subhedral*" - if they partly developed crystal face

"*anhedral"* - if they are not having developed crystal face

Mutual relation of grains:-

Depending on mutual relation of grains it may be classified into four sub groups

a) Equigranular texture
b) Inequigranular texture
c) Directive texture
d) Inter growth texture

a)*Equigranular texture*: igneous rocks containing mineral grains of more or less equal size are shaped to have an equigranular texture. They are;

a. Penidiomorphic texture:- most grains are euhedral Eg: lamprophyers
b. Hypidiomorphic:- most of the crystals are subhedral Eg: granites and syenites
c. Allotriomorphic texture:- anhedral crystals Eg: aplites
d. Microgranular texture:- fine micro grains
e. Orthophyric texture:- fine grained penidiomorphic texture
f. Felsitic texture: - containing a uniform mass of cryptocrystal matter

b) Inequigranular texture: - variations in grain size

- *Porphyritic texture*: - in igneous rocks large grains are surrounded by matrix or fine grains.
- *Polikilitic texture:-* when in a rock smaller crystals are enclosed by larger crystals the texture is called polikilitic texture
- *Ophitic texture* :- it is a special type of polikilitic texture in which bigger crystals of augite enclose smaller path of plagioclase
- *Intergranular texture:* - in many basalts plagioclase lathes occur in such a way that they form a network with triangular or polygonal interspaces.

c) Directive texture:-

They produce as a result of lava flow, during their consolidation are called directive textures. They are;

i. *Trachytic texture*: certain volcanic rocks such as trachyte, contain feldspar laths arranged in lines parallel to the direction of flow of lava. Such a texture is called as the trachytic texture.
ii. *Hyalopilitic texture*: in a volcanic rock if feldspar laths are intermixed with glasses the texture is called Hyalopilitic texture.

d) Inter growth texture:-

The inter growth of quartz and orthoclase may take place when they crystalline simultaneously that is called inter growth texture.

STRUCTURES OF IGNEOUS ROCKS:

Flow structures:-

Sometimes an igneous rock shows parallel or sub parallel bands or steaks which are caused by the flow of magma or lava during their cooling and crystallization. Such structures are called the 'flow structures'.

Xenolithic structures:-

Foreign rock fragments are included into the magma when it rises towards the earth's surface. Such entrapped fragments of foreign rocks are called the xenoliths and the structure is called the xenolithic structure.

Vesicular structure:-

Most lavas contain large amount of gas and volatiles. If they escape vesicles form, this structure is known as vesicular structure.

Amygdoloidal structure:-

The vesicles of volcanic rocks may subsequently filled by secondary minerals such as calcite and zeolites this structure is called 'amygdoloidal structure'

Pegmatitic structure:-

If the constituent mineral grains exceed several centimeter in size. The rock is said to have a pegmatic structure.

It may be said that the texture and structure of an igneous rock provide numerous clues that suggest the circumstances of formation of rocks.

5a)Write down physical properties and chemical composition of following minerals

1. Quartz 2.Calcite

Quartz: Quartz is a chemical compound consisting of one part silicon and two parts oxygen. It is silicon dioxide (SiO_2). It is the most abundant mineral found at Earth's surface, and its unique properties make it one of the most useful natural substances.

Physical Properties of Quartz	
Chemical Classification	Silicate
Color	Quartz occurs in virtually every color. Common colors are clear, white, gray, purple, yellow, brown, black, pink, green, red.
Streak	Colorless (harder than the streak plate)
Luster	Vitreous
Diaphaneity	Transparent to translucent
Cleavage	None - typically breaks with a conchoidal fracture
Mohs Hardness	7
Specific Gravity	2.6 to 2.7
Diagnostic Properties	Conchoidal fracture, glassy luster, hardness
Chemical Composition	SiO_2
Crystal System	Hexagonal
Uses	Glass making, abrasive, foundry sand, hydraulic fracturing proppant, gemstones

Calcite: Calcite is a rock-forming mineral with a chemical formula of CaCO3. It is extremely common and found throughout the world in sedimentary, metamorphic, and igneous rocks. Some geologists consider it to be a "ubiquitous mineral" - one that is found everywhere.

Calcite is the principal constituent of limestone and marble. These rocks are extremely common and make up a significant portion of Earth's crust. They serve as one of the largest carbon repositories on our planet.

Physical Properties of Calcite	
Chemical Classification	Carbonate
Color	Usually white but also colorless, gray, red, green, blue, yellow, brown, orange
Streak	White
Luster	Vitreous
Diaphaneity	Transparent to translucent
Cleavage	Perfect, rhombohedral, three directions
Mohs Hardness	3
Specific Gravity	2.7
Diagnostic Properties	Rhombohedral cleavage, powdered form effervesces weakly in dilute HCl, curved crystal faces and frequent twinning
Chemical Composition	$CaCO_3$
Crystal System	Hexagonal
Uses	Acid neutralization, a low-hardness abrasive, soil conditioner, heated for the production of lime

5b) Define Mineral and write about the physical properties used for mineral identification.

Mineral is naturally occurring homogeneous substance which is having a definite chemical composition and regular atomic structure, formed by inorganic processes. That means

- It must have been formed by natural processes.
- It must be an inorganic substance.
- It must be homogeneous.
- It must be solid and have a definite chemical composition.
- IT must be having a regular atomic structure.

Study of Physical Properties:-

- Physical properties of minerals like colour, shine(lustre), resistance to scratching (hardness), density, fissility(cleavage) can be studied with mere observation and feeling of mineral specimens.
- These properties are dependent on chemical composition, and atomic structure.

  Ex: Galena mineral occurred in nature with lend grey colour, bright metallic shine, opaque character, high density, tendency to break easily lay three different directions and is scratched easily by a knife but not by finger nail.
- This set of physical properties is never exhibited by any either mineral.
- From the civil engineering point of view it is very important to know more about these physical properties by studying different minerals practically.

The chief physical properties are colour, streak, lustre, hardness, habit, clearage, fracture, order, feel, tenacity, fluorescence, phosphorescence, magnetism, specific gravity and crystal forms.

Colour:- Colour of a mineral is due to absorption of certain wave length of light.

- Some minerals possess characteristic and fairy constant colour.

  Ex: lead – grey = galena

  Brass - yellow = pyrite
- Presence of small amount of impurities can give a variety of colours to white or colourless minerals.

  EX:-amethyst, rose-quartz [Changes because of titanium impurities.]

Streak: - the colour of the minerals powder is called streak it is more consistent and reliable than the body colour of the mineral.

- The steak is obtained by rubbing a mineral against an unglazed porcelain plate called "streak plate".

  EX:- hematite appears black colour, gives a red coloured streak.
- It is white colour in silicate, carbonates and transfer minerals, because of that it is less use full in minerals identification.

Lustre: Is very characteristic and useful property of minerals. It is a measure of the reflectivity of the mineral surface. (Or)

The lustre may be defined as the general appearance of mineral surface in reflected light.

The various types of lustres are:

- Metallic lustre...metal appearance Ex:Pyrite &Galena
- Vitreous lustre...like broken glass Ex:Quartz
- Pearly lustre...like pearls Ex:Muscorite, talc and calcite
- Silky lustre...slik like fibrous Ex:asbestos

- Resinous lustre...resin like surface Ex:sphaleerite
- Greasy lustre...grease like Ex:nephaline
- Earthy lustre...dull or earthy like Ex:kaolin(clay)

Hardness: - Is one of the most useful diagnostic properties of a mineral. It is defined as the resistance of a mineral to abrasion or scratching.

A numerical value is obtained by using the "Mohr scale of hardness". In this scale there are ten minerals which are arranged in the order of their increasing hardness

1. Talc 2. Gypsum	Scratched by a finger nail <=2.5
3. Calcite 4. Fluorite 5. Apatite	Scratched by a knife <=5
6. Orthoclase 7. Quartz	Hardly scratched by a knife <=6.5
8. Topaz 9. Corundum 10. Diamond	Not scratched by a knife >=7

Form/Habit:- Habit/Form of a minerals is defined as size and shape of the crystals(or) masses.

The chief habit/forms shown by minerals are (or)

- Fibrous→aggregate of long thin fibres EX:- asbestos.
- Tabular→minerals shows broad flat surface EX: feldspar
- Bladed→ as a small knife blades EX: kynaite
- Botryoidal → as like bunch of grapes EX: chalcedony
- Massive → that means non crystalline or cryptocrystalline (half crystalline) minerals occur as structure less mass they are massive Ex: flint

Cleavage: is the tendency of a mineral to break more easily with smooth surface along planes of weak bonding.

- It is classified as "perfect", "good", "poor", and "indistinct". The minerals shows perfect cleavages are mica, galena, calcite and flurite.
  - Quartz has no cleavage at all.

Fracture: minerals which do not exhibit cleavage break with an irregular surface.

- The nature of this broken surface is called fracture .
  - It should be other than cleavage plain.

I. **Conchoidal fracture**: it is a curved fractures surface showing concentric lines like shell. EX: quartz & glass

II. **Even fracture**: it is a fracture surface which is almost flat. EX:flint
III. **Uneven fracture**: it is a fracture surface which is irregular and large. EX: large number of minerals shows.

Specific gravity: is a number which represents ratio of the weight of a mineral to the weight of an equal volume of water

Distinguishing/diagnostic properties:

The set of physical properties which are consistently observed in a particular mineral are called as distinguishing / diagnostic properties.

6a) Describe various types of Unconformities with neat Sketches.

Unconformity is a product of diastorphism and involve tectonic activity in the form of upliftment and subsidence of land mass.

When a sedimentary rocks are formed continuously or regularly one after another without any major brake, they are said to be conformable beds, and this phenomenon is called conformity. All the beds belonging to conformable set shall possess the shame strike direction, dip direction and dip amount.

On the other hand, if a major break occurs in sedimentation in between two sets of conformable beds, it is called an unconformity.

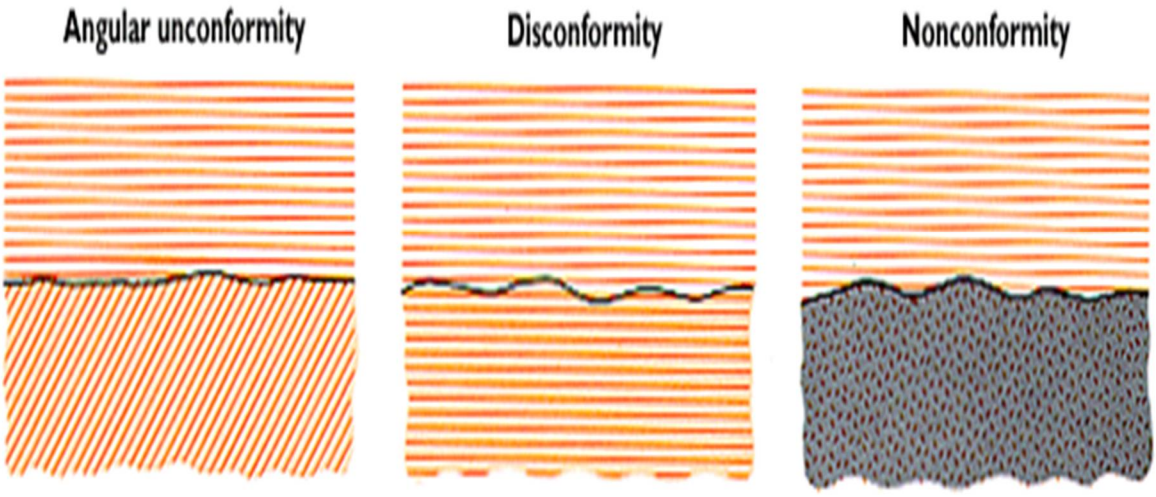
Types of Unconformities

Based on factors such as type of rocks, relative attitude of sets involved and their extent of occurrence, the different types of unconformities are named as

Non-Conformity: When the underlying older formation are represented by igneous or metamorphic rocks and the overlying younger formation are sedimentary rocks, the unconformity is called “non-conformity”.

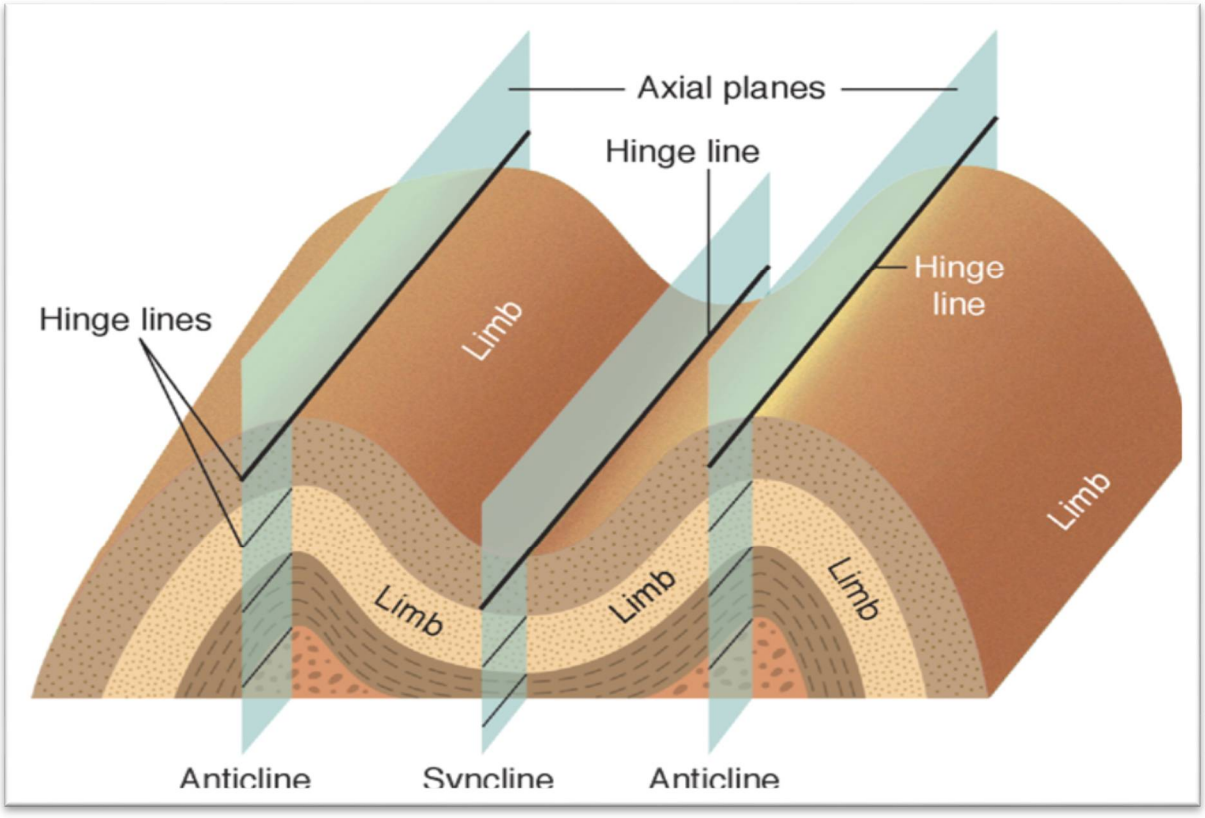
Angular Unconformity: When the younger bed and older set of strata are not mutually parallel, then the unconformity is called “angular unconformity”. In such a case, beds of one set occur with a greater tilt or folding.

Disconformities: if the bed of the younger and older set are mutually parallel and the contact plane of two sets is only an erosion surface, then the unconformity is called “disconformities”



6b). Mention Different parts of a fold with neat sketches.

Folds are one of the most common geological structures found in rocks. When a set of horizontal layers are subjected to compressive forces, they bend either upward or downward. The bend noticed in rocks are called folds.



When the beds are bent upwards, the resulting fold is called anticline. This fold is convex upwards.

Syncline is just opposite to anticline in its nature, i.e. when the beds are bent downwards the resulting fold is called syncline. This fold is convex downwards.

7a) What are the causes and effects of earthquake?

The important causes of the earthquake are:

Causes of Earthquake:

1. Tectonic Movement: This particularly happens when the continental plate collides against the oceanic plate. The oceanic plate is overridden by the continental plate. By a process called subduction jerky movements are caused along the inclined surface. Tectonic earthquakes have occurred in Assam in 1950.
2. Volcanic Activity: Earthquakes may also be caused by the movement of lava beneath the surface of the earth during volcanic activity. The earthquakes due to Krakatoa volcanic eruption in 1883 is a good example of volcanic eruption.
3. Dislocation of the Earth's crust: Earthquakes may be caused by the dislocation of the crust beneath the surface of the Earth.
4. Adjustment in inner Rock Beds: Earthquakes are also caused where is an adjustment between Sima [i.e., beneath the ocean is formed by Silica and Magnesium = Si + ma = Sima] and Sial (i.e., Continent is formed by Silica and Aluminium = Si + al = Sial) in the interior of the Earth's Crust. This Earthquake may be called as a Plutonic Earthquake.
5. Pressure of gases in the interior: The expansion and contraction of gases in the interior of the Earth sometimes cause a sudden shake on the Earth's surface.
6. Other Causes:
    1. Landslides and avalanches,
    2. Denudation of the Landmasses and depositions of materials,
    3. Faulting and folding in the rock beds are responsible for causing minor earthquakes.

Effects of Earthquake

Destructive Effects:

1. Earthquake causes dismantling of buildings, bridge and other structures at or near epicenter. Many men and animals are killed or buried under collapsed houses.
2. Rails are folded, underground wires broken. Fire breaks out inevitably in large towns.
3. Earthquakes originate sea waves called Tsunamis.
4. Earthquakes result in the formation of cracks and fissures on the ground formation.
5. The earthquakes cause landslides and disturb the isostatic equilibrium.
6. Landslide due to earthquake may block valleys to form lakes.

Constructive Effects:

1. Sometimes the earthquakes cause formation of hot springs which are very useful to people.
2. The earthquakes sometimes cause submergence in coastal land, and result in formation of inlets, bays and gulfs which help to develop of fishing and shipping etc.
3. Sometimes, the earthquakes cause emergence of costs and bring fertile shore out of water to give chance to develop crop production.

7b) Explain various Grouting methods which improve the rock mass properties.

Grouting is a high-cost treatment method and should be used where there is adequate confinement to handle the injection pressures. The typical applications include control of groundwater during construction, filling voids to prevent larger amounts of settlement, soil strengthening, and stabilization of loose sands, foundation underpinning, filling voids in calcareous formations and strengthening soils for protection during excavation. Selection of the most suitable method for stabilization will depend on the type of soil, degree of improvement and depth and extent of treatment required. Another factor to consider is whether the treatment is required for a new or existing structure.

Types of Grouting:

- Permeation Grouting:
- Compaction Grouting
- Hydro Fracture Grouting
- Jet Grouting
- Rock Grouting
- Compensation Grouting
- Deep Mixing Methods (DMM)

Permeation Grouting: This method describes the process of filling joints or fractures in rock or pore spaces in soil with a grout without disturbing the formation.

Compaction Grouting: Grout mix is specifically designed so as not to permeate the soil voids or mix with the soil. Instead, it displaces the soil into which it is injected.

Hydro Fracture Grouting: Hydro fracture grouting is the deliberate fracturing of the ground (soil or rock) using grout under pressure. Typically it is used to compact and stiffen the ground or to access otherwise inaccessible voids

Jet Grouting: The high-pressure water or grout is used to physically disrupt the ground, in the process modifying it and thereby improving it.

Rock Grouting: Rock grouting is the filling or partly filling by grout injection of fissures, fractures or joints in a rock mass with grouts without creating new or opening existing fractures.

Compensation Grouting: Compensation grouting is the responsive use of compaction, permeation or hydro fracture grouting as an intervention between an existing structure and an engineering operation.

Deep Mixing Methods (DMM): soil improvement method which is performed to improve the strength, deformation properties and permeability of the soil.

8a) Explain the necessity and importance of geophysical investigations.

- Geophysical methods are gaining importance very rapidly because of their success in solving a vast variety of problems.
- These investigations are carried out quickly. This means large area can be investigated in a reasonable short period and hence time is saved.
- The geophysical instruments used in the field are simple, portable and can be operated easily. This means fieldwork is not laborious.
- Since the work is carried out quickly and only physical observations are made. Without the use of consumables (like Chemicals), it is economical too.
- Different interferences to suit different purposes can be drawn from the same field data, for example electric resistivity data can be interpreted for knowing subsurface of rock types, geological structures, groundwater conditions, ore deposits depth to the bed rock, etc. Hence the investigations are multipurpose.

Applications of Geophysical Investigations

- Geophysical explorations are numerous, important and widely varied.
- Investigations aimed in solving problems of regional geology.
- Investigations aimed at locating and estimating economically important mineral deposits.
- Investigations aimed at locating and assessing groundwater potential and its quality
- Investigations aimed at solving problems connected with geology.

8b) Describe the Electric Resistivity Method of Exploration.

- Electrical resistivity methods, electromagnetic methods, self-potential methods and induce polarization methods are the very important categories of electrical methods.
- Methods electrical method are numerous and more versatile, They are more popular because they are successful in dealing with a variety of problems like groundwater studies, subsurface structure, and many others.
- In electromagnetic methods, electrical conductivity, magmatic permeability and dielectric constant of subsurface bodies are the relevant properties.
- The electrical resistivity's of subsurface formation vary from one another if they are inhomogeneous and are studied with the help of resistivity method. In the case of a resistive subsurface body, current lines move away from it and in the case of a conductive subsurface body, the current lines move towards it.

- Profiling and Sounding are two types of resistivity investigations. Profiling is done to detect lateral changes in resistivity. This throws light on the change in the subsurface lithology or structure from place to place.

- Sounding is done to determine the vertical changes in resistivity. In other words, this study reveals changes in lithology, etc. at a particular place with increasing depth.

9a) Mention the geological causes for the failure of dams and quote a case history.

A dam is a barrier across flowing water that obstructs, directs or slows down the flow, often creating a reservoir, lake or impoundments. Most dams have a section called a spillway or weir over which, or through which, water flows, either intermittently or continuously, and some have hydroelectric power generation systems installed.

Common causes of dam failure include:

- Sub-standard construction materials/techniques (Gleno Dam)
- Spillway design error (South Fork Dam, near failure of Glen Canyon Dam)
- Geological instability caused by changes to water levels during filling or poor surveying (Malpasset Dam).
- Sliding of a mountain into the reservoir (Vajont Dam – not exactly a dam failure, but caused nearly the entire volume of said reservoir to be displaced and overtop the dam)
- Poor maintenance, especially of outlet pipes Extreme inflow (Shakidor Dam)
- Human, computer or design error (Buffalo Creek Flood, Dale Dike Reservoir, Taum Sauk pumped storage plant)
- Internal erosion, especially in earthen dams (Teton Dam)
- Earthquakes

9b) Explain briefly the geological considerations for successful tunnelling.

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. 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. The thickness of concrete lining dependes on the extent of protection required, and the degree of weakness of the ground. It also depends on the overbreak phenomenon. Lining is provided to support weakparts 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.