UNIT - 1

INTRODUCTION:

Geology: (In greek, Geo means Earth, Logos means Science) is a branch of science dealing with the study of the Earth. It is also known as earth surface. The study of the earth as a whole, its origin, structure, composition and the nature of the processes which have given rise to its present position is called the geology. Geology comprises the following branches.

1. Crystallography: The study of the characters of crystals is known as crystallography. crystals are bodies bounded by flat faces (surfaces) arranged on a definite plate due to internal arrangements of atoms.

2. Mineralogy: The study of the characters of minerals (eg: quartz, pyroxene, amphibole, mica, chlorite, garnet) is known as mineralogy. A mineral is a naturally occuring homogeneous substance, inorganically formed with a definite chemical composition, with a certain physical properties and crystalline structures.

petrology: The study of rocks in all their aspects including their mineralogies, textures, structures, origin and their relationships to other rocks.

Geophysics: The section of the earth which include the structure, physical conditions and evolutionary history of the earth as a whole.

Geochemistry: The study of chemical composition of minerals and rocks of the earth.

Structural Geology: Is the study of rock structures such as folds that have resulted from movements and deformation of the earth's crust.

Stratigraphy: The study of the stratified rocks especially its sequence in time, the character of the rocks and correlation of beds at different localities.

Physical Geology: It deals with the geological processes which bring about changes in the crust and upon the surface of the earth. It also deals with the surface features of the earth. or its topography.

Geomorphology: The description and interpretation of land forms.

Palaeontology: Is the study of ancient life, determination of environment, evolution of organisms etc.,

Hydrogeology: The study of the geological factors relating to earth's water.

Mining Geology: deals with the method of mining of rocks and mineral deposits on earth's surface and subsurface.

Engineering Geology:

The principles and methods of geology is adopted for the purpose of civil engineering operations. Broadly speaking, engg geology has two divisions:

1) The study of raw materials

2) The study of the geological characteristics of the area where engineering operations are to be carried out such as groundwater characteristics; the load bearing capacity of rocks; the stability of slopes; excavation; rock mechanics etc for civil engineer.

Scope of geology in civil engineering:

→ Geology provides necessary information about the onstruction materials at the site used in the construction of buildings, dams, tunnels, tanks, reservoirs, highways and bridges.

→ Geological information is most important in planning stage, design phase and construction phase of an engineering project.

→ Geology is useful to know the method of mining of rock and mineral deposits on earth's surface and subsurface.

→ Geology is useful for supply, storage and filling up of reservoirs with water.

Importance of Geology from civil Engineering point of view.

→ Before constructing roads, bridges, tunnels, tanks, reservoirs, and buildings selection of site is important from the point of stability of foundation.

→ Geology provides a systematic knowledge of construction materials and their properties.

→ The knowledge about the nature at the rocks in tunneling and construction of roads.

→ The foundation problems of dams, bridges and buildings are directly related with geology of the area where they are to be built.

→ The knowledge of ground water is necessary in connection with excavation works, water supply, irrigation and many other purposes.

→ The knowledge of Erosion, Transportation and Deposition by surface water helps in soil conservation, river control.

→ Geological maps and sections help considerably in planning many engineering projects.

→ If the geological features like faults, joints, beds, ... found, they have to be suitably treated. Hence, the sta... of the rock structures is important.

→ pre-geological survey of the area concerned reduces the planning work.

Importance of physical geology, petrology & structural ge...

Importance of physical geology:

It deals with the geological processes which brin... about changes in the crust and upon the surface of th... earth. It also deals with the surface features of the ear... or its topography. The earth is concentrically divided into a number of spheres viz., (1) Atmosphere ; (2) Hydrosphere and (3) Lithosphere.

The outermost sphere is Atmosphere which consists of several gases and vapours and envelopes the earth. Atmosphe... is essentially a mixture of N_2 and O_2 with smaller quantities of vapour, CO_2 etc., Geologically atmosphere is important as the medium of climate and weather. Hydrosphere includes the ... natural waters of the earth ie., oceans, seas, lakes, rivers, streams and underground water. Lithosphere is the outerpart of the earth's crust consisting of rocks and minerals.

The geological processes include Denudation, Deposition, Earth movements, Igneous activity and metamorphism.

Denudation: The sum of the processes which result in the general lowering of the land surfaces or when erosion takes places, fresh country rock surfaces will be exposed and this process is called DENUDATION. Denudation consists of weathering, transportation and erosion.

Weathering is the process by which rocks are broken

→ If the geological features like faults, joints, beds, folds ... found, they have to be suitably treated. Hence, the stability of the rock structures is important.

→ pre-geological survey of the area concerned reduces the cost of planning work.

Importance of physical geology, petrology & structural geology:

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Weathering is the process by which rocks are broken

...tion and decomposed by the action of external agencies such as wind, rain, temperature changes. Weathering is the initial stage in the process of denudation.

Transportation is the main agency by which materials are moved by means of gravity, running water, wind etc.,

Erosion: mechanical disintegration (or) chemical decomposition of rocks and their subsequent displacement is called as erosion (or) erosion is the destructive process due to the effect of the transporting agents. The chief agents of erosion are running water, wind etc.,

Deposition: The material is transported mechanically and deposit.

- Earth movements: Include the uplift and depressions of land areas & sea floors.

Igneous activity: Includes emission of lavas, gases, other volcanic products etc.

Metamorphism: The process by which changes are brought about in rocks within the earth's crust by the agencies of heat, pressure and chemical fluids.

- Thermal metamorphism : heat alone acts

Dynamic metamorphism : Involves stress to break up the rocks.

Regional / Dynamothermal metamorphism : Both heat & pressure involves

Retrograde metamorphism : produces lower grade metamorphic rocks.

Auto metamorphism : chemical adjustment in newly solidified igneous rocks, brought about by a decrease in temperature.

Meander Development:

A meander in general is a bend in a water coarse. meander bend is formed when the moving water in a stream erodes the out banks and widens its valley. If the river encounters any obstacle, it shall not have the capacity to uproot it and therefore it takes a diversion and continues its downward coarse. This is responsible for the formation of deposits known as placer deposits.

By virtue of its relatively weak condition the river compulsorily undergoes a number of curves or bends which makes its path zig-zag. these bends are called meanders and the phenomenon is known as meandering. Meandering is therefore a characteristic feature of the mature stage.

In due course of time these bends become more and more acute due to deposition of sediments along the inner curve and erosion along the outer curve. ultimately under favourable conditions such as floods, these loops are cut off from the main course of the river. Such cut off bodies of water which are curved in plan are called cut off lakes or horse shoe lakes (or) ox bow lakes.

Delta: A delta is landform that is formed at the mouth of a river where the river flows into an ocean, or sea. Deltas are formed from the deposition of the sediment carried by the river as the flow leaves the mouth of the river. Over long periods of time, this deposition builds the characteristic geographic pattern of river delta.

Development of delta: The favourable conditions for the formation of delta are:

1. The river should have large amount of load.
2. The river should have totally exhausted its energy at the time of its merger with the sea.

The oceans at the mouth of the river should not be turbulent otherwise as Eg when loose sediments are deposited they are washed away by the waves and currents of the sea.

During delta formation the prevailing conditions will be such that the river will be shallow and will change its direction and velocity frequently. Under such conditions deltas develop a typical structure known as cross bedding.

Valleys Development:

Valleys: In geology, a valley is a depression with predominant extent in one direction. A very deep river valley may be called a canyon or gorge. The terms U-shaped and V-shaped are descriptive terms of geography to characterize the form of valley. Most valleys belong to one of these two main types or a mixture of them, at least with respect of the cross section of the slopes or hills.

Formation and development: A valley is an extended depression in the Earth's surface that is usually bounded by hills or mountains and is normally occupied by a river or stream.

Valleys are one of the most common landforms on the earth and they are formed through erosion or the gradual wearing down of the land by wind and water in river valleys for example the river acts as an erosional agent by grinding down the rock or soil and creating a valley. The shape of valleys varies but they are typically steepsided canyons or broad plains, however their form depends on what is eroding it, the slope of the land, the type of rock or soil and the amount of time the land has been eroded.

There are three common types of valleys which in... V-shaped valleys, U-shaped valleys and flat floored va...

Flat

V-shaped valleys / River valleys: A V-shaped valley, sometimes called a river valley, is a narrow valley with steeply sloped sides that appear similar to the letter "V" from a cross-section. They are formed by strong streams, which over time have cut down into the rock through a process called down cutting. These valleys form in mountainous and/or highland areas with streams in their "youthfull" stage. At this stage, streams flow rapidly down.

→ An example of a V-shaped valley is the Grand Canyon in the southwestern united states. After millions of years of erosion, the colorado river cut through rock of the colorado plateau and formed a steep sided canyon V-shaped canyon known today as the grand canyon.

→ The original natural large river valleys of the world such as Nile, ganges, Amazon, mississippi etc.,

U-shaped valleys/glacial valleys: A U-shaped valley is a valley with a profile similar to the letter "U" they are characterized by steep sides that curves in at the base of the valley wall. They also have broad, flat valley floors. U-shaped valleys are formed by glacial erosion. U-shaped valleys are found in areas with high elevation and in high latitudes, where the most glaciation has occured. Large glaciers that have formed in high latitudes are called continental glaciers or ice sheets, while those forming in mountain ranges are called alpine (or) mountain glaciers.

Due to their large size and weight, glaciers are able to completely alter topography. This is because they flowed down pre-existing river (or) V-shaped valleys during the last glaciations and caused the bottom of the "V" to level out into a "U" shape as the ice erode the valley walls, resulting in a wider, deeper valley. For this reason, U-shaped

...eys are sometimes referred to as glacial troughs.

Flat floored valleys: The third type of valley is called a flat-floored valley and are formed by streams, but they are no longer in their youthful stage, and are instead considered mature. The valley floor gets wider, because of the stream gradient the river begins to erode the bank of its channel instead of valley walls.

Over time, the stream continues to meander and erode the valley's soil, widening it further. With flood events, the material that is eroded and carried in the stream is deposited which builds up the floodplain of the valley. During this process, the shape of the valley changes from a V or U-shaped valley into one with a broad flat valley floor. An example of a flat-floored valley is the Nile-River valley.

Importance of petrology:

Rocks are divided according to their origin into 3 groups viz., IGNEOUS, SEDIMENTARY and METAMORPHIC. The study of rocks in all their aspects including their mineralogies, textures, structures; origin and their relationships to other rocks plays a major role in civil engineering operations.

Igneous rocks are formed when hot molten rock material called magma solidifies (or) igneous rocks from through cooling and crystallization of molten rock material. If the molten material is below the earth's surface. It is called magma or else it comes out about the surface, it is known as lava.

Sedimentary Rocks are formed due to weathering and erosion of the pre-existing rocks. Sedimentary rocks are classified on the basis of the character of the material and process which leads to its deposition. In addition, the depositional environment plays a major role in the formation of sedimentary rocks i.e., deposited the material by wind action (or) water action.

Metamorphic rocks are formed through the transformation of the pre-existing rocks under increased temperature and pressure conditions. This process of transformation is known as metamorphism. Formation of metamorphic rock from a pre-existing rock is controlled by the following parameters.

Examples for metamorphic rocks are:

Quartzite	Hornfels	Marble
Amphibolite	Eclogite	Schist
Gneiss	Khondalite	Slate
Phyllite		

Importance of structural geology:

Geological structures are the evidences of crustal deformation. Depending on the process involved, the following various types of structures develop in the geological formations

Folds: Folds are best displayed by stratified formations such as sedimentary (or) volcanic rocks or their metamorphosed equivalents. Folds can be seen in Gabbro, Granite gneiss, iron formations etc.,

Faults: when formations subjected to stress deform resulting in the development of fractures or a fracture in rock along which there has been an observable amount of displacement can be seen.

Joints: Joints are fractures (or) openings in the rock formations. These differea from the faults in that there is no displacement along them

Unconfirmities: An unconformity represents a long interval of non deposition during which erosion takes place

The earth crust is broken into 13 major plates which are in constant movement due to the convection currents in the interior of the earth. The movements of tectonic plates resulting in a wider, deeper valley, ...

the earth crust affect the solid rocks which cause folds; faults; joints etc.., study of these aspects are very important to a civil engineer in construction projects. strike and dip of beds or formations (or) joints also important for site location.

Weathering of rocks - It's effect & importance W.r.t Dams, Reservoirs, Tunnels.

The process by which rocks are broken down and decomposed by the action of external agencies such as wind, rain, temperature changes etc is called as weathering.

Mechanical weathering: In mechanical weathering, the process involves only fragmentation (or) break down of the rock into smaller Fragments/pieces. In nature, the physical breaking of rocks are caused by several processes. Waterfalls, land slides during their fall cause extensive breakdown of rocks. Thus gravity contributes to mechanical disintegration of rocks. However, all the processes involve widening of the fractures, resulting in the detachtment of blocks surrounded by the weak planes. The different types of processes in mechanical weathering are:

Frost wedging: The presence of water in the cracks of the rocks freezes during the night time and melts during the day time. Freezing of water involves an increase in the volume because of which the walls of cracks are wedged ultimately resulting in the detachment blocks surrounded by the weak planes.

Expansion and contraction process: solar radiation causes heating. which results in thermal expansion during day time and drop in the temperature during the night time causes contraction. The expansion and contraction are confined only to the surface layers of the rock and results often the fracting and detachment of top layers of the

Fracturing through pressure releases: Rocks at depth are confined under high pressures. However, if the rock material is uplifted due to tectonic processes to relatively lesser depths, it is subjected to lesser pressure conditions. So, the release of pressure leads to the deformation of rock and generates the fractures.

Effect of vegetation: During the growth of vegetation in rocky terrains. The roots penetrate into the existing weak planes and gradually the cracks are widened leading to physical breakdown of rock masses.

Chemical Weathering:

Chemical weathering involves chemical reactions resulting in the alteration of the rock leading to the formation of new alteration products. water is the best fluid that directly affects rocks by way of Dissolution; leaching; Hydration; oxidation, Hydrolysis etc,

Dissolution /carbonation: In case of carbonate rocks such as limestone, dolomite, marble when the river water traverses these rocks; carbonates are dissolved, resulting in the reduction of their sizes.

Leaching: means removable of soluble content from the rocks by water. Water is the powerful leaching agent which affects leaching for the most of the materials when come in contact with water. Eg: laterite is a porous rock and very weak when compared to its fresh parent lock.

Hydration: is the process where in hydroxyl molecules are injected into the molecular structures of minerals thereby bringing about the decomposition of minerals.

$K_2Al_2O_3 6SiO_2 + H_2O + CO_2 \longrightarrow K_2CO_3 + Al_2O_3 2SiO_2 2H_2O + 4SiO$

(K-feldspars) (Hydration) (Kaoline) (silic

Oxidation: The decomposition of minerals in a rock during chemical weathering is brought about by O_2 in water. For pyroxene changes into limonite because of oxidation through the following reaction.

$$4FeSiO_3 + O_2 + 2H_2O \longrightarrow 4FeO(OH) + 4SiO_2$$

(Pyroxene) (limonite) (silica)

Hydrolysis: In case of decomposition of minerals, instead of water molecule, only hydrogen of water enters into the mineral structure. This is called hydrolysis.

$$KAlSi_3O_8 + H^+ \longrightarrow HAlSi_3O_8 + K^+$$

othoclase feldspars. ion silicic acid ion

In addition, CO_2; O_2; N_2 of atmospheric gases which take part in the weathering of rocks.

Importance of weathering:

Weathering transports smaller fragments, pieces etc after the process of weathering. Weathering initiates the erosion of rock, causing alterations in minerals as well as in the surface layers. Weathering is a process that applies major role of engineering mechanics, eg: Kinematics, dynamics and fluid mechanics to predict the mechanical behavior of erosion. Together, soil and rock mechanics are the basis for solving many engineering geological problems with references to dams, reservoirs and tunnels.

Advantages of weathering from civil engineering point of view: → weathering produces soil which is vital for agriculture and for the production of agricultural

→ Weathering makes rocks into porous and permeable which allow the movement of groundwater in case of hard rocks like granites.

→ Economic minerals like bauxite deposits are also form due to weathering.

Disadvantages of weathering from civil engineering point of view:

→ weathering is not a welcome process, because it reduces the strength, durability and good appearance of rocks.

→ Therefore the weathered rocks are unfit to be at the site of foundation in case of civil structures like dams and bridges.

→ Weathered rocks are being weak, therefore unsuitable for tunneling.

→ Loose boulders due to weathering along steep slopes may turn out landslides which is civil engineering hazard.

Effect of weathering of a common rock Granite:

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

Granite consists of quartz, feldspar and accessory minerals. During the oxidation, feldspars in granite converts into sericite and then to kaolinite thereby silica removed from the reaction by ground water.

Feldspars ⟶ sericite (mica) ⟶ Kaolinite (clay)

Quartz minerals remain unchanged whereas muscovite or biotite becomes chlorite on decomposition. Pyroxenes decompose and pass into hornblende or breakdown into Chlorite.

The above changes due to weathering causes failure of a civil construction projects and hence the study of weathering of rocks is important for any civil project.

Finally, Geological considerations such as Topography and geomorphology of the site, impact of geological structures Lithology of the formations; identification of weak zones in addition to weathering of rocks plays an important role in civil engineering constructions.

Effect of weathering on other rocks: on the other hand, the decomposition of basic rock which contain ferro magnesium silicates produce soluble materials; iron-oxides; less silica.

Disintegration produce rough angular materials which may from form on the mountain top or accumulate at the foot hills. These loose accumulations are called TALUS (or) SCREE.

Mineralogy:

A mineral is a naturally occurring solid chemical substance formed through biogeochemical processes, having characteristic chemical composition, highly ordered atomic structure and specific physical properties.

Composition of crust and dominant minerals.

Over 7000 minerals, more each day. Fortunately, we don't need to be concerned with most of these. These geologically important minerals are primarily silicate minerals. The dominance of silicate minerals can be understood if we examine the composition of the bulk earth and of the continental crust.

Fe : 35% (wt) O : 46% O : 30% Si : 28%

Si : 15% Al : 8%

Mg : 13% Fe : 5%

Ni, S, Ca, Al Ca (3.6%), Na (2.8%), Mg (2.1%), K (2.6%), Ti (0.4%)

The bulk earth composition can be estimated from a variety of lines of evidence including:

1) analogy with meteorites

2) average density - compare that with density of crustal materials must be a lot of Fe in interior.

Minerals may be classified according to chemical composition. They are here categorized by anion group. The list below is in approximate order of their abundance in the earth's crust. The list follows the Dana classification system which closely parallel the strunz classification.

1. Silicate
2. Carbonate
3. Sulfate
4. Halide
5. Oxide
6. Sulfide
7. Phosphate
8. Native minerals

...cates:

The largest group of minerals by far are the silicat... which are composed largely of silicon and oxygen, with th... addition of ions such as aluminium, magnesium, iron, and calcium. Some important rock-forming silicates include the feldspars, quartz, olivines, pyroxenes, amphiboles, garnets and micas.

Sorosilicates:

Sorosilicates have isolated double tetrahedra groups with $(Si_2O_7)^{6-}$ (or) a ratio of 2:7 Nickel strunz classification.

Cyclosilicates:

Cyclosilicates, or ring silicates, have linked tetrahedra with or a ratio of 1:3. These exist a 3-member, 4 member and 6-member rings. Nickel-strunz classification: 09.C.

physical properties of mineral:-

The atomic structure evidenced in a number of physical properties. We will examine these links between atomic structures and hardness, density, clevage, habit.

Cleavage: plane of weakness resulting from weaker bonds.

Fracture: Breaking but not along cleavage.

Hardness: Mohr's scale.

1. Talc
2. Gypsum
3. calcite
4. Flourite
5. Apatite
6. Feldspar
7. Quartz

8. Topaz
9. Corundum
10. Diamond.

Specific gravity: The density of a mineral is determined by the kind of atoms and how they are arranged.

Luster: colour of a mineral powder is called luster.

Colour: The colour of a mineral may be diagnostic (or) may simply be related to the presence of minor impurities.

Streak: colour of a fine powder.

Quartz: Is the second most abundant mineral in the earth's continental crust, after feldspar. It is made up of a continuous framework.

Occurance: Quartz is an essential constituent of granite and other felsic igneous rocks. It is very common in sedimentary rocks such as sandstone and shale.

UNIT - II

Petrology

Definition of rock:

A rock is a aggregate of mineral consist of one mineral (or) many.

The solid earth is made of rock. There are three types of rocks. those that from mollen material or magma [igneous rocks], those that are deposited from air or water [sedimentary rocks] & those that have formed by alteration another rock [metamorphic rocks]. The chemical composition of a rock is expressed in terms of oxides for eg: SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, TiO_2 etc.

Classification of igneous rocks: * Igneous rocks are the first formed rocks in the earth's crust & hence there are called primary rocks, even though igneous rocks have formed subsequently.
* Igneous rocks are usually massive, unstratified, unfossiliferous & often occur as intrusive cutting across other rocks. The igneous rocks are classified based on silica %, silica saturation & depth of formation.

⇒ Classification based on silica %:

⇒ Acidic igneous rocks:

* Composed of quartz, alkali feldspars, mica minerals & compositionally rich in Si, Al, Na, K etc but are poor in Ca, Mg, Fe.
* Leucocratic due to presence of light coloured minerals.
* Relatively lighter rocks have a slightly higher specific gravity 2.6

⇒ Intermediate igneous rocks:

* Lacking of quartz or a little quartz present but dominantly composed of alkali feldspars & compositionally rich in Na, K.
* Mesocratic in color due to presence of dark colored minerals.

⟹ Basic Igneous Rocks:

* Dominantly composed of ferro-magnesium minerals such as hypersthene, feldspars, pyroxene, amphiboles, biotite & compositionally rich in Ca, Mg, Fe
* Melanocratic in color.
* Quartz (or) olivine is generally absent (or) occur in small quantities.

⟹ Classification based on silica saturation:

Depending on the silica content in parent magma; the mineral associations are categorized as:

* Oversaturation igneous rocks: When the parent magma is rich in silica, saturation minerals like feldspars & the surplus quantity of silica crystalizes as quartz.
* Saturated igneous rocks: When the parent magma has enough silica for the formation of minerals, the resulting rocks posses neither quartz nor any unsaturated mineral. Presence of saturated minerals [feldspars] are seen in Syenite, Diorite, Anorthosite, Gabbro.
* Unsaturated igneous rocks: When the parent magma has silica less than what is required for the formation of saturated minerals. Quartz is possible to the extent & feldspars, olivine, nepheline, leucite are present usually.

⟹ Classification based on depth of formation:

In terms of modes of occurance i.e, depth of formation, igneous rocks can be either intrusive (plutonic), extrusive (volcanic) (or) hypabyssal.

* Plutonic rocks: The igneous rocks which have formed under high temp & pressure at greater depths in the presence of volatiles in the earth's crust are called plutonic rocks. Greater pressure ensure total crystallization of minerals formed & the hot surroundings slow down the process of solidification. The net result of all these processes is the development of coarse grained texture.

Ex:- Granite.

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Volcanic rocks: The igneous rocks which have formed under low temp & pressure at shallow depths in the absence of volatiles in the earth's crust are called volcanic rocks. Rapid cooling & quick crystallization of lava makes faster the process of solidification due to heat difference. The net result of all these processes is the development of fine grained texture.
Ex: basalt.

* **Hypabyssal rocks**: The igneous rocks which have formed under moderate temp & pressure at shallow depths are called hypabyssal rocks. Medium rate of cooling causes for the formation of medium grained rocks.
Ex: dolerite

⇒ **Structures of Igneous rocks:**

* **Vesicular Structures**: This structure is due to porous in nature commonly observed in volcanic rocks. Most of the lava contains volatiles [gases like CO_2, water vapour] which escapes into the atmosphere by creating various sizes.
Ex: Scoria, Pumice.

* **Amygdaloidal Structures**: When secondary minerals such as calacite, zeolites, hydrated forms of silica are filled in vesicles in such case it is said amygdaloidal structure.
Ex: Deccan traps of India [i.e., basalts].

* **Columnar Structures**: with uniform cooling & contration causes a regular (or) hexgonal form, which may be ~~interested~~ Intersected by cross-joints. Ex: Columnar basalts.

* **Sheet Structures**: In this structures, the rocks appear to be made up of a number of sheets, because of the development of horizontal cracks. When erosion takes place, the overlying strata gradually disappear & ultimately the plutonic rocks exposed to the surface resulting the development of joints / cracks parallel to the surface. Ex: Granite.

* **Flow Structures**: After eruption of the lava flows, some of the bands (or) lines are drawn over the surface of the lava to the direction of lava flow. Ex: Rhyolite.

Texture of Igneous Rocks:

The texture of a rocks refers to the individual mineral grains of size, shape & mutual relations of mineral constituents & glassy matter in a rock. Depending on the nature of cooling, the textures in igneous are categorized into:

=> Degree of crystallinity: Rocks composed entirely of crystals are called holocrystalline, those composed entirely of glass are holohyalline, rocks that contains both crystals & glass are hypocrystalline / hemicrystalline.

=> Grain size: Overall there is a distinction b/w the grain size of rocks that have crystallized at depth are medium to coarse grained [eg: gabbros] & those that crystallized at shallow depth are fine grained.

* Phaneric texture: if minerals in the rock are big enough to seen by the naked eye. Ex: granite.
* Aphanitic rock texture: if minerals are too fine to be seen the texture is said to be aphanitic. Ex: basalts.

=> Based on growth of crystals / rock fabric: Fabric is the shape & mutual relationships among rock constituents:

* Euhedral: refers to grains that are bounded by crystal faces
* Subhedral grains that are bounded partly by some crystal faces.
* Anhedral, when crystal faces are absent, it is called anhedral.

Classification of Sedimentary rocks:

These are those formed due to weathering & (or) erosion of the pre-existing rocks. Also formed due to chemical precipitation (or) due to accumulation of organic remains such as plants & animal hard parts. Since the sediments represent secondary these rocks are also called as "secondary rocks."

=> Rudaceous rocks: A group of sedimentary rocks in which the particles ranges in size from 2mm upwards.

=> Arenaceous rocks: A group of sedimentary rocks in which the particles ranges in size from 1/16mm to 2mm.

=> Argillaceous rocks: A group of sedimentary rocks in which the particles range in size from 1/16 mm to 1/256 mm

Sedimentary Structures:

Several primary structures are evidenced in sedimentary rocks. These structures offer significant evidences of depositional conditions [environments]. These are:

=> Stratification: Indicates the time period involved in their deposition [rocks which displays layering or bedding].
Ex: shales.

=> Cross-bedding: Indicates shallow water deposits. [A series of inclined bedding planes having some relationship to the direction of current flow]. Ex: Sandstone.

=> Graded bedding: Indicates deep water deposits. [Coarser material at base & the finest material at the top due to involvement of a river (or) stream flow is called as graded bedding]
Ex: Greywacks.

=> Ripple marks: Indicates the shallow water deposition.

Texture of Sedimentary rocks:

=> Rudaceous rocks: Coarser rock fragments are cemented by a finer material (or) matrix & give rise to rock such as Conglomerates [rounded fragments] & breccias [angular fragments] whose average grain size of both is >2mm.

=> Conglomerates: It is rudaceous sedimentary rock which is made up of round or sub-rounded pebbles & gravel. Occasionally, cobbles & boulders also are encountered in some conglomerates. Mineralogically, pebbles are usually jasper, flint, quartz. The cementing material may be siliceous ferruginous, calcareous.

=> Breccias: Like conglomerates, breccias also are made up of pebbles, gravels & fine grained cementing material provides the binding medium. However, breccias are characterized by sharp & angular edges of pebbles indicates that the pebbles had undergone negligible transport & their parent rocks are likely not be far from the place of their occurance.

Classification Of Metamorphic rocks:

Igneous & Sedimentary rocks which are form under a certain physico-chemical environment, in terms of temp, pressure & chemically active fluids, Subsequent to their formation if any of these factors changes, the existing equillibrium gets distarb in the constituent minerals of parent rocks by metmorphism.

Temperature: Metamorphic changes mainly take place in the temp range of 350°c to 850°c.

Pressure: Uniform pressure increases with depth & effect on liquids & solids at great depths where direct pressure [stress] due to tectonic forces acts in any direction.

Chemically inactive fluids: The most common liquid is water. Also the magma or hot hydrothermal solutions may react directly with those rocks when they come in contact.

⇒ Dynamic metamorphism: When direct pressure is predominant & acts, rocks are forced to move past resisting in their crushing & granulation.

⇒ Geo-thermal metamorphism: Uniform pressure is predominant along with heat brings changes in oceanic salt deposits but not changes in silicate rocks.

⇒ Metasomatic metamorphism: This metamorphism alters the composition of the rocks significantly. Hydrothermal solutions are hot & causes for providing new minerals such as Pb, Zn, Mn etc.

⇒ Dynamothermal metamorphism: When an argillaceous rock undergo Dynamo thermal metamorphism different minerals are produced.

Ex: Gneisses & schists.

Chlorite ⟶ Biotite ⟶ Garnet ⟶ staurolite ⟶ Kyanite ⟶ sillimanite

Structures of Metamorphic rocks:

⇒ Gneissose Structure: Both equidimensional & other platy & prismatic minerals occur in considerable proportions & they appear in alternating bands. Ex: Granitic Gneiss.

⇒ Schistose Structure: If a rock consists of only prismatic or platy minerals without any segregation is called schistose structure.

Mica schist, Kyanite schist.

=> Grannulose structure: Only equidimensional minerals present in the metamorphic rocks. Prismatic or platy minerals will be either negligible or absent.

Ex: Marble, Quatzite.

=> Cataclastic Structure: It is produced under the influence of directed pressure upon hard & brittle materials in the upper zones of the earth crust.

Ex: Hornfels.

Textures of Metamorphic rocks:

=> Foliation: When chlorite, Mica, Talc etc orient themselves parallel to one other is called foliation i.e., the arrangment of in-equidimensional minerals.

=> Lineation: When hornblende, tourmaline, Actinolite, Tremotic orient themselves parallel to one other is called is called Lineation i.e., the arrangment of equidimensional mineral.

=> Xenoblastic texture: The constituent minerals of the rock have no well developed crystal faces.

=> Idioblastic texture: The constituents minerals have well developed crystals.

Study of Granite:

Granite is a plutonic igneous rocks, compact, massive & hard rock. Granites are unstratified but characterized by joints. It is a holocrystalline & leucocratic rock

Composition: Granite consists of quartz, feldspars include alkali feldspars & plagioclase feldspars, micas as essential minerals & accessory minerals are mafic minerals such as hornblende, biotite, zircon, garnet

Texture: Granites exhibit phaneric texture or graphic texture.

Hand specimen: Granite is grayish (or) pinkish in color. Feldspar appears with white or brownish - red color. Quartz colorless. Biotite is jet black. Hornblende is dark greenish black.

Varities: When quartz decreases & increase in mafic minerals, granite passes over to granodiorite & then diorite.

Study of dolerite:

Dolerite is a dark, fine grained black or dark greenish black igneous rock. It is intermediate in composition & melanocratic rock. Mineralogically & chemically, dolerite is similar to gabbro & basalt.

Composition: Dolerite consists of Plagioclase Feldspars & pyroxene. Iron oxides, hypersthene & biotite occur as common accessory minerals. Olivine is some times found if the parent magma was deficit of silica.

Texture: Dolerite is a massive & compact rock. It is neither porous nor permeable. The texture in dolerites is generally equigranular. Interlocking texture is also common in dolerite. Under the microscope dolerite exhibit Ophitic or subophitic texture.

Hand specimen: Dolerite is a fine grained rock with greenish black or black coloured. Feldspars can be observed by means of their Cleavage surfaces & biotite if present appears as small, jet black.

Special features: The compact nature & rich in mafic minerals make the rock emit metallic sound hit with a hammer. Dolerite occurs in nature as an intrusive rock i.e., as dyke.

Study of basalt:

Basalt is a black volcanic, massive, fine grained.

Composition: Basalt consist of plagioclase feldspars, pyroxenes & iron oxides. Biotite hornblende & hypersthense are the other accessory minerals. Pyrite may also seen sometimes.

Structures & Textures: Vesicular & amygdaloidal structures are common in basalts. However, columnar & flow structures are also observed in some cases. Basalts exhibit aphanitic textures in hand specimens.

Vesicular basalt: It is characterized by the presence of empty cavities or vesicles.

Amygdaloidal basalts: is a vesicular basalt with cavities filled up by secondary minerals of silica, zeolites, calcite. Among these, minerals may be used as semi-precious gemstones.

Spillite: is a soda-rich basalt in which plagioclase feldspar is albite or oligoclase instead of labradorite.

Uses: Massive basalts are highly durable & strongest having highest load bearing capacity. Used as building stones. Basalts are excellent for macadam & bitumen roads.

Study of Pegmatite:

It is a holocrystalline & coarse grained igneous rock.

Composition: Pegmatite resemble granites in mineralogy & hence it is describe as Granite pegmatite. When pegmatites are rich in alkali feldspars, it is called as Syenite pegmatites.

* **Granite pegmatite:** consists of alkali feldspars & quartz & rich in biotite of micas. In addition, rare minerals of cassiterite [tin-Sb], mispickel [arsenic - Ar] & hence pegmatites are economically very important.
* **Syenite pegmatites:** Contain rare earth elements like zirconium, cerium, lanthanum, uranium & thorium.

Texture: Pegmatite exhibit an interlocking texture.

Hand specimen: Pegmatite is generally coarse grained consist of larger sized minerals of feldspars & quartz. Feldspars are often light coloured & may appear as red, white (or) green. Hornblende looks dark greenish black.

Study of Sandstones:

Sandstone are generally porous & permeable & considered one of the best aquifers. By virtue of their porosity & permeability, they are not only capable of holding a good quality of groundwater but also yield the same when tapped.

Varieties:

* **Siliceous sandstones:** are the best rock for the all civil engineering purposes such as site of foundation; to be used as building stones, to be used for railways, tunneling etc.

* Ferruginous sandstones: come next in order of preference for structures.
* Calcareous sandstones: initially be strong but may not be durable since carbonate react with water & leaches out easily.

Study of limestone:

In hand specimens, limestones show different color of white, gray, buff, cream, pink, yellow & black. In nature, limestones occur both as porous & massive types.

Types of limestones:

* Chalk: A soft, white fine grained calcareous deposit with dull lustre. It is also consists of fossils viz foraminifera.
* Stalactites: results from the process when surface water with dissolved calcium carbonate pass through minute fractures & grows downwards from the roof of a cave.
* Stalagmites: If the rate of percolation of solution is excess than required evaporation, the solution falls on floor & form as a cone like deposit which grows from the roof of a cave.
* Drip stone: If growth continues stalactites & stalagmites may come together after sometimes producing a pillar like structure.

Study of Schist:

Like a gneiss, schist is also very common metamorphic rock due to schistose structure.

Diagnostic character: Schistose structure is present.

Color: Silvery white, jet black, dark green.

Grain size: fine to medium & sometimes even coarse grained.

Texture & Structure: Lineation or foliation texture occurs depending on when prismatic or platy minerals occur predominantly.

Minerals present: Actinolite, termolite, hornblende, sillimanite, tourmaline make up the bulk of a schist. In addition, chlorite, muscovite, biotite, talc, Kynite etc..

Types: Depending on the grade of metamorphism schists are

…ed as low grade schists [Mica schist, chlorite schist, talc schist, hornblende schist, Mica-garnet schist,] & high grade schist [sillimanite schist, eclogite schist].

Study of Marble:

It is a calcareous metamorphic rock & not hard or strong or durable. Its value is due to its pleasant color, good appearance, easy workability.

Color: Milky white, pleasant shades of green, yellow, brown, blue.

Acid test: Marbles react vigorously even with cold & dilute acids

Grain size: Fine to medium or even coarse grained & the rock is equigranular.

Texture & Structure: Granulose structure is common. No foliation occurs.

Structural Geology

Structural geology is the study of the three-dimensional distribution of rock units with respect to their deformational histories. The primary goal of structural geology is to use measurements of present-day rock geometries to uncover information.

Further information from geophysics such as gravity & airborne magnetics can provide information on the nature of rocks imaged in the deep crust.

* Fault * Fold * Joint * shear.

Rock microstructure (or) textures of rocks is studied by structural geologist on a small scale to provide detailed information mainly about metamorphic rocks & some features of sedimentary rocks, most often if they haven been folded.

Fault :-

Definition: A fault is a planar fracture (or) discontinuity in a volume of rock, across which there has been significant displacement. These forms within the earth's crust result from the action of tectonic forces.

Sizes of faults: They range in size from micrometers to thousands of kilometers in length & tens of kilometers in depths, but they are generally much thinner than they are long or deep.

Fault Classifications:

Classification of fault based on their actions & displacements:

* Active , * Inactive & * Reactivated faults.

* **Active faults:** are structures along with which we expect displacement to occur. By definitions, since a shallow earthquake is a process that produces displacement across a fault, all shallow earthquakes occurs on active faults.

* **Inactive faults:** are structures that we can identify, but which do no have earthquakes. As you can imagine, because of the complexity of earthquake activity, judging a fault to be inactive can be tricky, but often we can measure the last time substantial offset occured across a fault. If a fault has been inactive for millions of years, it's certainly

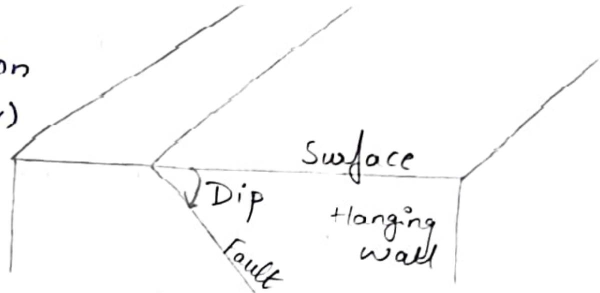
to call it inactive.

Reactivated faults: form when movement along formerly inactive faults can help to alleviate [relief] strain within the crust or upper mantle. Deformation in the New Madrid seismic zone in the central united states is a good example of fault reactivation.

Faulting Geometry:

In general fault classification based on the geometry of faulting, which we describe by specifying three angular measurements: dip, strike & slip.

* **Dip:** Dip is defined as the inclination of the bed caused by the faulting (or) folding.



* **Slip:** True relative displacement of originally neighboring point.
* **Strike:** The strike is an angle used to specify the orientation of the fault and measured clockwise from north. For example, a strike of 0° or 180° indicates a fault that is oriented in a north-south direction, 90° or 270° indicates east-west oriented structure.

Folds:

Folds is defined as the bent or deformed arrangment of stratified rocks. These rocks may be of sedimentary or volcanic origin.

In simple words fold is a bend in stratified rocks that results from movements within the earth crust & produces such structures as anticlines & synclines.

Size & shape of folds:

Folds in rocks vary in size from microscopic crinkles to mountain-sized folds. It is necessary to convey a sense of the shape of the fold. A fold can be shaped as a chevron, with planar limbs meeting at an angular axis, as cuspate with curved limbs, as circular with a curved axis, or as elliptical with unequal wavelength.

Fold types:

Folds are classified based on their structure & apperance: They are.

* Anticline: linear, strata normally dip away from axial center, oldest strata in center.
* Syncline: linear, strata normally dip toward axial center, youngest strata in center.
* Antiform: linear, strata dip away from axial center, age unknown or inverted.
* Synform: linear, strata dip toward axial centre, age unknown or inverted.
* Dome: non-linear, strata dip away from center in all directions, oldest strata in center.
* Basin: non-linear, strata dip toward center in all directions, youngest strata in center.
* Monocline: linear, strata dip in one direction b/w horizontal layers on each side.
* Chevron: angular fold with straight limbs & small hinges.
* Recumbent: linear, fold axial plane oriented at low angle resulting in overturned strata in one limb of the fold.

Causes of folding:

Folds appear on all scales, in all rock types, at all levels in the crust & arise from a variety of causes.

=> Fault-related folding: Many folds are directly related to faults, associate with their propagation, displacement & the accommodation of strains b/w neighbouring faults.

=> Compaction: Folds can be generated in a younger sequence by differential compaction over older structures such as fault blocks & reefs.

=> Sedimentary folding: Recently deposited sediments are normally mechanically weak & prone to remobilisation.

=> Slump folding: When slumps form in poorly consolidated sediments they commonly undergo folding, particularly at their leading edges, during their emplacement. The asymmetry of the slump folds can be used to determine paleoslope directions in sequences of sedimentary rocks.

Dewatering: Rapid dewatering of sediments, possibly triggered by seismic activity can cause convolute bedding.

⇒ Igneous intrusion: The emplacement of igneous intrusions tends to deform the surrounding country rock. In case of the high-level intrusions, near the earth's surface, this deformation is concentrated above the intrusion & often takes the form of folding, as with the upper surface of a loccolith.

Joints:

In geology the term joint refers to a fracture in rock where the displacement associated with the opening of the fracture is greater than the displacement due to lateral movement in the plane of the fracture of one side relative to the other. Typically there is little to no lateral movement across joints.

Influence factors for joints:

Stress, strain & deformations are the main factors influences joints in rocks.

Formation of joints in rocks:

Joints form in solid, hard rock that is stretched such that its brittle strength is exceeded. When this happens the rocks fractures in a plane parallel to the maximum principal stress & perpendicular to the minimum principal stress. This leads to the development of a single sub-parallel joint set. Continued deformation may lead to development of one or more additional joints sets.

Joints sets are commonly observed to have relatively constant spacing, which is roughly proportional to the thickness of the layer.

Types of joints:

Types with respect to formation.

* Tectonic joints: Tectonic joints are formed during deformation episodes whenever the differential stress is high enough to induce

* Anticline : linear ... irrespective of the tectonic regime tensile failure of the rock, irrespective of the tectonic regime. They will often form at the same time as faults. Measurements of tectonic joint patterns can be useful in analyzing the tectonic history of an area because they give information on stress orientation at the time of formation.

* Unloading joints: Joints are most commonly formed when uplift & erosion removes the overlying rocks thereby reducing the compressive load & allowing the rock to expand laterally. Joints related to uplift & erosional uploading have orientations reflecting the principal stresses during the uplift.

* Cooling joints: Joints can also form via cooling of hot rock masses, particularly lava, forming cooling joints, most commonly expressed as vertical columnar jointing. The joint systems associated with cooling typically are polygonal because the cooling introducing stresses that are isotropic in the plane of the layer.

Types based with respect to attitude & geometry:

* Strike joints: Joints which run parallel to the direction of strike of country rocks are called strike joints.

* Dip joints: Joints which run parallel to the direction of dip of country rocks are called dip joints.

* Oblique joints: Joints which run oblique to the dip & strike directions of the country rocks are called "oblique joints".

Unconformities:

An unconformities is a contact b/w two rock units in which the upper unit is usually much younger than the lower unit. Unconformities are typically buried erosional surfaces that can represent a break in the geological record of hundreds of millions of years or more.

Rocks below the unconformity are tilted and sheared off & rocks above it are level. The unconformity tells a clear story.

=> First a set of rocks was laid down.

=> Then these rocks were tilted, then eroded down to a level surface when a younger set of rocks was laid down on top.

Types of unconformities:

* **Disconformity:** A disconformity is an unconformity b/w parallel layers of sedimentary rocks which represents a period of erosion or non-deposition. Disconformities are marked by features of subaerial erosion. This type of disconformity in which erosion can leave channels and paleosols in the rock record.

* **Nonconformity:** A nonconformity exists b/w sedimentary & metamorphic (or) igneous rocks when the sedimentary rock lies above & was deposited on the pre-existing & eroded metamorphic or igneous rocks.

* **Angular unconformity:** An angular unconformity is an unconformity where horizontally parallel strata of sedimentary rock are deposited on tilted & eroded layers, producing an angular discordance with the overlying horizontal layers.

* **Paraconformity:** A paraconformity is a type of unconformity in which strata are parallel, there is little apparent erosion & the unconformity surface resembles a simple bedding plane. It is also known as non-depositional unconformity or pseudoconformity.

UNIT - III

GROUND WATER, EARTHQUAKE, & LAND SLIDES

Ground water :-

Ground water is a water located beneath the ground surface in Soil Pore spaces and in the fractures of rock formations.

* Parameters of ground water :-

1) Hydraulic head :-

changes in hydraulic head (h) are the driving force which causes water to move form one Place to another. It is composed head (ψ) and elevation head (z). The head gradient is the change in hydraulic head Per length of flow Path, and appears in Darcy's law as being Proportional to the discharge.

2) Porosity :-

Porosity (n) is a directly measurable aquifer Property; that the amount of Pore space b/w unconsolidated Soil Particles or whitin a fractured rock. Typically, The majority of ground water moves through the Porosity available to flow.

3) water content :-

water content (ϑ) is also a directly measurable Property; it is the fraction of the total rock which is filled with liquid water.

4) Hydraulic conductivity :-

Hydraulic conductivity (K) and transmissivity (T) are indirect aquifer Properties. T is the K integrated over the vertical thickness (b) of the aquifer. These Properties are measures of an aquifer's ability to transmit water. Intrinsic Permiability (K) is a Secondary Medium Property which does not depend on the viscosity and density of the fluid.

5) Specific storage and specific yeild :-

Specific storage (S_s) and its depth. integrated equivalent, storativity ($S = S_s b$) are indirect aquifer properties; they indicate the amount of ground water released from storage due to a unit depressurization of a confined aquifer.

-> Specific yield (S_y) indicates the amount of water released due to drainage from lowering the water table in an unconfined aquifer.

6) Permiability :-

Is an expression of the connectedness of the pores. for instance an unfractured rock unit may have a high porosity, but a low permiability.

* Common types of Ground water :-

1) Aquifer :-

An Aquifer is a wet underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand or silt) from which ground water can be usefully extracted using a water well.

Types of Aquifer :-

a) confined Aquifer :- An aquifer bounded above by impermeable beds of distinctly lower permiability than that of the aquifer it self. An aquifer containing confined ground water.

b) unconfined Aquifer :- An aquifer having a water table. An aquifer containing unconfined ground water.

c) Perched aquifer :- It is an type of unconfined aquifer where water stored on some patches of impervious layer also called as leaky Aquifer.

2) Aquitard :- A confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer; A leaky confining bed.

An aquitard does not readily yield water to wells or springs but may serve as a storage unit for groundwater.

3) Aquiclude :-

A body of relatively impermeable rock or soil that is capable of absorbing water slowly but functions as an upper or lower boundary of an Aquifer and does not transmit significant ground water.

* Geological controls of ground water Movement :-

Geology can Play a major role to movements of ground water which can be influence by the followings;

1) structures in rocks :-

hydro-geologists need to understand structural geology because structures are sites of ground water flow and Penetration, which can may affect. for instance, seepage of toxic substances from waste dumps or seepage of salty water in to aquifers like.

a) folds
b) faults
c) joints
d) shears
e) foliation & lineation.

2) Type of rock :-

a) Permeable materials, such as clastic sediments, karstic limestone and fractured rock, control the flowage and occurance of water.
b) Relatively impermeable materials, such as clays, silts, shale, siltstone and Massive rock are the major barriers for the flowage of water.

3) Topography :-

The Topography of an area can also mean the surface shape and features themselves. where the elevation can judging the water to flow in downward directions. countor line is the Most common usage in cartography, but isobath for underwater depths on bathymetric and isohypse for -ns are also used. The Process of drawing isohyte contour lines on is called isopletion.

* Ground Water Exploration :-

Ground water exploration aided by drilling is one of the major activities of the Board with an objective to discover aquifers in different hydrogeological conditions and determination of hydraulic Parameters to the extraction of ground water.

Attempts were made to gather maximum information about the subsurface structures using of different techniques viz., satelite images hydrological reconnaissance and geological exploration. An integration of the information, thus collected, helped in locating drilling sites for high yielding wells.

-> Some of the hydro-geological features were also studied where chances during the field works are described here.

(1) Areas of flow topography were investigated where chances of occurance of ground water is more.

(2) The static water level in the existing wells was observed which could give useful information about the depth of the water table and flow direction.

(3) The general drainge Pattern was studied which controls the recharge Potential of the ground water and suggest existence of fractures and structural anomalies and

(4) observation of certain type of vegetation was also studied, which are indicative of occurance of ground water.

03 (Different Geophysical Methods for ground water exploration:-

Electrical Resistivity Method:-

The Resistivity imaging method uses standard arrays developed for electrical resistivity sounding and profiling techniques and modifies them to create two dimensional resistivity profiles. The common methods are;

(1) wenner electrical resistivity method.

(2) schlumberger electrical resistivity method.

5

EARTH QUAKES

Earth Quakes:-

An Earth Quake is the result of a Sudden release of energy in Earth's crust that creates sesimic waves. The Seismicity, Seismism activity of an area refers to the frequency, type and size of earth-quakes experienced over a period of time. Earth Quakes are measured using observations from seismometers, also referred to as the Richter scale.

* Causes of Earthquakes:-

-> Due to fault types:-

There are three main type of fault that may cause an earth quake: normal, reverse and strike-slip. Normal and reverse faulting are examples of dip-slip. where the displacement along the fault is in the direction of dip and movement on them involves a vertical component. Normal fault is in the direction of dip and movement on them involves areas where the crust is being extended such as a divergent boundary.

Near Plate boundaries :-

Where Plate boundaries occur with in continental lithosphere deformation is spread at over a much larger area than the Plate Plate boundary it self. such as

a) Divergent Plates (Mid oceanic Ridge)
b) convergent Plates (Trenches or Island Arcs)
c) Transitional Plates (Rifts)

Due to volcanic activity :-

Earthquakes often occur in volcanic regions and are caused there, both by tectonic faults and the movement of magma in volcanoes.

Due to rapture dynamics :-

Earthquakes often occur in volcanic A tectonic earth quake begins by an initial rapture at a point on the fault surface, a process known as nucleation. The scale of the nucleation zone in uncertain, with some evidence, such as the rapture dimensions of the smallest earth quakes.

* Effects of Earth Quakes :-

1) Shaking and ground rapture
2) Land slides and avalanches
3) Fires
4) soil liquefaction
5) Tsunami
6) Floods
7) Human impacts.

→ Shaking and ground rapture are the main effects created by earthquakes. Principally resulting in more or less serve damage to buildings and other rigid structers.

...th quakes, along with severe storms, volcanic activity, coastal wave attack, and wildfires, can produce slope instability leading to landslides a major geological hazard. Landslide danger can produce slope may persist while emergency personnel are attempting rescue.

-> Earth quakes can cause fires by damaging electrical power or gas lines. In the event of water mains rupturing and a loss of pressure, it may also become difficult to stop the spread of a fire once it has started.

-> Soil liquefaction occurs when, because of the shaking, water-saturated granular material temporarily loses its strength and transforms from solid to a liquid.

-> Tsunamis are long-wave length, long-period sea waves produced by the sudden or abrupt movement of large volumes of water cause by earth quarks.

-> An earth quake may cause injury and loss of life, road and bridge damage, general property damage, and collapse or destabilization of buildings

* **SHIELD AREAS And SEISMIC BELTS :-**

Shield Areas :-

Shield Areas are defined as the stable and higher thickness of crustal bodies. Penisular India constitutes one of the prominent dominantly precambr-ian shield areas of the world. The geology and tenctonics of india are very complex. It records a history of crustal evolution from an Achaean core to active continent-continent collision. Knowlege of the regional crustal structure is important to address various geodynamic problems as well as to help in better understanding the lateral variations in the seismicity patterns.

Seismic Belt :-

Seismic Belt, narrow geographic zone on the Earth's surface along which most earthquake activity occurs. The outermost layer of the earth is made up of several large tectonic plates. The edges where these plates move against one another are the location of inter-Plate earth quakes that Pro[illegible] the seismic belts. Island arcs, Mountain chains, volcanism, deep troughs, and oceanic ridges are often of seismic belts

on the basis of occurance of earthquakes of different, intensi[ty] the National Building code of india divide the country into five seismic zones as described on the above map. The zone V is the highest risk zone where earthquakes of having intensity of 9 Plus on the Richter scale can take Place. Earth quake of intensity b/w 8 to 9 can be experienced in zone IV where as Earth quake can occur b/w 6 and 8 on the Richter scale in zone II of India.

* SEISMIC WAVES :-

There are two types of body wave, P-waves and S-waves. Pressure waves or Primary waves. are longitudinal waves that involve compress-ion and rarefaction in the direction that the wave is travelling. P-waves are the fastest waves in Solids and are therefore the first waves to appear on a seismogram. S-waves also called shear or Secondary waves, are transverse waves that involve motion Perpendicular to the direction of Propagation. S-waves appear latter than P-waves on a Seismogram. Fluids cannot support & this Perpendicular motion, or shear, so S-waves only travel in Solids. P-waves travel in both solids and fluids.

Surface waves :-

The two main kinds of surface wave are the Rayleigh wave, which has some compressional motion, and the love wave, which does not. Such waves can be theoretically explained in terms of interacting P/S waves. Surface waves travel more slowly than P-waves and S-waves, but because they are guided by the surface of the Earth they can be much larger in amplitude than body waves, and can be the largest signals seen in earthquake seismograms. They are Particularly strongly excited when their source is close to the surface of the Earth.

in a shallow earthquake or explosion.

RICHTER SCALE :-

Seismometers are sensors that sense and the motion on the earth arising from elastic waves. Seismometers may be deployed at earth's surface in shallow vaults, or in bore holes. A complete instrument Package that Records Seismic signals is called a seismograph. Networks of seismographs continuously record ground motions around the world to facilitate networks of the monitoring and analysis of global earthquaks and other seismic sources. Rapid location of earthquakes makes tsunami warnings Possible because Seismic waves travel considerably faster than tsunami waves.

* Precautions to be taken for Building construction in Seismic Areas :-

Earthquake loss estimation :-

Is usually defined as a Damage Ratio (DR) which is a ratio of the Earth quake damage repair cost to be total value of a building.

Rules for the construction of Earthquake Resistant Buildings :-

It is recommended that the following rules be followed for the construction of buildings in Earth quake Prone Areas.

Location of openings :-

a) The location and size of openings in walls have a significant effect upon the strength of a wall and its ability to resist earthquake forces.

b) openings are to be located away from a corner by a clear distance at least 1/4 of the height of the opening. It is recommended that the minimum distance be 15cm.

Masonry Buildings :-

An important factor contributing to the earthquake resistance concrete masonry buildings is the detailing and placing of steel reinforcement. The design of a reinforced concrete frame building should be undertaken by experienced engineers. The reinforcing guide given in this section therefore must only be used for simple single storey buildings constructed of good quality concrete blocks.

a) A vertical reinforced columns should be placed in all masonry walls with a maximum dimension b/w columns of 16 ft.

b) All exterior walls should be reinforced as shown in 3.4 of section

(B) Interior walls also require reinforcement for earth quakes.

c) window and door jambs should be reinforced and tied into the lintels.

Timber buildings :-

Although the foregoing principals apply to concrete block buildings there are two additional areas of concern with respect to timber buildings.

a) All corners and intersections must be adequately braced.

b) Earthquake forces tend to remove timber buildings from their supports, by shaking. Because of this it is important to securely fasten sills to foundations.

Steel Buildings :-

a) While steel buildings are generally beyond of these guidelines, it should be noted that the natural ductility of steel protects the frame itself from severe damage.

However, in many cases concrete block walls are used and the precautions already listed for these walls will apply. The wall reinforcement must be anchored by welding to the steel columns and beams, or the steel frame encased in concrete in which case the wall reinforcement can be tied into the concrete cage encasing the steel frame.

LAND SLIDES

Land slides :-

A land slide or landslip is a geological phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and ~~onto~~ onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability.

-> Debris avalanches: A slide of large masses of debris or mud down a mountain.
-> Earth flows: The motion characteristic of earthy materials.
-> Creep: A slow longitudinal movement or deformation of debris.
-> Lateral spread: Lateral spread cool flow are terms referring to landslides that commonly form on gentle slopes and that have rapid fluid-like flow movement, like water.

* Causes of landslides :-

Land slides occur when the stability of a slope changes a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone.

Natural causes of landslides include.

-> ground water :- ground water Pressure acting to destabilize the
-> soil structure :- loss or absence of vertical vegetative structure, soil nutrients, and soil structure.
-> Erosion :- erosion of the toe of a slope by rivers or ocean waves.
-> glaciers Melting :- weakening of a slope through saturation by snow melt, glaciers melting, or heavy rains.
-> Earth quakes :- earth quakes adding loads to barely stable slope.
-> slopes :- Earthquake - caused liquefaction destabilizing slopes.
-> volcanic eruptions.
-> Lanslides are aggravated by human activities, Human cause include.
-> blasting
-> vibrations :- Vibrations from Machinery or traffic
-> blasting
-> Earth work :- Earth work which alters the shape of a slope, or which imposes new loads on an existing slope.
-> rooted vegetation :- In shallow soils, the removal of deep-rooted vegetation that binds colluvium to bed rock.

Geological causes :-

-> Weak or sensitive Materials
-> weak weathered Materials
-> sheared, jointed, fissured Materials.
-> contrast in Permeability and stiffness of Materials.
-> Adversely oriented discontinuity.

Morphological causes :-

-> Tectonic or volcanic uplift
-> Glacial rebound
-> Fluvial, wave or glacial erosion of slope toe or lateral margins.
-> subterranean erosion
-> Thawing
-> Deposition loading slope.
-> Freeze - and - thaw weathering.

Man causes :-

-> Excavation of slope or its toe
-> Loading of slope or its crest
-> Drawdown
-> ~~Deformal~~ De-forestation
-> irrigation
-> Mining
-> Artificial vibraction
-> water leakage from utilities.

* Effect of land slides :-

Land slides are a major catastrophe the world as it is widespread and significant impact. The impact effects catastrophic land slides is dangerous to humans and to other living things.

For example, the slope of the saturated with water to form debris flows or mud flows. concentrated Mixture of rock and mud may destory the trees, houses, and cars and blocking the bridge. Mud mixed with river flow can cause devastating flooding along the route.

Pyroclastic flows arising from dust debris of ash, Poisonous gas and hot rock from volcanic eruptions that spread quickly to eat anything that traveled to the effects of destruction and death.

Damage To Infrastructure :- Land slides can lead to damage to Property resulting from the force flow or Mud. Infrastrucke land such as buildings, roads, Places of leisure and so on can be destroyed by the landslide occured.

Loss of life :- Loss of life is a dangerous effect upon the occurance of a landslide and it is difficult to avoid. Many lives will be lost upon the occurance of land slides.

changes in the Surface land scape:-

Landslide causes significant changes in the landscape the earth's surface. Pile of soil and Mud from the landslide activity caused the high ground may be flat land setting sediment can become thick very quickly.

Economic Decline:-

Landslides are certainly cause damage to Property. This brings losses to the economy of a country. Economic rehabilitation is also needed in the area that has experienced a landslide. This would cost a lot and some of the offending country economy.

* Measures To be taken to Prevent their occurance:-

Vulnerability to landslide hazards is a function of location, type of human activity, use and frequency of landslide events. The effects of landslides on People and structures can be lessened by total avoidance of landslide hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. local governments can reduce landslide effects through land-use Policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on the Past hazard history of a site and by Making inquiries to Planing and Engineering departments of local governments. They can also obtain the Professional services of an Engineering geo geologist, a geotechnical engineer, or a civil engineer, who can Properly evaluate the hazard Potential of a site, built or un-built.

The hazard from landslides can be reduced by aviding construction on steep slopes and existing landslides, or by stabilizing.

the slopes. stability increases when ground water is prevented from rising in the land slide mass by

(1) covering the land slide with an impermeable membrane,
(2) Directing surface water away from the landslide,
(3) Draining ground water away from the land slide, and
(4) Minimizing surface irrigation.

Slope stability is also increased when a retaining structure and the weight of a soil berm are placed at the toe of the land-slide or when mass is removed from the top of the slope.

* **Importance of study of ground water, Earth quakes & land slides:-**

Ground water typically plays an important role in earthquake and land slides, flows, and lateral spreads. slides occur when a slide surface fails and the overlying material slides down it with little internal deformation. The presence of water along or above the slide surface can trigger its failure; slides can be presence of water also along rotational (or) translational. In flows, the material is a mixture of rock, soil, and water, and the original structure of the material is destroyed as it moves down slope.

UNIT-IV

GEOPHYSICAL STUDIES

Importance of Geophysical studies principles of geophysical study by Gravity method.

Definition:- This method is defined as Geophysical method of surface and sub-surface investigation based on the gravitational forces in geology as well as in civil engg. & concerns.

Principle :- Gravitational forces.

parameters :- gravitational acceleration, gravitational potential.

working :- Gravitational forces make rocks press down on deeper rocks, increasing their density as the depth increases. [12] measurements of gravitational acceleration and gravitational potential at the Earth's surface and above it can be used to look for mineral deposits (see gravity anomaly and gravimetry). The surface gravitational field provides information on the dynamics of tectonic plates. The geopotential surface called the geoid is one definition of the shape of the earth.

Different types :- gravity anomaly gravimetry.

applications :-

1. Used for geophysical survey include transient electromagnetic and magnetotellurics.
2. Used to detect variations in electrical resistivity of underground structures.

3. provide quantitative information on seafloor spreading a part of plate tectonics.

4. the magnetization in rocks can be used to measure the motion of continents

5. Used for radiometric dating, the primary method for establishing an absolute time scale in geochronology.

6. Used to determine the thickness of crust

7. used to determine the earthquake origin

8. Used to determine the soil thickness.

9. Used to determine the Archaeological relics.

10. used in the exploration of ground water.

11. Used to locate the ground water.

Magnetic method :-

Definition :- This method is defined as Geophysical method of surface and sub-surface investigation based on the magnetic susceptibility in geology as well as in civil engg. in concerns.

principle :- Magnetic susceptibility.

parameters :- Magnetic flux, magnetic inclinations, Magnetic declination, paleo-magnetism.

working :- Governments sometimes operate units that specialize in measurement of the Earth's magnetic field. These are geomagnetic observatories, typically part of a national Geological survey, Each measurement of the magnetic field is at a particular place and time. If an accurate estimate of the field at some other place and time is needed, the measurements must be converted to a model and the model used to make predictions.

Different types/ instruments :- magnetic Rossby waves geomagnetic secular variation magnetic intensity magnetic declinations magnetic reversal.

applications :-

1. used for geophysical survey include transient electromagnetic and magnetotellurics.
2. used to detect variations in electrical resistivity of underground structures.
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6. used to determine the thickness of crust
7. used to determine the soil thickness
8. used to determine the earthquake origin
9. used to determine the Archaeological relics.
10. used to exploration of ground water.
11. used to identification of geological structure beneath the ground.
12. used to locate the ground water.

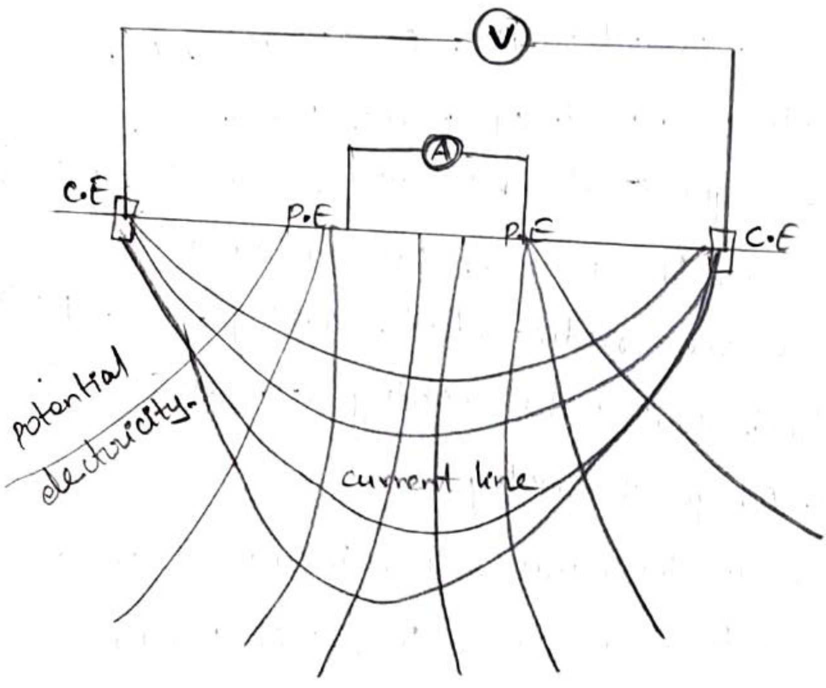
Electrical method :-

Defination :- This method is defined as Geophysical method of surface and sub-surface investigation based on the electrical potential, Electrical resistivity in geology as well as in civil engg. in concerns.

principle :- electrical potential, electrical resistivity.

parameters :- electrical induction, electrical potential, electrical resistivity.

working :-



measure spontaneous potential, a potential that arises in the ground because of manmade or natural distribution using current and potential electrodes. Telluric currents flow in earth and the oceans. They have two causes : electromagnetic induction by the time-varying, external-origin geomagnetic field and motion of conducting bodies (such as seawater across the Earth's parameters magnetic field. The distribution of telluric current density can be used to detect variations in electrical resistivity of underground structures.

Different types/Instruments:- induced polarization electrical resistivity.

a) werner electrical resistivity method.

b) schemberger electrical resistivity method.

applications:-

1. Used for geophysical survey include transient electromagnetic and magnetotellurics.

2) Used to detect variations in electrical resistivity of underground structures.

3: provide quantitative information on seafloor spreading, a part of plate tectonics.

4. The magnetization in rocks can be used to measure the motion of continents

5. Used to determine the thickness of crust.

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8. used to determine the Archaeological relics.

9. Used in the exploration of ground water

10. used in the identification of geological structure beneath the ground.

11. Used to locate the ground water.

Seismic method :-

Defination :- This method is defined as Geophysical method of surface and sub-surface investigation based on the vibrations in geology as well as in civil engg. In concerns.

Parameters :- P-waves ; S-waves, Rayleigh wave ; normal modes.

Principle :- vibrations.

working :- forecasting a probable timing, location, magnetitude and other important feautures of a forthcoming seismic event is called earthquake prediction. various attempts have been made by seismologists and others to create effective systems for precise earthquake predictions, including the VAN method.

Different types / instuments :- seismic reflection method seismic refraction method. VAN method. seismograms

applications :-

1. used for geophysical survey include transient electromagnetic and magnetotellurics.
2. Used to detect variations in electrical resistivity of underground structures.
3. provide quantitative information on seafloor spreading, a part of plate tectonics.
4. The magnetization in rocks can be used to measure the motion of continents.
5. used for radiometric dating, the primary method for establishing an absolute time scale in geochronology

6. Used to determine the thickness of crust
7. Used to determine the soil thickness
8. Used to determine the earthquake origin
9. Used to determine the Archaeological relics.
10. Used in the exploration of ground water.
11. Used to locate the ground water.

Radiometric method :-

Definition :- This method is defined as Geophysical method of surface and subsurface investigation based on the Radio-activity in geology as well as in civil engg. in concerns.

principle :- Radio-activity.

parameters :- γ - radiations
β - radiations
α - radiations
Radioactive decay.

working :-

Based on a comparison between the observed abundance of a naturally occurring radioactive isotope and its decay products, using known decay rates. The mathematical expression that relates radioactive decay to geologic time, is [10][13]

$$D = D_0 + N(t)(e^{\lambda t} - 1)$$

where 't' is age of the sample

'D' is number of atoms of the daughter isotope in the sample

D_0 is number of atoms of the daughter isotope in the original composition

N is number of atoms of the parent Isotope in Sample at time t, given by $N(t) = N_0 e^{-\lambda t}$, and λ is the decay constant of the parent isotope.

Different types/instruments :- Uranium - lead dating method. samarium - neodymium dating method. Potassium - argon dating method. Uranium-thorium dating method. Radiocarbon dating method.

Applications :-

1. used for geophysical survey include transient electromagnetic and magnetotellurics.
2. used to detect variations in electrical resistivity of underground structures.
3. provide quantitative information on seafloor spreading, a part of plate tectonics.
4. The magnetization in rocks can be used to measure the motion of Continents.
5. used for radiometric dating, the primary method for establishing an absolute time scale in geochronology.
6. Used to determine the thickness of crust.
7. Used to determine the soil thickness.
8. used to determine the earthquake origin
9. Used to determine the Archaeological relics.
10. Used to exploration of ground water.
11. Used in the identification of geological structure beneath the ground
12. Used to locate the ground water.

Geothermal method :-

Definations :- This method is defined as Geophysical method of surface and sub-surface investigation based on the thermal convection and heat flows in geology as well as in civil engg. In concerns.

Principles :- Thermal convection and heat flows

Parameters :- Geothermal gradient.

Working :- The geothermal gradient varies with location and is typically measured by determining the bottom open-hole temperature after borehole drilling. To achieve accuracy the drilling fluid needs time to reach the ambient temperature. This is not always achievable for practical reasons. In stable tectonic areas in the tropics a temperature depth plot will converge to the annual average surface temperature. However, in areas where deep permafrost developed during the pleistocene a low temperature anomaly can be observed that persists down to several hundred meters.

Different types/ Instruments :- geothermal electric measurers, thermo meters.

Applications :-

1. Used for geophysical survey include transient electromagnetic and magnetotellurics.
2. Used to detect variations in electrical resistivity of underground structures.

3. provide quantitative information on seafloor spreading, a part of plate tectonics.

4. The magnetization in rocks can be used to measure the motion of continents.

5. used to determine the thickness of crust

6. Used to determine the soil thickness

7. Used to determine the earthquake origin

8. Used to determine the Archaeological relics.

9. Used to exploration of ground water.

10. Used in the Identification of geological structure beneath the ground.

11. Used to locate the ground water.

Importance of Geophysical studies :-

Geophysics is the physics of the earth and its environment in space; also the study of the Earth using quantitative physical methods. The term geophysics sometimes refers only to the geological applications: Earth's shape, its gravitational and magnetic fields; its internal structure and composition; its dynamics and their surface expression in plate tectonics, the generation of magmas, volcanism and rock formation. Used to analyze potential petroleum reservoirs and mineral deposists, locate ground water, find archaeological relics, determine the thickness of glaciers and soils, and assess sites for environmental remediation.

1. used for geophysical survey include transient electro-magnetic and magnetotellurics.
2. used to detect variations in electrical resistivity of underground structures.
3. Provide quantitative information on seafloor spreading, a part of plate tectonics.
4. The magnetizations in rocks can be used to measure the motion of continents.
5. Used for radiometric dating, the primary method for establishing an absolute time scale in geochronology.
6. Useful for tracking groundwater flow. physical properties of water such as salinity have a large effect on its motion in the oceans.
7. Used to determine the thickness of crust
8. used to determine the soil thickness
9. Used to determine the earthquake origin
10. Used to determine the Archaeological relics.

Improvement of competence of sites by grouting :-

Grouting is a process by which open geologic defects are sealed to reduce seepage and or the strengthen the foundation. The grouting material may be based on suspension of cementitious solids in water (formerly called slurry grout).

consolidation grouting is done to improve the strength of the near-surface rock beneath concrete dams, and blanket grouting is done to reduce the permeability of the near surface rock beneath embankment dams. either type of grouting may be done on a pattern if the foundation is known as assumed to be uniformly fracture, but otherwise probably is best done in rows in the same manner as curtain grouting. patterns commonly consists of holes drilled at the corners of equilateral triangles.

Different types of grouting :-

permeation Grouting :-

Grout filling of accessible pores between the solid particles in a permeable soil. This technique is generally used to reduce permeability and/or to strengthen and stiffen the ground.

Hydro fracture Grouting :-

Involves the deliberate fracturing of the soil or rock by grout under pressure. The resulting compaction and stiffening of the rock or soil mass can, in appropriate conditions, provide ground improvement where permeation grouting is not practicable.

compensation Grouting :-

An active technique to mitigate settlement arising from other engineering works

UNIT - V

GROUND WATER

Ground water is water located beneath the ground surface in soil pore spaces and in the fractures of rock formations.

Parameters of ground water

1. Hydraulic head
2. Porosity & permeability
3. Water content
4. Hydraulic conductivity
5. Specific storage and specific yield

1. **Hydraulic head**: changes in hydraulic head (h) are the driving force which causes water to move from one place to another. It is composed of pressure head (ψ) and elevation head (z). The head gradient is the change in hydraulic head per length of flow path, and appears in Darcy's law as being proportional to the discharge.

2. **Porosity**: Porosity (n) is a directly measurable aquifer property; that the amount of pore space between unconsolidated soil particles or within a fractured rock. Typically, the majority of groundwater moves through the porosity available to flow (sometimes called effective porosity). Permeability is an expression of the connectedness of the pores. For instance, an unfractured rock unit may have a high porosity (it has lots of holes between its constituent grains), but a low permeability (none of the pores are connected).

3. **Water content**: Water content (θ) is also a directly measurable property; it is the fraction of the total rock which is filled with liquid water.

4. **Hydraulic conductivity**: Hydraulic conductivity (K) and transmissivity (T) are indirect aquifer properties (they cannot be measured directly). T is the K integrated over the vertical thickness (b) of the aquifer (T = Kb when K is constant over the entire thickness). These properties are measures

of an aquifer's ability to transmit water. Intrinsic permeability (k) a secondary medium property which does not depend on the viscos and density of the fluid (K and T are specific to water).

5. Specific storage and specific yield: Specific storage (S_s) and its de integrated equivalent, storativity ($S = S_s b$), are indirect aquifer prope (they cannot be measured directly); they indicate the amount of groun released from storage due to a unit depressurization of a confined aqui

Specific yield (S_y) indicates the amount of water released due to d from lowering the water table in an unconfined aquifer.

Aquifer

An aquifer is a wet underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand or silt) from which groundw can be usefully extracted using a water well.

Types of aquifers

1) Confined aquifer - An aquifer bounded above by impermeable bed beds of distinctly lower permeability than that of the aquifer itself An aquifer containing confined groundwater.

2) Unconfined aquifer - An aquifer having a water table. An aquifer containing unconfined ground-water.

3) Perched aquifers: it is an type of unconfined aquifer where wa stored on some patches of impervious layer also called as leaky aq

Artesian - An adjective referring to groundwater confined under hydrostat pressure. Artesian aquifer - An aquifer containing water under artesi pressure. And the common names will pronounce based on their mode and occurance are;

Aquitard - A confining bed that retards but does not prevent the flow water to or from an adjacent aquifer; a leaky confining bed. An aquitar does not readily yield water to wells or springs but may serve as a storage unit for groundwater.

Aquiclude - A body of relatively impermeable rock or soil that is capable of absorbing water slowly but functions as an upper or lower boundary of an aquifer and does not transmit significant groundwater.

GEOLOGICAL CONTROLS OF GROUND WATER MOVEMENT

'Geology' can play a major role to movements of groundwater which can be influence by the followings;

1. Structures in rocks: hydro-geologists or hydrologists need to understand structural geology because structures are sites of groundwater flow and penetration, which may affect, for instance, seepage of toxic substances from waste dumps, or seepage of salty water into aquifers: like

a. Folds

b. Faults

c. Joints

d. shears

e. Foliation and lineation.

2. Type of rock:

a) Permeable materials, such as clastic sediments, karstic limestone, and fractured rock, control the flowage and occurence of water.

b) Relatively impermeable materials, such as clays, silts, shale, siltstones, and massive rock are the major barriers for the flowage of water.

3. Topography: The topography of an area can also mean the surface shape and features themselves. Where the elevation can judging the water to flow in downward directions. Contour line" is the most common usage in cartography, but isobath for underwater depths on bathymetric maps, and isohype for elevations are also used. The process of drawing isohype contour lines on a map is called isopletion.

GROUND WATER EXPLORATION

Ground water exploration aided by drilling is one of the major activities of the Board with an objective to discover aquifers in diff. hydrogeological conditions and determination of hydraulic parameters the extraction of ground water.

Attempts were made to gather maximum information about the subsurface structures using of different techniques viz., satellite hydrogeological reconnaissance and geophysical exploration. An inte of the information, thus collected, helped in locating drilling sites fo high yielding wells.

Some of the hydro-geological features were also studied during the field works are described here.

(1) Areas of low topography were investigated where chances of occurrence of groundwater is more;

(2) The static water level in the existing wells was observed and could give useful information about the depth of the water table and direction;

(3) The general drainage pattern was studied which controls the potential of the groundwater and suggest existence of fractures and structural anomalies and

(4) Observation of certain type of vegetation was also studied, which are indicative of occurrence of groundwater.

Groundwater exploration takes these principles a step further by identifying areas most likely to yield successful new wells.

Precipitation & Meteorology

These analyze precipitation data from meteorological satellite data in conjunction with ground stations to provide estimates of precipitation, rainfall depth duration and rainfall return period

Geology & Hydrogeology

This analysis varies from regional assessments and the mapping of surface drainage, seasonally flooded areas, aquifer recharge areas and general lithology / aquifer identification to more detailed investigations involving all aspects of hydrologic exploration.

GIS & Modeling

These uses data layers such as geologic. structure, lithology, hydrolithologic units, drainage basins and features, recharge and cultural features to develop a map of exploration potential.

Different geophysical methods for groundwater exploration:

Electrical Restivity Method: The resistivity imaging method uses standard arrays developed for electrical resistivity sounding and profiling techniques and modifies them to create two dimensional resistivity profiles.

The common methods are;

(1) Wenner electrical resistivity method

(2) Schlumberger electrical resistivity method

EARTH QUAKES

An earthquake (also known as a quake, tremor or temblor) is the result of a sudden release of energy in the Earth's crust that creates seismic waves. The seismicity, sesimism or sesimic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers, also referred to as the Richter scale.

CAUSES OF EARTHQUAKE

Due to fault types

There are three main types of fault that may cause an earthquake: normal, reverse (thrust) and strike-slip. Normal and reverse faulting are examples of dip-slip, where the displacement along the fault is in

the direction of dip and movement on them involves a vertical co
Normal faults occur mainly in areas where the crust is being exten
such as a divergent boundary.

Near plate boundaries

Where plate boundaries occur within continental lithosphere, deformation is spread out over a much larger area than the plate boundary itself such as

a. Divergent plates (Mid Oceanic Ridge)

b. Convergent plates (Trenches or Island Arcs)

c. Transitional plates (Rifts)

Due to volcanic activity

Earthquakes often occur in volcanic regions are caused there by techonic faults and the movement of magma in volcanoes

Due to rupture dynamics

A techonic earthquake begins by an initial rupture at a point o fault surface, a process known as nucleation. The scale of the nu zone is uncertain; with some evidence, such as the rupture dime of the smallest earthquakes.

EFFECTS OF EARTHQUAKES

1. shaking and ground rupture

2. Landslides and avalanches

3. Fires

4. Soil liquefaction

5. Tsunami

6. Floods

7. Human impacts

shaking and ground rupture are the main effects created by earthquakes, principally resulting in more or less severe damage to buildings and other rigid structures.

Earthquakes, along with severe storms, volcanic activity, coastal wave attack, and wildfires can produce slope instability leading to landslides, a major geological hazard. Landslide danger may persist while emergency personnel are attempting rescue.

Earthquakes can cause fires by damaging electrical power or gas lines. In the event of water mains rupturing and a loss of pressure, it may also become difficult to stop the spread of a fire once it has started.

Soil liquefaction occurs when, because of the shaking, water-saturated granular material (such as sand) temporarily losses its strength and transforms from a solid to a liquid.

Tsunamis are long-wavelength, long-period sea waves produced by the sudden or abrupt movement of large volumes of water cause by earthquakes.

An earthquake may cause injury and loss of life, road and bridge damage, general property damage (which may or may not be covered by earthquake insurance), and collapse or destabilization (potentially leading to future collapse) of buildings.

SHIELD AREAS AND SEISMIC BELTS

shield areas are defined as the stable and higher thickness of crustal bodies. Peninsular India constitutes one of the prominent, dominantly Precambrian sheild areas of the world. the geology and techonics of India are very complex. It records a history of crustal evolution from an Archaean core to active continent-continent collision. knowledge of the regional crustal structure is important to address various geodynamic problems as well as to help in better understanding the lateral variations in the seismicity patterns.

Seismic Belt; narrow geographic zone on the Earth's surface along which most earthquake activity occurs. The outermost layer of the Earth (lithosphere) is made up of several large tectonic plates. The edges where these plates move against one another are the location of inter-plate earthquakes, produce the seismic belts. Island arcs, mountain chains, volcanism, deep ocean troughs, and oceanic ridges are often features of seismic belts.

On the basis of occurrence of earthquakes of different intensity the National Building Code of India divide the country divide the country five seismic zones as described on the above map. The zone V. is the highest risk zone where earthquakes of having intensity of 9 plus on Richter scale can take place. Earthquake of intensity between 8 to 9 be experienced in Zone IV whereas earthquake can occur between ... 8 on the Richter scale in Zone III of India.

SEISMIC WAVES

There are two types of body wave, P-waves and S-waves (both ... waves). Pressure waves or Primary waves (P-waves), are longitudinal waves that involve compression and rarefaction (expansion) in the direction that the wave is traveling. P-waves are the fastest waves in solids and the first waves to appear on a seismogram. S-waves, also called shear or secondary waves, are transverse waves that involve motion perpendicular to the direction of propagation. S-waves appear later than P-waves on a seismogram. Fluids cannot support this perpendicular motion, or shear, so S-waves (appear later than P-waves on a seismogram) only travel in solids. P-waves travel in both solids and fluids.

Surface waves: The two main kinds of surface wave are the Rayleigh wave, which has some compressional motion, and the Love wave, which does not. Such waves can be theoretically explained in terms of interacting P- ...

S-waves. Surface waves travel more slowly than P-waves and S-waves, but because they are guided by the surface of the Earth (and their energy is thus trapped near the Earth's surface) they can be much larger in amplitude than body waves, and can be the largest signals seen in earthquake seismograms. They are particularly strongly excited when their source is close to the surface of the Earth, as in a shallow earthquake or explosion.

RICHTER SCALE.

Seismometers are sensors that sense and record the motion of the Earth arising from elastic waves. Seismometers may be deployed at Earth's surface, in shallow vaults, or in boreholes. A complete instrument package that records seismic signals is called a seismograph. Networks of seismographs continuously record ground motions around the world to facilitate the monitoring and analysis of global earthquakes and other seismic sources. Rapid location of earthquakes makes tsunami warnings possible because seismic waves travel considerably faster than tsunami waves.

PRECAUTIONS TO BE TAKEN FOR BUILDING CONSTRUCTION IN SEISMIC AREAS

Earthquake loss estimation is usually defined as a Damage Ratio (DR) which is a ratio of the earthquake damage repair cost to the total value of a building.

Rules for the Construction of Earthquake Resistant Buildings.

It is recommended that the following rules be followed for the construction of buildings in earthquake prone areas:

Location of Openings:

a. The location and size of openings in walls have a significant effect upon the strength of a wall and its ability to resist earthquake forces.

b. Openings are to be located away from a corner by a clear distance to at least 1/4 of the height of the opening. It is recommended that minimum distance be 15".

Masonry Buildings

An important factor contributing to the earthquake resistance of con masonry buildings is the detailing and placing of steel reinforcement design of a reinforced concrete frame building should be undertaken by experienced engineers. The reinforcing guide given in this section therefore must only be used for simple single storey buildings constructed of quality concrete blocks.

a. Vertical reinforced columns should be placed in all masonry with a maximum dimension between columns of 16ft.

b. All exterior walls should be reinforced as shown in 3.4 of. Interior walls also require reinforcement for earthquakes.

c. All vertical wall reinforcement must be securely fixed to the foundation and belt course.

d. All vertical reinforcement is to be securely fixed to the foundation beam. Horizontal reinforcement must be placed every 3 courses.

e. Window and door jambs should be reinforced and tied into the

Timber Buildings

Although the foregoing principles apply to concrete block buildings are two additional areas of concern with respect to timber buildings

a. All corners and intersections must be adequately braced.

b. Earthquake forces tend to remove timber buildings from their sup by shaking. Because of this it is important to securely fasten sills foundations.

steel Buildings

a. While steel buildings are generally beyond the scope of these Guideliness, it should be noted that the naturally ductility of steel protects the frame itself from severe damage.

b. However, in many cases concrete block walls are used and the precautions already listed for these walls will apply. The wall reinforcement must now be anchored by welding to the steel columns and beams, or the steel frame encased in concrete in which case the wall reinforcement can be tied into the concrete cage encasing the steel frame.

Some additional features of Earthquake-Resistant construction

1. Adobe structures
2. Limestone and sandstone structures
3. Timber frame structures
4. Light-frame structures
5. Reinforced masonry structures
6. Reinforced concrete structures
7. Pre-stressed structures
8. steel structures

LAND SLIDES

A landslide or landslip is a geological phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability.

→ Debris avalanches: A slide of large masses of debris or rock ... a mountain.

→ Earth flows: The motion characteristic of earthy materials.

→ Creep: A slow longitudinal movement or deformation of debris.

→ Lateral spread: Lateral spread or flow are terms referring to ... that commonly form on gentle slopes and that have rapid fluid-like ... movement, like water.

CAUSES OF LANDSLIDES

Landslides occur when the stability of a slope changes from a ... to an unstable condition. A change in a stability of a slope can be ... by a number of factors, acting together or alone. Natural causes ... landslides include:

→ ground water: ground water (pore water) pressure acting to dest... the slope.

→ soil structure: Loss or absence of vertical vegetative structure, soil nutrients, and soil structure.

→ erosion: erosion of the toe of a slope by rivers or ocean waves

→ glaciers melting: weakening of a slope through saturation by s... glaciers melting, or heavy rains.

→ earthquakes: earthquakes adding loads to barely stable slope.

→ slopes: earthquake-caused liquefaction destabilizing slopes.

→ volcanic eruptions

→ Landslides are aggravated by human activities; Human causes in...

→ deforestation, cultivation and construction, which destabilize the al... fragile slopes.

→ vibrations: vibrations from machinery or traffic.

→ blasting

→ earthwork: earthwork which alters the shape of a slope, or which imposes new loads on an existing slope.

→ rooted vegetation: in shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock.

→ Construction, agricultural or forestry activities (logging) which change the amount of water which infiltrates the soil.

Geological Causes

⇒ Weak or sensitive materials

⇒ Weathered materials

⇒ sheared, jointed, or fissured materials

⇒ Adversely oriented discontinuity (bedding, schistosity, fault, unconformity, contact, and so forth)

⇒ Contrast in permeability and/or stiffness of materials.

Morphological Causes

⇒ Tectonic or volcanic uplift

⇒ Glacial rebound

⇒ Fluvial, wave, or glacial erosion of slope toe or lateral margins.

⇒ Subterranean erosion (solution, piping)

⇒ Deposition loading slope or its crest

⇒ Vegetation removal (by fire, drought)

⇒ thawing

⇒ Freeze-and-thaw weathering

⇒ Shrink-and-swell weathering.

Human Causes

⇒ Excavation of slope or its toe

⇒ Loading of slope or its crest

⇒ Drawdown (of reservoirs)

⇒ Deforestation

⇒ Irrigation

⇒ Mining

⇒ Aritifical vibration

⇒ Water leakage from utilities.

EFFECT OF LANDSLIDES:

Landslides are a major catastrophe the world as it is wide and significant impact. The effects of catastrophic landslides is dangerous to humans, and to other living things.

For example, the slope of the saturated with water to debris flows or mud flows. Concentrated mixture of rock and may destroy the trees, houses, and cars and blocking the bridge mixed with river flow can cause devastating flooding along the route.

Pyroclastic flows (pyroclastic) arising from dust debris of ash, gas and hot rock from volcanic eruptions that spread quickly to anything that traveled to the effects of destruction and death.

→ Damage To Infrastructure: Landslides can lead to damage to resulting from the force flow or mud. Infrastructure land such as roads, places of leisure and so on can be destroyed by the lands occured.

→ Loss of Life: Loss of life is a dangerous effect upon the occur of a landslide and it is difficult to avoid. Many lives will be lost upon occurrence of landslides.

→ Changes In The Surface Landscape! Landslide causes significant changes in the landscape of the earth's surface. Pile of soil and mud from the landslide activity caused the high ground may be flattened settling sediment can become thick very quickly.

→ Economic Decline! Landslides are certainly cause damage to property. This brings losses to the economy of a country. Economic rehabilitation is also needed in the area that has experienced a landslide. This would cost a lot and some of the offending country economy.

Measures To Be Taken To Prevent Their Occurence

Vulnerability to landslide hazards is a function of location, type of human activity, use, and frequency of landslide events. The effects of landslides on people and structures can be lessened by total avoidance of landslide hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce landslide effects through land-use policies and regulations. Individuals can reduce landslide their exposure to hazards by educating themselves on past hazard history of a site and by making inquires to planning and engineering departments of local governments. They can also obtain the professional services of an engineering geologist, a geotechnical engineer, or a civil engineer, who can properly evaluate the hazard potential of a site, built or un-built.

The hazard from landslides can be reduced by avoiding construction on steep slopes and existing landslides, or by stabilizing the slopes. Stability increases when ground water is prevented from rising in the landslide mass by

(1) Covering the landslide with an impermeable membrane,

(2) Directing surface water away from the landslide,

(3) Draining ground water away from the landslide, and

(4) Minimizing surface irrigation.

Slope stability is also increased when a retaining structure and the weight of a soil/rock beam are placed at the toe of the landslide or when mass is removed from the top of the slope.

IMPORTANCE OF STUDY OF GROUNDWATER, EARTHQUAKES AND LANDSLIDES

Groundwater typically plays an important role in earthquake and landslides, flow (debris flows, debris avalanches, earth flows, mudflows, and creep), and lateral spreads. Slides occur when a slide surface fails and the overlying material slides down. it with little internal deformation. The presence of water along or above the slide surface can trigger its failure. Slides can be rotational (occur on a curved slide surface) or translational (occur on a planar slide surface). In flows, the material is a mixture of rock, soil, and water, and the original structure of the material is destroyed as it moves down slope.