Module -2

Petrology:

Petrology is that branch of geology which deals with the study of rocks, with their mode of formation, composition and the uses for all types of engineering works.

Rock:

Definition:- Rocks are naturally occurring aggregates of mineral grains.

Rocks composed of grains of only one mineral are called Monomineralic rocks.

Ex: Marble:- Composed of calcite

S.St:- Composed of quartz

Dunite:- Composed of olivine

Rocks composed of grains of two / more minerals are called Polymineralic rocks.

Ex: Granite:- Composed of quartz, Orthoclase, Plagioclase, Biotite mica.

Basalt:- Composed of plagioclase, Augite.

Classification of Rocks:

Rocks are the building blocks of the earth's crust and they are classified on the basis of their mode of formation into three major groups as following.

1. Igneous rocks
2. Sedimentary rocks and
3. Metamorphic rocks.

Igneous rocks:-

Igneous rocks are formed by cooling and solidification of magma or lava. There are first formed at very high temperature at a very great depth. The igneous rocks which are formed upon the earth's surface are known as extrusive rocks (lava). The rocks which are formed at a great or moderate depth below the earth surface is known as intrusive rocks (magma).

Classification of igneous rocks:

Igneous rocks may be classified by different scientist by different basis, but on the basis of mode of solidification of magma into the following three types.

1. Plutonic rocks:
2. Hypabyssal rocks:
3. Volcanic rocks:

Plutonic rocks:

Plutonic rocks are those rocks, which are formed beneath the surface of the earth crust after the solidification of magma. Cools very slowly, thus these are coarsely crystallined rocks.

Hypabyssal rocks:

Hypabyssal rocks are those rocks, which are formed below the earth surface at a short distance, this happens when the magma solidifies in the form of thin sheets or wall like structure usually rocks are medium grained.

Volcanic rocks:

Volcanic rocks are those, which are formed on the surface of the earth. This happen when the magma is forced out on the surface of the earth. Due to a sudden change of pressure and temperature on the ground rapidly cools, thus are fine grained rocks.

Classification Igneous Rocks

Classification	Acid Igneous	Intermediate rocks	Basic rocks	Ultra basic rocks
Base on silica percentage	>66%	66-55%	55-40%	<40%
Based on mode of accurance				
1.Plutoic Igneous rocks	Gray granite Pink granite	Syenite	Diorite	Dunite
2.Hypabyssal Igneous rocks	Pegmatite, granite, porphyries	Syenite porphyry, diorite porphyry	Dolerite	-
3.Volcanic Igneous rocks	Rhyolite, obsidian, pumice	Trachite, Andesite	Basalt	-

Index properties:

The following are the important petrographic characteristic properties helpful in the identification and classifications of rocks in hand specimens by naked eye or with the aid of hand lens and also with some testing tools like pen knife, Magnet, streak plate and Dil.Hcl.

1. Colour
2. a) Texture b) Grain size
3. Mineral composition
4. Cementing Material
5. Specific gravity
6. Special properties
7. Acid reaction
8. Magnetism

1. Colour: - The colour of rocks depends upon the colour of their aggregated minerals or cementing materials and is generalized according to the overall shade.

2. a) Texture:- The texture is defined as the mutual relationship of the constituent mineral grains their size, shape and etc.

2. (b) Grain Size:-

This is the diameter of the component mineral grains, expressed as follows.

Fine grained – grain diameter 1 mm to less.

Medium grained – grain diameter 1 mm to 5 mm.

Coarse grained – grain diameter 5 mm and above.

Mineral Composition:

The combination and proportion of the component minerals.

a) Essential minerals – easily identified by necked eye.

b) Accessory minerals – finer particles of deleterious component.

Properties of rocks	Gray Granite	Dolerite	Gabbro	Basalt
Colour:	Gray, grayish white	Dark gray to black	Gray to black	Dark gray to black
Texture & grain size;	Fine grained, equigranular	Ophitic texture Fine to medium grained	Coarse grained equigranular	Fine grained, glassy vesicular
Mineral composition: Essential →	Quartz White Orthoclase Plagioclase Biotite mica	-Augite	-Plagioclase	-Plagioclase
Accessory →	Magnetite Hornblende	-Plagioclase -Iron ores -Olivine ±Quartz	-Augite -Hornblende. – biotite -Olivine -Apatite -Magnetite	-Augite -Magnetite -Iron pyrite
Specific gravity:	2.6	2.9	2.8 – 2.9	2.9
Crushing strength:	Very high	Very high	High	Low to medium
Occurrence:	Batholith	Intrusive Dyke	Plutonic basic Igneous rock	Lava flows
Engineering / Importance:	Building, ornamental, monumental, stone, road metal, concrete Aggregates, railway ballast, window & door sill, pillars, slabs, sinks, paving sets, grinding wheels & sculptures.	Dolerite is called black granite in industry ornamental, Memorial, Road Metal, Kitchen plates, Table tops, Decorative stones, Paper weights, Gift articles etc.	Ornamental, Concrete aggregates, Railway Ballast	Road metal, concrete, aggregates, kitchen plates used in the manufacture of fertilizers
Classification:	Acid igneous Plutonic rocks	Hybabyssal Igneous rock	Intermediate plutonic ligneous rock	Volcanic basic Igneous rock

Sedimentary Rocks:

Rocks which are formed under water in different situations. There rocks are derived from the consolidation of sediments of the preexisting rock. The distinguished products of pre-existing rocks are transferred by the influence of geological agents like, wind, water and glacier etc. through, the process of erosion, transportation, deposition as a sediment. This sediment deposit into the depressions of the earth, and gets consolidated and cemented to from sedimentary rocks.

Formation of sedimentary rocks: The process involved in the formation of sedimentary rocks are-

Detrital rocks'. This is disintegration of rocks or Erosion.

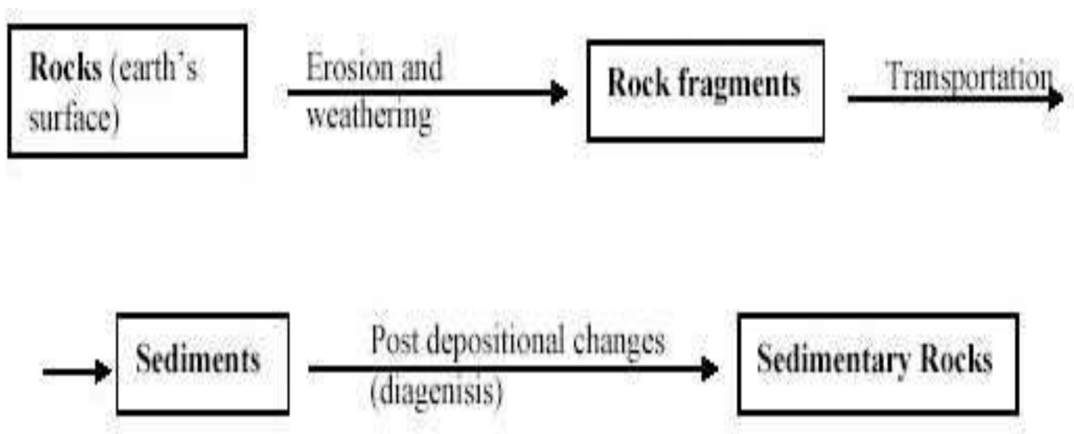
Transportation: Wind and the running water are the most important agents which transport the weathered product. During the course of transportation, the particle size becomes smaller and smooth because of abrasion.

Deposition: The sediments later deposited on the continents, sea shore or in the deep sea. Here, the compaction and consolidation of sediments takes place forming solid cohesive hard rock. The process of transformation of loose particles into hard rocks is called 'Diagenesis'.

The **diagenesis** is achieved by 'Welding or Cementation'

Welding: It is the process of compaction of sediment accumulation in lower layer of a basin due to the pressure exerted by the load of the overlying sediment layer.

Cementation: Here, the loose grains of sediments gets settled and held together by a binding material (FeO, CaO, SiO_2 in solution)



Classification of sedimentary rocks:

The classification of sedimentary rocks is based on the mineralogy, depositional environment, origin or mode of formation and structural features. However, for practical purpose, they are broadly classified into

1) Clastic and 2) Non-clastic rocks

1. Clastic rocks: They are mechanically formed rocks. These are formed due to the process of weathering, erosion, transportation and deposition and diagenesis of preexisting rocks. Based on grain size, they are further classified into

a) Rudaceous

b) Arenaceous

c) Argillaceous

a) Rudaceous rocks: If the grain size of sediment / particle are more than 2 mm in dia, they are called 'Rudites' and the rocks are called Rudaceous rocks. They are further classified into

Gravel (2-10 mm in dia)

Pebbles (10-50 mm)

Cobble (50-200 mm)

Boulder (>200 mm)

The grains may be rounded or angular / sharp which depends on the rate of transportation.

Rounded – Example: Conglomerate

Angular/sharp - Example: Breccia

b) Arenaceous rocks: If the size of the particle is in between 1 and 2 mm, then such sedimentary rocks are called arenaceous rocks. Here, the main constituent is sand (quartz and feldspar) and the cementing material is may be argillaceous, calcareous, ferruginous or siliceous material.

Example: Sandstone, Grit

c) Argillaceous rocks: If the size of the particle is < 1mm in dia, they are described as 'dust' and rocks are called argillaceous rocks. Argillaceous rocks are formed by the accumulation and compaction of dust particles. If the particles are loose and dry, the deposits are called 'dust', if it compact and semi wet it is mud and if it is wet, it is described as clay.

Example: Shale, Mudstone

2. Non-clastic rocks: They are formed either by chemical processes or organic process.

Accordingly, they are grouped into

a) Chemically formed rocks

b) Organically formed rocks

a) Chemically formed rocks; They are formed by precipitation, evaporation or crystallization from natural aqueous solution. They are further classified into

i) Sileceous deposits – formed by precipitation of silica solution

Ex: Flint, Chert, Jasper

ii) Carbonate deposits - formed by precipitation of carbonate rich water

Ex: Limestone, Dolomite, Magnesite

iii) Ferrugeneous rocks- formed by precipitate of oxides and hydroxides of iron

Ex: Bog iron ores

iv) Phosphatic deposits- formed by sea water rich in phosphoric acid

Ex: Phosphate compound

v) Evapories – formed by evaporation of sea water (bays and esturies).

Ex: Rock salt, Anhydrites, Gypsum, Borates

b) Organically formed rocks: Sedimentary rocks which are formed exclusively from remains of organisms (plant / animals).

Ex: Carbonaceous deposits – Coal and petroleum fossiliferous limestone

Properties of rocks	Sand Stone	Shale	Limestone	Laterite
Colour:	Dull white, reddish, brown, brick red, pink	Reddish brown, brick red, chocolate brown	White, pink, gray, green, black, multicoloured	Reddish brown, brick red
Texture & grain size;	Clastic Arenaceous (sandy) medium grained 1/10 mm to 2 mm	Clastic fine grained (clayey)	Non-clastic massive fine grained	Concretionary porous, fine grained
Mineral composition:	Quartz (Sand particles) Orthoclase (little) little muscovite & mica	Clays, mud, silts fine, sediments	Calcite, chert, Clay	Clay, Iron oxide, Al_2O_3
Cementing Material:	Fe_2O_3,SiO_2, $CaCo_3$	Fe_2O_3	$CaCo_3$	Iron Oxide
Crushing strength:	Medium	Low to Medium	Medium	Medium
Specific gravity:	2.8	2.6	2.7	2.6 – 2.8
Classification:	Mechanically formed arenaceous group of sedimentary rocks.	Mechanically formed argillaceous sedimentary rocks.	Chemically formed sedimentary rocks.	Residual deposited sedimentary rocks
Special Features:	Sp. /Current bedding ripple marks. Bedded and granular.	Laminated structure soft, Sun cracks, Rain prints	React with Dil. Hcl soft.	porous when soft can be cut, sun dried become hard deposited sedimentary rocks
Uses:	Building, Ornamental, structural, road, metal, rail road, Ballast, paving set, concrete aggregates	Bricks, Tiles, cement Manufacture	Cement manufacture. Flooring, Ornamental, Tooth paste, Road metal	Building stone, road metal, poor grade Iron ore.

METAMORPHIC ROCKS

Introduction:

The word "**Metamorphism**" comes from the Greek: Meta = change, Morph = form, so metamorphism means to change form. Metamorphic rocks are those rocks that are formed as a result of transformation that takes place in the pre-existing rock (Igneous/sedimentary rocks). When the pre-existing rocks are subjected to higher temperature, pressure and chemically active liquids and gases, the minerals present in the original rocks changes to new environmental condition. This adjustment processes continues until the minerals attain stability or equilibrium. By this, original minerals get recrystallized and the original structure and texture also changes. The process by which the metamorphic rocks are formed is known as metamorphism.

Agents or factors of metamorphism: Temperature, Pressure and Fluid are main agents responsible for metamorphism.

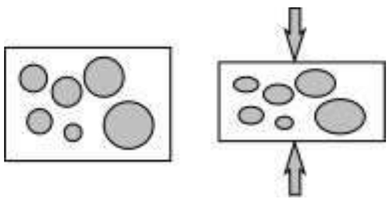
1. Temperature: It is responsible in bringing the recrystallization or reconstitution of the original minerals into newer ones. Here, there is no addition or subtraction of minerals from the rocks. The metamorphic reaction taking place between temperature of 300-800°C and even more upto 1000°C.

2. Pressure: Pressure is one of the important dominant factors in metamorphic rocks and in majority of rocks it is associated with temperature. It is of two types.

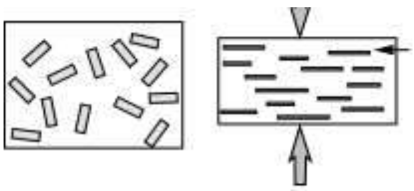
a) Load pressure – Here the pressure acts generally in a vertical direction due over burden resulting change in structure of the rocks.

b) Direct pressure - Pressure is from different direction resulting change in volume (differential stress)

Rounded grains (Ex.Quartz) become flattened in the direction of maximum stress.



Flaky / elongated minerals (Mica) have preferred orientation in the direction of maximum stress



3. Fluids: Any existing open space between mineral grains in a rocks can potentially contain a fluid. The chemical solution, gases and vapours plays an important role in metamorphism which is normally associated with temperature and pressure. The chemically active fluids facilitates recrystallization of original minerals. Due to rise in pressure and temperature. Water is the most important chemically active fluid.

Metasomatism: Sometimes fluids present around the rock comes in contact with the minerals at high temperature producing many changes in composition, and structure. This process of rock/mineral alteration by the agency of solution is called metasomatism.

Kinds of metamorphism: Depending upon the factors responsible for metamorphism, different kinds of metamorphism are noticed and they are

1. Thermal metamorphism

2. Dynamic metamorphism

3. Dynamo -thermal metamorphism

1. Thermal metamorphism: Here, temperature is the dominant factor and pressure and fluid are the sub-ordinate factors. When the thermal metamorphism occurs in the immediate contact of igneous intrusions, it is called contact metamorphism and when it occurs on a regional scale at depth it is called Plutonic metamorphism. As a result of thermal metamorphism, recrystallization of original minerals takes place.

Ex: Limestone → Marble, Sandstone → Quartzite

2. Dynamic metamorphism: This type of metamorphism takes place in the rock by means of direct pressure / stress which is a dominant which leads to new structures. It is also called Cataclastic / kinetic metamorphism and the rock undergo mechanical breaking down and they may be crushed into smaller ones by pressure.

Ex. Shale → Slate

3. Dynamothermal metamorphism: It is a kind of metamorphism where temperature and pressure are the dominant factors which operates upon pre-existing rocks. The metamorphism may be regional / local scale and it is called Regional metamorphism. Here, temperature promotes recrystallization as in the case of thermal metamorphism and the original mineral grains re-arrange into new minerals. Direct pressure / stress leads into the formation of new structures. Thus, the minerals developed under direct pressure are usually flat, tabular, and flaky in nature.

Ex. Granite → Gneiss

Properties of rocks	Gneiss	Slate	Marble	Quartzite
Colour:	Gray, banded	Gray, dark gray, black, red	White, pink, green, black, multicoloured	White, gray, pink. Brick red
Texture & grain size;	Parallel orientation (Alternate banded) Fine to medium	Schistose, compact fine grained	Granuture fine to coarse grained	Fine to coarse grained
Mineral composition: Essential Minerals Accessory Minerals	- Quartz - Orthoclase(White/Pink) - Biotite -Hornblende. Iron ore	-Clay minerals -Chlorite -Quartz -Feldspars -Mica -Iron pyrite -Magnetite & Hematite	Calcite($CaCo_3$) -Quartz -Iron ore -Garnet -Serpentine	Quartz -Mica -Iron ore
Specific gravity:	Medium 2.7	2.8 – 2.9	2.7	2.7
Crushing strength:	Very high	Medium	Medium	High
Origin / Occurrence:	A foliated rock formed by the regional metamorphism of sandstone,Conglomerate. Granite	Dynamic metamorphism of shale	Contact or thermal metamorphism of limestone	Thermodynamic metamorphism of sandstone
Classification:	Dynamic metamorphic rocks	Dynamic metamorphic rock	Thermal metamorphic rocks, reacts with Dil. Hcl	Regional or thermal metamorphic rock
Important / Uses:	Building stone. Ornamental stone. Road metal, concrete ballast. Pillars. Slabs	Flooring, roofing black boards & slates, mosaic, granules, interior & sanitary works, table tops electrical switch board refrigerator shelves	Architectural Ornamental, decorative, monumental, flooring staircases, statues etc.	Road metal, rail road ballast, glass making

Module -3

Geomorphology and Seismology:

Landforms

Landforms are natural features of the landscape, natural physical features of the earth's surface, for example, valleys, plateaus, mountains, plains, hills, glaciers.

Types of landforms

There are many different types of landforms on the Earth. Some of them were formed over millions of years and others were formed in a matter of hours. The formation of a mountain range, for example, would usually take a few million years. Events like earthquakes and volcanic eruptions can 'wipe off' landforms, or form new ones in a matter of hours. Examples of some natural landforms are mountains, oceans, rivers, hills, volcanoes, valleys, desserts, waterfalls, caves and cliffs. This chapter looks at the formation of some major types of landforms

Mountains

A mountain is a raised part of the Earth's surface. Mountains can be formed in different ways that involve internal (inside) or external (outside) natural forces. The movement of tectonic plates is called plate tectonics. **Plate tectonics** is an internal natural force because it happens inside the Earth. When tectonic plates collide, they raise the Earth's crust. As mentioned before, tectonic plates move very slowly, so it takes many millions of years to build a mountain. Mountains can also be formed by external natural forces like rain, wind and frost in the process of erosion.

Mountains with shapes that are sharp and jagged are called young mountains. Mountains that have a smoother, more rounded look are called old mountains. The South American mountain range, the Andes, is a young mountain range. Old mountains look smoother because they have been shaped by natural weathering over a longer period of time. The Himalayan Mountains, which are an older type of mountain, are still 'growing' due to plate tectonics.

Valleys

A flat area of land between hills or mountains is called a valley. Valleys are usually formed by river water. The speed at which a river deepens its valley depends on the speed of the flow of the river water and the type of materials from which the river bed (the bottom of the river) is made. Softer and lighter materials are moved by water faster than hard and heavy ones. That means that a river bed made from soft sediments can be changed or deepened faster than a hard and rocky one.

Oceans

An ocean is a large body of salty water that surrounds a large land mass. After studying different rock, scientists have established that the first ocean on the Earth was formed about 4000 million years ago. Even though early Earth did not have any water, it had the chemical elements that make up a water molecule. Some scientists believe that the Earth's first rain was just cooled-down volcanic steam. Rainwater started to collect in low-lying areas of the

Earth's crust, forming the first ocean. Another group of scientists believes that first water was 'delivered' on the Earth by massive ice-bearing comets.

Deserts

A desert is an area that receives very little or no rain through the year. Deserts usually form as a result of climate change. Deserts have very dry air and lots of wind. Deserts can be hot or cold. During the daytime the temperature in hot deserts is very high and at night it drops to a few degrees. A cold desert is a desert that has snow in the winter. An example of a hot desert is the Sahara desert. Sometimes people call Antarctica a frozen \desert. It has not rained or snowed in some places there for over 100 years. A cold desert never becomes warm enough for plants to grow in it. Deserts cover about a fifth of the Earth's land surface.

Rock Weathering:

It is a process that cause the breakdown of rocks, either to form new minerals that are stable on the surface of the Earth, or to break the rocks down into smaller particles. Weathering is the result of the interactions of air, water, and temperature on exposed rock surfaces and prepares the rock for erosion. Erosion is the movement of the particles by ice, wind, or water. The particles are then transported by that agent until they are deposited to form sedimentary deposits, which can be later eroded again or transformed into sedimentary rocks. Weathering is generally a long, slow process that is continuously active at the earth's surface.

There are three kinds of weathering: Mechanical, Chemical and Biological Weathering.

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

Processes of Mechanical Weathering

A single block is broken gradually into numerous small irregular fragments and then into smaller fragments. Further it is classified into Block disintegration and Granular disintegration.

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

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

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

Frost action: It results due to freezing of water which are trapped in the cracks of the rocks widens and deepens the cracks, breaking off pieces and slabs.

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

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

C**hemical weathering**: It is a process where chemical alteration or decomposition of rocks and minerals takes due to rain, water, and other atmospheric agents. Chemical weathering weakens the bonds in rocks and makes them more vulnerable to decomposition and erosion.

Processes of Chemical Weathering

The main agent responsible for chemical weathering reactions is water, oxygen and weak acids. These react with surface rocks to form new minerals that are stable in, or in equilibrium with, the physical and chemical conditions present at the earth's surface. Any excess ions left over from the chemical reactions are carried away in the acidic water. For example, feldspar minerals (which a silicate of potassium, sodium, calcium and aluminum) will weather to clay minerals, releasing silica, potassium, hydrogen, sodium, and calcium. These elements remain in solution and are commonly found in surface water and groundwater. Newly deposited sediments are often cemented by calcite or quartz that is precipitated between the sediment grains from calcium- and silica bearing water, respectively.

Water: Chemical weathering is most intense in areas that have abundant water. Different minerals weather at different rates that are climate dependent. Ferromagnesian minerals break down quickly, whereas quartz is very resistant to weathering.

Oxygen: Oxygen is present in air and water and is an important part of many chemical reactions. One of the more common and visible chemical weathering reactions is the combination of iron and oxygen to form iron oxide (rust).

Acids. Acids are chemical compounds that decompose in water to release hydrogen atoms. Hydrogen atoms frequently substitute for other elements in mineral structures, breaking them down to form new minerals that contain the hydrogen atoms. The most abundant natural acid is carbonic acid, a weak acid that consists of dissolved carbon dioxide in water. Other acids that can affect the formation of minerals in the near surface weathering environment are organic acids derived from plant and humus material.

Leaching - ions are removed by dissolution into water. In the example above, K^+ ion was leached.

Oxidation - Since free oxygen (O_2) is more common near the Earth's surface, it may react with minerals to change the oxidation state of an ion. This is more common in Fe (iron) bearing minerals, since Fe can have several oxidation states, Fe, Fe^{+2}, Fe^{+3}. Deep in the Earth the most common oxidation state of Fe.

Biological Weathering: Plant roots can extend into fractures and grow, causing expansion of the fracture and eventually can break rock. Animals burrowing or moving through cracks can break rock. Plants can penetrates into the ground just a few meters whereas microorganisms can penetrate to a greater than of 10-25 mts.

EARTHQUAKE

An earthquake is a sudden and rapid shaking of the ground due to passage of vibrations beneath caused by transient disturbance of elastic or gravitational equilibrium of rocks.

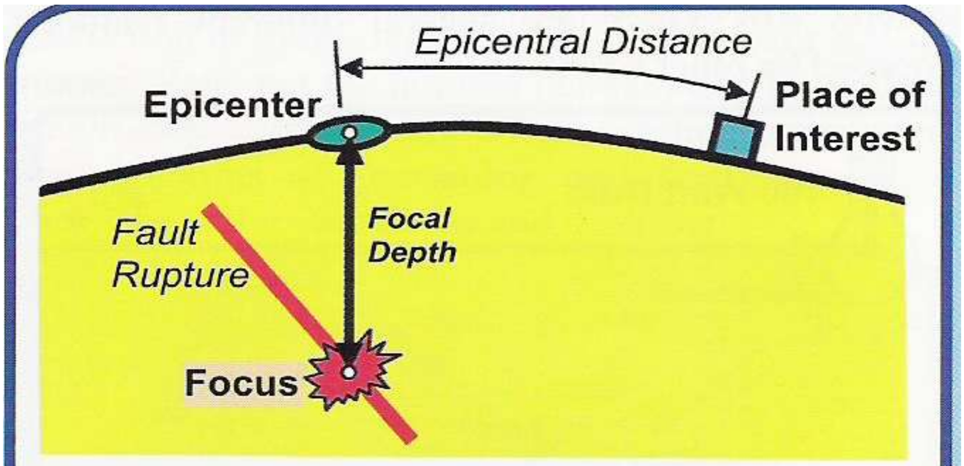


Figure 1: Basic terminology

An earthquake is the vibration of the earth produced by the rapid release of energy. Although earthquake occurs occasionally, but destruction they cause through loss of life and property. The exact spot underneath the earth surface at which an earthquake originates is known as its **FOCUS**, while the point on the earth surface lying above the focus is defined as the **EPICENTRE**.

Depth of Focus: - Earthquake focus is described

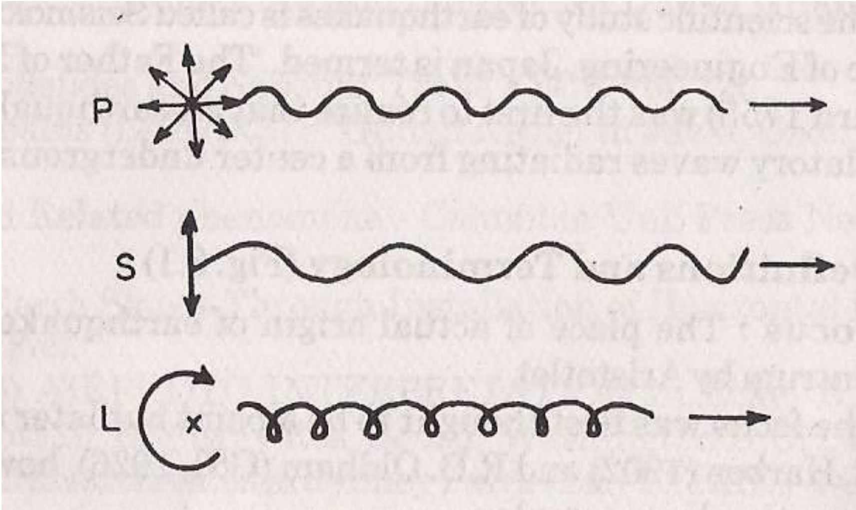
Shallow: - When it is less than 70km below ground surface

Intermediate: - Between 70 and 300 km and

Deep: - below 300 to 700km most earthquakes originate within the upper 250km

and none below 700km below the ground surface.

EARTHQUAKE WAVES: - The strain energy released by an earthquake sets up several types of pulses (wave motion) at the focus. These called seismic or earthquake waves travel in all directions in different paths, modes and speeds proportional to the densities of the materials through which they travel. The speed increases with density. When the waves reach the ground surface they spread out in ever widening circles around the epicenter like water waves from a point of impact in a pond and cause that span of the ground to shake.



P-waves (primary or push and pull waves): - These are high frequency short wavelength longitudinal compressive type, like sound waves. These take the quickest path and are transmitted by oscillations in the direction of propagation. P-waves travel through solids, semi-solids and liquids, i.e the crust the mantle and the core of the earth at speeds 5 to 15km/s

S-waves (Secondary or shake waves): -These are high frequency short wave-length transverse eaves like polarized light transmitted by oscillations perpendicular to the direction of propagation. These also take the quickest path but travel through solids and semisolids, only, i.e the crust and the mantle and are deflected at the core, S-waves travel at speeds 3 to 8km/s.

L-waves (Long or surface waves): - These are low frequency long wavelength waves produced by reflections and refractions of P and S waves in the immediate neighborhood of the epicenter. These travel with a rotary movement in the vertical plane, like sea waves and are transmitted along the periphery of the earth at speeds 3 to 5km/s.

EARTHQUAKE MOTION

Earthquake motion consists of two components- a vertical and a horizontal. The seismic vibrations. Earthquake waves arise vertically from the focus below and cause oscillations of the ground, at the epicenter. As the vibrations advance the horizontal component increases in proportion to the vertical.

EARTHQUAKE MAGNITUDE AND INTENSITY

Magnitude: - Magnitude of an earthquake is an instrumental rating of the energy (the size or strength of the quake) released by it. Magnitude varies with the wave amplitude of an earthquake recorded by a seismograph. By knowing the distance from a seismograph station to the epicenter and the maximum amplitude recorded, an empirical quantitative rating is estimated.

The intensity of an earthquake is a numerical index describing the degree of ground shaking and effects on life and property at any given locality. Intensity is essentially a function of an earthquake and local geological conditions. Intensity is severe at and around the epicenter area and decreases away from it.

Intensity number	*Designation of shock*	*Effects*	*Magnitude (Approx.)*
I	Instrumental	detected by instruments only	—
II	Feeble	felt by observers and by a few people at rest	2
III	Slight	generally felt by many	—
IV	Moderate	felt by all Utensils, glassware clink and clash window shutters rattle	3.5
V	Fairly strong	buildings tremble,, parked vehicles rock, wall clocks stop	3.5 – 4.3
VI,	Strong	sleeping people awakened,, disturbance of furniture	4.3 – 4.9
VII	Very strong	violent disturbance of furniture, walls crack, hanging objects swing,, church bells ring	4.9 – 5.5
VIII	Destructive	moving objects, vehicles, trains over thrown, rails twisted,, monuments,, chimneys,, towers sway crack and fall down,	5.5 – 6.5
IX	Ruinous	heavy damage to buildings, begin to collapse reservoirs sway	6.2 – 7.0
X	Disastrous	Buildings razed to ground, life lines destroyed	7 – 7.3
XI	Very Disastrous	only a few structures left,, dams affected breeched or overthrown,, ground cracked,	7.4 – 8.1
XII	Catastrophic	complete destruction, ground badly twisted	8.1

DISTRIBUTION OF EARTHQUAKE: - It is estimated that over 150000 quakes occur round the world every year. Several of them are terribly destructive involving heavy tolls and property damages.

World distribution

1). The Circum Pacific Seismic Belt,

2). The Mid Atlantic Seismic Belt,

3). The alpine-Himalayan trans Asiatic Seismic Belt

Indian distribution

1). Kutch Gujarat 1819

2). Assam, 1897

3). Bihar1934

4). Anjar-Gujarath,

5). Peninsular India (South India)

Indian continent is divided into (based on earthquakes)

Zone of Maximum Intensity: - Which comprises the Northeastern regions, especially the folded chains of Himalayas, geographically this area covers Assam, Himachal Pradesh, Kashmir, U.P, Nagaland.

Zone of Intermediate Intensity:- Which covers the regions of indo-Gangetic basin. This zone of moderate Intensity comprises the remaining areas of Punjab, West Bengal and Bihar.

Zone of Minimum Intensity: - No land mass is free from earthquake, all the regions are highly affected by this activity.

EARTHQUAKE HAZARDS

The energy released by an earthquake travel along the earth's surface, it causes the ground to vibrate in a complex manner by moving up and down as well as from side to side. The amount of structural damage attributable to the vibrations depends on several factors including

The intensity and duration of the vibration

The nature of the material upon which the structure arrest

The design of the structure

Earthquake effects are remarkable and directly proportional to the intensity of then tremblers and geologic setting of the affected area. Earthquake effects comprise of changes super induced upon land and sea levels, topography and surface and groundwater regimes as a result of readjustments of certain, components of the crust in order to restore equilibrium. The hazards are due to two important seismic events are Ground shaking and Tsunami generation.

Violent ground shaking induces topographic changes and ground failure by landslides, fissuring surface faulting and soil liquefaction. Ground shaking is maximum in epicenter regions. Generally topography of the affected areas is transformed partly or totally. Hill ranges rise or fall or rented. The ground is thrown into terraces or wave like a choppy sea and extensional cracks.

FIRE HAZARDS

The loss of life and property that accompany great quakes often is mainly due to secondary cause especially fire. If a quake strikes a modern town or city today it may cause uncontrollable fire due to electric short circuit severance of gas and water mains and flooding with attendant serious damages.

STRANGE BEHAVIOR OF ANIMALS

There are reports of fanciful behavior of animals sometimes before and during an earthquake. Tigers and chimpanzees scream. Domestic animals horses and cows become restless and run abut madly stampeding or seek highlands. Dogs and cats howl and huge closer to people. Rats disappear, pigs rush out in swarms. Rabbits try to climb walls and fences. Zoo animals refuse to get into their cages and shelters.

EARTHQUAKE SOUNDS

Earthquake records frequently refer to strange sounds that accompany ground shaking. It is reported that earthquake sounds are due to the shaking ground beating upon the air above like the membrane of a drum. The near vertical incident of P-waves is supposed to be responsible for the sounds with the ground behaving like an enormous loud speaker driven by them. It is observed that earthquakes occurring in areas of crystalline rocks like granite or gneiss produce strong high frequency sounds and those in thick sedimentary terrines produce softer low frequency sounds.

TYPES OF EARTHQUAKE PROOF STRUCTURES

Quake proof models: - TO bear the strain due to earthquake shocks and prevent or minimize damages and death two opposite methods of anti-earthquake construction in earthquake regions are recommended, they are Light and elastic constructions and Heavy and rigid constructions

Light and elastic constructions: - In India and elsewhere in earthquake countries most people in countryside live in non-engineered mud huts or timber structures. The mud habitats usually are constructed with mud walls and sloping thatched roof, in some cases bamboo walls with plaster or crude brick or rubble masonry. These fail in earthquakes with disastrous effects. Mud structures are very popular in India, especially in Kashmir, Kutch, Maharashtra, Bihar and Assam regions. Timber frame structures and Brick Masonry

Heavy and rigid constructions: - These are well built structures of brick and stone masonry, RCC frames with filler brick walls, and single or multistoried buildings. The main object of these is to construct stronger than ordinary building in order to prevent their collapse and loss of life and property, especially those of large selling's, schools, office building, hospitals, business complexes community halls etc. Where commonly good number of people assembles at a time and also certain vital or critical installations like powerhouses nuclear facilities.

Safety measures to be adopted for buildings to be construction in seismic areas. As stated earlier, an earthquake resultant building must be strong and sturdy. Hence, besides incorporating these additional safety factors in the design of such buildings the following other points must be given due attention to

1. Good quality materials, strictly according to the specifications, should be used.

2. The foundation should not be on soft ground and rather it should preferably be on the solid rocks. The depth of foundation should also be uniform.

3. The walls should be continuous in nature. The long walls and cross wall be erected simultaneously without any joints.

4. Doors and windows should be minimized.

5. Height of the building should be kept uniform.

6. All parts of the buildings, particularly its edges and corners should be well tied, so that it moves as a single unit during an earthquake vibration.

7. Construction of cantilevers, Chimneys, Arches and other extra projections should be avoided.

EARTHQUAKE AND CIVIL ENGINEERING

An earthquake is a vibratory motion having components in all directions. The vertical components are more dominant near the epicentral tracts and the horizontal components away from these tracts. Hence strong structures have to withstand bigger forces near the epicenter and soft and flexible structures are safer, away from the epicenter flexi bile structure suffer severe damage while hard structures as safer. Extensive research has been carried out in the last 50 years to develop new methods to minimize losses.

Buildings: - Steel – framed tall buildings in which the frame supports all wall and floor loads usually behave well during earthquake. Reinforced concrete buildings may develop cracks in walls and piers houses with roofs; wall and foundations tied into one strong unit behave safely during earthquake. Houses built with wood and flexible materials of construction absorb earthquake shocks. In our country modern methods are increasingly being adopted and reinforced brick buildings are built against earthquake forces. This method increases the construction cost 2-5%, but simultaneously saves buildings and lives. Even more recently by a new direction in research and developed insulators for absorbing energy transmitted by ground motion to reduce damage to structure. Some of these methods are useful for rigid structures.

Foundations: - The amount of damage caused by ground shaking depends on the type of foundation below the building or structure. These are built in low-strength roc materials such as sand and silt tend to absorb much of the shaking motion, hence buildings have not been designed to cope with strong shaking but rather to accommodate large foundation movements. Such buildings have to provide competent footings, adequate drainage and flexible power, water and sewage connections. Unconsolidated sandstone may saturate as a result of earthquake vibrations, sometimes the entire structure is destroyed.

Slopes and embankments: -Settlement of embankments can be minimized by careful compaction control during construction but even then settlement can occur. Landslides due to earthquakes have resulted in loss of lives and property. So embankment has to be designed with extra care. Highways and railway cuttings and avoidance of steep slopes for residential development re necessary in high seismic areas.

Dams: -Rock fill dams usually stand up well to earthquake shocks. A river valley project may consist of a dam or barrage, tunnel, powerhouses, buildings and bridges of various types, which may fail during strong earthquake.

Tunnels: - Tunnels, which intersect at geological fault, are often seriously affected by earthquake movement. Special tunnel deigns are necessary in seismically active zones. Generally rupture of the lining may cause flooding of partial dislocations. Earth tunnels are less affected by earthquake movements but the chances of liquefaction of the surrounding materials are real.

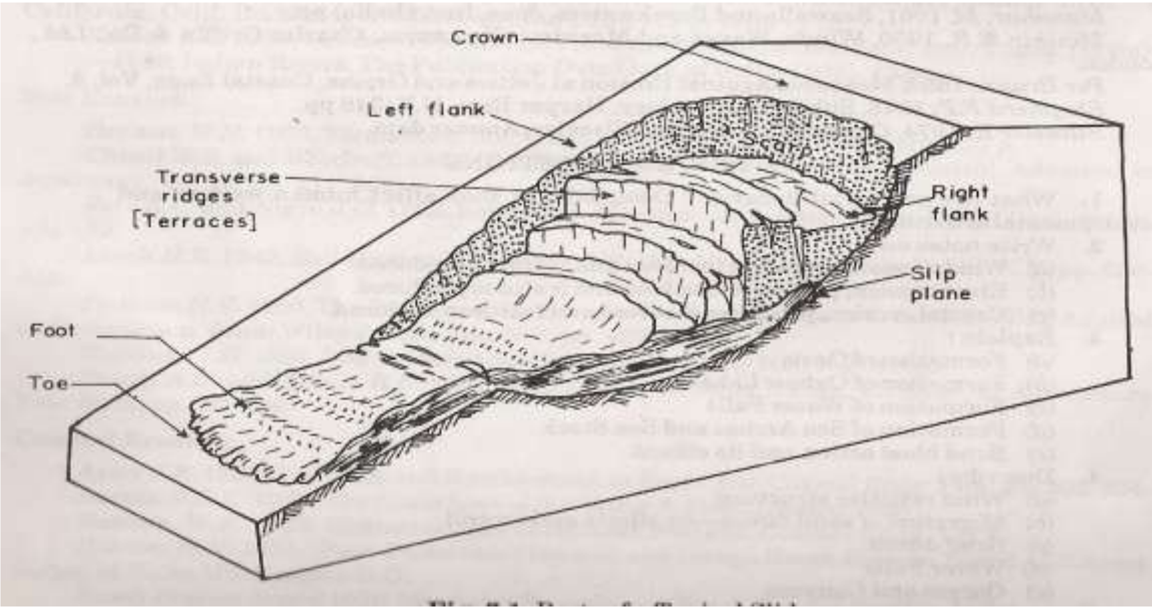
Impacts of reservoir-induced seismicity (RIS): The weight of the reservoir, by itself or in conjunction with other reservoirs in the region, can create the sorts of pressures that could result in an earthquake. The weight of the reservoir can also force water down cracks and faults till it catalyses an earthquake. The occurrence of reservoir-induced seismicity is now a well-accepted fact. RIS has occurred in various dams across the world. 17 of the 75 cases of RIS reported worldwide have been reported from India.

LANDSLIDE

A landslide is a slow or sudden downhill movement of slope forming rock and soil material under the force of gravity. Landslides or slopes failures are natural Erosional process. They occur in hillsides valley slopes, seacoasts, riverbanks and bends, on the slopes of volcanic cones and in earthquake prone areas. They also occur underneath as on lake or sea floor. Man in his urban and regional development activities also trigger landslides. Such as excavations, fills quarries, cuttings of roads, railway and canals etc. Landslides as natural erosional process not only modify the existing topography and landscape, they also cause immense damages to manmade structures and heavy loss of life.

PARTS OF TYPICAL SLIDE

A typical slide exhibits the following parts or regions



CROWN: - The upper portion still in place from which solid rock and soil materials are torn away from the rest of the slope.

SCARP: - The steep wall of the undisturbed material below crown around the periphery of the slide material

HEAD: - The upper part f the slide material

SLIP PLANE: - The shear surface – the surface of movement downhill of the slide material

FLANKS: - Sides of a slide, left flank and Right Flank

TRANSVERSE RIDGES: - Terrace or step like pressure or compression ridges

FOOT: - The line of intersection of the lower part of the slip plane and the original ground surface

TOE: - The lower portion in which the rock or soil material is heaped up

LENGTH: - Horizontal distance from crown to toe.

WIDTH: - Horizontal distance form flank to flank

HEIGHT: - Vertical distance, crown to toe

DEPTH: - Thickness of the slide mass between crown and foot.

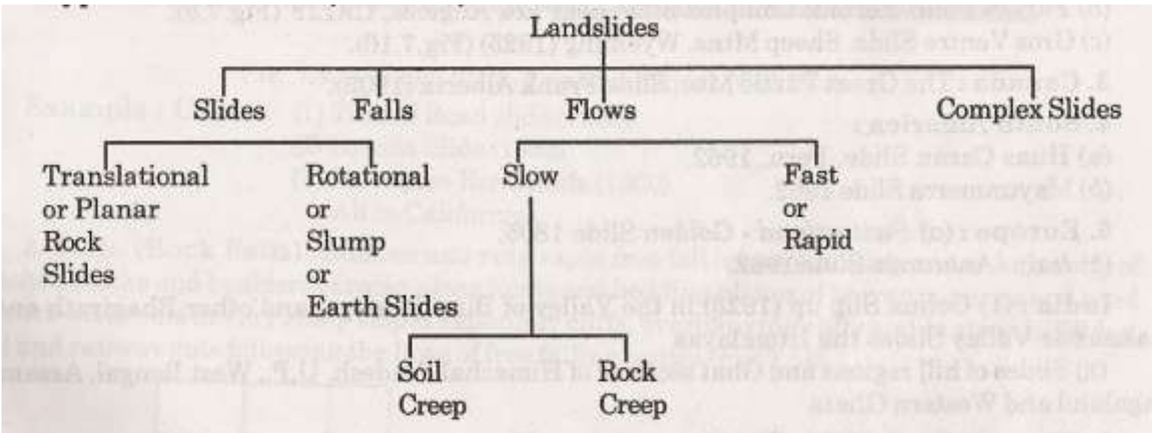
CLASSIFICATION AND TYPES OF LANDSLIDES

Landslides are of many types and are broadly classified according to their characteristic parameters

-Presence or absence of a definite slip plane

-Materials involved and their water content

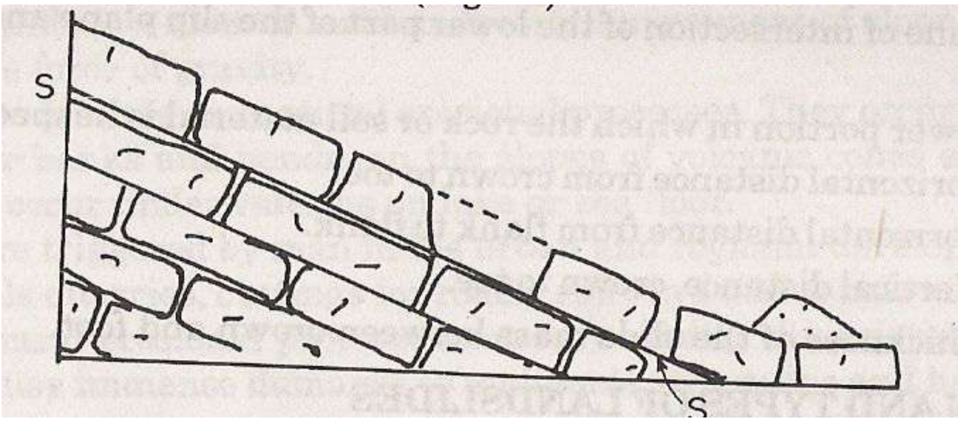
-Kind and rater of movement.



SLIDES: - Sudden downhill movements of rock and or unconsolidated rock material on a definite identifiable water lubricated or not down slope inclined plane called a shear or slip plane between the separating and remaining masses. The slip plane may be a bedding plane, joint plane, fault plane, and schistose or cleavage plane.

Slide movement: Slide movements are of two kinds according to the nature of the slip plane.

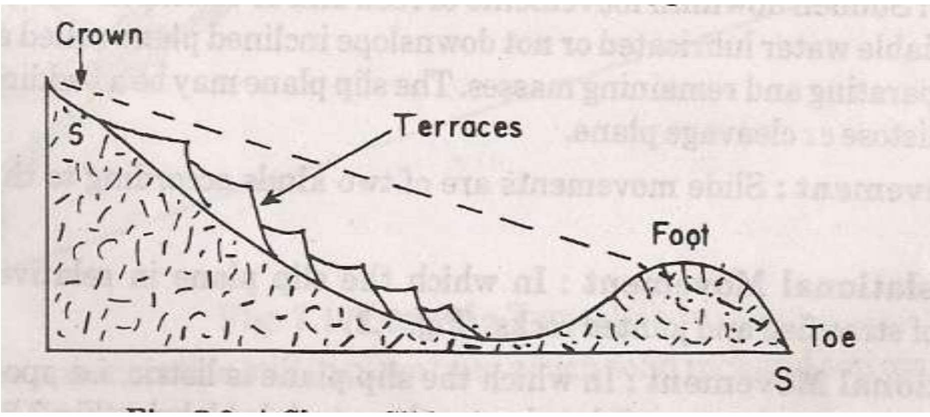
Translational Movement: - In which the slip plane in relatively a plane surface characteristic of stratified and jointed rocks.



Rotational Movement: - In which the slip plane in is spoon shaped, concave upwards, characteristic of unconsolidated or earth materials

Rock Slides (Block or planar slides): - These are typical translational slides common in slopes with stratified and jointed rocks and involve sudden or rapid movement of un deformed strata or blocks of rocks separated along joints or down slope dipping bedding planes at critical angles where the gradient of the slope is steeper than the dip of the beds. One or several of the water lubricated bedding planes form potential slip planes. The beds hold only so long as there is cohesion between them. When the dip approaches at the angle of limiting friction, the whole sequence of top strata above the slip plane slides down.

SLUMP: - These are typical rotational slides common in unconsolidated materials especially mud and clay. These occur when the foot or toe of a slope is cut away either by natural erosion or by human activity. These are also called slip outs. The slip plane is highly spoon shaped curved upward. The failed mass characteristically gets slumped at the toe area of the original slope, when a slope suffers multiple slides a terrace like features results.

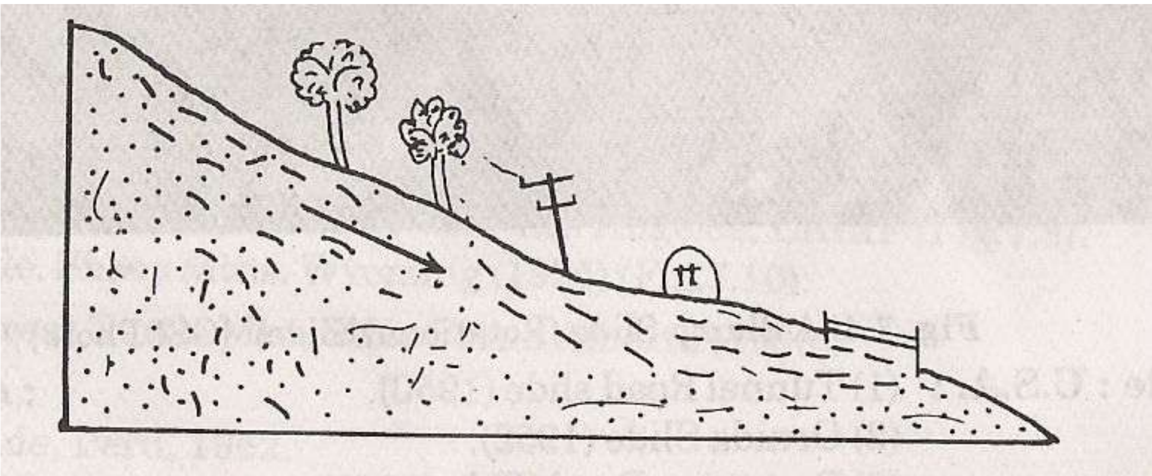


FALLS (Rock Falls): - Sudden and very rapid free fall leaping, rolling and or bouncing of detached blocks and boulders of rocks along joints and bedding planes of barren outcrops and solid bed rock materials in very steep slopes especially cliffs, overhanging cliffs and in steep hillsides, road and railway cuts following the laws of free falling bodies

FLOWS: - Slow to fast downhill movement of unconsolidated materials, earth sand and rock debris, dry or wet with water or ice and snow and in some cases bedrock itself. Flows are characterized by the absence of a recognizable slip plane. The movement resembles those of viscous fluids. Flows are of two types according to the materials and rate of movement slow or fast.

Slow Flows: - These are of two types

(a). Soil Creep: - A very slow almost imperceptible down slope plastic movement of wet or dry surface materials following the laws of viscous flows of fluids and semi fluids. Curved tree trunks recognize soil creep, tilted lampposts telegraph as well as displacement or destruction of foundations, buildings, and retaining walls, fences etc on sloping grounds



If water saturated materials are involved soil creep is called solifluxion and when it it's a wet mud without vegetation mud flow. Mudflows are common in areas effected by wild forest fires and on slopes of volcanic cones.

Fast Flows (Rapids Flows): -

Fast flows are sudden and very fast-to-fast downhill slide of soil, rock debris and boulders with large masses of ice and snow on steep slopes of Snow Mountains. It includes disruption of highways, railroads, recreation facilities heavy damage to buildings and loss of life.

CAUSES OF LANDSLIDES

Many factors are causing a mass of material to slide or flow. Some of them play a direct role and are easily understand whereas others are indirectly responsible for the instability of the landmass. All such factors that facilities land sliding is one way or another is generally grouped in tow headings.

1) Internal Factors

2) External Factors

Internal Factors: - These include such causes, which tend to reduce the shearing of the rock, further it is classified into, 1) the nature of slope, 2) water content, 3) composition and compaction of the mass, 4) geological structures

1) **the nature of slope: -** Some slopes are very stable even when very steep whereas other are unstable, even at very gentle slope. But a great majority of failure are confined to slopes only, indicating that slopes are directly responsible for mass failure.

2) **Water content: -** Much importance is attached to the role of water is causing mass movements. It may act in a number of ways to reduce the shearing strength of the rock or soil mass. Even presence of water in the pore spaces of rocks has been found to affect all the strength properties adversely. When water within the mass is also capable of flow around the grains. Similarly, when water happens to move along a plane of weakness within the mass, that plane gets lubricated and may turn into an effective plane of shear failure. In sliding type of failure this lubricating action is of great importance.

3) **Composition and compaction of the mass:** - Some materials are stable in a given set of conditions of slopes and water content whereas others may be practically unstable under those very conditions. This clearly suggests that compaction plays an important part in defining the stability of the masses. Sandstone exhibits a great variation in chemical composition. Siliceous Sandstones would be highly stable even during intensive rains and at steep slopes whereas clayey or calcareous may suffer repeated failure under same conditions.

Along with composition, the texture of rocks plays an important part-It indicates the degree and manner of packing of grains or crystals. Porosity and permeability of are the two important factors influencing the percolation of water through the mass.

4) **geological structures: -** Of all the geological structure the inclination(dip), joints, faults zones of the strata, presence or deposition of shear, fault zone, joints and other planes of weakness are important in defining their stability.

External Factors: - Earthquakes and blasting around mines due to this vibration is liberated from this mass failure may take place.

Preventative measures of Landslides

Many methods for controlling the slides are available and choice of many methods will depend of factors like nature of slide, the underlying cause for it, the nature and amount of material involved and the economical consideration, of such method most important are.

1) Providing adequate drainage

2) Construction of retaining walls

3) Stabilizing the slopes

Providing adequate drainage: - It involves the removal of moisture form within the rocks as well as preventing any further moisture to approach the material to sliding. This may be achieved either by surface drainage or by subsurface drainage; construction of interpretation ditches, waterways, trenches and drainage tunnels may become necessary. Grouting the joints and other fractures may also prove helpful.

Retaining structure: - Al such devices like construction of retaining wall etc. are aimed at stopping the moving mass by force and their success is always doubtful. Construction of retaining wall requires an accurate assessment of the forces, which the wall has to withstand. Retaining walls may prove exceptionally, successful where,

A) The ground is neither too fine nor too plastic

B) The sliding mass is likely t remain dry

C) The movement is of shallow nature

Slope treatment: - When the material is soil and situation is a slope the failure is attributed to a loss of stability. In such cases the treatment involves stability for the particular type of soil and slope and if such computation indicate that a given slope of soil will not be stable then the solution lies in either,

A) Flattening the slope

B) Decreasing the load

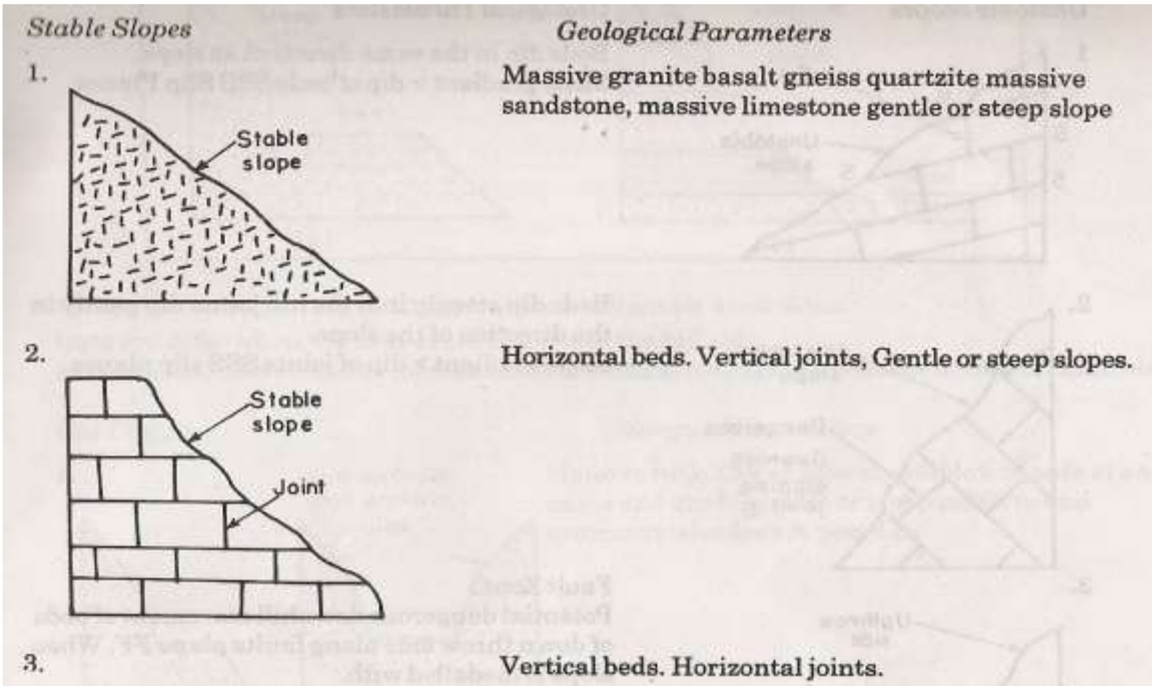
C) Increasing the shearing resistant of the soil by decreasing its water content with help of drains and evaporation

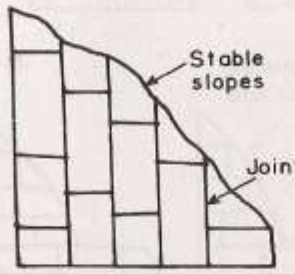
D) A forestation that is growth of vegetation cover with intricate and interwoven root system has also been found useful in stabilizing the barren slopes.

Effects on Hillside Homes and Structures, Landslide Damages:

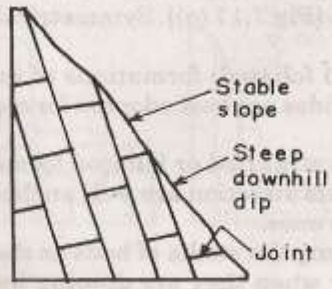
STABLE AND UNSTABLE SLOPE: -

Slopes thus may be classifies into stable and unstable slopes governed by critical geological parameters.





4. Steeply inclined beds dipping in the direction of natural slope dip of the beds > slope gradient joints dip.



Coastlines and their engineering considerations

There are a number of engineering issues that need to be considered prior to selection of an appropriate approach and option. These include

1. Coastal erosion is the wearing away of land or the removal of beach or dune sediments by wave action, currents and tide. It is a dynamic and often complex process it can be cyclical with periodic episodes of coastal retreat and rebuilding.

2. Beaches are eroded when they lose more sediment along shore, offshore than they receive from various sources.

3. In order to prevent coastal erosion, rigid protection methods are usually used throughout the world.

4. Erosion is controlled by engineering method with the help of the geology

Jetty

A J**etty** is any of a variety of structures used in river, dock, and maritime works that are generally carried out in pairs from river banks, or in continuation of river channels at their outlets into deep ocean water . This is also a hard structure stabilization. It helps in avoiding build up of unwanted sediments by collecting sand on one side of it before it reaches the structure.

Seawall

A **seawall** is a hard structure constructed parallel to the coastline that reduce the effects of strong waves and to defend the coast around a town from sea erosion.

Groins

Groins are impermeable structures that fingerlike, perpendicularly to the shore which extend from backshore into the littoral zone. This type of structure is easy to construct from a variety of materials such as wood, rock or concrete, steel, bamboo (Timber) and normally used on sandy coasts.

Revetments

Revetments are another type of hard structure of stone, concrete built parallel to the sea or at the front of a beach to protect the slope against wave or current–induced erosion.

Beach Nourishment

Beach nourishment is one of the most popular soft engineering techniques of coastal defense management schemes. Mainly, Beach Nourishment is the addition of sand and sediment to a beach to replace sand and sediment that has been eroded away. It involves the transport of the "nourishment material" from one area to the affected areas. The replacement sand is usually dredged up offshore and transported to the beach. Offshore sand is almost always much finer grained and muddier, therefore it erodes very quickly

Sand dune Stabilization

Mainly, coastal sand dune are of vital importance in providing natural protection to beaches and backshore areas from infrequent severe storms. Another way is Vegetation: it can be used to encourage dune growth by trapping and stabilizing blown sand.

WATERSHED MANAGEMENT

The maintaining (land use practice-includes both soil and water conservation (also controlling anthropogenic pollution activities)) of water draining through a common point and ultimately recharged in a basin (check dam, reservoir, ponds, underground) is termed as watershed management. Watershed management has been thus proposed to meet the needs of water of our society.

A watershed, also called a drainage basin or catchment area, is defined as an area in which all water flowing into it goes to a common outlet.

A Topographically Delineated Area that is drained by a Stream System.

Types of watershed

Watersheds is classified depending upon the size, drainage, shape and land use pattern.
1) Macro watershed (>50,000Hect)
2)Sub-watershed (10,000to50,000Hect)
3)Milli-watershed (1000to10000Hect)
4)Micro watershed (100to1000Hect)
5) Mini watershed (1-100 Hect)

Importance of watershed management

Watershed management helps to control pollution of the water and other natural resources in the watershed by identifying the different kinds of pollution present in the watershed and how those pollutants are transported, and recommending ways to reduce or eliminate those pollution sources.

Watershed management planning comprehensively identifies those activities that affect the health of the watershed and makes recommendations to properly address them so that adverse impacts from pollution are reduced.

It is to protect and improve the water quality and other natural resources in a watershed.

Components of watershed management

Entry point activity (EPA) - introducing development program to the community is the foremost activity done after the site selection

Land and water conservation practices- soil and water conservation practices are the primary step of watershed management program. Conservation practices can be divided into two main categories:

1) *in-situ* and 2) *ex-situ* management.

Contour bunds, graded bunds, field bunds, terraces building, broad bed and furrow practice and other soil-moisture conservation practices, are known as in-situ management.

Construction of check dam, farm pond, gully control structures, pits excavation across the stream channel is known as *ex-situ* management.

Floods and their control

Different measures have been adopted to reduce the flood losses and protect the flood plains. Depending upon the nature work, Flood protection and flood management measures may be broadly classified as under:

(a) Engineering / Structural Measures

(b) Administrative / Non-Structural Measures

Engineering /Structural Measures

The engineering measures for flood control which bring relief to the flood prone areas by reducing flood flows and thereby the flood levels are –

(a) An artificially created reservoir behind a dam across a river

(b) A natural depression suitably improved and regulated, if necessary or

(c) By diversion of a part of the peak flow to another river or basin, where such diversion would not cause appreciable damage.

(d) By constructing a parallel channel bye passing a particular town/reach of the river prone to flooding.

The engineering methods of flood protection, which do not reduce the flood flow but reduce spilling, are:

(i) Embankments which artificially raise the effective river bank and thereby prevent spilling and

(ii) Channel and drainage improvement works, which artificially reduce the flood water level so as to keep the same, confined within the river banks and thus prevent spilling.

Different aspects of some of the important measures for flood management are enumerated below

Reservoirs

Reservoirs can moderate the intensity and timing of the incoming flood. They store the water during periods of high discharges in the river and release it after the critical high flow condition is over, so as to be ready to receive the next wave. Their effectiveness in moderating floods would depend on the reservoir capacity available at that time for absorbing the flood runoff and their proximity to the likely damage center.

Embankments

Embankments (including ring bunds and town protection works) confine the flood flows and prevent spilling, thereby reducing the damage. These are generally cheap, quick and most popular method of flood protection and have been constructed extensively in the past.

Channel Improvement

The method of improving the channel by improving the hydraulic conditions of the river channels by desilting, dredging, lining etc., to enable the river to carry its discharges at lower levels or within its banks has been often advocated but adopted on a very limited extent because of its high cost and other problems.

Drainage Improvement

Surface water drainage congestion due to inadequacy of natural or artificial drainage channels to carry the storm water discharge within a reasonable period causes damages. It is often difficult to distinguish between flood and drainage congestion situations. This problem is rather acute in Andhra Pradesh, Bihar, Haryana, Punjab, Orissa, Uttar Pradesh, Assam and West Bengal, J&K, Gujarat and Tamilnadu. Therefore, improvement of drainage by construction of new channels or improvement in the discharge capacity of the existing drainage system is recommended as an integral part of the flood management programme in the country.

Diversion of Flood Waters

Diversion of flood waters takes a part of the flood discharge to another basin or to the same basin downstream of the problem area or to a depression where it could be stored for subsequent release.

Watershed Management

The watershed management measures include developing and conserving the vegetative and soil covers and also to undertake structural works like check-dams, detention basins, and diversion channels, etc. In the watershed management of upper catchment, land treatment through afforestation and grass land development practices should be supplemented by structural works for retarding the water velocity and arresting silt.

The administrative methods endeavor to mitigate the flood damages by;

(a) Facilitating timely evacuation of the people and shifting of their movable property to safer grounds by having advance warning of incoming flood i.e. flood forecasting, flood warning in case of threatened inundation

(b) Discouraging creation of valuable assets/settlement of the people in the areas subject to frequent flooding i.e. enforcing flood plain zoning regulation.

Providing absolute protection to all flood prone areas against all magnitude of floods is neither practically possible nor economically viable. Such an attempt would involve stupendously high cost for construction and for maintenance. Hence a pragmatic approach in flood management is to provide a reasonable degree of protection against flood damages at economic cost through a combination of structural and non-structural measures.

Drainage Patterns -Parameters and Development

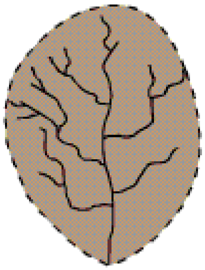
Drainage systems, also known as river systems, are the **patterns** formed by the streams, rivers, and lakes in a particular **drainage** basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land.

Drainage pattern to its network of stream channels and tributaries as determined by local geologic factors. Drainage patterns or *nets* are classified on the basis of their form and texture. Their shape or pattern develops in response to the local topography and subsurface geology. Drainage channels develop where surface runoff is enhanced and earth materials provide the least resistance to erosion. The texture is governed by soil infiltration, and the volume of water available in a given period of time to enter the surface.

Types of Drainage patterns

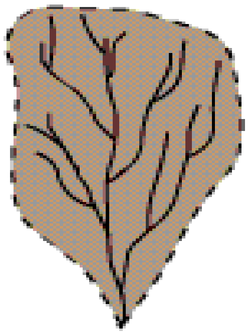
Dendritic drainage pattern

A dendritic drainage pattern is the most common form and looks like the branching pattern of tree roots. It develops in regions underlain by homogeneous material. That is, the subsurface geology has a similar resistance to weathering so there is no apparent control over the direction the tributaries take. Tributaries joining larger streams at acute angle (less than 90 degrees).



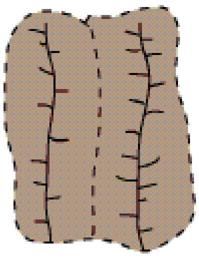
Parallel drainage pattern

Parallel drainage patterns form where there is a pronounced slope to the surface. A parallel pattern also develops in regions of parallel, elongate landforms like outcropping resistant rock bands. Tributary streams tend to stretch out in a parallel-like fashion following the slope of the surface. A parallel pattern sometimes indicates the presence of a major fault that cuts across an area of steeply folded bedrock. All forms of transitions can occur between parallel, dendritic, and trellis patterns.



Trellis Drainage Pattern

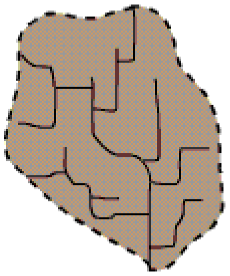
Trellis drainage patterns look similar to their namesake, the common garden trellis. Trellis drainage develops in folded topography like that found in the Appalachian Mountains of North America. Down-turned folds called synclines form valleys in which resides the main channel of the stream. Short tributary streams enter the main channel at sharp angles as they run down sides of parallel ridges called anticlines. Tributaries join the main stream at nearly right angles.



Rectangular Drainage Pattern

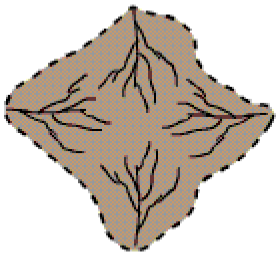
The rectangular drainage pattern is found in regions that have undergone faulting. Streams follow the path of least resistance and thus are concentrated in places were exposed rock is the weakest. Movement of the surface due to faulting off-sets the direction of the

Stream. As a result, the tributary streams make sharp bends and enter the main stream at high angles.



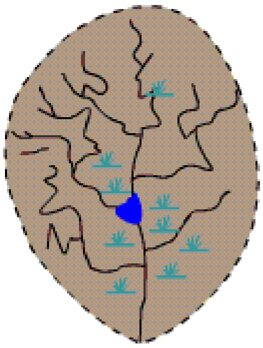
Radial Drainage Pattern

The radial drainage pattern develops around a central elevated point. This pattern is common to such conically shaped features as volcanoes. The tributary streams extend the head ward reaches upslope toward the top of the volcano.



Deranged Drainage Pattern

Deranged or contorted patterns develop from the disruption of a pre-existing drainage pattern. Figure 18.11 began as a dendritic pattern but was altered when overrun by glacier. After receding, the glacier left behind fine grain material that form wetlands and deposits that dammed the stream to impound a small lake. The tributary streams appear significantly more contorted than they were prior to glaciation.

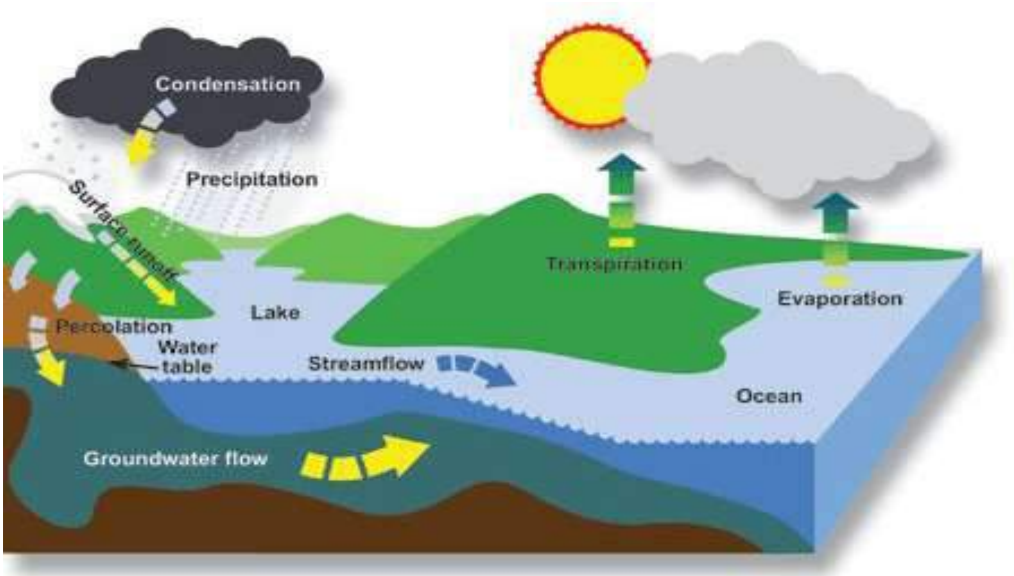


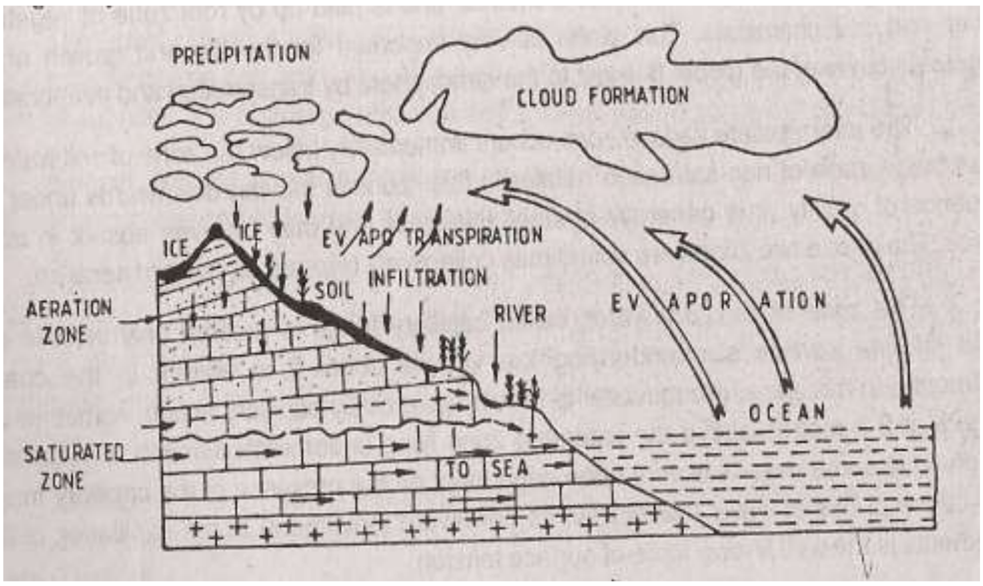
Module -4

Hydrogeology:

Hydrologic cycle

The water cycle, also known as the **hydrologic cycle** or the world's water cycle, describes the continuous movement of water on, above and below the surface of the Earth. Although the balance of water on Earth remains fairly constant over time, individual water molecules can come and go, in and out of the atmosphere. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. In so doing, the water goes through different phases: liquid, solid (ice), and gas (vapor).





<u>The stages of the cycle are</u>

1) Evaporation
2) Transpiration
3) Condensation
4) Precipitation
5) Infiltration
6) Percolation
7) Run-off

Evaporation: During part of the water cycle, the sun heats up liquid water and changes it to a gas by the process of evaporation. Water that evaporates from Earth's oceans, lakes, rivers, and moist soil rises up into the atmosphere.

Transpiration: Transpiration is the process by which plants lose water from their leaves. The water rises in to the air.

Condensation: Water vapour in the air gets cold and changes back into liquid, forming clouds. This is called condensation.

Precipitation: When the water in the clouds gets too heavy, the water falls back to the earth. This is called precipitation.

Infiltration: downward movement of water into soil.

Percolation: Rainfall seeps underground through a process called percolation, where water travels downwards through the tiny spaces between rocks and soil particles. The water eventually saturates the underlying rock much like water fills the tiny holes of a sponge. This helps to replenish aquifers under the ground.

Run-off: When rain falls on the land, some of the water is absorbed into the ground forming pockets of water called groundwater. Most groundwater eventually returns to the ocean. Other precipitation runs directly into streams or rivers. Water that collects in rivers, streams, and oceans is called runoff.

Occurrence of Groundwater in different terrains -Weathered, Hard and Stratified rocks.

The rainfall that percolates below the ground surface passes through the voids of the rocks and joints the water table. These voids are generally interred connected permitting the movements of the groundwater. Some of the rocks are not permitting the water inside, hence the mode of occurrence of ground water depends largely upon the type of formation, and hence upon the geology of the area.

The various kinds of rocks posses' variable water-bearing properties, depending chiefly on their permeability and porosity. Of the three important types of rocks, the Sedimentary rocks, generally, constitute the best aquifers, the Metamorphic rocks and especially the foliated ones, making moderate to good aquifers; and the Igneous rocks generally behaving as the poor aquifers. The various kinds of rocks and their water-bearing potentials are briefly discussed below.

SEDIMENTARY ROCKS AS AQUIFERS: - Among the Sedimentary rocks, Gravels possess the highest water retaining as well as water yielding capacities. This is truer in case of loose and weakly cemented coarse gravels. In general, next to Gravel, the other Sedimentary rocks in their successive order of decreasing water bearing capacity are; loose sand, sandstone, limestone etc. Shale (Clay) is the poorest in absorbing water, being impermeable although porous, and hence classified as aquicludes.

Among sandstones, the water-bearing capacity depends much upon their texture and nature of cementing material. Coarse-grained sandstone may be good aquifers. Whereas fine grained sandstone may prove to be the poorest aquifers.

The water-bearing capacity of limestone depends much upon the presence of solution channels, crevices, fissures and other such opening in the rock. Hence, fissured and cracks limestones may prove to be excellent aquifers and other compacted limestones may prove to be totally unproductive.

IGNEOUS ROCKS AS AQUIFERS: - The intrusive igneous rocks like granites, syenites etc., are generally very compact and dense and hence are non-porous. They are barren groundwater under normal conditions. However when they are traversed by fissures or cracks, they may be capable of holding some groundwater quantities. Even these cracks and fissures die out with depth, and as such, there is absolutely no possibility of getting any groundwater in these rocks at depths greater than 80-100mts.

The extrusive igneous rocks also exhibit great variations in their water-bearing properties. Basic igneous rocks like basalts are generally rich in cavities and contraction cracks; and as such may become permeable and sources of groundwater. Acidic igneous rocks like rhyolites may or may not contain groundwater, because such rocks although generally possess interstices, but may be filled up with ash and other material, and hence the uncertainty.

METAMORPHIC ROCKS AS AQUIFERS: - Non-foliated metamorphic rocks like Marble and Quartzite are generally impermeable, except along the original bedding, if the same is not completely destroyed during metamorphism. Foliated metamorphic rocks like Slates, Schist, Phyllites and sometimes even Gneiss may contain some good amount of Groundwater due to their being highly fractured.

Groundwater Contamination

Groundwater contamination occurs when man-made products such as gasoline, oil, road salts and chemicals get into the groundwater and cause it to become unsafe and unfit for human use.

Materials from the land's surface can move through the soil and end up in the groundwater. For example, pesticides and fertilizers can find their way into groundwater supplies over time. Road salt, toxic substances from mining sites, and used motor oil also may seep into groundwater. In addition, it is possible for untreated waste from septic tanks and toxic chemicals from underground storage tanks and leaky landfills to contaminate groundwater.

Potential Sources of Groundwater Contamination

Storage Tanks: May contain gasoline, oil, chemicals, or other types of liquids and they can either be above or below ground. There are estimated to be over 10 million storage tanks buried in the United States and over time the tanks can corrode, crack and develop leaks. If the contaminants leak out and get into the groundwater, serious contamination can occur.

Septic Systems:

Onsite wastewater disposal systems used by homes, offices or other buildings that are not connected to a city sewer system. Septic systems are designed to slowly drain away human waste underground at a slow, harmless rate. An improperly designed, located, constructed, or maintained septic system can leak bacteria, viruses, household chemicals, and other contaminants into the groundwater causing serious problems.

Uncontrolled Hazardous Waste:

In the U.S. today, there are thought to be over 20,000 known abandoned and uncontrolled hazardous waste sites and the numbers grow every year. Hazardous waste sites can lead to groundwater contamination if there are barrels or other containers laying around that are full of hazardous materials. If there is a leak, these contaminants can eventually make their way down through the soil and into the groundwater.

Landfills:

Landfills are the places that our garbage is taken to be buried. Landfills are supposed to have a protective bottom layer to prevent contaminants from getting into the water. However, if there is no layer or it is cracked, contaminants from the landfill (car battery acid, paint, household cleaners, etc.) can make their way down into the groundwater.

Chemicals and Road Salts:

The widespread use of chemicals and road salts is another source of potential groundwater contamination. Chemicals include products used on lawns and farm fields to kill weeds and insects and to fertilize plants, and other products used in homes and businesses. When it rains, these chemicals can seep into the ground and eventually into the water. Road salts are used in the wintertime to put melt ice on roads to keep cars from sliding around. When the ice melts, the salt gets washed off the roads and eventually ends up in the water.

Atmospheric Contaminants:

Since groundwater is part of the hydrologic cycle, contaminants in other parts of the cycle, such as the atmosphere or bodies of surface water, can eventually be transferred into our groundwater supplies.

GROUNDWATER PROSPECTING

The term groundwater prospecting means searching for the ground water. It not only includes to find out the places where ground water is available, but also to find out its approximate quantity and quality as well. Carrying out can do this job, what are called ground-water survey.

These groundwater surveys or investigations are extremely important in arid regions, where ground water is scarcely available. In such regions, if such surveys are not carried out in advance, and the excavation of wells is undertaken, then everything may come out to be futile, as no sufficient and good quality water may become available for obtaining the required water supplies.

Besides this problem of conducting such surveys for obtaining water supplies, another problem, which an engineer may face, is to detect whether any ground water would be encountered in underground construction operations, and the likely problems that it may create in those operations. The engineer will also have to find out the means and ways to check and control that ground water, and the problems created by it.

For both these purposes, investigations would have to be conducted to detect the presence of water at the given region or at the particular site, and to fairly estimate its quality or quantity, or both.

The very first indicator of the presence of groundwater in an arid region is the presence of plants and vegetations, especially the plants that habitually grow in arid regions only when they can send their roots down to the water table. The type of grown plants will also, to certain extent, indicate the depth of the water table. The plants may also to some extent indicate the quality of the groundwater.

The other important type of geophysical investigation, which may be performed for groundwater exploration, is called the Resistivity surveys. Resistivity surveys make use of the fact that water increases the conductivity of rocks, and thereby decreasing their resistivity. Hence, if it can be established geologically, that the same rock formation exists for a certain depth, say 100m, and by electrical testing it is found that the resistivity is decreasing below say 60m depths, then it can be easily concluded that water is present below 60m depths.

ELECTRICAL RESTIVITY METHODS

These methods are based on the principle that electrical resistivity of loose unconsolidated or partially consolidated surficial materials like the products of rock weathering and erosion such as soil loss, alluvium sand and clay is different from that of bed rock over which they are deposited. The more porous or jointed and fissured the rock lower is its electrical resistance. Thus intact igneous and metamorphic rocks in general greater resistance than sedimentary rock.

Geologic Bodies	Resistivity
Clays	200-500ohms/cm
Sedimentary Rocks	5000-10,000 Ohms/cm
Igneous Rocks	Above 10,000 Ohm/cm
Metamorphic Rocks	………do………

Equipment: - The receptivity equipment consists essentially

1). Power pack of a high voltage battery 200v as a source of current and a measuring assembly consisting of a voltmeter or potentiometer for measuring small potential difference accurately and a multi range millimeter for measuring current.

2). Four Stainless Steel metallic spikes (electrodes) about 800mm long 20m dia prod vided with heads for easy driving into the ground and clamps for cable connection.

3). Abundant stranded insulated single conductor cable of 0.5m2 conducting area. The cable is wound on portable reels.

FIELD PROCEDURE AND INTERPRETATION

In this method, four electrodes are driven into the ground in a straight line at equal distances and electric current is intruded through, two outer spikes called current electrodes, which are connected by insulated wire through a mill ammeter to a power pack. The current flows through the ground. Theoretically the current flow extends to indefinite depths but the intensity diminishes with dept. For practical purposes the current is considered to be confined within a depth approxcipamately equal to one-third the distance between the current electrodes. The current impressed into the ground is recorded by the millimeter. In homogeneous ground the lines of current flow have a definite shape independent of the medium of the distance between electrodes. As such the current penetration can be varied by varying the electrode spacing. Next, the voltage drop due to potential difference between two inner electrodes called potential electrodes is measured from the potentiometer. Restivity is then obtained by the expression

R=2P/I

R=Resistivity, P= Potential difference, I= Current applied between electrodes

The value of R so measured is only apparent resistivity of the ground as the ground is rarely homogeneous. The underground configuration of rocks is deduced by variations in the apparent resistivity obtained as a function of depth. The electrode system as a whole. The depth determined would be over the central point of electrode determined would be over the central point of electrode system. This forms the station sounded. Thus principally there are two distinct methods of resistivity determinations

a). Expanding electrodes separation techniques or Vertical Profiling

b). Lateral traversing techniques or Horizontal Profiling.

a). Expanding electrodes separation techniques or Vertical Profiling: - In this method electrode spacing is increased about a fixed central point thereby depth of current penetration is increased. If the ground is homogeneous resistivity is constant for all electrode spacing and equal to actual resistance of the geological formation. Therefore the graph of resistivity against electrode spacing would be a constant. The resistivity curve is then compared with a series of master curves, computed for various values of depth and resistivity ratio like those of master curves and depth is obtained.

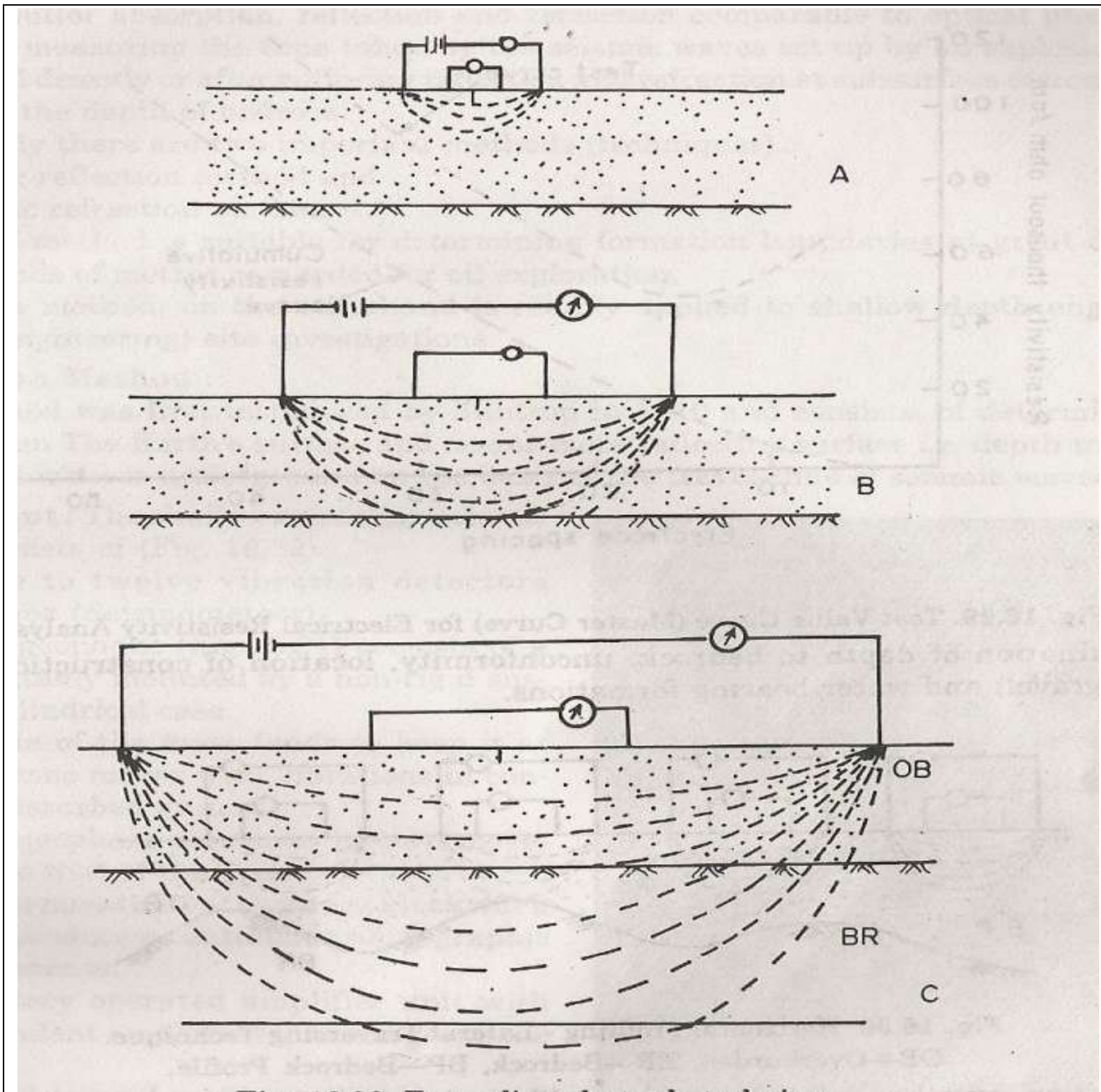
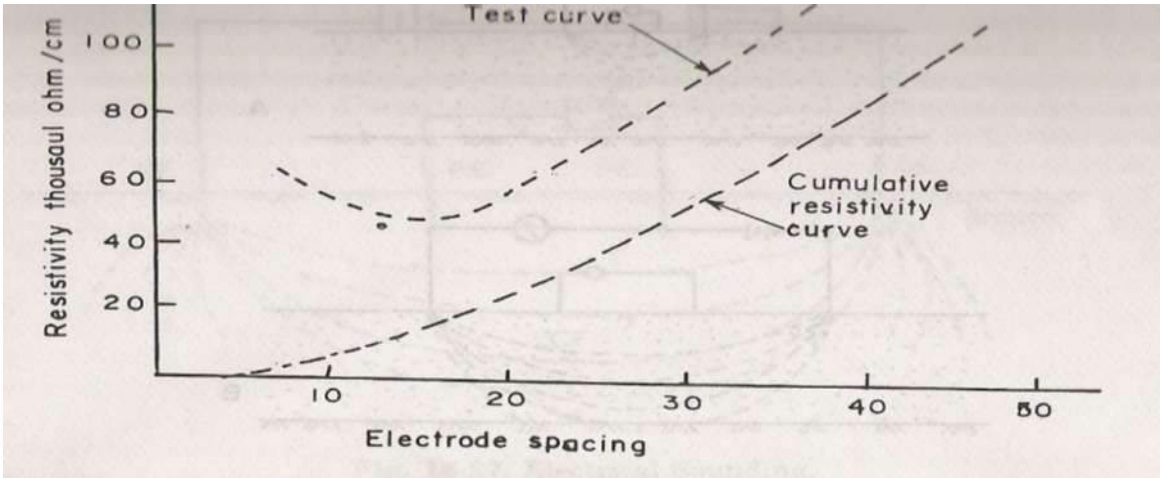


Fig. 16.28. Expanding electrode technique.
(*a*) Current flow confined to overburden, (*b*) in bedrock, (*c*) in deeper layer.



Test value curve for electrical resistivity analysis

b). Lateral traversing techniques or Horizontal Profiling.: - In this method electrode system is moved along a traverse while the electrode spacing is kept constant, i.e. the depth of penetration is kept constant and the horizontal variations or variations in depth of a given geological formation is determined. The apparent resistivity is measured at measured at successive stations along the line of traverse and plotted as ordinates against distance to obtain

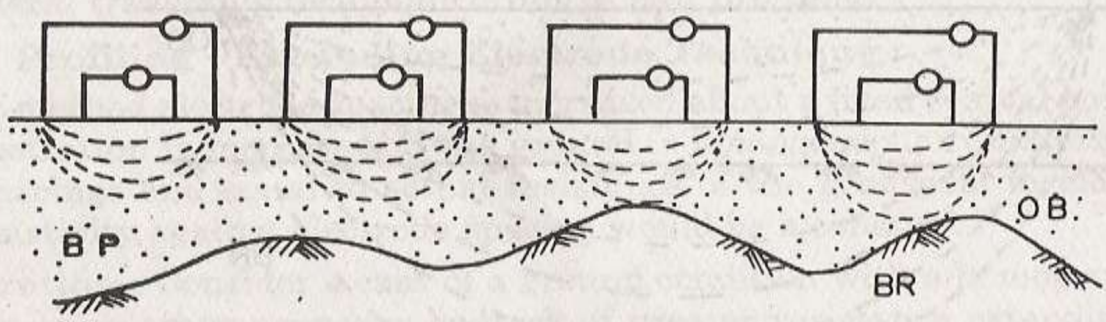


Fig. 16.30. Horizontal profiling - Lateral Traversing Technique. OB—Overburden, BR—Bedrock, BP—Bedrock Profile.

Electrical sounding methods are usually employed in engineering geology site investigations in conjunction with auger holes, trial pits, boring and core drilling in the determination of depth of bed rock, unconformity, location of construction materials (sand and Gravel) and water bearing formations.

In addition by other related techniques like using fine electrode configuration, the dip of strata concealed vertical dykes, faults etc, can be traced.

Seismic method

Seismic Prospecting: Prospecting based on the analysis of elastic waves generated in the earth by artificial means.

The elastic waves produced during sudden disturbance is called as Seismic wave. These seismic waves are recorded using the instrument, Seismograph and the record obtained is Seismogram.

It is an important geophysical prospecting applied in oil and natural gas deposits, deep ground water exploration, depth estimation, geotechnical problems.

Principles: Seismic prospecting depend upon the difference in wave velocity and transmission pattern of elastic waves through different rock formations.

The waves are generated by explosives, hammering big nails, weight dropping techniques.

Types of seismic waves:

Primary waves or longitudinal waves (P waves): High frequency, relatively low wavelength. In Solid, Liquid, Gas media. Particles- to and fro in motion

Shear waves (S waves): Relatively high frequency, relatively high wavelength. In Solid media.

Love waves (L waves): Low frequency, high wavelength, in Crust only. Responsible for earthquakes.

Propagation of seismic wave in any medium depends upon the elastic modulus and the density of the body. Only P and S waves are used for Seismic exploration purpose. The travel time gives the velocity, hence depth and structure can be determined.

TYPES OF AQUIFERS

AQUIFERS: Ground water occur in many types of Geological formations. Aquifers may be defined as a formation that contains sufficient, saturated permeable material to yield significant quantities of water to wells and springs.

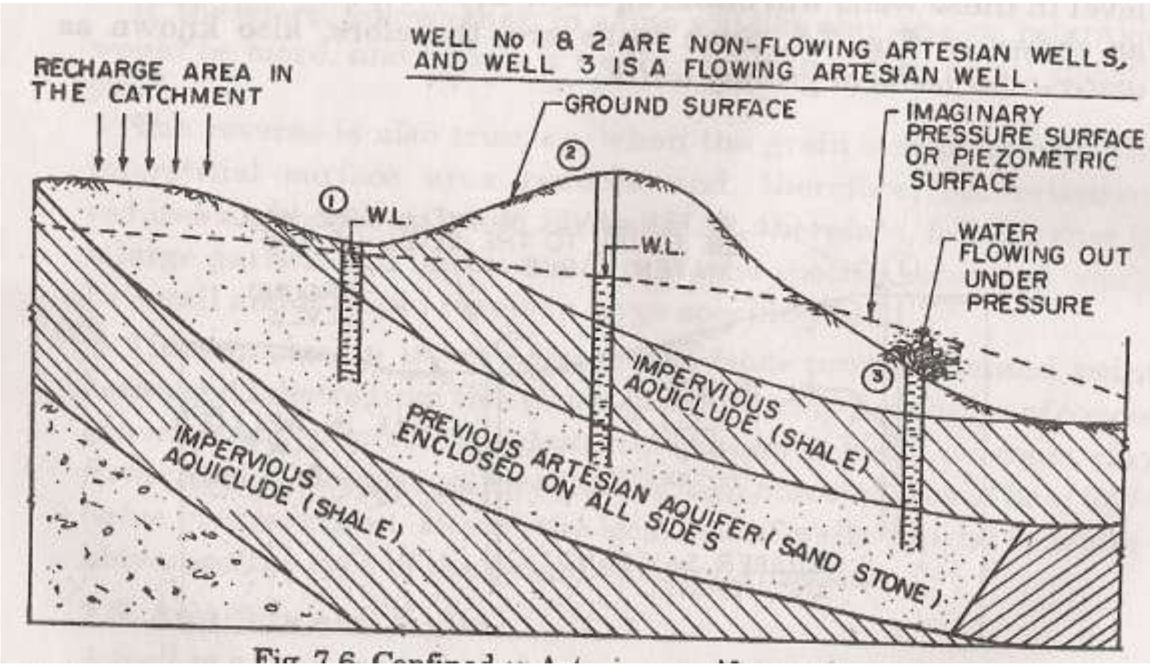
The word aquifer is derived from Latin. Aqua- means "water" and fer- means "to bear". Hence aquifer is a "water bearer".

Aquifers are generally aerially extensive and may be overlain or underlain by a confining bed. They may be defined as a relatively impermeable material stratigraphically adjacent to one or more aquifers

There are various types of confining beds.

1. Aquifers- means "water bearer".
2. Aquiclude- means "to shut or close".
3. Aquifuge- means "to drive away".
4. Aquitard- means "slow".

TYPES OF AQUIFERS



There are four types, they are

1. Unconfined aquifers (Water table aquifers):-

An unconfined aquifers is one in which a water table varies in undulating form and in slope, depending on the area of recharge and discharge, pump age from wells and permeability, rises and falls in the water table corresponds to changes in volume of water in storage within an aquifer.

2. Confined aquifers (Artesian or pressure aquifers):-

This type of aquifers occurs where ground water is confined under pressure (hydrostatic) greater than atmospheric by overlying impermeable strata. Water in wells stand above the top of the aquifer rather than storage changes. It exhibit only minor changes in storage and act as conducts from zones of recharge to those of discharge. The imaginary surface to which water rises in wells tapping an artesian aquifer is known as "PIEZOMETRIC SURFACE". A well be "free flowing" when this Piezometric levels rises above the ground surfaces. Such wells are called "Artesian wells".

3. Semi confined (Leaky) aquifers:-

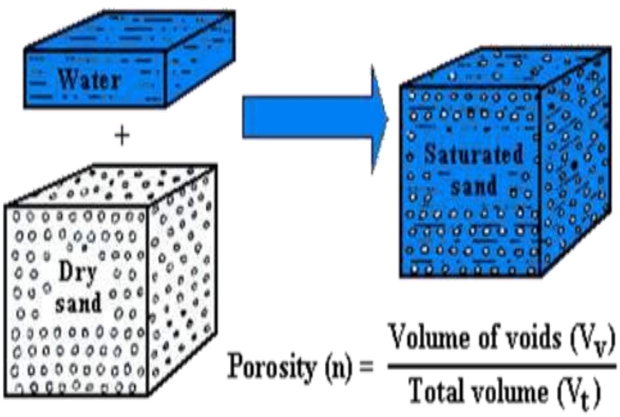
It is completely saturated aquifer bounded above by a semi pervious and below by an impervious layer. A semi pervious layer is defined as a layer which has low permeability. Lowering of piezometric levels in leaky aquifer for examples by pumping will generate a vertical flow of water semi pervious layer into the pumped aquifer. Horizontal flow component in the semi pervious layer is negligible since it is very low permeability.

4. Semi unconfined aquifer:- If the hydraulic conductivity of the semi pervious layer of the above case is very high an aquifer intermediate between semi-confined and unconfined aquifers may exit, and it is called as semi unconfined.

Aquifer parameters

Porosity

Porosity is nothing but the ratio between the total Voids or Pores to the total volume of the rock or material.



Permeability

Permeability is the ability of a formation to transmit water through its pores. It can be defined as the flow per unit cross sectional area of the formation when subjected to a unit hydraulic head per unit length of flow and has the dimension of velocity.

Specific yield

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

It can be expressed as follows;

$$\text{Specific Yield} = \frac{\text{Volume of water drained}}{\text{Total Volume of Rock or Aquifer}}$$

Specific retention

Specific Retention is the percentage (%) of total volume of the saturated Aquifer which will be held/retained in a unit volume of saturated Aquifer by molecular and surface tension forces against the force of Gravity after full Gravity Drainage.

It can be expressed as follows;

$$\text{Specific Retention} = \frac{\text{Volume of Retained Water}}{\text{Total Volume of Rock or Aquifer}}$$

Storitivity:

Storativity(S) or Storage *coefficient* is the volume of water that an Aquifer takes into storage per unit surface area of the Aquifer.

The amount of water per unit volume of a saturated formation that is stored or expelled from storage owing to compressibility of the mineral skeleton and the pore water unit change in head

Transmissibility

Amount of water that can be transmitted horizontally through a unit width by the full saturated thickness of the aquifer under a hydraulic gradient.

$T = K\, B$

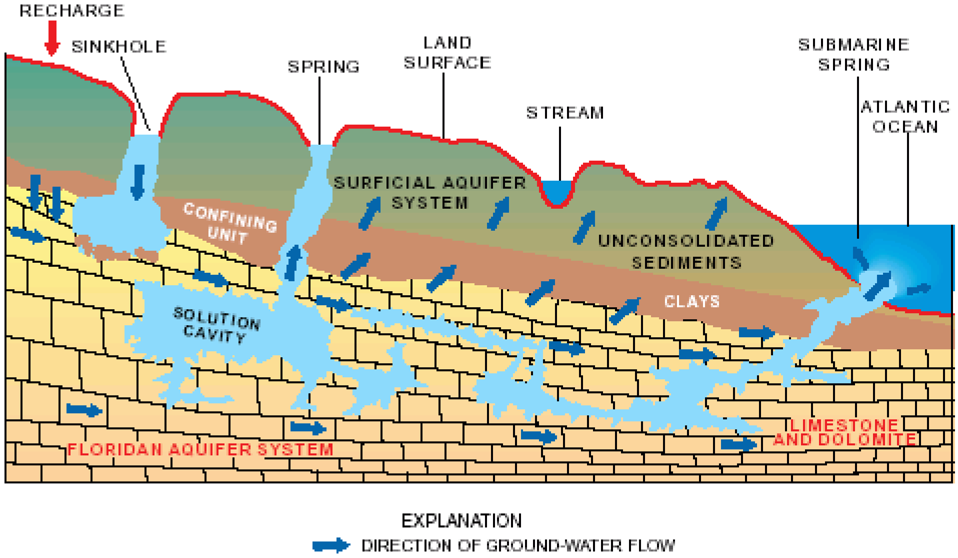
T: transmissivity (*L2/T or m2/d*)

K: hydraulic conductivity (*L/T*)

B: saturated thickness of the aquifer (*L or m*)

Springs

A spring is a water resource formed when the side of a hill, a valley bottom or other excavation intersects a flowing body of groundwater at or below the local water table, below which the subsurface material is saturated with water. A spring is the result of an aquifer being filled to the point that the water overflows onto the land surface. They range in size from intermittent seeps, which flow only after much rain, to huge pools flowing hundreds of millions of gallons daily.

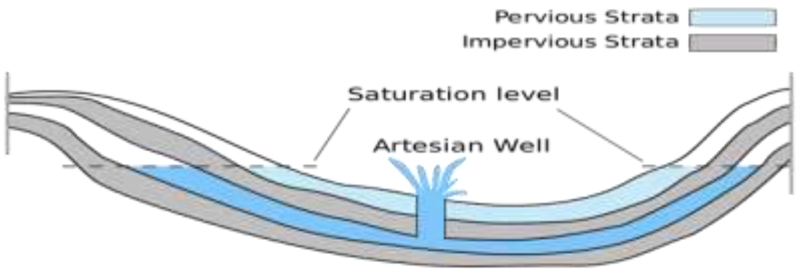


Springs may be formed in any sort of rock. Small ones are found in many places. In Missouri, the largest springs are formed in limestone and dolomite in the karst topography of the Ozarks. Both dolomite and limestone fracture relatively easily. When weak carbonic acid (formed by rainwater percolating through organic matter in the soil) enters these

fractures it dissolves bedrock. When it reaches a horizontal crack or a layer of non-dissolving rock such as sandstone or shale, it begins to cut sideways. As the process continues, the water hollows out more rock, eventually admitting an airspace, at which point the spring stream can be considered a cave. This process often takes tens to hundreds of thousands of years to complete.

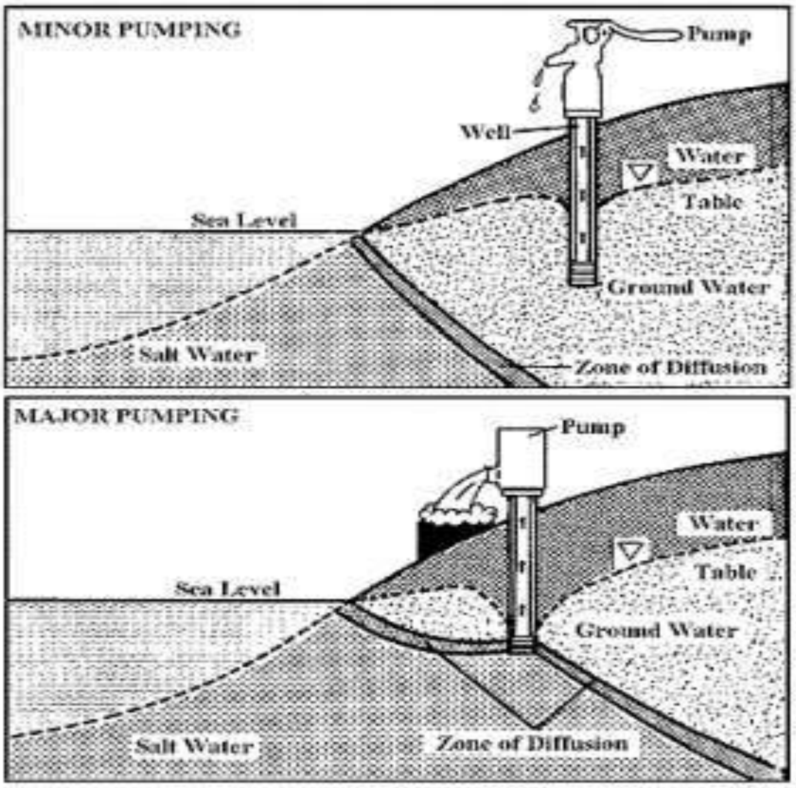
Artesian wells

If water reaches the ground surface under the natural pressure of the aquifer, the **well** is called a flowing **artesian well**. An aquifer is a geologic layer of porous and permeable material such as sand and gravel, limestone, or sandstone, through which water flows and is stored.



Seawater intrusions in groundwater

When groundwater levels in aquifers are depleted faster than they can recharge. This is directly related to the position of the interface and determines the amount of saltwater that can intrude into the freshwater aquifer system. Since saltwater intrusion is directly related to the recharge rate of the groundwater, this allows for other factors that may contribute to the encroachment of seawater into the freshwater aquifers. Climatic variables, such as precipitation, surface runoff, and temperature can play a big role in affecting saltwater intrusion. With lower precipitation amounts and warmer temperatures, the recharge rate will be much less due to lack of groundwater present and increased evaporation (Ranjan, 2007). Along with this, other factors may influence the groundwater recharge rate indirectly. An example of this would be the rising carbon dioxide emissions in the atmosphere. Increasing carbon dioxide levels can lead directly to an increase in average surface temperatures, indirectly increasing the evaporation rate and affecting the recharge of freshwater into the coastal aquifers. Figure illustrates a situation where major pumping of well water has lead to a cone of depression in the water table. Figure 4 illustrates a situation where major pumping of the well water has lead to a cone of depression in the water table. When this occurs, it will move the saltwater freshwater interface inland, resulting in a higher saline concentration in the aquifers' water, rendering it useless for human consumption, unless it is treated.



Remedial measures of Seawater intrusions

The coastal aquifers have to be managed carefully and cautiously to avoid problems like sea water intrusion and land subsidence. For this, detailed studies and regular monitoring are required.

• The aquifer geometry, distribution of the fresh water and saline water in the system has to be studied in detail.

• Constant monitoring of the pumping, movement of the fresh water saline water interface are to be carried out.

• Tidal influence into the aquifer has to be studied in detail and is to be monitored periodically.

• Safe yield of the aquifer has to be evaluated and accordingly the extraction has to be restricted.

• Remedial measures have to be done wherever sea water intrusion has taken place.

• Finding alternate source of water or other suitable remedial measure wherever serious ground water problem exists.

• Impose restriction for ground water withdrawal along over exploited, critical and other problem areas.

• Mass awareness/ mass interaction programmes shall be conducted to educate the masses and also to understand their problems.

• Preparing a policy document for the judicial and equitable distribution of the resource.

Artificial Recharge of Ground Water

The artificial recharge to ground water aims at augmentation of ground water reservoir by modifying the natural movement of surface water utilizing suitable civil construction techniques. Artificial recharge techniques normally address to following issues -

(i) To enhance the sustainable yield in areas where over-development has depleted the aquifer.

(ii) Conservation and storage of excess surface water for future requirements, since these requirements often changes within a season or a period.

(iii) To improve the quality of existing ground water through dilution.

(iv) To remove bacteriological and other impurities from sewage and waste water so that water is suitable for re-use.

The basic purpose of artificial recharge of ground water is to restore supplies from aquifers depleted due to excessive ground water development.

Artificial Recharge Techniques and Designs

A wide spectrum of techniques are in vogue to recharge ground water reservoir.

Similar to the variations in hydrogeological framework, the artificial recharge techniques too vary widely. The artificial recharge techniques can be broadly categorized as follows:-

a. Direct surface techniques

· Flooding

· Basins or percolation tanks

· Stream augmentation

· Ditch and furrow system

· Over irrigation

b. Direct sub surface techniques

· Injection wells or recharge wells

· Recharge pits and shafts

· Dug well recharge

· Bore hole flooding

· Natural openings, cavity fillings.

c. Combination surface – sub-surface techniques

- Basin or percolation tanks with pit shaft or wells.

d. Indirect Techniques

- Induced recharge from surface water source.
- Aquifer modification.

Module -5:

Geodesy

Topographical Maps

A map of a small area drawn on a large scale depicting detailed surface features both natural and man-made. Relief in this map is shown by contours.

You know that the map is an important geographic tool. You also know that maps are classified on the basis of scale and functions. They serve the purpose of base maps and are used to draw all the other maps. Topographical maps, also known as general purpose maps, are drawn at relatively large scales. These maps show important natural and cultural features such as relief, vegetation, water bodies, cultivated land, settlements, and transportation networks, etc.

These maps are prepared and published by the National Mapping Organization of each country. For example, the Survey of India prepares the topographical maps in India for the entire country. The topographical maps are drawn in the form of series of maps at different scales. Hence, in the given series, all maps employ the same reference point, scale, projection, conventional signs, symbols and colors.

The topographical maps of India are prepared on 1 : 10,00,000, 1 : 250,000, 1 : 1,25,000, 1 : 50,000 and 1: 25,000 scale providing a latitudinal and longitudinal coverage of 4° x 4°, 1° x 1°, 30' x 30', 15' x 15' and 5' x 7' 30", respectively.

Reading of Topographical Maps: The study of topographical maps is simple. It requires the reader to get acquainted with the legend, conventional sign and the colors shown on the sheets. The conventional sign and symbols depicted on the topographical sheets are shown below

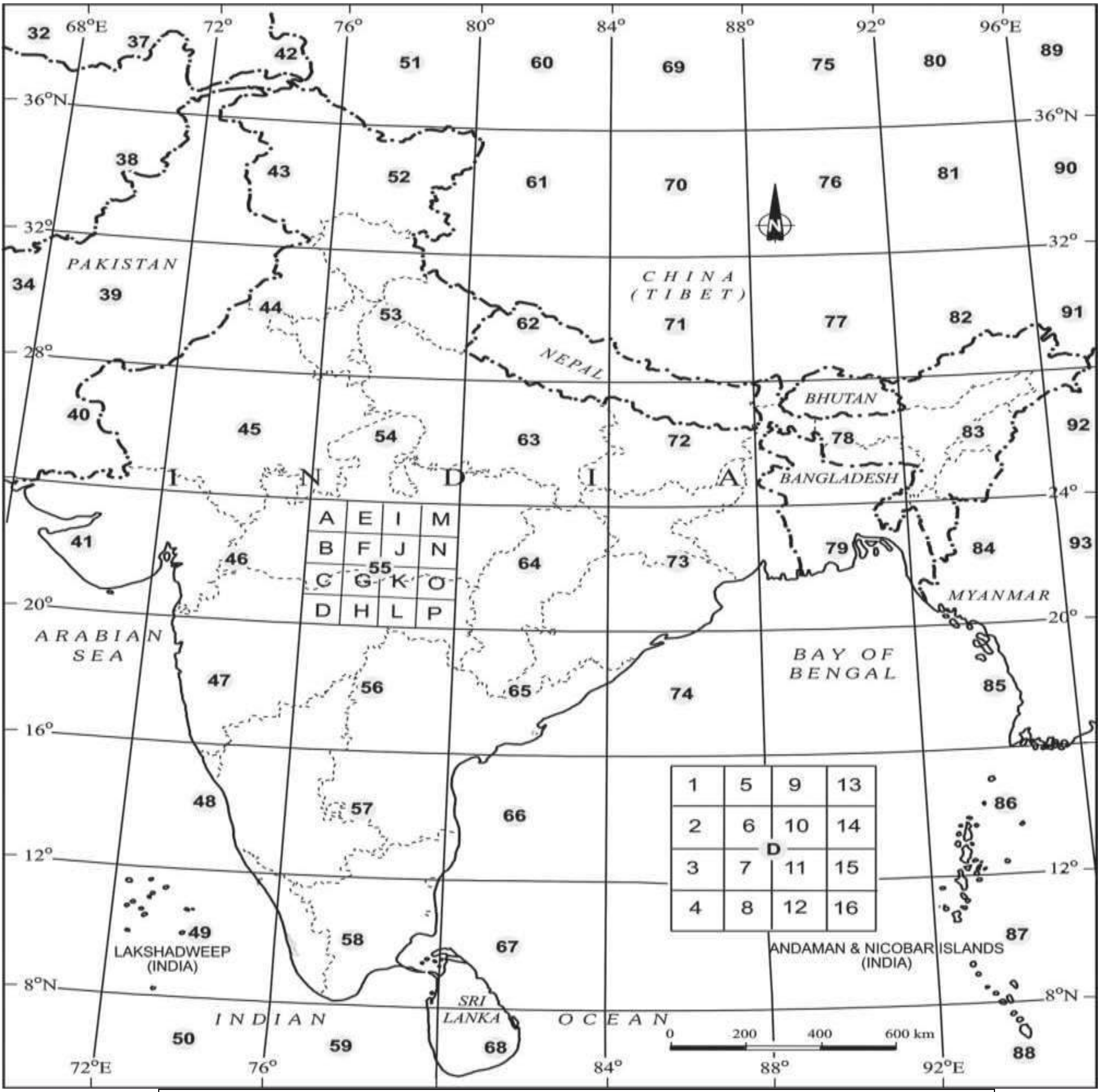
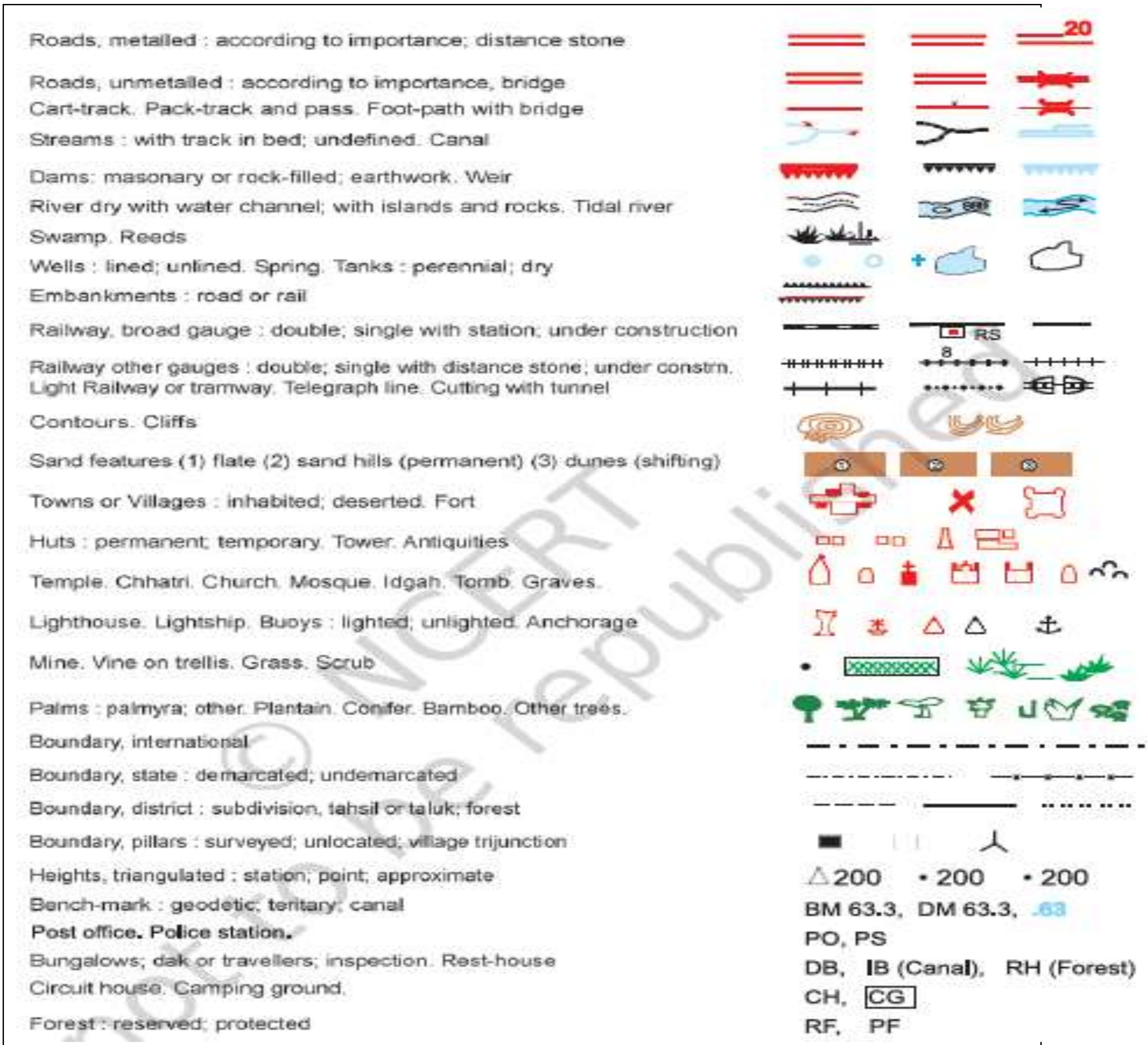


Figure 5.1 Reference Map of Topographical Sheets Published by Survey of India



Contours Maps

Contours are imaginary lines joining places having the same elevation above mean sea level. A map showing the landform of an area by contours is called a *contour map*. The method of showing relief features through contour is very useful and versatile. The contour lines on a map provide a useful insight into the topography of an area.

Earlier, ground surveys and levelling methods were used to draw contours on topographical maps. However, the invention of photography and subsequent use of aerial photography have replaced the conventional methods of surveying, levelling and mapping. Henceforth, these photographs are used in topographical mapping. Contours are drawn at different vertical intervals (VI), like 20, 50, 100 metres above the mean sea level. It is known as *contour interval*. It is usually constant on a given map. It is generally expressed in meters. While the vertical interval between the two successive contour lines remains constant, the horizontal distance varies from place to place depending upon the nature of slope. The horizontal distance, also known as the *horizontal equivalent* (HE), is large when the slope is gentler and decreases with increasing slope gradient.

Some basic features of contour lines are

° A contour line is drawn to show places of equal heights.

° Contour lines and their shapes represent the height and slope or gradient of the landform.

° Closely spaced contours represent steep slopes while widely spaced contours represent gentle slope.

° When two or more contour lines merge with each other, they represent features of vertical slopes such as cliffs or waterfalls.

° Two contours of different elevation usually do not cross each other.

REMOTE SENSING

"The art, science, and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring and interpreting imagery and digital representations of energy patterns derived from non-contact sensor systems".

According to India's National Remote Sensing Agency- "Remote Sensing is the technique of acquiring information about objects on the earth's surface without physically coming into contact with them".

Principles of remote sensing

1. Detection and discrimination of objects or surface features means detecting and recording of radiant energy reflected or emitted by objects or surface.

2. Different objects return different amount of energy in different bands of the electromagnetic spectrum, incident upon it.

3. Depend upon the property of material (physical, structural, and chemical), surface roughness, angle of incidence, intensity, and wavelength of radiant energy.

Stages in remote sensing

1. Energy Source or Illumination (A)

2. Radiation and the Atmosphere (B)

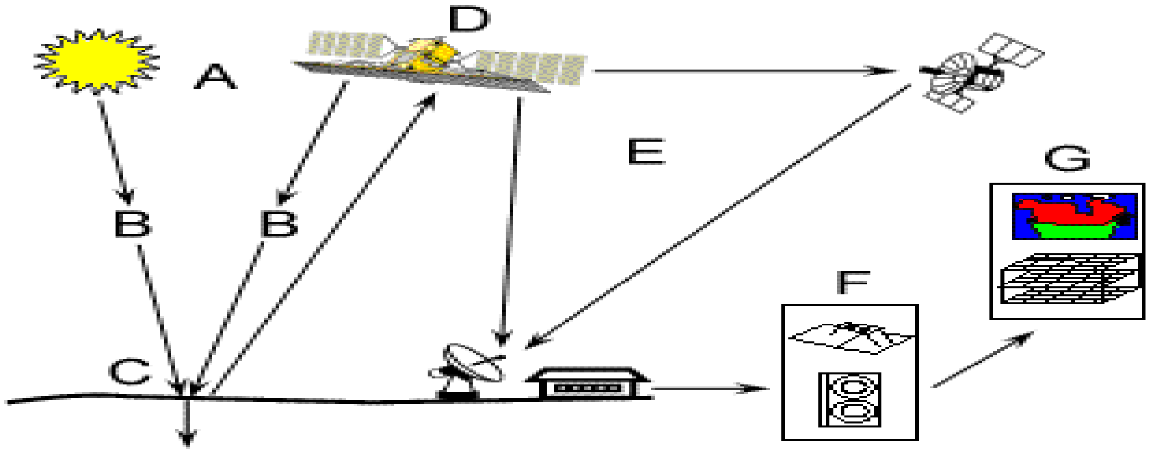
3. Interaction with the Target (C)

4. Recording of Energy by the Sensor (D)

5. Transmission, Reception, and Processing (E)

6. Interpretation and Analysis (F)

7. Application (G)



1. Energy Source or Illumination (A)

The first requirement for remote sensing is to have an energy source to illuminate the target (unless the sensed energy is being emitted by the target). This energy is in the form of electromagnetic radiation.

Energy Interactions with Atmosphere

As the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through.

3. Interaction with the Target (C)

Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface.

4. Recording of Energy by the Sensor (D)

After the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

Transmission, Reception, and Processing

The energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F)

The processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

7. Application (G)

i.Geology: geological mapping;

ii.Hydrology: monitoring wetlands and snow cover;

iii.Agriculture: crop type identification, crop condition monitoring, soil moisture measurement, and soil tillage and crop residue identification;

iv.Forestry: clear-cuts and linear features mapping, biomass estimation, species identification and fire scar mapping;

v.Oceanography: sea ice identification, coastal wind field measurement, and wave slope measurement.

vi.Shipping: for ship detection and classification.

Coastal Zone: for shoreline detection, substrate mapping, slick detection and general vegetation mapping.

vii.Military/Security Applications: detecting or locating metal objects.

Limitations of Remote Sensing

i.Perhaps the greatest limitation is that its utility is often oversold.

ii.It is not a panacea that will provide all the information needed for conducting physical, biological, or a science.

iii.It simply provides some spatial, spectral, and temporal information.

Geographic Information System (GIS)

GIS stands for Geographical Information System. It is defined as an integrated tool, capable of mapping, analyzing, manipulating and storing geographical data in order to provide solutions to real world problems and help in planning for the future.

A "geographic information system" (GIS) is a computer-based tool that allows you to create, manipulate, analyze, store and display information based on its location. GIS makes it possible to integrate different kinds of geographic information, such as digital maps, aerial photographs, satellite images and global positioning system data (GPS), along with associated tabular database information (e.g., 'attributes' or characteristics about geographic features).

Components of a GIS

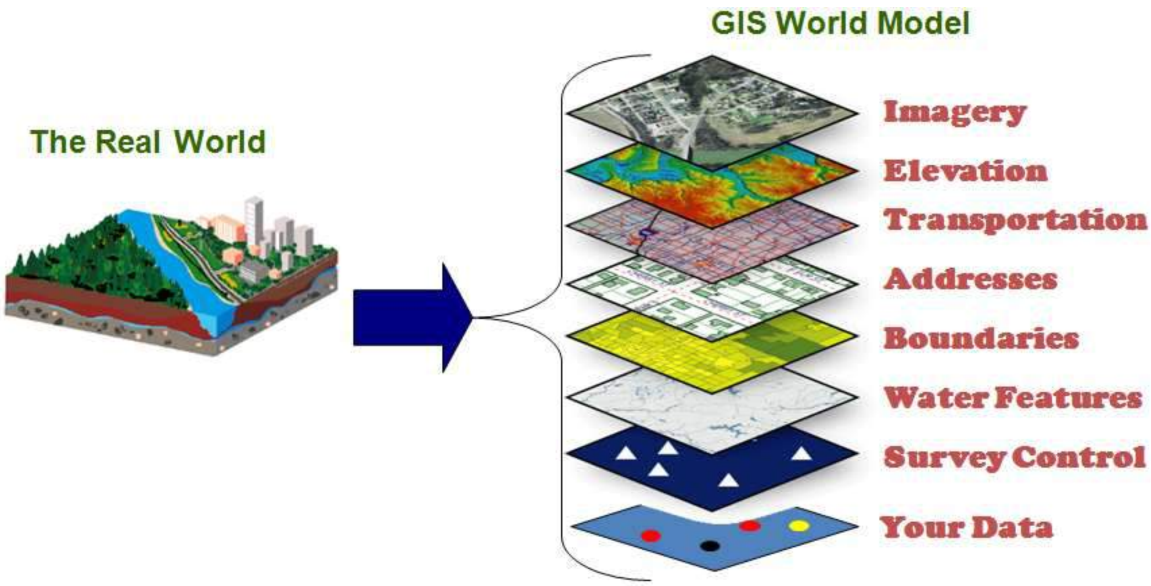
Hardware: It consists of the equipments and support devices that are required to capture, store process and visualize the geographic information. These include computer with hard disk, digitizers, scanners, printers and plotters etc.

Software: Software is at the heart of a GIS system. The GIS software must have the basic capabilities of data input, storage, transformation, analysis and providing desired outputs. The interfaces could be different for different software's. The GIS software's being used today belong to either of the category –proprietary or open source. ArcGIS by ESRI is the widely used proprietary GIS software. Others in the same category are MapInfo, Microstation, Geomedia etc. The development of open source GIS has provided us with freely available desktop GIS such as Quantum, uDIG, GRASS, MapWindow GIS etc., GIS softwares.

Data: The data is captured or collected from various sources (such as maps, field observations, photography, satellite imagery etc) and is processed for analysis and presentation.

Procedures: These include the methods or ways by which data has to be input in the system, retrieved, processed, transformed and presented.

People: This component of GIS includes all those individuals (such as programmer, database manager, GIS researcher etc.) who are making the GIS work, and also the individuals who are at the user end using the GIS services, applications and tools.



Geographic information (i.e.., land information, spatial information) is information that can be associated with a place name, a street address, section/township, a zip code, or coordinates of latitude and longitude.
A multitude of government functions require geographic information; at least 70 percent of all information used by local governments is geographically referenced. [1] For example, property records and assessment, planning and zoning, permit tracking, natural resource management, infrastructure and transportation management, economic development planning, and health and public safety.
All of these applications consider the location of certain features on the landscape in relation to other features. For instance, in assessment, the location of soil types relative to property parcels is considered, whereas in planning and zoning, the location of animal confinement facilities relative to residential areas might be relevant. A geographic information system (GIS) allows the user to examine and visualize these relationships. [2]

GIS allows you to examine and analyze geographic information at different levels of detail or from different perspectives. Then, it enables you to customize the display of your maps and analyses for presentation to particular audiences.

GIS and Coastal Management
GIS can be used for any number of coastal management applications, like improving the administration and enforcement of zoning ordinances. It can measure straight-line distances and areas, and thus determine a minimum lot width of 100 ft. and minimum lot

size of 20,000 sq. ft. as often mandated in subdivision regulations. Or, GIS can also be used to generate buffers around lines or designated areas.

The benefits of taking a GIS approach to coastal management, might include: (1) the ability to model, test, and compare alternative scenarios - before the proposed strategy is imposed on the real world; (2) the ability to handle much larger data bases and to integrate and synthesize data -- leading to a more holistic and coordinated management strategies; and (3) enhanced capacity for data exchange. [3]

GIS and Decision-Making
Local government units make countless land-related decisions. As a whole, these decisions shape the way in which land is used and the built environment is managed. GIS has tremendous potential for facilitating this decision-making process and for revealing the combined effect of incremental decisions. Indeed, many have praised GIS for its ability to provide “better information” – information that is faster, cheaper, more reliable, more readily available, and more understandable – which, in turn, might lead to “better decision-making”.

Global Positioning System (GPS)

The GPS is a satellite based navigation and surveying system for determination of precise position and time in post processing mode. It was developed by U.S Department of Defence (DOD) which revolutionized the field of modern surveying, navigation and mapping. GPS was considered as a ranging system from known positions on land, sea, air and space and an essential input for GIS. It is having a 24 hr service in all weather conditions. It can analyse upto 24 satellite orbiting at an altitude of 20,200 km. The system was replaced by NAVSTAR GPS (Navigation satellite timing and ranging GPS), launched in 1972 by US defense mapping agency.

GPS, which stands for Global Positioning System, is the only system today able to show the exact location on the Earth’s surface anytime, in any weather and anywhere.

The three parts of GPS are:

1. Satellites

2. Receivers

3. Software

THREE SEGMENTS OF THE GPS

1. Space Segment

Space Segment has 24 GPS space vehicles (SVs).Satellites orbit the earth in 12 hrs. 6 orbital planes inclined at 55 degrees with the equator. This constellation provides 5 to 8 SVs from any point on the earth.

2. Control Segment

It has 3 components

Monitor station: it accumulates ranging data from navigation segment, which transports shelters with receiver and computer and it is located in USA.

Master Control station: the accumulated data by MS's is transferred to MC's for processing in computer to provide and clock drift related to system time generating information like gravity field influencing the satellite motion.

Up-load Station: From MC's navigation messages are generated, is loaded into satellite memory and a day via ULS consists of parabolic antenna a transmitter and a computer.

They measure the distances of the overhead satellites every 1.5 seconds and send the corrected data to Master control.

3. User Segment

The user equipment consists of an antenna, a receiver, a data processor with software and control or display unit.

GPS and their use resource mapping

The surveying and mapping community was one of the first to take advantage of GPS because it dramatically increased productivity and resulted in more accurate and reliable data. Today, GPS is a vital part of surveying and mapping activities around the world.

When used by skilled professionals, GPS provides surveying and mapping data of the highest accuracy. GPS-based data collection is much faster than conventional surveying and mapping techniques, reducing the amount of equipment and labor required. A single surveyor can now accomplish in one day what once took an entire team weeks to do.

GPS supports the accurate mapping and modeling of the physical world — from mountains and rivers to streets and buildings to utility lines and other resources. Features measured with GPS can be displayed on maps and in geographic information systems (GIS) that store, manipulate, and display geographically referenced data.

Governments, scientific organizations, and commercial operations throughout the world use GPS and GIS technology to facilitate timely decisions and wise use of resources. Any organization or agency that requires accurate location information about its assets can benefit from the efficiency and productivity provided by GPS positioning.

GPS is especially useful in surveying coasts and waterways, where there are few land-based reference points. Survey vessels combine GPS positions with sonar depth soundings to make the nautical charts that alert mariners to changing water depths and underwater hazards. Bridge builders and offshore oil rigs also depend on GPS for accurate hydrographic surveys.

Aerial studies of some of the world's most impenetrable wilderness are conducted with the aid of GPS technology to evaluate an area's wildlife, terrain, and human infrastructure. By tagging imagery with GPS coordinates it is possible to evaluate conservation efforts and assist in strategy planning.

LANDSAT Imagery

Landsat. (lănd'săt') Any of various satellites **used** to gather **data** for **images** of the Earth's land surface and coastal regions. These satellites are equipped with sensors that respond to Earth-reflected sunlight and infrared radiation. The first **Landsat** satellite was launched in 1972.

Landsat Applications

Agriculture, Forestry and Range Resources	Land Use and Mapping	Geology	Hydrology	Coastal Resources	Environmental Monitoring
Discriminating vegetative, crop and timber types	Classifying land uses	Mapping major geologic features	Determining water boundaries and surface water areas	Determining patterns and extent of turbidity	Monitoring deforestation
Measuring crop and timber acreage	Cartographic mapping and map updating	Revising geologic maps	Mapping floods and flood plain characteristics	Mapping shoreline changes	Monitoring volcanic flow activity
Precision farming land management	Categorizing land capabilities	Recognizing and classifying certain rock types	Determining area extent of snow and ice coverage	Mapping shoals, reefs and shallow areas	Mapping and monitoring water pollution
Monitoring crop and forest harvests	Monitoring urban growth	Delineating unconsolidated rocks and soils	Measuring changes and extent of glacial features	Mapping and monitoring sea ice in shipping lanes	Determining effects of natural disasters
Determining range readiness, biomass and health	Aiding regional planning	Mapping volcanic surface deposits	Measuring turbidity and sediment patterns	Tracking beach erosion and flooding	Assessing drought impact
Determining soil conditions and associations	Mapping transportation networks	Mapping geologic landforms	Delineating irrigated fields	Monitoring coral reef health	Tracking oil spills
Monitoring desert blooms	Mapping land-water boundaries	Identifying indicators of mineral and petroleum resources	Monitoring lake inventories and health	Determining coastal circulation patterns	Assessing and monitoring grass and forest fires
Assessing wildlife habitat	Citing transportation and power transmission routes	Determining regional geologic structures	Estimating snow melt runoff	Measuring sea surface temperature	Mapping and monitoring lake eutrophication

Impact of Mining and Quarrying On Environment

For example the essential raw material for cement manufacture being Limestone, it has to be exploited from where it occurs. In India, only opencast mines are winning Limestone, a low cost material. To produce a tons of cement 1.5-1.6 tons of Limestone is required over 21,400 sq.m will come under mining operation every year depending upon the thickness of limestone to be exploited. Such huge operation will no doubt, leave its impact on relief and topography, hydrology, air forestry/agriculture wild life etc.

However the environmental impacts of operating the limestone mines may not be very serious as in the case of other such as chemical, fertilizer and metallurgical industries.

RELIEF AND LANDSCAPE ALTERATIONS: Mining operation and installation of various allied units will change the existing topography and will cause creation of huge pits or leveling of hills or creation of wastes heaps etc.

IMPACT ON HYDROLOGY: Mining activities in some cases may disturb the aquifer, the ground water flow and recharge capacity of the surrounding areas are affected due to change in topography.

CONTAMINATION OF WATER: Limestone mining by and large does not adversely contaminate the rain waters and ground water flowing through the exposed mine cuts but may carry fine particle of Limestone dust, which may cause silting problems, but they are non-toxic. Surface runoff from mine cuts may however be turbid during monsoons due to seepage of overburden soil etc.

AIR POLLUTION OR DUST POLLUTION: In mining air pollution is mainly caused by dust generation. Blasting is one of the pollutants as it creates fumes, dust, vibrations, air blaster, noise and fly rock fragments. The other activities such as drilling excavation, waste dumping will also cause dust nuisance. Crushing plant, conveyors and transfer points will be the other sources of dust generation.

NOISE POLLUTION: Noise may be defined as” Unwanted sound”. This implies sounds, which interfere with human communication, comfort health etc. The noise pollution in the Limestone blasting and movement of heavy earth moving equipment cause mine.

IMPACT ON FORESTRY /VEGETATION: The mining operation if carried out on hills, which are usually associated with forests and vegetation causes. Impairment (spoil) and affects climate, rainfall, soil erosion and causes in equilibrium between biotic substance and macro/microorganisms. When carried out on plains affect agriculture and grazing lands.

IMPACT ON WILDLIFE: Noise and habitation may probably cause migration of the existing wild life.

IMPACT OF HUMAN ENVIRONMENT: The impact of mining on human environment can be both beneficial and detrimental as it may provide job opportunities and overall development of the region, can also deprive some of them of their agricultural land. Sometimes it can help in water resources for water irrigation and domestic use.

VIBRATION, AIR BLAST AND NOISE CONTROL: The noise in mines is caused by blasting, movement of heavy earth moving equipment which in terms causes vibration and air blast. The following can control these: -

a). Avoiding blasting during night and foggy weather which associated with temperature inversion

b). Stemming of the blast hole properly

c). Avoid blasting when wind velocity is more than 25km/hr

d). Large scale plantation or shade giving trees also reduce the noise and Vibration level,

e). Using rock breaking, the secondary blasting (which usually produces a huge noise) can be avoided

FUMES CONTROL: ensuring complete detonation with the use of proper primers and boosters can reduce Production of blast fumes containing toxic gases. By maintaining well the engines of mining machinery the fumes from them can be controlled well.

DUST CONTROL: During mining the dust can be controlled by the following

a). DRILLING: the using suitable dust can control Dust Collector, which is also a stationary requirement.

b). BLASTING: If the topsoil is completely removed before blasting, dust generation during the same can be minimized.

c). CRUSHING: Dust can be reduced by using dust Collectors or by spraying dust suppressants including water.

d). TRANSPORTATION: Dust is generated when loaded dumpers move over unconcerned roads. This can be overcome by concreting the roads or by sprinkling water over the roads regularly.

Impacts of the reservoir

The creation of a reservoir provides a habitat for wetland species, especially water birds. The reservoir can also be a source of water to animals and plants in the adjoining areas and, where such areas have become unnaturally dry, this can be a significant environmental benefit. These benefits were not included in the cost-benefit analysis for any of the projects studied.

Impacts of backwater build-up: When a free flowing river meets the relatively static reservoir, there is a build-up of back-pressure and a resultant backwater. This can destroy the upstream ecology and cause damage to property. Backwaters can also build up due to the deposition of sediments and silt upstream of the reservoir as ‘backwater deposits’.

Impacts on aquatic ecosystems: Construction activities, including the diversion of the river through a tunnel, have major adverse impacts on the aquatic ecosystem. Vulnerable species, with either limited distribution or low tolerance, could become extinct even before the dam is completed.

Impact on terrestrial fauna and flora: The disturbance caused by construction activities, including noise and movement, building of roads, extraction of stone and soil, construction of buildings, etc. also negatively impact the fauna and flora at the dam site. As impoundment starts, the reservoir invariably submerges large tracts of forests and other ecosystems, including grasslands and wetlands.

Submergence of forests: Data was available on forest submergence for 60 dams. On the basis of these, the average forest area submerged per dam works out to approximately 4,879 ha. Therefore, the 1,877 dams built between 1980 and 2000 would have submerged 9,157,883 ha. (roughly 9.1 million ha.) of forests.

Impacts on cultivated biodiversity: Reservoirs also submerge productive agricultural land in the valley. This not only has a social and economic cost but also adversely affects cultivated biodiversity and a host of birds, insects, mammals and reptiles that have adapted to agricultural ecosystems. In many cases, traditional crop varieties and methods of cultivation disappear because of dams.