UNIT-5

K. Ganesh

:- Geophysics :-

BRANCHES OF GEOPHYSICS

Based on the aims of investigations. geophysics has two branches namely general geophysics and exploration geophysics.

General Geophysics :-

→ General geophysics comprises the investigations aimed at the study of the earth as a whole and its major surface features.

Exploration Geophysic's :-

→ Exploration geophysics deals with the geophysical investigation's made for the study of relatively shallow subsurface inhomogeneities and structures.

→ Its aim is to make specific investigation's of economic importance like exploration of oil & gas, ore deposits, ground water and for solving certain problems of engineering geology.

→ This Branch is also called geophysical prospecting 'or' applied geophysics.

Importance of Geophysical Investigation :-

Geophysical investigations are gaining importance very rapidly because of their success in solving a vast variety of problems. The other advantages are:

1. These investigations are carried out quickly. this means large area can be investigated in a Reasonably support short period & hence time is saved.
2. The geophysical instruments used in the field are simple. Portable (mostly) and can be operated easily. this means the fieldwork is not laborious.
3. since the work is carried out quickly and only physical observations are made without the use of consumables (like chemicals) it is economical too (Particularly in the case of gravity. magnetic and some electrical methods of investigations.)

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4. Different inferences to suit different purposes can be drawn from the same field data. for example. electrical resistivity data can be interpreted for knowing subsurface rock types. geological structures, ground water conditions, ore deposits, depth to the bed rock, etc. Hence the investigations are multipurpose.

5. scope to check the correctness of conclusions is possible. It can be done by employing different geophysical method's which are based on different principles and comparing the conclusions.

Applications of geophysical investigations which account for their inherent importance are as following

1. Non-geological :- detecting hidden treasures, ammunition dumps, buried pipeline patterns or pipes come under this category. such applications are not many.

2. Geological :- such applications are numerous, important & widely varied these can be broadly grouped into five kinds as follows.

(i) investigation's aimed at solving problems of regional geology.

(ii) investigation's aimed at locating geological structures which are favourable for accumulation of oil & gas.

(iii) investigations aimed at locating & estimating economically important mineral deposits.

(iv) investigations aimed at locating & assessing ground water potential and its quality

(v) investigations aimed at solving problems connected with engineering geology.

Gravity methods :-

Gravity methods represent a set of geophysical methods which make use of the natural gravity field of the earth

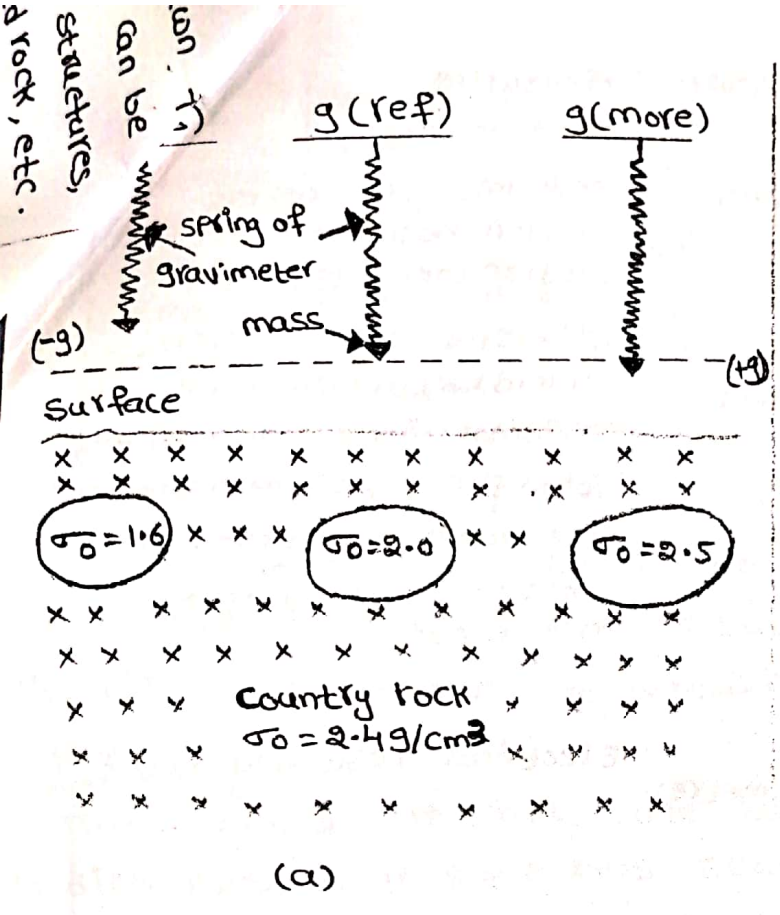
Physical property :-

"Density" property of the materials is the controlling physical property.

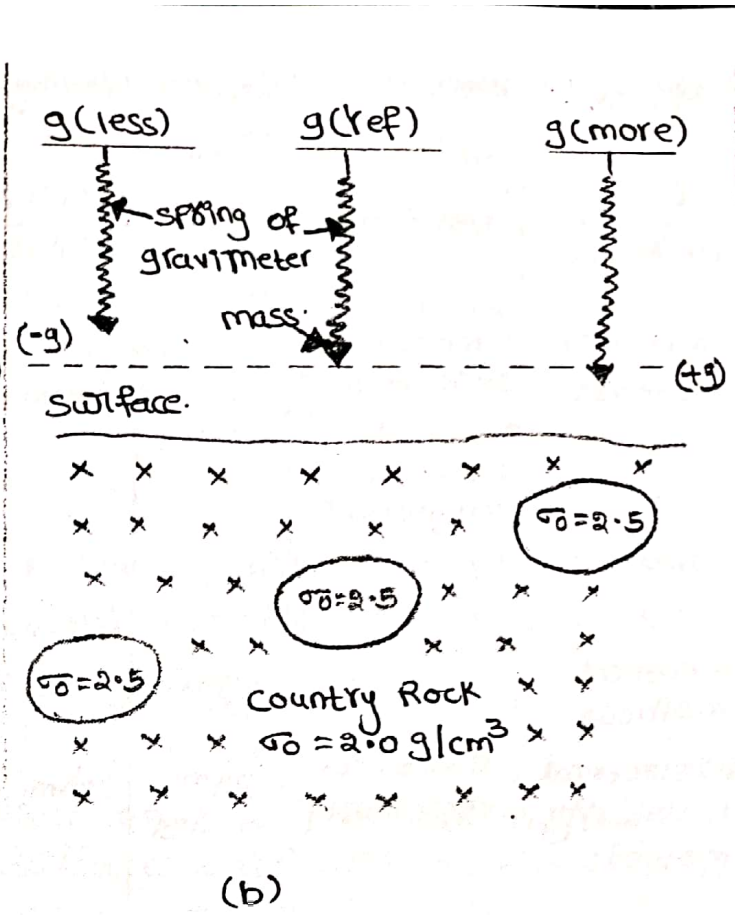
Principle :-

In gravity methods, the nature of distribution of gravity g on the surface is analysed. the gravity is influenced positively if the causative body is heavier, larger and occurs at a shallow depth.

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(a)



(b)

Fig. 15.2 (a & b) Principle of gravity method.

→ The gravimeter, used in relative gravity measurements is mass loaded spring.

→ This diagram shows illustrates the effect surface conditions.

→ If the subsurface has a relatively heavier body. the gravity pull is more there (+g). the spring extends becoming longer.

→ If the subsurface has relatively a ligher body there the gravity pull is less (-g) and the spring contracts becoming shorter.

→ The diagram illustrates the effect of depth of heavier (causative) body. If the subsurface has relatively heavier body at shallow depth the gravity effect is more (+g) there & if such a body lies. at greater depth the gravity effect is less (-g).

classification of geophysical methods

The different kinds of gravity methods that are followed during the investigations are

(i) (ground) gravity prospecting
(ii) gravity logging
(iii) airborne gravimetry
(iv) shipborne gravimetry.

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Sl. No.	Type	Physical property measured	unit (CGS system)	Geophysical unit	measuring Instruments.
1.	Gravity methods	Density	g/cc	(1) milligals (2) Eotvos units	Pendulums, gravimeters torsion balances gradientometers, etc..
2.	magnetic methods	1. magnetic susceptibility 2. natural remanent magnetism		Gammas	different magnetometers: schmidt's, ortorsion vertical/ horizontal force magnetometers, Proton precession magnetometers, flux gate magneto-meter, rubidium vapour magneto-meter, etc..
3	Electrical methods: (a) Electrical resistivity methods	Electrical resistivity	ohm metres	ohm metres	Electrical resistivity meters,
	(b) Electro-magnetic methods	Electrical conductivity	mhos metres	microvolts (in part of the primary field as %) and phase in degrees	Different electromagnetic units comprising a transmitter and a receiver with different types of oscillatory power sources and measuring devices.
	(c) self-Potential methods	Electro-chemical activity		millivolts	d.c. potentiometer.
	(d) Induced Polarization methods	Polarizability		millivolts (percentage of induced Polarization; milliseconds)	Different time domain or frequency domain instruments.
4.	seismic methods: (a) seismic reflection methods of seismic refraction methods	Elastic property (seismic wave velocity)	metres/ sec	metres / sec	multichannel (6/12/24/60) seismic instruments, single channel seismic refraction timer.
5.	Geothermal methods:	Thermal conductivity	Degrees	Degrees	Thermister thermometers, Platinum resistance thermometers, special crystal detectors, radiometers, etc.

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netric nods. , Gamma methods	Gamma ray intensity	millicurie (or) micro curie	counts per second	Different types of radiometers: Geiger-mueller counter scintillation counter, gamma ray spectorometer, etc..
(b) Emanation methods	concentration of radioactive emanation	α particles	emans (10^{-10} curie per metre)	Emanometers.

magnetic methods :-

Like gravity methods, these investigations also take advantage of the natural magnetic field associated with the earth (geomagnetic field) and its relation to subsurface geology.

Principle :-

-> The magnetic methods are based on the fact that the magnetic bodies present in the earth's subsurface contribute to the magnetic field of the earth.

-> The contribution of the magnetic body is directly proportional to the magnetic moment of the body and its size and is inversely proportional to the depth of its occurrence.

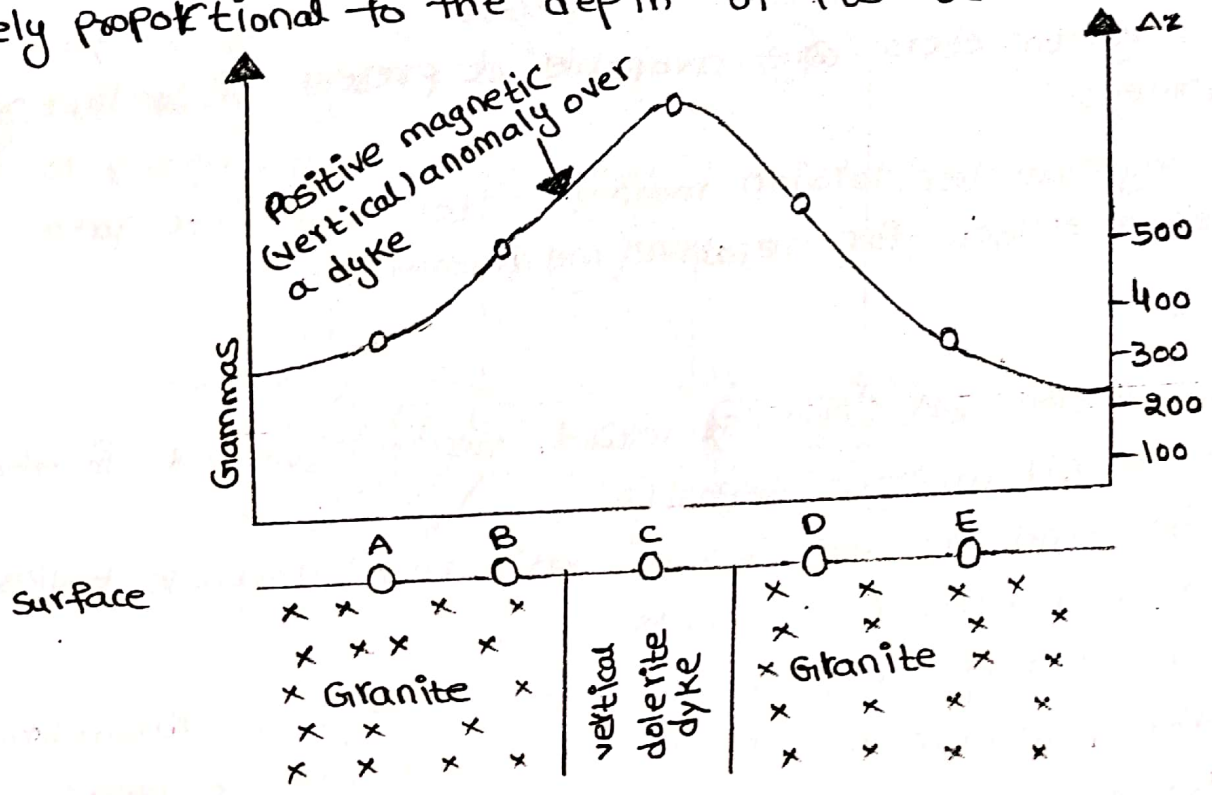


Fig. 15.3 Principle of magnetic method of prospecting

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parameters :-

The different parameters measured during magnetic investigation total magnetic field (intensity & direction) & different space components (vertical component, Z: horizontal component, H, inclination, I, & declination D).

The magnetic field is measured in terms of gamma
(1 gamma = 10^{-5} oersted)

methods :-

magnetic investigation are amenable for study not only on the ground but also from the sky or on the seas. the common method of this kind of investigations are

(i) magnetic prospecting
(ii) magnetic logging
(iii) airborne magnetometry
(iv) shipborne magnetometry.

Equipment :-

→ Different magnetometers are available at present of conducting magnetic surveys.

→ schmidt magnetometer, torsion magnetometer and flux gate manetometer are used for relative measurements.

Applications :-

1. For the delineation of large structural forms favourable for the accumulation of oil and gas deposits.
2. For detection and demarcation of basic and ultrabasic bodies
3. For location and tracing of faults.
4. For locating strongly magnetic iron ores, and under favourable conditions for locating chromite, maganese and bauxite deposite
5. In prospecting for ore bodies of copper nickel sulphides, tin, etc. If they are associated with magnetic minerals like magnetite and pyrrhotite.

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method :-

ciple :-

→ Electrical methods are based on the fact that the subsurface rmation's, structures, ore deposits, etc..

→ The process different electrical properties.

method's :-

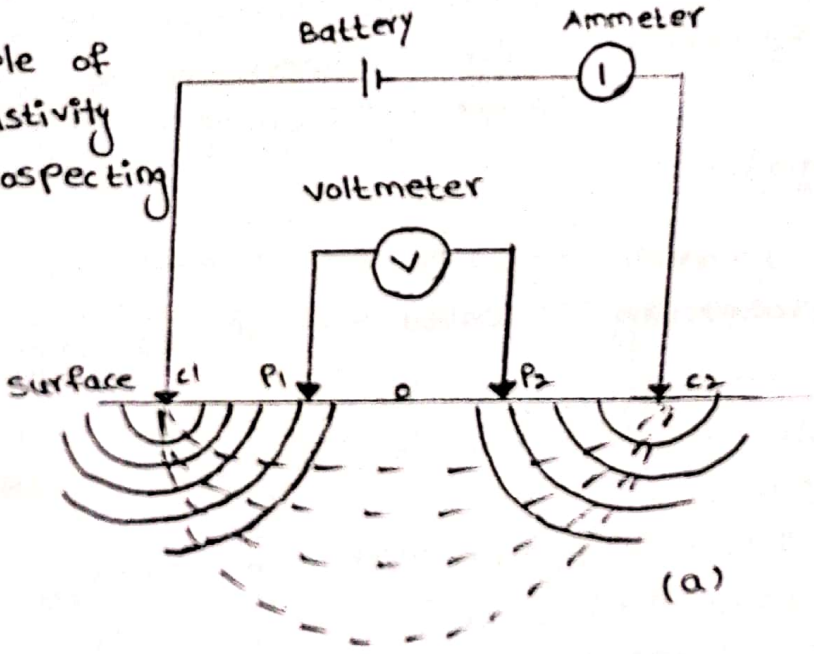
→ Electrical resistivity methods, electromagnetic methods, self-potential methods and induced polarization methods are the very important categories of electrical methods.

→ Among these methods, in self-potential methods, the natural electric field existing in an area is investigated.

Electrical Resistivity method :-

Principle :-

→ The electrical restivities of subsurface formations vary from one another. If they are inhomogeneous and are studied with the help of the resistivity method.



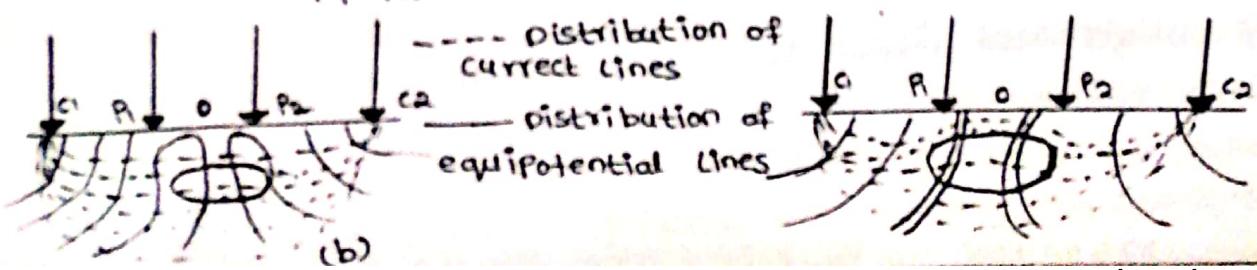
(a, b & c) Principle of electrical resistivity method of prospecting

(a)

Kingslar.

C_1 C_2 = Current electrodes

P_1 P_2 = Potential electrodes.



(b) (c)

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→ The diagram shows the pattern of distribution of current and equipo Line (with nearly equal intervals) in a homogeneous ground.
→ current is sent inside the ground through metallic electrodes C1 & C2. The potential difference is measured by non-polarising electrodes P1 & P2

Electromagnetic method :-

Principle :-

→ In this method, in principle an alternating magnetic field is established in the ground with the help of a suitable "source".
→ The electromagnetic field thus generated induces eddy currents in the conductive ore bodies in the subsurface.

methods

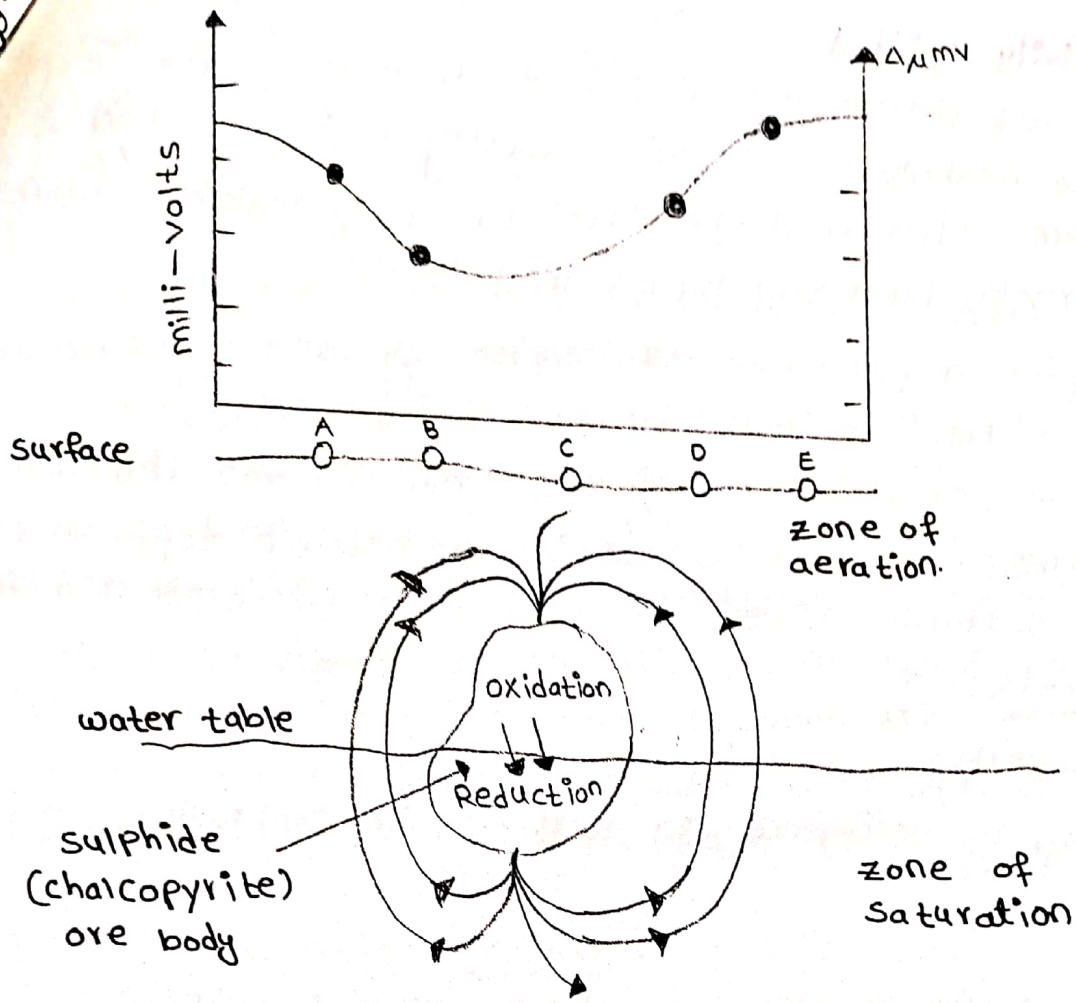
→ There are many versions of the electromagnetic methods depending upon the types of sources used for the generation of the primary field the frequency or the nature of the field employed.
→ The types of receivers, the components measured of the secondary field, the mutual geometric relations between the source and the receives etc...

Self-Potential method :-

Principle :-

→ This method of prospecting is based on the measurement of the electrical potentials naturally present in the earth
→ This method is also known as the "spontaneous polarization method" or simply as the sp method
→ several sulphide ores like pyrite, pyrhotite, chalcopyrite, molybdenite and cobaltite show spontaneous polarization.
→ Anthracite and graphite are known to give strong sp effects. the conditions the lead to the development of self-potential are shown in the diagram with reference to a sulphide body.
→ self-Potentials also develop due to filtration and diffusion - adsorption activities.
→ But these potentials are weak and do not exced a few tens of millivots. These are helpful in locating leakages from reservoirs.

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Principle of Self-Potential method of Prospecting

Induced Polarization method (IP method) :-

→ **Principle:-**

→ This method is based on the study of secondary electrochemical processes that take place in the subsurface consequent to a flow of electric current and its interruption.

→ An important type of Induced polarization effect is the electrode Polarization which take place when metallic minerals occur in a disseminated manner in a non-conductive rock matrix.

→ The direct electric current is sent into the ground, the flow of current in the aforementioned types of media will be, for a part of the time, ionic through the electrolyte in the non-conductive matrix and partly electronic through the solid conductive, mineral particles.

→ Thus at the electrolyte-conductive particle boundary, the charge is transferred from the ions in solution to the particles and vice versa.

→ on account of this, positive ionic charges pile up at the particle boundary where the current enters the particles. & negative ionic charges accumulate on the other side of the boundary.

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Electrical Resistivity method :-

1. These methods are particularly successful in ground water exploration.
2. In mining these methods are useful in Locating highly conductive bodies (like sulphide ore bodies and graphite) or highly resistant bodies (like quartz reefs, limestone bands and dykes).
3. They are helpful in petroleum exploration by locating favorable structures like anticlines, salt domes and fault traps.
4. In civil engineering projects, they are useful for the determination of the thickness of loose overburden or bedrock depth and in the selection of suitable sites for foundation of dams and bridges.

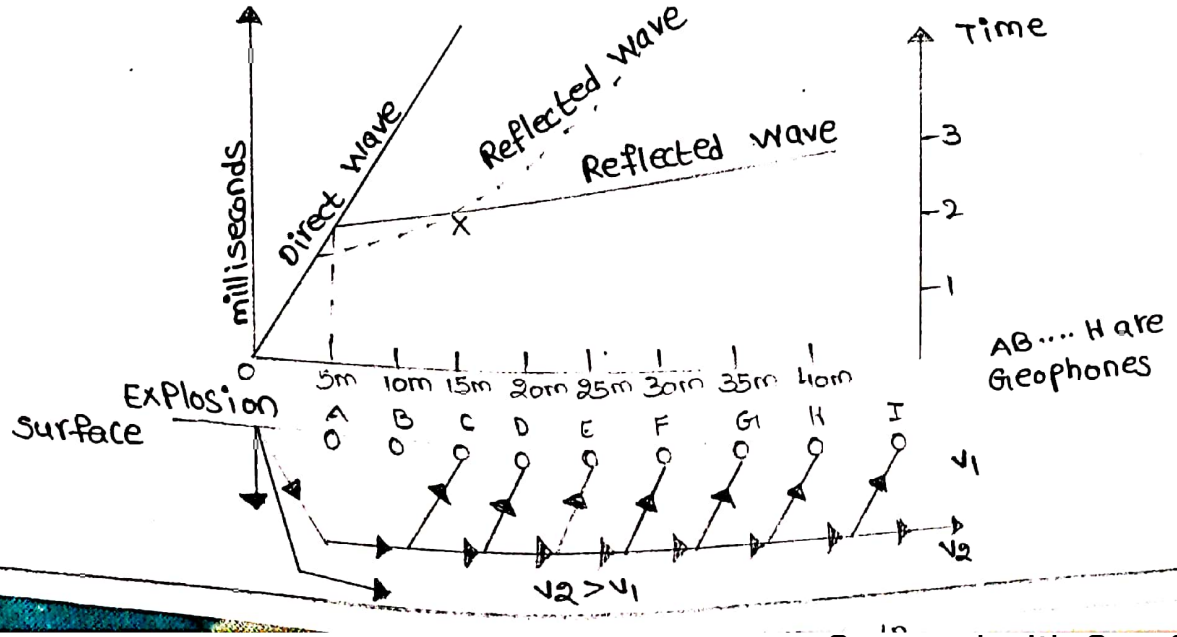
seismic methods :-

Controlling property :-

Elastic property difference in rock is the controlling property.

Principle :-

* Seismic methods of study are based on the principle that subsurface rock formations bear different elastic properties.
* Because of this the velocities of propagation of seismic waves through them change with changes in lithology.
* measurement of seismic wave velocity of Rock formation therefore provides a scope to distinguish different subsurface lithological units.
* In seismic methods, artificial explosions are made in the groun
* The seismic waves thus produced travel through the subsurface layers of the earth suffer reflection.



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Equipment :-

* OF all the geophysical instruments, those used in seismic prospecting are the most complicated and expensive
* A geophone (or-seismometer) - an amplifier - and a galvanometer are the basic units required for reflected or refracted wave registrations
* Together they make up "a seismic channel". For each is involved in seismic prospecting, provision for a number of channels is required.
* In fact, 12 or 24 channel seismic stations are quite common seismic stations will have suitable recording systems also.
* special single channel equipment, known as "seismic timer", can be economically used for solving shallow depth problems of a simple nature.

Application's of Relection methods :-

* seismic reflection studies are effective for depths more than 100m but are not suitable for shallow exploration.
* Reflection methods of study are considered indispensable in oil exploration because they are capable of revealing accurately the subsurface structures like anticlines, synclines, salt domes, faults and reefs.
* These methods are also used to locate sulphur, limestone and gypsum beds.

Refraction methods :-

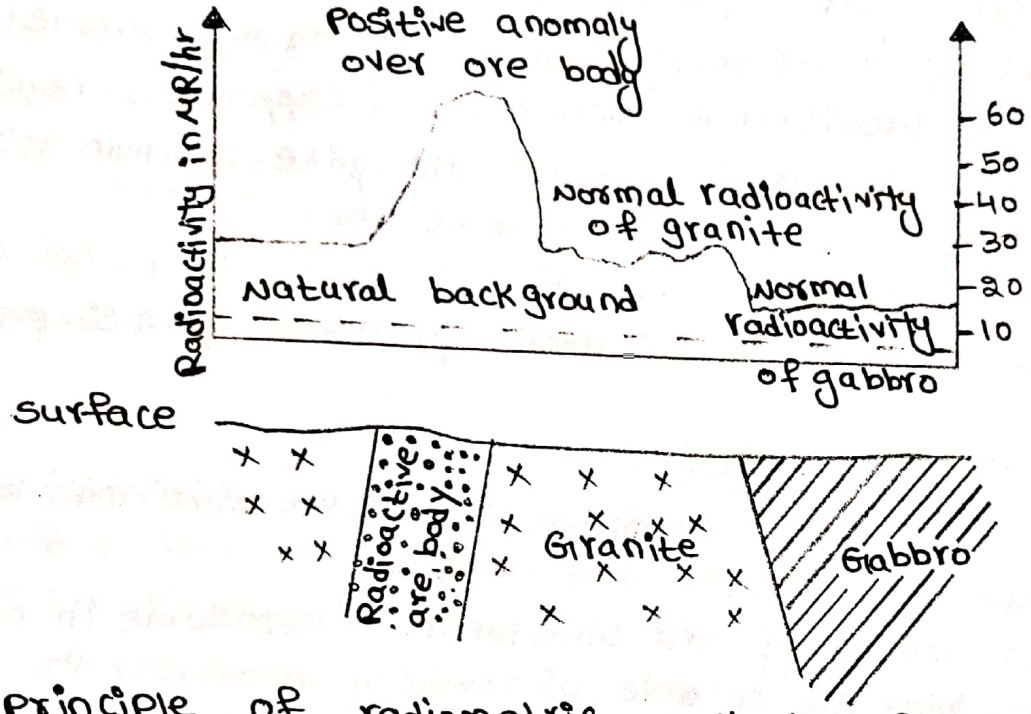
* seismic refraction methods are employed for investigating depths from close to the surface to several kilometres deep
* These methods are also followed for the investigation of deeper crustal parts under the deep seismic sounding (DSS) studies.
* Shallow seismic refraction investigations have found effective applications in investigating the suitabilities of foundation sites for civil engineering structures (such as bedrock depth studies & occurrence of the fault zone), ground water presence and even in solving mining problems.

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Radiometric methods.

Principle :-

- The nuclei of certain elements are unstable and change spontaneously into the nuclei of other elements.
- This change is accompanied by emission of radiations known as alpha and beta particles and gamma rays.
- This natural phenomenon is known as radioactivity.



Principle of radiometric method of prospecting :-

methods :-

* There are two types of natural radiometric methods, which are followed in the field, for the exploration of radioactive ores.
* They are the gamma methods and the emanation methods.
* In the gamma methods, the intensity of gamma rays from rocks and ores in an area in measured.
* In the emanation methods, the concentrations of radiactive emanations (radon and thoron) in soil/air are measured.

Equipment :-

* Instruments used in radiometric prospecting are called radiometers.
* A radiometer consist of three basic components
  (i) a detector of radiations
  (ii) an amplifying and recording unit
  (iii) a power supply unit.

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...le three types of instruments used in prospecting, namely,

...iger - muller counter.

...he scintillation counter

...) The gamma ray spectrometer.

Applications

Radiometric methods of investigation are useful in many ways, some of the important uses. are:

1) Exploration of uranium and thorium mineral deposits: This is the major application of these methods.

2) Indirect location of some rare elements and rare earth metals: zirconium, beryllium, lithium, etc., occurring in pegmatites, and tantalum, niobium, etc., occurring in alkaline rock are found to be always associated with traces of radioactive elements. This helps in their detection.

3) Geological mapping: This is possible because of the scope to distinguish different rock types, scope to locate faults, shear zones, etc, by radiometric methods.

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Unit 6

Geology of Dams, Reservoirs and Tunnels

K. Ganesh

Dams

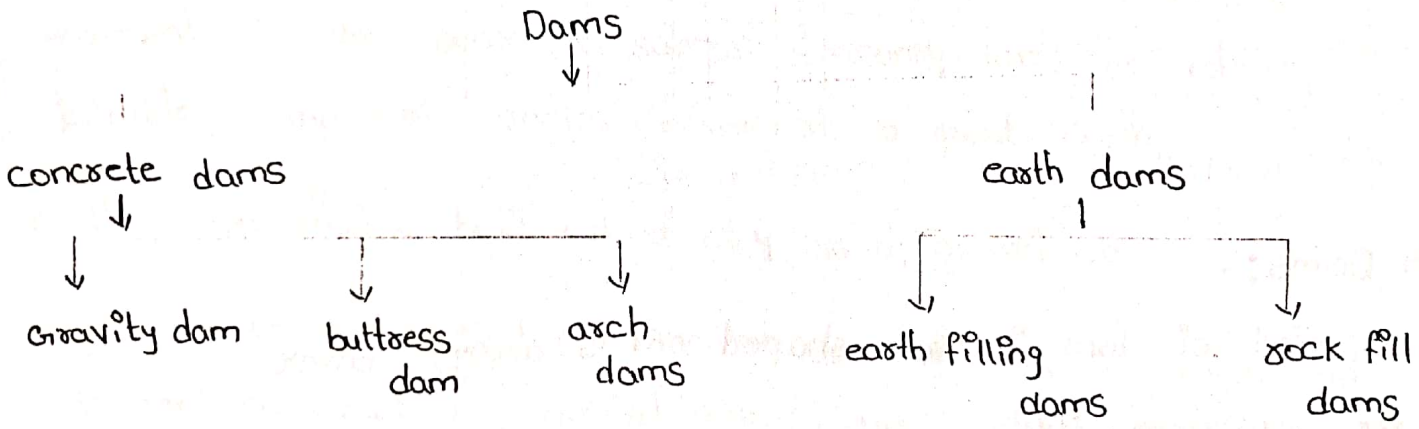
Introduction:- 1. Dams are the costliest multipurpose civil engineering constructions.

2. Dams deliver beneficial results for a long time to mankind.

3. This aspect might have promoted late Pandit Jawaharlal Nehru to admire them as modern temples.

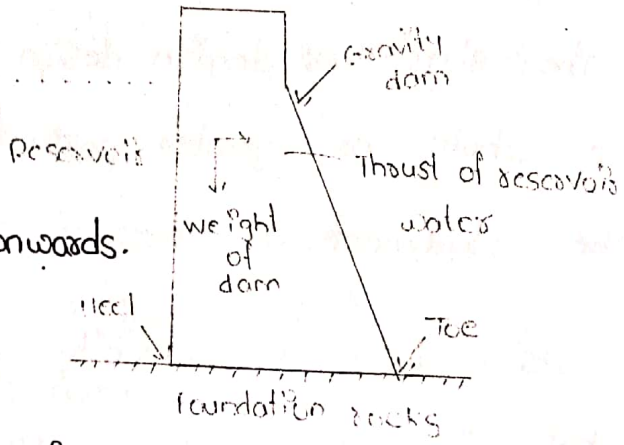
Types and purpose of dams:-

Types of dams:- Based on the construction material used,



Gravity dam:-

1. These dams are heavy and wall-like structures of concrete in which the whole weight acts vertically downwards.



2. The entire force acting on the dam wall is transmitted on the small area of foundation.

3. A dam of this nature is to be selected only in such places where very competent and stable rocks occur.

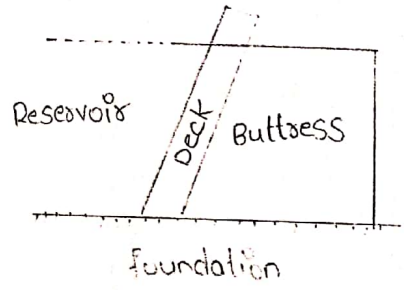
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Buttress dams :-

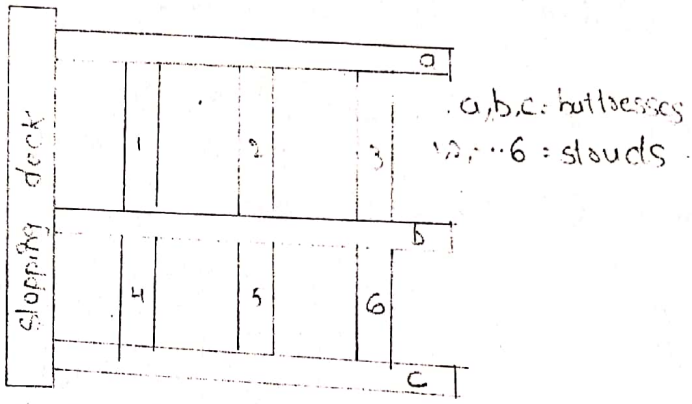
1. these are concrete structures in which there is a deck sloping upstream.

2. This deck which takes the entire load is supported from behind by walls called "buttresses" extending perpendicular to the axis of dams.

3. Such buttresses are further strengthened by cross-walls called struts.



a) side view of buttresses dam.



b) Top view of buttresses dam.

Arch Dams :-

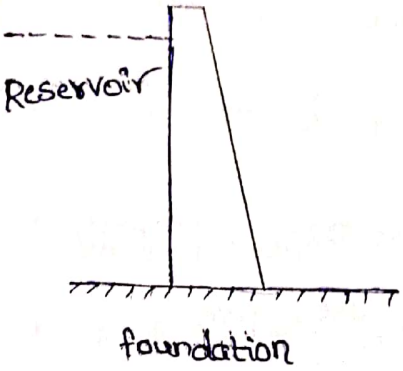
1. This kind of dam is arch-shaped and is always convex in the upstream side

2. The shape or ~~degisn~~ design of an arch dam is such that the whole or greater part of the load is transfered to the abutments.

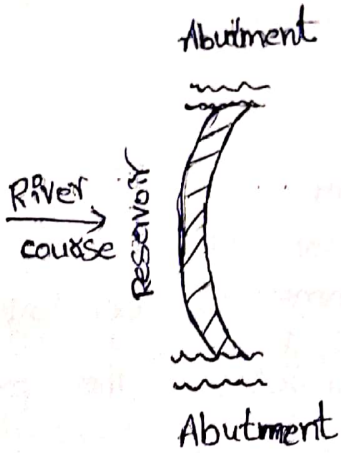
3. Its modulus of elasticity should be high enough to ensure that its deformation under thrust from the arch is not so great as to induce excessive stresses in the arch.

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dams are best suited to narrow, deep, river-cut gorges. but recently they have been considered even for somewhat wider valleys.



a) side view of arch dams



b) Top view of arch dam

Earth dams :-

1. Earth dams are planned in such places where the underlying material is too weak to support masonry dams or where suitable competent rocks occur at a great depth.
2. They are mainly bulit out of clay, sand, gravel etc.
3. Due to these factors i.e., greater area of base, low height and lighter construction material used, the weight exerted by the dam per unit area of ground will be relatively less.
4. These dams are Trapezoidal in shape.
5. when most of the material used is earth, it is called an "earth fill dam" and if most of the material used is rock, it is called a "rock fill dam".
6. one of the largest earth dams is the famous Ft. peck, Wyoming dam.
7. It is 4½ miles long, 4000 feet thick at the base and 250 feet high.

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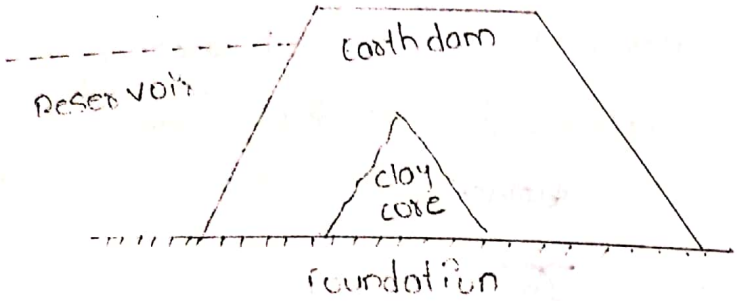


Fig:- Earth dam

Purposes of dams:- Dams are constructed to impound river water for various purposes. The principal uses are.

1. To provide stream regulation.
2. To provide water supply to meet the domestic, industrial and irrigation requirements.
3. To generate power.
4. To control floods
5. To regulate stream sediment loads and
6. To provide Inland water traffic.

Geological Considerations in the selection of a dam site:-

1. If a dam stands firmly but if its a reservoir leaks profusely (as in the case of Cedar Lake dam or Malpasset dam) then such a dam is to be treated only as a failure because the purpose for which it is constructed has not been served.
2. Careful geological studies bring out the inherent advantages or disadvantages of a site and such studies go a long way either in reducing or increasing the cost of a dam

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The important geological requirements which should be considered in the selection of a dam site are as follows

1. Narrow river valley
2. occurance of bed rock at a shallow depth
3. Competent rocks to offer a stable foundation.
4. proper geological structures.

1. Narrow River valley :-

1. At the proposed dam site, if the river valley is narrow, only a small dam is required, which means the cost of dam construction will be less.

2. on the other hand, if the valley is wide, a bigger dam is necessary which means the construction cost will be very high.

A few defects are as follows :-

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

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

c) The occurance of buried river channels crossing the site, either below the river bed or adjacent to it.

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d) Unsuitability of rocks in some places due to the presence of soluble materials like gypsum or due to faulting which may be concealed beneath sediments.

Bedrock at shallow depths:-

1. To ensure its safety and stability of a dam has to necessarily rest on very strong and very stable rocks

2. The foundation cost of the dam will naturally be less.

3. on the other hand, if competent bedrocks occur at great depths, the foundation cost will be very high because it involves extensive work of excavation of loose overburden and Concrete refilling.

4. Excavation for the filling foundation was one of the major items of work of that project.

5. Another example is the Koyna dam, here in the valley 6 to 7m of excellent competent basalt, there was weak volcanic breccia.

6. The thickness of sediments or lose overburden along the river valley depends on the nature and the stage of development of the river.

7. River mainly causes erosion in the initial and final stages. there may not be any significant loose overburden in such places.

8. Young stages should be carefully studied because.

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ii) ...y terrain which occurs in these stages may not provide a suitable topography for the occurance of a large reservoir basin

ii) and the flow of water, itself may not be high in such developing rivers for obvious reasons.

9. The general occurance of material like clay, silt and gravel, sand along the river bed, naturally makes it difficult to assess the thickness of loose over burden by mere surfacial studies.

10. The data recorded in the field during investigations are interpreted and the reavised bedrock profile is visualized.

11. Suitable number of bore holes are drilled at second points and the actual bedrock depths as observed at those places are recorded.

12. However, in some places, particularly in glaciated regions, the occurance of buried river valleys may pose unexpected problems

13. A buried river valley which occur in the river bed is generally deep and composed of loose drift which is highly porous and permeable material.

14. This poses problems of weakness and leakage which are dangerous for the success of the dam.

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14. Buried river valleys, occurance of huge boulders in a glacier region may also create unanticipated difficulty during the construction of dam.

15. Glaciers, which are huge bodies of moving ice in mountainous regions, are capable of transporting big boulders along with them and leave them at lower levels, when they retreat or disappear.

Competent Rocks for Safe Foundations :-

1. Rocks occur at the selected dam site, they will offer a safe basis. And weak sedimentary rocks, particularly shales, poorly cemented sandstones and cavernous limestones shall naturally be undesirable to serve as foundation rocks.

2. Though igneous rocks and their metamorphic equivalents, quantitatively, account for 95% of rocks of the crust, they occupy only 30% of the earth's surface while the others occupy 70% of the earth's surface.

3. As stated, earlier, among the actual varieties of rocks, granites and basalts are the most commonly found igneous rocks.

4. Among sedimentary rocks, shales, sandstones and limestones roughly account for 80%, 15% and 5% respectively, in terms of their occurrence.

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Suitability or otherwise of a site to serve as a foundation for major dams depends on factors such as

i) The existing rock type at the dam site
ii) The extent of weathering it has undergone
iii) The occurrence of intrusions.
iv) The extent of fracturing.
v) the occurance of geological structures
vi) The mode and number of rock types Concerned.

Suitability of Igneous rocks:-

Among the rock types, the occurrence of massive plutonic and or hypabyssal igneous rock is the most desirable at the dam site because they are very strong and durable due to their dense character, interlocking texture, hard silicate mineral composition, occurrence of negligible porosity and permeability, absence of any inherent weak planes.

Suitability of Sedimentary Rocks:-

Sedimentary rocks, the bedding and its orientation, thickness of beds, nature and extent of compaction and cementation, grain size, leaching of soluble matter, porosity and permeability, associated geological structures and composition of Constituents.

kingstar

1. shales are not only inherently incompetent but they also form slippery bases. Therefore they are undesirable at dam sites.

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2. Among sandstones, well-cemented siliceous and ferrugeneous are competent and suitable for the dam foundation.

3. Laterites and conglomerates are undesirable at dam sites.

Suitability of metamorphic Rocks:-

1. In this context of discussion of the competence of rock dam sites, it is also necessary to recollect that the competence of site rocks can be improved to a reasonable extent by adopting the suitable measures such as "grouting" or replacement of loose portions of rock by good concrete.

2. The compressive strength or stress at a foundation of even a large dam will rarely exceed 40 kg/cm^2 and the maximum till now is 70 kg/cm^2.

3. As compared to these moderate loads, the strength of igneous and metamorphic rocks in good condition will generally not fall below 500 kg/cm^2.

4. The question of lack of competence or strength of these rocks, therefore, will normally not araise unless they have other serious drawbacks.

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Of Reservoirs :-

Introduction :-

1. The mean annual precipitation on the land area of the earth is about 40".

2. This represents about 35,000 cubic miles of water. Each year, on an average, the rivers contribute to the sea about 7000 cubic miles of water or about 20% of the annual precipitation.

3. Hence necessary investigations, particularly geological investigation are carried out in advance, to study the suitability of the site to serve as the reservoir.

4. It is necessary that such investigations be carried out very thoroughly of the site to serve as the reservoir in advance because once the reservoir is put in to active service, the underlying area would remain submerged permanently under the reservoir water and would become inaccessible or difficult for any future studies.

5. These studies include many geological and non geological aspects such as water-tightness of the reservoir site; the life of the reservoir; the capacity of the reservoir; the area covered by the reservoir; the effect of evaporation, possible submergence of valuable economic mineral deposits,

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5. Submergence of fertile land, forests etc. submergences of places of interest like temples and historical monuments; ecological effect; and so on. After proper assessment of all these factors, the decision is taken for the selection of the site for reservoir location.

Reservoir silting :-

1. Silting of a reservoir is as harmful as the leakage of the reservoir and both can cause the failure of the reservoir, if they occur seriously.

2. one example of failure due to silting is the New Lane Austin dam on the colorado river.

3. The silting and leakage of the reservoir have a similar result or effect on the reservoir water quantity.

4. In both the cases, the quantity of water stored gets reduced. of course, silting is totally different from leakage.

5. In the case of silting, the deposition of sediments on the floor reduces the capacity of the reservoir, these by indirectly reducing the volume of reservoir water.

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Process of silting :-

1. The inherent nature of a river is to cause erosion when it has energy and to cause the deposition of sediments whenever it loses its energy.

2. The river to cause rapid erosion which means large amounts of sediments are formed.

3. Sediments always occur in every river. When a dam is constructed across a river, it acts as a barrier and checks the natural onward flow of water.

Life of a Reservoir :-

1. silting which commences at the bottom of the reservoir continues, and the thickness of deposited sediments gradually increases with the passage of time.

2. This process of silting correspondingly reduces the capacity of the reservoir to store water.

3. Since erosion is an effective process in the upstream course of a river, sediments get added continuously to the body of river.

4. The total volume of the silt likely to be deposited during the designed period of life of the dam is estimated, and approximately that much volume is left

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unused to allow for silting and is known as dead storage.

5. The remainder is known as effective storage or live storage the dead storage is generally more than 1/4 of the total capacity.

6. The period up to which the reservoir serves its purpose as expected is described as the "life of the reservoir".

7. Thus, in other words, means the period by which the sediments completely fill up in the reservoir basin because of gradual silting.

Measures to control the silting process:-

1. The foregoing information makes it very clear that the success of a reservoir from the economic point of view is dependent on the rate of silting or the life of the reservoir.

2. This is achieved by knowing the amount of sediment transported in the river concerned per unit time.

3. When the capacity of the reservoir is divided by this load, the life of the reservoir is known.

4. The sediments are products of erosion of geological formations occuring in the upstream side, careful geological investigation of the upstream side throws

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light on the scope for reducing erosion process.

5. Areas with loose soil, highly weathered rocks, weak argillaceous rocks like mud or claystones and rocks gently dipping on the downstream side are the sources which contribute sediments.

6. The highly fractured zones like fault zones, shear zones and places which are intensely jointed also contribute the bulk of sediments to the river.

Vegetation:-

Growing vegetation on loose soil is in fact a measure of soil conservation. This vegetation not only reduces the effect of flowing water by obstructing the flow but also prevents the removal of surface soil by the flowing water. This is so because the vegetation keeps the ground cohesive and compact by its numerous roots.

Covering with slabs on weak zones:-

The highly weathered rocks, weak rocks, and highly fractured zones which may be exposed along the course of the river also contribute large quantities of sediments to the river.

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Terracing of the slope and construction of retaining walls :-

If the slopes of the valley in some parts of the river are found to contribute sediments, considerably then this can be prevented by terracing the slope.

Check dams and settling basins :

1. When the aforementioned measures are implemented, naturally there will be a lesser amount of sediments in the river.

2. These sediments may be in quantity, they will settle in the reservoir and reduce its capacity to the extent.

3. These sediments present in the river are prevented from reaching the reservior site by some means, this would very much help in further limiting the silting process in the reservoir.

Diversion of Sediment - loaded waters :

1. Diversion of sediment - loaded waters around the reservoir is also a method locally used to diminish reservoir silting.

2. one of the most notable examples is the bypass canal at Lake overholser, a water supply reservoir of oklahama city in the USA.

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measure is estimated to have kept 93% of the stream sediments out of the reservoir.

Tunnels

Introduction:-

Tunnels are underground passages or routes used for different purposes. They are made by excavation of rocks below the surface or through the hills or mountains.

Purposes of Tunnelling:-

1. Tunnels are excavated across hills or highlands to lay roads or railway track for regular traffic and transportation of goods.

2. The main purpose of these tunnels are to reduce the distance between places of interest across natural obstacles like hills to save time and to provide convenience.

3. Additional routes of conveyance, have the advantage of leaving the ground surface undisturbed so that it can be used as desired. Such tunnels are also referred to as traffic tunnels.

4. Diverting the normal flow of river water through the tunnels, dug along the valley sides. Tunnels of such kind as diversion tunnels.

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5. pressure tunnels or hydro power tunnels are those which are used to allow water to pass through them under force. Such tunnels are meant for power generation.

Effects of Tunnelling on the Ground:-

1. The tunnelling process deteriorates the physical conditions of the ground.

2. popping refers to the phenomenon of fall of rocks of this kind which takes place in brittle and hard rocks like granite devoid of bedding or foilation. Thus, during tunnelling the ground is thoroughly affected adversly.

3. Fault zones and shear zones are naturally potentially weak. and tunnelling through them further deteriorates them and causes stability problems.

4. stability of the ground may be jeopardized when the tunnelled ground has unfavourable ground water conditions.

5. poisonous gases may also be encountered during the excavation of tunnels.

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...ning of Tunnels :-

1. when tunnels are made through weak or loose or unconsolidated formations, they are provided with suitable lining for safety and stability

2. lining refers to the support provided for the tunnel.

3. lining may be in the form of steel structures or concrete.

4. The main purpose of lining are to resist the pressures from the surroundings and to protect the shape of the tunnel.

5. lining is very effective technical remedial measure to over come the various drawbacks resulting from underground tunnelling, either geological or non-geological.

6. The thickness of concrete lining depends on the extent of protection required, and the degree of weakness of the ground. It also depends on the over break phenomenon.

7. Lining, being a very expensive treatment, needs to be provided only at such places where rocks are not capable of supporting themselves, i.e where the rocks are weak and likely to collapse.

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8. lining is also provided in such places where the seepage of water in to tunnel occurs and creates problems.

9. The zones of faulting or shearing also need suitable lining to impart strength to them.

10. Very strong and complete lining is reavuired in hydro Power tunnels which carry water under great pressure and even minor leakages can prove hazardous and hence are not permissible.

Geological Considerations for Successful Tunnelling :-

As already stated, the safety, success and economy of tunnelling depend heavily on the various geological conditions prevailing at the site.

Importance of Rock Types :-

Tunnels pass through underground rock masses, obviously the nature of rock types which are encountered along the tunnel alignment is very important for the safety and stability of tunnel.

Based on the general characteristics of different kinds of commonly occurring rocks, their bearing on tunnels may be summarized as follows:

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Suitability of Igneous rocks at the Tunnel site:-

1. Massive Igneous rocks i.e the plutonic and hypabyssal varieties, are very competent but difficult to work.

2. They do not need any lining or any special maintainence.

3. This is so because they are very strong, tough, hard, rigid, durable, imprevious and after tunnelling, do not succumb to collapse, floor bumps, side bulges or to any other deformation.

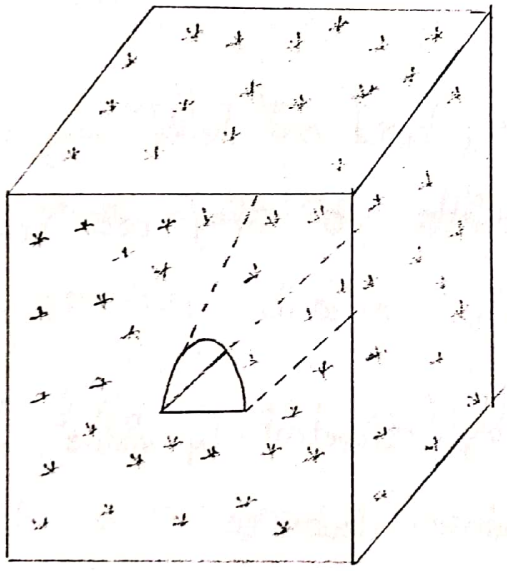


Fig: Tunnel in igneous rocks.

Sedimentary Rocks at the Tunnel site:-

1. Thick bedded, well-cemented and siliceous or ferruginous sand stones are more competent and better suited for tunnelling. They will be strong, easily workable and moreover, do not requiise any lining.

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2. proper lining is necessary for tunnels bulit in shales. mudstones are weaker than shales as they are less compacted.

3. Among limestones, dolomitic limestones are harder and more durable. They are better than other varieties.

Metamorphic Rocks at Tunnel site:-

1. Among different metamorphic Rocks, gneisses are nearly similar to granites in terms of their competence, durability and workability.

2. Quartzites are very hard and hence very difficult to work. They are more brittle too. They are competent and need no lining.

3. Marbles are reasonbly competent by virtue of their high compactness and granulose structure.

4. Their mineral content i.e calcite is soft (H=3) and bears excellent cleavage and hence may not cause any difficulty in tunnelling work.

5. slates are rather soft and possess slaty cleavage. Hence they are weak and reauire lining.

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Importance of Geological structures :-

The bearing of structures in tunnels is very important for two different reasons.

1. They modify the competency and suitability of rocks for tunnelling.

2. They may create or prevent ground water problems, which are critical importance in tunnelling. Joints, faults, folds and tiled characters are the most common structural features associated with rocks.

Effects of Joints at Tunnel site :-

1. These will be more qualitatively and quantitatively nearer the surface but generally disappear with depth.

2. closely spaced joints in all kinds of hearts are harmful.

3. Joints may be advantageous in the excavation process.

Importance of Ground water conditions :-

1. Among the different problems that may occur in tunnels, the ground water problem is the most serious one, because under adverse conditions, large quantities of ground water may gush out and inundate.

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2. All the water has to be pumped out to keep the working area dry and this pumping adds significantly to the expenditure on a tunnel.

3. The single most important factor which decides whether a severe ground water problem is likely to occur in a tunnel or not is the relative position of the water table.

4. But if the tunnel lies below the position of the water table then the ground water problem is inevitable.

5. The lithology and structure present at the tunnel site shall have a direct influence, while the topography, possible recharging sources of surfaces water bodies, hydrostatic pressure, climate, nature or rainfall etc, contribute indirectly to the problems.

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