# ENGINEERING GEOLOGY

Final term Paper

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# Ans 1:

## Cause of Earthquakes:

An earthquake is caused a sudden slip on a fault. The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edges overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust and cause the shaking that is felt by us.

The surface of the Earth is in continuous slow motion. This is plate tectonics--the motion of immense rigid plates at the surface of the Earth in response to flow of rock within the Earth. The plates cover the entire surface of the globe. Since they are all moving they rub against each other in some places, sink beneath each other in others or spread apart from each other. At such places the motion isn't smooth--the plates are stuck together at the edges but the rest of each plate is continuing to move, so the rocks along the edges are distorted (strain). As the motion continues, the strain builds up to the point where the rock cannot withstand any more bending. With a lurch, the rock breaks and the two sides move. An earthquake is the shaking that radiates out from the breaking rock.

## Consequences of Richter magnitude 5 earthquake:

| | | |
|---|---|---|
| 4-5 | Moderate | Walls crack |
| 5-5.9 | Moderate | Furniture moves. Can cause damage of varying severity to poorly constructed buildings. Zero to slight damage to all other buildings. Felt by everyone. |

## Seismic waves:

Seismic wave, vibration generated by an earthquake, explosion, or similar energetic source and propagated within the Earth or along its surface.

Seismic waves are the waves of energy caused by the sudden breaking of rock within the earth or an explosion. They are the energy that travels through the earth and is recorded on seismographs.

Seismic waves are usually generated by movements of the Earth's tectonic plates but may also be caused by explosions, volcanoes and landslides.

Seismology is the study of earthquakes and seismic waves that move through and around the earth. A seismologist is a scientist who studies earthquakes and seismic waves.

Seismologists use seismographs to record the amount of time it takes seismic waves to travel through different layers of the Earth. As the waves travel through different densities and stiffness, the waves can be refracted and reflected. Because of the different behavior of waves in different materials, seismologists can deduce the type of material the waves are travelling through.

The results can provide a snapshot of the Earth's internal structure and help us to locate and understand fault planes and the stresses and strains acting on them.

This wave behavior can also be used on a smaller scale by recording waves generated by explosions or ground vibrators in the search for oil and gas.

**Types of seismic waves**

There are three basic types of seismic waves – P-waves, S-waves and surface waves. P-waves and S-waves are sometimes collectively called body waves.

**Primary waves (P-waves):**

- First kind of waves and first waves recorded by the seismograph in the event of a disturbance
- P-waves travel through any kind of material, whether it is a solid, liquid or gas
- Typical speeds are 330 m/s in air, 1450 m/s in water and about 5000m/s in granite.
- Primary waves are made up of compression waves, also known as push-pull waves. The individual waves, therefore, push against one another, causing a constant parallel, straight motion.
- P-waves, though easier to record, are significantly smaller and do not cause as much damage because they compress particles in only one direction.

**Secondary waves (S-waves):**

- The S-waves are the second wave to reach a seismic station measuring a disturbance
- S-waves only move through solids and are stopped by liquids and gases
- S-waves lag behind P-waves as they travel 1.7 times slower
- S-waves are transverse waves, which means they vibrate up and down, perpendicular to the motion of the wave as they travel. In an S-wave, particles travel up and down and the wave moves forward, like the image of a sine wave.
- S waves are generally larger than P waves, causing much of the damage in an earthquake. Since the particles in an S wave move up and down, they move the earth around them with greater force, shaking the surface of the Earth.

**Surface waves:**

Surface waves are similar in nature to water waves and travel just under the Earth's surface. They are typically generated when the source of the earthquake is close to the Earth's surface. Although surface waves travel more slowly than S-waves, they can be much larger in amplitude and can be the most destructive type of seismic wave. There are two basic kinds of surface waves:

- Rayleigh waves, also called ground roll, travel as ripples similar to those on the surface of water. People have claimed to have observed Rayleigh waves during an earthquake in open spaces, such as parking lots where the cars move up and down with the waves.
- Love waves cause horizontal shearing of the ground. They usually travel slightly faster than Rayleigh waves.

# Ans 2:

## Role of geology in selection of sites for dams and reservoirs:

### Preliminary Investigation:

- Topographically studies
- Reservoir location
- Petrology studies
- Mineralogy studies
- Structural geological sites
- Factors like foundation, condition, water tightness of reservoir, availability of construction material
- General examination of rocks
- Indirect study methods for subsurface investigation
- Drill hole study

### Detailed Geological Investigation

- Study of geological topo sheet
- Study of the area with reference to geology
- Study of rock type
- Structural geology of the area
- History of the area with reference to rainfall
- Study of stream channel with diff order
- Study of seismic data
- Geomorphological study
- Preparation of geological map of the area
- Study of core drill data and its interpretation

- Detailed engineering geological properties of area

## SELECTION OF SITE:

❖ **TOPOGRAPHICALLY:** Most suitable place must be chosen for construction ideally it must be a narrow gorge or small valley with enough catchment area available behind so that calculated amount of water can be easily stored in the reservoir created upstream

❖ **Possibility of river diversion**: The way river can be diverted by a particular site for making way for construction of the dam may affect the design of the dam and also construction schedule

❖ **SEDIMENTATION POSSIBIBILLTIES:** The average quantity of sediment carried by the river has to be known, as precisely as possible. Which would give an idea of the rate which a proposed receiver way gets filled up.

❖ **TECHNICALLY:** The sound must be sound as possible, strong impermeable and stable, strong rocks makes the job of designer easy, they ensure better storage inventories, site must be stable to seismic shocks.

❖ **CONSTRUCTIONALLY:** The site should be far from the materials which will be used for the construction, their non-availability will make the cost of project high,

❖ **HUMMAN WELFARE:** Site selection should be done in such a way that it must cause minimum damage to public in the destruction or failure.

## Geological characters for investigation: Geology of the site

**a. Lithology:**

surface and subsurface studies must be carried out. These studies reveal the type, the composition and texture of the rocks along the valley floor.

**b. Structures:** Dip and strike

**c. Faults:** Dams founded on the fault zones are most liable to the shocks during an earthquake. Generally, the small scale fault zones can be treated effectively by grouting.

**d. Folds**: the effects of fold on rock are shattering and jointing along the axial planes and stressing of limbs. In the synclinal region dams placed on the upstream limbs have the risk of leakage from beneath the dam.

## Engineering properties of rocks:

❖ Strength parameter: it consists of three investigations –laboratory,

in-situ static and dynamic.

- The compressive and shearing strength of the rocks are estimated by laboratory test.
- These tests are complimented with in-situ studies using static and dynamic studies.
- Static study: by this test settlements and strains are recorded with different loadings which is used to estimate the bearing strength,

modulus of elasticity and Poisson's ratio.

- The dynamic method involves creating seismic waves artificially at selected locations and recording the velocity of the shock waves through the rocks of the sites. The shockwave velocity relates to the density, rigidity, porosity and permeability of the rocks at the site.

❖ Porosity and permeability:

- A dam is a water impounding structure. So water must not find easy avenues to escape other than provided in design such as spillways. So porosity and permeability of the rocks are tested both in laboratory and in-situ. Artificial treatment is given to the critical zones such as grouting to make the rocks water tight

❖ Material availability:

- If the cost of transportation of construction material is excessively high, then an alternate design with locally available materials, have to be considered.

❖ Seismicity:

- It is very important to analyses the behavior of the dam under earth quake vibrations thereby making it possible for the designer to check if a particular section of the dam is suitable or not.

# Ans 3:

## Protective measures of landslides:

I. Draining water from slopes. To Counter the effects of water a proper drainage system is the suitable measure. This involves the quick removal of percolated moisture by means of surface drainage and subsurface drainage.
II. Revegetation with plants that have deep roots. Growing vegetation, plants and shrubs on loose ground helps in keeping the loose soil together.
III. Terracing: it redistributes mass along a slope and reduces the slope angle.
IV. Retaining Wall: it can catch debris or stabilize regolith. To Counter the effect of slope Retaining walls may be constructed against the slopes, so that the material which rolls down is not only prevented from further fall but also reduces the slope
V. Rock bolts can be used to stabilize coherent masses
VI. Not to resort to reduce the stability of existing slopes. This is done by not undertaking any undercutting on the surface slope and by not undertaking any construction at the top of the hills.

## Ans 4:

## Difference between fault, joint and fold

| Fault | Joint | Fold |
|---|---|---|
| A fracture in bedrock along which rocks on one side have moved relative to the other side. | A fracture on a rock without noticeable movement. | Permanent wavelike deformation in layered rock or sediment. |

### a) Normal fault:

In normal fault the hanging walls moves down relative to the footwall.

## Effect of normal fault on earth crust:

The motion between the two is not always smooth, and sometimes the walls get caught on each other. Pressure builds up and can be released with a great amount of energy, producing an earthquake.

### b) Folds develop in any types of rock if it's true, explain why?

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

**Layer-parallel shortening**

When a sequence of layered rocks is shortened parallel to its layering, this deformation may be accommodated in a number of ways, homogeneous shortening, reverse faulting or folding. The response depends on the thickness of the mechanical layering and the contrast in properties between the layers. If the layering does begin to fold, the fold style is also dependent on these properties. Isolated thick competent layers in a less competent matrix control the folding and typically generate classic rounded buckle folds accommodated by deformation in the matrix. In the case of regular alternations of layers of contrasting properties, such as sandstone-shale sequences, kink-bands, box-folds and chevron folds are normally produced.

**Fault-related folding**

Many folds are directly related to faults, associated with their propagation, displacement and the accommodation of strains between neighboring faults.

**Fault bend folding**

Fault-bend folds are caused by displacement along a non-planar fault. In non-vertical faults, the hanging-wall deforms to accommodate the mismatch across the fault as displacement progresses. Fault bend folds occur in both extensional and thrust faulting. In extension, listric faults form rollover anticlines in their hanging walls. In thrusting, ramp anticlines form whenever a thrust fault cuts up section from one detachment level to another. Displacement over this higher-angle ramp generates the folding.

**Fault propagation folding**

Fault propagation folds or tip-line folds are caused when displacement occurs on an existing fault without further propagation. In both reverse and normal faults this leads to folding of the overlying sequence, often in the form of a monocline.

**Detachment folding**

When a thrust fault continues to displace above a planar detachment without further fault propagation, detachment folds may form, typically of box-fold style. These generally occur above a good detachment such as in the Jura Mountains, where the detachment occurs on middle Triassic evaporites.

**Folding in shear zones**

Shear zones that approximate to simple shear typically contain minor asymmetric folds, with the direction of overturning consistent with the overall shear sense. Some of these folds have highly curved hinge-lines and are referred to as sheath folds. Folds in shear zones can be inherited, formed due to the orientation of pre-shearing layering or formed due to instability within the shear flow.

**Folding in sediments**

Recently-deposited sediments are normally mechanically weak and prone to remobilization before they become lithified, leading to folding. To distinguish them from folds of tectonic origin, such structures are called synsedimentary (formed during sedimentation).

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

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

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

**Igneous intrusion**

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

**Flow folding**

Flow folding: depiction of the effect of an advancing ramp of rigid rock into compliant layers. Top: low drag by a ramp: layers are not altered in thickness; Bottom: high drag: lowest layers tend to crumple.

The compliance of rock layers is referred to as competence: a competent layer or bed of rock can withstand an applied load without collapsing and is relatively strong, while an incompetent layer is relatively weak. When rock behaves as a fluid, as in the case of very weak rock such as rock salt, or any rock that is buried deeply enough, it typically shows flow folding (also called passive folding, because little resistance is offered): the strata appear shifted undistorted, assuming any shape impressed upon them by surrounding more rigid rocks. The strata simply serve as markers of the folding. Such folding is also a feature of many igneous intrusions and glacier ice.

### c) What is the effect of faulting on outcrop?

Faulting is essentially a process of rupturing and displacement along the plane of rupture. Its effects may involve- changes in the elevation of the ground, omission of some strata where they are normally expected, repetition of some strata in a given direction and displacements and shifts in the continuity of the same rocks in certain regions.

### d) A site for a civil engineering project is going to be located on faulted zone explain what steps are required to control?

Generally small scale fault zones can be treated effectively by grouting. Grouting is generally capable of overcoming the adverse effects of joints because it fills the gaps of joints, increase compactness and competency of the rocks & reduce porosity & permeability.

# Ans 5:

## Tunneling on the basis of Geology:

Tunnels may be defined as underground routes or passages driven through the ground without disturbing the overlying soil or rock cover.

## Types of Tunnels on the Basis of Geology

1. **Hard rock tunnels**

Tunneling through hard rock almost always involves blasting

2. **Soft rock tunnels**

Soft Ground (Earth) Workers dig soft-ground tunnels through clay, silt, sand, gravel or mud.

## Geological Investigation for Tunnels:

These determine to a large extent solution to following engineering problems connected with tunneling:

a. **Selection of Tunnel Route (Alignment):**

There might be available many alternate alignments that could connect two points through a tunnel. However, the final choice would be greatly dependent on the geological constitution along and around different alternatives: the alignment having least geologically negative factors would be the obvious choice.

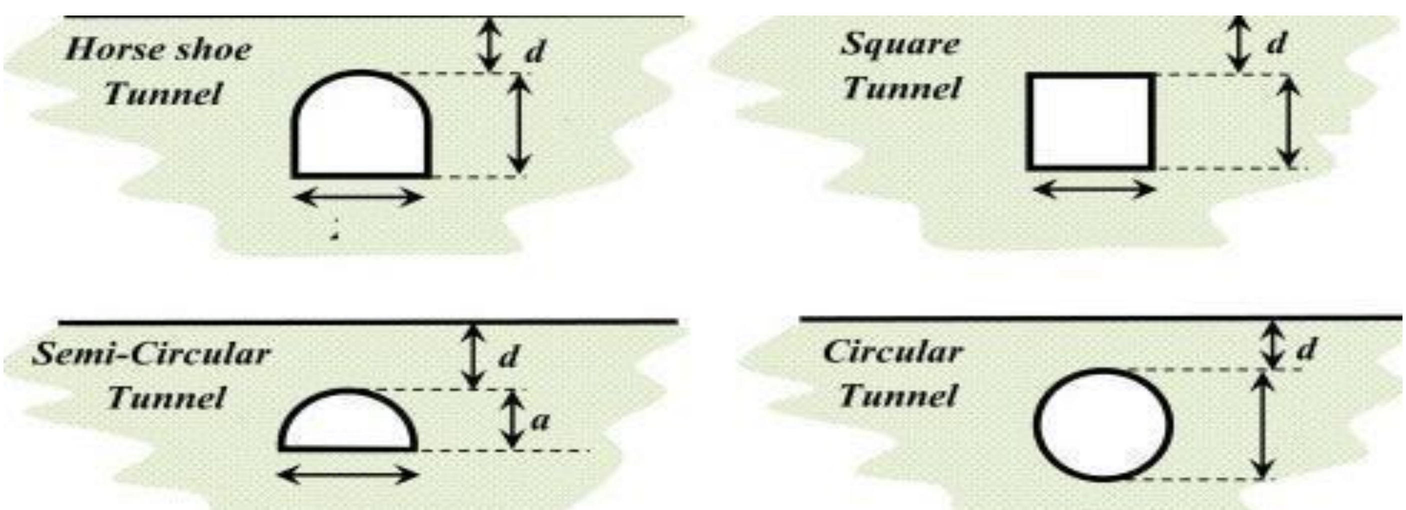
**b. Selection of Excavation Method:**

Tunneling is a complicated process in any situation and involves huge costs which would multiply manifolds if proper planning is not exercised before starting the actual excavation. And the excavation methods are intimately linked with the type of rocks to be excavated. Choice of the right method will, therefore, be possible only when the nature of the rocks and the ground all along the alignment is fully known. This is one of the most important aim and object of geological investigations.

**c. Selection of Design for the Tunnel:**

The ultimate dimensions and design parameters of a proposed tunnel are controlled, besides other factors, by geological constitution of the area along the alignment. Whether the tunnel is to be circular, D-Shaped, horse-shoe shaped or rectangular or combination of one or more of these outlines, is more often dictated by the geology of the alignment than by any other single factor.

D-shape or horse-shoe shape may be conveniently adopted but these shapes would be practically unsuitable in soft ground or even in weak rocks with unequal lateral pressure. In those cases, circular outline may be the first choice.




**d. Assessment of Cost and Stability:**

These aspects of the tunneling projects are also closely interlinked with the first three considerations. Since geological investigations will determine the line of actual excavation, the method of excavation and the dimensions of excavation as also the supporting system (lining) of the excavation, all estimates about the cost of the project would depend on the geological details.

**e. Assessment of Environmental Hazards:**

The process of tunneling, whether through rocks or through soft ground, and for whatsoever purpose, involves disturbing the environment of an area in more than one way. The tunneling methods might involve vibrations induced through blasting or ground cutting and drilling, producing abnormal quantities of dust and last but not the least, interference with water supply system of the nearby areas