QNo2:

A dam should have a secure foundation. To avoid taking conditions for granted the nature of the subsurface geology at the site can be explored by trial bores and a large scale map (say 40 cm to a km) may be prepared.

In most cases a dam will involve the excavations of a trench whether the dam structure is of concrete, masonry or earth will a core wall and the geological conditions in the trench zone should be known fully. An ideal dam, for the entire length of its foundation would need a sound and water tight rock (preferably in one kind of rock).

Such conditions in reality are not realized. Possibility of percolation below the dam site when the reservoir is full and the position of the impounded water body relative to the water table are factors worthy of consideration. Alternate sites must be investigated in their own merits.

The geology of the dam site including the foundation for the dam itself and the sites for other structures such as spillway, diversion tunnel and outlet works. To check whether the dam foundation has sufficient strength and durability to support the type of dam proposed, whether the foundation is watertight, especially, when karstified rocks occur in the site and in deeper horizons bellow the foundations.

2. The geology of the area to be occupied by the reservoir once the dam is completed. Whether the storage area is watertight or are there areas of cavernous limestone and/or gypsum which might lead to the dam not retaining water.

3. Stability of the slopes in the dam site and reservoir area whether landslides into the reservoir are possible which might cause a wave of water to be pushed over the top of the dam.

The main geological considerations in the selection of sites for dams are:

(a) The rocks which are underlying must have enough strength to withstand the weight of the dam and the resultant thrust.

(b) The rocks should be impervious to prevent leakage of water beneath the sole of the dam.

(c) The rocks should not contain fissures, joints and faults to prevent leakage of water.

An ideal site for a dam is therefore an impervious band of hard strong massive rocks free from joints throughout the length of the dam. As mentioned above granites, gneisses, schists etc. make good foundation for a dam.

Generally at many sites suitable for impounding reservoirs, we find superficial deposits such as peat, alluvium and even glacial drift are present and these overly the solid rocks. Peat should be avoided and since its thickness often may be difficult to estimate except from many bore holes. If considerable amount of peat is present, its removal is necessary.

The organic acids and colouring matter of peat will adversely affect the purity of water. In some sites where 8 to 10 m thick peat deposits existed they were treated by covering it with a layer of clean sand 0.5 m to 1m thick. Alluvium may not present such difficulty, though if trenches have to be cut difficult timbering may be needed. In some cases, the water content of the alluvium may pose difficulties during construction.

QNO3:

Types of Mass Wasting

A **rock fall** are the fastest of all landslide types and occurs when a rock falls through the air until it comes to rest on the ground—not too complicated. In Utah, they are common in the spring and fall because of freeze-thaw weathering. In the daytime, temperatures in the spring and fall tend to be above freezing, which allows liquid water to enter cracks within rocks.

At night, the temperatures cool below freezing and the water within the rocks freezes and expands which causes the rock to break more. The following morning, the ice will melt and go deeper within the crack to refreeze later that night. This freeze-thaw action over time can cause rocks to break off and fall to the ground. The debris the accumulates at the base of these steep slopes is called **talus**.

But rock falls can also occur when heavy precipitation is falling on a steep slope, causing the rocks to lose friction and fall. The YouTube video below is a rock fall captured in Taiwan in late August 2013, following heavy precipitation in the region.

Rotational Slides

Rotational slides occur when the a landslide occurs in a curved manner concave to the sky. When this type of slide occurs, the upper surface of the slide tilts backwards toward the original slope and the lower surface moves away from the slope. They are common when the soil tends to be deep in clay or soft sediment deposits. The video on the right is a large landslide again in Taiwan in early September 2013 following every rainfall. Needless to say, they were having a bad few days in the region.

Transitional Slides

Rather than rotating, a **translational slide** occurs when slope failure occurs parallel to the slope. Often times the slope failure occurs on soil composed of clay or shale, or along old fault lines, or previous slide areas. What makes translational slides dangerous is that they tend to flow faster and travel farther than rotational slides. The most expensive translational slide in U.S. history actually occurred in Thistle, Utah in 1983.

Debris flows are one of the most common, but most dangerous of the various types of landslides because of their speed and consistency. Debris flows tend to be a mixture of rock and water with two to three times the density of flooding streams. That density allows debris flows strip away the land and pick up objects as large as school buses. Debris flows are most common at the mouth of canyons along alluvial fans. Lets first explain an alluvial fan. When floods occur within the mouth of a canyon, either because of intense thunderstorms or snow melt, the erosive power of the water can pick up sediment and boulders – a debris flow. Now once the debris flow reaches the mouth of a canyon, the sediment gets deposited in a fan-shaped delta called an alluvial fan. The problem is that people like to live along alluvial fans because of their scenic view on the canyon. Another influence of debris flows is wildfires. When a wildfire strips an area of its vegetation, the bare soil is easily eroded away in either a thunderstorm or snow melt creating these debris flows. Because of Utah's topography and tendency to wildfires, debris flows are quite common.

Lahars were mentioned in the module on volcanoes, but in essence they are volcanic landslides. Recall that volcanoes eject pyroclastic material ranging is size from ash to boulders. Now there tends to be two ways lahars occur. One is if a thunderstorm precipitates large amounts of moisture on the pyroclastic material and the pyroclastics flow down slope. The other option is if a volcano is snow-capped and the heat from the volcano causes some of the snow to melt and mix with the pyroclastic material. What makes lahars so dangerous is that they have the consistency of concrete and can travel hundreds of miles. For a breakdown of potential landslide types in the State of Utah, check out the **Utah Geologic Survey**.

Measures against landslides

Personal measures

- Reinforcement of floor slabs and external walls in existing buildings.
- Installation of drainage pipes for rainwater, slope drainage.
- Planting of slopes that are vulnerable to landslides with deep-rooted trees and shrubs.

Technical/biological measures

- Drainage and/or grading of slope profiles increase the shear resistance
- Supporting structures such as anchors and piles (pinning of the slip plane) can restrain landslides
- Removal of material in the 'driving' section, or material deposition in the 'braking' section, can prevent further descent of the sliding body
- Protective forest

Planning measures and local protection

- The use of slopes prone to landslides must be avoided, or uses suitably modified
- Hydraulic and electrical connections must be flexible.

Organisational measures

- The relatively long advance warning period permits timely evacuation.

Prevention and Remediation of Landslides

Many methods are used to remedy landslide problems. The best solution, of course, is to avoid landslide-prone areas altogether. Before purchasing land or an existing structure or building a new structure, the buyer should consult an engineering geologist or a geotechnical engineer to evaluate the potential for landslides and other geology-related problems.

Listed below are some common remedial methods used when landslide-prone slopes cannot be avoided. There is no guarantee that any one method or combination thereof will completely stabilize a moving hillside.

Improving surface and subsurface drainage: Because water is a main factor in landslides, improving surface and subsurface drainage at the site can increase the stability of a landslide-prone slope. Surface water should be diverted away from the landslide-prone region by channeling water in a lined drainage ditch or sewer pipe to the base of the slope. The water should be diverted in such a way as to avoid triggering a landslide adjacent to the site. Surface water should not be allowed to pond on the landslide-prone slope.

Ground water can be drained from the soil using trenches filled with gravel and perforated pipes or pumped water wells. Swimming pools, water lines, and sewers should be maintained to prevent leakage, and the watering of lawns and vegetation should be kept to a minimum. Clayey soils and shales have low hydraulic conductivity and can be difficult to drain.

Excavating the head: Removing the soil and rock at the head of the landslide decreases the driving pressure and can slow or stop a landslide. Additional soil and rock above the landslide will need to be removed to prevent a new landslide from forming upslope. Flattening the slope angle at the top of the hill can help stabilize landslide-prone slopes.

Buttressing the toe: If the toe of the landslide is at the base of the slope, fill can be placed over the toe and along the base of the slope. The fill increases the resisting forces along the failure surface in the toe area. This, in turn, blocks the material in the head from moving toward the toe. However, if the toe is higher on the slope, adding fill would overload the soil and rock below the toe, thus causing a landslide to form downslope of the fill.

Constructing piles and retaining walls: Piles are metal beams that are either driven into the soil or placed in drill holes. Properly placed piles should extend into a competent rock layer below the landslide. Wooden beams and telephone poles are not recommended for use as piles because they lack strength and can rot.

Removal and replacement: Landslide-prone soil and rock can be removed and replaced with stronger materials, such as silty or sandy soils. Because weathering of shales can form landslide-prone soils, the removal and replacement procedure must include measures to prevent continued weathering of the remaining rock. Landslide material should never be pushed back up the slope. This will simply lead to continued motion of the landslide.

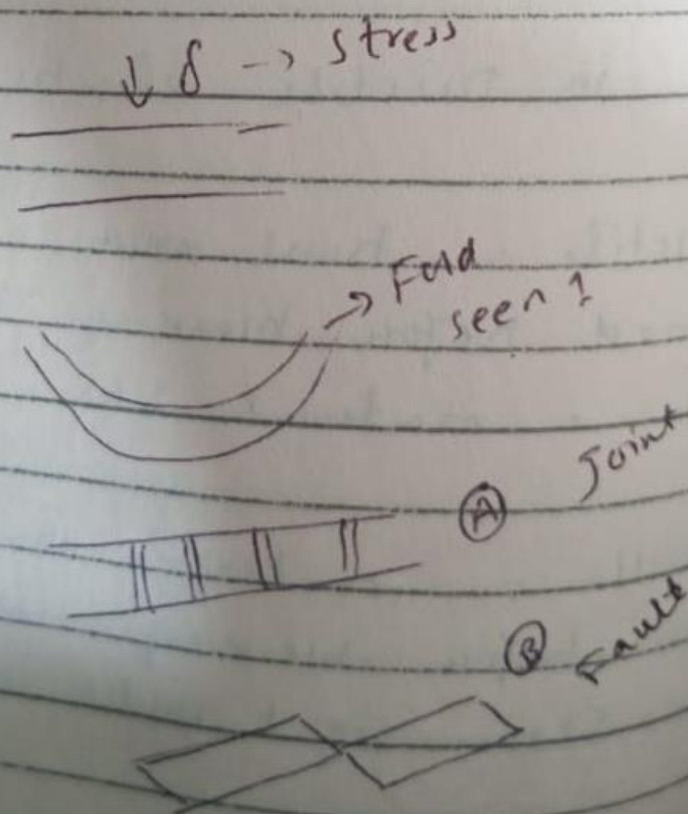
Preserving vegetation: Trees, grasses, and vegetation can minimize the amount of water infiltrating into the soil, slow the erosion caused by surface-water flow, and remove water from the soil. Although vegetation alone cannot prevent or stop a landslide, removal of vegetation from a landslide-prone slope may initiate a landslide.

Rock fall protection: Rock falls are contained by (1) ditches at the base of the rock exposure, (2) heavy-duty fences, and (3) concrete catch walls that slow errant boulders that have broken free from the rock outcrop. In some cases, loose blocks of rock are attached to bedrock with rock bolts, long metal rods that are anchored in competent bedrock and are threaded on the outside for large nuts. A metal plate with a center hole, like a very large washer, is placed over the end of the rod where it extends from the loose block, and the nut is then added and tightened. Once constructed, remedial measures must be inspected and maintained. Lack of maintenance can cause renewed landslide

QNO4:

Joint Definition :-

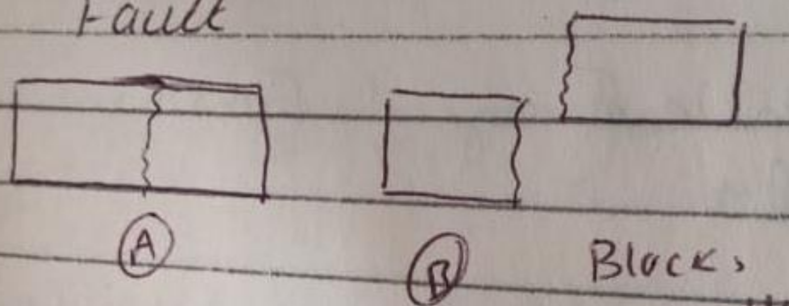
The fracture along which no or negligible moment ob serbed in rock body.

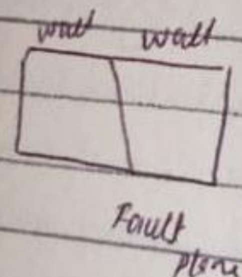


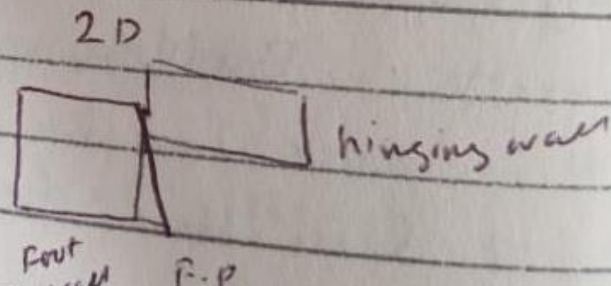
Fault 80

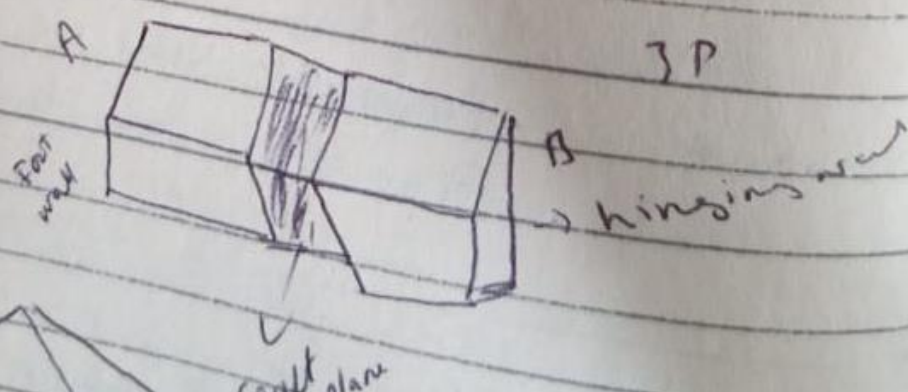
Any fracture along which movement has taken place or observed.

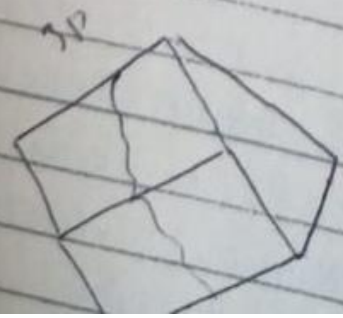
Fault







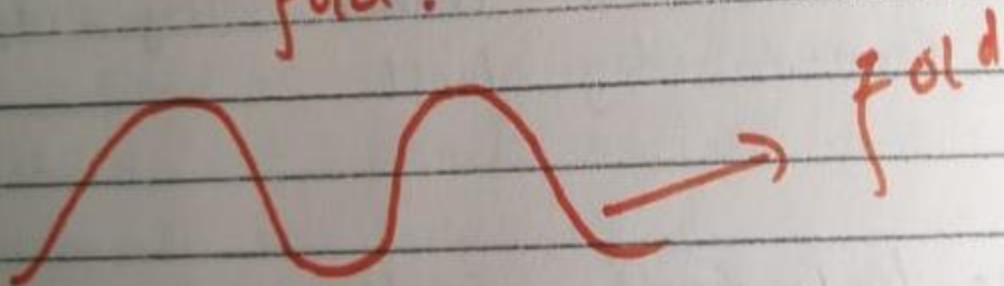




slip movement

Fold :-

fold is a wavy undulation of a body is called fold.



Explanation: In dip **faults** which occur parallel to the dip of the **outcrop**, the most prominent **effect** observed after **faulting** and erosion of the upthrown block is a horizontal shift between the two parts of the **outcrop**. ...
Explanation: Oblique **faults** with downthrow to the left side result in an offset with an overlap.

A **normal fault** is a **result** of the **earth's crust** spreading apart. This often occurs at plate boundaries, but it **can** happen at **faults** in the middle of plates also.

In structural geology, a **fold** occurs when one or a stack of originally flat and planar surfaces, such as **sedimentary** strata, are bent or curved as a result of permanent deformation.

Where should a site for a civil engineering project be located?

a) On faulted zone

b) On a folded strata

c) On a joint

d) Must be avoided to possible extent to be built on all three

Explanation: As far as possible the location of a civil engineering project must be avoided on a fault or a fold or a joint. But when there is no other choice, the same location can be treated with necessary methods and then the project can be implemented.

QNo5

Tunnels provide long-term solutions to a variety of infrastructure projects ranging from constructing roadways or pipelines through difficult terrain to freeing up valuable surface space in dense urban areas. In recent years, the rapid expansion of metropolitan areas has led nations around the world to give more and more consideration to the upfront investment of tunneling projects in order to promote more efficient use of surface space and recognize the significant benefits to society at large.

Geological Engineering in Tunneling:

Tunneling is a unique field, requiring geological, geotechnical, mining and civil engineers to work together with construction contractors and government agencies to deliver resilient and reliable subsurface infrastructure. Engineering Geologists and Geological Engineers bridge the gap between site characterization and tunnel construction, acting as a cornerstone of this interdisciplinary team. Roles of the Engineering Geologist and Geological Engineer in a tunnel/underground project include:

- Site characterization, including subsurface geology and pre-existing infrastructure
- Alignment optimization based upon ground conditions/ground behavior
- Development of Ground Model based upon understanding of ground conditions and ground behavior for site characterization and ground risk/hazard identification
- Identifying and managing geologic hazards (e.g., groundwater, problematic ground conditions, impacts to existing utilities and adjacent structures)
- Recommending appropriate excavation and ground support methods
- Recommending appropriate groundwater control measures
- Recommending appropriate pre-excavation support/ground improvement measures
- Estimating project design and construction schedules and costs
- Conducting resilience and reliability analyses
- Enabling effective communication within interdisciplinary teams
- Participation in project Risk Management process
- Participating in public outreach efforts associated with underground infrastructure projects

Types of Tunnels:

Planning the approach to any tunnel/underground project requires careful consideration of geologic setting, ground condition, ground behavior, and development of a engineering geological model to assist the design team in decision making and design parameters for evaluation of construction methods, control of groundwater, design of temporary support, and design of final linings. A clear understanding of the site-specific ground conditions and ground behavior drive the development of the excavation methods used for underground structures. Excavation methods include the following:

- Tunnel Boring Machines (TBM) – greater than 3m diameter (man access)
- Drill and Blast
- Sequential Excavation Method (SEM)
- Microtunnel Boring Machines (MTBM) – less than 3m diameter (no man access)

The excavation method is selected to optimize construction efficiency and ensure safety of construction personnel and the public during construction.

The responsibilities of the geologist have not ended when construction of a tunnel is started. Now the emphasis is changed to day-to-day inspection and mapping of the tunnel as the heading advances and careful correlation of underground geological features with those mapped on the surface during feasibility and design stage investigations. Information gathered by geological mapping of the tunnel is used to fill in the details of the generally incomplete picture of the geology obtained by surface exploration, and in many situations, will increase the ability of the geologist to predict changing conditions beyond the tunnel heading through an increase in his understanding of the significance of features noted at the surface.

In some situations data derived from geological study of a tunnel may assist greatly in interpretation of poorly or incompletely understood surface features, and a reexamination of the surface geology over the tunnel in the light of the new data may be very fruitful.

A function of the geologist during construction of a tunnel is preservation of the safety of the bore as it is related to changing geologic conditions, and to contribute, to the extent possible, to the avoidance of emergencies created by sudden and unexpected intersection of highly incompetent rocks or heavy water flows.

GEOLOGICAL MAPPING OF TUNNELS

Geological mapping of tunnels and other underground openings has reached an advanced state of elegance and refinement, largely because of the efforts of mining geologists who are concerned with the geological details of economic mineral deposits. The techniques of the mining geologists are equally applicable to mapping of tunnels and irregular underground openings of all kinds (McKinstry, 1948; Forrester, 1946).

Geological maps of tunnels are made on appropriate scales, depending on the complexity of the geology. Commonly used scales are 1 inch = 20 ft. and 1 inch = 40 ft. or 1 inch = 50 ft. In a typical mapping operation the geology is plotted in the horizontal, or nearly horizontal, plane parallel to the center line and at a convenient elevation in the tunnel. For tunnels of relatively small size, say up to 15 ft. in

QNo1;

To find out we need to go deep underground. At the centre of our planet—around 5,000 to 6,000 kilometres beneath the surface—is an extremely hot, solid core, made mostly of iron and possibly nickel surrounded by a molten outer core (also thought to be made of mostly iron and some nickel). Further out we find another high-temperature layer, called the convecting mantle, which isn't exactly molten, but some movement is still possible given sufficient time. This convecting mantle enables convection currents, driven by heat from the planet's core, to 'flow' slowly within it.

The uppermost section of the mantle is relatively cool and brittle, and deforms elastically. Finally above this layer is the crust, the outermost layer of the planet (the bit we stand on). This coupled layer of crust and uppermost mantle is called the lithosphere and although it feels solid as we walk around on it, the lithosphere is actually very thin compared to the other layers of Earth—it ranges from less than 20 kilometres to more than 200 kilometres thick in different areas.

But unlike a smooth eggshell that you may imagine, the Earth's crust is not a single, unbroken layer. Rather, it's made of sections called tectonic plates that sit on top of the slowly flowing and moving mantle.

These plates do not stay still: over time, they migrate around the planet, sometimes grinding against each other, or pushing into each other to build mountain ranges. In other places where plates are moving towards each other, one plate is forced underneath another plate. The results are known as subduction zones, and the world's largest earthquakes occur in these regions.

The major differences between P waves and S waves include wave speeds, wave types, travel capabilities, and wave sizes. Primary waves travel faster, move in a push-pull pattern, travel through solids, liquids and gases, and cause less damage due to their smaller size. Secondary waves travel slower, move in an up-and-down pattern, travel only through solids, and cause more damage due to their greater size.

Wave Speeds

P waves travel faster than S waves, and are the first waves recorded by a seismograph in the event of a disturbance. P waves travel at speeds between 1 and 14 km per second, while S waves travel significantly slower, between 1 and 8 km per second. The S waves are the second wave to reach a seismic station measuring a disturbance. The difference in arrival times helps geologists determine the location of the earthquake.

Type of Wave

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. 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.

Travel Capability

Because of their wave movement, P waves travel through any kind of material, whether it is a solid, liquid or gas. On the other hand, S waves only move through solids and are stopped by liquids and gases. For this reason, S waves are sometimes referred to as shear waves because they are unable to alter the volume of the material that they pass through. This also accounts why fewer S waves are recorded than P waves. Geologist used this difference to determine that the Earth's outer core is liquid, and continue to use this difference to map the internal structure of the Earth.

Wave Sizes

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. P waves, though easier to record, are significantly smaller and do not cause as much damage because they compress particles in only one direction.

magnitude level	category	effects	earthquak per yea
less than 1.0 to 2.9	micro	generally not felt by people, though recorded on local instruments	more than 100,000
3.0–3.9	minor	felt by many people; no damage	12,000–100,000
4.0–4.9	light	felt by all; minor breakage of objects	2,000–12,0

5.0–5.9	moderate	some damage to weak structures	200–2,000
6.0–6.9	strong	moderate damage in populated areas	20–200
7.0–7.9	major	serious damage over large areas; loss of life	3–20
8.0 and higher	great	severe destruction and loss of life over	fewer than 3