

# Engineering Geology

## Lecture-8

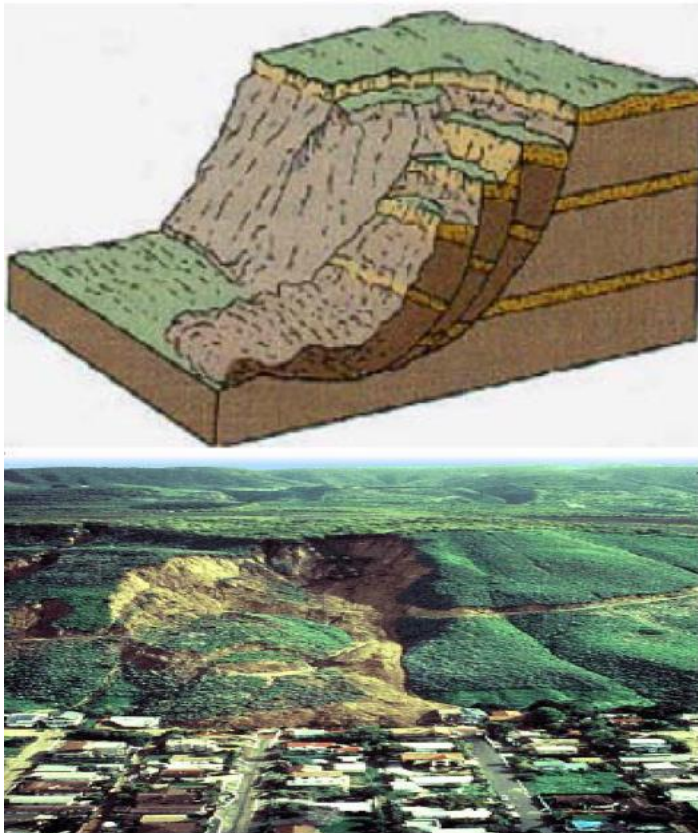
# Landslides

- Natural phenomena that occur with or without human activity
- Landslides encompass all categories of gravity-related slope failures in earth materials.
- Slopes are the most common landforms. Although they appear stable and static, slopes are actually dynamic, evolving systems. Material is constantly moving on slopes at rates varying from imperceptible creep to thundering avalanches and rock falls moving at high velocities.
- The slope does not need to be very steep for a landslide to occur.
- Slope failures can range from being a temporary nuisance by partially closing a roadway, to destroying structures, to being catastrophic and even burying cities.

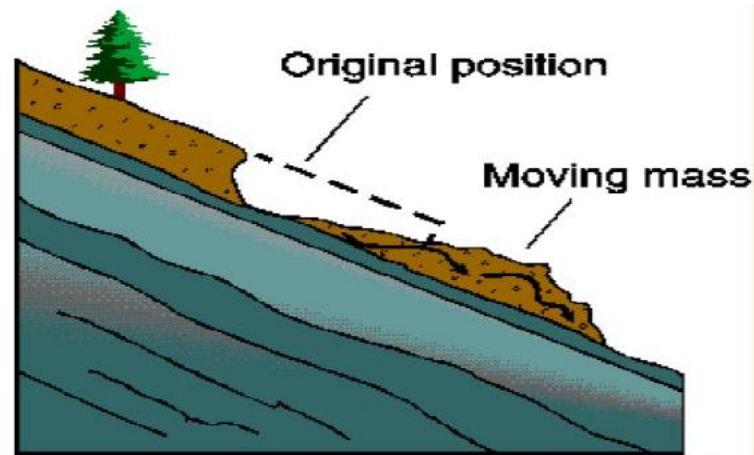
# Landslides

- The term' **landslide**' includes all varieties of mass movements of hill slopes and can be defined as the downward and outward movement of slope forming materials composed of rocks, soils, artificial fills or combination of all these materials along surfaces of separation by falling, sliding and flowing, either slowly or quickly from one place to another.
- **Landslide** = “the movement of a mass of rock, debris or earth down the slope”.

# Types of Landslides

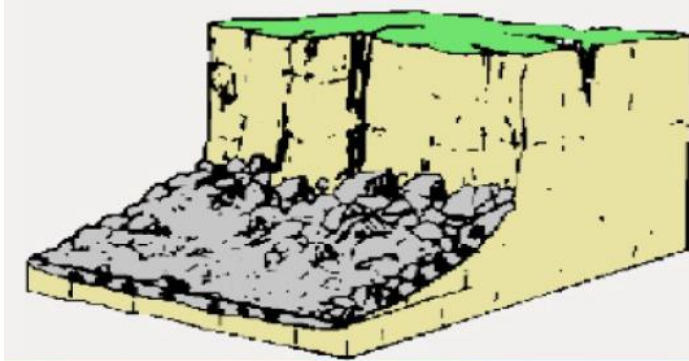


a) **Rotational slides** move along a surface of rupture that is curved and concave.



b) **Translational slides** occurs when the failure surface is approximately flat or slightly undulated

# Types of Landslides



## c) **Rock Fall:**

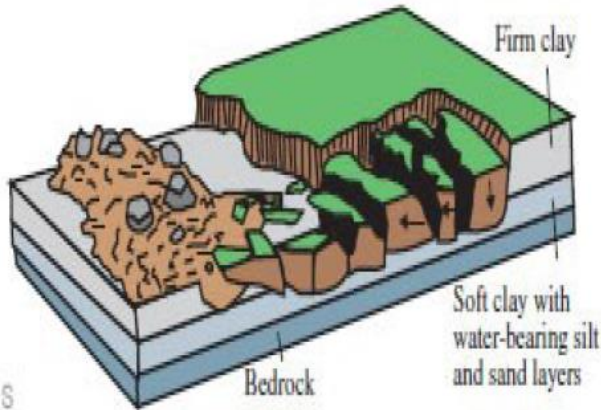
Free falling of detached bodies of bedrock (boulders) from a cliff or steep slope



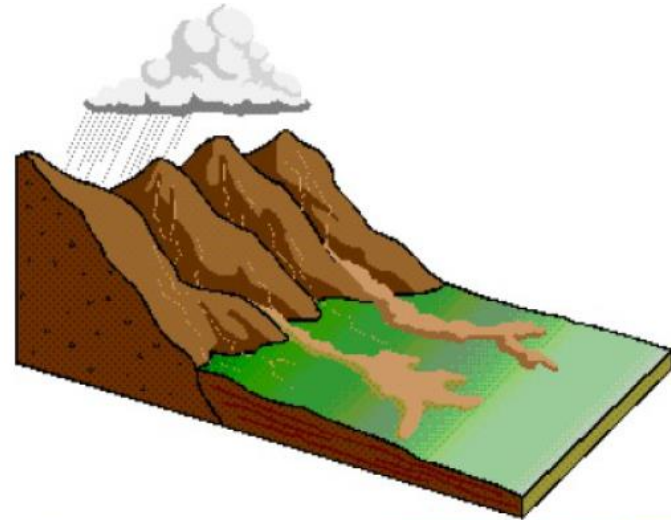
d) **Rock toppling** occurs when one or more rock units rotate about their base and Collapse.



# Types of Landslides



USGS



e) **Lateral spreading** occurs when the soil mass spreads laterally and this spreading comes with tensional cracks in the soil mass.



f) **Debris Flow:**  
Down slope movement of collapsed, unconsolidated material typically along a stream channel.

# Causes of Landslides

- A landslide is any geologic process in which gravity causes rock, soil, artificial fill or a combination of the three to move down a slope. Several things can trigger landslides, including the slow weathering of rocks as well as soil erosion, earthquakes and volcanic activity.
- Gravitational forces are always acting on a mass of soil or rock beneath a slope. As long as the **strength of the mass is equal to or greater than the gravitational forces**, the **forces are in balance**, the mass is in equilibrium, and movement does not occur. An **imbalance of forces results in slope failure** and movement in the forms of creep, falls, slides, avalanches, or flows.
- Gravity slope failures can be triggered by earthquake ground shaking or excess precipitation.
- Almost every landslide has multiple causes. Slope movement occurs when forces acting down-slope (mainly due to gravity) exceed the strength of the earth materials that compose the slope.
- Causes include factors that **increase the effects of down-slope forces** and factors that **contribute to low or reduced strength**. Landslides can be initiated in slopes already on the verge of movement by rainfall, snowmelt, changes in water level, stream erosion, changes in ground water, earthquakes, volcanic activity, disturbance by human activities, or any combination of these factors.

# Causes of Landslides

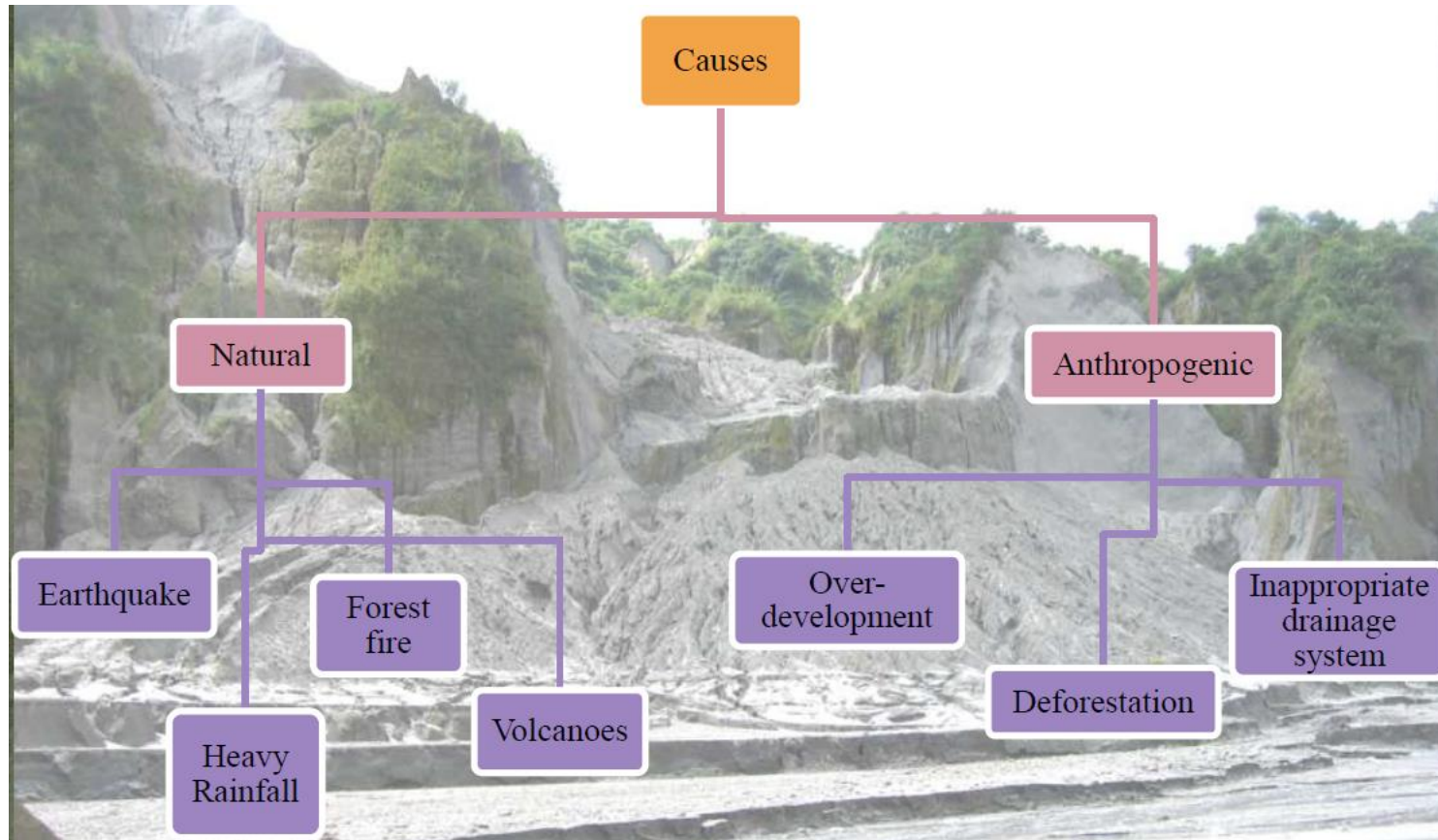
- Earthquake shaking and other factors can also induce landslides underwater. These landslides are called submarine landslides. Submarine landslides sometimes cause tsunamis that damage coastal areas.
- Earthquakes not only trigger landslides, but, over time, the tectonic activity causing them can create steep and potentially unstable slopes.
- A lahar is a special “landslide” or mud flow induced by an explosive volcanic eruption.



# Causes of Landslides

- In some cases, human activities can be a contributing factor in causing landslides. Many human-caused landslides can be avoided or mitigated. They are commonly deforestation, a result of building roads and structures without adequate grading of slopes, poorly planned alteration of drainage patterns, and disturbing old landslides. Illegal hill cutting and illegal mining (blasting) are also contributing factors.
- Detailed on-site investigation is required to determine the importance of human factors in causing any particular landslide.

# Causes of Landsliding



# Causes of Landslides

- **Internal Causes:**
- Influence of slope: Provides favourable condition for landslides; steeper slope are prone to slippage of land. It is known that most of the materials are stable up to certain angle- “Critical angle” or “angle of repose” – it varies from  $30^{\circ}$  for unconsolidated sediments to  $90^{\circ}$  for massive rocks and  $60^{\circ}$ - $90^{\circ}$  for partially jointed rocks.
- Ground water or associated water: Main factor responsible for slippage. Suppose the hard or massive rocks are underlain by softer rocks (shale or clay bed)
- When rain water percolates through some fractures or joints the clayey beds becomes very plastic and acts as slippery base, which enhance the chances of loose overburden to slip downward.
- Water is the most powerful solvent, which not only causes decomposition of minerals but also leaches out the soluble matter of the rock and reduces the strength.

# Causes of Landslides

- Lithology: rock which are rich in clay (montmorillonite, bentonite), mica, calcite, gypsum etc are prone to landslide because these minerals are prone to weathering.
- Geological structures: Occurrence of inclined bedding planes, joints, fault or shear zone are the planes of weakness, which create conditions of instability.
- Human Influence: undercutting along the hill slopes for laying roads or rail tracks can result into instability.
- Deforestation in the uplands, result into more erosion during the rainy season.

# Causes of Landslides

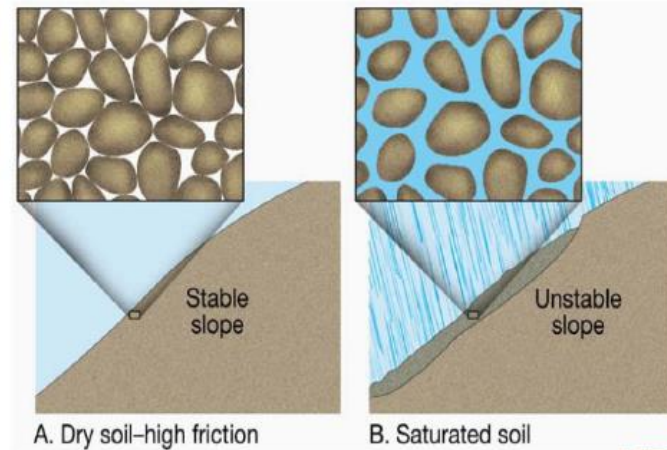
- **External factors**
- Most common is the vibration resulted due to earthquakes; blasting to explosives; volcanic eruption etc.
- Earthquakes often initiate mass failures on large scale.



# Causes of Landslides

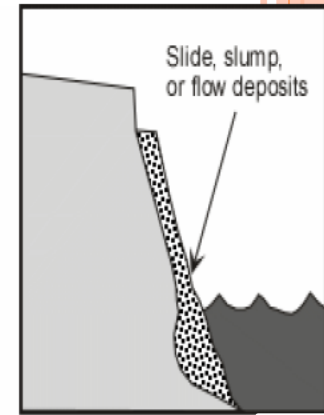
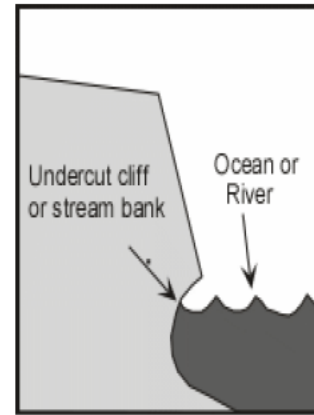
## A) Natural Factors:

- **Gravity:** Gravity works more effectively on steeper slopes.
- **Geological factors:** Geology setting that places permeable sands and gravels above impermeable layers of silt and clay or bedrock.
- **Heavy and prolonged rainfall:** slides occur often with intense rain by creating zone of weakness, also water tables rise with heavy rain makes some slopes unstable.
- **Earthquakes:** Ground vibrations created during Earthquakes.

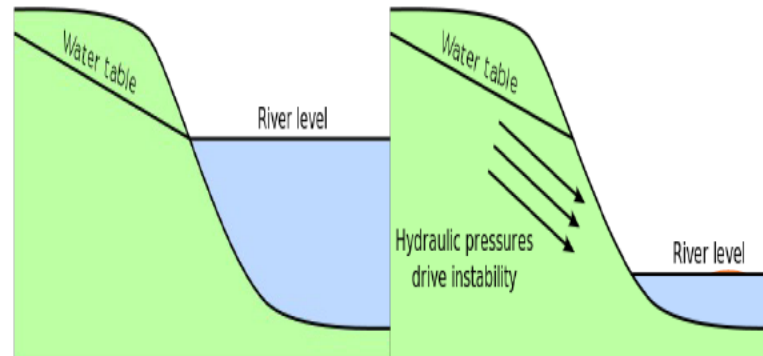


# Causes of Landslides

- **Waves:** Wave action can erode the beach or the toe of a bluff, cutting into the slope, and setting the stage for future slides.



- **Volcanoes:** volcanic ash deposits (sometimes called as lahars deposits) are prone to erosion and subjected to mud flows due to intense rainfall.
- **Fluctuation of water levels** due to the tidal action.
- **Deposition of loose sediments** in delta areas.



# Natural Factors

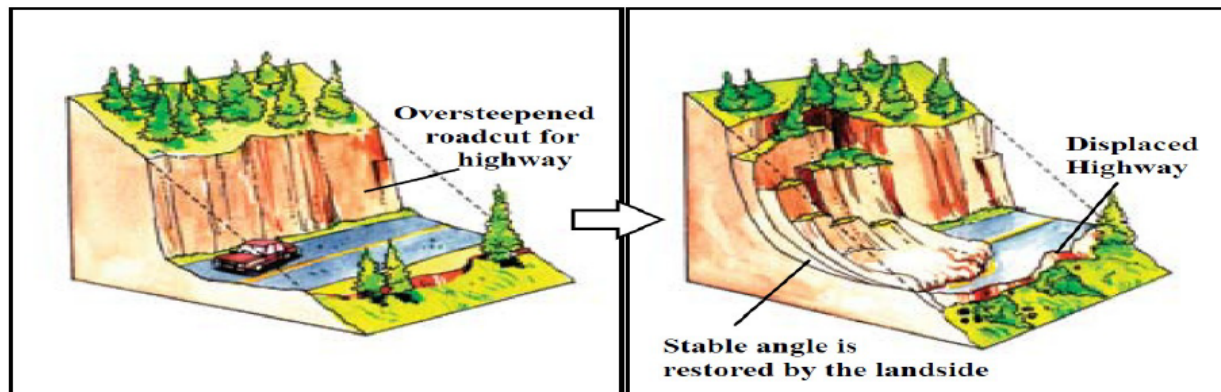
- **Volcanos:** Strato volcanoes are prone to sudden collapse, especially during wet conditions. The conditions commonly prevail after volcanic eruptions that kill vegetation over extensive areas and spread loose volcanic rocks over the landscape. During subsequent rainy seasons, swollen rivers will erode the new deposits and sometimes generate lahars that are dangerous to people downstream.
- **Forest fire:** fires cause soil erosion and induce floods and landslides due to the destruction of the natural vegetation. (E.g. ridges of Manipur-Nagaland border)

# Causes of Landslides

## B) Anthropogenic Factors:

- **Inappropriate drainage system:** Surface runoff of irrigated water on slopes exposes soil under cultivation to erosion. Part of this water is absorbed by soil increasing its weight, which **can put an additional load on the slope.**
- **Cutting & deep excavations on slopes for buildings, roads, canals & mining:**

causes modification of natural slopes, blocking of surface drainage, loading of critical slopes and withdrawal to toe support promoting vulnerability of







# Causes of Landslides

- **Change in slope/land use pattern, deforestation, agricultural practices on steep slopes:**  
contributed to creep and withdrawal of toe support in many cases.

## C) Combination of factors:

- For example, an earthquake may trigger a landslide, which in turn may dam a valley causing upstream flooding and subsequent dam burst. This will lead to flooding in lower catchments areas.





















# LANDSLIDE HAZARD: ECUADOR







Tumwater, WA March 21, 2001 -- A road near the Tumwater Mobile Estates collapsed during the Nisqually Earthquake on Feb. 28.

Photo by Jim Brown/ **FEMA News Photo**







# LANDSLIDE HAZARD: JAPAN





# LANDSLIDE HAZARD: WASHINGTON STATE





# LATERAL SPREADING: JAPAN







# LATERAL SPREAD: SAN FRANCISCO

