MODULE 34 - LANDSLIDES

OBJECTIVES

At the end of this article we would be able to answer the following questions:-

1. **Meaning of landslides and its causes**
2. **Different types of landslides**
3. **Learn how to recognize areas which are more prone to landslides**
4. **Mitigation measures to reduce the effects of landslides**
5. **Management practices**

SUMMARY

A landslide or landslip is a geological phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability. Typically, pre-conditional factors build up specific sub-surface conditions that make the area/slope prone to failure, whereas the actual landslide often requires a trigger before being released. Thus, the generic term landslide also refers to mass movements such as rock falls, mudslides and debris flows.

TRANSCRIPTION

INTRODUCTION

A landslide can be defined as the mass movement of earth down slope. It is a rapid slipping of a mass earth or rock from a higher elevation to a lower level under the influence of gravity and water lubricant. Landslide describes a wide variety of process that result in the downward and outward movement of slope-forming materials including rock, soil, artificial fill, or a combination of these. The materials may move by falling, topping, sliding spreading, or flowing. Landslide can occur in offshore, coastal and onshore environments. The primary driving force for a landslide is due to the action of gravity.

TYPES OF LANDSLIDE

Basically landslides are of two types:

1. **Flows** : Flows are a spatially continuous movement in which surfaces of shear are short-lived, closely spaced, and usually not preserved. These are classified on the type of material and the speed they travel into two categories:

i. **Very Slow flow** : where soil and rock can move by less than 16 mm / yr
ii. **Extremely Rapid flow** : This can move to over 5 m/ sec

This process occurs naturally, but can be sped up by human processes, including forest clearance.

There are five basic categories of flows that differ from one another in fundamental way:

a. **Debris Flow** – A debris flow is a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize as slurry that flow down slope. It is very rapid to extremely rapid (>5 m/s), at the angle 20-45 degrees, it will cause of high intensity rainfall.

b. **Debris avalanche** is a type of slide characterized by the chaotic movement of rocks soil and debris mixed with water or ice (or both). Debris avalanche is a very rapid to extremely rapid shallow flow of partially or fully saturated debris on a steep slope, without confinement in an established channel.. The angle of the slope is 20-45 degree and it will because of High intensity rainfalls

c. **Earthflow:** This has a characteristic "hourglass" shape. The slope material liquefies and runs out, forming a bowl or depression at the head. The flow itself is elongate and usually occurs in fine-grained materials or clay-bearing rocks on moderate slopes and under saturated conditions. Intermittent flow-like movement of plastic, clayey earth, the speed is slow to rapid (>1,8 m/h). The slope angle is 5-25 degrees

d. **Mudflow:** A mudflow is an earth flow consisting of material that is wet enough to flow rapidly and that contains at least 50 percent sand, silt, and clay-sized particles. It is very rapid to extremely rapid flow with greater than 5 m/s, the angle 20-45 degrees and it will causes of high intensity rainfall.

e. **Creep:** Creep is the imperceptibly slow, steady, downward movement of slope-forming soil or rock. Movement is caused by shear stress sufficient to produce permanent deformation, but too small to produce shear failure. Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges.

2. Slides

A slide is a down slope movement of soil or rock mass occurring dominantly on the surface of rupture or on relatively thin zones of intense shear strain. A slide develops where a crack forms at the top of the slope.

There are three types of 'slide':

- **Rotational rock slump**
- **Translational debris slide**
- **Earth block slide**

3. **Spread**
   Spread is defined as an extension of a cohesive soil or rock mass combined with a general subsidence of the fractured mass of cohesive material into softer underlying material. This type of landslide involves sudden horizontal movement on very gentle terrain. It's often initiated by earthquakes that liquefy the layer below the moving materials.

4. **Topples**
   Topples involve rock or soil that tilts and/or rotates forward on a pivot point. There is not necessarily much movement; however it may lead to falls or slides of the displaced material. Toppling is sometimes driven by gravity exerted by material upslope of the displaced mass and sometimes by water or ice in cracks in the mass

5. **Falls**
   Falls is a complex movement of materials on a steep slope including Rock and/or soil detach from the slope and moves rapidly to its new resting place. It is associated with undercut cliffs and riverbanks.
   The speed for the falls will be from very to extremely rapid and may be happen in just a second. The leaning soil that we call slope is start from 45degrees to 90 degrees inclined. Falls is happens when there are Vibration, undercutting, differentia weathering, excavation, or stream erosion imposed on the slope

6. **Complex**
   Where two or more of these movements are seen together.

CAUSES OF LANDSLIDE

Landslides occur when the stability of a slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone. Natural causes of landslides include:

Natural Causes

- Groundwater (pore-water) pressure acting to destabilize the slope.
- Loss or absence of vertical vegetative structure, soil nutrients, and soil structure (e.g. after a wildfire).
- Erosion of the toe of a slope by rivers or ocean waves.
- Weakening of a slope through saturation by snowmelt, glaciers melting, or heavy rains.
- Earthquakes adding loads to barely-stable slope.
- Earthquake-caused liquefaction destabilizing slopes.
- Volcanic eruptions.

Human Causes

Landslides are aggravated by human activities, Human causes include: deforestation, cultivation and construction, which destabilize the already fragile slopes

- Vibrations from machinery or traffic.
- Blasting.
- Earthwork which alters the shape of a slope, or which imposes new loads on an existing slope.
- In shallow soils, the removal of deep-rooted vegetation that binds colluvium to bedrock.

Construction, agricultural or forestry activities (logging) which change the amount of water which infiltrates the soil.

LANDSLIDE FACTORS

a) Ground Condition

Such as sensitive material, Collapsible material. Weathered Material, shearedmaterial, Jointed or fissured material.

b) Geomorphologic Processes

Such as erosion of the lateral margins. Subterranean erosion (solution, piping).Vegetation removal

c) Physical Processes

Such as intense (short period rainfall), earthquake, Volcanic eruption, shrink andswell weathering of expensive soils.

d) Man-made Processes

Such as excavation of the slope or its toe, loading of the slope or its crest, Drawdown(of reservoirs), defective maintenance of drainage systems, vegetation removal.

LANDSLIDES MITIGATION

The hazard from landslides can be reduced by avoiding construction on steep slopes and existing landslides, or by stabilizing the slopes.

Stability increases when ground water is prevented from rising in the landslide mass by-

(1) Covering the landslide with an impermeable membrane,
(2) Directing surface water away from the landslide,
(3) Draining ground water away from the landslide, and
(4) Minimizing surface irrigation.

Slope stability is also increased when a retaining structure and/or the weight of a soil/rock berm are placed at the toe of the landslide or when mass is removed from the top of the slope. However, landslide can be maintain with:

i. Modification of slope geometry
ii. Drainage
iii. Retaining structure

iv. Internal slope reinforcement

MANAGEMENT PRACTICES

BEFORE THE DISASTER

- Become familiar with the land around you. Learn whether landslides or debris flows have occurred in your area by contacting local officials, state geological surveys or departments of natural resources. Slopes where landslides or debris flows have occurred in the past are likely to experience them in the future.
- Support your local government in efforts to develop and enforce building ordinances that regulate construction in areas susceptible to landslides and debris flows. Buildings should be located away from known landslides, debris flows, steep slopes, streams and rivers, intermittent-stream channels, and the mouths of mountain channels.
- Watch the hillsides around your home for any signs of land movement, such as small landslides or debris flows or progressively tilting trees.
- Contact your local authorities to learn about the emergency response and evacuation plans for your area, and develop your own emergency plans for your family and business.

DURING THE DISASTER

If inside a building:

- Stay inside.
- Take cover under a desk, table, or other piece of sturdy furniture.

If outdoors:

- Try and get out of the path of the landslide or mudflow.
- Run to the nearest high ground in a direction away from the path.
- If rocks and other debris are approaching, run for the nearest shelter such as a group of trees or a building.
- If escape is not possible, curl into a tight ball and protect your head.

AFTER THE DISASTER

- Stay away from the slide area. There may be danger of additional slides.
- Check for injured and trapped persons near the slide area. Give first aid.
- Remember to help your neighbours.
- Listen to a battery-operated radio or television for the latest emergency information.
- Remember that flooding may occur after a mudflow or a landslide.
- Check for damaged utility lines. Report any damage to the utility company.
- Check the building foundation, chimney, and surrounding land for damage.
- Replant damaged ground as soon as possible since erosion caused by loss of ground cover can lead to flash flooding.

- Seek the advice of geotechnical expert for evaluating landslide hazards or designing corrective techniques to reduce landslide risk.

AREAS THAT ARE GENERALLY PRONE TO LANDSLIDES

- Existing landslides.
- Steep natural slopes, particularly in weak geologic materials.
- Steep construction-related cut or fill slopes.
- Areas in or at the mouths of drainages (such as canyons).
- Slopes below leaking canals or ponds.
- Developed hillsides where septic-tank soil-absorption systems are used and landscapes are irrigated.
- Below cliffs or hills with outcrops of fractured rock.

MAJOR LANDSLIDES IN INDIA (1990-2005)

- October 1990 Nilgris 36 people killed and several injured. Several buildings and communication network damaged
- July 1991 Assam 300 people killed, road and buildings damaged
- November 1992 Nilgiris
- June 1993 Aizawal 4 persons were buried
- July 1993 Itanagar 25 people buried alive 2 km road damaged
- August 1993 Kalimpong, West Bengal, 40 people killed, heavy loss of property
- August 1993 Kohima, Nagaland, 200 houses destroyed, 500 people died, about 5km road stretch was damaged
- November 1993 Nilgris 40 people killed, property worth several lakhs damaged
- January 1994 Kashmir National Highway 1A severely damaged
- June 1994 Varundh ghat, Konkan Coast, 20 people killed, breaching of ghat road damaged to the extent of 1km. At several places
- May 1995 Aizwal Mizoram, 25 people killed road severely damaged
- June 1995 Malori Jammu, 6 persons killed, NH 1A damaged
- September 1995 Kullu, HP, 22 persons killed and several injured about 1 km road
- destroyed
- 14,August 1998 Okhimath, 69 people killed
- 18,August 1998 Malpa,Kali river, 205 people killed road network to Mansarovar disrupted
- August 2003 Uttarkashi, Heavy loss of infrastructures
- July 2004 Joshimath – Badrinath, Heavy landslides hit Lambagarh areawashed away nearly 300 meter long road between Joshimath and Badrinath, 17 killed
- August 03, 2004 Landslide at Tehri dam project; 9 killed

HISTORICAL LANDSLIDES OF WORLD

- The Goldau on September 2, 1806.
- The Cap Diamant Québec rockslide on September 19, 1889.
- Frank Slide, Turtle Mountain, Alberta, Canada, on 29 April 1903.

- Khait landslide, Khait, Tajikistan, Soviet Union, on July 10, 1949.
- Monte Toc landslide (260 million cubic metres) falling into the Vajont Dam basin in Italy, causing a mega tsunami and about 2000 casualties, on October 9, 1963.

We have to always take precautions during the landslides and we have to avoid the land slides. Don't make the heap of the landslides. The water, the level of the water, the level of the mud should be in a uniform manner.

GLOSSARY

Aggravate – to enhance

Deforestation – to clear the forest or trees

Fragile – delicate, brittle

Colluviums – loose earth material that has accumulated at the base of a hill, through the action of gravity

Avalache – created by a slide of a top weak layer of snow collecting more snow as it slides down the mountain

Imperceptible – very slight

Deformation – a change in the shape or dimensions of a body

Ripples – to flow with a light rise and fall or ruffling of the surface

Topples – to fall forward, as from having too heavy a top

Canyon – a deep valley with steep sides

Landscape – a section or expanse of rural scenery, usually extensive, that can be seen from a single viewpoint

Sinkhole - natural depression or hole in the Earth's surface

Suffossion – undermining or digging under

Land use – Land use is the human use of land involves the management and modification of natural environment

FAQs

Q.1 What do you understand by the term landslides?

Ans. The term "landslide" describes a wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil,

artificial fill, or a combination of these. The materials may move by falling, toppling, sliding, spreading, or flowing.

Q. 2 Mention the natural causes of landslides.
Ans. Groundwater (pore-water) pressure acting to destabilize the slope, Loss or absence of vertical vegetative structure, soil nutrients, and soil structure, erosion of the toe of a slope by rivers or ocean waves, weakening of a slope through saturation by snowmelt, glaciers melting, or heavy rains, earthquakes, volcanic eruptions.

Q. 3 Mention the major human causes of landslide formation.
Ans. Excavation of slope or its toe, deforestation, irrigation, mining activities, artificial vibration, water leakage from utilities etc.

Q. 4 **Name the basic categories of flows.**
Ans. Debris flow, Debris avalanche, Earth flow, Mudflow and Creep.

Q. 5 Explain the landslide mitigation and prevention measures.
Ans. Hazards are mitigated mainly through precautionary means—for instance, by restricting or even removing populations from areas with a history of landslides, by restricting certain types of land use where slope stability is in question, and by installing early warning systems based on the monitoring of ground conditions such as strain in rocks and soils, slope displacement, and groundwater levels. There are also various direct methods of preventing landslides; these include modifying slope geometry, using chemical agents to reinforce slope material, installing structures such as piles and retaining walls, grouting rock joints and fissures, diverting debris pathways.

Q. 6 Mention the areas which are more prone to the landslides.
Ans. Existing landslides, steep natural slopes, areas in or at the mouths of drainages (such as canyons), slopes below leaking canals or ponds, developed hillsides where septic-tank soil-absorption systems are used and landscapes are irrigated, below cliffs or hills with outcrops of fractured rock.

Q.7 Define sinkhole?
Ans. A sinkhole is a natural depression or hole in the Earth's surface caused by karst processes- the chemical dissolution of carbonate rocks or suffosion processes for example in sandstone. Sinkholes may vary in size from 1 to 600 meters (3.3 to 2,000 ft) both in diameter and depth, and vary in form from soil-lined bowls to bedrock-edged chasms.

Q. 8 What should be done during the disaster if you are inside the building?
Ans. Stay inside and take cover under a desk, table, or other piece of sturdy furniture.

Q. 9 What is the difference between Debris Flow and Debris Avalanche?
Ans A debris flow is a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize as slurry that flow down slope. It is

very rapid to extremely rapid (>5 m/s), While **debris avalanche** is a type of slide characterized by the chaotic movement of rocks soil and debris mixed with water or ice (or both). Debris avalanche is a very rapid to extremely rapid shallow flow of partially or fully saturated debris on a steep slope, without confinement in an established channel.

Q. 10 How does topples occur?
Ans Topples involve rock or soil that tilts and/or rotates forward on a pivot point. There is not necessarily much movement; however it may lead to falls or slides of the displaced material. Toppling is sometimes driven by gravity exerted by material upslope of the displaced mass and sometimes by water or ice in cracks in the mass