

CHAPTER 8 MASS MOVEMENTS

Important Concepts

1. The movement of geological materials, usually downslope, in response to the force of gravity is called mass wasting or *mass movement*. Mass movements occur when *shearing stress* (downward pull) exceeds the *shear strength* (frictional resistance) of a material.
2. Factors influencing slope stability include slope steepness, moisture content, vegetation cover, earthquakes, the presence of quick clay or sensitive clay, and human activities.
3. For dry, unconsolidated material, the maximum slope angle at which the material is stable is called the *angle of repose*.
4. The very slow, often imperceptible, downslope movement of soils and rocks is called *creep*. Soil creep occurs more commonly than rock creep.
5. *Landslide* is the term used to describe rapid mass movements of soil or rock. Mass movements are classified on the basis of the type of material moved and the type and rate of movement:

Fall: the free-fall of material not always in contact with the ground. Most falls are rockfalls.

Slide: the downslope movement of a relatively coherent unit of rock or soil along a well-defined surface.

Slump: a slide that has moved a short distance. Soil slumps often display a rotational movement.

Flow: the downslope movement of a material in a chaotic fashion with mixing of particles within the flowing mass. Snow avalanches, debris avalanches, pyroclastic flows, and lahars are examples of flows.

6. Hazards related to mass movements can be lessened by reducing slope angle, using retaining walls, reducing the load on a slope, planting vegetation, placing supporting material at the base of a slope, using vertical piles or rock bolts to stabilize a slope, and reducing the moisture content of the slope material.
7. Areas prone to mass wasting can be recognized by noting missing areas of plant cover on vegetated slopes, curved or tilted trees, slanted utility poles and other stationary objects, cracked masonry, warped door or window frames, and broken utility lines or pipes. Aerial photography and topographic maps can reveal otherwise obscure mass movements.

Key Terms

angle of repose
creep
debris avalanche
fall
flow
frost heaving
landslide
mass movement
mass wasting
quick clays

rockfall
rock flour
scarp
sensitive clay
shearing stress
shear strength
slide
slope
slump
talus

Multiple Choice

- Mass movements occur when
 - the shearing stress on the material exceeds its frictional resistance (or shear strength) .
 - the frictional resistance (shear strength) of the material exceeds its shearing stress.
 - the angle of repose for the material reaches a maximum.
 - geological materials are affected by the downward pull of gravity, regardless of their shear strength.
- All else being equal, as slope steepness increases, the shearing stress of a material
 - steadily decreases.
 - steadily increases.
 - first increases, then decreases.
 - remains unchanged.
- The rockslide that buried the town of Goldan, Switzerland in 1806 was probably caused by
 - an earthquake.
 - the steepness of slopes due to tectonic movements.
 - frost heaving.
 - lubrication by water along bedding planes in layered rock.
- Of the states listed, the one having the lowest overall landslide potential is
 - West Virginia.
 - Mississippi.
 - California.
 - North Dakota.
- Which of the following materials would likely have the greatest angle of repose?
 - a pile of marbles
 - a pile of ball bearings
 - a pile of apples
 - a pile of concrete blocks
- Which of the following conditions would be least likely to cause mass movements on a steep slope?
 - removal of vegetation
 - heavy rainfall
 - reduction in pore pressure
 - an earthquake

7. Quick clays
 - a. are most commonly found in equatorial regions.
 - b. are formed from weathered volcanic ash.
 - c. are resistant to disturbance by seismic waves.
 - d. consist of very fine particles held together by salty pore water.

8. The Vaiont Reservoir disaster was caused by
 - a. an earthquake.
 - b. a landslide.
 - c. undermining of the dam due to the presence of solution cavities in the bedrock.
 - d. a poorly designed spillway.

9. Soil creep is often triggered by
 - a. earthquakes.
 - b. frost heaving.
 - c. the weight of surface vegetation.
 - d. reduction in soil moisture.

10. The rate of motion of a landslide is commonly related to
 - a. the weight of the material.
 - b. the proportion of moisture within the material.
 - c. the distance the material travels.
 - d. the chemical composition of the material.

11. Scarp formation is often associated with
 - a. slumps.
 - b. rockslides.
 - c. creep.
 - d. rockfalls.

12. Snow avalanches, debris avalanches, and volcanic lahars are all examples of
 - a. flows.
 - b. slides.
 - c. slumps.
 - d. falls.

13. A flow involving a wide variety of materials is called
 - a. a landslide.
 - b. an earthslide.
 - c. a debris avalanche.
 - d. a pyroclastic flow.

14. Reducing the risk of a landslide on an unstable, steep slope can be accomplished by all of the following except
 - a. reduction of slope angle.
 - b. placement of additional supporting material at the base of the slope.
 - c. reduction of slope load by the removal of material high on the slope.
 - d. increasing the moisture content of the slope material.

15. Signs of creep include all of the following except
 - a. accumulation of talus at the base of the slope.
 - b. curved or tilted tree trunks.
 - c. cracks in the ground surface parallel to the slope.
 - d. slanted utility poles.

16. The possibility of mass wasting should be investigated on a site
 - a. with more than a 15% slope.
 - b. with much steeper slopes above or below it.
 - c. in an area where landslides have occurred in the past.
 - d. All of the above are correct.

Fill In the Blanks

1. _____ is a general term for rapid mass movements.
2. _____ is the maximum slope angle at which a given dry, unconsolidated material is stable.
3. _____ is the expansion of wet soil as it freezes and the ice expands.
4. _____ is a fine-grained sediment of pulverized rock produced by glacial erosion.
5. _____ is an extremely slow mass-wasting event.
6. A _____ is a free-falling action in which the moving material is not always in contact with the ground underneath.
7. _____ is the accumulated debris that results from rockfalls or rockslides.
8. A _____ is a mass-wasting event in which a relatively cohesive unit of rock or soil moves downslope along a well-defined surface or plane.
9. A soil _____ is a slide that typically exhibits a rotational movement of the soil mass as it moves downslope.
10. A _____ is a mass-wasting event in which materials move in a chaotic, incoherent fashion.
11. The most rapid mass movements are normally rockfalls, avalanches, and _____.
12. Landslides are often triggered by heavy rain or _____.

True or False

Indicate whether the following statements are true or false. If false, correct the statement to make it true.

- _____ 1. The force behind mass movements is gravity.

- _____ 2. All things being equal, the angle of repose is greater for smooth, rounded particles than for rough, sticky, or irregular particles.
- _____ 3. The area of Portuguese Bend in Los Angeles County, California is an example of a slide area that was activated by human activities.
- _____ 4. Artificial reservoirs can cause landslides by increasing the pore pressures in rocks along the sides of the reservoirs.
- _____ 5. Creep, in addition to causing severe property damage, often results in the loss of human life.
- _____ 6. A snow avalanche is a type of slide.
- _____ 7. The most rapid mass movements can travel at speeds of hundreds of kilometers per hour.
- _____ 8. Generally, the most successful retaining walls are low and thick, rather than high and thin.
- _____ 9. Moisture-reduction techniques work best where rocks or soils are impermeable to water.
- _____ 10. Aerial photography can be a useful tool in the identification of inconspicuous mass movements.

Review Questions

- 1. Explain why landslides occur.
- 2. Discuss the different factors that affect slope stability.
- 3. Explain the different measures that can be taken to prevent, or at least minimize, the occurrence of landslides.

Surfing the Net

Natural Disaster Reference Database, with links to various reports and images (NASA):

<<http://ltpwww.gsfc.nasa.gov/ndrd>>

Excellent review of landslide hazards (U.S. Geological Survey):

<<http://www.usgs.gov/themes/landslid.html>>

Information about snow avalanches (The National Snow and Ice Data Center):

<<http://www-nsidc.colorado.edu/NSIDC/EDUCATION/AVALANCHE/>>

CHAPTER 8 ANSWER KEY

Multiple Choice

- | | | | |
|-------------------|------|-------|-------|
| 1. a | 5. d | 9. b | 13. c |
| 2. b | 6. c | 10. b | 14. d |
| 3. b | 7. d | 11. a | 15. a |
| 4. d (figure 8.1) | 8. b | 12. a | 16. d |

Fill In the Blanks

- | | |
|--------------------|-----------------|
| 1. Landslide | 7. Talus |
| 2. Angle of repose | 8. slide |
| 3. Frost heaving | 9. slump |
| 4. Rock flour | 10. flow |
| 5. Creep | 11. mudflows |
| 6. fall | 12. earthquakes |

True or False

1. True
2. False. All other properties being equal, the angle of repose is less for smooth, rounded particles than for rough, sticky, or irregular particles.
3. True
4. True
5. False. Although creep can cause serious property damage, lives are rarely threatened.
6. False. A snow avalanche is a type of flow.
7. True
8. True
9. False. Moisture-reduction techniques work best where rocks or soils are relatively permeable.
10. True