

have destroyed buildings, roads, and useful land at many places in semiarid regions.

★ 10.9.2. Landslides

Where a mass of earth or rock slides down the slope along a definite zone or surface, the movement is called a "*landslide*". This movement takes place under gravity and is facilitated by moisture which acts as a lubricating agent. The landslide starts with slow movements along a slip surface, followed by a more rapid movement of the separated portion of the earth mass. The slip surface is usually bounded by a crack which distinguishes a slide from creep in which a continuous crack is often absent. The chief types of landslides are: (i) slump, (ii) rock slides, and (iii) rockfalls.

Slump. In a nearly homogeneous cohesive material, such as clays and some soils, a slope fails primarily by shear and the slip surface is approximately cylindrical or spoon shaped. The movement of the mass starts by cracking along a shearing surface and then the separated mass slides down rapidly. Such a slide is called a "slump" or "shear slide". Slump is often accompanied by bulges at the toe (Fig. 10.20).

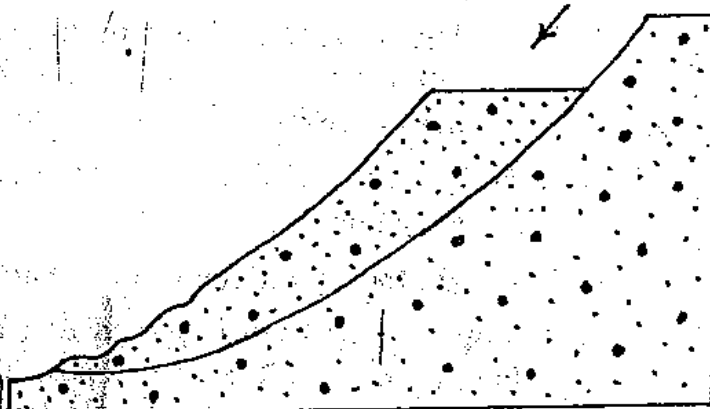


Fig. 10.20. Slump.

Rock Slide. When detached blocks of bed rock move down the hill, it is called a "*rock slide*". In a rock slide the movement takes place on bedding planes, joints or any other planes of weakness in the country rocks (Fig. 10.21).

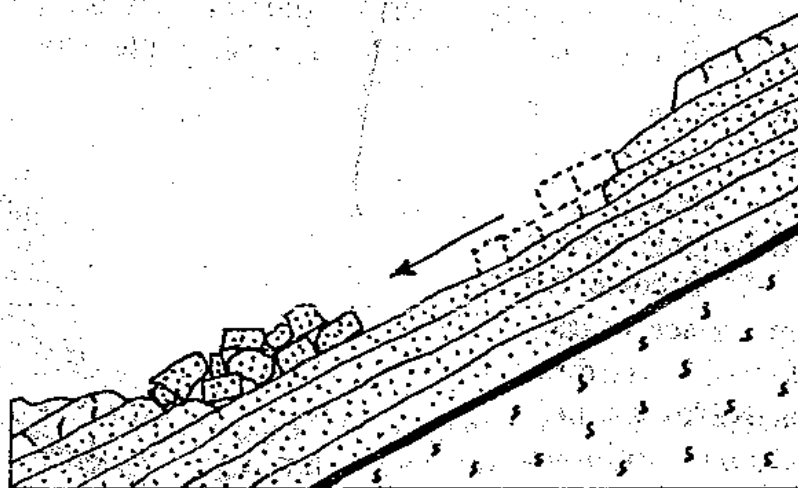


Fig. 10.21. Rockslide.

Rock Falls. From steep rock slopes, blocks of rock of varying sizes which are loosened by weathering, suddenly fall downward under the in-

fluence of gravity. This phenomenon is called "rockfall". The rockfalls supply "talus" which are commonly found at the foot of cliffs in the higher mountain regions.

10.9.3. Causes of Landslides

The factors which promote landslides are : (i) water, (ii) slopes, (iii) nature of rocks, (iv) structure of rocks, and (v) disturbance of equilibrium.

- (i) **Water.** The essential conditions which cause landslides, are lack of support in front and lubrication behind. Thus water is an important factor in causing landslides. It acts in three ways :
 - (a) Water diminishes the strength of rocks and thus help in their movement.
 - (b) The water that seeps into the rock or soil, not only produces lubrication but also exerts additional force on the grains tending to displace them along the direction of water movement.
 - (c) It adds weight to the material. Hence many landslides occur after rains.
 - (d) On freezing it exerts an expansive force.
- (ii) **Slope.** It has been observed that majority of the earth or rock failures are confined to slopes. This indicates that slopes are directly responsible for landslides. As a rule, steeper the slope, greater is the instability of such a mass.
- (iii) **Nature of Rocks.** Unconsolidated sediments, such as clay, sand, gravel, etc. can not stand permanently along slopes greater than their angle of repose (about 35°) and are likely to be affected by landslides. Where weak and slippery rocks like shale, volcanic tuff, phyllites or mica-schists are present, they are not likely to remain stable on steep slopes for a considerable period of time.
- (iv) **Structure of Rocks.** Joints, fractures, shear zones and bedding planes usually become the slip surface in case of rock slides. Landslides are particularly common on hill slopes where dip of rock beds is also in the same direction (Fig. 10.22).

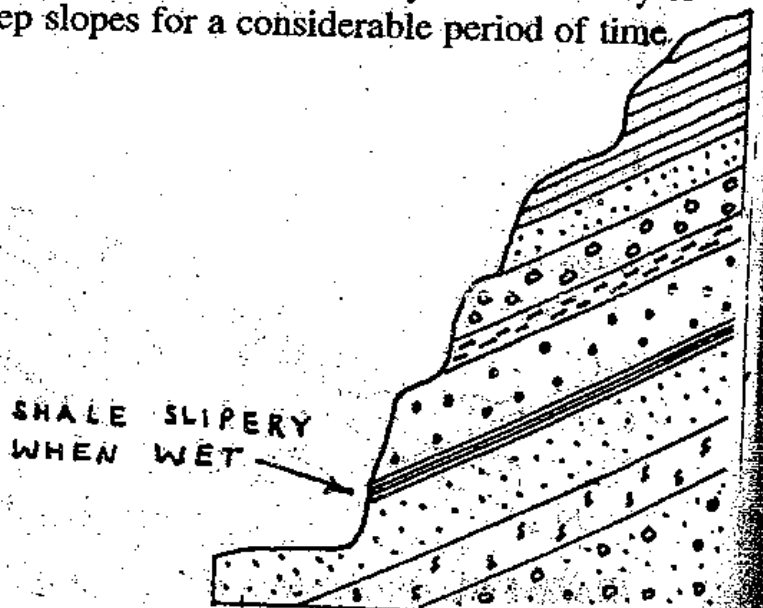


Fig. 10.22. Beds dipping towards hillslope.

10.9.4. Prevention of Landslides

The methods which are commonly used for prevention of landslides are as follows.

1. Slides in the impervious material are prevented by reducing slopes. Efforts should also be made not to allow the additional water to enter into the material.
2. In order to check the surface water to enter into the unstable ground, it is diverted and made to run off as rapidly as possible away from that area.
3. In pervious materials, the landslides may be prevented by increasing the internal friction of the mass by lowering the water content. Their water may be removed by drain pipes, by drainage through tunnels or by pumping from wells.
4. In situations where slides may cause loss of life and property, the loose rock material is prevented from sliding by constructing retaining walls, concrete piers or by use of piling.
5. At some places the unstable unconsolidated material may be consolidated by cement grouting, chemical means, and artificial freezing.

REVIEW QUESTIONS

1. Give a brief account of the importance of geology in civil engineering. Explain your answer by giving suitable examples.
2. Explain the importance of the geological investigation of dams. Describe the various geological factors that may cause trouble in the construction of a dam.
3. What is a tunnel? Describe the various geological problems met during the construction of tunnels both in the soft ground and in the hard rocks.
4. Give the importance of the geological survey of the dams and reservoirs. Outline the scheme of doing the geological investigation.
5. (a) Describe the various geological factors which affect the stability of bridges.
(b) Discuss the factors that help in selecting the rocks for building purposes.
6. (a) Describe the problems that are met in constructing dams on bedded rocks, faults, and shales.
(b) Give a brief outline of the geological survey of tunnels.
7. Write short on any two of the following.
(i) Factors promoting landslides.