CHAPTER 5
PREVENTIVE MEASURES FOR LANDSLIDES

5.1 GENERAL

The problem related to the stability of natural and man-made slope constitute the most challenging task to be tackled in the hilly terrains. In the recent years engineers and geologist have extensively studied several basic considerations in the design of stable slope in soil. Various techniques are available to reduce the potential instability of hill slopes.

The methodology and design procedure to be adopted for stabilization of a particular slope depend upon the following factors.

a) Slope geometry
b) Surface and subsurface hydrology
c) Presence of layer of lower strength
d) Available technology and expertise
e) Proposed development of slope area

5.2 PREVENTIVE MEASURES OF SLOPE FAILURE SUGGESTED FOR GUWAHATI AND ITS ADJOINING AREAS

There are a number of methods for slope stabilization and some of the methods are explained in the section below:
5.2.1. Soil Nailing

Soil nails are rigid bars. After being driven into the soil these are filled completely with the grout. They are used to stabilize the slopes or excavations by resisting against tensile, shear, and bending stresses imposed by slope movements. It is an alternative to retaining wall structures and are placed in those situations where construction of retaining wall is not feasible due to space constraints. According to Abramson et al. (2002), the soil mass behind the soil slope is divided into an active zone and a passive zone which are separated by a shear face called slip surface. The stabilizing manner is governed by the soil frictional force between the soil nail surface and soil which is generated by the surrounding soil mass in passive zone. For the soil nail to act as a good anchorage, it must penetrate beyond the slip surface into the passive zone. A typical example of slope stabilization using soil nailing is taken from Kharguli Site 3 (Refer Section 4.3.4).

From Fig. 5.1 (a, b) it has been found that with the introduction of soil nailing, the stability of slopes greatly increased.
5.2.2. Retaining walls

The retaining structures are generally erected to counteract the lateral forces imposed by soil movement and water pressure. They bring greater stability to dangerous slope or to support existing landslides. Hutchinson, 1977 observed that a properly designed and constructed rigid retaining structure can play a very useful role, particularly where the space is restricted. The most important consideration in the proper design of the retaining wall is to recognize and counteract the fact that the backfill material tries to move in the forward direction and downslope due to gravity. This creates lateral earth pressure behind the wall. This earth pressure is zero at the top of the wall and increases significantly in a homogenous fill with the depth of the wall. It is important to have proper drainage behind the wall as any ground water behind the wall that is not dissipated causes hydrostatic pressure on the wall and increases the instability of the slope. A typical example of slope stabilization using retaining wall is taken from Hengerabari Site 1 (Refer Section 4.3.1).
From Fig. 5.2 (a, b) it has been found that with the introduction of retaining wall, the stability of slopes greatly increased.

**Figure 5.2: Stabilization of Slopes by retaining wall in Hengerabari Site 1**
5.2.3. Geosynthetic Reinforcement

Geosynthetics are made up of synthetic polymers such as polypropylene, polyethylene, polyester, polyamide, PVC, etc. that are porous, flexible and are used to reinforce or increase the stability of a structure. These materials are derived from crude petroleum oils; although glass fiber, rubber and other materials are also sometimes used for the purpose. A geosynthetic performs the reinforcement function by improving the properties of the soil mass. The geosynthetic reinforcement combined with the soil to form a composite material, called reinforced soil that possesses high compressive and tensile strength. A typical example of slope stabilization using geosynthetic is taken from Hengerabari Site 1 (Refer Section 4.3.1).

From Fig. 5.3 (a, b) it has been found that with the introduction of retaining wall, the stability of slopes greatly increased.
5.2.4. Drainage of water

The stability of slopes can be increased by means of drainage. Water in a slope may come from two sources: surface water and ground water. The water control is generally maintained by installing surface and sub-surface drainage within and adjacent to potentially hazardous slopes.

Drainages are the most frequently used means of stabilizing the slopes. In general, slopes are mainly encountered with rise in ground water level and increase in the pore water pressure. Therefore, lowering the ground water levels and reducing the pore water pressures are a logical means to improve the stability of slopes. In addition, improving the drainage helps to stabilize a large volume of the ground at a very low cost. Drainage of water can be in the form of surface water drainage and sub-surface water drainage.
5.2.4.1. Surface Drainage:

Surface water that is allowed to flow down the slope can infiltrate into the ground through the discontinuities present in the soil or rock mass. The water infiltrating into the discontinuities thereby increase the driving force by building up of pore water pressure and therefore, contributing to the instability of the slope. Grading and shaping are the major considerations for the control of surface water. Surface water can be controlled by using a combination of topographic shaping and runoff control structures (Glover et al., 1978). The topographic shaping is used to control the rate and direction of the surface flow by changing the length, shape and gradient of the slope. In climates experiencing heavy rainfall that can rapidly saturate the slope and can cause soil erosion, it is beneficial to construct concrete ditches both behind the crest and on benches of the slope to intercept the water for stability. Construction of feeder drains, contour drains and main drains works effectively in draining out the water from the hilly areas.

5.2.4.2. Sub-surface Drainage:

Subsurface drainage is associated with the drainage condition which is below the ground i.e. to lower the ground water table and hence the water pressure to a level below the potential failure surface. There are numerous methods that can be incorporated to achieve the subsurface drainage. The two commonly adopted methods are discussed in the section below:

(i) Subsurface drainage blankets

If the quality of the soil at a shallow depth is poor, it is very much necessary to remove the poor quality soil and replace it by well-draining soil layer. The bottom portion of the excavation is then filled with stone layer embedded with a perforated pipe in it to capture
the flow. A drainage ditch should be installed to guide the water from the outlet pipe to the discharge point.

(ii) **Prefabricated drains:**

The prefabricated drains are composed of a plastic core encased by a geotextile are perforated pipes which are inserted in a drilled hole of slopes to provide underground drainage. These drain pipes are usually placed in the upward sloping position so that water may drain out by gravity. These drains are installed in a slope by drilling into the holes by means of an auger and placing a perforated drain pipe in the drill hole. The auger is withdrawn after the drilling process is finished leaving the drain pipe in place and the hole is allowed to collapse around the drain pipe. Prefabricated horizontal drains are used in such situations where the subsurface groundwater is located at such a great depth that the cost of stripping or placing trenches becomes very expensive. Prefabricated vertical drains (PVDs) are also used to expedite the movement of sub-surface water, thereby decreasing the chances of generation of high pore water pressure.