NATURAL RESOURCES CONSERVATION SERVICE
VIRGINIA ENGINEERING DESIGN NOTE #453 (DN-453)
LANDSLIDE TREATMENT

Landslide treatment is used to manage in-place materials, mine spoil (excavated over-burden), mine waste, or over-burden to reduce down-slope movement.

In most cases, the unstable or potentially unstable conditions cannot be attributed to one cause. Therefore, the solution is usually a combination of treatment measures, each either increasing the internal strength or decreasing the external load to the point where required stability is obtained. Slides are the most complex of geotechnical problems requiring analysis. The best available expertise in soil engineering is needed, and expert consultants should be hired, if necessary.

Landslides result from a combination of several factors, the most important being static load, slope of the surface and slip zone, soil characteristics in the slip zone, and the presence of water. The key to control is to bring about a favorable balance between the load that created a tendency to move and the resisting forces that restrain movement.

Safety

Extreme caution must be exercised and careful planning is required before permitting any personnel, drilling equipment, or construction machinery in the slide area. A slide is often active during wet periods and may be comparatively stable during dry periods. With this in mind, heavy drilling and machinery work should be scheduled during dry periods.

Water Control

Water creates problems in two ways. The addition of water to the materials above the slope zone increases the load. It also acts as a lubricant along the slip plane, or increases pore pressure within the slide material and in the slope area, thereby reducing internal strength. In both cases, water increases the potential for sliding.

There are three major sources of water within the slide area: surface runoff that finds its way onto the slide area, precipitation directly on the surface, and subsurface water from known or unknown sources. A combination of these sources usually contributes to the excessive water problem.

<u>Surface runoff water</u>

Keep surface runoff water from outside areas from entering the surface scarp area by using diversions, associated structures, and conveyance systems.

<u>Water from direct precipitation</u>

Infiltration can be limited and controlled by providing positive surface drainage, sealing the surface cracks and breaks on the slide and adjacent areas, and establishing vegetation.

Cut and fill to a depth of 3-4 feet may be required to reduce surface infiltration and seal cracks and breaks. Compaction of the material will further reduce infiltration, but care must be taken to prevent excessive compaction which would restrict vegetative establishment. Positive drainage will decrease seepage. Establishing a vigorous vegetative cover will increase evapotranspiration and help control erosion.

Ground water

Ground water that contributes to instability shall be controlled. Many slides remain active during reconstruction periods and further movement can be expected. Drains shall be designed to be operative after limited movement. A filter shall be used to prevent clogging of the drains.

Earth Material Control

Earth material and internal water are the load factors that contribute to the unstable conditions that cause slides. Possible treatments include removing earth materials to reduce the load and slope, increasing the internal strength of the earth material, providing external restraints to movement, and weighting the toe.

Loading control

In most cases, loading control consists of removing excess material to a safe location. However, in some cases, the solution may be to add material to the toe of the slide area to increase the load, resisting further movement. Removal of slide debris from the toe (downhill side) of the slide usually will increase the instability and cause further slide movement.

Increasing internal strength

Reducing the internal water of the slide material, removing or replacing the slide material, incorporating any admixture needed into it, and compacting it can increase the internal strength to resist a tendency to slide.

External restraints

In some cases, buttresses, bulkheads, retaining walls, pilings, tieback anchors, and gabions can be used to restrain further slide movement. These structures may provide the only practical solution where high-valued improvements are involved and movement must be contained in a short distance. The structures are normally very expensive and are not practicable otherwise. They also require complex design analyses, using the expertise of geologists, soil mechanics engineers, and structural engineers.