

SOIL CONSERVATION SERVICEKENTUCKY INTERIMGUIDE STANDARDLAND RECLAMATION, LANDSLIDES 453-1Definition

Treating mine spoil (excavated overburden), mine waste, overburden, or in-place material associated with previously mined areas to reduce downslope movement.

Scope

This practice applies to landslides or potential landslides in areas associated with abandoned mines.

Purpose

To prevent or stabilize landslides to: protect life, property and water conveyance systems; prevent excessive erosion and sedimentation; improve water quality and visual quality; and create a condition conducive to establishing surface protection and beneficial land use.

Conditions where practice applies

To areas where mine spoil, waste, overburden, or in-place material is unstable, moving or judged to have potential of moving downslope in a manner that will cause damage to life, property, or the environment and/or produce excessive sediment and debris. Land reconstruction is normally associated with this practice. The principals stated in this standard may also be applied to the treatment of landslides on unmined areas.

Planning considerations

1. Geology of the area and associated subsurface conditions.
2. Type and amount of spoil or waste.
3. Topography of the slide and adjacent areas, including known or estimated premine and preslide conditions.
4. Surface drainage and runoff patterns.
5. Ground-water profiles, seepage patterns, and sources of subsurface water.
6. Land use, dwellings, roads, structure, and water disposal system.
7. Procedures used during mining operations.
8. Slide potential during investigation and construction.
9. Rainfall and runoff.

Landslides result from a combination of several factors, the most important being static load, slope of the surface and slip zone, the soil characteristics in the slip zone, and the presence of water. The key to control is to bring

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about a favorable balance between the load which creates the tendency to move and the resisting forces which restrain movement. This can be accomplished by reducing the load, reducing the slope, increasing internal strength and/or providing external restraining forces. A good reference on landslides is the publication "Landslides: Analysis and Control," 234 p., Special Report 176, Transportation Research Board, National Academy of Sciences, 1978.

Investigations

Investigations are to be made to determine:

1. Surface profiles, cross sections, and topographic features.
2. Geologic profiles and cross sections showing attitude and condition of strata and details of the slip zone.
3. Soil properties, including gradation, density, strength, physical and chemical characteristics.
4. Groundwater conditions.
5. Depth and volume of material involved.
6. Extent of problem or potential problem area.
7. Estimated preslide profile and subsurface condition.
8. Conditions where slopes are stable in similar materials.

Extreme caution must be exercised and careful planning is required before putting any drilling equipment, construction machinery, or personnel on the slide area. A slide is often active only 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.

Design considerations and criteria

In most cases the unstable or potential unstable conditions cannot be attributed to one cause nor can all contributing causes be completely eliminated. Therefore, the solution is usually a combination of a number of treatment measures, each either increasing the internal strength or decreasing the external load to a point where required stability and conditions are obtained.

Slope Stability. Measures developed to prevent or stabilize slides shall be based on engineering analyses and judgment made by an engineer trained and experienced in soil mechanics. Slides are the most complex of geotechnical problems requiring analysis. The best available expertise in soil engineering is needed and may require engaging expert consultants.

Slope stability analyses shall account for all critical soil and loading conditions. The strength parameters of natural soil and rock or of waste materials shall be based on the appropriate conditions for each slide. Long term strength parameters ($c = 0$ and internal friction based on residual shear) are

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often required. The methods of slope stability analysis are to be appropriate for the loading conditions and the location and shape of sliding or potential failure surfaces. Appropriate factors of safety shall be provided based on the degree of uncertainty in the soil strength values used, the soil and water conditions assumed and the detail of the analysis used.

When there is a potential for loss of life or damage to farmsteads, residential areas, frequently traveled roads, other occupied facilities, or important public utilities, the measures shall include removal of the material subject to sliding or other positive control that insures safety.

Earthquake or seismic forces are to be considered in the appropriate locations. The criteria for geologic investigations, seismic assessments, and minimum seismic coefficients associated with earthquakes as contained in Technical Release No. 60 for earth dams shall apply.

Water Control. Water acts in two ways to create problems. The addition of water to the material above the slip zone increases the load. It also acts as a lubricant or increases pore pressure within the slide material and in the slip area reducing the internal strength. Water in both cases increases the potential for sliding.

There are three major sources of water within the slide area. Surface runoff, both local and foreign, that finds its way onto the slide area; water from direct precipitation on the surface; and natural ground water from known or unknown sources. A combination of these sources usually contributes to the excessive water problem and must be dealt with to the extent possible.

Surface Runoff Water. Runoff water from outside areas is to be controlled in a manner which minimizes its entry onto the slide area with diversions, associated structures, and conveyance systems.

Water from direct precipitation. 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 the area to a vigorous vegetative cover. Grading and shaping may be required to provide positive surface drainage. Terraces, structures, and waterways are to be installed as needed to provide safe water disposal without erosion and with positive grade to reduce seepage. Cut and fill to a depth of 3 to 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 exercised to prevent excessive compaction which would restrict vegetative establishment. Establishing a vigorous vegetative cover will increase evapotranspiration and control erosion.

Ground Water. Ground water that contributes to instability is to be controlled. Many slides remain active during the reconstruction period and

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further movement can be expected. Therefore, drainage systems are to be designed that will remain operative with limited movement. Pipes must be used with caution because of the potential of breaking and/or misalignment with further movement. Flat or near flat gradients should not be used for the same reasons. A properly designed filter shall be used to prevent clogging of the drains.

Earth Material Control. Earth material and internal water are the external load that contributes to the unstable conditions and that causes a slide. Treatment consists of removing earth material to reduce the load and/or slope, increasing the internal strength of the earth material and/or providing external restraints to movement.

Loading Control. In most cases loading control consists of removing excess material to a safe location. However, there are cases where the solution may involve adding material to the toe of the slide area to increase the load resisting further movement. In most cases, removal of slide debris from the toe (downhill slide) of the slide will increase the instability and cause further slide movement.

Slope Reduction. Desired slope reduction can sometimes be accomplished by grading and shaping to eliminate critical slopes within the slide area. It can also be accomplished as the final planned condition in an unloading situation.

Increasing Internal Strength. Reducing the internal water and the removal, replacement, incorporation of any admixture needed, and compaction of the slide material 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 may be the only practicable solution where high valued improvements are involved and movement must be contained in a short distance. They are normally very expensive and are usually not practicable otherwise. They also require complex design analyses, using the expertise of geologists, soil mechanics engineers, and structural engineers.

Other Considerations. All individual practices installed as a component of landslide treatment are to be designed and installed in accordance with applicable SCS standards and specifications. If SCS standards are not available, the practice is to be designed and installed using current, sound engineering technology.

All disturbed areas are to be provided with adequate water disposal systems and established to vegetative cover, or otherwise protected, to control erosion and sediment as soon as practicable. Temporary protective measures will be necessary if there is a long delay anticipated in establishing permanent cover. Foot and vehicular traffic is to be controlled to protect the area.

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Visual resources are to be given the same consideration as other design features. All disturbed areas shall be reshaped and regraded to blend in with the surrounding land features.

Instrumentation should be considered on major high hazard sites.

Maintenance

Maintenance activities are to be outlined in the reclamation or a maintenance plan. Periodic inspections are essential because of the potential of additional movement, failure of water disposal systems, failure of vegetation, and other problems. Water disposal system, subsurface drainage system, access roads, and vegetative cover are to be maintained to accomplish their intended purposes. Needed maintenance and repair activities are to be initiated promptly.

Plans and specifications

Plans and specifications for slide treatment shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve the intended purpose.

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