NATURAL RESOURCES CONSERVATION SERVICE

VIRGINIA CONSERVATION PRACTICE STANDARD

LAND RECLAMATION, LANDSLIDE TREATMENT

(No. and Ha, Acre)

Code 453

DEFINITION

Treating inplace materials, mine spoil (excavated over-burden), mine waste, or overburden to reduce downslope movement.

PURPOSE

To prevent or stabilize landslides to:

- Protect life and property
- Prevent excessive erosion and sedimentation
- Improve water quality and landscape resource quality
- To create a condition conducive to establishing surface protection and beneficial landuse.

CONDITIONS WHERE PRACTICE APPLIES

To areas where inplace material, mine spoil, waste, or overburden 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 produce excessive sediment and debris. Land reconstruction and stabilization is normally associated with this practice.

CRITERIA

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.

SLOPE STABILITY

Measures developed to prevent or stabilize slides shall be based on engineering analysis and judgement 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 expert consultants should be hired, if necessary.

Slope stability analysis 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=O and internal friction based on residual shear) are often required. The methods of slope stability analysis are to be appropriate for the loading conditions and for the location and shape of sliding or potential failure surfaces. Appropriate safety factors 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, and occupied facilities, or important public utilities, the measures shall include removal of the material subject to sliding or any other control to ensure safety.

Earthquake or seismic forces are to be considered on major high hazard sites. The criteria as contained in Technical Release No. 60 for earth dams shall apply for geologic

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investigations, seismic assessments, and minimum seismic coefficients associated with earthquakes.

WATER CONTROL

Water creates problems in two ways. The addition of water to the material 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.

SURFACE RUNOFF WATER

Runoff water from outside areas is to be controlled from entering the surface scarp area by using 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 vegetation.

Grading and shaping may be required to provide positive surface drainage. Terrace 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 0.9 to 1.2 m (3 to 4 ft.) 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. Establishing a vigorous vegetable cover will increase evapotranspiration and help control erosion.

GROUND WATER

Groundwater that contributes to instability is to be controlled. Many slides remain active during reconstruction periods and further movement can be expected. Therefore, drainage systems are to be designed to remain operative after limited movement. Pipes must be used with caution because of the potential of breaking and/or misalignment with further movement. Flat or nearly 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 load factors that contribute to the unstable conditions that cause slides. Treatment consists of removing earth material 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 instances, 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.

SLOPE REDUCTION

Slopes can sometimes be reduced by grading and shaping to eliminate critical slopes within the slide area. It can also be reduced as a result of loading control measures.

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 practicable solution where high-valued improvements are involved and movement must be contained in a short distance. The structures

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.

COMPONENT PRACTICES

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

ENVIRONMENTAL CONCERNS

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 a long delay is anticipated in establishing permanent cover. Foot and vehicular traffic is to be controlled to protect the area.

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

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 pre-mine, preconstruction, or pre-slide conditions.
4. Surface drainage and runoff patterns.
5. Groundwater profiles, seepage patterns, and sources of subsurface water.
6. Landuse, dwellings, roads, structures, and water disposal system.
7. Procedures used during mining operations or construction.
8. Slide potential during investigation and construction.
9. Rainfall and runoff.
10. Effect on and discharge capacity of watercourses affected by the landslide.
11. Water budget effect on volumes and rates of runoff, evaporation, deep percolation, and groundwater recharge.
12. Potential for a change in plant growth and transpiration because of changes in the amount of soil moisture in the vicinity of the structure.
13. Potential to reduce erosion and related movement of sediment or sediment-attached substances.
14. Short-term and construction-related effects on downstream water courses.
15. Potential to alter the discharge of toxic materials to ground or surface waters.
16. Effects on the visual quality of water resources.

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 conditions of strata and details of the slip zone.
3. The frequency and direction of any discontinuities (such as joints), the extent of the discontinuities, and the kind of infilling material present in them.
4. Soil properties, including gradation, density, strength, and physical and chemical characteristics.
5. Groundwater conditions.
6. Depth and volume of material involved.
7. Extent of problem or potential problem area.

8. Estimated pre-slide profile and subsurface conditions.

9. Conditions where slopes are stable in similar materials.

10. A determination of the earthquake history of the area.

Extreme caution must be exercised and careful planning is required before permitting any drilling equipment, construction machinery, or personnel in 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.

Landslides result from a combination of several factors, the most important being static load, slope of the surface and slip zone, and 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 the tendency to move and the resisting forces that restrain movement. This can be done by reducing the load, reducing the slope, increasing internal strength, and providing external restraining forces. A good reference on landslides is the publication, "Landslides: Analysis and Control," 1978. Transportation Research Board, National Academy of Sciences, Special Report 176, 234 p.

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 its intended purpose.

OPERATION AND MAINTENANCE

The maintenance plan is to include periodic inspections because of the potential for additional movement, failure of water disposal systems, failure of vegetation, and other problems. The water disposal system, subsurface drainage system, access roads, and vegetative cover are to be maintained to accomplish their intended purposes. Necessary maintenance and repair activities are to be initiated promptly.

REFERENCES

1. "Landslides: Analysis and Control", 1978. Transportation Research Board, National Academy of Sciences, Special Report 176, 234 p.

2. Technical Release No. 60.

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Approved Practice Narratives

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453 D1 Land Reclamation, Landslide Treatment: The landslide or potential landslide area will be stabilized as soon as the need becomes evident. This stabilization will protect life and property, improve water quality, and create land that has a more beneficial use.

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