Grading and shaping for erosion control and rapid vegetative establishment

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Erosion control of lands in humid areas drastically disturbed by coal surface mining is strongly influenced by four principal factors: climate, soils, vegetation, and topography. The climate for any given region is fixed. Man's control over climate is very limited. But he can schedule sensitive field operations around the local weather patterns. Vegetation is the most flexible of these factors. Plant materials are available for almost any situation in the humid regions of the United States, provided their establishment is supported by known conservation measures and if the soils and topography are suitable.

Objectives

The basic objective of an erosion control program for a surface mined area is to stabilize the disturbed area. When the area is stabilized, the volume of sediment generated will be minimized and off-site damage reduced. Therefore the principal objective of grading and shaping operations should be to manipulate the soil and topography to assist in the control of surface runoff, thus reducing erosion and improving effective vegetative establishment.

In addition, there are several secondary objectives. The grading and shaping features of an erosion control program must also be compatible with the land use planned for the area after mining and reclamation are completed. The soil and topography required should be identified before making the grading plan.

Plans for grading and shaping should include making full use of the materials or land resources at the site. Large rocks and boulders can be buried or they can be placed on toeslopes to make use of their properties of resistance to weathering. If durable, they can be used as rip-rap for stabilizing waterways or as special features on recreation sites. Brush and other woody materials can be windrowed at the toe of fills and used as a partial filter. They can be fed through a woodchipper and used as a mulch for soil stabilization. The potential use of all materials at the site should be considered in preparing the mining plan and in determining the use of the land after mining.

As a minimum the grading and sloping operations must conform to state laws. Most states have grading specifications included in their reclamation requirements. These specifications usually require that the peaks and ridges be reduced by grading to a rolling, sloping, or terraced topography. Areas reclaimed for uses such as forest plantation and wildlife may require less grading than for other uses. In addition some states require that acid-forming material be covered with a minimum depth (2 to 4 feet) of material suitable to support plant growth. Most states have set a time limit on the completion of the reclamation operations; a 2- to 3-year limit is most common.

Soil Characteristics

Soil materials resulting from mining have physical and chemical characteristics unique to each site. The physical-chemical characteristics of the soil materials at a particular site must be known and considered in planning the shaping and grading operations. The characteristics of such soils that most influence the stated objectives include the toxicity or potential toxicity of the material and the capacity to hold water.

Potentially toxic acid-forming material can be handled in two ways. It can be buried in the surface mine pit or it can be neutralized by adding lime. If the toxic material is identified, segregated, and stockpiled, it can easily be placed in the bottom of the pit. There are fewer problems in establishing and maintaining vegetation where potentially high acid-forming materials are covered with soil material favorable to plant growth.

The water-holding capacity of the material is the key to erosion control on most sites. Other soil characteristics that have a strong influence on the erosion potential of a soil are texture, organic matter content, percent slope, and effective length of slope.

Soil texture refers to the size and proportion of particles making up a particular soil. Soil texture classes

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are determined by the relative amounts of sand, silt, and clay. If sand is dominant, the soil is coarse-textured or "light" and allows water to infiltrate more rapidly. Too much sand, however, may make the soil too droughty for plant estalishment. Clay particles are dominant in fine-textured or "heavy" soils, which are often quite cohesive and slow to erode. Soils high in silt and very fine sand and low in clay and organic matter are generally the most erodible.

Organic matter is plant and animal residue in various stages of decomposition. The organic matter content of a soil has an inverse relationship to erodibility. As the amount of organic matter in a soil increases, the capacity of the soil to absorb surface water increases. As a result, runoff is reduced. Soil materials that result from mining operations are generally lacking in near-surface concentrations of soil organic matter. Deficiencies in near-surface organic matter can be remedied through establishment of vegetative cover and proper maintenance. Superior long-range benefits may be obtained by controlled deep incorporation of organic matter recovered from the original surface soil.

The ability of a soil to hold water depends on texture, soil depth, and organic-matter content. Soils that are able to hold large quantities of water are desirable from a plant growth standpoint, although some clays with excessive holding capacity cause problems.

Grading Considerations

Scheduling and Seasonal Limitations

Seasonal climatic variations play an important role in the scheduling of grading operations. The amount of rainfall and runoff during different periods of the year influences erosion. Because the soil is so vulnerable to erosion during the grading activities, those activities should be scheduled to coincide with the periods of low precipitation. The spring and early summer months often have the highest precipitation rates. Therefore, the bulk of grading operations, especially in critical areas, should be scheduled for midsummer and fall.

Soil stability is another consideration. Proper compaction cannot usually be obtained during the winter months when the ground is frozen. In early spring the ground is often too wet to be handled properly, and mud can impede the operation of grading equipment.

If there is a choice, it is better to grade during the most favorable time for seeding. From a moisture and temperature point of view, April, May, and June in the spring and late August, September, and October in the fall are the best times to seed for uniform emergence and seedling growth in West Virginia, Maryland, and Virginia.

Topographic Manipulations

The rate of runoff and, correspondingly, the rate of soil erosion can be controlled by manipulating the slope gradient and effective length of slope. Such control is particularly significant in area mining and mountaintop mining.

Slope design should be based on the erodibility of the surface soils, as well as the need to stabilize against mass earth movement. Return to approximate original contour, as required by most state laws, may not be desirable in all cases. A reduction in relief and an overall flattening of the topography is not only desirable from an erosion control standpoint, but may be necessary to convert the site to another type of land use. It must be remembered that shorter and flatter slopes are less erodible.

Where there is little flexibility as to the overall configuration of the slope, as is often the case with contour mining in steep terrain, diversion structures, such as reverse benches or terraces, ditches, and dikes, can be constructed above and along the spoil slopes to decrease the overall length of the slope.

Soil Surface Manipulations

The soil surface can be manipulated to reduce and detain runoff. Manipulation includes roughening and loosening the soil, mulching and revegetation, and topsoiling and adding soil amendments.

A roughened and loosened soil surface improves water infiltration, slows the movement of surface runoff, and benefits plant growth. Common methods of loosening and/or roughening a soil surface include scarification, tracking, and contour benching or furrowing. Scarification is usually accomplished by disking or harrowing on the ground contour, but it can also be done by a crawler tractor equipped with ripper bars or by dragging the teeth on the bucket of a front-end loader over the ground.

Tracking is done on steep slopes where equipment cannot be moved safely along the ground contour. It is accomplished by running a cleated crawler tractor up and down the slope. When this method is used, it is important that the cleat marks overlap. The cleats leave shallow grooves that run parallel to the contour. If the slope is not too steep, furrows can be made on contours by angling the dozer blade. Some overtopping of these furrows occurs, but they help control erosion.

The prompt establishment of a cover of vegetation or the placement of a fibrous, organic mulch on a denuded soil surface also reduces and detains surface flow. Additionally, it stabilizes the soil. Vegetation or mulch protects the surface and prevents the soil from being compacted and sealed during a rainfall. Live vegetation and mulching materials make the soil more porous and remove soil moisture.

The permeability of the surface soil also has a major bearing on the rate of surface runoff. If the soil remaining after grading is highly impermeable, it may be desirable to top-dress the graded area with a more suitable soil. This process should enhance revegetation efforts. Decreased surface runoff is a secondary benefit.

Commonly used equipment for grading and shaping are dozers, pull scrapers, motor scrapers, trucks, and high lifts. Power shovels, gradalls, and draglines are sometimes used in the backfilling operation.

The types of equipment used influence the quality of the final grading and shaping. Some compaction is needed to improve slope stability. However, the surface or root zone should be loose to permit water movement and good plant growth. The type of equipment used will have an effect on these conditions.

Guidelines for Grading and Shaping

Scheduling of Operations

Grading and shaping operations should be scheduled with two objectives in mind. The first objective is to minimize the total surface area disturbed at any one time. The second objective is to schedule earth moving operations which considers seasonal climatic variations. The schedule should require the shaping and grading operations, including seedbed preparation and mulching, to be conducted as a continuous operation during the best seasons of the year.

Soil Placement

Two major objectives in placing soil materials resulting from mining operations are (1) to provide a stable soil mass and (2) to provide a suitable growth medium. These objectives are extremely difficult, if not impossible, to attain without a thorough analysis of the overburden materials during preplan-

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ning. This analysis will identify potentially toxic materials that must be buried or neutralized. It will also identify the layer of the soil that would be most desirable for plant growth. The occurrence of ground water, particularly aquifers or springs that might saturate and threaten stability of the soil mass, can also be identified and provided for in the soil reconstruction process. Reconstruction should replace old acid soils with nonacid young soils; provide high levels of available plant nutrients (phosphorus, calcium, magnesium, and potassium); replace hardpans and relatively shallow root zones with deeper soils; and provide boulder-free surface soils.

Utilization of Existing Materials

Grading and shaping plans should take advantage of materials present at the site. If clayey materials are present in the overburden material, they can be used to segragate toxic soil materials, create an artificial ground water table, and line the walls and bottoms of water-holding impoundments. Large rocks and boulders, which are usually buried, can also be used to anchor the toes of outslopes and stabilize steeply sloping soils. They can also be broken down and used as rip-rap to stabilize slopes, water courses, and outfalls. Nonmarketable woody plant materials, which are also usually buried, can be processed through a wood chipper and used as a mulch. Before a decision is made to discard any material, it should be thoroughly evaluated for possible use.

Control of Runoff

Grading and shaping are major considerations in the control of runoff. Runoff can be controlled through a combination of surface soil manipulations, topographic shaping, and erosion control structures.

Soil surface manipulations include roughening and loosening the soil, mulching and revegetation, topsoiling, and adding soil amendments. Mulching and revegetation are not strictly shaping and grading operations, but they are generally inseparable from these operations. The shaping and grading operations by themselves cannot do much to prevent rainfall erosion. The impact of falling raindrops can be controlled quickly with mulches and the rapid establishment of grasses and legumes. The preparation of the soil surface through soil surface manipulations will help to keep the mulch in place and establish vegetation.

Topographic shaping is used to control the rate of runoff and to reduce the rate of soil erosion. This objective is accomplished by manipulating the gradient, length, and shape of the slope. In addition, topographic shaping has a major influence on the stability of the slopes. Slope design, therefore, should be based on the erodibility of the surface soils and the stability against landslides.

The grading and shaping operations must recognize the needs of the post-mining land use. These requirements and characteristics vary considerably among the many possible land uses, which include reforestation, recreation, agriculture, and urban development. The elements with the greatest possible variance include slope length and steepness, water supply, storm runoff handling, and selection of plant materials.

Selection of Equipment

The selection of the proper size and kind of equipment for grading and shaping is important. A large piece of equipment (D9 or greater) provides the greatest capacity to move earth. However, it may not be the most economical for grading and finishing the job to the required standards.

Most successful operators have found that a large dozer (D9 or equal) can be used for backfilling and rough grading. After this stage use of a smaller dozer (D-7 or equal) has proved to be the most economical, mainly because of its greater maneuverability. This smaller size equipment has the capability to final-grade closer to requirements and to construct water disposal measures. Long blades and the overall physical size of large dozers limit their use in constructing these water disposal measures.

Equipment selection is also governed by the distance earth has to be moved. General guides are as follows:

Up to 300 feet—Dozer
300 feet to 1,000 feet—Pull scraper
1,000 feet or greater—Motor scraper

Applicable Conservation Measures

Numerous conservation measures have been developed to supplement the grading and shaping operations in controlling erosion and establishing effective vegetation. The applicable measures fall into two major categories: measures for runoff control and measures for soil stabilization.

Measures for Runoff Control

Measures used in controlling runoff can be grouped into three types according to their function. The three basic functions are:

(1) reduction and detention of runoff
(2) interception and diversion of runoff
(3) conveyance of safe disposal of concentrated flow

Measures to reduce and detain runoff include those practices discussed under surface soil manipulation and topographic manipulation. Included in these practices are:

(a) roughening and loosening the soil
(b) mulching and revegetation
(c) topsoiling and soil amendments
(d) reduction of slope length and gradient
(e) use of concave slopes

Interception and diversion practices are used to intercept runoff before it reaches a critical area and to divert it to a safe disposal area. Interception and diversion practices perform two important functions at surface coal mines. They isolate onsite critical areas (i.e., raw spoils, partially stabilized spoils, highwalls, access roads, and other areas) from offsite runoff. In addition, they control runoff velocities on steep or long spoil slopes and abandoned access roads. Interception and diversion is accomplished through the use of various conservation structures, including reverse benches or terraces, cross-slope ditches, earth dikes, and combined ditch and dike (diversion).

The diversion and the interception of runoff necessitates the conveyance and disposal of concentrated flows. Safe conveyance of concentrated flow requires practices that reduce the velocity of runoff or maintain low velocity, and as a result, control its ability to detach and transport soil particles. In handling concentrated flow, the objective is to safely convey the water without erosion. This is accomplished by designing the measures to withstand the expected velocities. For most vegetated waterways there must be only intermittent flow, and velocity cannot exceed 5.0 feet per second. If greater velocities are expected or base flow or seepage occurs, structural protection is needed such as rip-rap or concrete linings. Other structures such as culverts and chutes can also be used to convey concentrated flows to safe outlets. Temporary storage of runoff in impoundments and energy dissipators (level spreaders, concrete or road blocks, etc.) are other methods that may be used.

Measures for Soil Stabilization

The second category of erosion control measures is soil stabilization. Soil stabilization practices are designed to protect the soil from the erosive action of rainfall, ensuing runoff, and wind. Stabilization measures can be either vegetative or nonvegetative and short term or long term.

Vegetative stabilization refers to the use of different types of vegetation to protect the soil from erosion. Nonvegetative stabilization, on the other hand, refers to a multitude of practices that use materials other than vegetation such as mulch, gravel, etc. in preventing soil erosion. A combination of both vegetative and nonvegetative measures is usually required. □