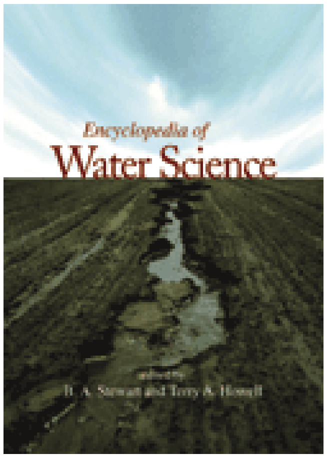

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Erosion, Mechanical Control

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INTRODUCTION

Soil erosion is a naturally occurring process. Accelerated erosion is a problem common to agriculture, mining, and construction wherever natural cover is reduced and soil is left unprotected. Mechanical erosion control measures are implemented to minimize onsite and offsite impacts of these activities, as well as to rehabilitate degraded lands. Often, mechanical erosion controls are applied in combination with vegetative erosion control techniques. The general goals of erosion control technologies are to alter runoff patterns and protect the soil surface, thereby reducing the erosive power of water. This entry reviews mechanical erosion control technologies and the hydrologic and erosion processes they affect.

EROSION PROCESSES

Hillslope erosion caused by running water and the factors affecting soil loss are summarized in the Universal Soil Loss Equation (USLE).[1] The USLE is a model for predicting long-term average soil losses from fields based in part on the factors of slope length and steepness, and cover management. These are the primary factors that can be altered and improved through mechanical erosion control. Long, steep slopes with minimal protective cover are subject to high erosion rates. Decreased vegetative cover, often associated with land use, results in higher velocity runoff and increased concentrated flow. The primary approach to mechanically controlling soil erosion is to reduce the erosive power of flowing water by reducing the forces applied to the soil or by reducing the susceptibility of the soil to erosion. This is often accomplished by armoring surfaces, altering runoff patterns, and reducing sediment transport capacity.

In general, erosion includes the processes of soil detachment, transport, and deposition. Although the USLE does not address concentrated flow, channel processes, or deposition, the general principles of reducing or altering flow patterns, reducing velocity, and maintaining vegetative or rock cover also apply to controlling erosion in channels.

MECHANICAL EROSION CONTROL TECHNOLOGIES

Mechanical erosion control technologies can be grouped according to the hydrologic processes they impact. Technologies are available to alter overland flow, protect the soil surface, minimize channel scour, and induce deposition (Table 1). Decisions regarding which technology, or combination of technologies, to employ depend on several factors including safety (as in the case of a dam or the potential for downstream impacts), regulations, time frame of the project, cost, labor, local climate including rainfall and runoff patterns, drainage patterns, topography, and soils. In addition, site-specific erosion control needs, such as in response to construction where the source and extent of erosion are known, may require different technologies than landscape scale erosion control implemented to rehabilitate degraded watersheds. Erosion control structures are often specified based on a design storm. A design storm provides information on the amount of precipitation and runoff that the erosion control structure will accommodate. Design storms are often designated based on the anticipated storm volume for a specified return frequency at the location of interest.[2]

Technologies for Reducing Overland Flow Erosion

In the absence of concentrated flow paths, runoff travels across the landscape as shallow overland flow. The infiltration of overland flow provides soil moisture critical to vegetation. Over long distances of steep slope, runoff can reach velocities sufficient to detach and transport soil. Terraces intercept runoff and divert it from the field at reduced velocities. Water spreading berms reduce the overland flow slope and increase the flow length, thereby increasing the residence time of runoff and reducing its erosive energy. Soil moisture and storage are increased thereby improving conditions for vegetation, which in turn acts to maintain soil onsite. Although diverting water at the top of steep slope sections can limit gullying and headcut advance,

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Table 1 Summary of mechanical erosion control technologies

Technology group	Structure
Overland runoff alteration	Terraces Water spreaders Berms Diversion dikes Straw wattles Filter fences Vertical mulch (upright brush/vegetation/ stubble) Detention ponds
Surface protection	Hydromulch (wood fiber/straw) Geotextiles Rock mulch Polyacrylamide (PAM) Vegetation plantings Rolled erosion control products (wattles)
Channel and concentrated flow structures	Gabions Riprap Rock or log check dams Porous structures Drop structures Energy dissipaters Plastic fencing
Sediment detention	Sediment detention basin Vegetation

locating water diversions near the end of slopes is often more effective as the area contributing to flow and the amount of flow increases.

Technologies for Surface Protection

Several technologies are available to protect the soil surface. These materials act to mimic vegetative cover or create conditions for establishing vegetation. Hydraulically applied erosion control covers, such as wood fiber or straw, are often applied in combination with seed to protect exposed soil. Geotextiles, or high tech fabrics, for filtering sediment are commonly used on construction sites and to line eroding channels. The fabrics usually come on a roll and a variety of specifications are available depending on soil type and application. These fabrics may be treated to prevent degradation if the fabric is integral to a long-term stabilization project, or they may degrade as vegetation is established. The use of geotextiles may require technical consultation to ensure the characteristics of the fabric are best suited for the characteristics of the soil. Chemical amendments such as polyacrylimide (PAM)[3] can be added to soil to increase infiltration and reduce surface erosion. Wattles, or rolled straw, are effective for controlling erosion on roadsides and on slopes when anchored perpendicular to flow paths. Wattles are commonly used to protect areas where there is a need to reduce concentrated flow velocity and shear along the surface. Their placement reduces the flow length, slows the flow, and spreads the water.

Technologies for Concentrated Flow and Channels

Structures for controlling erosion in concentrated flow in channels are generally larger than those required for upland flow areas. Check dams and small water diversion dikes can be constructed with local materials and labor. These structures are often expected to both reduce erosion and retain sediment onsite. Check dams are built below small headcuts to trap eroded sediment and limit the headward migration of the channel. Water diversion dikes can alter the path of concentrated flow, increasing the travel length and thereby reducing the velocity.

Erosion control structures in large channels may require engineered designs and considerable expense. Wire baskets filled with rock, called gabions, can be used to build retaining walls and protect channel banks (Fig. 1). Porous structures that act to dissipate energy can be built across the channel to reduce flow velocity and induce deposition while allowing water to pass through. Geotextiles are often integral to porous structures to act as a filter for retaining small particles, improving seepage, and reducing scour.

If there is a substantial change in elevation along a channel course, a drop structure may be required to carry runoff to a lower elevation without causing erosion.[4] Drop structure are usually built of concrete or rock based on an engineered design with significant costs associated with both design and construction.

Technologies for Deposition

Increasingly, the potential for offsite impacts of sediment requires that onsite erosion control techniques be designed in the context of watershed scale processes. Sediment that travels within a watershed can be trapped at a downslope point. Small agricultural ponds are ubiquitous and serve a variety of purposes including water supply, recreation, and sediment detention. Effective sediment detention ponds must be designed to accommodate expected runoff and sediment loads while limiting maintenance required to maintain storage capacity.[5] Sediment detention basins

Fig. 1 Stair stepped gabions, wire mesh, and concrete reinforced bank controlling erosion on the edge of an irrigated field in southern Arizona.

and stilling ponds are often used in combination with erosion control technologies to improve onsite retention and to minimize the downstream impacts of sediment. The best sediment control is erosion control.

CONCLUSION

Mechanical erosion control technologies, methods, and practices evolve as new materials and applications are developed. Erosion control is critical for maintaining soil onsite and minimizing off site impacts. Erosion control practices are often implemented in response to laws and regulations, which may strongly influence their selection and design. Perhaps one of the most important aspects of erosion control is the fact that failure to control erosion can result in significant long-term damage that becomes increasingly expensive to repair.

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