Developing Erosion Control Plans for Highway Construction

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A recommended procedure for developing erosion control plans for highway construction is presented. These procedures can be found in *Best Management Practices for Erosion and Sediment Control*, an FHWA manual developed through the Federal Lands Highways Coordinated Technology Implementation Program. These recommendations result in part from recent legislative requirements under the Environmental Protection Agency's National Pollutant Discharge Elimination System regulations. Erosion control plans are developed by following basic principles of erosion and sediment control. In addition, a three-phase approach based on construction stages is presented to guide the designer through the process. Finally, a brief overview of best management practices is presented.

Although erosion and sediment control practices in highway construction have been implemented for more than 20 years, recent environmental awareness and regulations have highlighted the issue. Consequently, designers are taking a more structured approach to erosion and sediment control. Erosion control provisions are now part of the engineering plans and contract. Although many of the same traditional best management practices (BMPs) are used, they are now shown on a separate set of plans referred to as an *erosion control plan*. The development of these plans follows general erosion control principles. A three-phase procedure is presented to assist the designer in developing quality erosion control plans. These procedures are the result of the Federal Lands Highways Coordinated Technology Implementation Program study which was produced in the FHWA manual *Best Management Practices for Erosion and Sediment Control* (*1*).

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

The 1987 amendments to the Clean Water Act required the Environmental Protection Agency to establish the National Pollutant Discharge Elimination System for point source dischargers of storm water. This mandate led to permit requirements for municipalities greater than 100,000 people and dischargers from industrial activities. In these regulations construction sites that disturb more than 2 ha (5 acres) are classified as industrial dischargers. This requires operators and owners to obtain permits authorizing the discharge of storm water from these sites.

Although different permitting options are allowable, most states have elected the option of filing a notice of intent (NOI) to be covered under a general permit. In addition to containing information about the construction activity, the NOI is a certification that a storm water pollution prevention plan has been prepared for the site. This also certifies that the plan complies with all state and local requirements (plans or permits) for erosion control and storm water management. States not covered under the September 9, 1992, regulations have developed similar regulations for the particular state.

The pollution prevention plan is a document that is kept on site during construction and that provides guidelines for minimizing pollution. The plan must include a site description, a description of controls that will be used at the site (erosion and sediment controls, storm water management measures), a description of maintenance and inspection procedures, and a description of pollution prevention measures for any non–storm water discharges that exist.

EROSION CONTROL PLANS

Regardless of the terminology used, the essence of the pollution prevention plan is what has traditionally been called the erosion control plan. The purpose of the erosion control plan is to provide the best available guidance in preventing erosion and controlling sediment during construction. These plans are usually developed by the engineer responsible for the design of the project. This person is most knowledgeable about the particular site and has already performed some of the computations that are used in designing the BMPs.

The erosion control plans describe the location and type of controls to be implemented during construction. Special resources such as wetlands, surface waters, and so forth, are clearly identified on the plan along with protection measures. Any known problems, including highly erodible soils, unstable slopes, and so forth, are also identified. In addition, the plans typically include basic drainage information such as drainage patterns, drainage areas, and the sizes and locations of drainage structures.

In most cases a narrative is included to assist in the implementation of the plan. The narrative addresses issues that may not be clearly conveyed with a drawing. This may relate to construction sequences, maintenance on the controls, timing of stabilization, or other critical factors.

Erosion Control Principles

In developing the erosion control plans, several overall principles are observed. If these principles are followed through each stage of construction, the appropriate controls can be selected and erosion will be minimized.

The key to successful erosion and sediment control is the prevention of erosion. In highway construction this is best achieved through effective stabilization of the slopes and waterways. By preventing erosion from occurring in the first place, the overall net loss of sediment from the site is minimized. Stabilization is achieved with temporary and permanent turf establishment, mulching,

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erosion control mats, and blankets. It is much more effective to prevent erosion from occurring than to try to filter or trap sediment with other measures. Controls based on the principles of filtering and trapping have limited efficiencies and are used as backup measures.

Another related principle for minimizing erosion is to limit the time and area of exposure. The potential for erosion is greatly reduced if less area is disturbed or if the area is disturbed for a shorter duration. In some instances stabilization can take place as the construction progresses instead of waiting until the final grade is established. Stabilization is ultimately required for all disturbed areas, so timely stabilization is also cost-effective. Although minimizing the disturbed area may be difficult, it should be considered in determining the construction limits. These limits should be clearly shown on the plans.

A third principle in controlling erosion and sedimentation is to retain the sediment on the site. This is achieved by using devices that filter sediment from runoff or that detain runoff so that heavy particles will settle out. By using controls such as a silt fence, straw bales, or brush barriers, sediment can be filtered from runoff before it leaves the site. These devices should be used only for sheet flow or low concentrations of flow. When flow occurs in greater quantities, runoff can be detained in a settling structure until the particles settle out. These temporary devices are called sediment traps or, for larger areas, sediment basins. Settling structures are appropriate when disturbed areas of sufficient size drain to one location. The sizes of the structures are based on the contributing drainage area. Since these structures can become quite large, sufficient area must be available to construct the facility on the site. These larger devices have limited application to highway construction because of limited right-of-way. In addition, the inclusion of these controls may violate the principle of minimizing the disturbed area.

An additional principle that should be followed is to manage only the sediment and runoff from the site. This becomes more challenging in highway construction where off-site drainage intercepts roadways or where roads cross streams. When possible runoff from undisturbed areas should be diverted around disturbed areas by constructing diversion berms and channels. Also, streams and swales should remain uncontrolled, allowing clean water to pass through the site. It is inefficient to combine sediment-laden runoff with clean runoff before passing the runoff through filter barriers or settling structures. With settling structures, the storage volume becomes very large if drainage from undisturbed areas is allowed to flow to the structure.

Erosion Control Phases

Erosion control plans should be developed with the previous principles in mind. In addition, the plans must address the different stages of construction. By dividing the construction into three separate phases, the selection of the erosion controls is easier, especially on larger, more complicated projects. The three phases that the erosion control plans should address are the initial clearing phase, the intermediate grading phase, and the final stabilization of the site. The initial phase should address the perimeter controls required at the initial clearing stage to prevent sediment from leaving the site. The intermediate phase should reflect the controls required during construction. This includes the point from grubbing operations until the final grade is reached. The third phase of erosion control is the final stabilization of the site and installation of the permanent controls.

Phase 1: Initial Phase, Perimeter Controls

The first phase addresses the type and location of the initial perimeter erosion and sediment controls. Ideally, these controls will be installed after the clearing and before any grubbing of the site. The controls will be located on the basis of the natural topography of the site and the limits of construction. The purpose of these controls is to prevent any off-site damage by minimizing the sediment that leaves the site. In most cases these controls remain in place throughout the construction of the project. Typical perimeter controls include filter barriers (silt fence), diversion structures, and settling structures.

Phase 2: Intermediate Controls

The most critical and most difficult phase of erosion control is the intermediate phase, especially in new construction. This is the stage of construction when earthmoving activities are at a maximum. Intermediate controls are implemented as the project progresses from the grubbing stage to the final grade. At this point the site is most susceptible to erosion. Temporary erosion controls must be implemented in incremental stages as construction progresses. In addition, some permanent structural controls such as culverts and waterways are installed. Intermediate controls consist of the following: temporary slope drains, temporary channel linings, temporary and permanent turf establishment, check dams, and settling structures.

When practical, turf establishment or stabilization may be performed in incremental stages on cut-and-fill slopes. As the cut or fill progresses, areas may be seeded and mulched in 15- to 20-ft vertical increments. This turf establishment may be temporary or permanent.

Phase 3: Final Stabilization

The last phase of erosion control consists of the final stabilization of the site. This includes final stabilization of the slopes and waterways, outfalls, and other disturbed areas. Most final controls are permanent; however, some temporary controls may be used. Final controls include permanent turf establishment, channel linings, temporary slope drains, check dams, and outlet protection. Some controls may actually serve in more than one phase. For instance, filter barriers and settling structures may control sediment from the initial phase through the final slope stabilization. Also, in some reconstruction projects, the only erosion control phases may be the initial and final controls. The most important factor is to ensure that each appropriate phase is considered when selecting controls and developing erosion control plans.

BEST MANAGEMENT PRACTICES

A variety of BMPs are available for preventing erosion and controlling sedimentation. They can be categorized broadly as vegetative and structural practices. Measures such as controlling the amount and duration of exposed soil are often referred to as nonstructural practices. The measures can also be broken down into temporary and permanent measures. The critical point is that the correct measures be selected and used for the proper application.

Vegetative Practices

Vegetative practices are the most desirable measures for use in erosion control. This includes both temporary and permanent stabilization of slopes, as well as the use of vegetated channels and ditches. Mulching is also an integral part of vegetative stabilization. In some cases mulching may be performed without seeding as a temporary stabilization method.

A common practice is to stabilize an area as construction progresses rather than waiting until the final grade is reached. This requires control over the staging of construction activities, but it is a practice required in many states.

A variety of products are available to assist in the establishment of vegetation. These include various types of erosion control blankets and matting. These are composed of both organic and inorganic materials that protect the seedbed until the vegetation is established. In some cases the product remains in place as part of the root mat to increase the structural integrity of the vegetation.

Structural Controls

Vegetative practices alone are not adequate to prevent erosion from occurring and sediment from leaving a site. Structural measures must also be incorporated into the plans. These are implemented from the initial phase through the final stabilization of the site.

The first measure installed at a site is usually some type of filter barrier. The most common is a silt fence, but straw bales and sometimes brush barriers are used. These are all devices that filter sediment from runoff. These devices are for sheet flow applications only. They are not recommended for use with concentrated flow.

If the disturbed area drains to a suitable location and sufficient right-of-way is available, a settling structure such as a sediment trap or sediment basin can be used. These structures detain runoff so that the heavier particles can settle out. For drainage areas less than 2 ha (5 acres), a sediment trap is used. Runoff exits the storage volume over a rock spillway or through a pipe outlet.

For drainage areas greater than 2 to 4 ha (5 to 10 acres), a sediment basin is constructed. This operates on the same principle as a sediment trap; however, the outlet structure is a riser pipe. In addition, an emergency spillway is constructed to pass flows greater than the 10-year flow. For both structures the storage volume is determined on the basis of the drainage area. In the past this volume was determined to be 126 m^3/ha (1,800 ft^3/acre). The current trend is to increase this volume to 252 m^3/ha (3,600 ft^3/acre) and to divide it equally into dry and wet storage. In other words half of the storage volume maintains a permanent pool of water, whereas half of it is temporary storage that is allowed to draw down over a 10- to 24-hr period.

Since the storage volume is directly related to drainage area and the goal is to trap only the runoff from disturbed areas, it becomes critical to properly manage the runoff from the site. This can be done by constructing diversion berms and channels to direct clean runoff away from the site and to channel sediment-laden runoff to settling structures. Diversions are used as perimeter controls and are usually vegetated, but they are sometimes lined with fabrics or riprap. Another device related to diversions is the temporary slope drain. These are flexible conduits that carry water safely down a slope while vegetation is being established. These are used as intermediate controls during grading operations and as temporary final controls during slope stabilization. Most often they are used in conjunction with berms.

To stabilize vegetated waterways, check dams are constructed to slow the erosive channel velocities. These obstructions, typically constructed of dumped rock, are placed directly in the waterway, causing the water to pond behind them. They are not sediment-trapping devices, although the obstructions cause sediment to accumulate behind them. The spacing of check dams is determined on the basis of the height of the dam and the slope of the channel.

Finally, outlet protection is provided to stabilize the outfall of the waterways. Typically, rock riprap is placed at the outfall to prevent scouring under the high velocities. If velocities are extremely high, energy dissipators are designed for this application.

CONCLUSION

In summary, recent legislation and environmental awareness have prompted a greater concern for the erosion and sedimentation generated by construction activities. Many practices are available for controlling erosion and sedimentation in highway construction. These practices include both vegetative and structural controls with an emphasis on timely stabilization of the site. By selecting and implementing appropriate controls at the proper sequence in construction, the net loss of sediment from the site can be minimized.

REFERENCE

1. *Best Management Practices for Erosion and Sediment Control.* FHWA, U.S. Department of Transportation.

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