Highway Drainage and Erosion Control

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INTRODUCTION

One of the most important phases of the county highway operation is highway drainage and erosion control. Adequate control is essential for safe and convenient operation of motor vehicles in all weather as well as for achieving reasonable economy in maintaining the highway system.

The cost of controlling water on and near the highway is a significant part of total highway expense. It is estimated that 25 per cent of road construction cost goes directly for drainage facilities. In a maintenance operation it is probable that the percentage is much greater. What does this mean for your county? The average county highway budget is greater than half a million dollars. If yours is an average county, then you spend in the neighborhood of $150,000 directly or indirectly for drainage every year. How much of this goes towards better roads and how much just to "staying even" with Mother Nature? The answer depends on how well you get to the roots of the problem and how much you simply struggle with the effects of a bad situation.

Drainage and erosion control involves the removal of excess surface and underground water occurring on and near the highway right-of-way. Its importance stems from the needs of our society to move increasing amounts of traffic in all weather conditions, safely and with a minimum of delay, coupled with the fact that excess water is one of the most destructive effects imposed on highways. Water falling on roads and not removed promptly, seeps into lower layers of the pavement, weakening the soil, sometimes completely destroying its stability and undermining the capacity of the pavement to carry traffic. Furthermore, water traveling over exposed earth surfaces has tremendous power to move soil, with the frequent result that material is removed from places where we want it, and deposited just exactly where we do not want it. Soil removed from slopes is dumped in ditches. Embankments are gouged out. Structures are undermined. Ditches are filled with

deposition and culverts are reduced in effectiveness or blocked completely.

Inasmuch as we are determined to build and maintain roads, which by their very existence interfere with nature's drainage, we must give great attention to the planning and development of adequate measures and facilities for their protection. The coverage of such a topic in such a short paper is, of course, extremely limited. A few minutes devoted to recalling the principles involved will be time well spent, however, for the extent to which the principles are applied in everyday practice is the measure of permanence of the work. If the principles are neglected in our maintenance operations, the same maintenance will need to be done over again year after year. But maintenance directed at the *source* of a problem will eliminate the problem and the maintenance efforts and costs that it would otherwise involve.

Only the *surface* aspects of highway drainage and erosion control are considered here. No attempt is made in this paper to deal with the equally important questions of subsurface drainage. The techniques required to carry out the principles, of course, depend largely on local conditions.

EROSION CONTROL

Successful erosion control depends on several basic steps:

1. keep soil slopes flat enough for inherent stability,
2. provide surface cover to protect from flowing water, and
3. divert excess water from slopes and around structures. These are universal requirements among roads of all classes, and it will be worth our while to take a closer look at them now.

Flat Slopes for Stability

Most cuts and fills that are not too high—say less than five to ten feet—should be on 4:1 or flatter slopes. This reduces erosion potential by limiting velocity of surface runoff and reducing interference to wind. Construction and maintenance are easy, and protective surface cover is readily established. Cut slopes on which no maintenance equipment need be operated, will often be satisfactory at 3:1. Not directly related to erosion control, but equally important, flat slopes are safe from a traffic standpoint. A vehicle generally can move onto a 4:1 slope with little danger of serious accident. Note, too, the important point that all edges and surface intersections should be freely rounded. This reduces erosion potential and makes surface stabilization with grass easier.

It is readily seen, of course, that with increasing depth of cut or fill, the volume of material and the right-of-way required rapidly become excessive. Then slopes need to be steepened, usually to 2:1, which should be considered the maximum except for around structures or in particularly rough country. Three to one fill slopes are bad because of the temptation to operate equipment on them. Equipment digs up turf on such steep slopes, thus hastening erosion. Rock slopes, of course, usually may be much steeper—say ½:1 or even ¼:1 in sound rock. When establishing soil slopes one should keep in mind, however, that not only the first cost is important, but also that excessive maintenance costs year after year can easily outweigh supposed "savings" achieved by using steep slopes for ordinary soil cuts and fills.

Vegetation for Permanent Surface Protection

The second fundamental is to provide a permanent protective lining to soil surfaces. Even inherently stable slopes, if earth surfaces are exposed to water and wind, will erode quickly, leaving badly scarred slopes subject to worsened stability problems. The soil is transported down the slopes and deposited in roadside ditches and culverts. Sometimes whole sections of the slope slough off and fill the ditch. This kind of damage raises maintenance costs in two ways—clean-up of ditches and structures, and repair of slopes.

For most highway slopes the best cover is grass—a 4:1 mixture of tall fescue and blue grass is a good one for Indiana conditions. This should be seeded with 1 to 2 lb per 1000 sq ft as soon as grading is complete, then mulched to give protection until the grass gets started. One to two inches of hay mulch spread over the seed bed will break the impact of rain and slow surface flow. It will also serve to maintain favorable conditions for germination. Initial fertilization of the seed bed, and an occasional shot in the arm when cover gets thin, can provide stable cover indefinitely with little maintenance cost.

On steep slopes or poor soil types where it is difficult or impossible to establish grass, other vegetation is sometimes useful. An outstanding example is Crown Vetch. This legume has excellent holding power and requires little or no maintenance. It also produces a dividend of blossom for several weeks each summer.

Diversion of Excess Water from Slopes and Structures

In addition to stabilizing surfaces, sound engineering practice also involves limiting the forces which tend to destroy the surface which brings us to the third principle—diversion.

This means that where large volumes of water accumulate above highway slopes or around structures, that water should be collected by berms or ditches, and conducted to a safe outlet where it is discharged to nature's drainage system.

For cut slopes diversion may be accomplished by providing a channel above the slope, paralleling the slope and outletting into the roadside ditch or other drainage beyond the cut. On fill slopes on a long grade, diversion may be provided by a dyke or berm at the pavement edge, with outlets at intervals so that excessive volumes of water do not accumulate in the roadway. The end should be diverted from the road before reaching a structure at the low point, where concentrated flow could completely wash out a structure. The berm should be kept as far to the side as possible so as not to restrict traffic.

SURFACE DRAINAGE

No matter how well located and designed, every road interferes with nature's drainage to some degree. In order to keep this interference to a minimum, and thus to minimize the destructive effect of excess water on our highways, attention needs to be directed at several points:

1. Surface slopes—transverse and longitudinal slopes to remove water from the traveled way,
2. Collecting ditches—channels to collect and conduct water away from the facility,
3. Stable outlets for safe discharge of water, and
4. Culverts for continuity of flow.

Proper functioning of all components of the system is necessary at all times since the flow is continuous from point of beginning of flow to final discharge in a natural channel of adequate capacity to contain the water.

Transverse and Longitudinal Slopes to Drain Pavement

The requirements for transverse slopes are generally familiar. Slopes of ⅛ in. to ¼ in. per ft are satisfactory for paved surfaces. Unpaved roads require ¼ in. to ½ in. per ft. On the shoulder, slopes are increased to ½ in. to 1 in. per ft. Though often neglected on county roads, transverse drainage is easily provided simply by grading the road surface in the form of an inverted "V."

In addition to transverse slope, it is important to maintain longitudinal grades of at least 0.5 per cent. When longitudinal grades are slight, it is especially important to obtain good compaction and grading during construction. Otherwise, small amounts of settlement, or irregularity in crown will result in incomplete drainage of the surface. The

additional complication of getting ditches to drain on flat grades is also evident.

Roadside Ditches Collect and Transport Runoff

Ideally, from the standpoint of drainage, every road would run along a ridge, or drainage divide. Since this is obviously impossible, the water shed from the roadway, and in some places that from nearby ground, must be collected in channels beside the roadway and conducted to appropriate discharges. There are three typical cross sections in common use for roadside ditches. For hydraulic efficiency these channels would preferably have a parabolic, or curved, cross section. On the other hand, demand for simplicity of construction often has resulted in the choice of a triangular or V-shaped ditch which is inefficient and highly susceptible to erosion. A happy compromise is the trapezoidal, or flat bottomed ditch, which is reasonably efficient, safe for traffic, and not difficult to construct.

The bottom of the ditch should be at least a foot below the edge of the shoulder, so that normal flow will not tend to saturate the pavement. If side slopes follow the same criteria as for fill and cut slopes—4:1 or flatter—this will provide adequate waterway capacity in most locations.

In ditches, as on slopes, erosion control is of great importance. The most economical protection where grades are not too great is a turf lining. The well established cover shown here provides good protection at low cost. The same fescue and blue grass seed mixture used for erosion control on slopes can be used in ditches, though seeding should be a little heavier, say 1½ to 3 lb per 1000 sq ft. Reed canary grass will also serve well as a lining for ditches, is easily established, and requires little care.

Where grades are moderately steep or the drainage area large, starting a grass lining from seed may be difficult or impossible. The use of sod will often overcome this obstacle. A dense sod will withstand considerable flow immediately after placing.

A few locations will have water velocities so great that turf will not withstand the abrading action. Then some hard lining is required, or else velocity must be reduced by some means such as drops or check dams.

While velocity and soil type are the real criteria of whether a turf lining will hold, there is a rough correspondence with slope. Turf is adequate in nearly all cases where slope is no greater than 5 to 6 per cent. On steeper grades turf is difficult to establish at best, and frequently will not be permanent.

Stable Outlets to Establish Waterways

The most critical part of many roadside ditches is the outlet. Here is the greatest concentration of water in the system up to this point, and here, too, is likely to be the steepest slope. Provision must be made for discharge through a stable channel so that progressive washouts will not destroy the roadside nor undermine the structure crossing the waterway.

Outlet slopes less than 10 per cent are frequently possible if channels are flared away from the roadway. Steeper channels may be constructed directly down a slope and protected with a hard lining of rubble, asphalt, or concrete. Alternatively, a drop inlet may be installed in the ditch, with a pipe running to the water course.

Culverts for Continuity of Flow

The subject of culverts is, of course, much too extensive to be covered in this paper. It is appropriate, however, to point out the need for culverts wherever driveways or other obstructions occur in roadside ditches. A ditch is worse than useless if flow is not continuous to the outlet; it is harmful because of the depth of water that may be ponded. In addition, it is good practice to provide a dip in a driveway profile as it crosses the ditch, to prevent runoff from the drive from washing over the road.

CONCLUSION

In summary, the basic principles involved in controlling erosion and providing proper surface drainage have been reviewed. It is important to provide inherently stable soil slopes for highway cuts and fills, and to protect them, with grass or other cover, from surface erosion. Excess water should be diverted before it reaches exposed slopes or structures.

Proper drainage requires adequate transverse slopes and longitudinal grades on roadways, collecting ditches along the roadside, and stable outlets to established water courses. Culverts should be placed wherever obstructions occur in channels to provide continuous flow.

These are the fundamentals we can't afford to forget. Yes, it does cost money to carry out good rehabilitation programs. But it costs *more* and we get *less* if we putter away at the *symptoms* of poor drainage and erosion control. Let's attack the *heart* of the problems, each year doing our work well enough so we won't have to do it over again next year, and the next. Remember, we *can't afford* the luxury of a skin treatment.