DRAINAGE - DESIGN

By
E. D. Dryfoose, Engineer of Roads,
Illinois Division of Highways

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Drainage Problems

The existence of water has always created drainage problems in the location and construction of highways. A brief resume of these problems includes flooding of areas above bridges and culverts; undermining of structures; erosion of embankments, shoulders, slopes and ditches; reduction of supporting strength of subgrade; heaving and settlement of non-rigid pavements; and blow-ups, corner breaks, cracking and high joints in rigid type pavements. The solution of all these drainage problems is relatively simple, consisting of the intercepting, collecting, transporting and disposing of both surface and ground water. Each of these steps is necessary, but perhaps the most important is the final disposal of the water. In rolling or rough topography this is usually easy to accomplish, but in level country the disposing of the water is frequently very difficult. Sometimes the only solution is to construct the roadbed several feet above the general ground level and to use wide, relatively shallow ditches. This will keep the water table somewhat below the subgrade even though water may stand in the ditches at times.

Highway Location

In the location and design of highways surface water is always encountered and frequently ground water is close enough to the surface to require control. When there are two or more choices for the location of a highway, the existence of surface or ground water may be the deciding factor in the selection. One or more of the possible locations may traverse topography where drainage is not feasible or where the providing of proper drainage would cause excessive costs.

Ground Water Drainage

Ground water drainage is much more difficult to visualize and control than surface water. Unless the geology along the highway is well known, it is advisable to have a competent geologist make an investigation of the soil conditions and the location of ground water. This should be done during the wet season, as there are many locations which appear satisfactory during most of the year

but which carry considerable subsurface water during a short period of time.

Intercepting Drains

Ground water, if not intercepted and controlled, will produce a soft subgrade and possibly frost boils or slides. In rolling or hilly country the ground water strata is usually on a grade and the most effective method of controlling water under this condition is by the use of intercepting drains placed either in the shoulder or in the backslope on the upstream side. These drains should be placed in the top of the impervious strata just below the pervious water-bearing strata, and porous material should be placed in the trench over the drain for the depth of the pervious strata. The drains should have sufficient fall to be self cleansing and the outlet should be unobstructed.

Collecting Drains

In relatively level topography, where ground water is near the surface, collecting drains are required in order to lower the water table and keep capillary water below the subgrade. These drains should be placed at the bottom of the pervious water strata, or if this strata is too deep, at a depth of about 5 to 6 feet, and should have a covering of porous backfill. They may consist of a single line of pipe under the center of the pavement or surface course, or else two parallel lines, one on each side of the pavement. If two lines are used, cross drains arranged herringbone fashion may also be required. Collecting drains will be effective only if the soil is permeable. Impermeable soils must be removed and replaced with gravel, crushed stone or other porous material. French drains or pipe drains are required to remove the water which collects in all porous subbase.

Modern highway alignment and grades require long sight distances in order to provide safety for present and future highway users. In providing these long sight distances, the profile of the road frequently cuts through ground water strata. Wherever this condition occurs, intercepting drains must be installed across the highway and connected to either pipe or ditch outlets. Failure to provide these intercepting drains where the road cuts through ground water strata will almost certainly cause future maintenance problems.

Surface Water

Surface water is controlled by drainage through or parallel to the highway. Streams and other water flowing across the highway

require bridges and culverts for drainage. These structures should provide waterway openings which will discharge the maximum flood flow without raising the elevation of the high water or creating velocities which will undermine the structures or erode the adjacent embankments. Stream channels should be straightened so as to permit the water to escape more rapidly and to prevent silting at the inside and erosion at the outside of the stream curves. Where a small stream is on a relatively steep grade, ditch checks or drop inlets constructed on the upstream side of the highway will aid in prohibiting scour and the depositing of sediment in the openings of the bridge or culvert.

Uniform Crowns

High crowns are a hazard to traffic and should not be used. A crown of approximately one inch in a 20-ft. concrete pavement has been rather widely accepted, but the amount of crown for other types and widths of surfaces has not been so well standardized. Further study should be given to minimum crown gradients which will adequately drain various types of surface courses. There should be a more universal use of these minimum crowns.

Gutter Types

Gutters not only serve a drainage function but greatly reduce maintenance costs on shoulders and provide additional safety. They may either be integral with the pavement, as the so-called lip curb, or they may be separate units adjacent to the pavement. Gutters should have very flat slopes in cross section so that no appreciable obstacles are created for traffic. They should be used on grades steeper than approximately one and one-half per cent and on flatter grades in soil that erodes easily. Their use is also recommended at the lower edge of the pavement on superelevated curves. The size of gutter will be dependent not only on the water to be transported but on the amount of sediment contained in the water. Gutter outlets should not create an obstruction to traffic.

There has been a tendency to use too little gutter along our rural highways, but the additional first cost is justified in lower maintenance costs, additional safety and better appearance.

Lip Curb

Illinois adopted lip curb in 1926 and used it on grades up to $2\frac{1}{2}$ per cent until 1933. It was found that the water-carrying capacity of this type of gutter, however, was insufficient. It also tends to reduce the effective width of pavement. In 1933 the use of lip curb was discontinued and a separate gutter provided instead.

Shoulders

Wide shoulders not only further safety but aid drainage by providing a greater evaporation area and a greater distance for capillary water to travel from ditches to a point under the pavement. Shoulders in relatively stable soil should be seeded with deep rooted mat-forming grass. Strawing of the shoulders will aid in securing a crop of grass. Shoulders in easily erodible soils should be stabilized by an admixture of selected earth or oil. The construction of gravel shoulders is a questionable policy, as this type tends to act as a reservoir for water and keeps the pavement subgrade wet.

Slopes

Slopes should not be steeper than 3 to 1 on primary roads, except for high fills where guard rail is used. Erosion of side and backslopes is greatly reduced where flat slopes are used. Slopes should be well sodded or seeded. Strawing is again an aid in securing a stand of grass on slopes.

Ditches

Ditches should have sufficient gradient so that water does not become impounded. Ditch gradients, however, should not be so great as to cause scour, and ditch checks or drop inlets should be used to control the gradient of the flow line. As an aid to appearance and safety, ditches should be shallow and have rounded cross sections.

The attempt to eliminate ditches completely on rural roads is not believed to be sound policy. There is always some water to be carried, and the ditch is one of the most effective and economical methods for performing this function.

A ditch should not be deepened where a large amount of water is to be transported. The capacity for increased flow should be obtained by widening the shallow ditch. A ditch also serves as a storage area for snow during the snow removal period.

Although trees and shrubs planted in ditches tend to stop erosion, they also may stop the flow of water and cause damage to the highway.

Ditches may influence the ground water immediately adjacent to them, but they have little influence on ground water under the pavement unless the soil is very pervious and acts as a natural drain.

Auxiliary Ditches

Trenches or auxiliary ditches should be provided along the top of cut sections in order to collect and transport water from adjacent fields and thereby prevent backslope erosion.

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Drainage problems should be anticipated in the design of a highway, and everything possible should be done in preparing the plans so that surface and ground water will be adequately controlled. If this is not done the maintenance engineer will have continual trouble, the safety of the highway will be threatened, and appearance will often be spoiled.