Aesthetics of Highway Drainage Design

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•A PRINCIPAL consideration for aesthetic treatment of drainage on a highway is cooperation with nature. So what we do to provide drainage must always be done with careful regard to natural laws of physics and biology. A pool of water exerts pressure against its confines; flowing water has momentum in addition to pressure, and cannot be diverted from its course without imposition of a force. Flowing water also exerts drag on its boundaries, will dislodge particles not firmly bedded, and will transport them, so long as the velocity remains constant. But if the velocity decreases due to weeds or a lessening of grade, particles will settle out, gradually raising the level of the channel or creating bars.

A meandering stream channel with its pools and bars may be a thing of beauty, but when the storm comes and the river rises ten feet, twenty feet, or more, the flood waters may tear away the soil holding the tree in place and it, along with dozens of others likewise uprooted, may crash against the bridge which man in his ignorance has placed across the river, destroying in a matter of minutes the structure which took months to build. One must witness such happenings to gain a never-to-be-forgotten respect for the forces of nature.

Since those trees grew to maturity along the stream banks, we can deduce that for many years the floods had not reached a magnitude sufficient to create the forces which tore them out. But we have only to study an aerial photograph of the valley to see evidence that the stream channel in ages past has occupied innumerable channels. When we must recognize this, it should be clear that we cannot expect a mere highway across or along the river to control all future changes in the stream channel. We have much to learn in winning the cooperation of nature in such situations.

STORM WATER

The first lesson is to be conscious of the storm water paths and water levels when the highway is located. Obviously we will have the least trouble with storm waters if we locate the highway along a ridge route. At the same time we will gain the vista overlooking a valley on one or both sides. But the ridges do not always go in the general direction that the traffic must (assuming a utilitarian, rather than a purely scenic or recreational highway). So we must go downhill to the cities strung out along the river, where the people live or cross over the river and climb the next ridge.

For the alignment and grade standards required the highway may along the way cut deeply through the ridge, or be carved along the hillsides. In the process, natural drainage will be disturbed and storm water will seek new paths on its way down to the river. Unless these new paths are provided and adequately protected, erosion will create ugly gullies and spew sediment onto the highway where the flow breaks loose. Only meticulous care in anticipating the probable volume of water and its erosive force, and in designing and carefully constructing the conveyance channels, will avoid this desecration of the landscape and impediment to traffic on the highway.

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ROADSIDE CHANNELS

Protection does not necessarily mean paved channels. In the humid sections of the country, sodding can take care of most of the roadside and intercepting channels along the right-of-way. The all too prevalent spectacle of ribbons of concrete along the brow of cuts, joining other unnatural-looking ribbons alongside the shoulder, then dropping down along the toe of the fill slope, is largely unnecessary. These designs arise from standard instructions to draftsmen to show paved channels for every ditch that exceeds a given grade. The procedures long used by the Ohio State Highway Department, among others, and now described fully in a new Bureau Public Road publication (1), indicate that grass-lined channels are commonly adequate. A little more time and thought is required to follow such procedures, but the effort is more than offset by the saving in cost of construction, as well as by the more natural-looking roadside.

Not only is there a saving in construction cost, but often the grass channel, if properly constructed, will require less maintenance. Paved channels are difficult to seal against leakage through joints or cracks. In sandy or silty soils the pavement then is easily undermined and the lining breaks up. Frost can also cause damage. A well-sodded channel is free of these troubles and blends into the landscape.

Some highway engineers are still advocating ditch checks for erosion control in roadside channels. These checks are not only unsightly, dangerous, and difficult to maintain, but most of the time they are unnecessary. In humid regions, where grass can be maintained, hardly any roadway grade is so steep that a grass-lined channel would not control the erosion. In the semi-arid and arid regions there might be some warrant for ditch checks but, if crushed stone or gravel is available in suitable gradation, erosion can be controlled by lining the channel with such materials at much less cost than paving the channel. Such treatment also blends into the barren landscape. Otherwise, use every opportunity to keep water away from the roadway with dikes spreading the water over the desert, and by not constructing roadside channels unless they are really needed. For example, on the downhill side of a low embankment no channel is necessary.

Frequently, to avoid excessive erosion on embankment slopes, in arid or semi-arid regions, surface water accumulated from the roadway may be confined by a dike on the outer edge of the shoulder. At intervals this flow must be discharged down the slope. For aesthetic as well as practical reasons, a closed buried corrugated metal pipe is preferable, since paved chutes are subject to all sorts of difficulties. The main problem then becomes one of capturing the flow at the inlet, and dissipating the energy at the outlet. Region 9 has developed a design by experiments performed at the Denver Hydraulic Laboratory of the Bureau of Reclamation; it meets these criteria and seems to be working well in practice.

CULVERTS

For the small stream channels crossing the highway, culverts must be provided. The cheapest culvert is probably a pipe projecting from the plane of the embankment, but it is at the same time least attractive and least efficient. One can greatly increase the capacity of a projecting metal pipe culvert at a given pool level with little or no increase in total cost by building a concrete or masonry headwall recessed into the embankment, and at the same time improve its appearance.

Another treatment used commonly, and sometimes too carelessly, is to bevel the metal pipe to the plane of the embankment slope. A difficulty which can (and does) arise is that under high pool levels, an uplift force develops under the upstream lip of the pipe, and folds it up, blocking the entrance. The remedy is simply to anchor the end of the pipe.

A new type of culvert entrance now beginning to be used is not only very efficient hydraulically, but fits into the embankment naturally and minimizes upstream ponding. This is the tapered entrance with a steep drop on the culvert apron between the converging wingwalls.

Precast end sections for concrete pipe and prefabricated ends for metal pipe fit unobtrusively to the fill and facilitate mowing. Improvement in their geometry is still desirable for hydraulic efficiency.

HIGH VELOCITY JETS

Problems in aesthetics can be created at culvert outlets by the high-velocity jet which emerges when the flow line is steep or the pool level is high. In easily eroded soils such a jet can create a scour hole and endanger the culvert outlet and the adjacent embankment. The remedy is to provide adequate means for energy dissipation. One method is to place rip-rap along the bottom and sides of the channel for a certain distance. (Frankly, no one knows quite how much or what sizes of rip-rap are necessary.) The most positive solution is to construct a reinforced concrete stilling basin. Designs for several different types are available. Unfortunately all of them are relatively expensive, and none would win a beauty prize, although they are less objectionable than a huge hole with caving banks.

MEDIAN DRAINAGE

The dangerously massive inlet structures sometimes built for median drainage are a crime against highway safety. Wide medians are, among other things, intended to protect the motorist whose car might get out of control. But he would not have a chance if he crashed into one of these monstrous median inlets. Such large structures are totally unnecessary. The quantity of water collected in the grass median is usually small enough that a flush inlet with either a grate or a vertical opening in the upstream face connecting with a short paved accelerating channel will do the trick. The height of the vertical opening need be only a few inches. While this would cause a bump, it would be no worse than jumping a low curb. The grate, if used, does have the disadvantage of clogging with grass cuttings, leaves, or trash just when it is most needed.

Separate roadways located on either side of an undisturbed natural stream make an aesthetically commendable highway drainage design which has been widely used and deserves application wherever feasible. In this arrangment culvert headwalls visible from the opposite roadway must blend into the surroundings.

A dangerous and unsightly situation exists on divided highways when a deep channel connecting culverts under the two roadways cuts across an otherwise smooth grass median. The remedy is to make the culvert continuous across the median. An inlet can be provided over the culvert for median drainage. The continuous culvert is more efficient hydraulically, the hazard to a car out of control is removed, and the appearance of the highway is improved.

CROSS-SECTION

Wide-bottomed roadside channels with flat side slopes (at least 4:1 where feasible) have long been recognized as desirable for appearance. More important, such flat slopes, if well rounded where they intersect the shoulder and back slope, are much safer. A car forced off the road or out of control has a reasonable chance of crossing a wide flat channel without overturning or causing injury to its occupants. Likewise, there is less chance of damage to the vehicle. At the same time, the attractive grassed channel with flat side slopes and wide bottom can convey large quantities of storm water at a relatively shallow depth—again, a safety factor. Furthermore, standard mowers can readily operate on such a cross-section.

A streamlined cross-section, besides blending well with the landscape in rolling terrain, also will keep clear of drifting snow, since the wind can sweep across the roadway smoothly with no eddies to deposit snow. Flat side slopes on embankment sections also eliminate the need for guardrails which would break the smooth contour and cause deposit of snow.

In summary, let us recall the opening theme: the most important consideration for aesthetic treatment of highway drainage is to cooperate with nature. The main effort should be to minimize the disruption of natural drainage-ways, to provide culverts fre-

quently so as to avoid carrying storm water long distances, to use native sod grasses wherever possible in drainage channels, and to fit the road to the landscape.

POSTSCRIPT

Although most people are unlikely to think of a large highway bridge as a "drainage structure," it is appropriate to mention one aspect of bridge aesthetics as a postscript to this discussion. A monumental bridge is itself a sight worth seeing. All too often, the motorist speeds over beautiful, impressive bridges, but because the roadway is on a straight alignment, he may barely realize they are there. Yet, among the impressive sights that many stretches of highway have to offer, not the least dramatic may be the highway's own bridges leaping across canyons or marching across broad valleys. Where a choice of bridge approach locations is possible, it is certainly worth while to consider this factor in planning the layout. Sometimes it is possible for a roadside park or lookout to give the motorist the opportunity for such a view. While most of this article has been concerned with how drainage design can work with nature for maximum effectiveness and efficiency, the works of man, too, have aesthetic values for the highway user.

REFERENCE

1. Searcy, James K., Design of Roadside Drainage Channels. Hydraulic Design Series No. 4, U.S. Bureau of Public Roads, May 1965.