Highway Shoulders as Related to Surface Drainage

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THE design of highway shoulders and the surface drainage of highways are interrelated. That is, the design of the shoulder can have a definite effect on the surface drainage and, conversely, the method of handling surface drainage may have an important effect on the stability and durability of the shoulder.

Figure 1 shows eight typical shoulder designs with provisions for handling surface runoff from the pavement. Designs A, B, and C, which permit the water to drain freely off the pavement, are the preferred types. With low highway grades and when reasonably stable, such shoulders give little trouble from drainage.

Four different situations in which the stability and maintenance cost of the shoulders are affected by surface drainage can be discussed briefly.

1. There is the problem of conducting pavement runoff across the shoulder to the ditch or fill slope where the highway is on a substantial grade. Under these conditions, the runoff from the pavement has a directional component parallel to the highway. If the shoulder is erodable, the water erodes a small channel usually along the edge of the pavement and when sufficient water accumulates, it breaks over the edge of the fill slope and erodes a gully down the slope. This frequently occurs at a culvert or bridge abutment located at the bottom of the hill. There is need for the development of an effective and economical method for handling this water. Designs D and E show two methods for handling this longitudinal flow on embankment sections. Shoulder design D is widely used in the semiarid and arid sections of the country where vegetative protection can be established on fill slopes, only with difficulty. This design usually requires a paved shoulder and dike normally constructed with asphaltic concrete. The water must be intercepted and carried down the fill slope in a pipe or paved open flume. The frequent error in this design is making the entrance to the pipe or slope flume so small that the water overtops the edge of the flume or dike and erodes the slope along side the flume or over the pipe. A common fault in the use of the valley gutter (shown in design E, Figure 1) is that the horizontal curve in the paved channel at the bottom of the slope, designed to take the water across the shoulder, is made too sharp and the water jumps out of the channel. This curve must be very gradual and the valley gutter itself must be large enough to carry the water coming to it. Where the grades are continuous for several hundred feet, it may be necessary either to intercept the water in an inlet set in the valley gutter or carry it over to the top of the slope in the gutter itself, then down the slope in a flume or pipe at one or more points along the grade. The inlet probably makes the better looking design and considering its proximity to traffic a grate with long parallel slots should be used. Design F shows the use of a valley gutter in a cut section. ion..

2. The design represented by sketch G is considered undesirable from a drainage standpoint. Like design H, it holds the water on the pavement where it can interfere with traffic. It is difficult and expensive to intercept and dispose of such water. Where this design is used in a cut section, runoff from the shoulder and back slope not only brings additional water to the pavement but this water may also carry debris which clutters up the pavement and adds to the cost of maintenance. This runoff can be handled much more effectively and economically by intercepting it off the pavement as in designs A, B, and F.

3. In the case where an approach to a bridge is purposely depressed over a flood plain shoulder design is affected by drainage. By allowing the rising flood water to overtop the approach road before it reaches the underside of the bridge, the bridge is relieved of pressure, the velocity through it is reduced, and it is possible to build a shorter bridge than would otherwise be necessary. Where such overflow is frequent, such as once every one or two years or more often, it may be economical to protect the downstream shoulder by paving, riprap, or even sod, depending upon the difference in elevation between the water on opposite sides of the road at the time flow over the road started. Research now being done will permit more accurate predictions of the differ-

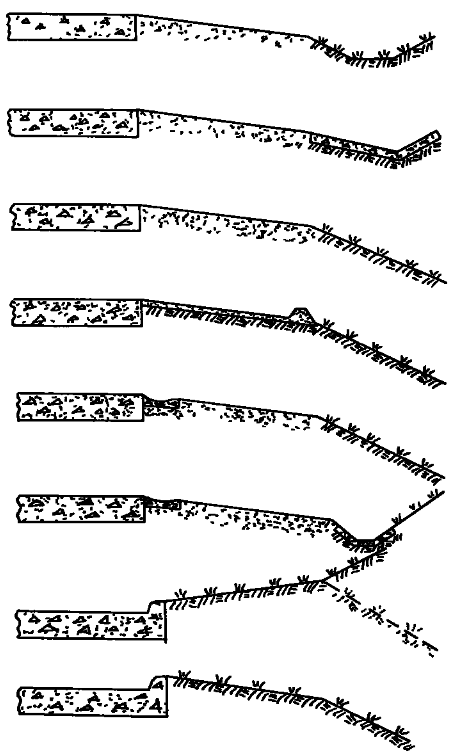

Figure 1. Typical shoulder designs.

ence in elevation and, thus, determinations of the type of shoulder protection needed.

4. A common cause of shoulder failure due to runoff is caused not by the design of the shoulder but by improper or inadequate culvert design, occurring at side-hill locations on long descending grades where runoff is intercepted by the ditch on the hill side of the roadway. This water and that from small streams running out of the hill must be carried across the highway. If the capacity of the culvert is inadequate, water will build up at the entrance and overtop the shoulder. The water running down the inside shoulder and ditch can cause serious erosion of the shoulder. Present research on the hydraulic operation of culverts should permit more accurate determinations of the capacity of different types and sizes of culverts and, through proper culvert design, great reductions in this type of shoulder damage.

These four conditions represent common causes of shoulder failures resulting from highway surface drainage. While present research will aid in solving the last two problems and the second can be corrected by avoiding a design where runoff is drained over the curb onto the pavement, more research is needed with regard to the handling of pavement runoff on steep grades and fill sections.

Discussion

HARRY H. IURKA, Senior Landscape Architect, New York State Department of Public Works — Will you not accept the problem stated by Brant of determining desirable and safe slope of turf shoulders?

STIFEL W. JENS, 101 S. Meramec Avenue, St. Louis, Missouri — This discussion is limited to a few remarks relating to drainage as it affects or is affected by shoulder design. The paper delineates very clearly the major considerations in the relationship of surface drainage to highway shoulder design. There should be added to the discussion of design G the very serious result of this type of design occurring in winter when temperatures during the day may cause sufficient snow melt to result in sheet flow of water across the slab and freezing of such sheet flow in the late afternoon or evening, with the very serious hazard of a sudden slick in the vehicle path. The temptation to pitch shoulders toward the slab in cut sections, especially in urban expressways through high value areas, should be resisted, even though slightly wider rights-of-way and somewhat more excavation may be involved. Leroy F. Johnson also called attention to this, but it cannot be over-emphasized.

Designs A, B, and C which are the preferable types, do point to the desirability of satisfactory subgrade drainage to permit the moisture under the pavement to find its way out to either or both sides of the improved roadway. It was noted that some of the cross-sections indicated in slides showed the granular base continuous to the outer edge of the shoulders. While this is undoubtedly costly from a drainage viewpoint, it is highly desirable since, in addition to draining the moisture that might otherwise be trapped in the base course under the pavement, it drains the infiltrated and percolation rainfall and runoff that occurs over the shoulder surfaces. There have often been cross-sections in which the pavement has been constructed in a trench, with little or inadequate attention to lateral disposition of any moisture collecting beneath the pavement. Under such conditions, the moisture running off the pavement surface across the shoulder infiltrates to some extent and lessens the stability of the shoulder and possibly of the subgrade adjacent to the edge of the pavement.

Item 3, concerning the purposely depressed approach to a bridge, with a consequent lessening of length of bridge required, certainly deserves very careful and serious consideration in many instances, since the over-all costs of many small bridges and an occasional large one, could be significantly reduced by such means.

RICHARD ACKROYD, Closure — After considering Iurka's question, it is realized that the answer given during the sumposium was not adequate. As now interpreted, the problem stated by Brant, is as follows:

"Since it is acknowledged that the texture of turf requires a steeper slope to drain off water than a smoother shoulder surface, how steep a shoulder is permissible? Is the recommended 1 in. per ft too steep? Could it be steeper?"

Observation of highways in those states with which the author is familiar indicates that turf shoulders generally become soft and unstable, particularly during the spring season. They rut very easily and these ruts retain water — increasing the instability. Most of these shoulders according to state standards are apparently designed with a 1-in.-per-ft cross slope. If these shoulders could be more effectively drained, their stability should be improved. One way of providing better surface runoff would be to increase the cross slope to 1¼ in./ft or 1½ in./ft. This would reduce the depth of flow on the shoulder and the amount of water absorbed by the soil should be less. The shoulder would then be less likely to be soft and subject to rutting. Once ruts are formed, however, the small increase in slope will not help much. Ohio adopted a 1½ in./ft cross slope for turf shoulders in 1951 and used it until 1953, then returning to 1 in./ft. From a cursory observation, these shoulders with the steeper cross slope were apparently more stable. Unless it is determined that the 1½ in./ft cross slope is hazardous to traffic, it is preferable to the flatter slope for use with turf shoulders.

The author is not familiar with the experience record of the stabilized turf shoulders referred to by Brant and other roadside development engineers, but it would appear that, having a less dense growth of grass, such shoulders should offer less resistance to the flow of water and so perhaps the 1-in.-per-ft cross slope would be adequate. Acknowledging their esthetic values, it appears that turf shoulders still catch and hold cinders, sand, and other debris and thus tend to build up. They also require mowing.

A factor that appears to have a much greater influence on the stability of any type of shoulder than the cross slope is the practice adopted by many states of placing a permeable subbase under the pavement and extending it through the shoulder to the ditch line. This point was not mentioned in the original presentation because it does not strictly concern surface drainage; the assumption was that it would be covered by others. It was mentioned by the following speakers: Mr. Dent in connection with flexible pavements, Mr. Spencer in connection with pumping, Mr. Shepard in connection with construction practices in Ohio, Mr. Ridge in connection with maintenance, and Mr. Stokstad in connection with soils. These speakers all pointed out the value of having this permeable subbase under the shoulder, both for removing water from under the pavement and for stabilizing the shoulder.

Mr. Jens' discussion, submitted subsequent to the meeting, also pointed out the importance of this method of draining the subbase.

The author would also like to concur in the comments made by Jens regarding the possibility of ice on the pavement resulting from water draining off the shoulder onto the pavement, as it would in design G.