SUMMARY REPORT 140-4(S)

CRITERIA FOR GUARDRAIL NEED AND LOCATION ON EMBANKMENTS

SUMMARY REPORT
of
Research Report Number 140-4
Study 2-5-69-140

Cooperative Research Program of the
Texas Transportation Institute and the Texas Highway Department
In Cooperation with the
U. S. Department of Transportation, Federal Highway Administration

April, 1972

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

Criteria for Guardrail Need and Location on Embankments

by

Hayes E. Ross, Jr., and Edward R. Post

When a vehicle, traveling at a high speed, leaves the roadway and strikes a guardrail, a hazardous situation obviously exists. It is also hazardous when there is no guardrail and the vehicle must traverse the ditch. Neither event is desirable. Nevertheless, for a given type of guardrail, a given ditch or embankment configuration, and given vehicle encroachment conditions, one situation will be less severe than the other. The primary objective of this study was to develop criteria from which the less severe condition can be selected.

Highway engineers have had only meager amounts of information to make an objective decision regarding the need and location of guardrail. In many cases criteria are based on the results of a particular statistical analysis of accident information, compiled by the California Division of Highways in 1966.[1] The results of that study, while of significance for the specific guardrails used in California during the period of the accident records (before 1966), should be used with discretion on other guardrail designs. The guardrail, used in California during this period, was mounted on posts spaced either on 10 foot centers or on 12½ foot centers. As the post spacing decreases the lateral stiffness of the guardrail increases. In general, as the lateral stiffness of guardrail increases its resistance to impact deformation increases, and as a consequence the collision severity increases. In Texas, most of the guardrail is supported on posts spaced on 6 foot-3 inch centers.

To determine the severity of an automobile traversing an embankment the HVOSM computer program[2] was used. The orientation and accelerations of the automobile were computed as it traversed the embankment. A combination of mathematical simulations and full-scale test data was used to determine the severity of an automobile in collision with a guardrail. Accelerations at the center of gravity of the automobile served as the indicator or measure of severity.

Guardrail should be used for conditions in which the severity of an errant automobile redirected by the guardrail would

[1]Glennon, J. C., and Tamburri, T. N., "Objective Criteria for Guardrail Installation," Highway Research Record 174, 1967, p. 192.

[2]HVOSM: Highway-Vehicle-Object-Simulation-Model, a computer program which was developed at the Cornell Aeronautical Laboratories and modified for specific problem studies at TTI.

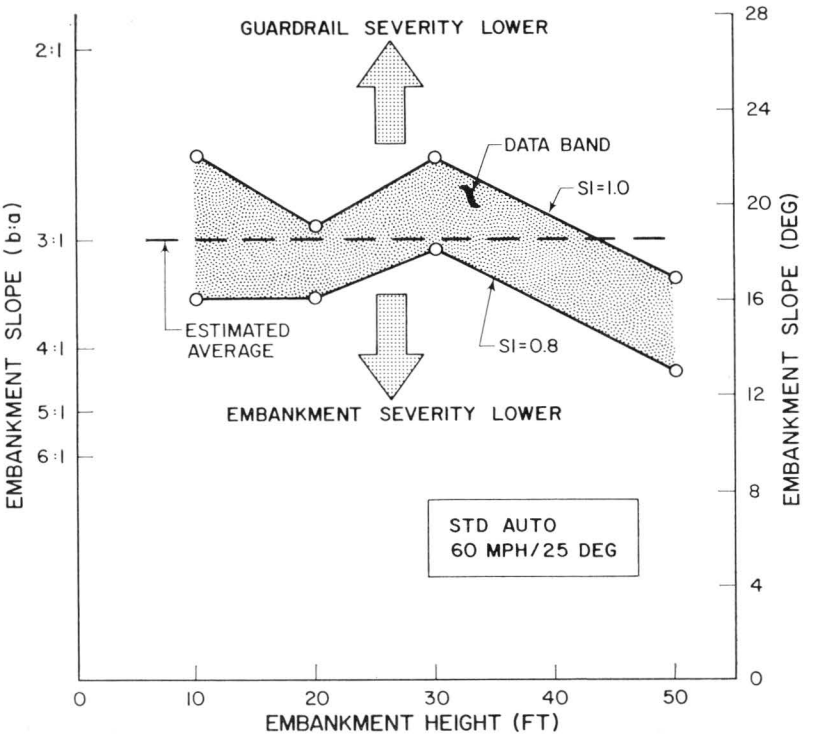

Figure 1. Warrant for guardrail on embankments.

be less than the severity of the automobile traversing the unprotected embankment. For an automobile leaving the roadway at 60 mph with a 25 degree encroachment angle, criteria were established for selecting the less severe alternative, i.e., guardrail versus no guardrail. The criteria are developed for a steel W-beam guardrail with 6 ft.-3 in. post spacing. This is the primary type guardrail used by the Texas Highway Department.

The criteria, shown in Figure 1, is in graphical form for ease of application. The dotted line represents the best estimate or average Equal-Severity-Curve. If a given combination of side slope and ditch depth falls below the curve, guardrail is not recommended, and vice-versa for combinations above the curve. Discretion would obviously be necessary for those configurations below the curve where obstacles exist along or at the bottom of the side slope. In those cases, guardrail in the immediate vicinity of the hazard would probably be needed. If adopted, the criteria developed in this study would result in the use of less guardrail for embankment protection than now required by present criteria.

It should be noted that the safer option (guardrail versus no guardrail) determined by use of this criteria will not necessarily insure a "safe" situation, i.e., severe injuries may still occur. This approach will, however, provide an objective means of selecting the safer of two hazardous situations.

In another phase of this study, an investigation was made to determine the relative severity between the W-beam guardrail with 6 ft.-3 in. post spacing and no guardrail for a 3:1 embankment, 20 feet in depth with a flat-bottom ditch, and various automobile encroachment conditions (50 mph, 60 mph, and 70 mph in combination with encroachment angles of 10 degrees, 17.5 degrees, and 25 degrees). It was concluded that for shallow angles, a guardrail collision is higher in severity than traversing the 3:1 embankment. However, as the speed and angle of departure increases, the severity of traversing the embankment approaches that of striking a guardrail.

In terrain where large fill heights are required, a 6:1 slope is often provided up to 20 feet off the shoulder's edge and a $1\frac{1}{2}$:1 slope from that point to the bottom of the fill. Guardrail protection is usually provided for the steeper $1\frac{1}{2}$:1 slope. The final phase of this study was addressed to the question: If the rail is placed on the 6:1 slope, how far off the shoulder should it be located to minimize the possibility of an automobile vaulting it? It was concluded that the rail should be 12 feet or further from the shoulder's edge.

The published version of this report (two volumes) may be obtained by addressing your request as follows:

R. L. Lewis, Chairman
Research & Development Committee
Texas Highway Department—File D-8
11th and Brazos
Austin, Texas 78701
(Phone 512-475-2971)