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Roadside Safety Research Program Pooled Fund Study

MODIFIED G4(1S) W-BEAM GUARDRAIL ON 2H:1V SLOPE

INTRODUCTION

The American Association of State Highway and Transportation Officials (AASHTO) Roadside Design Guide recommends that guardrail be installed with the back edge of the guardrail posts 2 ft from a slope break. In many mountainous areas or in locations with tight environmental controls, this width is difficult to provide. As a result, designers often have to make a trade-off between reduced shoulder width and a less than optimal guardrail placement. The Washington Department of Transportation (WSDOT) Design Manual provides for the placement of the guardrail post closer to or on slopes as steep as 1H:1V. A research effort undertaken by Polivka, et al (October 2000) of the Midwest Roadside Safety Facility (MwRSF) recommended a design with 7 ft long posts spaced 3 ft-1-1/2 inches on center with the back edge of the post placed at the break to a 2H:1V slope. However, in many cases, steeper slopes are encountered and more width is desired.

DESIGN AND ANALYSIS

The objectives of this project were to investigate the sensitivity of standard guardrail to placement in front of or on a slope and develop an alternate method for installing guardrail in front of or on slopes steeper than 2H: 1V.

The researchers reviewed the design details of guardrails on slope previously developed to evaluate the behavior of the guardrail when subjected to *NCHRP Report 350* tests. Lateral stiffness of the guardrail system is the primary design feature that determines the maximum deflection of the guardrail during a collision and changes in lateral stiffness of the guardrail system along its length

Modified G4(1S) W-Beam Guardrail on 2H:1V Slope

can influence pocketing of a vehicle. Design features found to be important in terms of capacity of the guardrail to contain and redirect a vehicle are slope, post spacing, post length, post placement, and soil strength.

Researchers performed a bogie impact test on a 6-ft post on level ground with slope break 2 ft behind the back of the post to serve as a reference test. Subsequently, the research team performed bogie tests to evaluate the performance of three post lengths and two different slope configurations. The tests were performed for a 7-ft post placed on a 2H:1V slope, 8 ft posts placed on a 2H:1V slope, 8 ft posts placed on a 1.5H:1V slope, and 9 ft posts placed on a 1.5H:1V slope. All posts were placed 1 ft down from the slope break. Additional bogie tests were performed to evaluate the performance of adding a soil plate by welding it to the post. The posts with soil plates did not perform differently from posts without soil plates. Based on the results of the bogie tests, an 8-ft post on 2H:1V slope was recommended for use in full-scale simulation and testing.

The LS-DYNA computer program was used to evaluate the performance of

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of the recommended guardrail design. Three simulations were performed for three guardrail systems on slope using 8-ft long posts: 1) a W-beam (12 gauge) guardrail system with standard (6 ft-3 inch) post spacing, 2) a W-beam (12 gauge) guardrail system with half (3 ft-1.5 inch) post spacing, and 3) a W-beam (10 gauge) guardrail system with standard (6 ft-3 inch) post spacing.

The researchers performed a simulation of *NCHRP Report 350* test 3-11 (2000P vehicle, 62 mi/h, 25 degree) on the selected design. It is believed this is the critical test for this design and test 3-10 (820C vehicle, 62 mi/h, 20 degree) is not required.

CRASH TESTING

Based on the results of the simulation effort, a candidate guardrail design was selected for crash testing. The design was a W-beam (12 gauge) guardrail system with 8-ft posts placed on a 2H:1V slope. The posts were placed 1-ft off the slope break and were spaced at 3 ft-1.5 inches (half the standard spacing for a common strong-post W-Beam guardrail).

A 2000 GMC C2500 pickup, truck weighing 4610 lb and traveling at a speed of 62.3 mi/h, impacted the guardrail on 2H:1V slope 5.9 inches downstream of post 15 at an impact angle of 25.1 degrees. The guardrail on 2H:1V slope contained and redirected the 2000P vehicle. The 2000P vehicle did not penetrate, underride, or override the installation. However, the vehicle rolled onto its side while exiting the test installation. Maximum dynamic deflection of the W-beam rail element during the test was 2.71 ft.

No detached elements, fragments, or other debris were present to penetrate, or show potential for penetrating the occupant compartment, or to present hazard to others in the area. Maximum occupant compartment deformation was 0.8 inches in the lateral space across the floorpan from kickpanel to kickpanel.

Barrier after Test

Longitudinal occupant impact velocity was 19.0 ft/s and longitudinal ridedown acceleration was -10.2 g/s. Exit angle at loss of contact was not obtainable.

CONCLUSIONS

In the full-scale crash test, the 2000P vehicle was contained and redirected. However, after exiting the installation, the vehicle rolled onto its left side and came to rest on its left side 135 ft downstream of impact and 34 ft forward of the traffic face of the rail. Due to this rollover event, the guardrail on 2H:1V slope did not meet the criteria for *NCHRP Report 350* test 3-11.

Additional work is ongoing to evaluate alternative designs.

Test Vehicle after being uprighted

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