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Roadside Safety Pooled Fund

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W-BEAM GUARDRAIL ON BOX CULVERT

INTRODUCTION

The primary objective of this project was to test and evaluate a guardrail design with standard post spacing for use across low-fill box culverts in accordance with *NCHRP Report 350* TL-3. A second objective of this project, was to develop a W6x9 post with welded base plate detail for use with an epoxy anchoring system that simplifies installation. Posts anchored to a simulated concrete box culvert using the Hilti RE500 Epoxy anchoring system were evaluated through pendulum testing. The strength of the base plate, post welds, and anchoring system was sufficient to result in plastic failure of the posts under an impact load. The W6x9 post and anchorage detail was subsequently incorporated into the full-scale crash test installation.

DESIGN AND ANALYSIS

Prior to constructing the full-scale test installation, full-scale pendulum tests were performed on W6x9 steel posts anchored to smaller deck sections as previously described. Two pendulum tests were performed on two W6x9 steel posts anchored to the deck specimens. Each post was anchored using four 7/8-inch diameter Super Hilti Anchoring System (HAS) rods. The rods were anchored to the concrete using Hilti's RE500 epoxy anchoring system. Full-scale pendulum testing performed on the post and base plate connection design revealed that the base plate connection strength was suitable to resist the ultimate plastic bending strength of the W6x9 steel shape. The results of the pendulum testing served to validate the calculated strength of the base plate and anchor design for the W6x9 steel post.

The base plate connection design utilizing 7/8-inch diameter A193 HAS threaded rods and anchored using Hilti's RE500 epoxy adhesive anchoring systems was adequate to develop the plastic strength of the W6x9 posts. This base plate connection was designed to resist the full plastic bending strength of the W6.9 post. Based on the results from the full-scale pendulum testing on the W6x9 post design, the similar design performed on the W8x21 would also likely develop the full plastic strength of this larger post size. The W8x21 base plate connection was also designed to resist the plastic bending strength of the W8x21 post. One of the intended applications of the W8x21 post is for stiffening guardrail in the vicinity of bridge piers when the standard design cannot be accommodated. In such situations, the guardrail posts may need to be bolted to the surface of a spread footing.

W-Beam Guardrail on Box Culvert

The W6x9 steel posts were welded to 12 inch x 12 inch x 7/8 inch thick base plates. The total length of the posts was 37 inches. Each steel post with base plate was anchored to the 9-inch thick simulated box culvert slab using four 7/8-inch diameter A193 Super HAS all-threaded rods, 8½ inches in length. These threaded rods were embedded 6 inches in the box culvert slab and were anchored using HILTI RE500 Epoxy Anchoring System.

CRASH TESTING

The simulated box culvert slab tested was 105 ft in length by 75 inches in width by 9 inches thick. The fill height constructed on top of the box culvert slab was 9 inches. A 9-inch high by 10-inch wide concrete headwall was constructed on the field side edge of the box culvert slab. The W6x9 steel posts were located 28 inches from the field side edge of the simulated box culvert slab.

A 1998 Chevrolet C2500 pickup truck, weighing 4614 lb and traveling at an impact speed of 62.9 mi/h, impacted the W-Beam Guardrail on Box Culvert installation just downstream of post 13 at an impact angle of 23.9 degrees.

The W-Beam Guardrail on Box Culvert contained and redirected the 2000P vehicle. The W-beam rail element ruptured, however, the 2000P vehicle did not penetrate the rail.

Although the rail element ruptured and separated from the posts, the rail element did not penetrate or show potential for penetrating the occupant compartment, or present undue hazard to others. Maximum occupant compartment deformation was 0.71 inch in the lateral area across the floor pan of the vehicle.

The 2000P vehicle remained upright during and after the collision event. The 2000P vehicle subsequently came to rest 128 ft downstream from impact and 13.5 ft toward traffic lanes.

Longitudinal impact velocity was 5.6 m/s, and longitudinal ridedown acceleration was -15.6 g's. Exit angle at loss of contact with the guardrail was 31.7 degrees, which was 133 percent of the impact angle.

Barrier after Test

Vehicle after Test

CONCLUSIONS

NCHRP Report 350 test 3-11 was performed to evaluate a guardrail system across low-fill culvert. The W-beam rail element was ruptured by the impact from the vehicle. Even though the rail element was ruptured, the vehicle was contained and redirected without penetrating, underriding, or overriding the installation. The rail element ruptured after the vehicle was redirected and while it was exiting out of the barrier system. The occupant risk values recorded for this test were acceptable with respect to *NCHRP Report 350* criteria. Based on the review of all available test data, the W-Beam Guardrail on Box Culvert met the required criteria for TL-3 according to the specifications for *NCHRP Report 350* test 3-11.

The W6x9 post and anchorage details developed under this project demonstrated satisfactory performance. No damage to the deck or failure of the adhesive anchors was observed in the full-scale testing. The W6x9 post and anchorage details tested for this project can be used in lieu of the conventional through-bolt design for this and other box culvert guardrail design that meet *NCHRP Report 350*, including the half-post spacing system previously tested.

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Technical Report

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