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PARTICIPATING PARTNERS:

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California Department of Transportation

Louisiana Department of Transportation and Development

Minnesota Department of Transportation

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Roadside Safety Pooled Fund

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W-Beam Guardrail on Low-Fill Box Culvert

INTRODUCTION

Guardrail installations frequently must pass over reinforced concrete box culverts used for transverse drainage under highways. In many cases, the depth of fill over the box culvert is very shallow and will not allow the proper embedment of steel or timber guardrail posts. A typical detail in these cases is a shortened W6×9 steel post attached to a steel base plate bolted to the top of the box culvert. An epoxy adhesive anchoring system is sometimes preferred to permit installation of the post without the need to enter the culvert and install a bolt-thru anchoring system.

RESEARCH APPROACH

In Phase I of this pooled fund study, *NCHRP Report 350* test 3-11 was performed to evaluate a guardrail system with standard post spacing (6 ft-3 inches) across a low-fill culvert. [5] During this test, the W-beam rail element ruptured. The adhesive anchoring system worked as designed with the new W6×9 post and welded baseplate detail. No damage to the deck or failure of the adhesive anchors was observed.

In Phase II, the height of the W-beam guardrail system was raised from 27 inches to 31 inches above finished grade. The posts were spaced on 6 ft-3 inch centers; however, the W-beam rail splices were relocated to the midspan of the 6 ft-3 inch post spacing. Also, the crash test performed on the W-beam guardrail on low-fill box culvert was in accordance with test 3-11 of the new crash test guidelines, AASHTO *MASH*, which involves the 2270P vehicle (a 5000 lb (1/2 ton) Quad Cab Pickup) impacting the guardrail at a speed of 62 mi/h and an angle of 25 degrees.

31-inch W-Beam Guardrail on Low-Fill Box Culvert

DESIGN DETAILS

In Phase II, the box culvert guardrail installation consisted of a 12 gage W-beam guardrail system supported by W6×9 steel posts anchored to a simulated box culvert. Standard 6-inch × 8-inch × 14-inch long wood blockouts were used to block out the W-beam guardrail from the steel posts. The height of the W-beam guardrail system was 31 inches above finished grade. The posts were spaced on 6 ft-3 inches centers. The W-beam rail splices were located at the midspan of the 6 ft-3 inch post spacing. The posts were anchored to the top of a simulated box culvert slab using the Hilti RE500 epoxy anchoring system. For this test installation, 9 inches of compacted standard soil material was constructed on top of the simulated box culvert slab. The total length of the simulated concrete box culvert slab was 105 ft. The W-beam guardrail system was anchored on each end using ET Plus end terminals.

The W6×9 steel posts were welded to 12-inch × 12-inch × ⅞-inch thick base plates. The total length of the posts was 40⅛ inches. Each steel post with base plate was anchored to the 9-inch thick simulated box culvert slab using four

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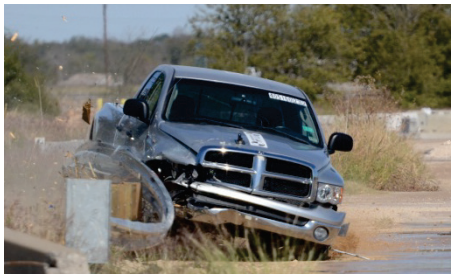
⅞-inch diameter A193 Super HAS all-threaded rods, 8½ inches in length. These threaded rods were embedded approximately 6 inches in the box culvert slab and were anchored using the HILTI RE500 Epoxy Anchoring System.

The simulated box culvert slab tested for this project 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 approximately 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 W6×9 steel posts were located 28 inches from the field side edge of the simulated box culvert slab. Transverse steel reinforcement in the slab consisted of #3 bars spaced at 12 inches on centers in the top and bottom mats. Longitudinal steel reinforcement in the bottom mat consisted of #5 bars spaced 4½ inches on centers. Longitudinal steel reinforcement in the top mat consisted of #3 bars spaced 6 inches on centers. Transverse reinforcement in the 9-inch high headwall consisted of #3 stirrups spaced at 12 inches on centers. Four #3 longitudinal steel bars were evenly spaced inside the stirrup reinforcement in the headwall.

CRASH TESTING

MASH test 3-11 involves a 2270P vehicle weighing 5000 lb ±110 lb and impacting the box culvert guardrail at a speed of 62.2 mi/h ±2.5 mi/h and an angle of 25 degrees ±1.5 degrees. The target impact point was 5 ft-3 inches upstream of post 12. The 2003 Dodge Ram 1500 Quad Cab pickup truck used in the test weighed 5005 lb and the actual impact speed and angle were 62.9 mi/h and 26.1 degrees, respectively. The actual impact point was 5 ft-4 inches upstream of post 12.



2270P Vehicle Redirecting during Test with W-Beam Guardrail over Low-Fill Box Culvert

W-Beam Guardrail on Low-Fill Box Culvert after Test

Vehicle after Test

The W-Beam Guardrail on Low-Fill Box Culvert contained and redirected the 2270P vehicle. The vehicle did not penetrate, underride, or override the installation, however, the rail element was torn half the width at post 12. Maximum dynamic deflection during the test was 45.1 inches. Several blockouts separated from the installation. However, none of these detached elements penetrated or showed potential for penetrating the occupant compartment, nor to present undue hazard to others in the area. No occupant compartment deformation occurred. The 2270P vehicle remained upright during and after the collision event. Maximum roll and pitch angles were -9 degrees and -11 degrees, respectively. Occupant risk factors were within the limits specified in *MASH*. The 2270P vehicle exited within the exit box specifications. The W-Beam Guardrail on Low-Fill Box Culvert performed acceptably according to the specifications for *MASH* test 3-11.

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