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Roadside Safety Pooled Fund

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Pin & Loop Barrier with Drainage Slots

INTRODUCTION

Adequate storm water drainage is necessary for safety on vehicular bridges and roadways. WSDOT has developed a single slope concrete barrier that provides drainage to scupper openings located through the base of each barrier segment. This barrier is planned for use on high-speed roadways where drainage of the pavement surface is needed. The purpose of this project was to review the proposed barrier geometry and perform engineering analyses to size reinforcing steel and placement to resist Test Level 3 (TL-3) impact with respect to *MASH* crash specifications for TL-3 impact conditions.

DESIGN DETAILS

The Washington Pin and Loop Barrier system tested for this project consisted of precast concrete barrier segments that were 12 ft-6 inches in length and 34 inches in height. The barrier segment was 8 inches wide at the top and 21 inches wide at the base with a uniform single slope surface on each side face of the barrier. A 4-inch high by 15-inch wide "V" shaped cutout was centered in the base of the barrier and continuous along the entire length of the barrier segment. In addition to this longitudinal drainage slot, a drainage scupper opening was located at the center of the barrier segment. The drainage scupper opening was 9-inch high by 28 inches in width. This drainage scupper opening would permit drainage from the roadway through the barrier segment or along the barrier through the "V" shape drainage slot located in the base of the barrier. Three ¾-inch diameter steel loops were constructed on the ends of the barrier segments. These loops overlay three loops on the end of the adjacent barrier segment. The

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

segments were connected together by inserting a 1¼-inch diameter steel rods. The ¾-inch steel loops were fabricated using A36 material. The 1¼-inch diameter steel rods were fabricated from ASTM F1554 grade 105 material and were 31 inches in length.

Vertical reinforcement (stirrups) in each barrier segment consisted of #4 rebar stirrups spaced as close as 4 inches on the ends to 11½ inches toward the center of the barrier segment . The stirrups were spaced on 7-inch centers (3 spaces) immediately above the drainage scupper located in the center of the segment. Longitudinal reinforcement in the barrier segment consisted of twelve #5 bars. The bars located in the bottom of the barrier segment were bent to accommodate the drainage scupper opening located in the center of the barrier segment.

The test installation consisted of 16 barrier segments connected together using the 1¼-inch diameter ASTM F1554 grade 105 rods. The total length of the test installation was approximately 200 ft. The minimum compressive strength of the concrete used to construct the units was specified to be 4000 psi. All reinforcing steel used to construct the barrier units was specified to be grade 60 material.

CRASH TESTING

MASH test 3-11 involves a 2270P vehicle weighing 5000 lb ±100 lb impacting the WSDOT pin and loop barrier with drainage slots at an impact speed of 62.2 mi/h ±2.5 mi/h and an angle of 25 degrees ±1.5 degrees. The target impact point was 4.3 ft upstream of the joint between segments 6 and 7.

The 2003 Dodge Ram 1500 pickup truck, traveling at an impact speed of 62.0 mi/h, impacted the WSDOT pin and loop barrier with drainage slots 3.3 ft upstream of the joint between segments 6 and 7 at an impact angle of 26.1 degrees. At approximately 0.023 s, the vehicle began to redirect, and at 0.032 s, segments 6 and 7 began to deflect toward the field side. A crack appeared in segment 7 near the joint between segments 6 and 7 at 0.070 s. The truck began to roll counterclockwise at 0.184 s. At 0.201 s, the vehicle was traveling parallel with the barrier at a speed of 53.2 mi/h. As the vehicle exited the barrier, it continued to roll counterclockwise and came to rest on its left side 202 ft downstream of impact and 31 ft toward traffic lanes.

There was no visible damage to the pins. Spawling of the concrete at the joints and gouging of the traffic face of the barrier segments in the impact area was evident. Working width was 6.0 ft. Maximum dynamic deflection and maximum permanent deformation of the barrier was 5.4 ft.

Maximum exterior crush to the vehicle was 11.0 inches at the left front corner at bumper height. The floor pan sustained a small dent measuring 4 inches × 6 inches × 0.5 inch deep. Maximum occupant compartment deformation was 1.0 inch in the rear passenger compartment near hip height.

In the longitudinal direction, the occupant impact velocity was 14.4 ft/s, the highest 0.010-s occupant ridedown acceleration was 5.9 Gs, and the maximum 0.050-s average acceleration was -6.7 Gs.

Pin & Loop Barrier after test

Vehicle after test

Vehicle after being uprighted

In the lateral direction, the occupant impact velocity was 22.3 ft/s, the highest 0.010-s occupant ridedown acceleration was 10.4 Gs, and the maximum 0.050-s average was 10.2 Gs.

SUMMARY AND CONCLUSIONS

The WSDOT pin and loop barrier with drainage slots contained and redirected the 2270P vehicle. Maximum deflection of the barrier during the test was 5.4 ft. No detached elements, fragments or other debris were present to penetrate the occupant compartment, show potential for penetrating the occupant compartment or to present undue hazard to others in the area. Maximum occupant compartment deformation was 1.0 inch in the rear passenger area near the hip level. After loss of contact with the barrier, the 2270P vehicle rolled counterclockwise 121 degrees and came to rest on its left side. Occupant risk factors were within the limits specified in *MASH*. The 2270P vehicle exited within the exit box.

According to criteria for *MASH* test 3-11, the WSDOT pin and loop barrier with drainage slots did not perform acceptably due to rollover of the test vehicle.

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