**W-Beam Transition to Curved Concrete Bridge Railing Report Comparison**

**W-Beam Guardrail Transition to a Curved Concrete Parapet**

A similar design featuring a W-beam guardrail transition to a curved concrete parapet has been found in Brondstad et al []. Two tests, test nos. NC-1 and NC-1M, were conducted at nominal speeds of 60 mph and angles of 25 degrees with 4,500-lb sedans. Summaries of the tests are given below.

**Test No. NC-1**

This system was configured with eight 6-ft long, W6x15.5 structural steel posts with 12-in. long W6x15.5 steel blockouts. The four posts adjacent to the parapet had a 1 ft - 6¾ in. post spacing and the next four were at a 3 ft - 1½ in. spacing. A wooden blockout was placed between the guardrail and the curved concrete parapet.

The test vehicle, a 1978 Dodge with a gross static weight of 4,642 lb, impacted the transition at a nominal speed of 60 mph and at an angle of 25 degrees. The vehicle was smoothly redirected. However, the left-front wheel pushed up against the parapet, indicating wheel snag on the last post. The system met all safety performance criteria of NCHRP Report No. 230.

**Test No. NC-1M**

Due to the snagging of the wheel in test NC-1, the system was modified by placing a second section of W-beam guardrail below the first. This single 12-ft 6-in. W-beam rail was bolted to the posts, but not attached to the parapet/wingwall itself. The rail was then field bent behind and attached to the furthest upstream post that it traversed. In this instance, it was the fifth post from the parapet.

The vehicle was smoothly redirected, and the lower section of W-beam significantly reduced the wheel snag observed previously in test no. NC-1. The system met all safety performance criteria of NCHRP Report No. 230.

**W-Beam Guardrail to Vertical and Safety-Shape Concrete Parapets**

Texas Transportation Institute (TTI) conducted a study of W-beam guardrail to concrete parapet transitions [2]. The system configurations consisted of vertical concrete parapets and safety-shaped concrete parapets where curved sections were cut out of them. At the transition point between the W-beam and the concrete parapet, a 6-in. and an 8-in. diameter, 12-in. long, Schedule 40 galvanized steel spacer tube was used for the vertical concrete parapet and the safety-shape concrete parapet, respectively. The purpose of the spacer was to provide a controlled collapsible spacer between the rail and the parapet.

**Test No. 7199-2 (Vertical Concrete Parapet)**

For this system, the first three posts adjacent to the concrete parapet were 8-ft long, W8x21 structural steel posts with an embedment depth of 68 in. The next three posts were standard 6-ft long, W6x15 structural steel posts with an embedment depth of 44 in. The six posts were placed at a 3 ft - 1½ in. spacing. The rail element consisted of one 25-ft section of 12-guage W-beam guard rail mounted at a height of 27 in. Backup plates were located at each post. A 6-in. diameter spacer tube was placed between the rail and the concrete parapet.

The test vehicle, a 1982 Oldsmobile Ninety-Eight with a test inertial mass of 4,500 lb, impacted the transition 6.0 ft upstream from the end of the concrete parapet at 61.4 mph and at an angle of 25.1 degrees. The vehicle was successfully redirected, but a considerable amount of wheel contact with the end of the parapet occurred. The spacer tube performed as designed by collapsing approximately 1 in. in a controlled manner before significant pocketing and snagging occurred. The system met all safety performance criteria of NCHRP Report No. 230. Although deemed acceptable, due to the crash results, it was then desirable to enhance the impact performance by using a nested W-beam rail.

**Test No. 7199-3 (Vertical Concrete Parapet)**

This system consisted of eight W6x15 structural steel posts with an embedment depth of 44 in. The post spacing between the first five posts adjacent to the concrete parapet was 1 ft – 6¾ in., and the next three posts were at a 3 ft – 1½ in. spacing. The two additional posts were not attached to the rail system and were installed with the face of the blockout adjacent to the back side of the rail. The rail element consisted of nested 12-guage W-beam rail mounted at a height of 27 in. A 6-in diameter spacer tube was placed between the rail and the concrete parapet

The test vehicle, a 1980 Oldsmobile Ninety-Eight with a test inertial mass of 4,500 lb, impacted the transition 6.0 ft upstream from the end of the concrete parapet at 62.0 mph and at an angle of 24.4 degrees. The vehicle was successfully redirected. However, wheel contact with the end of the flared face of the parapet occurred. The spacer tube collapsed approximately 2½ in. and fulfilled its designed function. The system met all safety performance criteria of NCHRP Report No. 230.

**Test No. 7199-5 (Vertical Concrete Parapet)**

This system consisted of six 6-ft long, W6x15 structural steel posts with an standard embedment depth of 44 in. and a spacing of 3 ft- 1½ in. The rail element consisted of nested 12-guage W-beam rail mounted at a height of 27 in. A rub-rail consisting of C6x8.2 steel channel was attached beneath the original W-beam rail, in order to mitigate wheel contact on the concrete parapet. The rub-rail was anchored to the concrete parapet and connected to the front flanges of the steel guardrail posts. The upstream end of the rub-rail was terminated behind the fifth post in the transition. A 6-in. diameter spacer tube was placed between the rail and the concrete parapet.

The test vehicle was a 1984 Cadillac Coupe DeVille with a test inertial mass of 4,500 lb. The test vehicle impacted the transition 6.0 ft upstream from the end of the concrete parapet at 61.0 mph and at an angle of 24.7 degrees. The rub rail effectively prevented wheel snag on the end of the concrete parapet, and the vehicle was successfully redirected. The steel spacer pipe collapsed 1½ in. The system met all safety performance criteria of NCHRP Report No. 230.

**Test No. 7199-9 (Safety-Shape Parapet)**

This system consisted of three 8-ft long, W8x21 structural steel posts with an embedment depth of 68 in. placed adjacent to the safety-shape concrete parapet at a spacing of 3 ft – 1½ in. The next three posts were 6-ft long, W6x15 structural steel posts with an embedment depth of 44 in. at a spacing of 3 ft – 1½ in. The rail element consisted of nested 12-guage W-beam rail mounted at a height of 27 in. Because the safety-shape barrier was sloped it was necessary to add a specially made steel spacer block to increase the distance between the W-beam rail and the exposed toe of the concrete barrier. The block was tapered to reduce the potential of wheel snag when impacted from the opposite direction. An 8-in. diameter spacer tube was used between the rail and the flared face of the parapet.

The test vehicle, a 1982 Cadillac Fleetwood Brougham with a test inertial mass of 4,500 lb, impacted the transition 6.0 ft upstream from the end of the concrete parapet at 60.1 mph and at an angle of 25.3 degrees. The dynamic deflection of the rail exceeded predicted amounts, which was potentially attributed to poor soil compaction, and resulted in increased wheel snag on the end of the concrete parapet. The left-front wheel contacted the concrete parapet, causing the motor to be pushed back into the firewall and resulting in a substantial amount of intrusion into the occupant compartment. The 8-in. diameter spacer tube between the nested rail and the flared portion of the concrete parapet collapsed approximately 2¾ in. Due to the significant amount of intrusion into the occupant compartment, this test did not meet all safety performance criteria in NCHRP Report No. 230 and was deemed a failure.

**Test No. 7199-10 (Safety-Shape Parapet)**

This system consisted of three 8-ft long W8x21 structural steel posts with an embedment depth of 68 in. placed adjacent to the safety-shape concrete parapet and followed by three 6-ft long, W6x15 structural steel posts with an embedment depth of 44 in. All six posts were placed at a 3 ft – 1 ½ in. spacing. The rail element consisted of a nested 12-gauge W-beam rail mounted at a height of 27 in. Because the safety-shape barrier was sloped it was necessary to add a specially made steel spacer block to increase the distance between the W-beam rail and the exposed toe of the concrete barrier. The block was also tapered to reduce the potential of wheel snag when impacted from the opposite direction. An 8-in diameter spacer tube was used between the rail and the flared face of the parapet. A rub-rail made of C6x8.2 steel channel was placed below the W-beam rail. The rub-rail was blocked out the same distance as the W-beam rail element by extending the W6x15 post blockout an additional 8½ in. to a total length of 22½ in. The end of the rub-rail was anchored to the sloped face of the toe, and the lower flange was tapered to allow further extension onto the safety-shape barrier. In order to maintain a vertical face for the rub-rail, a wooden block, trimmed to match the slope of the toe, was placed behind the rub-rail. In addition, a tapered steel end shoe was used at the end to minimize the potential for wheel snag due to impacts from the opposite direction. The rub-rail was attached to the posts in the same way described in test no. 7199-5.

The test vehicle was a 1983 Oldsmobile Regency with a test inertial mass of 4,500 lb. The test vehicle impacted the transition 6.0 ft upstream from the end of the concrete parapet at 62.7 mph and 26.5 degrees. Although wheel contact with the toe of the parapet occurred, the rub rail significantly reduced the severity of the wheel snag when compared to that observed in test no. 7199-9. The transition performed as intended and successfully redirected the vehicle. The vehicle began to yaw counter-clockwise after exiting the test area. The 8-in. spacer tube between the nested rail section and the concrete parapet collapsed approximately 2 in. The concrete parapet showed signs of cracking near the anchor bolts and the junction between the sloped face and the toe. The system met all safety performance criteria of NCHRP Report No. 230.

**W-Beam Transition to Vertical Flared Back Concrete Bridge Parapet (Test No. 405491-2)**

Another system with similarities to the curved concrete parapet with W-beam and crush tube was found; however, this system consisted of concrete barrier that was not curved, but rather flared back away from the traffic side []. The traffic face of the vertical flared back concrete parapet transitioned from a safety-shape to a vertical face barrier over a distance of 2,300 mm. The vertical face extended another 750 mm and then flared back away from the traffic side 215 mm over a longitudinal distance of 850 mm. The eight posts adjacent to the concrete barrier were 1,830 mm long, W150x12.6 structural steel posts. The first four were spaced at 476 mm, and the next four posts were at 953 mm. All posts had 150-mm x 200-mm timber blockouts. The rail element consisted of nested 12-gauge W-beam guardrail mounted at a height of 685 mm. A 6-in. diameter steel spacer tube was used between the rail and the flared face of the parapet.

The test vehicle, a 1989 GMC 2500 pickup truck with a test inertial mass of 2000 kg, impacted the transition 150 mm upstream of post 4 at a speed of 99.8 km/h and at an angle of 25.3 degrees. The transition successfully contained and redirected the test vehicle. However the vehicle rolled one revolution counterclockwise, resulting in significant damage that may have caused serious injury to occupants. The vehicle came to rest in adjacent traffic lanes. Due to these occurrences, the system failed to meet all safety performance criteria for NCHRP Report No. 350.

**Vertical Flared Back Transition (Test No. 3-21)**

Another system with similarities to the curved concrete parapets with a W-beam was found; however, this system consisted of concrete barrier that was not curved, but rather flared back away from the traffic side of the barrier [4-5]. The traffic face of the vertical flared back concrete barrier transitioned from a safety-shape to a vertical face barrier over a distance of 2,300 mm. The vertical face extended another 750 mm and then flared back away from the traffic side 215 mm over a longitudinal distance of 850 mm. The first three posts adjacent to the parapet were 2,290-mm long, W200x19 with an embedment depth of 1,605 mm. The next five posts were 1,980 mm, W150x13.5. The spacing between the first four posts adjacent to the concrete parapet was 476 mm with the spacing increased to 953 mm for the remaining posts. Backup plates were utilized between the posts and the rail starting at the fifth post from the end of the concrete parapet. All of the posts had 150-mm x 200-mm timber blockouts. Nested 12-gauge W-beam guardrail was mounted to the first five posts with single 12-gauge W-beam guardrail for the rest of the system at a height of 685 mm. A rub-rail consisting of C152x12.2 channel, was mounted using tapered wood blockouts on the first three posts and no blockout at post 4. The rub rail was bent back behind and terminated at post no. 5.

The test vehicle, a 1994 Chevrolet 2500 pickup truck with a test inertial mass of 2000 kg, impacted the transition 690 mm from the end of the bridge parapet at 101.2 km/h and at an angle of 24.7 degrees. The transition successfully contained and redirected the vehicle; however, the vehicle rolled one revolution upon exiting the transition and intruded into other traffic lanes. Due to these occurrences, this test failed to meet all of the safety performance criteria for NCHRP Report No. 350.

**REFERENCES**

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