Texas A&M Transportation Institute
3135 TAMU
College Station, TX 77843-3135

979-845-6375
Fax: 979-845-6107
http://tti.tamu.edu/crashtesting

18 ft-9 inch Thrie Beam Transition

Roadside Safety Pooled Fund
Engineering Support/Professional Opinion Project

Literature Review

Prepared by:

Sana Moran, E.I.T.
William Williams, P.E.

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Overview

A literature review was performed and completed for the 18 ft-9 inch Thrie Beam Transition system. A summary of the projects that were reviewed for this study follows.

Development and Implementation of the Simplified MGS Stiffness Transition

The finding in Report No. TRP-03-210-10/TRB 2012 Paper No. 12-3367 was considered for this project (ref. 1). The Midwest Roadside Safety Facility (MwRSF) researchers developed a simplified version of the original MGS stiffness transition by utilizing two common sizes of steel posts, and it was full-scale crash tested according to *MASH* (ref. 2) Test Level 3 (TL-3).

The design of the stiffness transition for this project included a standard Midwest Guardrail System (MGS), a previously accepted thrie beam approach guardrail transition (AGT) system, and an asymmetrical W-beam to thrie beam transition element. The thrie beam AGT consisted of a nested 12-gauge thrie beam attached to W6×15 steel posts at half-post (37½-inch) spacings, which represented a critical configuration (one of the stiffest AGT) after researchers reviewed the previously accepted FHWA AGT systems.

Test Nos. MWTSP-2 and MWTSP-3 were performed on this stiffness transition design. Test No. MWTSP-2 was performed according to test designation *MASH* Test No. 3-21 with a 2270P pickup truck. Test no. MWTSP-3 was performed according to test designation MASH Test No. 3-20 with an 1100C small car. Figure 1 and Figure 2 show the test impact drawings for Test Nos. MWTSP-2 and MWTSP-3, respectively.

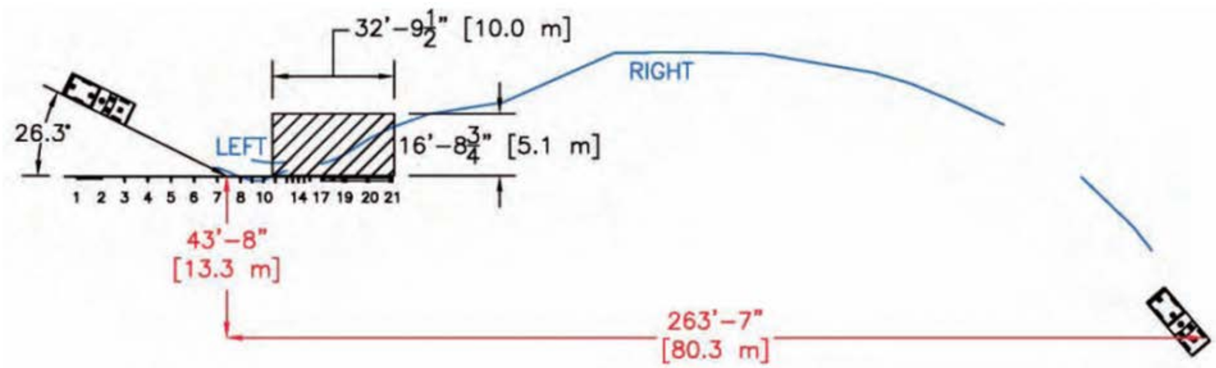


Figure 1. Test Impact Drawings for Test No. MWTSP-2.

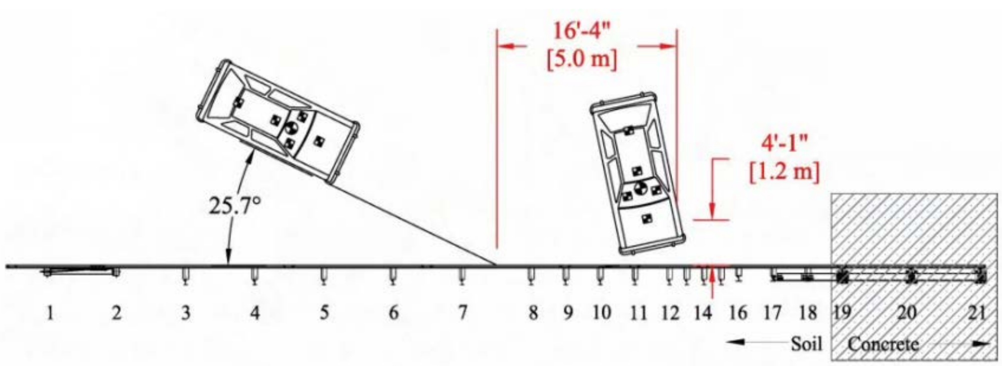


Figure 2. Test Impact Drawings for Test No. MWTSP-3.

A new, simplified steel-post stiffness transition between the MGS and a thrie beam AGT previously accepted by FHWA was developed and tested for this project. This system consists of standard steel posts and an asymmetric W-to-thrie transition element. A stiff thrie beam guardrail transition was used during the full-scale crash test. This new system satisfied all *MASH* TL-3 criteria. Figure 3 shows the details of the recommended transition design for the MGS system to thrie beam and tube bridge railing using steel posts.

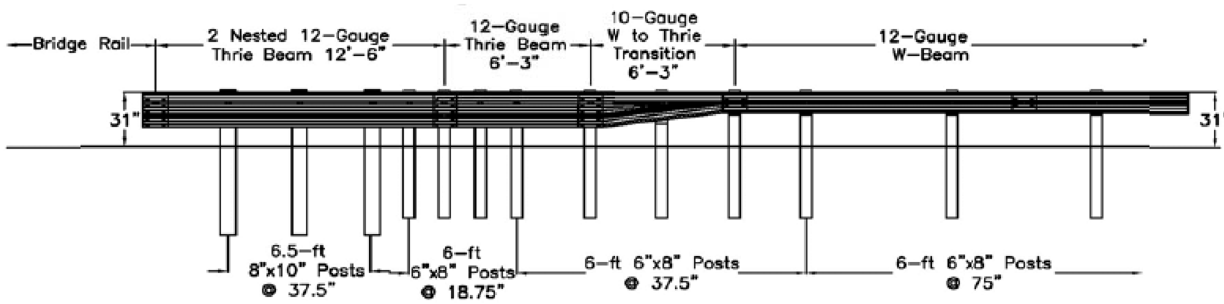


Figure 3. Adapted Simplified Steel-Post Stiffness Transition (Transition to Thrie Beam and Tube Bridge Railing Steel Post Version).

Evaluation of the Midwest Guardrail System Stiffness Transition with Curb

MwRSF researchers developed a W-beam to thrie beam stiffness transition with a 4-inch tall concrete curb to connect a 31-inch tall W-beam guardrail, commonly known as the MGS, to a previously developed thrie beam approach guardrail system (ref. 3). Standard steel posts commonly used by state departments of transportation were used for the upstream stiffness configuration.

The full-scale crash test installation used a 12 ft-6 inch long thrie beam and channel bridge railing system, a 12 ft-6 inch nested thrie beam guardrail, a 6 ft-3 inch standard 12 gauge thrie beam guardrail, a 6 ft-3 inch long asymmetrical 10 gauge W-beam to thrie beam transition segment, and a 50 ft standard 12 gauge W-beam rail attached to a simulated anchorage device. The lap-splice connections between adjacent rail sections were configured to reduce vehicle snag at the splices. The guardrail components were supported by two BCT timber posts (posts nos. 1 and 2), 16 steel guardrail posts (post nos. 3 through 15 are W6×8.5 members and posts nos. 16 through 18 are W6×15 members), and three steel bridge posts (W6×20 member, post nos. 19 through 21).

Three tests were performed for this project: Test Nos. MWTC-1, MWTC-2, and MWTC 3. Test Nos. MWTC-1 and MWTC-2 were performed according to test designation *MASH* Test No. 3-20 with an 1100C small car. Test No. MWTC-3 was performed according to test designation *MASH* Test No. 3-21 with a 2270P pickup truck. Figure 4 through Figure 6 show the test impact drawings for Test Nos. MWTC-1, MWTC-2, and MWTC-3, respectively.

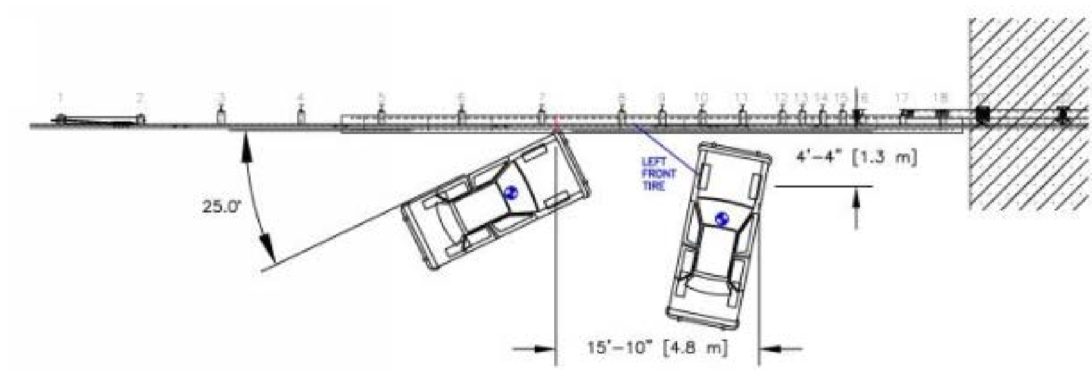


Figure 4. Test Impact Drawings for Test No. MWTC-1.

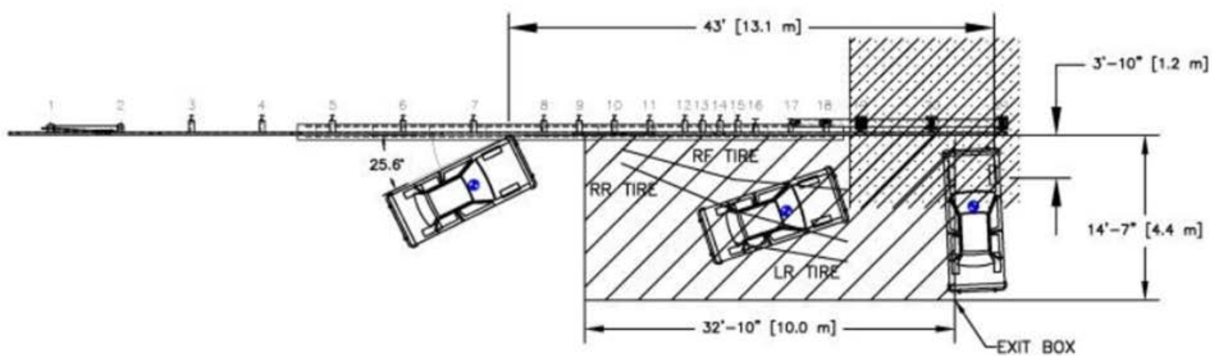


Figure 5. Test Impact Drawings for Test No. MWTC-2.

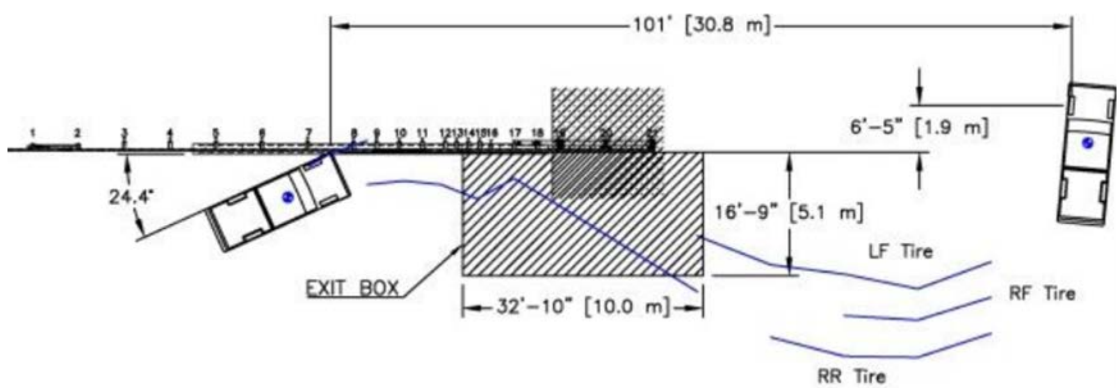
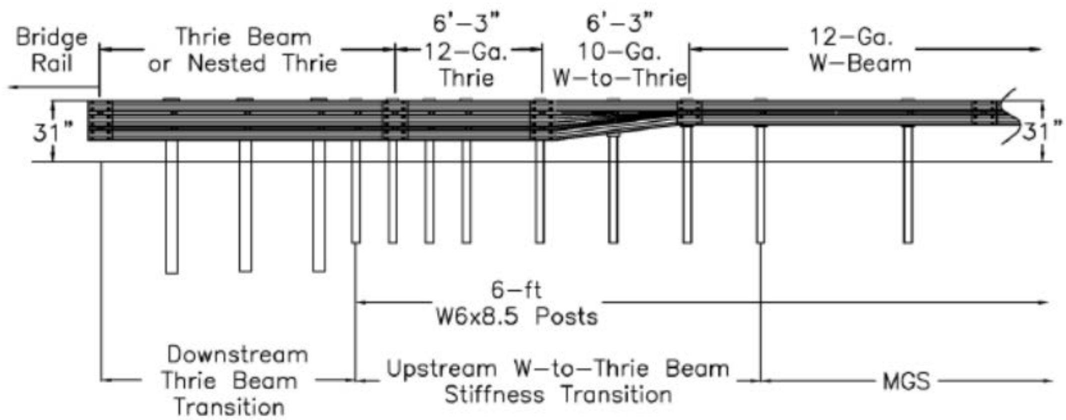


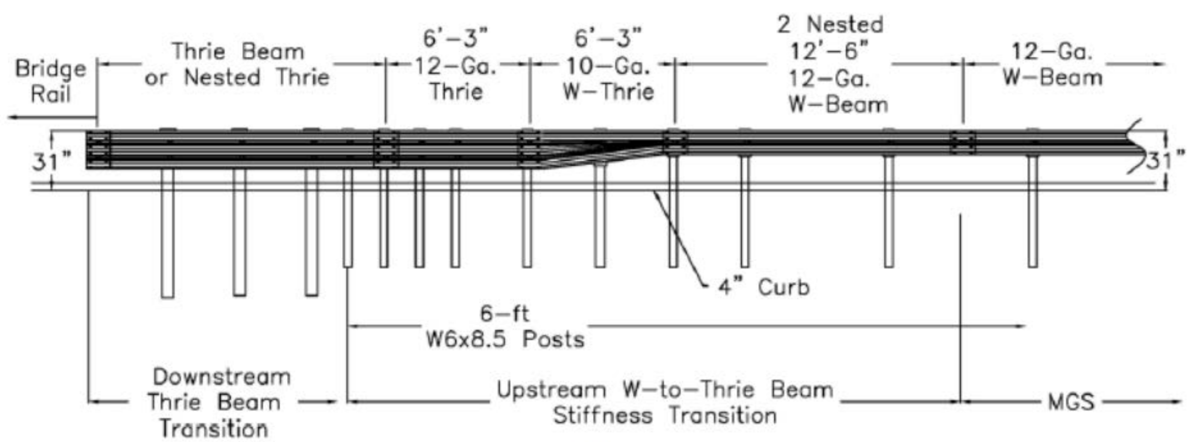
Figure 6. Test Impact Drawings for Test No. MWTC-3.

The initial crash test (Test No. MWTC-1) was performed according to test designation MASH Test No. 3-20 with an 1100C small car. The MGS Stiffness Transition with Curb did not perform acceptably for *MASH* Test 3-20 according to *MASH* TL-3 requirements. The front end of the 1100C vehicle penetrated under the W-beam rail while the wheel climbed up and overrode the curb. The combination of these events caused the W-beam rail to rupture at the splice adjacent to the rail elements, which eventually caused the W-beam rail to rupture at the splice adjacent to the W-beam to thrie beam transition element.

After the failed crash test, the design was modified to incorporate an additional 12 gauge W-beam segment such that 12.5 ft of nested guardrail preceded the asymmetric W-beam to thrie beam transition element. After this modification was incorporated in the stiffness transition system, Test Nos. MWTC-2 and MWTC-3 were performed with an 1100C small car and 2270P pickup truck, respectively. This modified upstream stiffness transition between the MGS and thrie beam approach guardrail transition with curb resulted in a successful completion of the *MASH* TL-3 testing matrix. Therefore, this modified system was found to satisfy current safety standards. Figure 7 presents the details of the recommended transition system with and without a curb tested for this project.



(a)



(b)

Figure 7. MGS to Thrie Beam Stiffness Transition Details (a) without a Curb and (b) with a Curb, 4-Inch Maximum Curb Height.

MASH Test 3-21 on TL-3 Thrie Beam Transition without Curb

TTI researchers evaluated the impact performance of a modified transition design for approach W-beam guardrail to a rigid concrete bridge rail without a curb element beneath the transition rail (ref. 4). The test was performed in accordance with *MASH* guidelines following the impact conditions for Test Designation 3-21.

The surrogate bridge rail parapet was constructed according to TxDOT 36-inch single slope traffic rail (SSTR) bridge rail standards found on the TxDOT standards. The metal beam guard fence was constructed using 19 posts. Posts 1 and 2 were installed as part of the standard 31-inch ET-2000 Terminal. Posts 3 through 11 were installed as part of a standard 12 gauge W-Beam Guardrail (RWM04a). Each post in this section is a 72-inch long W6x8.5 SLP (PEW01) attached to the 12 gauge rail element using an 8-inch wood blockout. The posts in this section were placed at the mid-span of the guardrail. Between posts 11 and 13, a 10 gauge thrie beam to W-beam non-symmetric transition segment is used and is supported by a 72-inch long W6×8.5 SLP. Between post 13 and the end of the bridge parapet, a nested 12 gauge thrie beam (RTM02a) configuration is used and is supported by 84-inch long W6×8.5 posts with 6×8×18-inch wood blockouts. A 10 gauge thrie beam end shoe (RTE01b) was used to connect the nested thrie beam to the ¼-inch thick adapter plate. Figure 8 shows a photograph of the installation.

Figure 8. TxDOT TL-3 Thrie Beam Transition without Curb.

The TxDOT TL-3 Thrie Beam Transition without Curb did not perform acceptably for MASH Test 3-21 due to vehicle rollover. Indications of wheel snagging on the end of the concrete parapet may have contributed to the destabilization of the vehicle.

Three design changes were proposed by researchers to possibly improve the performance of the system. A short curb may be placed at the end of the parapet under the rail to help prevent wheel snagging. The steel blockout at the end of the parapet could be increased in depth to offset the rail to decrease the amount of snagging. Also, the posts in the nested section of the guardrail could be strengthened by using a larger size post and increasing the embedment depth to overall stiffen the transition and ultimately reduce the dynamic deflections. Some previous studies suggest that excessive deflection in the transition region can induce vehicle instability, but if the system becomes too stiff, the upstream end of the transition section may need to be redesigned and evaluated.

MASH TL-3 Testing and Evaluation of the TxDOT T131RC Bridge Rail Transition

TTI researchers designed and crash tested a transition design for the TxDOT T131RC Bridge Rail that would meet the strength and safety performance criteria for *MASH* TL-3 (ref. 5).

The TxDOT T131RC Bridge Rail Transition consists of two nested 12 gauge thrie beam sections supported by six W6×8.5 posts spaced at 37 ½ inches on centers. The 12 ft-6 inch long nested thrie beam section was connected to a 6 ft-3 inch long 10 gauge asymmetric transition piece on the upstream end. The nested thrie beam transition was connected to a 10 gauge end shoe on the downstream end. This end shoe was anchored to the end of the T131RC Bridge Rail. The height from the finished grade to the top of the W-beam guardrail and transition was 31 inches.

The TxDOT T131RC Bridge Rail Transition contained and redirected both the 1100C vehicle and the 2270P vehicle. Overall, all *MASH* TL-3 requirements were met, therefore the TxDOT T131RC Bridge Rail Transition performed acceptably as a *MASH* TL-3 transition. Figure 9 through Figure 11 show photographs of the test installation.

Figure 9. T131RC Bridge Rail Transition Impact View.

Figure 10. T131RC Bridge Rail Transition Connection (Traffic View).

Figure 11. T131RC Bridge Rail Transition Connection (Field View).

References

1. S. K. Rosenbaugh, R. K. Faller, R. W. Bielenberg, K. A. Lechtenberg, D. L. Sicking, and J. D. Reid. *Development of the MGS Approach Guardrail Transition using Standardized Steel Posts*. MwRSF Research Report NO. TRP-03-210-10, Midwest Roadside Safety Facility, Lincoln, NE, December 21, 2010.

2. American Association of State Highway and Transportation Officials, *Manual for Assessing Safety Hardware*, AASHTO Subcommittee on Bridges and Structures, Washington, D.C., 2016.

3. B. J. Winkelbauer, S. K. Rosenbaugh, R. W. Bielenberg, J. G. Putjenter, K. A. Lechtendberg, R. K. Faller. *Dynamic Evaluation of MGS Stiffness Transition with Curb*. MwRSF Research Report TRP-03-291-14. Midwest Roadside Safety Facility, Lincoln, NE, June 30, 2014.

4. D. R. Arrington, R. P. Bligh, and W. L. Menges. *MASH Test 3-21 on TL-3 Thrie Beam Transition without Curb*. TTI Test Report No. 9-1002-12-3. Texas A&M Transportation Institute, College Station, TX, July 2013.

5. W. F. Williams, R. P. Bligh, and W. L. Menges. *MASH TL-3 Testing and Evaluation of the TxDOT T131RC Bridge Rail Transition*. TTI Test Report No. 9-1002-12-4. Texas A&M Transportation Institute, College Station, TX, March 2013.