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# PROFESSIONAL RECOMMENDATION MEMORANDUM

**Project Name:** **Engineering Support Services and Recommendations for Roadside Safety Issues/Problems for Member States**

**Sponsor:** **Roadside Safety Pooled Fund**

**Task 17-6:** **Concrete Shape Transitions/Transitioning from Different Shapes**

**DATE:** **March 03, 2021**

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**Overview/Problem Statement**

Transitioning from different concrete barrier shapes is sometimes desired in roadside barrier systems. Transitioning to different shapes in rigid concrete barrier can create disparities in the concrete between to two rigid shapes. These disparities, if severe, can result in poor crash performance with respect to the MASH Specifications. TTI has performed a literature search for this topic. The results from the search are as follows.

**Midwest Roadside Safety Facility, MwRSF Research Report No. TRP-03-356-16, "Development of the Manitoba Constrained-Width, Tall Wall Barrier" (ref. 1) -** The purpose of this project was to design and test a tall concrete median barrier capable of satisfying MASH TL-5. The barrier designed for this project was tested successfully with respect to MASH TL-5. Following the development of the Manitoba Constrained-Width, Tall Wall, transitions systems were developed for connecting the TL-5 Manitoba Constrained-Width, Tall Wall median barrier to: (1) a TL-4 single-slope median barrier; (2) an 815-mm (32-in.) tall F-shape median barrier; (3) dual TL-5 roadside barriers; and (4) dual 815-mm (32-in.) tall F-shape roadside barriers. A transition was also developed between the TL-4 median barrier and a vertical concrete parapet for connection to guardrail or crash cushions. All of these transitions were developed utilizing a maximum lateral flare rate of 10.0:1 and a maximum vertical flare rate of 5.0:1 to prevent vehicle instabilities during impact events. This information was based on LS-DYNA simulations. Figure 1 shows the details for the height transition developed for this project.

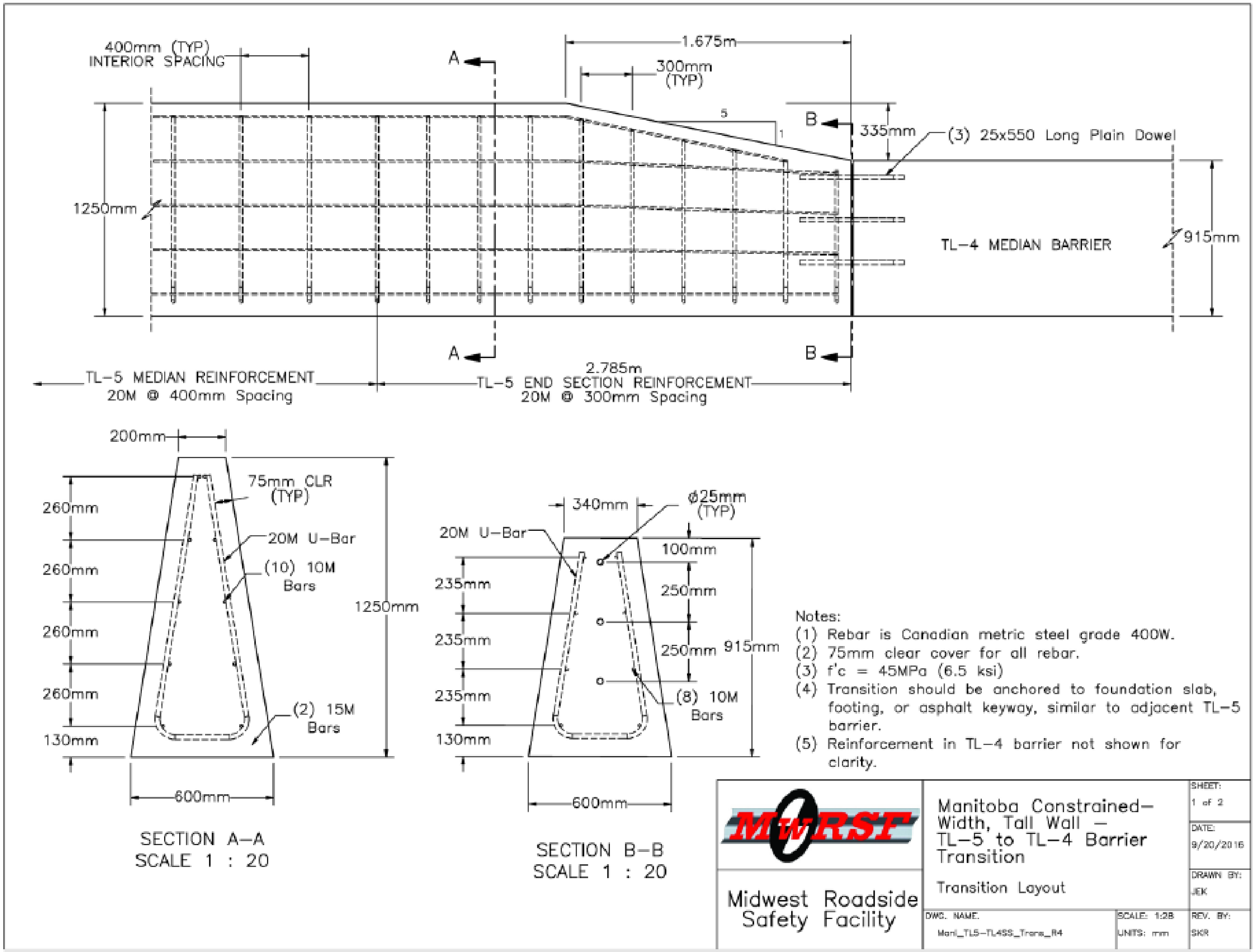


**Figure 1. Concrete Height Transition Details**

**Midwest Roadside Safety Facility, Research Report No. TRP-03- 208-10**, "**Development of a Temporary Concrete Barrier to Permanent Concrete Median Barrier Approach Transition" (2)** - MwRSF researchers stated in this report, "To prevent vehicle snag and instabilities, changes in barrier heights and/or lateral offsets were transitioned gradually." Barrier height changes have previously been designed and successfully crash tested with vertical flare rate up to 5.0:1. Thus, all barrier height transitions should be transitioned at vertical flare rate of 5.0:1 or flatter. Details of the height transition design are shown in Figure 2. A photo of the installation after successful MASH Test 3-21 was performed is shown in Figure 3

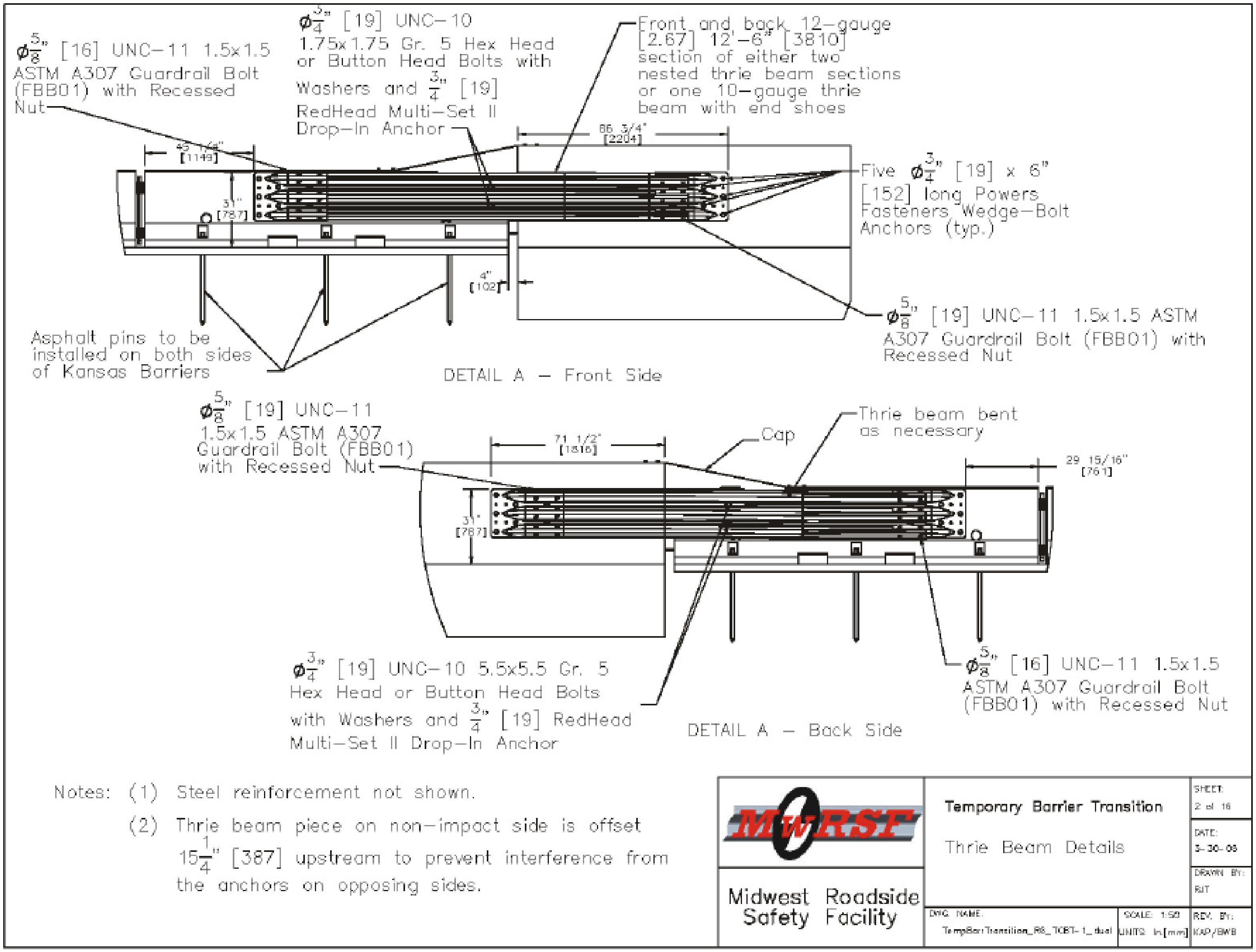


**Figure 2. Concrete Height Transition Details for MASH Test 3-21**

**Figure 3. Concrete Height Transition Details after MASH Test 3-21**

**Roadside Design Guide (3)** – The Roadside Design Guide recommends utilizing lateral flare rates flatter than 20:1 for rigid barrier systems. However, these barrier system flare rates were thought to be extremely conservative when applied to barrier shape changes as many transition buttresses have successfully utilized much steeper lateral tapers. These guidelines were published prior to MASH testing.

**University of Nebraska-Lincoln, Thesis Prepared in Fulfilment Requirements for the Degree of Master of Science, "Development of a Transition Between an Energy-Absorbing Concrete Barrier and a Rigid Concrete Buttress" (4) -** A recent LS-DYNA computer simulation study on concrete barrier transitions indicated that lateral flare rate up to 6:1 may be crashworthy according to MASH. However, the simulations indicated that both OIV values and occupant compartment deformations to passenger vehicles were approaching the MASH limits. Thus, the study recommended utilizing a lateral flare rate of 10:1 for rigid barrier shape changes. Based on this research, all lateral offset changes between barrier configurations for this project were to be transitioned with lateral flare rates of 10:1 or flatter. The following transition sections developed for this project provided design details for each of the noted transitions utilizing these geometric constraints. Details of the MASH TL-5 transition tested and reported in MwRSF Research Report No. TRP-03-356-16 are shown in Figures 5 and 6.

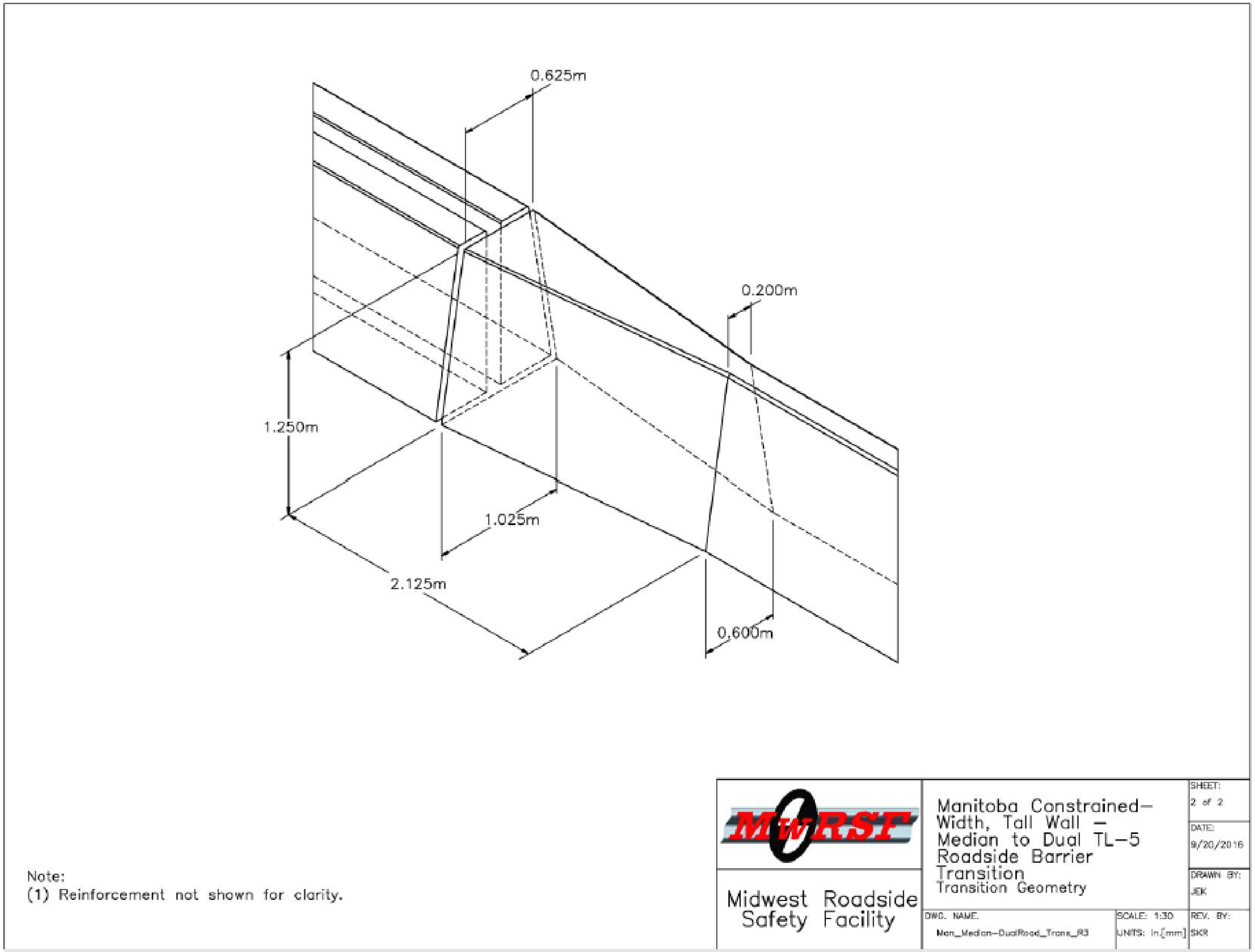


**Figure 5. Transition Details for MASH TL-5 Median Barrier**

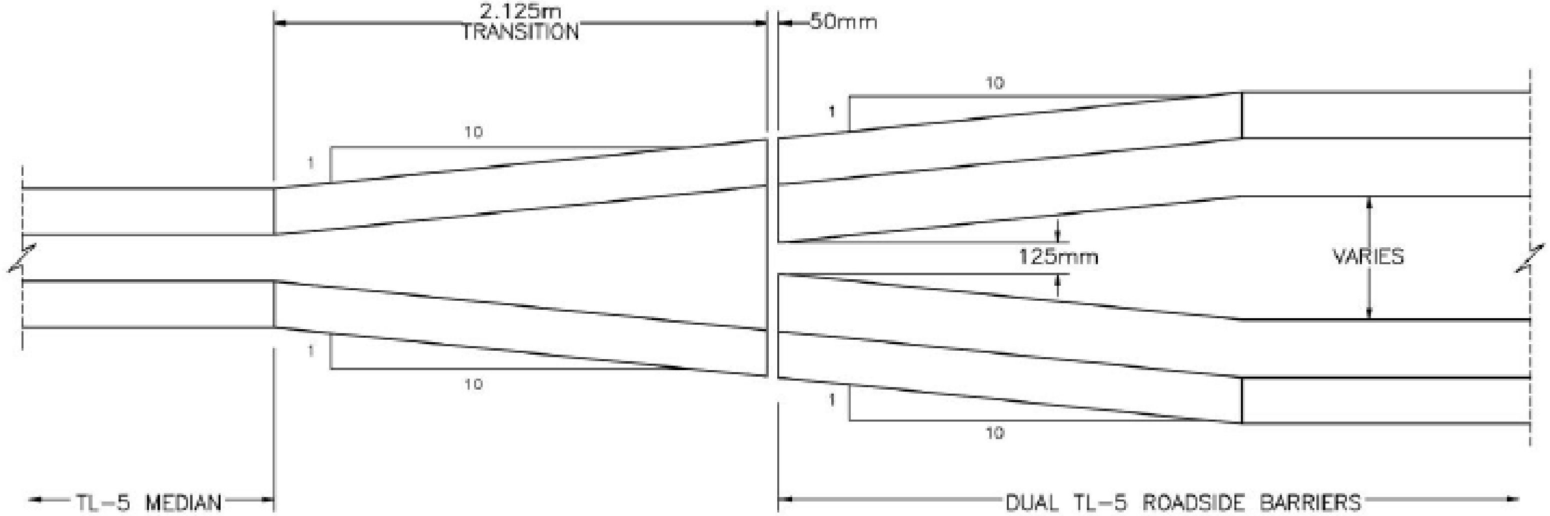


**Figure 6. Plan View of MASH TL-5 Transition Details showing Lateral Flare Rates**

**Texas A&M Transportation Research Report No. 690902-PCL1-3, "MASH Testing of Branching Transition Barrier and Barrier Mounted Sign System" (5)**
For this project, MASH Tests 3-20 and 3-21 were performed on a 18.5:1 lateral flare rate (3.1 degrees). These tests were successful with respect to MASH Specifications.

**Summary and Recommendations**
A 18.5:1 lateral flare rate was tested successfully to MASH TL-3. The research team recommends using 18.5:1 lateral flare rate or flatter for transitioning between rigid concrete barrier shapes. A 5.0:1 vertical flare rate was successfully tested to MASH Test 3-21. All barrier height transitions (transitions from lower top to taller top barrier heights) can be at 5.0:1 or flatter. These flare rates are recommended until further MASH crash testing can prove steeper flare rates can be used.

**References**


1. Scott K. Rosenbaugh, Jennifer D. Schmidt, Elizabeth M. Regier, Ronald K. Faller, *Development of the Manitoba Constrained-Width, Tall Wall Barrier*, MwRSF Research Report No. TRP-03-356-16, Midwest Roadside Safety Facility, September 2016.

2. Wiebelhaus, M.J., Terpsma, R.J., Lechtenberg, K.A., Reid, J.D., Faller, R.K., Bielenberg, R.W., Rhode, J.R., and Sicking, D.L., *Development of a Temporary Concrete Barrier to Permanent Concrete Median Barrier Approach Transition*, Research Report No. TRP-03-208-10, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, July 15, 2010.

3. *Roadside Design Guide*, 4th Edition 2011, American Association of State and Highway Transportation Officials (AASHTO), Washington D.C., 2011.

4. Schmidt, T.L., *Development of a Transition Between an Energy-Absorbing Concrete Barrier and a Rigid Concrete Buttress*, Thesis Prepared in Fulfilment Requirements for the Degree of Master of Science, University of Nebraska-Lincoln, Lincoln, Nebraska, July, 2016.

5. Nauman M. Sheikh, Wanda L. Menges, Darrell L. Kuhn, MASH Testing of Branching Transition Barrier and Barrier Mounted Sign System, TTI Research Report No. 690902-PCL1-3, Sponsored by Powell Contracting Limited, November 2016