Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2011
June 15, 2011

Project No.:	RPFP-07-01 – SPR-3(017) Supplement #38
Project Title:	Cost-Effective Upgrading of Existing Guardrail Systems
Starting Date:	February 26, 2007
Completion Date:	December 31, 2012
Principal Investigator:	Reid, Rohde, Sicking, Faller
Co-PIs & Team Members:	Lechtenberg, Rosenbaugh
Author:	K. Lechtenberg

Progress:

Task	% Completed
1. Field study of existing guardrail installations	100
2. Compilation of field study findings	100
3. Selection of installations to investigate	100
4. Sensitivity study to decrease the size of the analysis matrix	100
5. RSAP analysis	100
6. Research report	25

Activity This Quarter:

The additional RSAP analysis utilizing runout lengths as shown in the updated Roadside Design Guide was completed. Documentation of the research study was initiated.

Activity Next Quarter:

A draft report of research study will be completed. Submit draft report to Pooled Fund member states for review and comment.

Problems/Comments:

The analysis was completed with the longer runout lengths. Thus, additional analysis will be completed with the shorter runout lengths that will be published in the updated Roadside Design Guide

Total Percentage of Project Completion:

It is anticipated that 85% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2011
June 15, 2011

Project No.:	RPFP-06-08 – SPR-3(017) Suppl. #35
Project Title:	Evaluation of the Safety Performance of Vertical and Safety Shaped Concrete Barriers
Starting Date:	July 1, 2005
Completion Date:	December 31, 2011
Principal Investigator:	Rohde, Sicking, Reid, Faller
Co-PIs & Team Members:	Albuquerque
Author:	K. Lechtenberg/D. Albuquerque

Progress:

Task	% Completed
1. Literature review on concrete barriers, rollovers, ran-off-road crashes, and occupant and vehicle safety	100
2. Acquire accident reports for all bridge rail related accidents in the State of Iowa	100
3. Identify which accidents actually involve a bridge railing	100
4. Create data base of accident information for bridge rail crashes	100
5. Analyze data base to determine added risk associated with safety shaped concrete barriers when compared to vertical concrete barriers	100
6. Research report	75

Activity This Quarter:

The additional data analysis utilizing a different statistical model for the injury analysis as suggested during the initial internal review was completed. A second draft of the research report was prepared and is undergoing internal review.

Activity Next Quarter:

The draft report will be completed and submitted to the Pooled Fund member states for review and comment. The final research report will be published.

Problems/Comments:

This project required collecting an additional 6 years of data since the relationship between barrier shape and rollover propensity was being masked by factors such as traffic volume and operating speeds. No work occurred during the Third and Fourth Quarters of 2009 due to shifting of priorities for key project personnel and the need to obtain advanced analysis techniques. Limited data was received for bridge accident sites located on county roads thus the study was limited to bridges located on State maintained highways.

Total Percentage of Project Completion:

It is anticipated that 93% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	RPFP-06-01 // SPR-3(017) Suppl. #35
Project Title:	Termination of Temporary Concrete Barrier
Starting Date:	7/1/2005
Completion Date:	12/31/2011
Principal Investigator:	Rohde, Sicking, Faller, Reid
Co-PIs & Team Members:	Bielenberg
Author:	Bielenberg

Progress:

Task	% Completed
1. Computer simulation to determine LON and anchorage	100
2. Design of anchorage system	100
3. Full-scale crash testing with 2270P	100
4. Documentation and analysis of test results	100
5. Summary report, final CAD details, FHWA approval letter	98

Activity This Quarter:
(Provide an informative summary of tasks/activities that occurred this quarter)

Prior to this quarter, MwRSF had completed the design and full-scale crash testing of the termination and anchorage for temporary concrete barrier. In addition, the summary report of the system was completed and submitted to the sponsors. During the last quarter, MwRSF obtained the federal approval letter for this system. FHWA approval letter B221 was received by MwRSF documenting the FHWA approval of the system. MwRSF also worked on compiling the CAD details required for submission of the termination and anchorage for temporary concrete barrier to the Hardware Guide. The Hardware guide details were reviewed at the AASHTO Task Force 13 meeting on May 25th, and the comments and edits from that meeting are being implemented.

Activity Next Quarter:
(Provide an informative summary of the tasks/activities that are planned for the following quarter)

The only work remaining in this project is to finalize the CAD details for the Hardware Guide. The Hardware Guide details were reviewed at the AASHTO Task Force 13 meeting on May 25th, and the comments for that meeting are currently being implemented. This effort should be completed in the upcoming quarter.

Problems/Comments:

There are no problems or issues to report at this time.

Total Percentage of Project Completion:

98%

Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2011
June 15, 2011

Project No.:	RPFP-06-01 – SPR-3(017) Supplemental #35
Project Title:	Cost Effective Measures for Roadside Design
Starting Date:	July 1, 2005
Completion Date:	December 31, 2011
Principal Investigator:	Rohde, Sicking, Reid, Faller
Co-PIs & Team Members:	Lechtenberg
Author:	K. Lechtenberg

Progress:

Task	% Completed
1. Field study of roadside hazards on low-volume roads	100
2. Compilation of field study findings	100
3. Selection of common roadside hazards for analysis	100
4. RSAP analysis and evaluation of selected roadside hazards	100
5. Research report	50

Activity This Quarter:

Internal review of the draft research report has continued.

Activity Next Quarter:

Complete internal review of the draft research report. Submit draft report to Pooled Fund member states for review and comment. Publish the final research report.

Problems/Comments:

Due to a shifting of staff priorities, work of reviewing the internal draft report was greatly diminished.

Total Percentage of Project Completion:

It is anticipated that 85% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.: RPFP-06-02 // SPR-3(017) Suppl. #35
Project Title: Develop Temporary Concrete Barrier Transition
Starting Date: 7/1/2005
Completion Date: 12/31/2011
Principal Investigator: Rohde, Sicking, Faller, Reid
Co-PIs & Team Members: Bielenberg
Author: Bielenberg

Progress:

Task	% Completed
1. Poll of sponsors to determine critical transition need	100
2. Computer simulation to determine LON and anchorage	100
3. Design of anchorage system	100
4. Full-scale crash testing with 2270P	100
5. Summary report, final CAD details, FHWA approval letter	98

Activity This Quarter:
(Provide an informative summary of tasks/activities that occurred this quarter)

Prior to this quarter, MwRSF had completed the design and full-scale crash testing of the temporary concrete barrier transition. After review and consultation with the sponsoring states, a transition between F-shape temporary concrete barrier and a permanent, single-slope concrete barrier was chosen as the critical transition design for development and testing. In addition, the summary report of the system was completed and submitted to the sponsors. During the last quarter, progress focused on finishing a few final tasks. MwRSF is awaiting a response regarding federal approval of the temporary concrete barrier transition. FHWA has received the request and is in the process of evaluating it. MwRSF also worked on compiling the CAD details required for submission of the temporary concrete barrier transition to the Hardware Guide. The Hardware Guide details were reviewed at the AASHTO Task Force 13 meeting on May 25th, and the comments for that meeting are currently being implemented.

Activity Next Quarter:
(Provide an informative summary of the tasks/activities that are planned for the following quarter)

The only work remaining in this project is to finalize the CAD details for the Hardware Guide. The Hardware Guide details were reviewed at the AASHTO Task Force 13 meeting on May 25th, and the comments for that meeting are currently being implemented. This effort should be completed in the upcoming quarter.

Problems/Comments:

There are no problems or issues to report at this time.

Total Percentage of Project Completion:

98%

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	RPFP-11-CONSULT // SPR-3(017) Suppl. #37
Project Title:	Annual Consulting Services Support
Starting Date:	7/1/2010
Completion Date:	12/31/2013
Principal Investigator:	Sicking, Faller, Reid
Co-PIs & Team Members:	Bielenberg
Author:	Bielenberg

Progress:

Task	% Completed
1. Respond to sponsor inquiries and provide quarterly summary	75
2.	
3.	
4.	
5.	

Activity This Quarter:
(Provide an informative summary of tasks/activities that occurred this quarter)

This project allows MwRSF to be a valuable resource for answering questions with regard to roadside safety issues. MwRSF researchers and engineers are able to respond to issues and questions posed by the sponsors during the year. Major issues discussed with the States have been documented in our Quarterly Progress Reports.

In the past quarter MwRSF has responded to a series of state inquiries. The Quarterly Progress Report summarizing these responses is attached to this document.

MwRSF also developed a prototype website for the consulting effort during the past quarter. This website will allow the states to submit problems directly to the website. MwRSF will then respond to the consulting problems through the website, and the problems and responses will be archived in a searchable database. The website is currently functional and the Pooled Fund states were asked to review the website design and provide comments. These comments have been received and MwRSF is currently working with the website developer to implement the changes.

Activity Next Quarter:
(Provide an informative summary of the tasks/activities that are planned for the following quarter)

MwRSF will continue to answer questions and provide support to the sponsors during the upcoming quarter. In addition, MwRSF will continue the effort to finalize the consulting services website and hope to have it fully functional be the end of the upcoming quarter.

Problems/Comments:

There are no problems or issues to report at this time.

Total Percentage of Project Completion:

75%

<u>Pooled Fund Consulting Summary</u>

Midwest Roadside Safety Facility
March 2011 – June 2011

This is a brief summary of the consulting problems presented to the Midwest Roadside Safety Facility over the past quarter and the solutions we have proposed.

Problem # 1 – Wildlife Crossing Holes in Barriers

State Question:

Our environmental specialist that handles threatened and endangered species has proposed a small wildlife crossing for single-slope barrier (shown below). He met with a contractor who ensured him the construction of the barrier as shown is entirely feasible, even for slip forming.

Given the diameter of the opening, I suspect this would neither add a snag point nor in any other way significantly decrease the crashworthiness of the barrier. I'm basing that on 3.4.2.1 of the Roadside Design Guide which states that single cross drainage structures with diameters less than or equal to 36 in. are traversable. Of course that is referring to inslopes and not barriers.

The dimensions shown below were those given to me, but I would also like to know if I could extrapolate your opinion to an 18 in., 21 in., or 24 in. CMP. Any diameter larger than that would begin to conflict with the reinforcing steel in the barrier.

Do you concur with my analysis of this situation?

Joe Jones

MwRSF Response:

Joe:

It is well known that the structural capacity of a barrier is controlled by its ability to safely contain and redirect the heavy, taller vehicles which impact at high-speeds. Thus, a structural analysis could be performed to modify the barrier reinforcement in regions where drainage holes are desired. Drainage openings in concrete parapets should be acceptable as long as the hole does not interfere with the structural steel reinforcement and the barrier capacity is not weakened in this region. If the 42-in. tall, single-slope concrete barrier section is weakened with a lateral hole, then the longitudinal and/or vertical steel reinforcement surrounding this area may need to be increased in order to provide equivalent or greater barrier capacity.

In general, it would be my first impression that the size of the half hole (i.e., 15 in. diameter by 7.5 in. tall) through the barrier would not significantly degrade barrier performance as long as the vertical steel anchorage could be placed at its normal locations adjacent to the opening, adequate longitudinal steel is provided, and as long as the small car's front wheel does not negatively interact with the downstream side of the opening. Small cars have wheel center heights ranging from 10 to 12 in. As such, it would be necessary to ensure that the wheel/steel rim does not snag on the downstream side of the hole, cause increased vehicle climb up the barrier, or result in barrier override or vehicle instability.

For rigid, vertical shapes, it would seem reasonable to assume that a hole height less than or equal to 50% of small car wheel center height, or 5 to 6 in., would not post too much concern for small car instability, climb, or snag. For rigid, safety shape parapets, the safety risks would be accentuated due to increased lateral snag distance at the downstream side of hole caused by a sloped, front face on a barrier system. As such, the maximum allowable hole height would likely be lower for safety-shape parapets as compared to vertical parapets. Previously, MwRSF provided guidance as to a 3-in. maximum allowable hole height for safety-shape parapets. Single-slope parapets would likely fall somewhere between the two noted above, or between 3 and 6 in. However, it should be noted that no official safety guidance or criteria exists for configuring the size and height a drainage holes in rigid, concrete barriers.

Safe half-hole heights for single-slope parapets are believed to fall somewhere between 3 to 6 in. using my best engineering judgment. It would seem possible for them to work 7.5 in. as well. However, my concerns for small car rim snag on hole edge, wheel climb on hole, instability go up as we increase hole size. If I were picking a recommended upper limit for the single slope barrier, I would say 5-6 in. for half-hole height.

Based on the enclosed information, I am unable to extrapolate the noted guidance to the larger opening sizes shown below.

Respectfully,

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

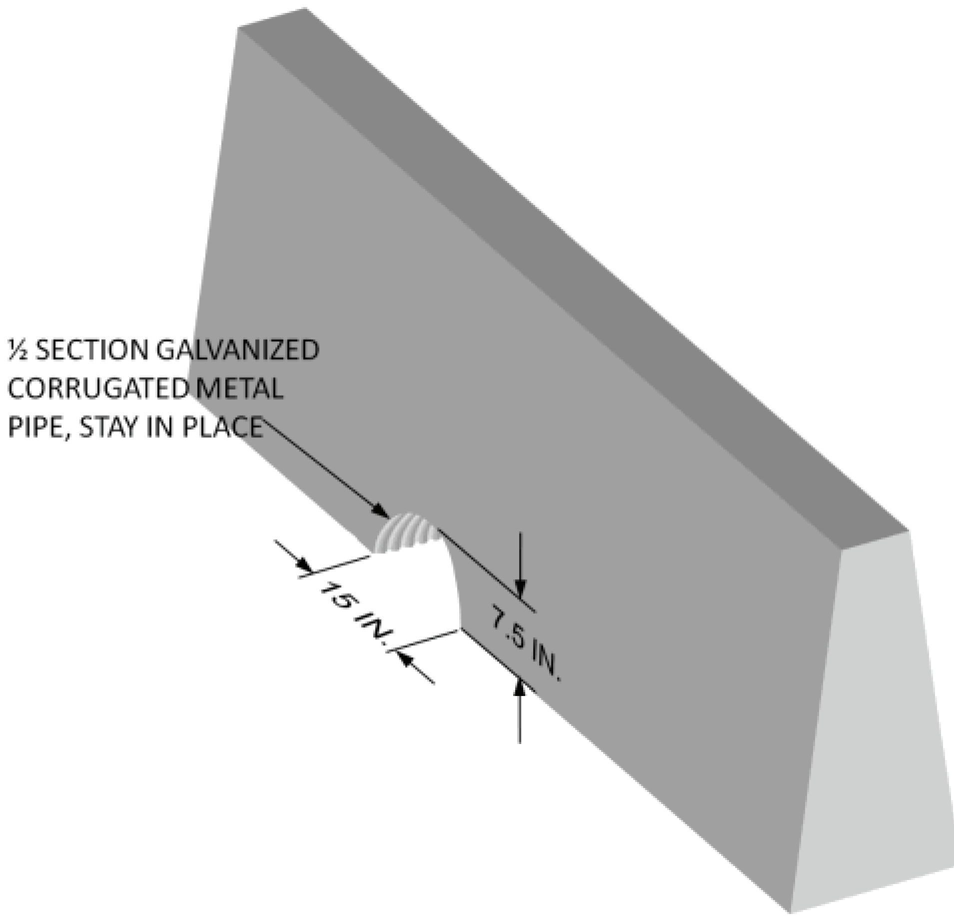


Figure 1. Wildlife Crossing Holes in Barrier

Problem # 2 – Extent of Lateral Encroachment 17-22

State Question:

Wisconsin requested information on the extent of lateral encroachment based on highway class as determined in the NCHRP 17-22 data for use in justifying clear zones.

MwRSF Response:

Erik,

Attached is the information you requested on the extent of lateral encroachment based on highway class. The data shows the median and various percentile lateral extents for different speeds.

Let me know if this meets your needs.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Speed Limit mph	Crashes	Average Maximum Lateral Offset m	Standard Deviation m	50th Percentile m	60th Percentile m	70th Percentile m	75th Percentile m	80th Percentile m	90th Percentile m
45	194	6.9	6.01	5.60	7.36	8.58	9.58	11.08	15.25
50	68	8.6	9.37	5.48	7.32	10.81	11.78	12.79	17.92
55	371	8.5	14.06	6.00	7.37	8.96	9.80	11.65	16.53
60	2	8.9	7.97	8.87	-	-	-	-	-
65	77	11.3	9.11	9.19	10.68	16.30	16.97	18.30	24.25
70	113	14.2	11.40	11.80	14.18	16.36	17.39	20.26	25.25
75	59	16.2	8.81	17.00	18.50	20.00	21.23	22.25	29.20
Other/Unk	6	5.4	4.6	3.1	-	-	-	-	-

Figure 2. Extent of Lateral Encroachment

Problem # 3 – Universal Breakaway Steel Post Modification

State Question:

Ron,
Can the universal breakaway steel post use the bolts placed in the bottom post/ plate using a keyhole slot?

We have access to the top of the bottom post - for repairs of the top post.

If we slide the bolt against something that keeps the bolt from rotating we can repair it from the top side without digging under it. I'm thinking of something similar to the slot on the flange under my toilet. The keyway does not need to be this long.

For a hex head the bottom would need ribs on each side or a channel from the larger opening back to the left under the small opening to hold the head from turning.

Phil TenHulzen PE
Design Standards Engineer

MwRSF Response:

Phil:

It may be possible to utilize this concept to reduce the clearance on the bottom side of the lower plate to that required to place wrench on bolt head versus to place hand under to hold a nut/wrench. With slots, one would likely need to use thicker plate to account for the weakened region around the hole. However, it may be possible to do this with bogie testing in each direction to compare with final modified design. Bogie testing on final design would also be needed since changes were made between prior crash tests.

Maybe in an upcoming Pooled Fund year and/or if other states are interested in a simplified design, we could investigate this option.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 4 – Downstream Anchorage for One Way Roadway

State Question:

Bob,

Here is a PDF with some question about the type 2 end treatment.

Erik Emerson P.E.

MwRSF Response:

Hi Erik,

I have answers for your questions regarding the end anchorages for the MGS.

1. The post bolt, nut, and washer hardware specification is according to the Hardware Guide. Note that the specifications and the diameter are consistent for all post bolts, but the length of the bolt varies depending on the blockout and type of post used. For the BCT posts in the end anchorage, the specs should be:
    a. 5/8" diameter x 10" long ASTM A307 guardrail bolt galvanized according to ASTM 153 (AASHTO M232 Class C) or ASTM B695 (AASHTO M298 Class 50)
    b. 5/8" diameter A563 DH heavy hex nut galvanized according to ASTM 153 (AASHTO M232 Class C) or ASTM B695 (AASHTO M298 Class 50)
    c. 5/8" diameter F436 flat washer galvanized according to ASTM 153 (AASHTO M232 Class C) or ASTM B695 (AASHTO M298 Class 50)
2. As a side comment, your details should show a 6" long, 2" Schedule 40 pipe sleeve in the BCT hole.
3. The post bolt hole in the BCT post should be 7 1/8" down from the top of the post. The detail you have shows a second hole at 10 3/8". This hole is for use with standard W-beam mounted at 27 ¾".
4. Another side comment, page 2 of your detail shows two different cable end fittings. We would prefer that you use the one shown on the bottom as it is what we test with. The end fitting should also be Grade 5 material in order to have sufficient ductility. Some people

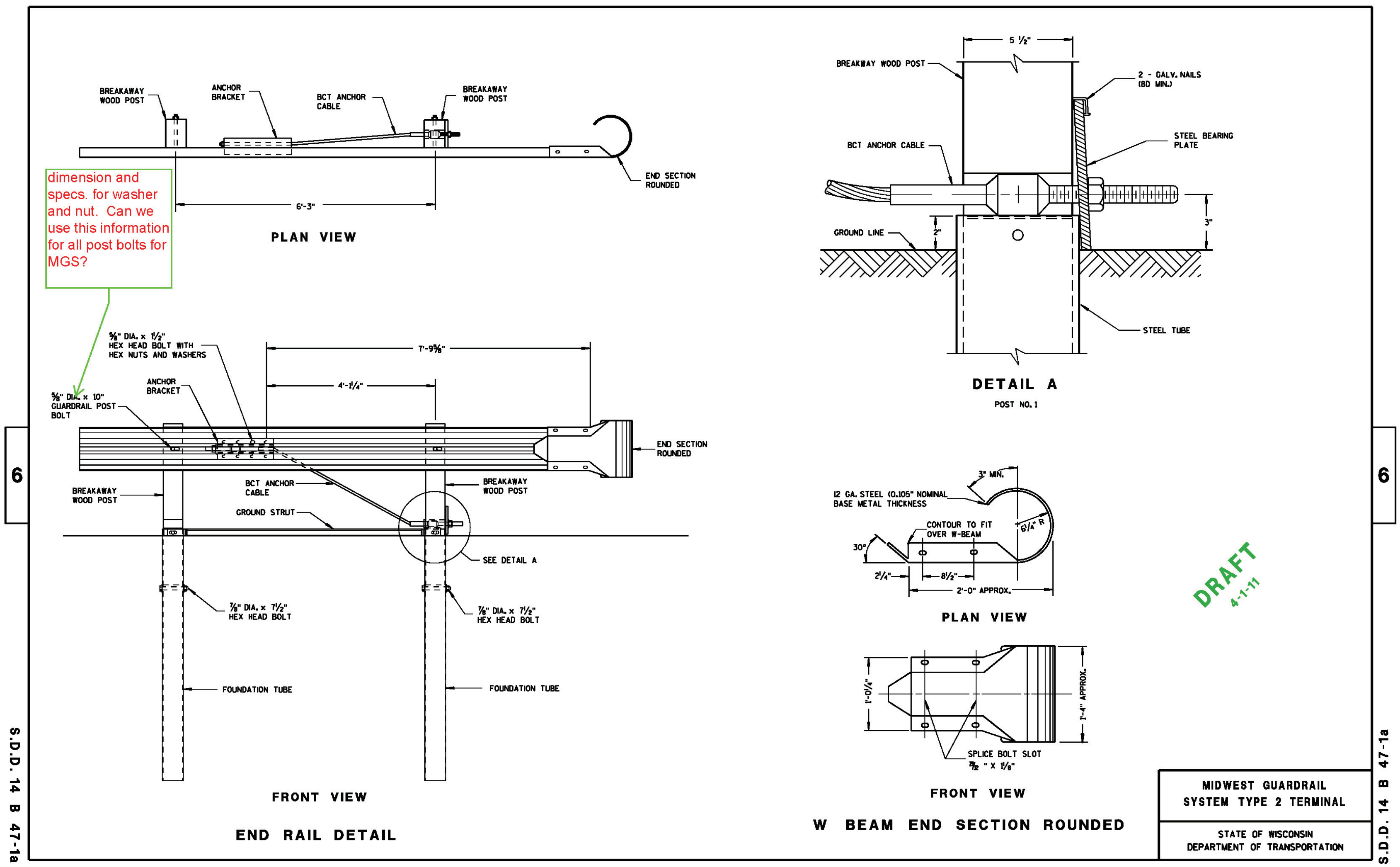


Figure 3.MGS Type 2 Anchorage

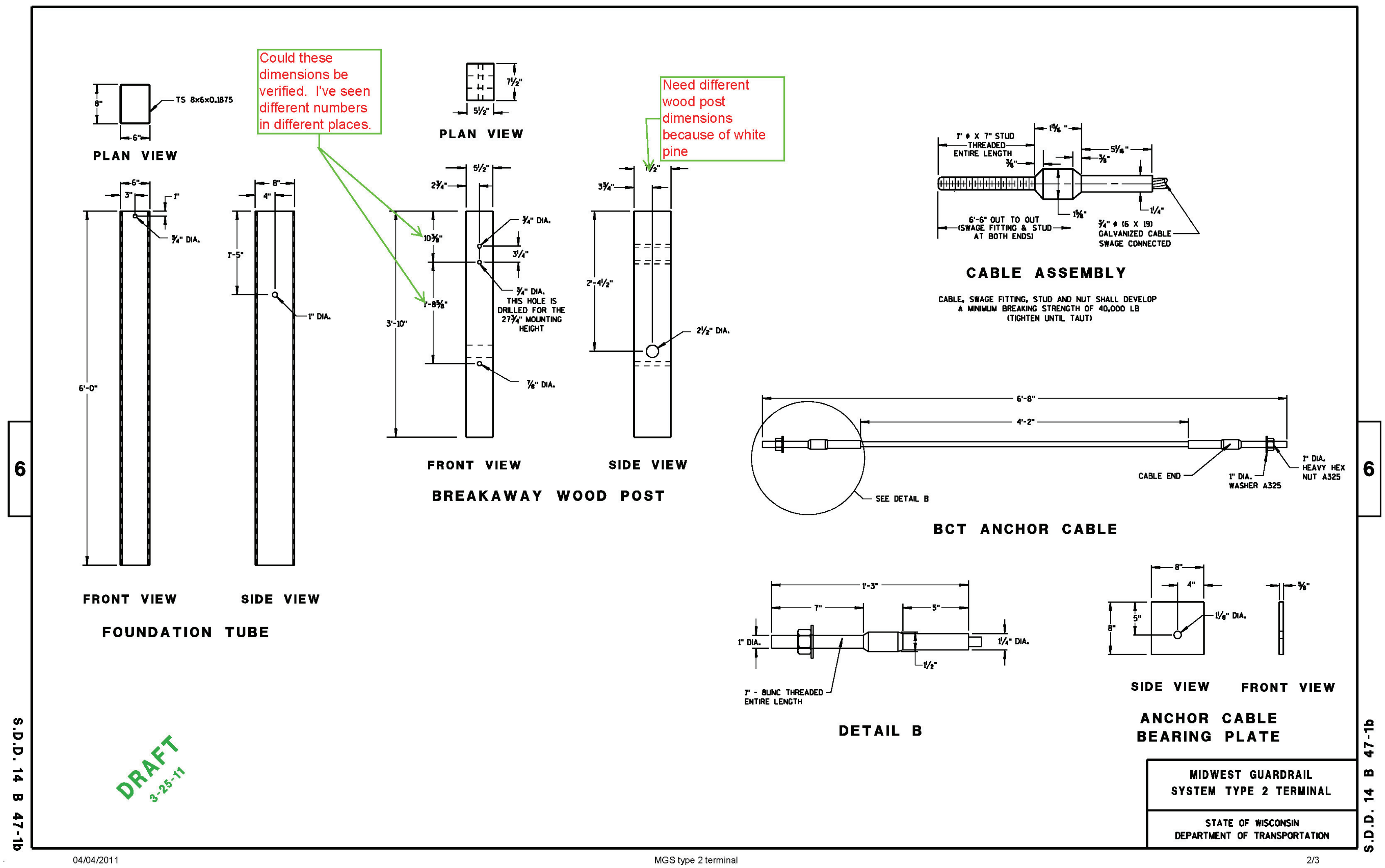
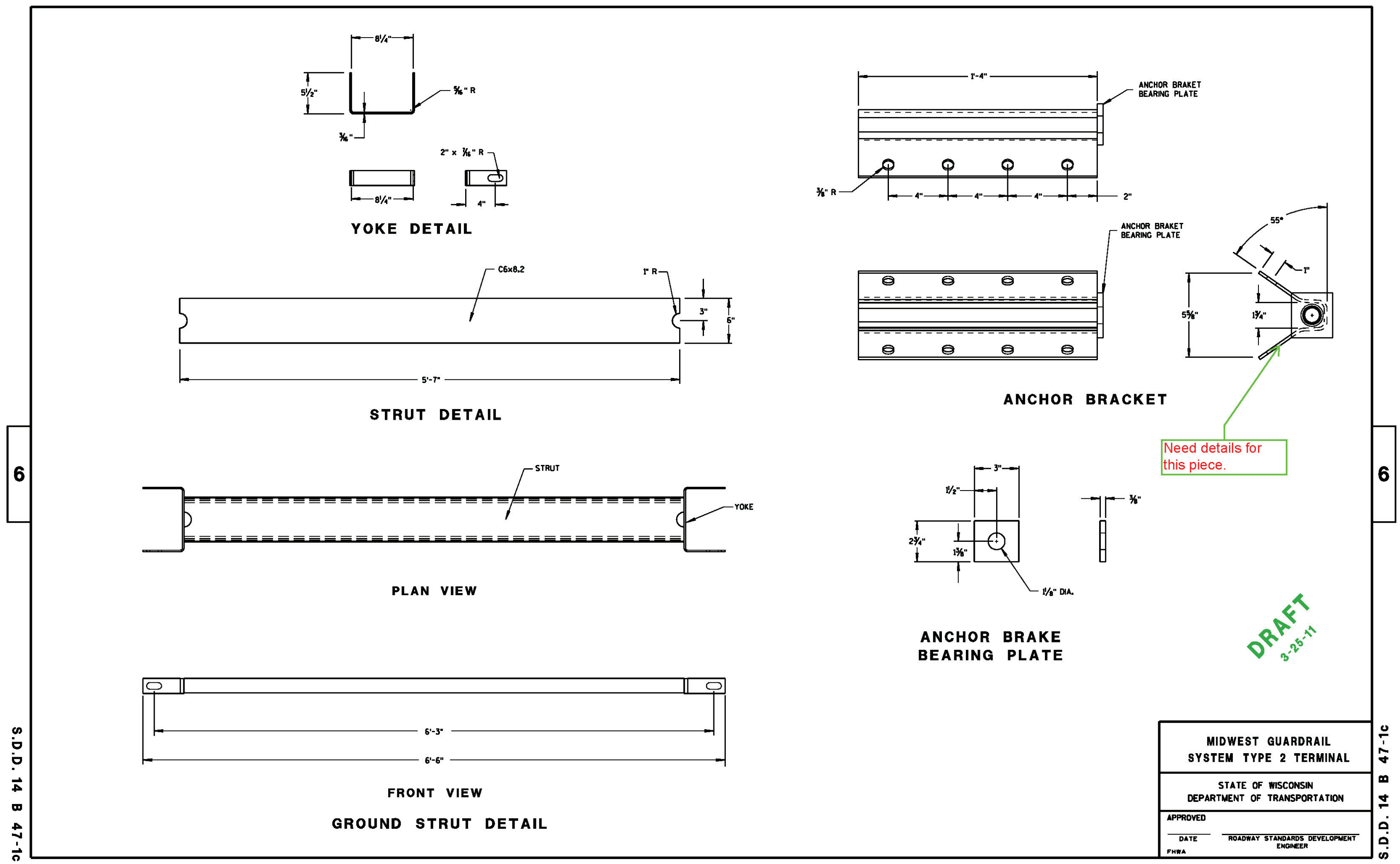


Figure 4.MGS Type 2 Anchorage



04/04/2011 MGS type 2 terminal 3/3

Figure 5.MGS Type 2 Anchorage

have ordered Grade 8 cable end fittings, but these are too brittle and can fracture under loading.

5. The cable anchor bracket is a standard part from the Hardware Guide (FPA01). I have attached the details from the hardware guide with the remaining dimensions.
6. One last item to discuss was your desire to adapt the end anchorage to use white pine posts. Ron and I discussed this and we believe that it is possible, but it will require some further investigation. From the CRT work that Scott did in the white pine report, we could expect that the white pine BCT post would increase in size by around 2". This in turn would increase the size of the foundation tube and the angle of the cable to the guardrail. The larger foundation tube would increase the soil resistance of the tube, and it might need to be made shorter in order to prevent excessive loading of the anchorage. We think that this kind of change can be accomplished, but we would recommend component testing of the anchorage prior to recommending its use. The component test required would be a simple jerk test on the redesigned anchorage to verify its force vs. deflection properties.

Please let me know if this addresses you questions.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Problem # 5 – Cable Guardrail on Slope and End Terminal Questions

State Question:

Ron,

The new in-line cable end treatment requires post 3 through 7 to be spaced @ 16'. What is the offset to a fixed object in this area?

When we design a long run of guardrail in the past we have used an intermediate anchorage section. Is this still necessary?

If so, is there a design for the new in-line intermediate anchorage section?

The spacing in front of a 1.5:1 slope requires 4' post spacing. Is it acceptable to have 16' post spacing then 4' spacing?

Or, is there a suggested length of transition of 8' post spacing?

Have you been able to run a simulation when our slope is 2:1, with a 2% lane and 4% shoulder slopes? I think this will keep the front tire on the slope and not require the 4' post spacing.

Phil TenHulzen PE
Design Standards Engineer

MwRSF Response:

Phil:

I sent a packet to you through the mail today regarding the review of your current cable end terminal details. You requested that effort some time ago.

More recently, you requested additional comment on the low-tension, three-cable barrier system. Those comments are provided below in Red.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

The new in-line cable end treatment requires post 3 through 7 to be spaced @ 16'. What is the offset to a fixed object in this area?

**A 2000P pickup truck was crash tested at the length-of-need of the end terminal at the TL-3 conditions of NCHRP Report No. 350. The vehicle impacted post no. 3 which was 15 ft downstream from the upstream steel anchor post. For this crash test, the working width was reported to be approximately 84 in. when using a 254-ft long installation.

**Please note that the target impact angle for this test was 20 degrees, as required by NCHRP Report No. 350. The new MASH guidelines now utilize an impact angle of 25 degrees. With higher impact angles, one would expect higher angle loading and slight increases in anchor movement, thus resulting in greater barrier deflection and working width near the system ends.

When we design a long run of guardrail in the past we have used an intermediate anchorage section. Is this still necessary?
**As noted above, the test installation was 254 ft long. For longer test installations than denoted above, dynamic barrier deflections and working widths would be expected to increase.

**A prior Pooled Fund R&D program resulted in the successful development, testing, and evaluation of three alternative anchor systems in lieu of the large cast-in-place reinforced concrete anchor blocks. However, the R&D program did not evaluate changes in anchor spacing. As such, we would recommend that NDOR continues to utilize an anchor spacing equal to or smaller than that currently specified, especially since barrier deflections and working widths could be greater with the use of the alternative anchor options.

If so, is there a design for the new in-line intermediate anchorage section?
**The alternative anchor options were developed for terminating and anchoring the ends of the three cables. I am unclear as to the difference between end anchor hardware and the anchor

hardware used at intermediate anchor sections. Please forward those details to us for review as I am unaware of prior crash tests performed to evaluate the safety performance of the overlapped cables with two intermediate anchor sections crossed in opposite directions.

The spacing in front of a 1.5:1 slope requires 4' post spacing. Is it acceptable to have 16' post spacing then 4' spacing?
**The SdDOT three-cable guardrail to W-beam transition utilizes a cable barrier with 16-ft post spacing that transitions into a cable barrier with 4-ft post spacing in advance of the BCT W-beam terminal. No intermediate post spacing was integrated into this original SdDOT design. More than 60 ft of cable barrier with 4-ft spaced posts was used to prevent pocketing near the BCT end. No testing was performed upstream of the 4-ft post spacing design. However, I do not believe that the reduction in post spacing would create a significant pocketing concern for large vehicles or penetration concern for small cars when used in combination with the standard cable hook bolt.

**For the three-cable barrier with 4-ft post spacing in front of a 1.5:1 fill slope, MwRSF performed a 2000P crash test according to the TL-3 conditions of NCHRP 350. An 820C small car test was not performed nor deemed necessary by the MwRSF team. The successful 2000P crash test resulted in nearly 125 in. of dynamic deflection when placed 4 ft from the slope break point, thus resulting in the vehicle extending nearly 6 ft off of the slope. The vehicle's lateral extension off of the slope further accentuated the barrier deflections observed in the 2000P test.

TTI crash tested a 3-cable barrier on level terrain with a 16-ft post spacing at TL-3 of NCHRP 350. This testing resulted in 3.4 m (134 in.) of dynamic deflection, which was slightly larger than the deflection observed above in the ditch. **Since it is uncertain where the 4-ft post spacing will end w.r.t. the ditch start/finish, it would be reasonable to expect the 4-ft spacing to overlap regions of level terrain. When the 4-ft post spacing is installed on level terrain, dynamic deflections would likely be reduced below 125 in.

****Although it would not be deemed necessary at this time, one may consider the use of 4 or 5 spans with posts spaced on 8 ft centers prior to reaching the 16-ft post spacing region.**

Or, is there a suggested length of transition of 8' post spacing?
**See comments noted above.

Have you been able to run a simulation when our slope is 2:1, with a 2% lane and 4% shoulder slopes? I think this will keep the front tire on the slope and not require the 4' post spacing.

**No work on this project has been performed. This work was included in a Pooled Fund study that was not funded in the Year 21 final program. I will copy this request to John Reid and Bob Bielenberg to determine what level of effort would be required to conduct this specific request.

John/Bob:
Please review Phil's request in order to determine the level of effort that would be required to answer his specific question. If you have further questions for him, please email/call Phil to acquire clarifications and additional details. Thanks!

Problem # 6 – Low Tension Cable Barrier Adjacent to 2:1 Slope

State Question and Responses:

Below is an email correspondence regarding low-tension cable barriers and their use adjacent to 2:1 slopes. Due to the back and forth nature of the email correspondence, the entire email list has been copied here for consistency.

Phil:

We were unable to find any prior pickup truck research/testing demonstrating that the 3-cable, low-tension barrier with 16-ft post spacing is crashworthy when installed 2 ft from the slope break point of a 2:1 fill slope. Please let us know if you locate the supporting research so that we can add it to our literature review. Thanks!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Midwest Roadside Safety Facility (MwRSF)
Nebraska Transportation Center
University of Nebraska-Lincoln
130 Whittier Research Center
2200 Vine Street
Lincoln, Nebraska 68583-0853

(402) 472-6864 (phone)
(402) 472-2022 (fax)
rfaller1@unl.edu

From: csstolle@huskers.unl.edu [mailto:csstolle@huskers.unl.edu]
Sent: Monday, May 02, 2011 8:55 AM
To: Ronald K. Faller
Subject: RE: Cable Guardrail Qs

Dr. Faller,

Based on the low-tension cable barrier research I conducted, I had no instances of testing in the last 30 years of a cable barrier 2 ft from a 2:1 slope. There was sedan testing conducted in 1965 by New York where a low-tension cable barrier was placed 18" from the break point of a 2:1 slope; however, this was never tested with a truck and the truck performance on this configuration would be necessary for approval according to 350, much less MASH.

Based on my research I would be unable to recommend that configuration. Unless some research which I have not seen turns up somewhere, this would be considered untested.

Cody S. Stolle, M.S.M.E., E.I.T.
Graduate Research Assistant
Midwest Roadside Safety Facility
University of Nebraska-Lincoln

2200 Vine Street
130C Whittier Building
PO Box 830853
Lincoln, NE 68583-0853

csstolle@huskers.unl.edu
(402) 472-9043
Fax (402) 472-2022

From: Ronald K. Faller [rfaller1@unl.edu]
Sent: Friday, April 29, 2011 5:00 PM
To: 'TenHulzen, Phil'
Cc: 'Osborn, Mark'; 'Dean L. Sicking'; csstolle@huskers.unl.edu; rbielenberg2@unl.edu; 'Ronald K. Faller'
Subject: RE: Cable Guardrail Qs

Phil:

I am not aware of the low-tension crash testing with the cable barrier placed 2 ft from the slope break point of a 2:1 fill slope. One of our PH.D, students, Cody Stolle, has conducted a intensive literature review on the testing of cable barrier systems. I am copying this email to him so that he can let you know any specific details of this testing.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Midwest Roadside Safety Facility (MwRSF)
Nebraska Transportation Center
University of Nebraska-Lincoln
130 Whittier Research Center
2200 Vine Street
Lincoln, Nebraska 68583-0853

(402) 472-6864 (phone)
(402) 472-2022 (fax)
rfaller1@unl.edu

From: TenHulzen, Phil [mailto:Phil.Tenhulzen@nebraska.gov]
Sent: Tuesday, April 26, 2011 8:40 AM
To: Ronald K. Faller; Sicking, Dean

Cc: Osborn, Mark
Subject: FW: Cable Guardrail Qs

Q about 16' spacing see below comments from Nick & Dick.
From below – Dick Albin stated -"However, I know there are states that would install with 16' spacing if the cable was 2' from a 2:1 slope as you show below and I don't believe that is a major concern."

I prefer to use the 16' spacing 2' from a 2:1.

Ron / Dean - Would you confirm that this is the current practice and reference any testing to support this.

Thanks
Phil

From: Nick.Artimovich@dot.gov [mailto:Nick.Artimovich@dot.gov]
Sent: Thursday, April 07, 2011 7:31 AM
To: Dick.Albin@dot.gov; TenHulzen, Phil
Cc: Frank.Julian@dot.gov
Subject: RE: Cable Guardrail Qs

Phil,

I agree with Dick Albin's responses.
However, I spoke with Dr. Dean Sicking yesterday (he was in D.C. with one of his grad students) and they are talking 13 inches for the bottom cable and 45 inches for the top cable for a high-tension four-cable system. Their research is showing that early cable-release from the post is critical to prevent the cables from causing serious damage to impacting vehicles.

I suggest you contact UNL/MWRSF for the latest scoop on their recommendations.

Nick Artimovich

Nicholas Artimovich, II
Highway Engineer, Office of Safety Technologies
Federal Highway Administration HSST
1200 New Jersey Avenue SE, Room E71-322
Washington, DC 20590
email: nick.artimovich@dot.gov
phone: 202-366-1331
fax: 202-366-3222
web: http://safety.fhwa.dot.gov

From: Albin, Dick (FHWA)
Sent: Wednesday, April 06, 2011 8:04 PM
To: TenHulzen, Phil
Cc: Artimovich, Nick (FHWA); Julian, Frank (FHWA)
Subject: RE: Cable Guardrail Qs

Phil,
I tried to answer your questions below. I cc'd Nick and Frank in case they have anything additional to offer.

Dick Albin

Richard B. (Dick) Albin, P.E.
Safety Engineer
Federal Highway Administration
Resource Center Safety and Design Technical Services Team
711 S. Capitol Way, Suite 501
Olympia, WA 98501-1284
303-550-8804
e-mail - dick.albin@dot.gov

From: TenHulzen, Phil [mailto:Phil.Tenhulzen@nebraska.gov]
Sent: Wednesday, March 30, 2011 1:12 PM
To: Albin, Dick (FHWA)
Subject: Cable Guardrail Qs

Dick,
Low tension cable:
I like the low tension cable because of its safety record & for the anchorage in the sandy soils we have in Nebraska.

> I agree that the low tension (generic) system is a very good system. Most states have gone to the high tension to reduce deflection distance, reduce maintenance, and reduce the number or anchors needed. To me the biggest of these was the maintenance because we often had to convince the maintenance folks in order to get it installed.

We have implemented this 3 cable low tension system cable w/ heights @ 30" 27" & 24".

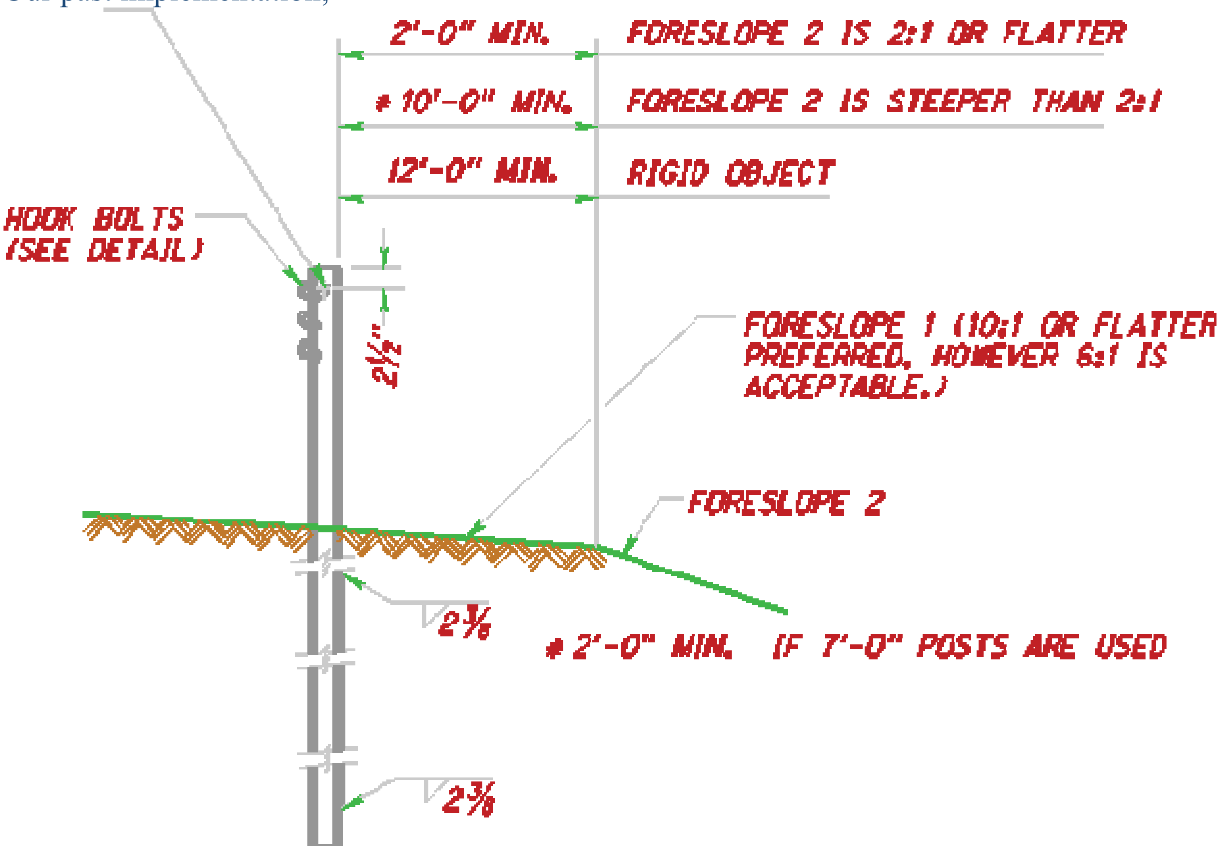
> Most Low tension systems I am aware of have the bottom cable at 21". Some states have installed it with the top cable at 33" and with 6" spacing between the cables. For medians, lower cables are being used to address the underride issue. I am not aware of a crash tested system with the lower cable at 24".

How close can this be placed to a 2H:1V? And with what post spacing?
The testing of 4' post spacing @ 1' from a 1.5H:1V failure, and 4' post spacing @ 4' from a 1.5H:1V pass has us considering 4' post spacing at 4' from a 2H:1V – this is impossible in some locations with 2H:1V at the edge of shoulder.

> I am not sure I have an absolute answer for you on this so I will give you some opinion. I believe the slope behind the cable is much less of a concern than the slope in front of the cable. The critical concern for cable is having the bumper of the vehicle engage at least one cable.
> I have seen tests of a high tension system in front of a vertical drop-off. While the tires went over the edge, the cables engaged the body and brought it back.

I am aware that MwRSF tested a system in front of the 1.5:1 slope with ¼ post spacing. **However, I know there are states that would install with 16' spacing if the cable was 2' from a 2:1 slope as you show below and I don't believe that is a major concern.**

Our past implementation;



This sketch with 16' post spacing has seemed to work very well.

Now we are updating our plans to the inline steel I beam end treatment & I'm wondering – is this the best system?

Is this still the generic system but with a proprietary end treatment like what is used on the high tension systems?

I want to implement the 4-cable 14" to 34" – the system MwRSF tested & met 350 in the median 4:1 down to 4:1 up section.

This system will improve catching the variety of bumper heights.

Would this be acceptable to implement this system for roadside use?

I think the systems that are being tested on 4:1 slopes would be excellent for roadside use and may change the way we treat slopes and roadside objects. I was thinking the MwRSF system was higher than 34" and I know they are looking at lowering the bottom cable. I think the considerations on the roadside make it easier since you wouldn't have a back slope where the vehicle might bottom out.

Let me know if I created new questions or not.

Thanks

Phil

From: Dick.Albin@dot.gov [mailto:Dick.Albin@dot.gov]
Sent: Monday, March 14, 2011 9:55 AM
To: TenHulzen, Phil
Subject: RE: AFB20 2011 Mid Year Meeting Draft Agenda and Registration Information

Phil,
I have wanted to broadcast a portion of our meetings but I usually have problems with the internet access/quality. I will look into it for the meeting in May.

Cable barrier – Are you using the generic (low tension) cable barrier where you install an anchor every 2000'? Most states have changed over to require the high tension systems that don't require the intermediate anchors.

In general, placing the cable 2' in front of a 2H:1V slope is considered acceptable. I know Brifen tested a system at the edge of a vertical drop and it worked and the folks at MwRSF tested a system 4' in front of a 1.5H:1V slope with 4' post spacing.
http://trid.trb.org/view.aspx?type=MO&id=855946
http://www.brifenusa.com/

I like the systems that are now being tested on 4H:1V slopes. The MwRSF is testing a generic system and several manufacturers have tested their systems. In general, these systems have 4 cables that cover a wider range of heights to help catch the smaller vehicle that might try to go under as well as the larger vehicle that might try to go over. Having a system that was tested on a 4:1 slope gives a better tolerance to the slope issues that we have seen. The approach being taken at MwRSF is to test the barrier at the worst location and then it should work anywhere in the median. There are some debates on this but we hope to reach agreement on the number of tests for median testing so that everyone is approaching it consistently (this will be discussed in May).

The biggest con of the 4 cable systems tested on 4:1 slopes is the additional cost but I think it will be worth it.

31" Guardrail
I believe that states should switch over to the 31" guardrail for new installations. It doesn't cost any more (both Washington and Illinois found no additional cost) and provides much better performance in a number or areas. In Washington, we adopted it because it allowed us to reduce the height as a result of overlays, and still have a crashworthy system (standard guardrail at 28" height passes MASH testing).

For transitions to bridges there are a couple options. My preference is to use a "stacked" W-Beam. You maintain the 31" height of the rail but add a w-beam rub rail. The stacked W Beam was tested under NCHRP 350 for a 28" guardrail and when WSDOT was developing the plans, Dick Powers with FHWA HQ confirmed that we didn't need to retest with a 31" height. Attached is a link to the WSDOT standard plan

http://www.wsdot.wa.gov/publications/fulltext/Standards/english/PDF/c25.18-01_e.pdf
The other option is to use a thrie beam transition that was developed by MwRSF.
http://www.wsdot.wa.gov/publications/fulltext/Standards/english/PDF/c25.20-04_e.pdf
I attached a couple of photos of these transitions.

Hope this helps. Let me know if you have additional questions.

Dick Albin

Richard B. (Dick) Albin, P.E.
Safety Engineer
Federal Highway Administration
Resource Center Safety and Design Technical Services Team
711 S. Capitol Way, Suite 501
Olympia, WA 98501-1284
303-550-8804
e-mail - dick.albin@dot.gov

From: TenHulzen, Phil [mailto:Phil.Tenhulzen@nebraska.gov]
Sent: Friday, March 11, 2011 2:56 PM
To: Albin, Dick (FHWA)
Subject: RE: AFB20 2011 Mid Year Meeting Draft Agenda and Registration Information

Dick,
AFB20 2011 Mid Year Meeting:
Thanks for the invitation; I will not be able to travel out of state this year.
Will there be a way to view the sessions on line?

Roadside Cable Guardrail:
We are updating our cable plans to include the in-line anchorage with 3 cables.
What is the current guidance about slopes behind the cable guardrail?
We have many installations of the cable guardrail on the shoulder of our highway 2' from a 2:1 slope
I have considered using 4 cable as tested for the median 14" to 34", what are the pros / cons of this.

MGS 31":
What guidance can you give for implementation of 31" including the Bridge Approach Section?

Thanks for your guidance

Phil TenHulzen PE
Design Standards Engineer
Nebraska Dept. of Roads
Lincoln, NE. 68509-4759
(402) 479- 3951

Phil.TenHulzen@nebraska.gov

Problem # 7 – MGS behind 6" curb

State Question:

Hi Ron,

Hopefully this is a quick and easy one for you: What is your current recommendation regarding the maximum offset of the MGS behind a 6” AASHTO Type B curb for TL-3 conditions? I am specifically interested in the case where the top of rail height is 31 inches relative to the gutter elevation.

Thanks,

-Chris

,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,,

Chris Poole, P.E.
Roadside Safety Engineer

MwRSF Response:

Chris:

I am enclosing a copy of a presentation that I gave a few years ago at a TRB AFB20 summer workshop. This presentation was given prior to conducting the failed TL-3 test at the 8 ft offset location. At that time, we had critical lateral locations where we believed one would need to transition from 31” to 37” MGS relative to the road. However, testing would be needed to evaluate these limits.

Originally, the research study was geared toward a performance limits study where we would increment through critical test conditions and locations. However, the project was refocused by the sponsors in the middle of the study where the performance limits portion was replaced with testing at practical locations and then later a lower test level following a failed TL-3 test. As such, we later obtained a successful TL-2 test at the 6-ft lateral offset but still were unable to explore all of the critical locations.

We really are unable to provide much guidance beyond our original MGS testing with the 6” offset at TL-3 and extrapolate some guidance at TL-2 due to the 2270P test. No small car testing was performed with combination curbs and barriers.

Let me know if you have any additional questions.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 8 – MnDOT Questions Regarding Bridge Barriers

State Question and MwRSF Response:

MnDOT had a conference call with MwRSF to discuss various questions regarding barriers on superelevations and cross slopes. A summary of the discussion is located below.

TO: Bridge R&D Committee Members
Meeting Attendees, Dave Dahlberg

FROM: Paul Rowekamp, Bridge Standards Engineer

DATE: April 14th, 2011

SUBJECT: Discussion Regarding Barriers & Barrier Transitions with Staff from the Midwest Roadside Safety Facility (Univ of Nebraska, Lincoln)

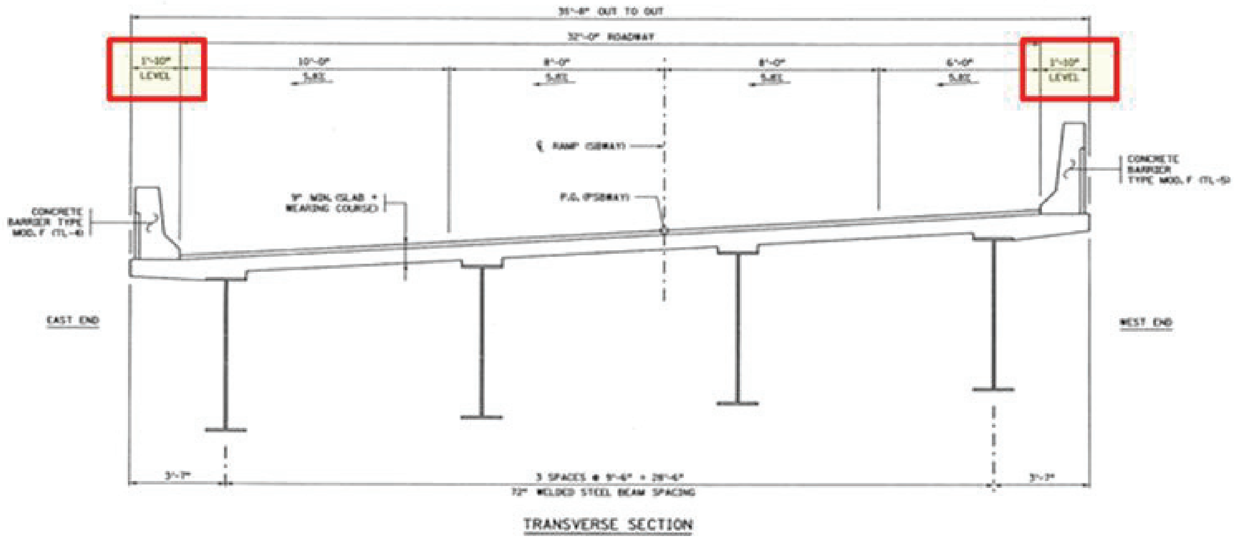
This is a summary of discussions from a teleconference held on March 31st, 2011 regarding various bridge barrier and barrier transition issues.

Attendees: From the Midwest Roadside Safety Facility (MwRSF) in Lincoln, NE (on the phone): Dean Sicking, Ron Faller, Bob Bielenberg; From the FHWA: Romeo Garcia, Will Stein; From the Mn/DOT Office of Technical Support: Mike Elle, Jim Rosenow; From the Mn/DOT Bridge Office: Keith Molnau, Kevin Western, Dan Prather, Arielle Ehrlich, Paul Rowekamp

The group met to discuss various issues regarding barriers including the following;

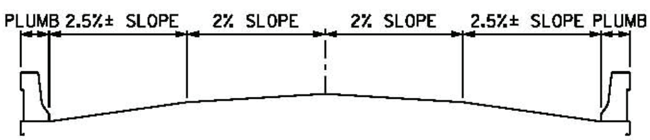
#1). Mn/DOT's current policy regarding placement of traffic barriers on bridges is to place them "plumb" or "level" as indicated in the drawing below.

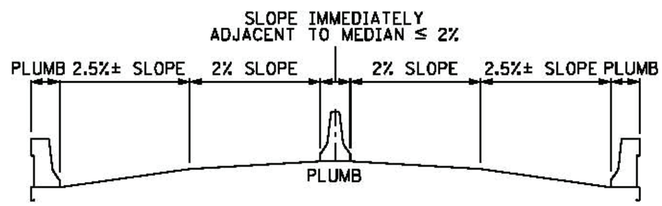
Typical Mn/DOT Bridge Barrier Placement



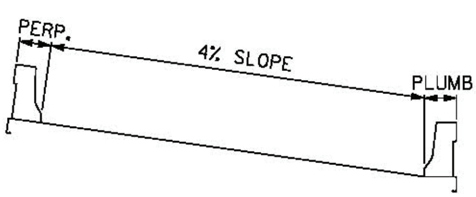
Based on simulation and testing of 3 barrier types, the MwRSF suggested consideration of different guidance depending on the cross slope of the roadway/bridge;

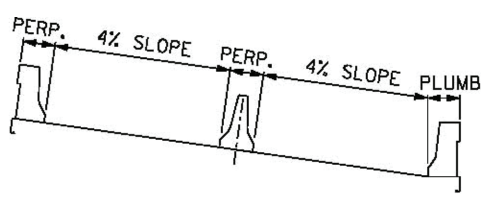
a) for driving surfaces with a normal crown section the barriers may be constructed plumb or "level", as shown in the sketch below:



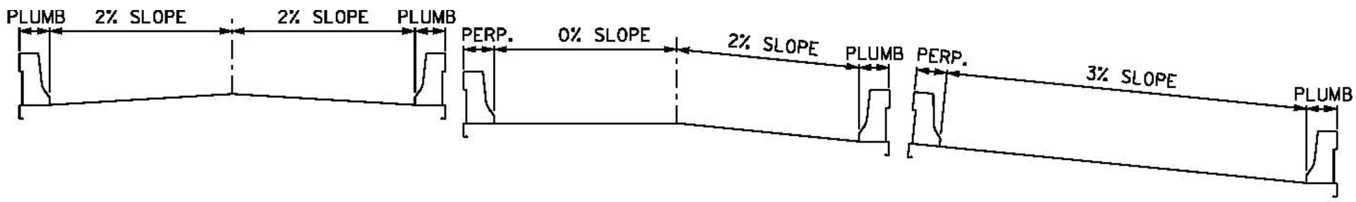


b) for driving surfaces with a <u>constant</u> cross slope or superelevation <u>exceeding</u> 2%, the angle between the bridge deck or roadway and the vertical axis of the barrier should not exceed 90 degrees as shown below:

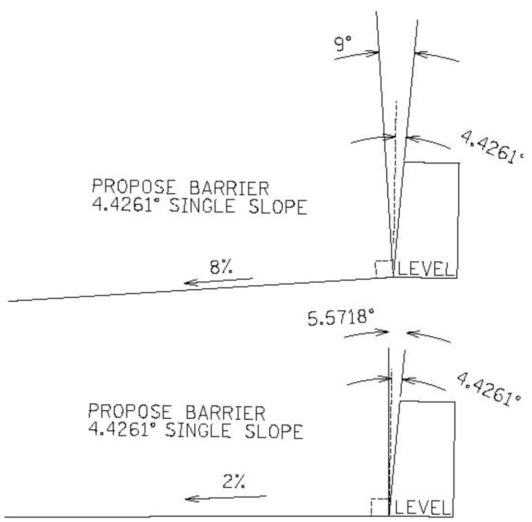




c) for bridge decks with a <u>variable or changing</u> cross slope or superelevation, the angle between the bridge deck or roadway and the vertical axis of the barrier should transition from plumb to perpendicular (or vice versa) starting at 0% as shown below (in this example the cross section changes from a "normal" cross slope to a 3% superelevation, the barrier changes from "level" to "Perpendicular" at 0% slope):



As indicated by the examples above, the vertical position of the barrier axis varies depending on the adjacent bridge/roadway slope, hence, it's imperative that the bridge and roadway designers work together to make sure that design plans are well coordinated and that the detailing on the bridge plan matches the roadway plan and vice versa.
If Mn/DOT eventually adopts a single slope barrier the relative change in slope between barrier face and roadway surface should be limited to about 9 degrees. And, since barriers tested with either a vertical face or a single slope with a 9 degree slope both performed well, it was suggested that, logically, any slope between vertical and 9 degrees should perform well. Therefore a slope that, when mounted 'plumb' on a deck from 2% - 8% slope would result in a single slope not to exceed the acceptable 9 degrees (measured normal to the deck). Hence, a single slope barrier with a 4-5 degree slope may ultimately become a preferred shape (see sketch below).



MwRSF believes that there is a strong potential that this may be feasible. However, the previous safety shape and single slope testing that these geometric recommendations are made on were not evaluated using the MASH vehicles and impact conditions. Thus, further study may be required to verify this recommendation.

The Florida DOT has also recently discussed this issue and the same changes were recommended to them by the Texas Transportation Institute. In 2002, TTI investigated parapet orientation on super elevated structures for Florida DOT through computer simulation. Florida DOT has historically used Jersey shaped concrete barriers on their elevated structures. Barriers have been installed both vertical and perpendicular to the road surface. The study was limited to known

NCHRP 350 impact conditions for the pickup with up to 10% cross slope. Vertically oriented parapets on the upper portion of the super elevation introduced more instability with increased cross slope. Thus, it was recommended that the barrier at the top of the cross slope be installed perpendicular to the deck to improve vehicle stability.

The same recommendations would apply to median barrier.

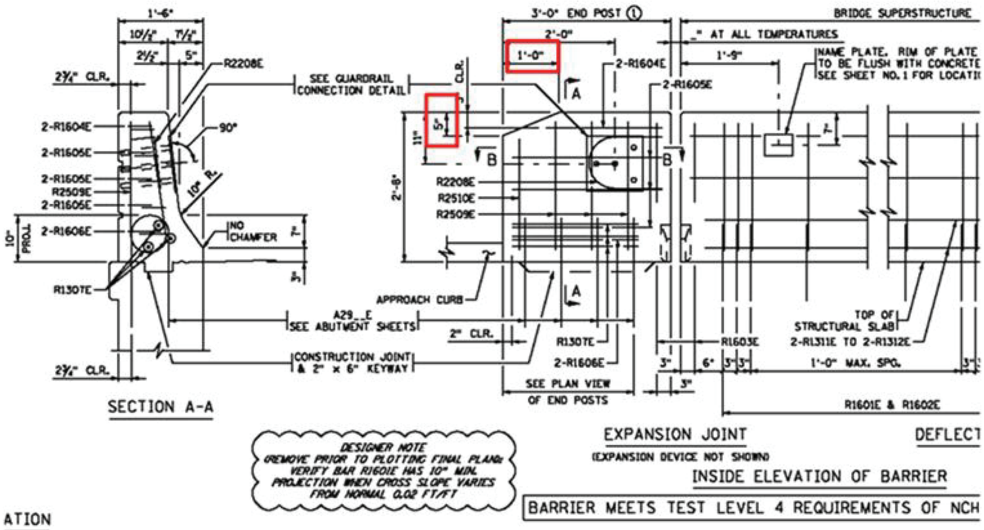
#2). Mn/DOT's current policy on when to use TL-5 barrier (42" high) on a bridge (in lieu of 32" high TL-4) includes the following criteria; Degree of curvature > 5 degrees (radius of 1145 ft) and speed > 40 mph. Other states in our region have been considering guidance that would implement TL-5 barriers more frequently.

A 3 yr study of bridge barriers in California, Texas, and Wyoming with designs based on the 1964 AASHTO Bridge Specifications predicted that there would be limited penetration of the barriers over the life of the bridge. Additional studies on barriers from Kansas came to basically the same conclusion based on a 32" barrier height. Studies and tests have also shown it is possible for a vehicle to climb over most "tall" barrier shapes. It's also understood that while taller barriers may provide more protection for large semi-tractor trucks & trailers such barriers generally cause more damage and injuries to passenger vehicles and their occupants. Given the percentage of cars and small trucks vs. large trucks on most highways it seems logical to optimize the barrier height/shape for passenger vehicles, not large trucks.

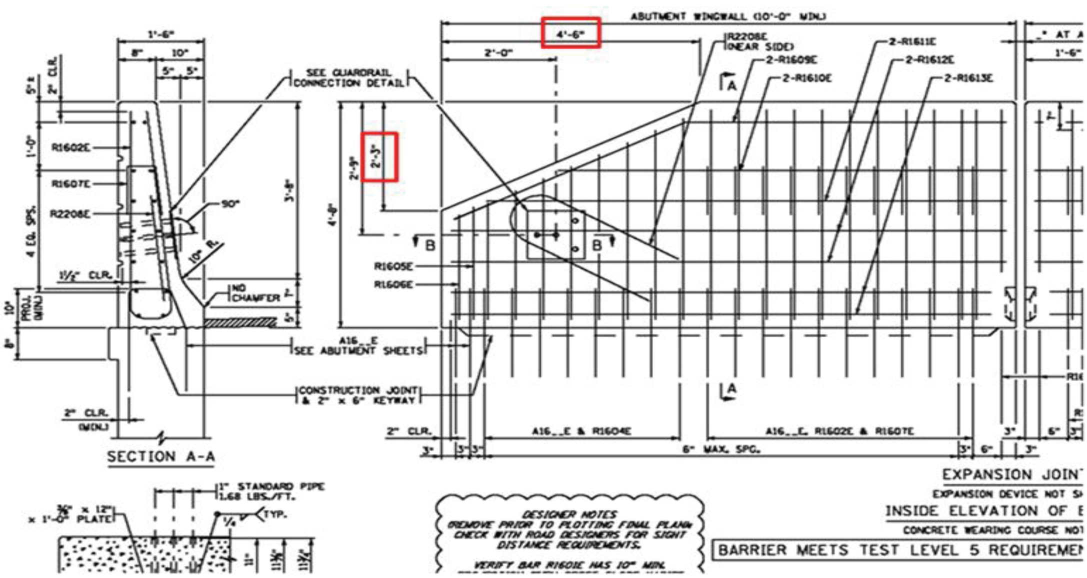
NCHRP study 22-13(3) started in the fall of 2010 and will last 24 months. This study will produce recommended guidelines for the selection of test levels TL-2 through TL-5 for bridge railings/barriers. Early results of the research imply that a TL-3 barrier may be adequate for most circumstances. In addition, recent research studies by MwRSF and TTI suggest that TL-4 barrier will likely need a minimum height of 34 or even 36 inches. In MwRSF's judgment, the expense of a TL-5 rail is difficult to justify for safety reasons under almost any circumstances.

It was decided that Mn/DOT will maintain its existing policy regarding use of TL-5 barriers until completion of the 22-13(3) research.

#3). At the end of a 32" or 34" tall concrete barrier, where it transitions to a guardrail connection, Mn/DOT details a slight slope (5V:12H) to the top of the barrier (see top sketch below). What is the appropriate slope or taper length that should be used when transitioning from a 42" (or taller, glare screen barrier that is 4'6" tall, 6V:12H taper) barrier to a guardrail connection?



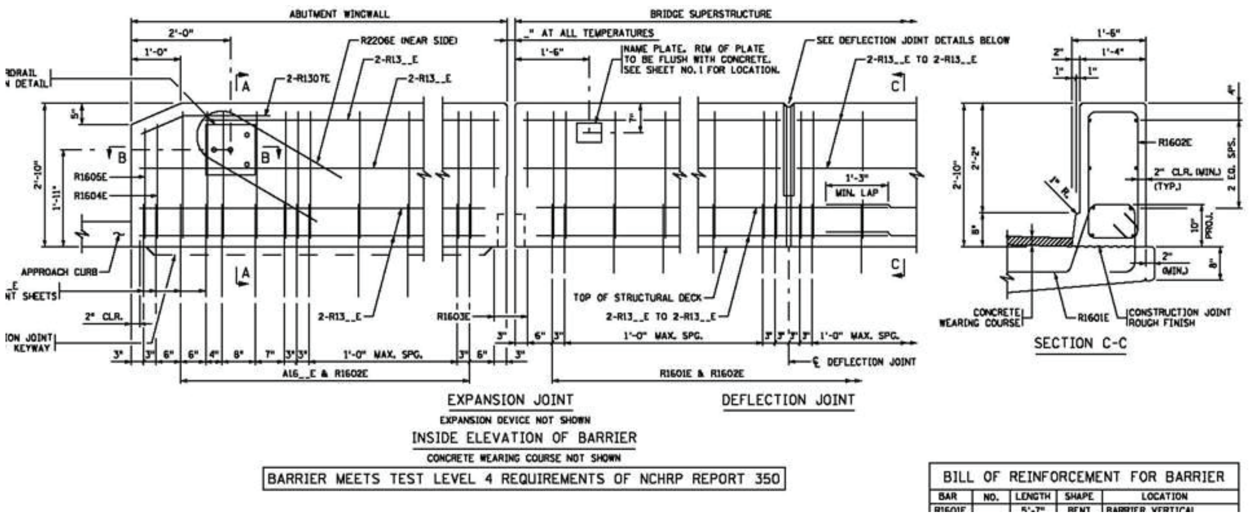
TL-4 (32" Tall) Barrier



TL-5 (Glare Screen) Barrier

The 5V:12H taper shown on the end of the 32" and 34" tall Mn/DOT TL-4 barrier has been crash tested and is okay to remain as is. End tapers for barriers taller than 34" should be modified to 1V:8H. The Bridge Standards Unit will put a "temporary hold" on tall bridge barrier standards (>34") showing the 5V:12H taper and begin the process of revising the standards to 1V:8H.

#4). Mn/DOT has developed a vertical face bridge barrier as shown below. Other states have developed single slope barrier faces. What are the advantages, disadvantages and design considerations for the various shapes?



TL-4 (Vertical Face) Barrier

Texas has developed a single slope shape with a 10.3 degree slope. California has developed a shape with a 9.1 degree single slope. Some observations based on studies of bridge rails in Iowa and elsewhere;

The safety shape generally causes more rollovers and injuries than the vertical shape.

The single slope generally leads to more "climbing" and rollovers than the vertical shape.

The vertical shape is more prone to "head slap" injuries than either the safety or single-slope shapes.

The rate of serious injuries and fatalities are fairly similar for all 3 shapes.

There is no clear very best shape.

If vertical shapes taller than 32" are implemented, they should consider a blockout above 32" to reduce head slap injuries.

Similar to the conclusion from item #1 above, a single slope barrier with a 4-5 degree slope may ultimately become a preferred shape, but further research and study is necessary.

#5). General discussion

The MwRSF has previously developed standards for a Midwest Guardrail System (MGS) that is capable of spanning up to 25' over culverts without intermediate posts. No further testing or studies are planned regarding increasing the current 25 foot maximum span. Mn/DOT eventually plans to implement the MGS system but has higher priority standards development issues to deal with first.

The Mn/DOT Standards Unit recently revised and updated the standards for temporary concrete barrier. Next steps will include revising the anchors used to hold the barriers in place. The Bridge Office will likely eliminate any bridge related standards involving anchoring temporary barriers to pavement or ground surfaces and will reference the forthcoming roadway standards.

The MwRSF will provide Mike Elle/Jim Rosenow with guidance regarding "free" distance requirements behind unanchored temporary barriers on bridges.

It seems likely that new TL-4 barrier requirements will necessitate increasing the height from 32" to 34 or 36" for new installations. It's likely that existing 32" installations will be allowed to remain inplace without need for retrofit as long as the shape and capacity has previously passed NCHRP 350. The costs of retrofitting existing 32" tall TL-4 barrier to 34 or 36" cannot be justified by the slight increase in safety and performance.

Problem # 9 – Soil Gaps Around Foundation Tubes

State Question:

Dear MwRSF,

If I remember correctly, during our meetings with MwRSF staff, there was some discussion about beam guard failing because a gap between the soil tubes and the soil surrounding it.

WisDOT is putting the final touches on its existing barrier guidance and would like to place some statement in our design guidance to instruct our designers to review soil tubes and the soil around the tubes. What gap distance between the soil tube and the soil around the soil tube should corrective action be taken.

Sincerely,

Erik Emerson P.E.
Standards Development Engineer-Roadside Design

MwRSF Response:

Hi Erik,

We would not recommend allowing a minimal soil gap at any existing anchorage foundation tubes. As general guidance, we would recommend that there be no visible soil gaps around foundation tubes. Visible soil gaps of 1/3" or less could be repaired by tamping and recompacting the soil around the foundation tubes. For soil gaps larger than 1", we would recommend that the anchorage be pulled and reinstalled with the tubes plumb and reset.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Problem # 10 – High Tension Cable Guardrail with a 1V:3H Slope Behind

State Question:

Hi Bob,

I couldn't remember if you are the point man for DOT questions, and I am not sure if the new website is fully operative for questions, so here goes:

We have a situation where we want to place guardrail on a 1V:8H slope which extends a few feet behind the guardrail, before breaking off on a 1V:3H slope. Would a high tension cable guardrail such as Trinity's TL-3 system perform adequately in this situation? The standard system deflects up to around 9 feet (16 foot post spacing), so an impacting vehicle would be traversing the 1V:3H slope during redirection. I believe this deflection would not extend beyond the 1V:3H slope. Please see the attached drawing.

Thanks!

-Bill

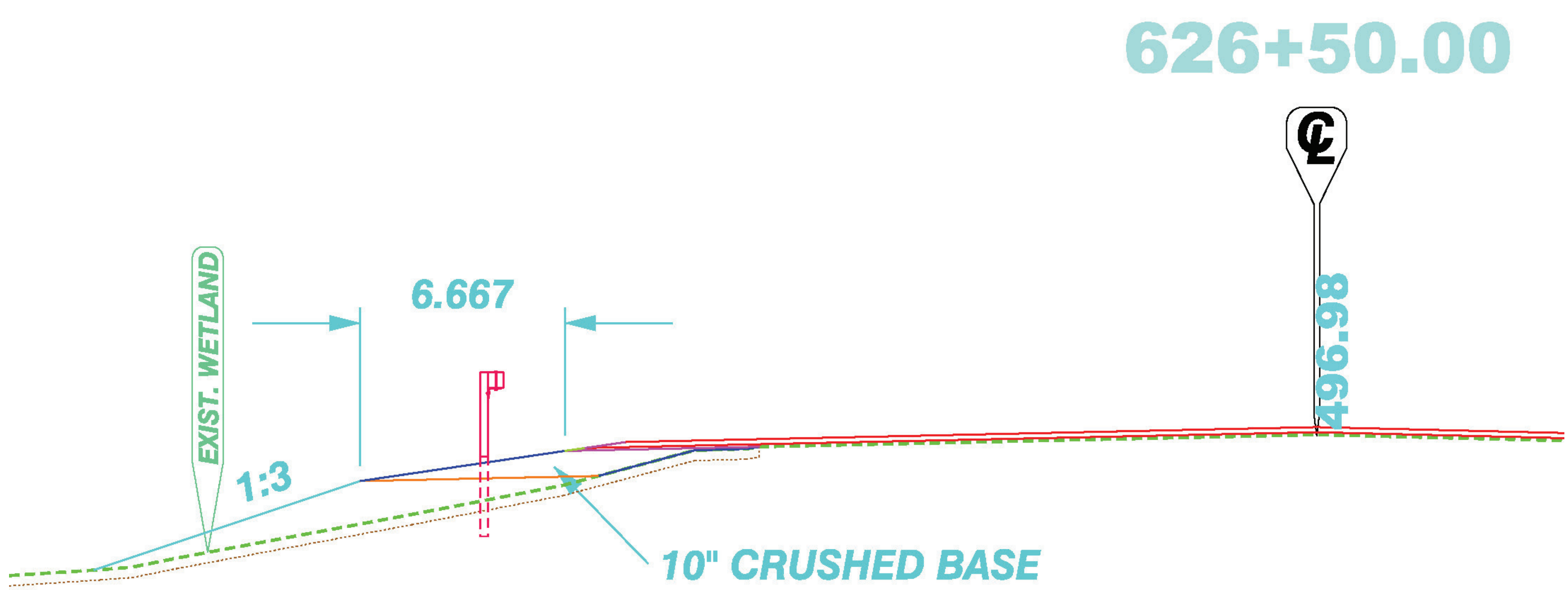


Figure 6. High Tension Cable Guardrail with a 1V:3H Slope Behind

MwRSF Response:

Hi Bill,

We looked over your installation and compared it with the testing we conducted with the MGS on 8:1 slope and our current cable testing. In that testing, we found that with a 5 ft offset, the MGS (with a 31 in. top rail height) just captured and contained the 2270P vehicle. We don't have similar cable testing on 8:1 slopes to compare with, but we know that the cable can redirect vehicles on the 4:1 slope as long as the vehicle is effectively captured. Based on this comparison we would recommend that the Trinity system be installed with the 2 ft offset rather than the larger 5 ft offset. The decreased offset should compensate for the cable heights of the Trinity system. In addition, offset should allow for capture of the vehicle and redirection even with the 1:3 slope behind the system. We believe that if the Trinity system captures the vehicle then the system will redirect the vehicle even if it intrudes on the 1:3 slope to some extent.

This short offset recommendation is based on the fact that the Trinity system has not been tested on approach slopes, and thus it is difficult to make recommendations regarding its performance in those situations. In our experience, it is necessary to capture the front corner and rear corner of the vehicle with a cable system on slope to capture and redirect the vehicle. Therefore, the shorter 2 ft offset will gives more confidence that the system will perform safely.

Let me know if you have further comments or questions.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Problem # 11 – Bolt Holes in Guardrail Posts

State Question:

Ron,

We will be allowing the use of steel guardrail posts here soon, and I have a quick question. Does it matter to which side of the flange the holes are drilled? It seems that most states show the holes to the right of the flange on the elevation/front view. Would you see any benefit to drilling holes on both sides of the flange?

Thanks,

-Chris

,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,,

Chris Poole, P.E.
Roadside Safety Engineer

MwRSF Response:

Chris:

We typically place a hole on the upstream side of the front flange as well. However, I believe that the guardrail system would perform in an acceptable manner if the bolt were placed on the downstream side of the front flange as well. In most reverse direction impacts, the guardrail bolt would effectively be located on the downstream side of the front flange.

Many suppliers are fabricating guardrail posts with hole punched on both front and back flanges as well as left & right sides of each flange. The additional holes allow for the post to be more easily placed at a guardrail slot location without concerns for direction, side, etc. In general, it would seem reasonable to try to follow a practice of placing guardrail bolt on upstream side of front flange.

On another note, there may be a very slight increase in costs to punch all of the extra holes, depending on how the punching/drilling process was completed.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 12 – Sand Barrel Attenuator Guidance

State Question:

Is there any later guidance about an apparent discrepancy between the design procedure in the 2002 RDG and results from crash testing? I've seen that a version of the RDG is available with a 2006 update to Chapter 6, but do not understand that Chapter 8, including the sand barrel design issue is changed.

Table 8.3 in the 2002 RDG gives a transfer of momentum method. It gives lower predicted deceleration than observed in crash tests. The example attached uses data from Test 3-41 in FHWA acceptance memo CC-29 (6/28/1995). The calculation predicts a maximum deceleration of 8.0 G's, while the crash testing produced 14.2 G's. I've also included an example based on test 3-41 from acceptance memo CC-52 of 7/10/1998. The latter calculation predicts 7 G's, while testing documented 9.5 G's.

By changing the distance over which the impulse acts to about 1.7', the first (CC-29) calculation can be calibrated to match the crash test result. I tried a similar approach for tests 3-41 in acceptance memo's CC-28 and CC-52 and found calibration of this parameter ranged from 1.3 to 2.2 feet. The lower value of 1.3 feet for test 3-41 of memo CC-28 involved a heavier pickup truck (4934#) and higher speed (68 mph). In general, it appears that the more energy in the impacting truck, the higher the calibration factor is needed.

Because the transfer of momentum is elastic, some energy is going to other actions – breaking the drums, deforming the vehicle, and bulldozing the sand. The sand and the drums have some variations from test to test. If the systems were inelastic and frictionless, the transfer of momentum equations would correctly predict the change in velocities, but accelerations would be excessive. This appears to be a more complex problem than presented in the RDG methods.

I'm looking into this because we would like to adopt sand barrel arrays to comply with MASH, and don't find any crash testing under these criteria.

<<Sand barrel design comparison to crash testing.xlsx>>

David L. Piper, P.E.
Safety Implementation Engineer
Bureau of Safety Engineering

MwRSF Response:

Hi Dave,

I think there are a couple of items here that are leading to your comparison issues.

First, the simple inertial procedure in the RDG generates a change in velocity based on and impulse momentum calculation. From this, you can estimate an average deceleration due to the impact of the vehicle with each row of barrels. This is an average deceleration and not an instantaneous acceleration like we measure in testing. Thus, the estimation procedure will always yield a lower acceleration value than the full-scale test. To deal with this, we have typically limited the average deceleration values for our sand barrel array calculations to 12 g's or less. This is conservative, but it is done to account for the difference between the actual and average calculated accelerations. The other mechanisms you mention have some effect on the acceleration as well, but the issue you are seeing is due mostly to the calculation of average acceleration rather than instantaneous.

I noted that you are attempting to vary the deceleration distance to yield better results. We would not recommend this. As noted above, you are only calculating average decelerations, so we cannot expect the values to match. Instead, design the arrays with the 12 g limit noted above. We typically use 36" or 3' for the deceleration distance which is the typical diameter of the sand barrels.

I have attached a spreadsheet that we have developed to analyze sand barrel arrays. Feel free to use it to develop you MASH compliant versions. The sheet allows you to vary the array configuration for different speeds and vehicle masses and notifies you with colored formatting to indicate when the array has slowed the car sufficiently or exceeded the deceleration limits.

One thing I should note is that when designing these barrel arrays you should consider more than the head on impacts. In addition, you should address a coffin corner type impact similar to test designation 3-36 in MASH. This should be done to ensure that vehicles impacting downstream of the first barrel of the system do not experience excessive deceleration but are still brought to a controlled stop. In addition, if you the barrel array is used in installations where it can be impacted from the reverse direction, you should consider additional smaller barrels on the downstream end of the system to prevent excessive deceleration. Examples of these additional barrels can be found on page 97 and 98 of TRP-03-209-09.

Let me know if you need any further assistance with the array design.

Bob Bielenberg, MSME, EIT
Research Associate Engineer

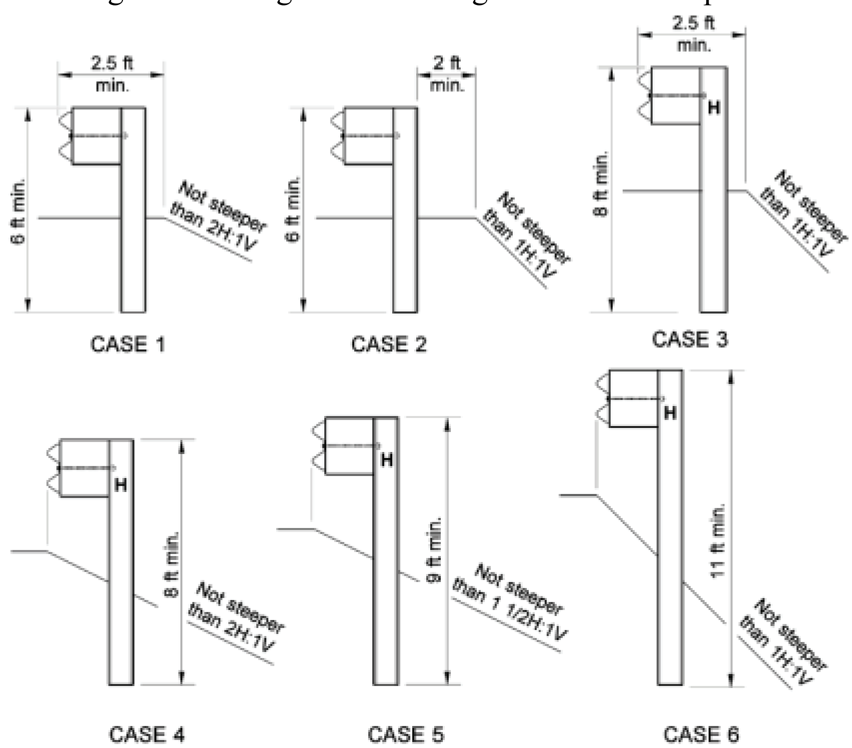
Problem # 13 – CRT Posts Adjacent to Slopes for MGS Long Span

State Question:

Robert:

I found your e-mail on the "Midwest Guardrail System for Long Span Culvert Applications" and was hoping you could offer some quick advice.

I'm using the Washington State Design Manual which provides the following installation cases.



I'm spanning 25' and need to install 3 CRT posts on each side of the culvert. What are your thoughts on using 11' long CRT posts on each side as shown in CASE 6 above? I'm trying to stay within my R/W and not have to spend money on a retaining wall.

Thanks for your time

Dan Smith
Engineer Tech III

MwRSF Response:

Hi Dan,

MwRSF has successfully developed and crash tested two W-beam guardrail systems to span across long concrete box culverts, such as those measuring up to 25 ft in length. For the first system, the metric-height W-beam guardrail was configured with a 27-3/4-in. top mounting height, while the Midwest Guardrail System (MGS) was utilized for the second configuration with a 31-in. top mounting height. For both designs, three 6-in. x 8-in. by 6-ft long wood CRT posts were placed adjacent to the long span using the 6-ft 3-in. post spacing. Beyond the CRT wood posts, the guardrail system was transitioned into a steel post, wood block, semi-rigid barrier system which also used 6-ft long posts and a 6-ft 3-in. post spacing. For both crash-tested systems, a region of level, or relatively flat, soil fill was provided behind the CRT wood posts.

We recommend providing 2 ft of level, or mostly level, soil grading behind the wood CRT posts. However, we understand that this can be difficult. As such, your inquired as to whether the wood CRT posts could be lengthened to account for the reduction in soil resistance resulting from an increased soil grade behind these six posts, especially when placed at the slope break point of a 2:1 fill slope.

Recently, MwRSF performed limited research to determine an acceptable MGS post length for a 6-in. x 8-in. solid wood post installed at the slope break point of a 2:1 fill slope. MwRSF determined that 7.5-ft long wood posts are an acceptable alternative when considering the 31-in. tall MGS placed at the slope break point of a 2:1 fill slope using 6-ft 3-in. post spacing.

The MGS Long Span system utilizes six CRT wood posts. A CRT post's moment capacity about its strong axis of bending is approximately 81 percent of that provided by the standard wood post. In the absence of dynamic component test results, it is believed that the six CRT wood posts could also be fabricated with the 7.5-ft length when used in the MGS Long Span system. If the steep fill slopes continue beyond the location of the CRT posts, then the guardrail would transition to the MGS for 2:1 Fill Slopes using either 6-in. x 8-in. by 7.5-ft long wood posts or W6x9 by 9-ft long steel posts.

Thus, for the cases you sent, we believe Case 2 is acceptable and that Case 1 and Case 3 would be acceptable if 7.5 long CRT posts were used. We cannot recommend the use of extended length CRT posts on steep slopes as you have shown in Cases 4-6. Determination of proper CRT post lengths for this type of installation would require additional analysis and testing in order to ensure proper function of the CRT's in the long span system.

Please let me know if you have any comments or questions.

Thanks

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Problem # 14 – Short Radius Guardrail Installation

State Question:

Dear MwRSF,

James Nall of Mesa County Colorado contacted me about WisDOT's short radius terminal. He then followed up our discussion by contact staff at TTI, and FHWA.

I was wondering if MwRSF could also take a quick look at this Mr. Nall's problem.

My first guess is to remove the beam guard and delineate, but this is just base on the fact that the installed system is not crashworthy and it may not be possible to install any crashworthy alternative without significant modification to the drainage canal or service road.

Sincerely,
Erik Emerson P.E.
Standards Development Engineer-Roadside Design

MwRSF Response:

Erik:

This would appear to be a low- to moderate-speed, low- volume crossing situation. From a roadside safety perspective, one would possibly argue for complete removal of the system if adequate end treatment and shielding of the hazard via the ends cannot be achieved. I realize the public wants the feeling of security with a rail for pedestrians and bicyclists, but rail height for those purposes is inadequate anyway. Without seeing the width and available space along service roads at ends, it is difficult to determine what other options may be available.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 15 – Minimum Rail Height for MGS Long Span and MGS Transition to Rigid Barrier

State Question:

Dear MwRSF,

Does MwRSF has any recommendation for the minimum rail height for the MGS long span or MGS transition to rigid barrier?

On overlay projects, the can overlay the bridge or the roadway. These overlays will reduce the effective height of the thrie beam. I believe that we will have to accept that the transitions to rigid barrier may be lower than 31”.

Erik Emerson P.E.
Standards Development Engineer-Roadside Design

MwRSF Response:

Hi Erik,

With regards to the MGS long span, we recommend that the system be installed at 31”. The MGS long-span guardrail was tested with a top rail height 31.0 in. Previous reports on the standard MGS system have allowed installation at heights as low 27.75 in. However, the reduced post embedment of the MGS system was a major factor in the performance of the MGS long-span design. Thus, in order to retain the improved load distribution and reduced rail strains, the MGS long span should be installed with a top rail mounting height of 31.0 in. Reduction of the rail height below this value will likely reduce the performance of the barrier system.

With respect to the MGS transition, the answer is a little less clear. We would expect that a slightly lower transition height would allow for redirection of the vehicle. However, all thrie beam transition testing that I have seen was conducted at 31” or at the metric height of 31 5/8”. In addition, lower transition heights would expose more of the concrete barrier at the downstream end of the transition and create a potential snag hazard. Thus, we would generally recommend a height of 31” for the MGS transition as well.

We understand the need for states to overlay their roadways, but it can have detrimental effects on barrier performance. With respect to transitions, the issue has not been adequately addressed with respect to the current MASH vehicles and impact conditions.

We cannot say with certainty that overlays adjacent to the MGS transition will not affect its performance. Adding a 2”-3” overlay in the transition area will increase the impact load height on the post and the relation of the vehicle front to the barrier. This in turn could increase the moment on the posts and affect the lateral deflection and stiffness of the system. In addition, there would be concerns for vehicle stability as well as an increased potential for wood posts in the transition to fracture.

Bob Bielenberg, MSME, EIT
Research Associate Engineer

Problem # 15 – Alternative Approach Guardrail Transition

State Question:

Hi Scott,

Iowa DOT is considering the use of an alternative approach guardrail transition, based on the results of TRP-03-210-10. We currently use the wood-post version of the “Adapted Iowa Transition” that’s shown on page 167 of the report. However, we were wondering if there might be a simpler design out there that we could use. Our preference is a design that uses larger post spacing near the bridge end, similar to the layout of the W6x15s used in the report. We are interested in both steel and wood post designs.

I have attached a drawing that shows the three most common bridge end post shapes that are encountered in Iowa. If you need exact dimensions on these, let me know. Type A on page one is the current bridge end post design and is the most common by far. If possible, we would like to be able to use the same AGT for all three types.

Our only constraint is that the transition cannot be longer than our current design (25 feet from the bridge to the end of the W-to-Thrie transition piece).

Can you see what other designs are available, if any, that could be adapted to meet our needs?

Thanks,

-Chris

,,,,,,   ,,,,,,   ,,,,,,   ,,,,,,   ,,,,,,   ,,,,,,

Chris Poole, P.E.
Roadside Safety Engineer

MwRSF Response:

Chris,

I have reviewed all of the FHWA accepted transition designs as well as the MwRSF tested transition designs. From this review, there seems to be two different styles of thrie beam transitions to concrete bridge rail:

1. Use posts similar to the line posts (W6x9 or 6"x8" wood posts) but with increased embedment depths at ¼ post spacing (18.75"). A prime example of this style of transition is the transition you are currently using.
2. Use significantly larger posts (W6x25, W8x24, or 10"x10" wood posts) at 37.5" spacing. These larger posts are typically chosen so that the first post adjacent to the bridge rail can be omitted for drainage purposes (see page 165 of the report you noted, TRP-03-210-10). However, do to the omitted post and the oversized transition posts need to compensate for the gap, the recommended stiffness transition had a length of 31'-6" to the US end of the W-to-thrie transition element. You expressed that you needed to stay at your current 25' length, so this probably is not the answer you were looking for.

The original approach transition utilized to developed the stiffness transition shown in report TRP-03-210-10 was designed for attachment to a steel post, thrie beam and steel channel bridge rail system. Thus, I would not recommend utilizing this transition for attachment to concrete barriers until further evaluation/crash testing proves its crashworthiness.

I have attached the recommended wood post alternative to the transition you noted from page 167 of the steel post transition report. The attached figure comes from the wood post transition report that is currently under in-house review at MwRSF and should be sent to the Midwest Pooled Fund States in the near future.

Scott Rosenbaugh
Midwest Roadside Safety Facility (MwRSF)

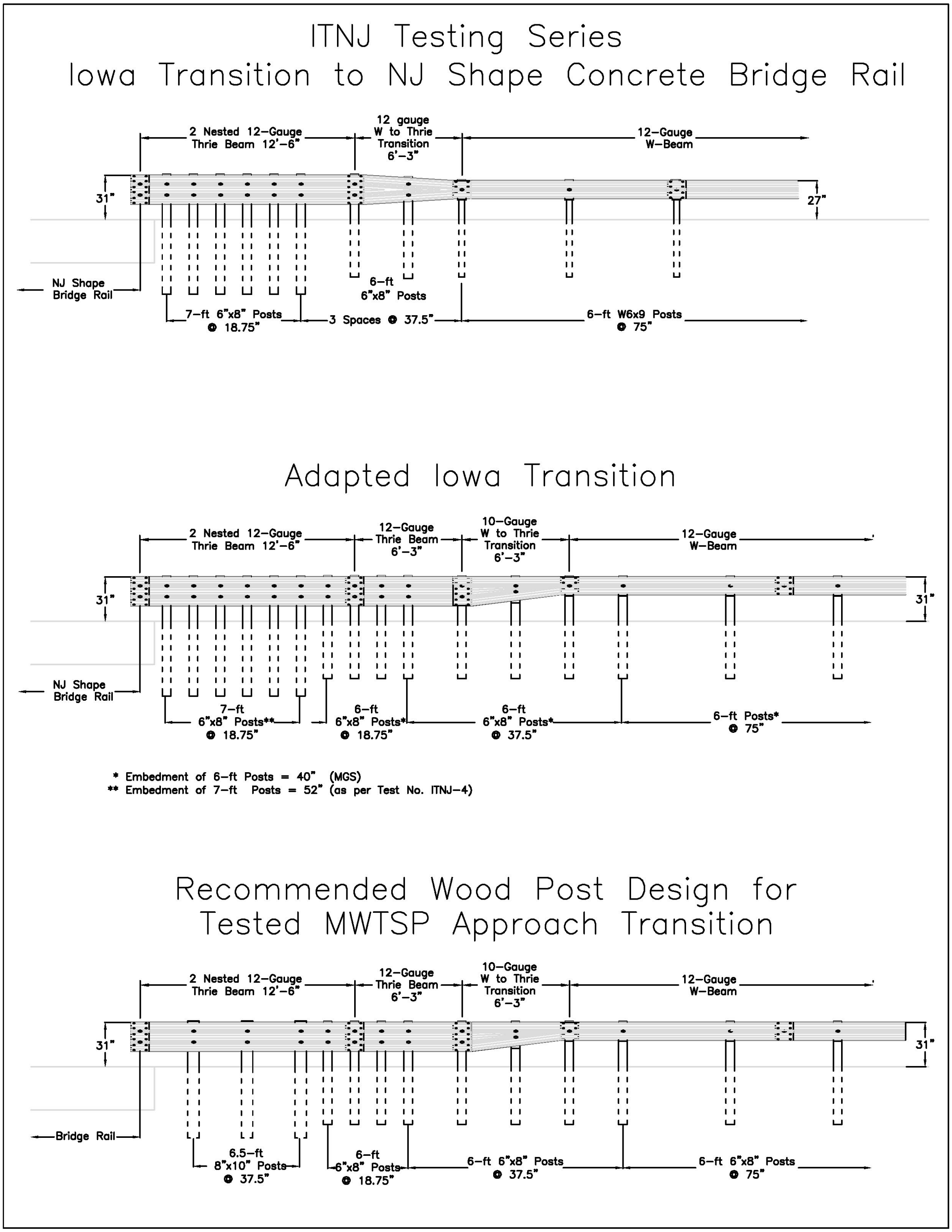


Figure 7. Alternative Wood Post Transition

Problem # 16 – Retro-fitting a Single Slope Concrete Barrier

State Question:

Dear MwRSF,

An existing project has had to remove a section of single slope concrete barrier to work on a structure. The existing single slope barrier was cut in the middle of the run. Now the existing single slope barrier has a free end. The region is asking what should they do when the match a new single slope barrier into the old single slope barrier.

As I see it we have two options:

1. Let the existing single slope barrier have a free end and place the new single slope concrete barrier per standard specifications.
2. Drill into the existing single slope barrier. Place reinforcement steel to transfer impact forces into the new single slope barrier.

Our Standard Detail Drawings are located at:

<http://roadwaystandards.dot.wi.gov/standards/fdm/SDD/14b32.pdf>

I'm concerned about transferring impact energy from the old barrier to the new. But I am not sure that we can easily drill into the existing barrier to place reinforcement.

Could MwRSF provide a recommendation on which way to proceed? If installing reinforcement is the desirable option, could MwRSF provide a design?

The project in question is already in construction. If MwRSF could provide guidance soon.

Erik Emerson P.E.
Standards Development Engineer-Roadside Design
Wisconsin Department of Transportation

MwRSF Response:

Erik,

I would use dowels to connect the two sections. The dowel bars should be the same size and at similar locations as the existing longitudinal steel. Further, the dowels should be embedded into each end (old and new) far enough to develop the full load of the bar (splice/development length of bar or specified by the epoxy used to secure dowels in old barrier section.).

Scott Rosenbaugh
Midwest Roadside Safety Facility (MwRSF)

Problem # 17 – Iowa Transition and Curbs

State Question:

Ron,

You have alluded several times over the years that the Iowa guardrail transition might not need the 4-inch curb installed below it. Could you please follow up with FHWA on this issue to see if the 4-inch curb requirement can be waived? There are many situations where installation of the curb would be difficult.

Here is a link to our current bridge end post styles and guardrail attachments (Types A, B, C):
http://www.iowadot.gov/design/SRP/IndividualStandards/eba202.pdf

And here is a link to our current transition:
http://www.iowadot.gov/design/SRP/IndividualStandards/eba201.pdf

Let me know if you have any questions.

Thanks,

-Chris

,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,,

Chris Poole, P.E.
Roadside Safety Engineer

MwRSF Response:

Hello Will and Nick!

I have been asked by the State of Iowa to follow up on an old issue pertaining to approach guardrail transitions. In the mid to late 90s, MwRSF successfully developed, crash tested, and evaluated two thrie beam approach transition systems for use in shielding and attaching to the ends of safety shape and vertical concrete parapets. A series of three acceptance letters were prepared on this topic - B-47, B-47a, and B-47b - based on the NCHRP Report No. 350 guidelines. Crash tests were performed on both steel and wood post systems which were spaced on 1 ft - 6 3/4 in. centers near the bridge/parapet end. During the R&D effort, the Pooled Fund States stated that they may desire to utilize a curb at the ends of the bridge rail to better accommodate water drainage. As such, MwRSF incorporated a 4-in. tall wedged shaped concrete curb under the thrie beam region. MwRSF believed that the curb's presence would provide a critical evaluation as impacting front wheel/rim could become wedged under and upward into the tighter space and/or increase vehicular instabilities. If testing with the curb was found to be satisfactory, then MwRSF researchers believed that the non-curb option would also be acceptable.

Later, TxDOT and TTI cooperated to further investigate some changes to the approach guardrail transition, including an elimination of the steel connector plate under the thrie beam end shoe, the elimination of the curb, a different geometry to step back the lower concrete toe near the barrier end using steeper flare rate, and non-use of special chamfer at parapet end.
In the MwRSF testing program, a special connector plate was used to allow the thrie beam and show to remain vertical while attached to a sloped face of the NJ safety shape. In the TTI testing program, the steel connector plate was eliminated, and the rail/end shoe was twisted backward near the top region to lay on the upper sloped face. Subsequently, the modified transition was crash tested under NCHRP 350 using a pickup truck. During this test, the pickup truck rolled over. TTI researchers later concluded that the curb was necessary to provide acceptable safety performance even though several other changes were incorporated. In MwRSF's opinion, the other system changes could also have contributed to the poor barrier performance. Unfortunately, this testing program was stopped and only continued with the development and testing of a TL-2 W-beam transition.

During NCHRP Project No. 22-14(2), MwRSF conducted another pickup truck crash test into the approach guardrail transition system noted above in Paragraph 1 but using the forthcoming MASH criteria. One crash test was performed on an identical transition system which included the curb underneath. Following testing, the barrier system was judged to provide acceptable safety performance. In this effort, higher lateral barrier deflections were observed as compared to those found in the prior successful MwRSF testing program. Once again, MwRSF considered the system to be acceptable both with and without curb. However, State DOTs are unable to use the system without curb due to the language provided in the original B-47 series of acceptance letters.

To date, no full-scale crash testing has been performed on an identical approach guardrail transition system that excluded the wedged-shaped curb.
As such, I am inquiring as to whether FHWA continues to maintain that the approach guardrail transition must be installed with the curb located underneath or whether there has been any changes in stance on this issue.
Regardless, I will forward your FHWA's response to the State of Iowa and the Pooled Fund Program member states. Thanks again for any clarifications on this issue in advance!

Respectfully,

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Midwest Roadside Safety Facility (MwRSF) Nebraska Transportation Center University of Nebraska-Lincoln
130 Whittier Research Center
2200 Vine Street
Lincoln, Nebraska 68583-0853

(402) 472-6864 (phone)
(402) 472-2022 (fax)
rfaller1@unl.edu

Hello Ron:

We have reviewed the crash tests videos of subject testing and offer the following appraisal of that review.

Via careful review of crash tests provided by TTI, we conclude the decision which TTI has rendered from their crash test is correct (i.e., transition w/o curbing failed).
We however remain open minded on any additional testing brought forward to our attention in the future.

Therefore and until additional testing is presented, FHWA continues to maintain that approach guardrail transition must be installed with the curb and/or rub-rail located underneath rail element to be considered acceptable installations constructed on NHS system.

Thank you.

Best Regards,

Will

William P. Longstreet
Highway Safety Engineer | Office of Safety Technologies
USDOT, Federal Highway Administration | HSST

Will:

Thank you very much for the additional review and consideration on behalf of the State DOTs. If any new crash tests are performed in the future which are believed to potentially alter FHWA's opinion, we will bring this material and results to your attention. Once again, thank you for the additional examination. I will forward FHWA consistence stance on this matter to the Pooled Fund Program member states. Thanks!

Respectfully,

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 18 – Iowa Transition and Curbs - Blockout Length and Depth Inquiry

State Question:

Ron,

I've got a follow-up question regarding steel-post versions of the Iowa transition: Are we limited to the version shown in the ITNJ report (6.5-foot W6x9s with tapered tube blockouts)? Or is there an allowable substitution we can make in order to use the 19-inch wood blockouts with steel posts?

-Chris

,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,,

Chris Poole, P.E.
Roadside Safety Engineer

MwRSF Response:

Chris:

The Iowa approach guardrail transitions were developed and crash tested with steel and wood post options. The systems were configured as follows:

Steel Post – Test ITNJ-2

6.5-ft long by W6x9 Steel Post w/ 49" embedment depth
17.4-in. long by TS 7"x4"x3/16" steel tapered blockout w/ 3.2 in. extending below lower thrie beam bolt

Wood Post – Test ITNJ-4

7-ft long by 6"x8" Wood Post w/ 52" embedment depth
18-in. long by 6"x8"wood blockout w/ 3.1 in. extending below lower thrie beam bolt

Several years ago, MwRSF developed and crash tested transition designs which utilized 19-in. long wood blockouts. In this case, two tests (STTR-3 and 4) were successfully conducted with a 4-in. extension below the lower thrie beam bolt when used in combination with a half-post spacing AGT.

More recently, MwRSF also developed and crash tested standard and simplified designs which utilized 19-in. long wood blockouts when adapting the MGS to a thrie beam transition which utilized a half-post spacing AGT. For these tests, a 4-1/8 in. extension was used below the lower thrie beam bolt.

Currently, the Iowa DOT is specifying a 19-in. long blockout with a 4¼-in. extension below the lower thrie beam bolt. The IADOT has inquired as to whether: (1) the 19-in. long wood blockout with a 4¼-in. lower extension is a acceptable alternative to the slightly shorter blocks having slightly smaller extensions and (2) it would be expected to provide satisfactory safety performance.

Based on my review of the prior systems and satisfactory crash testing results, I believe that a 19-in. long wood blockout with a 4¼-in. extension below the lower thrie beam bolt could be used in FHWA-accepted thrie beam approach guardrail transitions configured with either quarter-post or half-post spacings. This block length and lower extension should still allow the lower thrie beam corrugation to push back and/or fold under when impacted by vehicle wheels. In addition, it is my opinion that 7 or 8-in. deep wood blockouts could be substituted with 12-in. deep wood blockouts.

If you have any questions regarding this request, please feel free to contact me at your earliest convenience. Thanks!

P.S. – I will be looking into the post length issue next.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 19 – Iowa Transition and Curbs - Blockout Length and Depth Inquiry – Part 2

State Question:

Ron,

Would your recommendation remain the same if we were to increase the extension below the lower thrie beam bolt by 1/8 in. to 4-3/8 in.? See the attached drawing for proposed blockout dimensions.

-Chris

,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,, ,,,,,,
Chris Poole, P.E.
Roadside Safety Engineer

MwRSF Response:

Chris:

I do not believe the additional 1/8 in. of blockout length beyond the lower guardrail bolt would cause to change my opinion. As such, you should be fine using the slightly longer block.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 20 – Iowa Approach Guardrail Transition - Steel Post Alternative - Recessed Steel Post, Tapered Steel Block, & Full-Height Wood Block

State Question:

Chris Poole had a question regarding the length of the posts in the Iowa approach guardrail transition.

MwRSF Response:

Chris:

Your current inquiry pertains to the desire to utilize 7-ft long, W6x9 steel posts in lieu of the 6.5-ft long, W6x9 steel posts in an approach guardrail transition configuration which was based on the use of posts installed on a quarter-post spacing.

Background

In the late 1990's, two Iowa approach guardrail transitions with a quarter-post spacing near the concrete buttress were developed and crash tested under NCHRP 350 with steel and wood post options. The systems were configured as follows:

Steel Post – Test ITNJ-2

6.5-ft long by W6x9 Steel Post w/ 49" embedment depth
top of steel post recessed approximately 2.44" below top of tapered tubular steel blockout
Maximum (visible) dynamic deflection was found to be approximately 5.2 in.

Wood Post – Test ITNJ-4

7-ft long by 6"x8" Wood Post w/ 52" embedment depth
top of post flush with top of wood blockout
Maximum (visible) dynamic deflection was found to be approximately 3.9 in.

Recent Testing

Later and under NCHRP Project 22-14(2), the original steel-post AGT was retested under the proposed MASH guidelines using the new 2270P pickup truck. During this test, the maximum dynamic deflection was found to be 11.4 in., which was significantly higher than the magnitude of the visible dynamic deflections found in the prior NCHRP-350 crash testing programs.

Thoughts

The two transition designs noted above utilized slightly different post embedment depths – 49 versus 52 in. Although two depths were used, one may be able to argue for the standardization of this parameter.

For the steel-post, steel-blockout AGT, a tapered steel blockout was successfully used in combination with a slight recessed post. The tapered steel block and recessed post were used to reduce concerns for the pickup truck to extend over the thrie beam rail and snag on the metal elements as well as decrease the potential for vehicle instabilities. These features were originally implemented as design improvements to a thrie beam AGT for attachment to Missouri's single slope concrete median barrier. For the both the successful AGTs for both the Iowa and Missouri systems, the steel post was recessed in combination with a tapered steel blockout.

For the wood-post, wood-blockout AGT, a full-height post and blockout was successfully used in the crash testing program. In this test, the vehicle extended over the rail and contacted the wood components but was believed to more easily gouge the upper regions, thus likely reducing the resistance imparted to the pickup truck and potentially reducing concerns for vehicular instabilities.

Based on a review of the prior crash testing programs noted above, it would seem reasonable that a consistent embedment depth of 52 in. could be utilized in the steel post AGT. Unfortunately and in the absence of supporting test results, it would also seem appropriate to maintain the use of a recessed top of steel post in the region of quarter-post spacing as well as a tapered steel tubular blockout. However, it would seem appropriate to allow the use of a full-height wood blockout in combination with a recessed steel post.

If you have any further questions or comments regarding this information, please feel free to contact me at your earliest convenience. Thanks!

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Problem # 21 – Iowa Approach Guardrail Transition - Steel Post Alternative - Recessed Steel Post, Tapered Steel Block, & Full-Height Wood Block – Part 2

State Question:

Thanks so much, Ron. What are your thoughts about using wood blockouts that were designed for use with wood posts (post bolt holes centered horizontally within the blockout), but using them with steel posts (post bolt holes off-center due to the flange)?

MwRSF Response:

Chris:

I would maintain the use of a centered wood blockout installed to a steel post. Thus, an off-centered bolt hole should be used in a wood blockout if attached to a steel wide-flanged post. A routed section in a wood block could be used to reduce block rotation. Non-routed blocks could be used in AGT designs which were configured with two guardrail bolts or if alternative anti-rotation methods (i.e., toe nails) were utilized.

Ron

Ronald K. Faller, Ph.D., P.E.
Research Assistant Professor

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.: SPR-3(017) Suppl.#38 2611120090004 - RPFP-07-03
Project Title: Performance Limits for 6in High Curb in Advance of MGS w/update
Starting Date: 2007-02-26
Completion Date: 2012-12-31
Principal Investigator: Reid
Co-PIs & Team Members: Rohde, Sicking, Faller
Author: John D. Reid

Progress:

Task	% Completed
1.	
2.	
3.	
4.	
5.	

Activity This Quarter:

This project is completed.

Activity Next Quarter:

No further work.

Problems/Comments:

This will be the last quarterly report for this project.

Total Percentage of Project Completion: 100%

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.: SPR-3(017) Suppl.#38 2611120090007 - RPFP-07-06
Project Title: Cable Guardrail End Terminal Development using 350 Update Vehicles
Starting Date: 2007-02-26
Completion Date: 2012-12-31
Principal Investigator: Reid
Co-PIs & Team Members: Rohde, Sicking, Faller
Author: John D. Reid

Progress:

Task	% Completed
1. Background and literature review	100%
2. Design and analysis	60%
3. Full-scale testing	0%
4. Report	0%
5.	

Activity This Quarter:

Performed simulation parameter studies with the 3-cable terminal model to better determine causes of poor performance and possible design modifications to improve performance. Determined to influence the behavior were cable tension, impact location, debris impacted by the vehicle during the early stages of the event, and initial yaw rate of the vehicle.

Began development of the 4-cable high tension terminal system based on the 3-cable terminal simulation study.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 13, 2011

Project No.: RPFP-08-02, SPR-3(017) Suppl. #44
Project Title: Continued Development of a High-Tension, Four-Cable, Median Barrier System for Use in 4:1 DV itches (Year 18 program)
Prior Funding: Original Cable Median Barrier R&D in Years 12, 14, & 16
Starting Date: 9/1/2007
Completion Date: 12/31/2011
Principal Investigator: Reid, Rohde, Sicking, and Faller
Co-PIs & Team Members: Bielenberg, Lechtenberg, Holloway, Meyer, and Rosenbaugh
Author: Faller, R.K.

Progress:

Task	% Completed
LS-DYNA computer simulation modeling of cable barrier systems	100
Static-pull testing on cable brackets	100
Dynamic bogie testing of cable brackets and bolting hardware	100
Dynamic bogie testing of cable posts in soil	100
Dynamic bogie testing of cable anchor bracket and cable splice	100
Barrier construction and crash test 4CMB-1 (2270P)	100
Barrier construction and crash test 4CMB-2 (1100C)	100
Combine test results with report containing test no. 4CMB-3	100
Internal review and editing of combined research and test report containing test nos. 4CMB-1 through 4CMB-3	95

Activity This Quarter:

Corrections were made to the 3-D Solidworks CAD details. New text was prepared for several sections describing the conceptual development of the barrier system. Minor editing of the research and test report was conducted.

Activity Next Quarter:

The draft report containing the results from test nos. 4CMB-1 through 4CMB-3 will be completed in the July 2011. The project should be closed in August 2011.

Problems/Comments:

No problems are anticipated.

Total Percentage of Project Completion:

At this time, it is anticipated that 99% of the effort has been completed.

Activity Next Quarter:

Develop details and bogie test the 4-cable high tension terminal system under consideration. This bogie test would assess the cable release mechanism with high cable tension. This test is similar to what was done for the 3-cable low tension terminal project.

Problems/Comments:

Detailed design and full-scale testing for this project cannot be started until the High Tension Cable Barrier System is completed.

This is Phase I of the project. Phase II was funded in Year 20: TPF-5(193) Suppl. #21 2611211028001 – RPFP-10-CABLE-3.

Total Percentage of Project Completion: 15%

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 13, 2011

Project No.: RPFP-08-07, SPR-3(017) Suppl. #49
Project Title: MGS Implementation (Year 18 program)
Starting Date: 9/1/2007
Completion Date: 12/31/2011
Principal Investigator: Reid, Rohde, Sicking, and Faller
Co-PIs & Team Members:
Author: Faller, R.K.

Progress:

Task	% Completed
Standard, Half, and Quarter Post Spacing	100
MGS with Curbs and MGS with 2:1 Slopes	100
MGS with Culvert Applications	100
MGS Stiffness Transition	0

History

In 2007, Pooled Fund consulting funds were used to assist states with the MGS implementation effort. MwRSF began the effort with a review of CAD details from the Illinois and Washington DOTs. Project correspondence occurred via email with a pre-determined Technical Working group. To date, three subject areas were covered and are as follows: (1) Standard, Half, and Quarter Post Spacing; (2) MGS with Curbs and MGS on 2:1 Slopes; and (3) MGS with Culvert Applications. A fourth category, MGS Stiffness Transition, was delayed in order to await the completion of a simplified, steel-post and wood-post approach guardrail transition.

The final reporting of the simplified, steel-post, approach guardrail transition system attached to the MGS was completed in the Fourth Quarter of 2010. The draft reporting of wood post R&D effort will be completed in June 2011, including dynamic bogie post testing and Barrier VII analysis. Following State DOT review and comment in July 2011, the final report will be published in early August 2011. After this time, the MGS implementation activities will commence.

Activity This Quarter:

No substantial progress to report.

Activity Next Quarter:

The MGS implementation effort will commence in the Third Quarter (August) of 2011 after the simplified, wood-post transition report has been finalized.

In order to make preparations for this activity to commence in August 2011, MwRSF requests that NDOR accumulate contact information (i.e., names and email addresses) for those willing to participate in the discussions involving the implementation of the MGS.

Problems/Comments:

No problems to report at this time. Since the initial MGS implementation discussions occurred in 2007, MwRSF plans to briefly review the initial topics again.

Total Percentage of Project Completion:

At this time, it is anticipated that 70% of the effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 13, 2011

Project No.:	RPFP-09-01, TPF-5(091) Suppl. #1 (Year 19 Program)
Project Title:	New Funding for High-Tension, Cable Barrier on Level Terrain with New Cable Attachment
Prior Funding:	Original Cable Median Barrier R&D in Years 12, 14, 16, & 18
Starting Date:	8/15/2008
Completion Date:	7/31/2011
Principal Investigator:	Reid, Sicking, and Faller
Co-PIs & Team Members:	Bielenberg, Lechtenberg, Holloway, Meyer, and Rosenbaugh
Author:	Faller, R.K.

Progress:

Task	% Completed
Continued dynamic bogie testing of simplified cable bracket hardware and cable posts in soil with test documentation and reporting (10 budgeted – 43 conducted)	100
BARRIER VII Computer Simulation	0
Barrier construction and crash test 4CMB-4 (1100C)	80
Barrier construction and crash test 4CMB-5 (2270P)	80
Crash test documentation & reporting (4CMB-4 and 4CMB-5)	25

Prior Activity:

On December 22, 2010, MwRSF conducted a 1100C small car retest on the high-tension, four-cable median barrier system with modified cable bracket located in a 4:1 V ditch and 4 ft away from the ditch bottom and up the back slope. The 1100C small car retest (test no. 4CMB-4) was successfully performed using the TL-3 safety performance guidelines found in MASH.

Activity This Quarter:

On May 10, 2011, MwRSF conducted a 2270P pickup truck test on the high-tension, four-cable median barrier system with modified cable bracket located in a 4:1 V ditch and 12 ft away from the front slope break point. The 2270P pickup truck test (test no. 4CMB-5) was unsuccessful according to the TL-3 safety performance guidelines found in MASH. During the test, the left-front bumper struck a post which subsequently bent backward and downstream, thus pulling the upper cable slightly downward. As a result, the upper cable did not engage the front bumper, and the vehicle overrode the barrier system, struck the back ditch, and rolled over. To date, several ideas have been brainstormed to mitigate vehicle override, including raising the top cable, adding a 5^{th} cable, reducing post length above grade to allow upper region of top clip to not engage post nor slot, etc. However, no changes will be made until the research team is certain that the 10.5-in. cable spacing can safety contain a mid-size passenger sedan.

As such, the high-tension, 4-cable barrier system was constructed in the region of level terrain in advance of the V-ditch. A 1500A Ford Taurus passenger sedan was prepared for crash testing. This crash test (4CMBLT-1) will be performed to evaluate whether the 10.5-in. cable spacing can prevent vehicle penetration through the barrier system. The results from this test will be used to help determine which design modifications should be incorporated near the top of the system to contain and redirect the 2270P vehicle. At the present, the sedan crash test may occur in mid-June.

For test no. 4CMB-5, a different Critical Impact Point (CIP) was utilized and different than that used in successful test no. 4CMB-1. Revisions to MASH were made after test no. 4CMB-1 was conducted. A new CIP was implemented into the final MASH document, consisting of an impact 1-ft upstream from a post.

Prior to conducting test no. 4CMB-5, barrier construction was initiated for future test no. 4CMB-6 using an 1100C small car. For 4CMB-6, the barrier system was placed 4 ft laterally away from the backside slope break point.

In May 2011, TTI and MwRSF researchers prepared several draft test matrices and CAD details for use in crash testing and evaluating high-tension cable median barrier systems under MASH and for use with sloped terrain. Drs. Ronald Faller and Roger Bligh presented the proposed matrices at the summer workshop and meeting of the Transportation Research Board (TRB) AFB20 Committee on Roadside Safety Design in Cleveland, Ohio, on May 24, 2011. A copy of the presentation will be made available on the AFB20 website.

On May 19, 2011 and under NCHRP Project No. 22-14(4), TTI researchers conducted an 1100C small car test on the same cable barrier system installed in a 30-ft ditch and 4 ft away from the backside slope break point. During the test, the small car was captured after experiencing a tendency to override the cable barrier system. However, one of the cables became entangled on the offside guidance hardware attached to the right-front wheel and likely caused the vehicle to rollover. Crash videos from this TTI test will be made available on the AFB20 website within the PowerPoint presentation noted above.

Finally, State DOT comments were incorporated into the draft R&D report covering the continued dynamic component testing program for the modified cable bracket. A final report was prepared in May 2011 and published in June 2011.

Activity Next Quarter:

The final data analysis, test documentation, and draft reporting for test nos. 4CMB-4 and 4CMB-5 will be completed in the Third Quarter of 2011.

Based on sponsor feedback obtained at the April 2011 Midwest States Pooled Fund Program meeting, the project team was to focus its efforts on the level terrain crash testing program. As noted above, the crash test with the 1500A passenger sedan is now scheduled for mid-June. Once completed, the project team will coordinate the subsequent level terrain crash tests using 2270P and 1100C vehicles with the necessary design modifications required to later meet a 2270P retest in ditch and at 12-ft lateral offset. This work is budgeted under the Year 22 Pooled Fund Program.

Finally, TTI researchers plan to continue with one, and possibly two, full-scale vehicle crash tests in a 30-ft wide ditch on the Midwest Cable Barrier System after any necessary design modifications are implemented.

Problems/Comments:

The remaining project funds were exhausted and deemed insufficient to complete the crash testing, demolition, and reporting of test no. 4CMB-4 and 5 due to the extensive component testing program utilized to develop a simplified cable-to-post bracket. As such, these efforts were continued into the Year 20 continuation and future Year 22 project funds.

Total Percentage of Project Completion:

At this time, it is anticipated that 75 percent of the project has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	RPFP-09-02, TPF-5(091) Suppl. #2
Project Title:	Phase I – Guidelines for Post Socketed Foundations for Four-Cable, High-Tension, Barrier Systems
Starting Date:	8/15/2008
Completion Date:	7/31/2011
Principal Investigator:	Reid, Sicking, and Faller
Co-PIs & Team Members:	Rosenbaugh
Author:	Rosenbaugh, S.K.

Progress:

Task	% Completed
1. Literature Review on Previous Systems	100%
2. Socket Design and Analysis	75%
3. Fabrication and Bogie Testing of Post Sockets	50%
4. Analysis of Test Data	50%
6. Written Report	50%

Activity This Quarter:

Previously, 4 socketed foundation designs were evaluated through dynamic bogie testing. All 4 of these first round designs experienced heavy damage in the form of concrete fracture and plastic deformation of the reinforcing steel. As a result, 4 new reinforcement designs were configured to provide additional strength to the socketed foundation.

This quarter, the 4 new designs for the socketed post foundations were fabricated and cured. They are currently waiting to be tested as the bogie test pit needs to be emptied and filled with sand.

Also, work continued on assembling the Phase I research report which will document the first round of design, testing, and reinforcement recommendations.

Activity Next Quarter:

Dynamic bogie testing of the new post sockets will be conducted. Upon completion of the bogie tests, the data will be analyzed and conclusions shall be made concerning the strength and design of the 2nd generation of socketed foundations. Additionally, work shall continue on the Phase I research report.

Problems/Comments:

It is anticipated that this project will need to be extended. Currently, around $50,000 remains in the project due to MATC matching funds being used through the earlier development stages of this project. The MATC funds have been depleted, but this has left the Phase I project with more funds yet to be spent. As such, the continuing work which would have been conducted under Phase II of the project is being charged to the Phase I project until the funds are gone.

Total Percentage of Project Completion:

At this time, it is anticipated that 30% of the TOTAL project effort (both phase I and II) has been completed. Speaking specifically on Phase I of the project, it is estimated that 80% of the project has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	RPFP-09-03, TPF-5(091) Suppl. #3
Project Title:	Further Development of the MGS Transition to the Transition Using Fewer Components
Starting Date:	8/15/2008
Completion Date:	7/31/2011
Principal Investigator:	Reid, Sicking, and Faller
Co-PIs & Team Members:	Rosenbaugh, Polivka
Author:	Rosenbaugh, S.K.

Progress:

Task	% Completed
1. Literature Review	100%
2. Bogie Testing Program	100%
3. Data Analysis	100%
4. BARRIER VII Analysis	100%
5. Written Report	90%

Activity This Quarter:

The first draft of the wood post, MGS transition was completed, including the recommendations for attachment to various other thrie-beam approach transitions. The report is currently in an internal editing stage.

Activity Next Quarter:

The draft report for the equivalent wood post stiffness transition sent out to the States for review/editing as soon as the in-house edits are completed and implemented into the report.

Problems/Comments:

No anticipated problems.

Total Percentage of Project Completion:

At this time it is estimated that 95% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 14, 2011

Project No.:	TPF-5(091) Suppl.#5 2611211009001 - RPFP-09-05
Project Title:	Annual LS-DYNA Enhancement Support Year 3
Starting Date:	2008-08-15
Completion Date:	2011-07-31
Principal Investigator:	Reid
Co-PIs & Team Members:	Sicking, Faller
Author:	John D. Reid

Progress:

Task	% Completed
1. Update the end anchorage model of the MGS.	60%
2. Silverado model connection problem.	50%
3.	
4.	
5.	

Activity This Quarter:

Task 1

The new MGS end anchorage model was updated as much as possible without the plan bogie testing for calibration and validation.

Task 2

The 2270p model developed an instability in the connection between the front panel and bracket of the truck bed, see Figures 1 – 3. This occurred when using the truck model on 4-to-1 slope for the high tension cable project. Significant time was spent uncovering this instability and the cause of such. With that knowledge, several ideas for fixing the problem were developed and one was selected and tested. Results look promising but there is more work to be done on this problem.

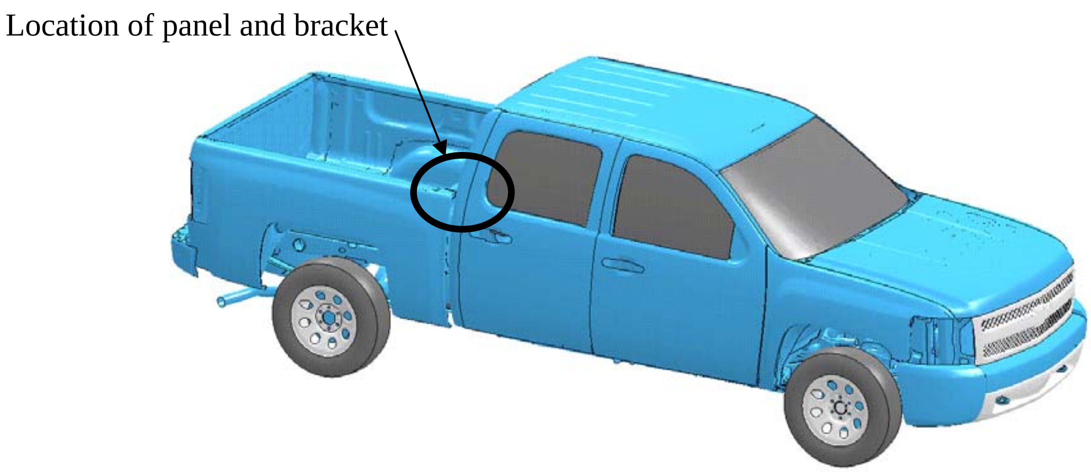


Figure 1. 2270p – Silverado Truck Model

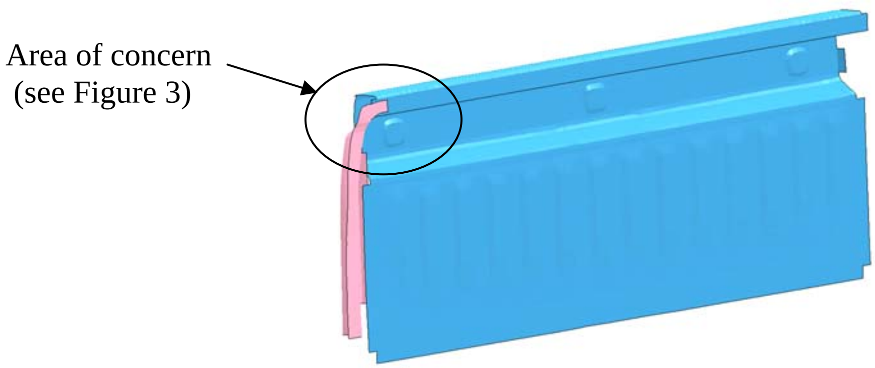


Figure 2. Front Panel and Bracket of Truck Bed

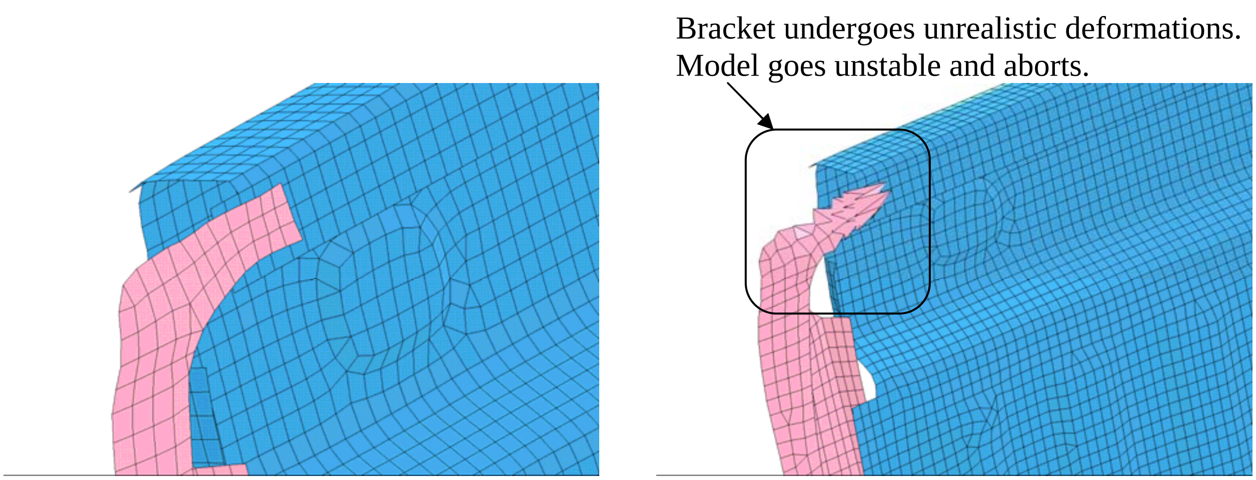


Figure 3. Welded Connection between Panel and Bracket

Activity Next Quarter:

Task 1

Bogie testing on the end anchorage system is scheduled for next quarter under a separate project. This testing will provide physical behavior of the system during impact, including loads through the components and connections. Additionally, the movement through the soil of the anchorage will be captured. Results from the bogie testing will be used to calibrate and validate this new model.

Incorporate the new anchorage model into the MGS model and perform various studies on it to ensure it is behaving as required.

Task 2

Fix the connection problem found in the truck bed and update the master model of the 2270p.

Problems/Comments:

Task 1

Bogie testing did not occur last quarter as written in the last quarterly report. Thus, "Activity Next Quarter" repeats from that report.

Total Percentage of Project Completion: xx%

Without up-to-the-minute financials it is not possible to determine if this project is out-of-money at this time. If it is, then any extra charges for LS-Dyna modeling during this quarter will be charged to LS-Dyna Support Year 4 project.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 16, 2011

Project No.: RPFP-10-POLE, TPF-5(193) Suppl. #18
Project Title: Impact Evaluation of Free-Cutting Brass Breakaway Couplings
Starting Date: 7/1/2009
Completion Date: 7/31/2012
Principal Investigator: Reid, Sicking, and Faller
Co-PIs & Team Members: Rosenbaugh, Polivka,
Author: Rosenbaugh, S.K.

Progress:

Task	% Completed
1. System Component Fabrication and Test Site Preparation	100%
2. Pendulum Testing	100%
3. Data Analysis and High Speed Test Extrapolation	100%
4. Determination of Pole Size/Weight Limits	100%
5. Written Report	100%
6. FHWA Acceptance	75%

Activity This Quarter:

Previously, a total of 7 pendulum tests spread over 3 rounds of testing were conducted at the Valmont Pendulum Testing Site. The test data was analyzed and extrapolated to predict the high speed test results. Conclusions were then made concerning the allowable size and weight limits for both steel and aluminum poles in combination with the brass couplings. The final report was completed in December 2010.

This quarter, MwRSF has had conformation that FHWA received the acceptance letter package. An outside consultant for FHWA has been in contact with MwRSF while reviewing the submitted documents and is preparing a recommendation report for FHWA. MwRSF expects to receive an FHWA acceptance letter for the Brass Couplings in the near future.

Also, drawings are currently being put together for submission to the Task Force 13 hardware guide.

Activity Next Quarter:

Acceptance letter with FHWA and the Task Force-13 breakaway support guide drawings shall be finalized.

Problems/Comments:

No anticipated problems

Total Percentage of Project Completion:

It is anticipated that 99% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2011
June 15, 2011

Project No.: RPFP-09-06 – TPF-5(091) Supplement #6
Project Title: Phase II – Development of an MGS Bridge Rail
Starting Date: August 15, 2008
Completion Date: July 31, 2011
Principal Investigator: Reid, Sicking, Faller
Co-PIs & Team Members: Lechtenberg, Bielenberg, Rosenbaugh, Holloway
Author: K. Lechtenberg

Progress:

Task	% Completed
1. Design of low-cost bridge rail	100
2. Simulation of design	100
3. Full-scale crash testing with 2270P and 1100C	100
4. Documentation and analysis of test results	100
5. Research report, final CAD details, FHWA acceptance	95

Activity This Quarter:

MwRSF worked on compiling the CAD details required for submission of the MGS bridge rail to the Bridge Rail Guide. The draft version of these CAD details is currently under internal review.

Activity Next Quarter:

A request for federal acceptance of the MGS bridge rail will be submitted to FHWA as well as finalizing the CAD details for the Bridge Rail Guide.

Problems/Comments:

There are no problems or issues to report at this time.

Total Percentage of Project Completion:

It is anticipated that 95% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	RPFP-10-CABLE-1, TPF-5(193) Suppl. #19
Project Title:	Phase II – Guidleines for Post Socketed Foundations for Four-Cable, High-Tension, Barrier Systems
Starting Date:	7/1/2009
Completion Date:	7/31/2012
Principal Investigator:	Reid, Sicking, and Faller
Co-PIs & Team Members:	Rosenbaugh
Author:	Rosenbaugh, S.K.

Progress:

Task	% Completed
1. Socket Design and Analysis	0%
2. System Fabrication and Test Site Preparation	0%
3. Dynamic Component Testing	0%
4. Data Analysis	0%
5. Written Report	0%

Activity This Quarter:

At this time, no work has been completed on Phase II. Work will begin on Phase II of the project when the Phase I project money has been spent.

Activity Next Quarter:

Continuation of the Phase I work.

Problems/Comments:

N/A

Total Percentage of Project Completion:

The Phase II project has not yet begun.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 14, 2011

Project No.: RPFP-10-Cable-2, TPF-5(193) Suppl. #20 (Year 20 Program)
Project Title: Replacement Funding for High-Tension Cable Barrier on Level Terrain
Prior Funding: Original Cable Median Barrier R&D in Years 12, 14, 16, 18, & 19
Starting Date: 7/1/2009
Completion Date: 7/31/2012
Principal Investigator: Reid, Sicking, and Faller
Co-PIs & Team Members: Bielenberg, Lechtenberg, Holloway, Meyer, and Rosenbaugh
Author: Faller, R.K.

Progress:

Supplemental Funding Tasks	% Completed
Barrier construction and system removal – 4CMB-5 & 4CMBLT-1	80
Barrier construction – 4CMB-6 (halted as post design may change)	40
Test no. 4CMB-4 reporting	25
Crash test no. 4CMB-5	100
Crash test no. 4CMBLT-1	50
Test nos. 4CMB-5 and 4CMBLT-1 documentation & reporting	10

Prior Activity:

In the First Quarter of 2011, MwRSF began construction of the cable barrier system, including the modified cable bracket, at two locations – (1) 12 ft laterally away from the slope break slope adjacent to the roadway edge and for use with the TL-3 2270P pickup truck test (4CMB-5) and (2) 4 ft laterally away from the backside slope break point and for use with the 1100C small car test (4CMB-6).

Activity This Quarter:

Construction was continued on the two cable barrier systems within V ditch as well as the first level terrain barrier system. The barrier system located 12 ft away from the front slope break point was completed, and crash test no. 4CMB-5 was performed but with unsatisfactory results. The barrier system located 4 ft from back slope break point was partially constructed, and test no. 4CMB-6 is delayed. The barrier system was also constructed on level terrain with plans to conduct test no. 4CMBLT-1 on June 14th.

Activity Next Quarter:

The data analysis and reporting of test nos. 4CMB-4, 4CMB-5, and 4CMBLT-1 will carry over into the Year 22 program. The removal of the 4CMB-5 system, construction and removal of 4CMBLT-1 will also carry over to the Year 22 program. All future work regarding 4CMB-6 will be covered in the Year 22 program.

Problems/Comments:

Year 22 project funds are required to cover the ongoing activities which occurred in May and June 2011.

With a failed 2270P test (4CMB-5), future funding will be required to redesign and retest the modified cable barrier system at the 12-ft lateral offset. This effort was not budgeted in the Year 22 Pooled Fund Program.

As the cable barrier test matrices have continued to evolve, additional critical tests have been identified. To date, an 1100C test on the front slope has been added and was not budgeted in the Year 22 research program. The most current test matrices were presented at the TRB AFB20 summer meeting and workshop and will be made available on the AFB20 website.

Total Percentage of Project Completion:

At this time, it is anticipated that 100 percent of the project funds have been utilized to complete several tasks for many different tests, as noted above.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	TPF-5(193) Suppl.#21 2611211028001 - RPFP-10-CABLE-3
Project Title:	Development of Crash-Worthy HT 4 Cable Terminal
Starting Date:	2009-07-01
Completion Date:	2012-07-31
Principal Investigator:	Reid
Co-PIs & Team Members:	Sicking, Faller
Author:	John D. Reid

Progress:

Task	% Completed
1.	
2.	
3.	
4.	
5.	

Activity This Quarter:

Activity Next Quarter:

Problems/Comments:

This is Phase II of the project. Phase I was funded in Year 17: SPR-3(017) Suppl.#38 2611120090007 – RPFP-07-06.

No reporting on this phase of the project will be done until Phase I is complete; see that project for status.

Total Percentage of Project Completion: 0%

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	TPF-5(193) Suppl.#22 2611211029001 - RPFP-10-MGS
Project Title:	Maximum MGS Guardrail Height
Starting Date:	2009-07-01
Completion Date:	2012-07-31
Principal Investigator:	Reid
Co-PIs & Team Members:	Sicking, Faller
Author:	John D. Reid

Progress:

Task	% Completed
1. Full-scale crash testing	100%
2. Report on full-scale crash testing	75%
3. Develop plan for analysis phase	10%
4. Analysis phase	10%
5.	

Activity This Quarter:

No progress was made on this project. However, a graduate student was hired with the intent of this project being his major responsibility.

Activity Next Quarter:

Complete the first draft of the full-scale crash testing report. Determine plan for the Barrier-VII and LS-DYNA analysis effort that was to follow after the full-scale testing.

Problems/Comments:

On June 29, 2010, MwRSF conducted one small car crash test (test no. MGSMRH-1) into a 34-in. tall Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 safety performance guidelines of MASH. The small car was successfully contained and redirected. Photographs for this test are shown below. On September 9, 2010, a second small car test (test no. MGSMRH-2) was conducted into a 36-in. tall Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 MASH safety performance guidelines. Again, the small car was successfully contained and redirected.

Total Percentage of Project Completion: 65%

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 14, 2011

Project No.:	TPF-5(193) Suppl.#24 2611211031001 - RPFP-10-LSDYNA
Project Title:	LS-DYNA Modeling Year 4
Starting Date:	2009-07-01
Completion Date:	2012-07-31
Principal Investigator:	Reid
Co-PIs & Team Members:	Sicking, Faller
Author:	John D. Reid

Progress:

Task	% Completed
1.	
2.	
3.	
4.	
5.	

Activity This Quarter:

Activity Next Quarter:

Problems/Comments:

This is a continuation of Year 3 and thus, no progress to report until funds are exhausted in that project.

Total Percentage of Project Completion:

Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2011
June 15, 2011

Project No.: RPFP-11-MGS-1 – TPF-5(193) Supplement #31
Project Title: Wood Post for MGS
Starting Date: July 1, 2010
Completion Date: December 31, 2013
Principal Investigator: Reid, Sicking, Faller
Co-PIs & Team Members: Lechtenberg, Bielenberg, Rosenbaugh, Holloway
Author: K. Lechtenberg

Progress:

Task	% Completed
1. Full-scale crash testing (MASH 3-10 and 3-11)	15
2. Analysis and documentation of test results	0
3. Research report	0
4. Hardware guide drawings and FHWA acceptance	0
5.	

Activity This Quarter:

Previously, CAD details were completed and construction materials were acquired.

No activity occurred this quarter.

Activity Next Quarter:

Construction will occur with potential crash testing toward the later part of the quarter.

Problems/Comments:

The same test pit is being used for Project No.:RPFP-11-MGS-3 – TPF-5(193) Supplement #33, Project Title: MGS without Blockouts. This system will be constructed and tested following the completion of the aforementioned project.

Total Percentage of Project Completion:

It is anticipated that 2% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.:	RPFP-11-MGS-2, TPF-5(193) Suppl. #32
Project Title:	MGS Guardrail Attached to Culverts
Starting Date:	7/1/2010
Completion Date:	12/31/2013
Principal Investigator:	Reid, Sicking, and Faller
Co-PIs & Team Members:	Rosenbaugh
Author:	Rosenbaugh, S.K.

Progress:

Task	% Completed
1. State Survey on Culvert Design	0%
2. System Design	0%
3. Component Fabrication and Test Site Preparation	0%
4. Dynamic Testing and Data Analysis	0%
5. Final Design and Culvert Recommendations	0%
5. Written Report	0%

Activity This Quarter:

Work has not yet begun on this research project.

Activity Next Quarter:

Work next quarter will begin with the survey of culvert designs used in the various Pooled Fund States.

Problems/Comments:

N/A

Total Percentage of Project Completion:

No work has begun on this research project

Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2011
June 15, 2011

Project No.:	RPFP-11-MGS-3 – TPF-5(193) Supplement #33
Project Title:	MGS without Blockouts
Starting Date:	July 1, 2010
Completion Date:	December 31, 2013
Principal Investigator:	Reid, Sicking, Faller
Co-PIs & Team Members:	Lechtenberg, Holloway
Author:	K. Lechtenberg

Progress:

Task	% Completed
1. Full-scale crash testing (MASH 3-10 and 3-11)	100
2. Analysis and documentation of test results	40
3. Research report	0
4. Hardware guide drawings and FHWA acceptance	0
5.	

Activity This Quarter:

Crash test no. MGSNB-1 (MASH test designation 3-11 with the 2270P vehicle) was performed on May 17th with satisfactory results. Data analysis of test no. MGSNB-1 was initiated. The system was repaired and constructed for MASH test designation 3-10 with the 1100C vehicle with plans to conduct crash test no. MGSNB-2 on June 15th.

Activity Next Quarter:

Data analysis of test nos. MGSNB-1 and MGSNB-2 will be completed. The reporting of the two crash tests will be initiated. The system will be removed.

Problems/Comments:

There are no problems or issues to report at this time.

Total Percentage of Project Completion:

It is anticipated that 45% of the research effort has been completed.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.: RPFP-11-MGS-4, TPF-5(193) Suppl. #34
Project Title: Asses Standardized Weld Detail
Starting Date: 7/1/2010
Completion Date: 12/31/2013
Principal Investigator: Reid, Sicking, and Faller
Co-PIs & Team Members: Rosenbaugh
Author: Rosenbaugh, S.K.

Progress:

Task	% Completed
1. Survey of State Weld Details/Recommendations	0%
2. Design and Analysis of Culvert Post attachment/Weld	0%
3. Dynamic Component Testing	0%
4. Data Analysis and Conclusions	0%
5. Written Report	0%

Activity This Quarter:

Work has not yet begun on this research project.

Activity Next Quarter:

Work next quarter will begin with a survey of the Pooled Fund States current weld practices and recommendations.

Problems/Comments:

N/A

Total Percentage of Project Completion:

No work has begun on this research project.

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 15, 2011

Project No.: RPFP-11-BULLNOSE // TPF-5(193) Suppl. #35
Project Title: Universal Steel Breakaway Post for Thrie Beam Bullnose
Starting Date: 7/1/2010
Completion Date: 12/31/2013
Principal Investigator: Sicking, Faller, Reid
Co-PIs & Team Members: Bielenberg
Author: Bielenberg

Progress:

Task	% Completed
1. Full-scale Crash Testing	100
2. Analysis and documentation of test results	100
3. Summary report	100
4. Hardware Guide drawing and FHWA approval submittal	80
5.	

Activity This Quarter:
(Provide an informative summary of tasks/activities that occurred this quarter)

This research project provided continuation funding for the development and testing of a universal breakaway steel post for the thrie beam bullnose barrier system. The initial development and crash testing was performed under a recent MnDOT research study using the NCHRP Report No. 350 safety performance guidelines.

Following the completion of two successful full-scale crash tests in the fall, MwRSF completed the analysis and documentation of the crash test results. In addition, a summary report detailing the results from the crash tests was finalized and submitted to the sponsors.

Schmidt, J.D., Sicking, D.L., Faller, R.K., Reid, J.D., Bielenberg, R.W., and Lechtenberg, K.A., *Investigating the Use of a New Universal Breakaway Steel Post - Phase III*, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-244-10, Project No.: TPF-5(193), Supplement No. 35, Project Code: RPFP-11-BNOSE - Year 21, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 16, 2010.

The results from the development and testing program were also presented at the 2011 Transportation Research Board AFB20 Committee meeting. A request for federal approval of the universal breakaway steel post for the thrie beam bullnose barrier system was submitted to FHWA.

MwRSF has discussed the system with FHWA officials and the approval is pending. MwRSF also worked on compiling the CAD details required for submission of the universal breakaway steel post for the thrie beam bullnose barrier system to the Hardware Guide. The draft version of these CAD details is currently being created.

Activity Next Quarter:

(Provide an informative summary of the tasks/activities that are planned for the following quarter)

The only work remaining in this project is to finalize the CAD details for the Hardware Guide. After the initial draft of the Hardware Guide CAD details are completed and reviewed internally, the CAD will be submitted to the AASHTO Hardware Guide committee for review and incorporation.

Problems/Comments:

There are no problems or issues to report at this time.

Total Percentage of Project Completion:

92%

Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2011
June 14, 2011

Project No.:	TPF-5(193) Suppl.#37 2611211050001 - RPFP-11-LSDYNA
Project Title:	LS-DYNA Modeling Year 5
Starting Date:	2009-07-01
Completion Date:	2012-07-31
Principal Investigator:	Reid
Co-PIs & Team Members:	Sicking, Faller
Author:	John D. Reid

Progress:

Task	% Completed
1.	
2.	
3.	
4.	
5.	

Activity This Quarter:

Activity Next Quarter:

Problems/Comments:

This is a continuation of Year 4 and thus, no progress to report until funds are exhausted in that project.

Total Percentage of Project Completion:

Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2011
June 15, 2011

Project No.: RPFP-11-TF-13 – TPF-5(193) Supplement #38
Project Title: Annual Fee to Finish TF 13 and FHWA Standard Plans
Starting Date: July 1, 2010
Completion Date: December 31, 2013
Principal Investigator: Reid, Sicking, Faller
Co-PIs & Team Members: Lechtenberg
Author: K. Lechtenberg

Progress:

Task	% Completed
1. Prepare CAD details for Hardware Guide	70
2.	
3.	
4.	
5.	

Activity This Quarter:

This project is used to supplement the preparation of the TF-13 format CAD details. Previously, it was determined that there are 13 systems and 11 components that need to be prepared in the TF-13 format.

Two (2) of the 13 systems were reviewed at the May 2011 TF-13 meeting. Continued preparation of the CAD details for the other systems and components occurred.

Activity Next Quarter:

Complete preparation of the TF-13 CAD details for the remaining 8 systems and 11 components. Revise the 5 reviewed system drawings per comments. Submit the completed ones to AASHTO TF-13 for review.

Problems/Comments:

At the present time, standard TF13-format CAD details are now required and subjected to review and comment by TF 13 members. This review is taking place during the TF-13 meetings which occur twice a year. After the initial review, the drawings are edited and then reviewed again at a later meeting. Once the CAD details are deemed acceptable and meet TF 13 guidelines, they are integrated into the electronic, web-based, version of the existing barrier hardware guide. Consequently, it requires a minimum of 6 months to get a drawing accepted for inclusion in the hardware guide; that is if there are only minimal edits to be made to the drawing. Sometimes, TF-13 requires a second review and more edits, thus adding another 6 months on to the time for its acceptance. For example, five (5) of the 13 systems were submitted for review during the September 2010 meeting. However, the allotted time only allowed the review of three (3) of the systems. The other two (2) were reviewed during the May 2011 meeting. Thus, some drawings may be in the review state at TF-13 for over a year before they are even looked at for the first time.

TF-13 is in the process of developing an online review system which will expedite the review process and allow more systems to be reviewed prior to their semi-annual meetings. Then at the TF-13 meetings it will be a final review and vote on if the drawings are ready to be implemented into the online guide.

<u>Total Percentage of Project Completion:</u>

It is anticipated that 70% of the research effort has been completed.