Midwest States Pooled Fund Program
Quarterly Progress Report – Second Quarter 2015
March 1, 2015 to May 31, 2015

DRAFT REPORTS – POOL FUND

Rosenbaugh, S.K., Bielenberg, R.W., Humphrey, B.M., Faller, R.K., Reid, J.D., and Lechtenberg, K.A., *Cable-to-Post Attachments for a Non-Proprietary High-Tension Cable Barrier – Phase II*, Draft Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-313-15, Project Nos. TPF-5(193) Supplement Nos. 44 and 64, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, April 27, 2015.

FINAL REPORTS – POOL FUND

Bielenberg, R.W., Schmidt, T.L., Faller, R.K., Rosenbaugh, S.K., Lechtenberg, K.A., Reid, J.D., and Sicking, D.L., *Design of an Improved Post for Use in a Non-Proprietary High-Tension Cable Median Barrier*, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-286-15, Project Nos. TPF-5(193) Supplement Nos. 44 and 45, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, May 7, 2015.

Rosenbaugh, S.K., Schmidt, T.L., Faller, R.K., and Reid, J.D., *Development of Socketed Foundations for S3x5.7 Posts*, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-293-15, Project Nos. TPF-5(091) Supplement No. 2 and TPF-5(193) Supplement No. 19, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, April 28, 2015.

DRAFT REPORTS – PROJECT RUN THROUGH POOL FUND, FUNDED BY INDIVIDUAL STATE

None

FINAL REPORTS – PROJECT RUN THROUGH POOL FUND, FUNDED BY INDIVIDUAL STATE

None

DRAFT REPORTS – FHWA PROJECT

Schmidt, J.D., Rosenbaugh, S.K., Faller, R.K., Bielenberg, R.W., Reid, J.D., Lechtenberg, K.A., Holloway, J.C., and Kohtz, J. E., *Design and Evaluation of an Energy-Absorbing, Reusable Roadside/Median Barrier, Phase 3*, Draft Report to the Nebraska Department of Roads and Federal Highway Administration, MwRSF Research Report No. TRP-03-317-15, Project No. NDOR DPU-STWD (94), Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, May 29, 2015.

FINAL REPORTS – FHWA PROJECT

None

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #19	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Phase II - Guidelines for Post-Socketed Foundations for 4-Cable, High-Tension, Barrier System		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Rosenbaugh	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211026001	RPFP-10-CABLE-1	7/1/2009
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/2012	4/30/2015	3

Project schedule status:

☐ On schedule ☑ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$92,207	$89,341	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$14,902	

Project Description:

This project is the second Phase of a project which was undertaken the year previous - split up due to available funds in previous year not being sufficient to cover entire project.

High-tension cable barriers often incorporate socketed post foundations to simplify repair of the system after an accident. Barrier posts are designed to slide in and out of a ground socket for easy replacement of damaged components. Unfortunately, there have been numerous examples of socketed post foundations that are damaged during a cable barrier crash. In most cases, socket damage requires repair crews to either replace the socket itself or drive a post directly into the soil adjacent to the damaged component. Either situation defeats the purpose of using sockets and greatly increases the time necessary to restore a damaged barrier. The increased repair time translates into higher maintenance costs and increased risk to repair crews working adjacent to high-speed facilities.

Many existing socketed post foundation designs are constructed by drilling a hole in the soil, placing a steel sleeve in the hole, and backfilling with Portland cement concrete. Many of these designs do not have sufficient reinforcement to resist impact loads that are transmitted into the socket. Further, many of the sockets are too short to resist frost heave that can push the posts out of the ground. Thus, there is a need for general design guidelines that states can incorporate to assure that socketed post foundations perform as intended when used in the field.

Objectives/Tasks:

1. Design new socket foundations for barrier posts.
2. Fabrication and dynamic testing of socketed foundations.
3. Analysis of test data and evaluation of socketed foundation designs.
4. Written report documenting all work and conclusions.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The report containing the design, testing, and analysis for socketed foundations supporting Midwest Weak Posts (MWPs) was made final in July 2014, and sent to the project sponsors in September 2014.

The report concerning foundation designs for S3x5.7 posts was completed and made final in April 2015.

The remaining project funds have been shifted for use in the continued development of the non-proprietary, high-tension cable barrier system.

Anticipated work next quarter:

The project has been closed.

Significant Results:

Phase I of this project included the evaluation of 4 new socketed foundation designs. 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.

Round 2 of testing saw four foundations designs evaluated in sand. Although concrete shear failure occurred in all designs, the 60" embedment proved adequate to resist rotation in weak/saturated/sandy soils. Round 3 of testing determined 36" was the required embedment depth for 12" diameter foundations placed in strong soil (AASHTO Gr. B).

Round 4 of testing was conducted utilizing the Midwest Weak Post as opposed to the S3x5.7 posts used previously. The weaker post resulted in virtually no damage to the foundation while allowing for reduced reinforcement. When utilizing the MWP, minimum embedment depths of 24 in. and 36 in. were specified for standard strong soils and sandy soils, respectively.

Round 4 of testing utilized larger 15" diameter foundations to support S3x5.7 posts. The larger shafts increased the foundations shear strength and prevented concrete cracking/spalling. An embedment depth of 30" was found to limit foundation movement to less than 3/4"

Round 5 of testing proved that a 4" asphalt pad prevented cracking in 12" foundations supporting S3x5.7 posts.

Objectives/Tasks:	% Completed (Phase II)
1. Design new socket foundations for barrier posts.	100%
2. Fabrication and dynamic testing of socketed foundations.	100%
3. Analysis of test data and evaluation of socketed foundation designs.	100%
4. Written report documenting all work and conclusions.	100%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Additional (matching) funds for Phase-I of this project were obtained through a Mid-America Transportation Center program. This matching funding was used during the first round of design, testing, and evaluation for the socketed foundations. Thus, some of the original Phase-I funding remained as it was not used until the MATC funding was depleted. As a result, the continuing work which would have been conducted under Phase II of the project was charged to the Phase I project until the funds were gone. Although the test charges from Round 2 of testing have been placed on this project's budget, significant time was charged to the Phase II project beginning only in mid 2013.

This project was originally set to close on July 31, 2012. However, the additional funding obtained for Phase-I of the project has resulted in remaining funds in the Phase-I project and nearly all of the funds remaining for Phase-II. Therefore, an extension was granted extending the closing date to 4/30/2013.

A significant delay was also the result of a change to the post in the non-proprietary cable system being developed by MwRSF. The new posts were to be significantly weaker than the original S3x5.7 posts, so continued development of the foundation with the S3x5.7 would result in an overly conservative design. Thus, it was decided to wait until the new post design was finalize before further foundation design and testing was conducted.

Upon completion of the project, there was approximately $12,000 remaining. These funds have been shifted for use to continue the development of the non-proprietary, high-tension cable barrier system.

Potential Implementation:

Upon successful completion of this project, State DOT's will have the option to use a socketed post foundation for cable barrier system posts (non-proprietary systems / posts). These socketed foundations will allow for quick, easy, and inexpensive repairs to damaged sections of cable barrier systems.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): NE Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl.#21	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:
Additional Funding to Complete Development of a Crash-Worthy Terminal for Midwest Four-Cable, HT, Barrier System

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller	402-472-3084	jreid@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
RPFP-10-CABLE-3	2611211028001	July 1, 2009
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
July 31, 2012	April 30, 2016	4

Project schedule status:

☐ On schedule ☐ On revised schedule ☐ Ahead of schedule ☑ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$159,193	$143,535	40%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$4,835	

Project Description:

Objective: Redesign the cable release m echanism and foundation of the three cable end terminal to accommodate four high tension cables.

Tasks
1. Background and literature review - completed
2. Design and analysis, including bogie testing part 1 - completed
3. Report part 1 - completed
4. Design and analysis, including bogie testing part 2 - in-progress
5. Full-scale testing
6. Report

This is Phase II of the project. Phase I was funded in Year 17: SPR-3(017) Suppl.#38 - "Testing of Cable Terminal for High Tension Cable (1100C & 2270P)"

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Task 4.
Several design concepts were brainstormed to allow the cables to release when impacted in the reverse direction. One concept that was further explored with LS-DYNA simulation was changing the cable locations to be evenly distributed on both sides of the posts and to transition the top two cables to be at 30.5" above the ground and the bottom two cables to be at 23" above ground. The simulation results still showed potential for the car to become entrapped under the cables which could lead to excessive vehicle decelerations.

Task 6.
Writing continued on the draft report summarizing the design and analysis conducted after the first round of bogie testing.

Anticipated work next quarter:

Task 4.
Writing will continue on the third report which will summarize the cable end terminal design, simulation, and recommendations.

Significant Results:

Report TRP-03-268-12 documenting part 1 of this project was published July 17, 2012.
"Development and Recommendations for a Non-Proprietary, High-Tension Cable End Terminal System"

History of cable terminal design changes were documented in a Midwest Roadside Safety Facility internal document, June 2013.

Report TRP-03-294-14 documenting part 2 of this project was published March 21, 2014.

Simulations of a bogie vehicle impacting the end terminal system at 0 and 15 degrees released the cables quickly and easily with minimal damage to the cable anchor bracket and cable release lever.

Simulations of small cars impacting in the reverse direction near the cable anchor bracket indicated potential problems of excessive vehicle deceleration and vehicle stability. New concepts were brainstormed to release the cables in the reverse direction to mitigate these potential problems.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Note: The life spent to date from the first quarter of 2015 should have been $138,700 and not $136,758.

Final design details and full-scale testing for this project cannot be conducted until the High Tension Cable Barrier System is completed. Because of timing in that project, this project is behind schedule.

$64,736 of the project funds have been re-allocated to PF-Yr 24 Cable Project. $64,736 of that re-allocation has been reflected on page 1 of this quarter report under "Total Amount of Funds Expended This Quarter".

The bogie testing in Task 4 and the full-scale testing in Task 5 that were originally budgeted will not be completed as the scope and funds of this project have changed. Further design and evaluation of the cable end terminal system was funded during Year 26 of Midwest States Regional Pooled Fund Program.

Potential Implementation:

The revised terminal will provide a non-proprietary end terminal for high tension barrier cable systems once the design is finalized and a full-scale crash testing program has been successfully completed.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin Department of Transportation

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #41	☐ Quarter 1 (January 1 – March 31) ☑ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☐ Quarter 4 (October 4 – December 31)

Project Title: Crashworthy Pedestrian Rail		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211061001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2011
Original Project End Date: 6/30/2014	**Current Project End Date:** 9/30/2015	**Number of Extensions:** 2

Project schedule status:

☐ On schedule ☑ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$234,629	$220,160	70%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$6,237	

Project Description:

Situations arise on the roadside where a barrier or rail is required to prevent pedestrians from crossing into a certain area which may be acceptable for an errant vehicle. Although these rails would not need to redirect or stop an errant vehicle, they must also not present additional hazards to the motoring public. These rails/fences should not cause excessive decelerations, vehicle snag points, vehicle instabilities, or produce fragments that may cause harm to other motorists when impacted. In addition, pedestrian rail systems must comply with the Americans with Disabilities Act (ADA). Therefore, a need may exist for a crashworthy pedestrian rail to protect pedestrians and prevent improper street crossings.

The objective of this research effort is development of a pedestrian rail to be ADA compliant and crashworthy. The objectives will be to identify the highest priority, crashworthy pedestrian rail need, to develop viable design concepts to meet that need, to finalize development of the crashworthy pedestrian rail system, and to perform the necessary MASH compliance tests for the system.

Objectives / Tasks
1. Literature review
2. Identification of rail needs and design criteria
3. Pedestrian rail design concepts
4. Component testing of design concepts
5. Summary report of design concepts
6. Finalize system details
7. Full-scale crash testing (MASH 2-91)
8. Full-scale crash testing (MASH 2-90)
9. Written report documenting design, testing, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Documentation of the design effort including all rail, posts, and connections for the three welded aluminum concepts and the modular concept as well as the bogie testing and full-scale testing effort continued.

Anticipated work next quarter:

Documentation of the design effort including all rail, posts, and connections for the three welded aluminum concepts and the modular concept will be completed. The results of the bogie testing and full-scale crash testing will be completed.

Significant Results:

Based on the results of the six bogie tests, the critical impact orientation is believed to be the end-on orientation. All of the systems when impacted at a 25 degree angle broke away and did not exhibit much potential for vehicle intrusion. A system that has the posts, rails, and spindles welded appeared to perform better than if they are held together with a set screw or just inserted into the rail.

On October 24, 2014, the Pedestrian Rail system was subjected to AASHTO MASH TL-2 longitudinal channelizer test conditions using a 1100C small car vehicle (test designation 2-90). In test no. APR-1, the small car impacted the system at a speed and angle of 45.2 mph and 25.1 degrees, respectively, resulting in an impact severity of 29.7 kip-ft. The system fractured as intended and the vehicle penetrated through the system as anticipated with five panels fracturing away during the impact. The occupant impact velocities and occupant ridedown accelerations were within the suggested limits provided in MASH. The test was acceptable according to the safety performance criteria of AASHTO MASH for test designation no. 2-90.

On November 12, 2014, the Pedestrian Rail system was subjected to AASHTO MASH TL-2 longitudinal channelizer test conditions using a 1100C small car vehicle (test designation 2-90). In test no. APR-2, the small car impacted the system at a speed and angle of 44 mph and 90 degrees (end-on impact), respectively. The vehicle traversed through the first five panels with the panels fracturing but not as quickly as intended. When the vehicle encountered the sixth panel, the panel was actually leaning on the seventh panel which caused the vehicle to experience high decelerations. Since the numbers obtained from the two different accelerometer units straddled the maximum limits in MASH, FHWA was contacted to determine how to interpret/choose the value to report.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

The 2010 version of the Aluminum Design Manual introduced new welded factors which had to be taken into consideration during the connection design development.

Fabrication of the aluminum systems is taking much longer than anticipated due to limited local aluminum fabricators and the small quantity.

Seven bogie tests were conducted and only four were initially budgeted. These were necessary in order to evaluate the concepts prior to selecting the most promising design for full-scale testing.

Potential Implementation:

The results from this research will provide a cost effective, ADA compliant, crashworthy, pedestrian rail that prevents foot traffic from crossing but does not pose as a hazard to errant vehicles.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): NE Department of Roads

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #51	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Annual LS-DYNA Modeling Enhancement Support		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: RPFP-12-LSDYNA	**Other Project ID (i.e., contract #):** 2611211071001	**Project Start Date:** July 1, 2011
Original Project End Date: June 30, 2014	**Current Project End Date:** June 30, 2015	**Number of Extensions:** 1

Project schedule status:

☐ On schedule ☐ On revised schedule ☐ Ahead of schedule ☑ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$36,543	$60	0

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
0	0	0

Project Description:

The objective of this research effort is to maintain a modeling enhancement program funded by the Pooled Fund Program States to address specific modeling needs shared by many safety programs. Funding from this project would go towards advancement of LS-DYNA modeling capabilities at MwRSF. The exact nature of the issues to be studied would be determined by the most pressing simulation problems associated with current Pooled Fund projects.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

A review of the usage of LS-Dyna at MwRSF was conducted. Specifically addressed were (1) pre-processing methods using HyperMesh and LS-PrePost, and (2) short term LS-Dyna needs.

Pre-Processing (i.e., generating LS-Dyna models) must continue to be a combination of using HyperMesh for difficult mesh creation, LS-PrePost for overall model assembly, and direct dyna deck editing using a standard text editor. Thoughts and ideas were shared during the meeting to help each other learn various things.

Specific LS-Dyna modeling topics to address in the next year or so included (1) soil modeling, (2) bolt hole contact, (3) cable contact, and (4) error handling.

Anticipated work next quarter:

A detailed summary of current state-of-the-art soil modeling techniques will be developed. This will be accomplished by a detailed analysis of several models that use various techniques as well as various soil material models contributed by TTI, NCAC, Chalmers and other research groups. A two-hour discussion on this soil modeling investigation will be conducted by MwRSF researchers at this summer's AFB(20) meeting in Chicago.

Significant Results:

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Due to the nature of this project, this project is worked on when the need arises or when there is a slack in other project priorities. Thus, the funds were not expended in the original project period and a no-cost time extension was obtained.

Potential Implementation:

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #56	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Increased Span Length of the MGS Long Span		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Bielenberg, Lechtenberg	402-472-3084	jreid@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
RPFP-13-MGS-3	2611211082001	7/1/2012
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2015	6/30/2015	0

Project schedule status:

☐ On schedule ☐ On revised schedule ☐ Ahead of schedule ☑ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$212,730 + suppl $36,605	$91,661	50%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$10,447	

Project Description:

The current MGS long-span guardrail system provides the capability to span unsupported lengths up 25 ft. While this span length has many useful applications, many culvert structures exceed the span length of the MGS long-span system. Other solutions for mounting guardrail to culverts exist, but mounting hardware to culverts can also cause difficulties. If the long span can be adjusted to accommodate longer spans, the difficulties associated with mounting hardware to the culvert can be avoided.

The objective of this research effort is to design and evaluate the MGS long-span design for use with unsupported spans greater than 25 ft. The research effort could be focused in one of two directions. The research could focus on determination of the maximum unsupported span length for the current long-span design or it could focus on evaluating potential modifications that may allow for significantly longer unsupported spans. The increased unsupported span design would be designed to meet the TL-3 safety criteria set forth in MASH.

Objectives / Tasks

1. Literature review of previous long-span systems - completed
2. Simulation of both original and any new long-span system designs - completed
3. Design modifications to extend unsupported length - completed
4. Full scale crash testing of new design (two MASH 3-11 tests) - in-progress
5. Data analysis and evaluation - in-progress
6. Written report documenting all design work, simulation, testing, and conclusions - in-progress

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Task 4.

Test no. mgsls-1 successfully crash tested the increased span length MGS system on May 18, 2015. The test consisted of a 31.25-ft span MGS system with the wood CRT posts near the span replaced by universal breakaway steel posts. Details of the test and results are still being analyzed and will be available in the next quarter report.

Anticipated work next quarter:

Task 4.
It is predicted that the second full-scale crash test will be conducted in the next quarter.

Task 5.
Data analysis and evaluation of both tests will be completed.

Task 6.
Test report writing will begin.

Significant Results:

Initial simulations of an increased span length indicate successful redirection at a span length of 31.25-ft and 37.5-ft.

The 43.75-ft and 50-ft span lengths were ruled out as potential span lengths for future full-scale crash testing due to questionable vehicle capture and severe impacts with the downstream wing wall.

The 31.25-ft span system will proceed to full-scale crash testing. The wood CRT posts will be replaced with universal breakaway steel posts.

Objectives / Tasks	% Complete
1. Literature review of previous long-span systems	100%
2. Simulation of both original and any new long-span system designs	100%
3. Design modifications to extend unsupported length	100%
4. Full scale crash testing of new design (two MASH 3-11 tests)	65%
5. Data analysis and evaluation	5%
6. Written report documenting all design work, simulation, testing, and conclusions	35%

The simulation and design phase report for this project was published: "Increased Span Length of the MGS Long-Span Guardrail System," MwRSF Report TRP-03-310-14, December 17, 2014.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This project has a cost of $249,335. There was insufficient funding in Pool Fund Year 23 to fund this entire amount. Thus, the budget for Year 23 is $212,730, and the remaining is being funded by contingency funds in Pool Fund Year 23.

Due to the higher than normal rainy season, the full-scale testing program has been delayed, resulting in an overall project delay. A no-cost time extension has been submitted.

Many project costs associated with the full-scale crash test conducted during the current quarter were not posted in time to be reported in this quarter report.

Potential Implementation:

The MGS long-span system has the ability to perform safely without nested rail and with a minimal barrier offset. These features make the barrier a very functional, efficient, and safe option for protection of low-fill culverts. Development of an increased unsupported span length for the MGS long-span system will add to the flexibility of the design and provide for improved protection of culvert headwalls and vertical dropoffs with a length greater than 25 ft.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #57	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Weak-Post W-beam Guardrail Installed in Mow Strips		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Bielenberg, Lechtenberg	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211083001	RPFP-13-MGS-5	7/1/2012
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2015		

Project schedule status:

☐ On schedule ☐ On revised schedule ☐ Ahead of schedule ☑ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$162,896	$89,276	95%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$5,015	

Project Description:

Over the years, it has become desirable to place a longitudinal concrete slab or continuous asphalt pavement under W-beam guardrail systems in order to reduce the time and costs for mowing operations around guardrail posts. Likewise, many times guardrail posts must be installed in un-yielding pavements. Unfortunately, the placement of guardrail posts in pavement restricts energy dissipation by restricting the posts from rotating through the soil. Thus, installations in pavements have incorporated a blocked-out area or "leave-out" that surrounds each post. These leave-outs allow post rotation in the soil and result in acceptable safety performances for standard W-beam guardrails.

Recently, the MGS Bridge Rail was developed and successfully crash tested under the TL-3 MASH guidelines. This system utilized weak steel posts placed in tubular steel sockets that were side-mounted to a concrete bridge deck. The energy dissipation mechanism for this system was designed as bending of the weak posts instead of post rotation through soil. Since the posts are installed in rigid sleeves, MwRSF believes that the MGS Bridge Rail could be adapted for use in guardrail applications where mow strips are required. In this situation, it would be unnecessary to provide large leave-outs around the posts of guardrail systems installed in un-yielding pavements. Thus, The objective of this research effort is to adapt the MGS Bridge Rail system for use in mow strips and other pavements.

Objectives / Tasks

1. State survey of existing mow strip practices
2. System design and analysis
3. Dynamic bogie component testing
4. Full scale crash testing (MASH 3-10 and 3-11 tests)
5. Data analysis and evaluation
6. Written report documenting all design work, simulation, testing, and conclusions

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, eleven dynamic component tests and one full-scale crash test were conducted during the evaluation of the weak-post guardrail system in both asphalt and concrete mow strips. Work this quarter focused on completing the data analysis from the full-scale test, and writing of the project report summarizing all design, testing, analysis, and conclusions completed as part of this project. A first draft of the report has been completed and is currently undergoing internal reviews.

Anticipated work next quarter:

Completion of the project report and closing of the project.

Significant Results:

A survey of the Pooled Fund States revealed the critical mow strip to be 4 in. thick and 4 ft wide. Both asphalt and concrete versions of the mow strip shall be investigated through dynamic component tests. Component testing testing demonstrated that a 4" concrete pad has sufficient strength to withstand the imapct loads without damage. However, testing within the asphalt mow strips illustrated that the posts will push through the asphalt and displace up to 3 inches.

When a 10" wide shear plate was welded to the back of 24"-30" deep sockets, both lateral and longitudinal tests resulted in minimal damage to the 4" asphalt mow strip and minimal displacements to the socket. However, an impact of dual 24" sockets spaced at 37.5" within 4" of asphalt resulted in asphalt fracture socket rotations.

A full-scale test was conducted on the weak-post guardrail system placed within 30" deep sockets spaced at 17.5" along the centerline of a 4' wide, 6" deep asphalt mow strip. The system successfully redirected the 2270P vehicle, but the asphalt behind the posts was damaged. A 2"-3" crack opened along the post line throughout the impact region of the system and the asphalt behind it was pushed back and cracked further.

Another dual post test was conducted, this time with the posts installed in a 4" thick by 4-ft wide concrete pad. During the test, the posts bend over and the concrete pad remained undamaged.

Objectives / Tasks	% Complete
1. State survey of existing mow strip practices	100%
2. System design and analysis	100%
3. Dynamic bogie component testing	100%
4. Full scale crash testing (MASH 3-10 and 3-11 tests)	100%
5. Data analysis and evaluation	100%
6. Written report documenting all design work, simulation, testing, and conclusions	80%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Matching funding in the amount of $60,000 was obtained through the Mid-American Transportation Center. Thus, additional component testing was conducted to explore various options for installing the S3x5.7 posts within both concrete and asphalt mow strips. Thus, the project is currently running a bit behind schedule.

Potential Implementation:

Adapting the MGS bridge rail to be placed in various pavements will allow designers to install the weak post, MGS system in mow strips without requiring leave-outs, breakaway posts, or other additional hardware. It is anticipated that the new post foundation design will significantly reduce labor and system costs associated with installation, repair, and maintenance of guardrail installed in mow strips and other pavements. Insight will also be gained regarding the potential performance of other weak post guardrail systems when installed in mow strips.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl # 62	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title: Safety Investigation & Design Guidance for Curb & Gutter Near Energy-Absorbing Terminals		
Name of Project Manager(s): Schmidt, Bielenberg, Faller, Reid	**Phone Number:** (402) 472-0870	**E-Mail** jennifer.schmidt@unl.edu
Lead Agency Project ID: 2611211094001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2013
Original Project End Date: 6/30/2016	**Current Project End Date:** 6/30/2016	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$173,716	$60,876	35%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
$12,355(7.1%)	$12,355	35%

Project Description:

AASHTO highway design policies discourage the use of curbs along high-speed roadways. This guidance is largely based on the fact that curbs may cause impacting vehicles to become airborne, thus resulting in loss of control by the driver. In the case of a laterally skidding vehicle, a rollover may also be induced upon striking the curb (i.e., tripping). However, safety appurtenances, such as guardrail end terminals and crash cushions, are often placed in combination with curbs. Nonetheless, curbs are often installed along high-speed roadways for several reasons, including restricted right-of-way, drainage considerations, access control and other curb function requirements. In these situations, eliminating existing curbs or laterally offsetting curbs away from the traveled way may represent an expensive or unattainable alternative.

Historically, the safety performance of energy-absorbing guardrail end terminals has been based on the results of full-scale crash tests performed on level terrain. However, very limited research has been performed to investigate the safety performance of these features when installed in combination with curbs. Thus, there is a need to investigate whether curb placement in advance of guardrail end terminals significantly degrades barrier performance as a result of the changes in vehicle trajectory prior to impact. In addition, design recommendations are necessary for determining the safe placement of curb and gutter installed adjacent to energy-absorbing guardrail end terminals.

The objective of this research effort is to develop guidance for the safe placement of curbs adjacent to energy-absorbing guardrail end terminals. A combination of computer simulation and full-scale crash tests will be used to identify potential safety hazards, define critical curb and terminal impact scenarios, and select optimal curb placement. The effort will focus on a single, representative energy-absorbing, guardrail end terminal configuration that is selected during the study effort. In addition, the impact conditions for the simulation and crash testing programs will correspond with those published for Test Level 3 (TL-3) in the MASH impact safety standards.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

All baseline simulations on the G4(1S) (12 different impact conditions) and on the MGS (12 different impact conditions) were created. Simulations of NCHRP Report 350 and MASH impacts were completed and seem reasonable. Modeling techniques (contacts, mesh size, etc.) were varied for impacts with the Geo Metro to improve results. All full-scale crash test results conducted on end terminals similar to the generic end terminal were compiled and compared to the simulations. The simulations seemed to be reasonably accurate at producing results similar to the crash tests with the exception of rail buckling. The modeling methodology for the energy-absorbing mechanism in the end terminal will predict buckling due to the lack of compression force in the rail.

Writing commenced on the draft report which documents the background and simulation work thus far.

A meeting was held on April 28 with WisDOT and Wisconsin FHWA representatives to discuss the results of the project thus far. WisDOT selected Option 2 for how to install end terminal height, which is, when a curb is present, the breakaway/groundline features will remain at groundline, the curb will have soil backfill, and the height of the end terminal will be measured from the top of soil/top of curb. If Option 2 shows undesirable results, Option 1 (no backfill behind curb) or Option 3 (breakaway/groundline features are customized based on curb height so that guardrail height remains measured from roadway surface) may be recommended.

Anticipated work next quarter:

A complete validation of the G4(1S) and MGS end terminal models will be finished.

Several models with the MGS on longitudinal curbs will be developed. Curb parameters to be varied include curb height (up to 6"), curb shape (sloped or vertical), and curb offset from the face of guardrail (either 0 or 6"). Simulations will also begin with the MGS on curbs. Up to 7 impacts may be conducted per curb configuration, including:

- 2270P (Silverado) impacting end at 0 deg (MASH test no. 3-31)
- 2270P (Silverado) impact end at 5 deg (MASH test no. 3-33)
- 2270P (Silverado) impacting end at 15 deg (MASH test no. 3-33)
- 1100C (Yaris) impacting end at 5 deg (MASH test no. 3-32)
- 1100C (Yaris) impacting end at 15 deg (MASH test no. 3-32)
- 1100C (Yaris) impacting end at 0 deg at deep quarter point offset (MASH test no. 3-30)
- 1100C (Yaris) impacting end at 0 deg at shallow quarter point offset (MASH test no. 3-30)

Significant Results:

End terminal models with the G4(1S) and MGS were developed. Twelve impact conditions were simulated for both the G4 (1S) and MGS models, and the results were reasonable when compared to full-scale crash testing. .

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The development of design guidelines for the safe placement of energy-absorbing guardrail end terminals behind curbs will provide beneficial information for highway designers and engineers and reduce the risk of highway agencies adopting inadequate and potentially unsafe curb-barrier combinations. These guidelines would also serve to reduce inconsistencies in the recommendations from one highway agency to the next, inconsistencies which could be the source of significant tort risk. These guidelines could potentially reduce highway agency expenses associated with curb removal in front of guardrail end terminals if certain combinations are found to be safe and no longer prohibited. In addition to being costly, curb removal is hazardous to both workers who are exposed to highway traffic in construction zones and the motorists who must traverse a restricted travel way. Any funds which can be saved by avoiding curb removal could be used for implementing other cost-beneficial safety improvements.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #63 Pooled Fund Project RPFP-14-AGT-1	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:

Dynamic Testing and Evaluation of Curb Placed Under Asymmetrical MGS-to-Thrie Beam Transition (Continued Funding)

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211095001	RPFP-14-AGT-1	7/1/2013
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2016	6/30/2016	0

Project schedule status:

☐ On schedule ☐ On revised schedule ☑ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$59,946	$15,657	75%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$17	

Project Description:

Recently, MwRSF researchers successfully developed and crash tested a simplified, steel-post stiffness transition for adapting the 31-in. tall Midwest Guardrail System (MGS) to existing, thrie beam approach guardrail transition systems. This system utilized an asymmetrical transition section, which maintained a top mounting height of 31 in. The system was successfully crash tested to TL-3 impact safety standards of MASH. However, this simplified stiffness transition system was not evaluated with a lower concrete curb placed below the rail.

Many states are interested in placing curbs underneath and throughout the length of common approach guardrail transitions. However, the addition of a curb can potentially lead to severe consequences. Specifically, small car vehicles may become wedged between the bottom of the asymmetrical rail and the top of the curb leading to excessive vehicle decelerations, increased risk to occupants, and vehicular instabilities. Light truck passenger vehicles may climb the curb and contact the rail with the vehicle c.g. positioned higher than normal, thus potentially causing excessive vehicular instabilities, and even rollover. Unfortunately, no crash testing has been performed near the upstream end of the new simplified stiffness transition with the presence of curbs. Therefore, full-scale vehicle crash testing is deemed necessary to verify the safety performance of curb placement below the asymmetric transition element.

After a failure of MASH test designation no. 3-20 during the original Year 23 Pooled Fund project, this supplementary project was created to fund the re-design and re-test of the transition system with lower curb.

Objectives & Tasks

1. Full-scale crash testing (MASH test designation nos. 3-20 (2 tests) and 3-21(1 test).
2. Data analysis and evaluation.
3. Report documenting R&D effort, including brainstorming, redesign, construction, crash testing, conclusions, and recommendations.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The hardware guide drawings are undergoing internal review and edit.

Anticipated work next quarter:

The hardware guide drawings will be completed. It is anticipated toward the end of the next quarter, the request for FHWA eligibility will be submitted.

Significant Results:

Test no. MWTC-1 (MASH test designation no. 3-20) illustrated that the placement of a 4-in. tall curb in combination with the MGS stiffness transition with asymmetrical transition rail element can significantly degrade barrier performance from that observed when the curb was not installed. The 1100C full-scale crash test resulted in rail rupture at the upstream end of the asymmetrical W-beam to thrie beam transition element, and the vehicle snagged on several transition posts.

Test no. MWTC-2 (MASH test designation no. 3-20) demonstrated that the use of 12 ft - 6 in. of nested W-beam rail in advance of the asymmetrical segment was able to mitigate factors that led to guardrail rupture. In addition, this small car re-test showed that the MGS stiffness transition in combination with lower curb met the TL-3 MASH impact safety standards when used with 12 ft - 6 in. of nested W-beam rail.

Test no. MWTC-3 (MASH test designation no. 3-21) was conducted on the modified system on May 16, 2013 and satisfied all of the MASH safety performance criteria. The test demonstrated that the 2270P pickup truck was successfully contained and redirected by the MGS stiffness transition in combination with lower curb when used in combination with 12 ft - 6 in. of nested W-beam rail.

Objectives/Tasks	% Complete
1. Full-scale crash testing (MASH test designation nos. 3-20 and 3-21).	100%
1a. Full-scale crash test of modified transition (MASH test no. 3-20)	100%
2. Data analysis and evaluation.	100%
3. Report documenting R&D effort, including redesign, crash testing, and conclusions	100%
4. TF-13 Hardware Guide Drawings	90%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This project was created to supplement an existing project, Pooled Fund Year 23 - RPFP-13-AGT-1, which carries the same project title. A failure during the first full-scale crash test of the original study required a redesign and a retest of MASH test designation no. 3-20. Since the retest was not part of the original budget, this supplementary project was created to fund it.

To date, all work has been charged to the original project. However, funds in the original project were exhausted during the fourth quarter of 2013. Therefore, all remaining charges will be posted to this project.

Potential Implementation:

The successful crash testing of the MGS stiffness transition with asymmetric transition element and lower concrete curb will allow State Departments of Transportation to provide continuous hydraulic runoff control between approach guardrail transitions and W-beam approach rails. The use of continuous concrete curb will help to mitigate soil erosion near bridge ends as well as its costly maintenance and repair.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #64	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title: Continued Development of the Midwest Four-Cable, High-Tension, Median Barrier (Continuation Funding)		
Name of Project Manager(s): Reid, Faller, Lechtenberg, Bielenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211096001	**Other Project ID (i.e., contract #):** RPFP-14-CABLE1	**Project Start Date:** 7/1/13
Original Project End Date: 6/30/16	**Current Project End Date:** 6/30/16	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$375,513 (+$264,372 from Yrs 20 & 22)	$414,015 ($149,944 R&D/Reporting	20

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$53,599 ($49,033 R&D/Reporting Cc	

Project Description:

The Midwest Roadside Safety Facility (MwRSF) has been conducting research for the Midwest States Regional Pooled Fund Program to develop a non-proprietary, high-tension, four-cable, median barrier that is capable of being used anywhere in a V-ditch with 4H:1V side slopes. Three tests still remain to complete the test matrix of the cable barrier system in a V-ditch. In addition, the four-cable, high-tension, median barrier has never been tested on level terrain. There is a concern that FHWA may not approve this design without testing on flat ground, especially when considering the wide cable spacing and increased cable heights. Further, the barrier deflections observed in crash tests performed in a 4H:1V V-ditch are likely higher than would be observed on flat ground. Crash testing of the barrier installed on level terrain would identify barrier deflections and working widths that can be expected when the barrier is used in narrow medians with gentle slopes and would allow for better performance comparisons between the Midwest four-cable barrier and other proprietary systems.

Objective: To complete the development, testing, and evaluation of the four-cable, high-tension, median barrier system for use on level terrain.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The report containing the folded C-channel posts and Midwest Weak Posts was finalized and published.

Internal review of the draft report containing the component testing of the shear plate brackets was completed. The draft report was submitted to the Pooled Fund members for review and comment. The report was finalized and published.

Internal review of the draft report containing the full-scale crash tests (test nos. MWP-1 through MWP-3) was initiated.

The report containing the component testing of the non-bolted connection concepts was initiated.

The report containing the full-scale crash tests (test nos. MWP-4, MWP-6, and MWP-7) was initiated.

On April 2, a conference call was held with the member states. Discussion included review of the full-scale crash tests MWP-6 and MWP-7, review of the investigation into methods to alleviate the floorboard penetration issue observed in the full-scale tests, and further investigation into eliminating the floorboard penetration by weak posts.

Numerous methods to alleviate the floorboard penetration issue observed with the Midwest Weak Post were investigated through component testing. Review of the results was initiated.

Anticipated work next quarter:

The report containing the folded C-channel posts and Midwest Weak Posts will be disseminated to the sponsors. The report containing the component testing of the shear plate brackets will be disseminated to the sponsors.

Internal review of the draft report containing the full-scale crash tests (test nos. MWP-1 through MWP-3) will continue. There is a potential the draft report may be sent to the member states for review toward the end of the next quarter.

The report containing the component testing of the non-bolted connection concepts will continue to be written.

The report containing the full-scale crash tests (test nos. MWP-4, MWP-6, and MWP-7) will continue to be written.

Further investigation into potential methods to alleviate the floorboard penetration issue will continue. Information gathered during the component testing will be disseminated to the sponsors.

Significant Results:

On March 26, 2014, MwRSF conducted a 1500A crash test (test no. MWP-1) into the Midwest high-tension cable median barrier with the Midwest Weak Post placed at the slope break point of a 6:1 slope using a 1500-kg Ford Taurus according to the TL-3 safety performance guidelines of MASH, specifically test designation no. 3-17. The vehicle was successfully contained and redirected.

On April 18, 2014, MwRSF conducted one pickup crash test (test no. MWP-2) into the Midwest high-tension cable median barrier with the Midwest Weak Post using a 2270-kg Dodge QuadCab according to the TL-3 safety performance guidelines of MASH, specifically test designation no. 3-11. The pickup was successfully contained and redirected. However, the member states had concerns about the dynamic deflections of the system. Thus, the system was further modified by reducing the post spacing to 8' to attempt to reduce the system deflections and reducing the number of keyways and holes to make the post stronger.

On July 11, 2014, MwRSF conducted one pickup crash test (test no. MWP-3) into the Midwest high-tension cable median barrier with the Midwest Weak Post with 8' post spacing and a reduction in the number of keyways and holes using a 2270-kg Dodge QuadCab according to the TL-3 safety performance guidelines of MASH, specifically test designation no. 3-11. The pickup overrode the cables and eventually rolled over. Hence, the system was further modified by reducing the top cable height to 38", increasing the bottom cable height to 15.5", adjusting the inner cable spacing to 7.5", and increasing the post spacing to 10'.

On October 20, 2014, MwRSF conducted one pickup crash test (test no. MWP-4) into the modified Midwest high-tension cable median barrier with the Midwest Weak Post using a 2270-kg Dodge QuadCab according to the TL-3 safety

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This project is an extension to previous projects (RPFP-08-02: Four-Cable Median Barrier in 4:1 V-Ditch; RPFP-09-01: New Funding for High-Tension Cable Barrier on Level Terrain with New Cable Attachment; RPFP-10-CABLE-2: Replacement Funding for High-Tension Cable Barrier on Level Terrain; RPFP-12-CABLE1&2: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-Ditch; and RPFP-12-CABLE1&2: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase II, Level Terrain).

A portion of this project ($264,372 is not included in the project budget shown on page 1) will be funded with the following projects:
$64,746 from Project No.: RPFP-10-CABLE-3 – TPF-5(193) Supplement #21, Project Title: Additional Funds to Complete Development of Crashworthy HT, 4-Cable Barrier Terminal
$199,626 from Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #46, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase III, End Terminal

To date, total funds spent are from the following project funds:
$64,736 from Project No.: RPFP-10-CABLE-3 – TPF-5(193) Supplement #21
$199,626 from Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #46
$149,698 from this project, Project No.: RPFP-14-CABLE-1 - TPF-5(193) Supplement #64

In addition, Contingency Funds from several prior years have been designated for Cable R&D and Cable Reporting. To date, $149,944 has been posted to the contingency funds for Cable R&D and Cable Reporting.

Potential Implementation:

The successful completion of the development, testing, and evaluation of the Midwest four-cable, high-tension, median barrier on level terrain will allow the member states to implement a non-proprietary, high-tension, cable system along our nation's highways and roadways. In addition, the crash testing of the four-cable, high-tension, median barrier on level terrain would also provide a more complete understanding of barrier performance (i.e., dynamic deflections, working width, etc.) when used in relatively flat, narrow medians. The crash results from the level terrain testing will be used in combination with computer simulation to evaluate the effects of reduced post spacing. The successful completion of this project along with the non-proprietary four-cable, high-tension, median barrier in V-ditch and cable guardrail end terminal would help to assure acceptance by FHWA and improve its chances for widespread implementation.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #66	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Pooled Fund Center for Highway Safety		
Name of Project Manager(s): Reid, Faller, Lechtenberg, Bielenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211086001	**Other Project ID (i.e., contract #):** RPFP-14-PFCHS	**Project Start Date:** 7/1/2013
Original Project End Date: 6/30/2016	**Current Project End Date:** 6/30/2016	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$11,519	$8,528	50%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$2,712	

Project Description:

Many of MwRSF's inquiries from members of the Midwest States Pooled Fund program can be answered based upon prior pooled fund or other research. Further, even though answers to pooled fund inquiries are normally routed to all pooled fund states in the quarterly progress report, there are numerous repeat questions every year. The quarterly summaries are helpful to member states, but they are temporary and not well organized by the type of question or specific topic. Many pooled fund inquiries could be answered through the development of a Center of Highway Safety web site. A dedicated and well-maintained Pooled Fund Center for Highway Safety web site would provide for all of these needs. It would provide for a searchable database of previous MwRSF inquiries and solutions, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features. This safety center would also be helpful to non-member states with problems or inquiries similar to those identified by the member states.

In Year 22, the Midwest States Pooled Fund states sponsored the development of a Pooled Fund Center for Highway Safety web site. This project allowed for the development of the first phase of the web site and archiving of materials on the web site. In the past year, a web site for the Midwest States Pooled Fund consulting questions and responses was developed and made available. The web site is currently operational and provides functions for submitting questions and inquiries to MwRSF as well as posting of the responses. It also provides a searchable database of previous MwRSF inquiries and solutions. The website is located at http://mwrsf-qa.unl.edu/.

In addition to the consulting web site, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features has been started. MwRSF is currently in the process of making this web site operational and uploading the archived reports and CAD. MwRSF anticipates that this archive will be fully functional in the near term. The report and CAD archive as well as the Midwest States Pooled Fund consulting web site will be integrated with the main MwRSF web site in the near future as well.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Maintenance, repair, and upkeep of the website continued.

All completed projects in the first quarter 2015 were added to the research archive site.

Continued development of a page dedicated to the Pooled Fund to include historical information, state contacts, active projects, and problem statement submission. Prototype of the Pooled Fund page is being reviewed by MwRSF.

Anticipated work next quarter:

Continue maintenance, repair, and upkeep of the website.

Continue updating the archive with completed projects as they are completed.

Adding videos of older full-scale crash tests to the research archive site.

Continue the development of the dedicated Pooled Fund page. Anticipate a completed prototype of the Pooled Fund page for member states to review.

Significant Results:

Several newly completed projects were added to the research archive.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This is a continuation of funding for the original project started in Pooled Fund Year 22, Project No.: RPFP-12-PFCHS-1 – TPF-5(193) Supplement #48, Project Title: Pooled Fund for Highway Safety. Funding from Project No.: RPFP-13-PFCHS – TPF-5(193) Supplement #60, Project Title: Pooled Fund for Highway Safety will be used prior to starting this project.

Potential Implementation:

The Pooled Fund Center for Highway Safety web site would provide immediate access to a wide library of roadside safety materials for designers and engineers, including reports, CAD details, etc. It would also provide a searchable database of previous solutions and responses to prior Pooled Fund inquiries and problems. The web site would also be available through controlled access to state DOT's around the country which would promote improved roadside safety.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #67	☐ Quarter 1 (January 1 – March 31) ☑ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☐ Quarter 4 (October 4 – December 31)

Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans		
Name of Project Manager(s): Reid, Faller, Lechtenberg, Bielenberg	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211099001	**Other Project ID (i.e., contract #):** RPFP-14-TF13	**Project Start Date:** 7/1/13
Original Project End Date: 6/30/16	**Current Project End Date:** 6/30/16	**Number of Extensions:** 0

Project schedule status:

☐ On schedule ☐ On revised schedule ☑ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$3,695	$2,522	55

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$308	

Project Description:

Each year, the Midwest States Pooled Fund program sponsors several roadside safety studies at the Midwest Roadside Safety Facility (MwRSF) of the University of Nebraska-Lincoln. Some of these research efforts result in the development of new roadside safety features. As part of this effort and on behalf of the member states, MwRSF seeks FHWA acceptance for those devices or systems meeting current impact safety standards. In the future, FHWA will require standard Task Force (TF) 13-format CAD details along the typical system details when requests for hardware acceptance are made.

MwRSF prepares 2-D and/or 3-D CAD details for newly developed roadside safety features that are subjected to full-scale vehicle crash testing. The CAD details used to describe the as-tested systems or components are not always prepared and presented in the same format as now required by AASHTO TF 13 and FHWA. As such, additional CAD details and background information must be prepared when FHWA acceptance is sought under MASH or when the new system or associated components are submitted for inclusion in the electronic version of the barrier hardware guide.

Objective: For all new barrier hardware, the member states request that MwRSF seek formal FHWA acceptance and placement of standardized TF-13 CAD details in the electronic version of the highway barrier guide. This funding shall be used to supplement the preparation of the TF-13 format CAD details.

Tasks:

1. Prepare CAD details for Hardware Guide

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Continue updating the drawings reviewed online by the barrier and component review group during the AASHTO TF-13 meetings.

Anticipated work next quarter:

Continue to update drawings based on comments received from online review of drawings.

Significant Results:

This project is used to supplement the preparation of the TF-13 format CAD details. Previously, it was determined that there are 14 systems and 11 components that need to be prepared in the TF-13 format. During discussions with the AASHTO TF-13 subcommittee in July 2011, new components had to be generated from the existing system drawings. Thus, the original 11 components became 32. Two of the systems and one component had limited work that need to be completed on the drawings as they were to be included in the Bridge Rail Guide and Luminaire Guide, respectively.

In evaluating the separation of the components, it was determined that some could be combined into one drawing based on the same type of component, but just one varying parameter.

Summary of original list created in 2011 of Barrier Drawings through 2014 Quarter 3:
31 systems - 31 approved
41 components - 41 approved
2 systems submitted to Bridge Rail Guide
1 component submitted to Luminaire Guide

Summary of new systems and components since 2014 Quarter 2 to be submitted yet: (Note a majority of the work is being completed under the original system projects):
8 systems
13 components

Task % Complete

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Funding from Project No.: RPFP-13-TF13 – TPF-5(193) Supplement #53, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans will be used prior to starting this project. All funding from previously mentioned project has been exhausted.

Potential Implementation:

Newly-developed highway safety hardware will be contained in the electronic, web-based guide, thus promoting the standardization of barrier hardware across the U.S. and abroad.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #68	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Minimum Offset for Standard MGS Adjacent to 2H:1V Slope		
Name of Project Manager(s): Ron Faller, John Reid, Bob Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211100001	**Other Project ID (i.e., contract #):** RPFP-14-MGS-8	**Project Start Date:** 7/1/2013
Original Project End Date: 6/30/16	**Current Project End Date:** 6/30/16	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$89,991.00	$75,240.00	85%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,437.00	

Project Description:

W-beam guardrail is often used to protect motorists from steep roadside slopes adjacent to high-speed roadways. A roadside slope placed immediately behind a guardrail system greatly reduces the soil resistance associated with lateral deflection of the barrier. This reduction in the post-soil forces greatly reduces a system's energy-absorption capability, significantly increases dynamic rail deflections, and can potentially produce issues with vehicle capture or vehicle override. Further, when the guardrail extends over the embankment, the gap between the bottom of the rail and the ground will be greatly magnified and thereby increase the risk of severe wheel snag.

The MGS guardrail system has greatly improved the safety performance and stability of guardrail installed at the slope breakpoint of slopes as steep as 2H:1V. However, current MGS installations adjacent to 2H:1V slopes utilize increased length posts in order to provide sufficient embedment to generate the proper soil resistive forces. This requirement creates issues with state DOT hardware inventories and maintenance due to the need to stock and maintain non-standard length posts. In order to reduce hardware inventories, states have chosen in some cases to install the standard MGS system at an offset from the slope. Current guidance requires a minimum offset of 1 ft to 2 ft from the back of the post to the the slope breakpoint for the standard MGS system with 6-ft long posts depending on the slope grade. This large offset maintains the safety performance of the system but creates a great deal of additional expense in terms of earthwork. Thus, a need exists to evaluate a minimum offset for the standard MGS guardrail system adjacent to a 2H:1V fill slope in order to reduce current issues with state hardware inventories and earthwork costs.

The objective of this research effort is to evaluate the minimum offset for installation of the standard MGS guardrail system with 6-ft long W6x9 posts spaced at 75 in. on centers adjacent to a 2H:1V fill slope. The evaluation will focus on a system with the posts installed at the slope break point of a 2H:1V slope. The minimum offset will be evaluated through one full-scale crash test according to the TL-3 impact criteria in MASH for test designation 3-11.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

MwRSF completed the full-scale crash test of the MGS guardrail system with 6-ft long W6x8.5 posts spaced at 75 in. on centers adjacent to a 2H:1V fill slope. On August 14th, the standard MGS (6-ft W6x8.5 posts and 12" blockouts) installed with the centerline of the posts at the slope break point of a 2:1 slope was subjected to AASHTO MASH TL-3 test conditions using a 2270P pickup truck vehicle (test designation 3-11). In test no. MGSS-1, the pickup truck impacted the system at a speed and angle of 61.6 mph and 26.2 degrees, respectively, resulting in an impact severity of 123.7 kip-ft. The system adequately contained and safely redirected the pickup truck. The occupant impact velocities and occupant ridedown accelerations were within the suggested limits provided in MASH. The maximum lateral deflection of the system and working width of the system were approximately 73 in. and 77.5 in., respectively. The test was acceptable according to the safety performance criteria of AASHTO MASH for test designation no. 3-11.

The final documentation of that crash test has been completed and the effort to write the research report is underway. At this time, the initial draft report for the research is complete, and the report is going through internal review and edits at MwRSF prior to being submitted to the Midwest Pooled Fund states for comment.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will complete the internal reviews and edits of the summary report and submit the report to the MwRSF Pooled Fund members for comments. Once the report is complete an FHWA eligibility submission for the system will be made by MwRSF.

Significant Results:

One full-scale crash test of the MGS guardrail system with 6-ft long W6x8.5 posts spaced at 75 in. on centers adjacent to a 2H:1V fill slope was completed and the results met the MASH safety requirements.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

Determination of the minimum offset for the standard MGS guardrail system adjacent to a 2H:1V fill slope will result reduced embankment earthwork required for guardrail installations on slopes and reduced state DOT hardware inventories for the MGS system. These benefits will provide for a decrease in project costs to the states while still providing a safe barrier system.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #69 MwRSF Project No. RPFP-14-MGS-11	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title: MGS Working Width for Lower Speed Impacts		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211101001	**Other Project ID (i.e., contract #):** RPFP-14-MGS-11	**Project Start Date:** 7/1/2013
Original Project End Date: 6/30/2016	**Current Project End Date:**	**Number of Extensions:**

Project schedule status:

☐ On schedule ☐ On revised schedule ☑ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$49,044	$31,888	99%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$14,744	

Project Description:

The Midwest Guardrail System (MGS) has been crash tested and accepted for use according to MASH TL-3 safety performance criteria. However, the MGS may be placed adjacent to roadways with reduced speed limits and ADT's that warrant a barrier with a lower test level, e.g., TL-1 or TL-2. Currently the same MGS system is used in these situations for consistency and ease of installation and maintenance. The working width required for the MGS is expected to be lower when evaluated at the TL-2 or TL-1 impact conditions. However, no research has been done to date to determine the dynamic deflections and working width values of the MGS at these lower test level conditions. Evaluation of these working widths may lead to significant savings on roadways warranting lower test level barriers where the clear space is not available.

The objective of this research effort is to provide dynamic deflection and working width recommendations for the standard MGS system and the MGS system installed adjacent to a 6-in. tall curb at the MASH TL-1 and TL-2 impact conditions. These deflections shall be determined through LS-DYNA computer simulation. It is anticipated that the research effort will be conducted in two phases. The first phase will evaluate the dynamic deflection and working width of the standard MGS system on level terrain. The second phase will evaluate the dynamic deflection and working width of the standard MGS system with a 6-in. offset from a 6-in. tall curb.

Objectives / Tasks:

Phase I - Evaluation of Standard MGS (Completed)

1. LS-DYNA computer simulation
2. Summary Report

Phase II - Evaluation of MGS installed with a 6" curb (In Progress)

1. LS-DYNA computer simulation
2. Summary Report

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Final simulations were completed for the scenarios of MGS installed in conjunction with a 6-in. AASHTO Type B curb. Results were tabulated and analyzed, and alternative applications to reduce MGS working widths were explored and considered. An internal draft of the report was completed, revised, sent to sponsors.

Anticipated work next quarter:

The draft report will be revised based on comments from state DOTs. The report will then be finalized, printed, and provided to sponsors.

Significant Results:

The MGS model has been validated and calibrated against TL-3 impacts. Simulations of lower speed impacts have begun, but definitive results have not yet been recorded.

Objectives / Tasks:	% Complete
Phase I - Evaluation of Standard MGS	
1. LS-DYNA computer simulation	100%
2. Summary Report	100%
Phase II - Evaluation of MGS installed with a 6" curb	
1. LS-DYNA computer simulation	100%
2. Summary Report	100%
Draft Report Sent to Sponsors	100%
Final Report Sent to Sponsors	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

Determination of the dynamic deflection and working width of the MGS system with and without curbs at lower test levels would provide for more installation options of the MGS in areas where a lower test level barrier system is warranted but space for placement of the barrier is limited. In addition, installation costs may decrease as the need to move hazards and provide additional clear area behind the MGS system will be reduced.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Iowa DOT

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #73	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Attachemnt of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase I		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Bielenberg, Faller, Reid, Rosenbaugh	(402) 472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130087001		2/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/2015	7/31/2015	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$50,891.00	$37,799.00	85

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$1,678.00	

Project Description:

The research objective is to design and evaluate alternative epoxy adhesive anchorages for use in the laDOT BR27C combination bridge rail system. The alternative epoxy adhesive anchorages would be developed to have equal or greater capacity than the current cast-in-place anchorage, so that they can be used in new construction or as a retrofit to modify existing bridge railings. The proposed epoxy attachment designs will be evaluated through dynamic component testing.

The research effort will consist of redesign, testing, and evaluation of alternative epoxy adhesive anchorage systems for attaching the beam and post system to the concrete parapet according to the details for the BR27C combination bridge railing. This first task in this effort would be for MwRSF to review the current cast-in-place anchorage design and develop alternative epoxy adhesive anchorage configurations. This effort could include an inline anchor system and/or a four anchor system similar to the cast in place configuration but with spacing more compatible with the clearances required for a drill in system. The alternative epoxy adhesive anchorage systems would be submitted to laDOT for review and selection of the one or two preferred systems to be tested and evaluated.

Dynamic component testing will be used to evaluate the proposed epoxy adhesive anchorages and to demonstrate that the capacity of the proposed epoxy anchorages was equal to or greater than the existing cast-in-place anchorage system. The capacity of the current cast-in-place anchorage has not been fully quantified with testing. Thus, one dynamic component test would be performed on the post using the current cast-in-place anchorage configuration. Additional dynamic component tests would also be performed on the proposed alternative epoxy adhesive anchorage systems. The target impact conditions for all tests would be identical. The tests would be configured so that the applied impact load would occur at a height on the post/rail in order to produce a bending moment in the post and combined loading on the anchorage system similar to that provided during vehicle crash events. The force versus deflection, energy dissipated versus deflection, and failure modes would be documented for each test and compared to one another. These comparisons would be used to verify that the proposed anchorages provided equal or greater capacity than the current

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

MwRSF sent the updated research costs reflecting the revised project scope to laDOT on April 14, 2015.

As noted in the previous progress report, the testing of the original BR27C attachment and the three proposed epoxy anchorage configurations was analyzed, compared and sent to the sponsors. Force versus deflection curves from all four tests were compared. All of the alternative anchorages exceeded the capacity of the cast-in-place anchorage. Thus, all three of the alternatives should be acceptable.

MwRSF is currently finalizing on the report for this testing. It is anticipated that the summary report will be completed in July 2015.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will complete the work to create a summary report to document the results of the study.

Significant Results:

None.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

As noted previously, changes to the project scope have affected the budget of the research to some degree. However, laDOT agreed to the revised scope and budget changes. MwRSF will work with laDOT with regards to any changes to the scope and budget.

Potential Implementation:

The development of alternative epoxy adhesive anchorage systems for use in laDOT combination bridge rails would provide for simpler and more cost-effective construction of combination bridge rails. The new designs would also provide more effective options for new and retrofit construction.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #74	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Redesign of Low-Tension, Cable Barrier Adjacent to Steep Slopes		
Name of Project Manager(s): Faller, Reid, Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211106001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2014
Original Project End Date: 12/31/15	**Current Project End Date:** 12/31/2015	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$124,345	$11,167	30%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$3,490	

Project Description:

Previously, the MwRSF investigated the performance of low-tension cable barrier adjacent to slopes as steep as 1.5H:1V. Full-scale crash testing of the standard, non-proprietary, cable system offset 12" from the slope breakpoint resulted in the 2000P vehicle overriding the barrier and rolling over. Subsequently, the post spacing was reduced from 16' to 4' and the barrier offset was increased to 4'. A second full-scale crash test on this modified system resulted in a successful TL-3 test with the 2000P. While the design modifications provided safe redirection, there were some drawbacks. The closely spaced posts have been difficult and costly to install, and the additional lateral offset from the slope break point can also be difficult to achieve in practice. Thus, a need exists to reconsider the cable barrier adjacent to slope design.

The objective of this study is to review the design of the low-tension cable barrier adjacent to a steep slope and determine design modifications to improve its Implementation, such as increased post spacing and reduced lateral barrier offset. Additionally, cable heights and tensions, attachment hardware, and even system posts may be altered to improve crash performance. Future full-scale vehicle crash testing according to MASH TL-3 criteria would be used to evaluate the modified system in Phase II of the project (currently unfunded)

Major Task List

1. Literature review of cable barrier on/adjacent to slopes
2. Concept Design
3. Component Testing of Post Configurations
4. LS-DYNA model development, validation, and calibration
5. LS-DYNA simulation of various cable barrier modifications
6. CAD details of proposed cable system designs
7. Preparation of research report and recommendations for future research
8. Preparation of Technical Brief for NDOR.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, it was decided to stay with current hardware components for this new system, specifically S3x5.7 posts, J-bolt attachments, and a low-tension 3 cable layout. The post was selected over the new Midwest Weak Post (MWP) due to its additional strength that may help reduce deflections and keep the vehicle stable on steep slopes. J-bolts were selected as a cost effective alternative to the newer tabbed brackets utilized in the MwRSF's new high-tension cable system (which wouldn't serve much purpose when all the cables are on the same side of the post. Finally, a low-tension 3-cable system allows the use of NDOR's current anchorage system. If necessary, the components of this preliminary design may be later changed to satisfy performance standards.

This quarter, a component testing of S3x5.7 posts on level terrain and adjacent to slope was conducted. Component testing began with two baseline tests with posts installed on level terrain. Both of the level terrain tests showed post yielding and rotation in the soil with average force levels through 15" of deflection of approximately 5.4 kips.

Subsequent post tests were conducted with the posts incrementally shifted toward a 1.8:1 slope-break-point until a significant loss of resistance was observed. Additionally, the post's soil plate for these test was placed on the front of the post rather than the back in order to provide for development of higher soil resistive forces. Tests were conducted at offsets of 2', 1', and 6" from the slope-break-point of the 1.8:1 slope. The tests at the 1' and 2' offsets found that similar force-deflection levels could be maintained at these offsets. The force levels for the 6" offset was reduced from the baseline tests due to large displacement of the soil behind the post. Thus, it appears that offsets as low as 1' may be feasible for the cable barrier adjacent to steep slope. No work was done at this time to revise the soil plate for placement closer than 1' from the slope-break-point.

A sixth dynamic component test was conducted on the S3x5.7 post in order to examine the potential for floorboard

Anticipated work next quarter:

Work shall begin on the development of the LS-DYNA model of the cable system adjacent to slope.

The scope of the research effort may potentially be altered based on the floorboard testing mentioned above and the feedback from the TAC.

Significant Results:

The literature review of all full-scale tests on cable barrier systems adjacent to or within slopes was completed and summarized in a table. A preliminary design was established, and a component testing methodology was determined.

Major Task List	% Complete
1. Literature review of cable barrier on/adjacent to slopes	100%
2. Concept Design	75%
3. Component Testing of Post Configurations	80%
4. LS-DYNA model development, validation, and calibration	5%
5. LS-DYNA simulation of various cable barrier modifications	0%
6. CAD details of proposed cable system designs	0%
7. Preparation of research report and recommendations for future research	0%
8. Preparation of Technical Brief for NDOR.	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

The results of the floorboard testing of the S3x5.7 posts will need to be discussed with the TAC in order to determine the potential to proceed with the existing post section.

Potential Implementation:

Redesign of the low-tension cable barrier adjacent to steep slopes would provide roadway designers with a lower cost and more-easily implemented solution for shielding steep slopes that would still provide safe redirection of errant vehicles.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #75	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Length of Need for Free-Standing, F-Shape, Portable 12.5' Concrete Protection Barrier		
Name of Project Manager(s): Ron Faller, Bob Bielenberg, John Reid	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211107001	**Other Project ID (i.e., contract #):** RHE-08	**Project Start Date:** 7/1/2014
Original Project End Date: 12/31/15	**Current Project End Date:** 12/31/15	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$189,820.00	$6,197.00	40%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$1,487.00	

Project Description:

The objective of this research effort is to investigate and evaluate the safety performance of the previously developed F-shape PCB system in order to determine minimum system length and the number of barriers required for the beginning and end of the length of need. It is proposed that the system be evaluated according to the TL-3 criteria set forth in MASH. Two full-scale crash tests would be conducted to evaluate the performance of PCB system in order to evaluate its safety performance and investigate its dynamic deflection. The research effort will be split into two phases. Phase I, will be conducted to investigate the F-shape PCB system through computer simulation modeling in order to determine minimum system length and the number of barriers required for the beginning and end of the length of need. Phase II, would consist of the full-scale crash testing required to validate the system length and beginning and end of length of need recommendations from Phase I.

Phase I

The research effort for Phase I will begin with LS-DYNA computer simulation of the F-shape PCB system. Previous research efforts at MwRSF involving the F-shape PCB have developed reasonably accurate computer simulation models of the free-standing F-shape PCB system. These models will be used to analyze PCB system length and beginning and end of the length of need requirements. Four cases are proposed for analysis.

1. Simulation of the minimum number of PCB segments required on the upstream end of the barrier installation for a long overall system length.
2. Simulation of the minimum number of PCB segments required on the downstream end of the barrier system for a long overall system length.
3. Simulation of the minimum number of PCB segments required on the upstream end of the barrier system for a minimum overall system length.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

During this quarter, MwRSF completed simulation of impacts on the upstream and downstream ends of the 200 ft long barrier system to determine the length of need. Simulations were conducted at seven impact points on the upstream of end of the barrier system and eight impact points on the downstream end of the barrier system. These simulations were then reviewed to determine where the length of need starts and ends for the long system. Review of the beginning of length-of-need models found that the simulations models predict vehicle redirection for impacts as far upstream as the first barrier segment. However, barrier system deflections, joint loads, and vehicle stability tended to become significantly worse when impacting on the first three barrier segments downstream of the the end of the system.

Similarly, when the simulations of vehicle impacts for determination of the end of length-of-need were reviewed, impacts as far downstream as the second to last barrier segment displayed the potential for vehicle redirection. Impact on the last barrier segment partially redirected the vehicle but demonstrated more of a gating behavior. Barrier system deflections, joint loads, and vehicle stability tended to become significantly worse when impacting on the last three barrier segments downstream of the the end of the system.

Base on these results, it was determined that three barriers will be recommended for both the beginning and the end of length-of-need for the TCB system, until the results can be further discussed with the TAC. The next step of the simulation analysis was to conducted impacts at the selected beginning and end of length-of-need lengths for a reduced system length in order to verify that the length-of-need definitions work for shorter lengths and to examine the minimum potential length of the TCB system. Simulation models are currently being evaluated using a seven barrier long TCB system. The results of these models have not be evaluated.

These findings will be discussed in detail at the upcoming July 21st TAC meeting in order to determine what scenarios the

Anticipated work next quarter:

In the next quarter, MwRSF will continue the simulation effort for determining minimum system length and the number of barriers required for the beginning and end of the length of need. The researchers will continue evaluation of the simulation models of impacts on reduced system lengths to determine a minimum system length. The simulations will also be used to determine deflections for the reduced system lengths.

Recommendations for full-scale testing of the minimum system length will be developed based on the simulation results and simulations investigating the 85% impact severity on both the standard length and reduced length systems will be performed.

Significant Results:

Simulations of various impact points on the upstream and downstream end of the PCB system for determining the length of need were evaluated and preliminary beginning and end of length-of-need definitions were chosen.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

Evaluation of the F-shape PCB minimum system length and the number of barriers required for the beginning and end of the length of need will provide NDOR with improved and validated guidance for their PCB system configurations. These guidelines will improve the safety of PCB installations and may potentially shorten the number of barriers used in these types of installations. This will improve the flexibility of the PCB systems and reduce the number of impacts. The research would also define the increase in barrier deflection for shorter system lengths and better define necessary clear areas behind the PCB segments in work zones.

MwRSF will work closely with NDOR engineers and the TAC committee throughout the evaluation of the LON for PCB systems in order to ensure that the research effort meets the project goals and supplies adequate information to NDOR. This should ensure that the results of the study are viable for NDOR as well as state DOT's across the country.

The dissemination of the research results will be made through the use of a final report describing the computer simulation and investigation of PCB system lengths and the full-scale testing used to evaluate the proposed guidelines. In addition, the results of the research effort will be published as a paper in a refereed journal, if warranted. Following the completion of the study, the results of the study will be disseminated by MwRSF personnel in future NDOR transportation presentations given to State DOTs and to participants of technical engineering conferences, industry meetings, trade shows, and conventions so that dissemination and distribution of the final research results will provide the most significant impact in terms of safety benefit for the motoring public.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #76	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:
Development of a TL-3 Transition between Temporary Free-Standing, F-Shape 12.5' Concrete Protection Barrier and Guar

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Ron Faller, Bob Bielenberg, John Reid	402-472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211108001	RHE-11	7/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
12/31/15	12/31/15	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$213,677.00	$7,600.00	20%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$4,704.00	

Project Description:

The objective of this research is to evaluate the safety performance of the transition between guardrail and free-standing F-shape TCB developed in Phase I of the research effort. The safety performance evaluation is to be conducted according to the TL-3 impact safety standards published in MASH.

The research effort for Phase II would consist of final design, fabrication, and testing of the TL-3 transition between temporary concrete barrier and guardrail selected by the sponsor from Phase I. Design details of the proposed transition would be fully developed in three-dimensional CAD software. Next, fabrication and installation of the transition system would be completed at the MwRSF's full-scale crash test facility. It is anticipated that three full-scale crash tests would be required to fully evaluate the transition system. These tests would include MASH test designation nos. 3-20 and 3-21 which are tests to evaluate the design of the barrier transition with 1100C small car and 2270P pickup truck vehicles. In addition, it is anticipated that a reverse direction impact of test designation no. 3-21 with the 2270P vehicle would be required for evaluation of the transition for installations that require two-way traffic adjacent to the barrier. Following the completion of the full-scale crash testing, a summary report will be completed detailing the evaluation effort as well as providing guidance for implementation of the new transition design. MwRSF will also prepare a technical brief and a PowerPoint presentation of the research results to NDOR at the completion of the project.

Major Task List:

1. Project planning and correspondence
2. Development of design details in 3D CAD and review by TAC
3. Fabrication of hardware and installation at MwRSF test site.
4. Three full-scale crash tests according to TL-3 of MASH.

a. MASH test no. 3-20 with the 1100C small car

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

MwRSF previously submitted the final CAD details for the first full-scale test of the guardrail to PCB transition system to the field crew at the MwRSF Outdoor Test Facility for placement into the testing que. All of the materials and hardware for the testing have been ordered and/or fabricated. It is anticipated that the testing of the system will be conducted in the 3rd quarter of 2015.

The first full-scale test will be MASH test designation no. 3-21, which will evaluate the transition from the guardrail to the PCB system by impacting upstream of the connection between the two systems. The test matrix is listed below.

1. Test no. 3-21 - Impact of the 2270P vehicle on the centerline of the fifth guardrail post upstream from the end-shoe attachment at a speed of 62 mph and an angle of 25 degrees.
2. Test no. 3-21R - Reverse direction impact of the 2270P vehicle 12 ft – 6 in. upstream from the end-shoe attachment at a speed of 62 mph and an angle of 25 degrees.
3. Test no. 3-20 - Impact of the 1100C vehicle on the critical impact point of the guardrail to PCB transition at a speed of 62 mph and an angle of 25 degrees. MASH procedures and engineering analysis will be used to determine the critical impact point.

Anticipated work next quarter:

It is anticipated that the first full-scale test of the guardrail to PCB transition will be conducted in the upcoming quarter. The actual date for the full-scale crash testing will be determined as soon as resources are available. However, completion of the testing is dependent on the schedule of existing crash testing commitments and may not occur if projects with higher priority in the testing que prevent the test from being completed.

Significant Results:

None.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The research study is directed toward improving the safety by minimizing the risk for the motoring public traveling within our nation's work-zones and on our highways and roadways. Since W-beam guardrail has proven to provide better safety performance than temporary concrete barriers, the development of an effective transition between the two can help preserve guardrails outside the immediate work-zone area, thus providing an overall higher level of safety for motorists. The new transition would also eliminate the use of an unproven connection between guardrail and temporary barriers. Further, limiting the use of temporary concrete barriers strictly to the work zone area will also minimize the traffic disruption that these barriers can create to motorists passing in work zones.

MwRSF will work closely with NDOR engineers and the TAC committee throughout the concept development of a MASH TL-3 transition design between TCBs and the MGS in order to ensure that the system is practical, able to be constructed, and cost efficient. This should ensure that the system is viable for NDOR as well as state DOT's across the country.

The dissemination of the research results will be made through the use of a final report describing the transition development and recommendation for full-scale crash testing and publication of a paper in a refereed journal, if warranted. Following the completion of the study, results from this study will be disseminated by MwRSF personnel in future NDOR transportation presentations given to State DOTs and to participants of technical engineering conferences, industry meetings, trade shows, and conventions so that dissemination and distribution of the final research results will provide the most significant impact in terms of safety benefit for the motoring public.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl # 77	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:

Phase IIA Vehicle Dynamics Testing, Validation of Vehicle Models & Computer Simulation of Rock Ditch Liners

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Bielenberg, Faller, and Lechtenberg	(402) 472-3084	jreid@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130089001		6/30/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2017	6/30/2017	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$110,000	$7,444	10%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$6,105	

Project Description:

The primary research objective for this study includes the continued development of safety guidelines for use in the design and placement of ditch liners and check dams along highways and roadways. During the Phase I effort and as part of the initial research funding, preliminary safety guidelines were proposed along with a preparation of a research plan for use in their future evaluation. At this time, the Wisconsin Department of Transportation has deemed the preliminary guidelines viable and has requested that continued research be performed to further evaluate and modify the guidelines using computer simulation and full-scale vehicle crash testing.

Due to the significant scope of this ongoing research program, the study has been split into multiple phases. The objective for each specific phase is listed below:

Phase I - Develop preliminary guidelines for the safe construction of rock ditch liners and rock check dams – (Completed 2011)

Phase II - Conduct LS-DYNA computer simulation to develop critical crash testing matrix for evaluating vehicular impacts into rock ditch liners and rock ditch checks.

This current project is a subset of Phase II. This subset is limited to simulation of a 1100c vehicle over a 1:1 slope ground rock ditch liner and one full-scale crash test of such.

Phase III - Perform a series of full-scale crash tests on rock ditch liners and check dams placed in a traversable ditch.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Further preliminary investigation with LS-DYNA was conducted to determine meaningful impact conditions for full-scale testing. It was observed that faster impacts and longer traversal times over the rough terrain led to larger instabilities. Plans for full-scale testing were developed based on site constraints, vehicle time spent traversing the rocks, and braking runout distance. Plans were discussed and revised based on sponsor comments. Local quarries were contacted, quotes were obtained, and the layout for the full-scale test was established at the test site.

Anticipated work next quarter:

A brief survey will be conducted to determine which state DOTs utilize rock ditch liners, and obtain details of the liners in use. The test area will be prepared by cutting a no-grade/no-slope trench and filling it with rocks per Wisconsin specifications, measuring 150 ft long and approximately 20 ft wide with a slight flare. Full-scale testing will be conducted at 45 to 50 mph with a Toyota Yaris vehicle for comparison with available LS-DYNA vehicle models.

Significant Results:

None to date.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

Rock ditch liners are a convenient method of controlling erosion and improving water runoff. If rock ditch liners can be proven to be safe and traversable for errant vehicles, these liners may be used in erosion-sensitive locations adjacent to federally-funded highways.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl # 78	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Transition from Free-Standing TCB to Reduced Deflection TCB		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Schmidt, Bielenberg, Faller, and Reid	(402) 472-0870	jennifer.schmidt@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130090001		6/30/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2017	6/30/2017	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$95,852	$2,394	2.5%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
$877 (1%)	$877	

Project Description:

Recently, the Wisconsin Department of Transportation sponsored a research project to develop a retrofit design for reducing deflections for temporary concrete barriers (TCB) without anchoring the barriers to the bridge deck or roadway. This research was successful in reducing the deflection of the TCB system, as the addition of steel tubes to both the front and back sides of the barrier reduced the deflection of the TCB system by roughly 50 percent. However, the effort was focused on developing the length-of-need of the system and did not include design of a transition between the reduced deflection TCB system and standard F-shape TCB segments. Thus, a need exists to develop a transition between the new reduced deflection system and free-standing TCB segments.

The objective of this research effort is to develop a MASH TL-3 transition between the recently developed reduced deflection TCB system and free-standing, F-shape TCB segments. The research effort will focus on development of a design that safely transitions between the stiffness and deflection of the two barrier systems while maintaining vehicle stability. The design will also focus on minimizing the length of the transition and additional hardware components. Phase I of this project will involve initial development and computer simulation of the transition design (work described herein). Phase II of the project (currently unfunded) will include full-scale crash testing to evaluate the transition.

Main Objectives/Tasks

1. Literature Review
2. Concept Development
3. Selection of Transition Design
4. LS-DYNA Analysis and Evaluation
5. Project Report

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

A meeting was held to brainstorm concepts for the transition. The simplest transition would be to terminate the tubes and taper it to the face of the F-shape TCB at a 5:1 or 6:1 taper. This will be evaluated with some initial simulation to determine if pocketing, vehicle snag, or excessive vehicle climb occurs due to the tube termination. Other concepts involve a longer transition section in which the tubes are continued and tapered, without a cap at the joints or with other mechanisms depending on how gradual the stiffness change needs to be.

Initial Solidworks drawings were created of the concept.

Anticipated work next quarter:

The initial model with a simple tube taper will be created in LS-DYNA and simulations will be ran to determine how the tube taper effects the vehicle stability and system performance.

Significant Results:

None to date.

Main Objectives/Tasks	% Complete
1. Literature Review	100%
2. Concept Development	40%
3. Selection of Transition Design	30%
4. LS-DYNA Analysis and Evaluation	0%
5. Project Report	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

Development of a crashworthy transition system between the reduced-deflection TCB system and freestanding TCBs would provide states with a robust TCB system capable of reducing deflections without anchoring to the road surface. In addition, the system can be used in median applications and could be attached to standard, free-standing TCB segments on each end to allow for easier implementation and integration with existing work zones.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #79	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
TL-4 Evaluation of the Midwest High-Tension, 4-Cable Barrier		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Lechtenberg, Bielenberg, Rosenb	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211096001	RPFP-15-CABLE-1	8/1/14
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/17	7/31/17	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$408,235	$0	0

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$0	

Project Description:

The Midwest Roadside Safety Facility (MwRSF) has been conducting research for the Midwest States Regional Pooled Fund Program to develop a non-proprietary, high-tension, four-cable, median barrier that is capable of being used anywhere in a V-ditch with 4H:1V side slopes. Three tests still remain to complete the test matrix of the cable barrier system in a V-ditch. In addition, the four-cable, high-tension, median barrier has never been tested on level terrain. There is a concern that FHWA may not approve this design without testing on flat ground, especially when considering the wide cable spacing and increased cable heights. Further, the barrier deflections observed in crash tests performed in a 4H:1V V-ditch are likely higher than would be observed on flat ground. Crash testing of the barrier installed on level terrain would identify barrier deflections and working widths that can be expected when the barrier is used in narrow medians with gentle slopes and would allow for better performance comparisons between the Midwest four-cable barrier and other proprietary systems.

Objective: To complete the development, testing, and evaluation of the four-cable, high-tension, median barrier system for use on level terrain.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

None.

This is additional funding to continue the development of the Midwest Four-Cable, High-Tension, Median Barrier once the funds from the other projects are exhausted (Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #44, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-ditch, Project No. RPFP-12-CABLE1&2 – TPF-5(193) Supplement #45, Project Title: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase II, Level Terrain, and Project No.: RPFP-14-CABLE-1 - TPF-5(193) Supplement #64, Project Title: Continued Development of the Midwest Four-Cable, HT, Median Barrier (Continuation)).

See Project No.: RPFP-14-CABLE-1 – TPF-5(193) Supplement #64, Project Title: Continued Development of the Midwest Four-Cable, HT, Median Barrier (Continuation) for a detailed explanation of the work completed this quarter.

Anticipated work next quarter:

None

Significant Results:

None

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This project is an extension to previous projects (RPFP-08-02: Four-Cable Median Barrier in 4:1 V-Ditch; RPFP-09-01: New Funding for High-Tension Cable Barrier on Level Terrain with New Cable Attachment; RPFP-10-CABLE-2: Replacement Funding for High-Tension Cable Barrier on Level Terrain; RPFP-12-CABLE1&2: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase I, V-Ditch; RPFP-12-CABLE1&2: Completion of the Development and Evaluation of the Midwest Four-Cable, High-Tension, Median Barrier Phase II, Level Terrain; RPFP-14-CABLE-1 - TPF-5(193) Supplement #64, Project Title: Continued Development of the Midwest Four-Cable, HT, Median Barrier (Continuation)).

Potential Implementation:

The successful completion of the development, testing, and evaluation of the Midwest four-cable, high-tension, median barrier on level terrain will allow the member states to implement a non-proprietary, high-tension, cable system along our nation's highways and roadways. In addition, the crash testing of the four-cable, high-tension, median barrier on level terrain would also provide a more complete understanding of barrier performance (i.e., dynamic deflections, working width, etc.) when used in relatively flat, narrow medians. The crash results from the level terrain testing will be used in combination with computer simulation to evaluate the effects of reduced post spacing. The successful completion of this project along with the non-proprietary four-cable, high-tension, median barrier in V-ditch and cable guardrail end terminal would help to assure acceptance by FHWA and improve its chances for widespread implementation.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #80	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: MGS Guardrail with an Omitted Post		
Name of Project Manager(s): Ron Faller, John Reid, Bob Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211112001	**Other Project ID (i.e., contract #):** RPFP-15-MGS-5	**Project Start Date:** 8/1/2014
Original Project End Date: 7/31/2017	**Current Project End Date:** 7/31/2017	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$99,973.00	$34,168.00	40%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$32,639.00	

Project Description:

The objective of this research effort is to develop guidelines for MGS installations with a single omitted post for clearance of obstacles. The research would attempt to focus on the omission of a post without the use of CRT posts adjacent to the unsupported span. Full-scale crash testing would be conducted to evaluate the use of a single omitted post according to the TL-3 impact safety requirements in MASH. Following successful full-scale crash testing, additional analysis would be conducted to evaluate the potential for omission of a single post in multiple locations in a run of guardrail and the corresponding minimum spacing between the omitted posts.

The research effort will begin with the construction of the MGS with a single omitted post at the MwRSF Outdoor Test Facility for evaluation. The system will be evaluated according to the MASH guidelines for test designation no. 3-11 with the 2270P pickup truck vehicle. It is believed that the 1100C vehicle test can be waived for this system because the 2270P vehicle will provide a more stringent test of the failure modes expected in with the omitted posts such as excessive dynamic deflection, pocketing, vehicle snag, and rail rupture. The CIP for this test will be selected based on maximizing the potential for vehicle pocketing and post snag using the CIP charts in MASH and the researchers engineering judgment. The full-scale vehicle crash test will be conducted, documented, and evaluated by MwRSF personnel and in accordance with the MASH guidelines.

Following the successful full-scale crash testing, results from the crash testing will be applied to estimate potential concerns associate with multiple single omitted posts that are spaced apart in a run of MGS guardrail. Results from the full-scale test would also be analyzed to provide further guidance on allowable spacing between omitted posts based on the behavior of the guardrail system during the test.

After completion of the full-scale crash testing, a summary report of the research project will be completed detailing the tested barrier system, full-scale crash test results, evaluation of barrier performance, additional analysis, and

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, MwRSF began the research effort to investigate the MGS with a single omitted post. Prior to conducting a full-scale crash test, MASH requires selection of a critical impact point (CIP) for the test. In order to determine the CIP for the MGS with a single omitted post, BARRIER VII was used to simulate impacts a various points along an MGS system with a single post removed. The BARRIER VII analysis looked at several factors, including maximum rail deflection, maximum rail tensile forces, vehicle snag on posts, and pocketing of the barrier. Based on this analysis, it was determined that an impact ¾ of the way between post nos. 11 and 12 was critical as it displayed the highest level of vehicle snag and rail deflection and the the second highest rail forces. Pocketing was not significant for any impact point.

CAD details for the tested system were completed and the details were sent to the MwRSF Outdoor Test Facility for placement in the test que during the 4th Quarter of 2014.

On April 29th, 2015, the standard MGS (6-ft W6x8.5 posts and 12" blockouts) with an omitted post was subjected to AASHTO MASH TL-3 test conditions using a 2270P pickup truck vehicle (test designation 3-11). In test no. MGSMP-1, the pickup truck impacted the system at a speed and angle of 63.4 mph and 25.3 degrees, respectively, resulting in an impact severity of 121.3 kip-ft. The system adequately contained and safely redirected the pickup truck. The occupant impact velocities and occupant ridedown accelerations were within the suggested limits provided in MASH. The maximum lateral deflection of the system and working width of the system were approximately 49 in. and 50 in., respectively. The occupant crush measurements have not been completed yet, but we do not anticipate any exceeding the limits provided in MASH. Therefore, we can tentatively say that the test was acceptable according to the safety performance criteria of AASHTO MASH for test designation no. 3-11.

The summary report of the research is currently in the MwRSF report que and is in the process of being completed.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will continue the documentation and summary report for this research.

Significant Results:

Test No. MGSMP-1 was conducted on April 29th, 2015. The MGS system successfully redirected the 2270P vehicle with a single omitted post.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

The successful development and evaluation of a MGS guardrail with omitted posts would provide states with a potentially simpler and less-costly alternative for dealing with post conflicts within a run of guardrail.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #81 MwRSF Project No. RPFP-15-AGT-1	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Standardized Concrete Parapet for Use in Thrie Beam AGT's		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Rosenbaugh	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211113001	RPFP-15-AGT-1	8/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/2017	7/31/2017	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$125,906	$6,678	20%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$2,147	

Project Description:

Although most approach guardrail transitions (AGTs) look similar, each AGT has a unique combination of features including rail thickness, post size and spacing, use of a hydraulic curb, and downstream parapet or bridge rail in which it attaches to. However, due to the sensitivity of transition regions, these variables are not interchangeable between AGTs. Thus, each AGT is specific to its own features as well as the bridge railing or parapet to which it is anchored.

Crash testing has illustrated the sensitive nature of these AGT designs with recent failures occurring due to an alteration of an AGT feature (e.g., addition/removal of a curb or changes to the rigid parapet geometry and attachment hardware). The majority of these failures have been the result of excessive vehicle contact on the lower, upstream corner of the rigid parapet. This result indicates that the parapet toe and end geometry may be even more critical than previously believed. Thus, there exists a need to develop a standard concrete parapet end geometry for use with all thrie beam AGTs.

The objective of this research effort is to develop a standardized concrete parapet end section for attachment of various thrie beam AGTs.

Objectives / Tasks:

1. Literature Review
2. Parapet Design and Analysis
3. System CAD Details
4. System Construction
5. Full-scale Crash Test
6. System Removal
7. Data Analysis
8. Design Recommendations

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

Previously, a preliminary geometric design was presented and approved for continued development by the members of the Midwest Roadside Safety Pooled Fund. This design had a vertical face, was 32" tall, and a dual chamfer on its leading edge (4"x12" below the thrie beam and 4"x4" behind the thrie beam). At the Annual Pooled Fund meeting in April, preliminary drawings were presented to the group for discussion. Here it was decided to shorten the parapet length to 7 ft, raise the height of the parapet to 36" to match TL-4 bridge rail heights, and include a 6:1 vertical taper on the front end of the parapet to prevent snagging above the thrie beam. Adjustments were also necessary to the internal reinforcement to account for these shape changes and to ensure TL-4 strength.

The design alterations and the detailed drawings reflecting them have been completed. The drawings have been sent to the MwRSF testing facility for construction and evaluation under MASH TL-3. A single full-scale test with a 2270P pickup truck will be conducted on the new parapet design.

Anticipated work next quarter:

The project is now in the MwRSF testing queue. A full-scale test installation of the new standardized parapet attached to a thrie beam approach guardrail transition will be constructed at the MwRSF test site. A single full-scale test will be conducted on the test installation, a MASH 3-11 test with a 2270P pickup truck.

Significant Results:

An extensive literature review of all AGTs to concrete parapets was summarized in a reference table. The table was utilized during the design process to develop a buttress that minimizes snag while maximizes vehicle stability. Through a voting process, the states selected a dual taper design over a single taper design. The length of the parapet was shortened to 7 ft and the height was raised to 36 inches to match the height of MASH TL-4 bridge rails. Design details for the system including geometric shape and reinforcement were completed.

Objectives / Tasks:	% Complete
1. Literature Review	100%
2. Parapet Design and Analysis	100%
3. System CAD Details	95%
4. System Construction	0%
5. Full-scale Crash Test	0%
6. System Removal	0%
7. Data Analysis	0%
8. Design Recommendations	0%
9. Written Project Report - First Draft	0%
10. Written Project Report - Edits and Finalization	0%
11. Hardware Guide Drawings	0%
12. FHWA Approval Letter	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

A single design for the concrete parapet end section at the downstream end of AGTs will simplify state design standards. No longer will transitions be associated with only a single concrete parapet shape. All thrie beam transitions will be able to connect to the new parapet. The designer then only needs to transition the parapet to the proper shape and height of the bridge rail.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): NE Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl.#82	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Tree Removal Marketing Program		
Name of Project Manager(s): Reid, Faller, Lechtenberg, Bielenberg	**Phone Number:** 402-472-6864	**E-Mail** rfaller1@unl.edu
Lead Agency Project ID: RPFP-15-TREE-1	**Other Project ID (i.e., contract #):** 26112110114001	**Project Start Date:** August 1, 2014
Original Project End Date: July 31, 2017	**Current Project End Date:** July 31, 2017	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$80,815	$627	5%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$232	0%

Project Description:

Over the last 30 years, numerous studies have been conducted that resulted in guidance on tree removal and/or protection. However, this information is spread across many research reports. Consequently, decision makers often do not have all of the facts and research when deciding to remove or plant new trees. Thus, they are often making decisions without assessing the involved safety risks.

The objective of this research effort is to develop marketing strategies that would advise state DOTs and the public about the statistics and safety risks associated with roadside trees. In addition, this research should investigate methods for prioritizing treatment of the hazard posed by roadside and median trees.

Task 1 Literature Review: Review prior and ongoing studies addressing guidelines and recommendations related to roadside treatments and collisions with trees or other landscaping as well as risks associated with vehicle-tree collisions.

Task 2 State Crash Data: Review and compile selected state DOT and/or city data related to roadside tree crashes.

Task 3 Survey States: Survey all state DOTs to determine success stories for marketing and involving the use of clear zone concept, implementation of tree removal, and/or tree shielding.

Task 4 Marketing: Contact UNL-based or private marketing firms to propose approaches for compilation of data into usable marketing materials and approaches.

Task 5 Summary Report: Compile a summary report of literature search and state DOT survey results. The report will also contain information on potential firms for development of outreach materials.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

A literature review was continued regarding studies involving roadside tree safety, tree-related motor-vehicle crashes, treatment of roadside tree hazards, etc. Three marketing and advertising student workers were hired as MwRSF continued internal discussions regarding potential marketing approaches for addressing roadside tree safety. MwRSF held multiple meetings with the marketing and advertising students to review compiled material and establish a meaningful trajectory forward.

Anticipated work next quarter:

Marketing and advertising student workers will complete the background study and review, initiate a survey of the state DOTs, and brainstorm initial concepts for the marketing campaigns. They will also develop summaries in readable guides and explore means by which to provide this information publicly using social media.

Significant Results:

None

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None

Potential Implementation:

Numerous studies exist which provide recommendations on protection or removal of trees along roadsides. However, state DOTs do not have a good way to disseminate this information to their staff and the public. In addition, there is a need to make the public aware of the statistics involved with tree impacts and the safety issue that roadside and median trees pose. The collection and improved presentation of data would provide states with effective methods for educating designers, politicians, and the driving public as well as advance efforts to reduce the number of roadside trees and the associated hazard they pose to motorists.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #83	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Annual Consulting Services Support		
Name of Project Manager(s): Ron Faller, John Reid, Bob Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211115001	**Other Project ID (i.e., contract #):** RPFP-15-CONSULT	**Project Start Date:** 8/1/2014
Original Project End Date: 7/31/17	**Current Project End Date:** 7/31/17	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$50,001.00	$20,268.00	40%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$10,666.00	

Project Description:

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 and all questions and support are accessible on a MwRSF Pooled Fund Consulting web site.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

In the past quarter MwRSF has responded to a series of state inquiries. The Quarterly Progress Report summarizing these responses has been attached to this document. The summary will also be available for download at the recently completed MwRSF Pooled Fund Consulting web site - http://mwrsf-qa.unl.edu/

We are continuing to work with and improve the MwRSF Pooled Fund Consulting web site as our experience with it grows. We would ask that all Pooled Fund member states use the new site from this point forward for their inquiries and to contact us with any issues they experience with the web site.

Anticipated work next quarter:

MwRSF will continue to answer questions and provide support to the sponsors during the upcoming quarter.

We would ask that all questions be submitted through the web site so that they can be answered and archived therein.

http://mwrsf-qa.unl.edu/

Significant Results:

A quarterly summary of the consulting effort was provided and users can use the web site to search and find responses as well.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None.

Potential Implementation:

None.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #84	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Pooled Fund Center for Highway Safety		
Name of Project Manager(s): Reid, Faller, Lechtenberg, Bielenberg, Rosenb	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211116001	**Other Project ID (i.e., contract #):** RPFP-15-PFCHS	**Project Start Date:** 8/1/2014
Original Project End Date: 7/31/2017	**Current Project End Date:** 7/31/2017	**Number of Extensions:** 0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$11,468	$2,767	50%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,573	

Project Description:

Many of MwRSF's inquiries from members of the Midwest States Pooled Fund program can be answered based upon prior pooled fund or other research. Further, even though answers to pooled fund inquiries are normally routed to all pooled fund states in the quarterly progress report, there are numerous repeat questions every year. The quarterly summaries are helpful to member states, but they are temporary and not well organized by the type of question or specific topic. Many pooled fund inquiries could be answered through the development of a Center of Highway Safety web site. A dedicated and well-maintained Pooled Fund Center for Highway Safety web site would provide for all of these needs. It would provide for a searchable database of previous MwRSF inquiries and solutions, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features. This safety center would also be helpful to non-member states with problems or inquiries similar to those identified by the member states.

In Year 22, the Midwest States Pooled Fund states sponsored the development of a Pooled Fund Center for Highway Safety web site. This project allowed for the development of the first phase of the web site and archiving of materials on the web site. In the past year, a web site for the Midwest States Pooled Fund consulting questions and responses was developed and made available. The web site is currently operational and provides functions for submitting questions and inquiries to MwRSF as well as posting of the responses. It also provides a searchable database of previous MwRSF inquiries and solutions. The website is located at http://mwrsf-qa.unl.edu/.

In addition to the consulting web site, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features has been started. MwRSF is currently in the process of making this web site operational and uploading the archived reports and CAD. MwRSF anticipates that this archive will be fully functional in the near term. The report and CAD archive as well as the Midwest States Pooled Fund consulting web site will be integrated with the main MwRSF web site in the near future as well.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

See progress in Project No.: RPFP-14-PFCHS – TPF-5(193) Supplement #66, Project Title: Pooled Fund for Highway Safety.

Anticipated work next quarter:

None

Significant Results:

None.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

This is a continuation of funding for the original project started in Pooled Fund Year 22, Project No.: RPFP-12-PFCHS-1 – TPF-5(193) Supplement #48, Project Title: Pooled Fund for Highway Safety. Funding from Project No.: RPFP-13-PFCHS – TPF-5(193) Supplement #60, Project Title: Pooled Fund for Highway Safety and Project No.: RPFP-14-PFCHS – TPF-5 (193) Supplement #66, Project Title: Pooled Fund for Highway Safety will be used prior to starting this project.

Potential Implementation:

The Pooled Fund Center for Highway Safety web site would provide immediate access to a wide library of roadside safety materials for designers and engineers, including reports, CAD details, etc. It would also provide a searchable database of previous solutions and responses to prior Pooled Fund inquiries and problems. The web site would also be available through controlled access to state DOT's around the country which would promote improved roadside safety.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #85	☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Annual Fee to Finish TF-13 and FHWA Standard Plans		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Lechtenberg, Bielenberg, Rosenb	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211099001	RPFP-15-TF13	8/1/14
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/17	7/31/17	0

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$3,602	$0	0

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$0	

Project Description:

Each year, the Midwest States Pooled Fund program sponsors several roadside safety studies at the Midwest Roadside Safety Facility (MwRSF) of the University of Nebraska-Lincoln. Some of these research efforts result in the development of new roadside safety features. As part of this effort and on behalf of the member states, MwRSF seeks FHWA acceptance for those devices or systems meeting current impact safety standards. In the future, FHWA will require standard Task Force (TF) 13-format CAD details along the typical system details when requests for hardware acceptance are made.

MwRSF prepares 2-D and/or 3-D CAD details for newly developed roadside safety features that are subjected to full-scale vehicle crash testing. The CAD details used to describe the as-tested systems or components are not always prepared and presented in the same format as now required by AASHTO TF 13 and FHWA. As such, additional CAD details and background information must be prepared when FHWA acceptance is sought under MASH or when the new system or associated components are submitted for inclusion in the electronic version of the barrier hardware guide.

Objective: For all new barrier hardware, the member states request that MwRSF seek formal FHWA acceptance and placement of standardized TF-13 CAD details in the electronic version of the highway barrier guide. This funding shall be used to supplement the preparation of the TF-13 format CAD details.

Tasks:

1. Prepare CAD details for Hardware Guide

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

None

This project will not be started until the completion of Project No.: RPFP-14-TF13 – TPF-5(193) Supplement #67, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans.

Anticipated work next quarter:

None

Significant Results:

This project is used to supplement the preparation of the TF-13 format CAD details.

Task	% Complete
1. Prepare CAD details for Hardware Guide	0%

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Funding from Project No.: RPFP-14-TF13 – TPF-5(193) Supplement #67, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans will be used prior to starting this project.

Potential Implementation:

Newly-developed highway safety hardware will be contained in the electronic, web-based guide, thus promoting the standardization of barrier hardware across the U.S. and abroad.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Nebraska Department of Roads

INSTRUCTIONS:

Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☑Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Adaptation of the SAFER Barrier for Roadside and Median Applications		
Name of Project Manager(s): Ron Faller, John Reid, & Jennifer Schmidt	**Phone Number:** 402-472-6864	**E-Mail** rfaller1@unl.edu
Lead Agency Project ID: 2611211036001	**Other Project ID (i.e., contract #):** DPU-TWD(94)	**Project Start Date:** 7/1/2009
Original Project End Date: 6/30/2011	**Current Project End Date:** 6/30/2015	**Number of Extensions:** 4

Project schedule status:

☐ On schedule ☐ On revised schedule ☐ Ahead of schedule ☑ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$990,000.00	$783,556	79%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
$94,818 (9.6%)	$94,818	79%

Project Description:

Concrete barriers have gained widespread application along our nation's highways and roadways, primarily as median barriers and bridge railings. Most of these barriers are largely maintenance free and can provide the capacity to contain high-energy truck impacts at much lower construction costs than metal barriers. However, accident data has shown that impacts with these barriers cause more fatalities than observed with flexible guardrails. Vehicular impacts into rigid concrete barriers often impart high decelerations to vehicles and their occupants. Thus, there is a need for an energy-absorbing roadside/median barrier that lowers vehicle decelerations but still has the capacity to contain high-energy truck impacts without significant increases in cost. The objectives of the research are to identify the most promising highway application for SAFER Barrier technology and adapt the barrier system to this highway application. The adapted barrier design must provide optimized energy management for highway vehicles, consider construction costs in comparison to existing barrier technologies, be more damage resistant, and require no to limited routine maintenance and repair. The research will be accomplished through the following tasks.

1. Identify target applications.
2. Analyze energy management and deformation of current SAFER barrier during high-speed impacts to guide selection of new highway barrier.
3. Brainstorm and develop concepts for the design of the new barrier and energy absorbers.
4. Evaluate the best concepts and energy absorbers with finite element analysis and static, dynamic, and durability tests.
5. Develop and simulate a preferred final design concept.
6. Construct barrier prototypes for full-scale crash tests and refine finite element simulations & designs as needed:
a. MASH TL-3 with 2270P vehicle; b. MASH TL-3 with 1100C vehicle; c. MASH TL-3 with either 2270P or 1100C vehicle if re-design is necessary; d. MASH TL-4 with 10000S vehicle; & e. retests as needed.
7. Prepare final report to document the research, development, testing, and evaluation effort.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

The data collected during test no. SFH-3 were analyzed and the test was determined to be successful according to MASH safety performance criteria. With the results of all three crash tests, the barrier satisfactory safety performance according to the MASH TL-4 evaluation criteria for longitudinal barriers. The reductions in lateral acceleration for the passenger vehicles met the desired levels. During both of the passenger vehicle impacts, more damage occurred to the barrier than desired, which included concrete spalling at the beam joints, gouging on the front faces of the beams, and two posts were cut by the small car. Damage also occurred to the concrete beams and top metal rail during the impact with the single-unit truck, although some damage was permissible during the larger truck impacts. A meeting was held to discuss possible design refinements and modifications to the barrier to mitigate the damage seen during testing. The barrier has been designated as the RESTORE barrier.

The third volume of the research report series, which details all system design and simulation as well as further component tests that were conducted leading up to the first full-scale crash test, was sent for sponsor review on May 29, 2015. The fourth volume of reports, which details the results of all three full-scale crash tests, was sent for sponsor review on June 15, 2015. Writing also continued on a fifth report, which will detail the initial background and development of a future stiffness transition to a rigid concrete parapet.

Design continued on the stiffness transition between the deformable barrier and a TL-4 rigid concrete parapet end or buttress. A pinned-end connection with impacts near the end of the system is being evaluated using the LS-DYNA barrier model developed previously.

Anticipated work next quarter:

The third and fourth reports will be finalized. The stiffness transition design concepts will be further evaluated according to the design criteria including: snag mitigation with impacts from 1100C, 2270P, and 10000S vehicles, structural integrity to transition and transfer TL-4 loads to a rigid parapet, construction tolerances, etc.

Four component tests are anticipated to be completed to evaluate the performance of posts with damage and in cold temperature. The energy vs. deflection properties of one post cut during test no. SFH-2 will be determined and compared to an undamaged post. The energy vs. deflection properties of posts subjected to cold temperatures will also be determined to estimate the performance of the barrier under a large range of temperatures.

Additional analysis, design, and LS-DYNA computer simulation may be conducted if further design refinements are explored. At this time, crash tests to evaluate potential barrier modifications/refinements may be recommended in the future with additional project funding and include 1100C, 2270P, or 10000S vehicles.

Significant Results:

Report TRP-03-318-15 documenting phase 4 of this project will be sent to sponsor for review in June 2015.
Report TRP-03-317-15 documenting phase 3 of this project was sent for sponsor review on May 29, 2015.

Test no. SFH-3 was conducted on March 13, 2015 and was successful.
Test no. SFH-2 was conducted on August 11, 2014 and was successful.
Test no. SFH-1 was conducted on July 2, 2014 and was successful.

Report TRP-03-280-13 documenting phase 2 of this project was published February 6, 2014.
Report TRP-03-281-13 documenting phase 1 of this project was published July 16, 2013.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

Throughout the project, several concerns regarding the use of rubber posts have arose and have been addressed. The barrier was redesigned multiple times in advance of the first crash test in order to obtain a more successful performance in a variety of environmental conditions, to optimize the concrete and steel rail, and to have greater confidence for a successful crash test result. Installation concerns were also addressed, which will allow the barrier to be installed in a larger range of conditions in the real world. Therefore, the start of the full-scale crash testing program was delayed. All required full-scale crash tests have been successfully completed on the length-of-need longitudinal barrier system. Additional design refinements are recommended to reduce damage to the barrier and maintenance costs. A transition from the length-of-need longitudinal barrier to a rigid concrete barrier is also desired before the system could be installed on roadways. Therefore, the additional investigation will not be completed by the current project end date. The budget of the project has not been affected.

The project is currently scheduled to end on June 30, 2015. As such, MwRSF requests a 1-year, no-cost, time extension to continue the effort to brainstorm design refinements and develop a crashworthy transition concept, which would move the close date to June 30, 2016.

Thus far, some deviation in the number of static and dynamic component tests and the number of full-scale tests has occurred. Forty component tests were originally budgeted to evaluate barrier and energy-absorber prototypes. The component testing program was to be adjusted as needed depending on the development of the system. To date, 2 static and 2 dynamic tests have been conducted on barrier prototypes and 10 static and 26 dynamic tests have been conducted on energy-absorber prototypes, for a total of 40 tests. An additional 13 materials tests in tension, compression, and shear were also conducted to characterize the rubber and to develop a material model in LS-DYNA. However, funds totaling $50,818 still remain under the component testing task as of April 2015. Four more dynamic components tests are

Potential Implementation:

Study findings on rubber material models under high-velocity impacts are available to future researchers to use in other investigative efforts. The rubber post, open concrete median barrier concept has demonstrated a significant reduction in lateral vehicle accelerations and occupant risk values for passenger vehicles, and the barrier also has demonstrated the ability to contain TL-4 single-unit truck impacts under MASH test conditions. The barrier demonstrated restorability during full-scale crash testing. However, some damage occurred in the impacts with passenger vehicles and the single-unit truck. Note that the damage should not affect the structural integrity of the barrier as the barrier should be reusable after impact events. With further design refinements, the barrier could have very low maintenance requirements for TL-4 impact events. It is anticipated that severe injuries and fatalities could be reduced with the RESTORE barrier installed in lieu of current rigid concrete median barriers along urban, high-speed roadways.

Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

03-10-2015 to 06-15-2015

Illinois Type TP-1 Railing

Question
State: IL
Date: 03-16-2015

We worked together about a year ago regarding a bicycle railing attachment to an F-Shape parapet. I would appreciate your suggestions and direction on the attached Illinois Type TP-1 Railing.

We only allow this railing on Local projects (not State or Federal routes). Since it is mounted in conjunction with and on the back side of an 8" sidewalk with no barrier in front of it, it would be used for low speed applications (posted speed limit $\leq$ 45 mph) per AASHTO 13.4. We have it listed as a TL-2 barrier but I don't have records that can verify this. Are railings mounted on the back side of raised sidewalks with posted speed limits $\leq$45 crash tested and evaluated for an AASHTO Test Level similar to railings in direct contact with traffic?

The height of the railing (42" above the sidewalk) satisfies the geometric height requirement of AASHTO Article 13.8 but the spacing of the railing elements does not satisfy the geometric opening requirements. We offer a concrete stub wall with a metal railing mounted on top that can be used for these applications but our County Engineers prefer to have an open steel railing. Do you see any possible recourse in salvaging this railing?

Thank you again for your suggestions and direction.

Attachment: http://mwrsf-

qa.unl.edu/attachments/7d026e8ecc51622c49c74e3f363d4795.pdf

Response
Date: 03-17-2015

To answer your first question, sidewalk-mounted bridge railings have traditionally been crash tested and evaluated in a similar manner to those mounted directly to concrete bridge decks. In fact, I have seen crash tests on several bridge railings that offered both non-sidewalk and sidewalk mounting options, and testing was performed on each variations. Further, some of these systems were even tested at lower performance/test levels. To my best recollection, there have been tests on all-steel beam and post systems as well as combination parapets with upper beam and post systems. In summary, these crash tests have occurred on bridge rails mounted on sidewalks and curbs at multiple test levels as well as on a variety of bridge rail types. Of course, many more tests have been performed on non-sidewalk-mounted bridge rails than sidewalk-mounted bridge rails.

With regard to the second question, I assume that the geometric opening requirements for which you are referencing is tied to the size of sphere that shall not pass as a function of elevation along the height of barrier. If that is the case, then one could consider modifications to add rails, modify rails, etc. Historically, there have been other guidelines for rail offset from post, opening size for snag mitigation, and rail location, as I recall. Those guidelines led to development of many steel beam and post railing systems over last 20 to 30 years. As a first step, we could investigate whether this particular design is nearly identical to any other crashworthy designs under AASHTO PL-1 & PL-2, NCHRP Report No. 350 TL-2, TL-3, & TL-4, or AASHTO MASH TL-2, TL-3, & TL-4. From that review, it may be possible to estimate whether or not the TP-1 system would likely be crashworthy based on prior testing. Is that what you would like us to do? Please let me know if further investigation is desired. Thanks!

Johnson County, BRF-001-5(106)--38-52, IA 1 over Ralston Creek bridge replacement

Question
State: IA
Date: 03-16-2015

I received a question from our bridge office about how we should handle a city request for tubular rail to match another bridge on their route. Please see the image below and the attached KMZ fle. Is this something that should even be considered? The design they have does not look too bad to me other than a couple snag points. I could try to find a detailed design of the rail if that helps. Would it be possible to design something that would look similar and be crash worthy? The speed limit is 25 MPH.

Attachment: http://mwrsf-qa.unl.edu/attachments/1f9a9d8c5aaa85795d20083948085478.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/f440a82df7ecb14310c66c018a95cf4d.zip

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Response
Date: 03-16-2015

The preferred option would be to consider a crashworthy system or at least mitigate against critical concerns, such as significant vehicle snag, launching/override, rollover, etc. In the end, it may be low enough of risk to have some leeway if posted speed or speed advisory sign denotes 25 mph or less. In the past we have been willing to give some on the urban roadside tree issue if posted speeds were 25 mph or less.

Thus, it might be feasible to post a speed advisory before bridge of 25 mph maximum. This discussion only pertains to inside separator rail.

Response
Date: 03-17-2015

I wondered if you were comfortable with also using the concrete end section shown in the photo below. It appears that the end section is only approximately 6' long which is much shorter than our standard IDOT concrete barrier tapered end section (which is 16' long - see attached). We are in the process of concepting a bridge replacement that has 4 adjacent entrances and using the tapered end section detail will result in having to relocate some of these entrances.

I appreciate your help!

Response
Date: 03-18-2015

With regards to the end section, the response is largely the same. A crashworthy end section like the one shown in the attachment is preferred. However, if the speed is the area are kept below 25 mph, then concerns with vehicle vaulting or rapid deceleration upon impact with the end section shown would be reduced. That does not mean to say that the potential is eliminated, only that the use of the end section is more feasible if the speeds are limited.

Retrofit, Low-Deflection, Temporary Concrete Barrier System

Question
Date: 03-20-2015

I just looked at your recent research report Development of a Retrofit, Low-Deflection, Temporary Concrete Barrier System., It is very good on this important topic.

Couple questions,

One, Is the defection distance critical when the barrier is used to separate traffic during construction.

Two, Is it reasonable to use one of the concepts considered but not tested such as the

composite with the thrie beam attached.

Response
Date: 03-20-2015

. I have made comments below in red.

Thanks

Bob Bielenberg, MSME, EIT

Research Associate Engineer

Midwest Roadside Safety Facility

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402-472-9064

rbielenberg2@unl.edu

I just looked at your recent research report Development of a Retrofit, Low-Deflection, Temporary Concrete Barrier System.. It is very good on this important topic.

Couple questions.

One. Is the defection distance critical when the barrier is used to separate traffic during construction.

The deflection distance is not as critical, but should be considered when separating traffic. Previous research at MwRSF investigated the TCB deflection limits for less critical TCB installations [http://mwrsf.unl.edu/researchhub/files/Report243/TRP-03-113-03%20(revised).pdf]. This research argued that when temporary concrete barriers are used on the edge of a bridge, the risk of the entire line of barriers falling off the deck requires that deflection limits be selected to preclude such behavior in almost all impact scenarios. Hence, it was recommended that at the edge of a bridge deck, design deflection limits should be selected to contain more than 95 percent of all crashes, basically the TL-3 impact conditions. In all other barrier applications, the consequences of a barrier exceeding the design deflection criteria are not severe. In these situations, a more modest deflection limit criterion based on an 85th percentile impact severity was deemed more appropriate.

In chapter 15 of report TRP-03-295-14, we did an analysis of deflections for the low-deflection TCB at the 85th percentile impact. Based on these results, the computer simulations indicated that dynamic deflections for the low-deflection TCB system would range between 18.2 in. (462 mm) and 23.6 in. (599 mm) at the 85th percentile impact condition. In order to be conservative, it is recommended that installations in non-critical locations use an estimated dynamic deflection value of 24 in. (610 mm) until further full-scale crash testing at reduced IS values or in-service evaluation of system damage for lower severity impacts indicate that lower deflection estimates are more appropriate. This deflection value would correspond to a working with of 46.5 in. (1181 mm). For critical installations adjacent to drop-off or bridge deck edges, the full-scale crash tested system deflection should be applied.

Two, Is it reasonable to use one of the concepts considered but not tested such as the composite with the thrie beam attached.

I would not recommend using one of the untested concepts at this time. It is feasible that one or more of the untested concepts may work, but without more analysis and testing we cannot be confident in their safety performance. In the case of the thrie beam stiffening you noted, that design has not been fully developed in terms of attachment details to the barrier sections and the amount of deflection reduction in undefined.

Median bullnose guardrail weed prevention

Question
State: WI
Date: 03-27-2015

Could you take a look at this.

We have had some people install rock inside a bullnose to minimize weed growth.

I have concerns about too large of rock could prevent post rotation or trip a vehicle.

Too small of rock could decelerate the vehicle too much and cause vehicle instability.

Attachment: http://mwrsf-qa.unl.edu/attachments/d60da6f33e94f3f1f9f457558748f874.pdf

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Response
Date: 03-30-2015

We are not overly concerned about the vehicle tripping as the aggregate size is not overly large and the slopes in the area are relatively flat.

There is some concern about the mat and rock surrounding the posts affecting the rotation and energy dissipation of the posts in the system. To alleviate that issue, we would recommend that you use leave outs around the posts consistent with our previous recommendations for posts in rock.

http://mwrsf.unl.edu/researchhub/files/Report246/TRP-03-119-03.pdf

Thanks

Thomas County 2108-01 PCB Anchorage

Question
State: KS
Date: 04-01-2015

We have a question from a
contractor regarding the acceptability of the attached anchorage system for use in temporary concrete safety barrier applications. I have not seen a system like this used before. Could you please take a look at the attached information submitted to KDOT and let us know if you have any concerns with this anchorage system? I have also attached our Standard Drawing depicting our typical anchorage system.

Thanks for your help,

Attachment: http://mwrsf-qa.unl.edu/attachments/5d2c84f3d5d7986df28b664ade33d4bd.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/5bf03c80e94717489debf9b933b8b96a.pdf

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Response
Date: 06-07-2015

The system that was tested for Kansas to anchor the TCB through the holes in the toe of the barrier used ⅛-in. diameter, ASTM A307 anchor bolts with heavy hex nuts and 3-in. x 3-in. x ½-in. thick washers spaced evenly across the traffic side of each PCB segment. Each anchor bolt was epoxied into the concrete with an embedment depth of 12 in. The test installation consisted of sixteen 12-ft 6-in.) long, redesigned F-shape PCB segments placed adjacent to a simulated bridge deck edge with a total system length of 204 ft. During test no. KTB-1, a 4,448-lb (2,018-kg) pickup truck impacted the system 5 ft – 5 in. upstream from the joint between barrier nos. 8 and 9 at a speed of 62.0 mph (99.8 km/h), and at an angle of 25.3 degrees. The system contained and redirected the vehicle with maximum lateral dynamic and permanent set deflections of 11.3 in. and 3½ in., respectively, and was considered successful according to TL-3 of NCHRP Report No. 350.

In the past, we have often been asked what embedment depth was required for the epoxy anchorage of the A307 rods used in that system. Adhesive anchorage capacity depends on many factors, including anchor size, anchor embedment, concrete strength, adhesive bond strength, spacing effects, edge effects, and other factors. Thus, we have typically recommended that the embedment for the anchor rods should be selected to develop the ultimate shear and tensile capacities of the anchorage. For the 1 1/8" dia. A307 rod, the ultimate shear and tensile capacities are 26.4 kips and 45.8 kips, respectively.

In the case of the alternative anchorage shown, we would make a similar recommendation. Thus, the cast in anchor shown would need to develop shear and tensile capacities of 26.4 kips and 45.8 kips, respectively. It appears that the system shown has an allowable anchor capacity of 27 kips and a max capacity of 54 kips in

tension. The shear loading is not listed. Thus, I would check the shear loading and confirm it is sufficient.

Do they install these cast-in-place anchors when the concrete is poured and then set the barriers in those exact locations? This seems difficult.

Temporary Barrier Rail questions

Question
State: IA
Date: 04-07-2015

I have two
questions regarding the attached Temporary Barrier Rail standard (BA-401) that I received from the field and would appreciate your assistance with.

1. On
page 3 we show details of Strap and Stake Anchorages. We state a Strap Anchorage is only allowed on PCC and Bridge Decks and provide the anchor bolt dimensions in circle note 6, while the Stake Anchorage is allowed on Composite, HMA, and PCC. We have a contractor asking if they can use a Strap Anchor on a Composite (say 3" HMA overlay over original PCC) if they use a longer bolt to provide the required depth into the PCC as specified in circle note 6, in this example at least 3" longer. Thoughts on whether the longer bolt should provide the originally intended anchorage?

2.

Also
on page 3 we have Table A Anchorage Requirements, which indicates to designers and contractors when TBR needs to be anchored. The question has come up as to how many sections upstream and potentially downstream of an obstacle need to be pinned as well. I've attached a mock situation to assist. Let's assume the dropoff is sufficiently great, so the TBR needs to be pinned and only the minimum 6" offset is available. I'm taking the worst case blanket approach here but also realize that pinning an entire run of TBR for one small section with an obstacle is too conservative.

a.

What
distance should be pinned upstream of the obstacle if we assume there are at least eight sections of 12.5' long unpinned TBR upstream of these potentially anchored sections to sufficiently redirect a vehicle per other guidance (TRP-03-209-09, page 6 for one)?

b.

What
distance should be pinned upstream if we have less than eight sections upstream?

Thanks in
advance for your time and assistance.

Attachment: http://mwrsf-qa.unl.edu/attachments/a79689f13efd50da3269471dd92c3c94.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/b1cc124da162744d78c93f710eabd5fc.pdf

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Response
Date: 04-13-2015

Comments below.

Let me know if you have further questions.

I have two questions regarding the attached Temporary Barrier Rail standard (BA-401) that I received from the field and would appreciate your assistance with.

1. On page 3 we show details of Strap and Stake Anchorages. We state a Strap Anchorage is only allowed on PCC and Bridge Decks and provide the anchor bolt dimensions in circle note 6, while the Stake Anchorage is allowed on Composite, HMA, and PCC. We have a contractor asking if they can use a Strap Anchor on a Composite (say 3" HMA overlay over original PCC) if they use a longer bolt to provide the required depth into the PCC as specified in circle note 6, in this example at least 3" longer. Thoughts on whether the longer bolt should provide the originally intended anchorage?

   The use of the steel strap tie-down has been restricted to concrete pavements with overlays due to concerns that installation through asphalt will increase the bending loads on the bolt and the moment on the drop-in anchor that could reduce the capacity of the anchorage. Thus, we would not recommend using a longer bolt with the drop-in type anchor.

We looked into this issue and some potential alternatives previously for Missouri and did not come up with a solution.

http://mwrsf-qa.unl.edu/view.php?id=636

2. Also on page 3 we have Table A Anchorage Requirements, which indicates to designers and contractors when TBR needs to be anchored. The question has come up as to how many sections upstream and potentially downstream of an obstacle need to be pinned as well. I've attached a mock situation to assist. Let's assume the dropoff is sufficiently great, so the TBR needs to be pinned and only the minimum 6" offset is available. I'm taking the worst case blanket approach here but also realize that pinning an entire run of TBR for one small section with an obstacle is too conservative.

   a. What distance should be pinned upstream of the obstacle if we assume there are at least eight sections of 12.5' long unpinned TBR upstream of these potentially anchored sections to sufficiently redirect a vehicle per other guidance (TRP-03-209-09, page 6 for one)?

   With respect to the upstream side, the length of anchored barrier on the upstream side would be based on your deflection to the hazard. It could be as simple as the anchored barrier only being needed directly in front of the hazard as that is where the deflection needs to be reduced. It should be noted that an approach transition is needed for the steel pin and bolt through tie-down options.

   http://mwrsf.unl.edu/researchhub/files/Report133/TRP-03-180-06.pdf

   http://mwrsf.unl.edu/researchhub/files/Report54/TRP-03-208-10.pdf

   b. What distance should be pinned upstream if we have less than eight sections upstream?

   I am not sure I follow. The pinned/anchored sections need to be directly in front of the reduced deflection area of the hazard. Then

an stiffness transition must be placed on the upstream end as noted above. We would recommend 8 free-standing TCB segments on both the upstream side of the transition and following the downstream end of the pinned/anchored TCB's. On the downstream side of the pinned/anchored TCB's, a transition is not needed, but we still recommend that 8 free-standing barrier be used. This distance may be able to be shortened following ongoing research on TCB LON requirements being conducted through NDOR, but we are recommending a conservative approach for now.

Thanks in advance for your time and assistance.

Temporary Barrier Rail opening

Question
State: IA
Date: 04-08-2015

We are developing a detail to allow an opening in TBR for contractor access and I'm struggling to find guidance on what buffer length we should be using upstream of the opening for both the anchored and unanchored conditions. Attached is the current draft version.

The downstream unanchored distance comes from the eight sections of TBR needed to develop strength per page 6 of TRP-03-209-09. The anchored distance comes from an assumption that work is not taking place behind the flared TBR sections. That assumption may or may not be correct in the field, but from an ideal situation, it seemed like a reasonable one.

Please advise and thank you for your time.

Attachment: http://mwrsf-qa.unl.edu/attachments/fe4368b0ad7cfea8e53d62c941e55abd.PDF

Response
Date: 04-13-2015

I have reviewed the detail you sent.

Currently, we have recommended that a minimum of 8 barrier segments be used prior to the beginning of length of need or downstream of the end of the length of need for TCB installations. This recommendation is based on testing of these systems typically being performed on 200' long (16 barriers) systems. Thus, what you have shown in the detail for free-standing TCB is appropriate based on our current knowledge. We do not have a clear definition in the performance of the TCB when impacted near the ends of the system, so we have been conservative.

We currently have a project with NDOR to evaluate the actual beginning and end of LON lengths for the F-shape TCB, but that work is not yet completed.

In the past we have also recommended that openings in runs of TCB be overlapped. I am not sure if that is possible for your purposes, but this option is a little more well defined, as the overlap of the PCB runs creates less uncertainty near the ends of the installations. For overlapping TCBs, we have recommended an overlap of at least 8 or 9 barrier segments for each run - front and back. The gap between both barrier runs could be reduced to 6 to 12 in. or so due to both barrier systems being freestanding, thus reducing the propensity for vehicle snag/pocketing. If limited space exists at the roadside edge for the overlapped option, one may consider the slight flaring of the rearward (shielded) TCB system in order to save space near the shoulder. In your case, a larger gap could be used to facilitate vehicle access. In addition, overlapping of the TCB systems eliminate the need for the sand barrel array.

Some states have asked about using the steel pin tie-down to anchor the segments and shorten the beginning and end of LON, however, we have not investigated that at this time and it may need to be further investigated prior to our full endorsement of it.

For the downstream end of the system, we have developed an end anchor for the TCB system that could be applied. This anchor was tested to MASH TL-3 and allows for the LON to start at the first barrier segment. See report below.

http://mwrsf.unl.edu/researchhub/files/Report63/TRP-03-209-09.pdf

You refer to this below, but I don't believe that you would need the 50' denoted in the detail for the anchored system. If the TCB were unanchored, I would recommend sticking with the 100' shown.

Let me know if you need anything else.

Bullnose in Gore Area

Question
State: WV
Date: 04-10-2015

The Internet Police kicked me off Linkedin and you guys apparently had some server issues yesterday.

What would be Midwest's thoughts of using the new Thrie Beam Bullnose in the gore of an exit ramp?

Everyone here thinks it's a great idea, but I remind them that at what point are we going to begin a flare to match the existing mainline and ramp guardrail.

I would propose to flare at Post 8 as shown on the Wisconsin drawings. Is this Wisconsin detail a result of the Midwest research?
The flare at Post 8 I propose is based on the beginning of "Unbent Standard Thrie Beam".

I am trying to address an existing ramp where the mainline and ramp guardrail was terminated with a pair of Tangent End Terminals essentially beside each other. None of us believe this is an acceptable design, since to our knowledge there is no testing of TET's in this placement.

The TET's do not look like this today, I have some pics if you would like to see them.

Attachment: http://mwrsf-qa.unl.edu/attachments/c3fe5b66f5d364d6e1752a2a99c96857.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/510db0b878eb30988802173074 45c5c7.pdf

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Response
Date: 04-14-2015

The detail you sent from WisDOT is based on our bullnose system that was tested to NCHRP 350 criteria. We do believe that it can be used in gore areas and it has been done in the past. You can get the reports and other details for the system at the links below.

http://mwrsf.unl.edu/researchhub.php?search-textbox=bullnose&submit=Search

With regards to the start of the taper or flare, we have allowed flaring of the system to begin at post no. 5 with a flare rate of 15:1 based on RDG guidance. That flare may change based on your conditions and the RDG guidance for them.

With regards to the grading, we have addressed this issue in the past by stating that the bullnose itself should be on a maximum grade of 10:1. This applies to cross slopes and v-ditches. We also recommend that the 10:1 slope area be applied for at least 60' in front of the system to provide for more stable tracking of errant vehicles prior to impact. For the longitudinal slopes prior to the 10:1, we have come up with several options in conjunction with the Minnesota DOT. Can get you those if you need them.

Only one other thing to note. Because the gore installation has similar traffic flow on both sides, you will have to make sure that the thrie beam splices are lapped correctly with the traffic flow on each side of the system. For two way traffic, lapping all of the guardrail the same as it moves around the system is fine. However, with the gore installation, this would cause the splices to be setup wrong along one side. I would suggest simply switching the splice on either side of the nose as needed.

Thanks

Black Rebar vs. ECR or Calcium Nitrite in PCB

Question
State: WI
Date: 04-15-2015

MnDOT
needs MwRSF's opinion on the following Portable F-Shape Concrete Barrier specification (reinforcing bar specification).

We currently specifically the following on our plan (attached):

Reinforcing
steel shall be Grade 60 and shall conform to either of the following:

Epoxy-coated deformed bars as specified in Spec 3301.

Spec 3301: deformed and plain billet steel reinforcing bars for use with calcium nitrite
corrosion inhibitor (30% calcium nitrite solution.)

The spec 3301 is a MnDOT specification concerning Reinforcement Bars (attached).

A question has come up from a manufacturer. They are asking if the epoxy-coated steel reinforcing is required for crash test performance. They are also asking the same question regarding the alternative of using use of corrosion inhibitor in the concrete.

The barrier will not be owned by MnDOT, that is, it will remain the property of the Contractor. The barrier is required (and inspected) to be in good condition every time it's placed on a MnDOT project, but it will always be the property of the contractor. Therefore, the long term durability and barrier condition risk is transferred to the contractor if they choose a less durable construction method for the barrier (provided that it does not risk the barrier safety performance).

A few of our neighboring states just call out the following:

Use Grade
60, ASTM A615 for these bars.

Attachment: http://mwrsf-qa.unl.edu/attachments/59614fa63b15ba696799522152ee100a.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/6e21578ac1e23ffbea95f3d695e59501.pdf

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Response
Date: 04-15-2015
Hello Michael,

I reviewed Minnesota's specs and some additional supporting material regarding corrosion protection for concrete barrier reinforcement.

First, I wanted to highlight a Pooled Fund consulting question answered in 2010 regarding concrete barrier reinforcement specs for the loop bars:

The loop bar steel is the A706 spec because we have found that the small bend diameter can cause reduced ductility and toughness in some grades of steel which compromises the impact strength of the loop. As such, we current specify that the loop steel must have a minimum yield strength of 60ksi, a minimum tensile strength of 80 ksi or 1.25 times the yield strength " whichever is higher, and a minimum % elongation of 14%. A706 and A709 steel can both meet that spec with the correct grade. Others may as well. The bars can be deformed or smooth as long as the steel is within spec. Some of our states prefer smooth, so it is on the drawings that way.

Minnesota's specs are similar for the loop bars with regards to strength. However, I did not see a note for how the loop bars are protected from corrosion. Some states have used galvanization or stainless steel for loop bars. Epoxy-coated loop bars may experience cracking or peeling during installation or impacts, and exposure to the environment may create a galvanic circuit.

Several online resources have proven valuable for evaluating effectiveness of epoxy coated reinforcement (ECR) and generalized corrosion resistant reinforcement (CRR), compared to "black bars" (BB). Those resources are attached.

Based on the available research, I concluded the following:

(1) In the short term, BB has a higher concrete chemical and physical bond than ECR. Thus, use of ECR may decrease reinforcement bond strength slightly. The effect is not particularly pronounced and MwRSF has used both types of reinforcement in concrete barriers with success. The MIT research synthesis indicated that the recommended factor to account for bond slip in reinforced concrete was 1.35x, and the ACI code recommends a 20-50% longer anchorage length to account for reduced concrete-to-epoxy interface strength. In conclusion, the bond strength of BB is slightly higher than ECR, but in general the effect is not extreme.

(2) Service life of ECR reinforcements have been shown to be vastly increased compared to BB. Although there are still maintenance issues that occur over time, particularly in harsh environments with frequent freeze-thaw cycles and in environments with large chlorine concentrations such as locations with heavy use of chlorinated de-icers or salts, ECR may increase service life for permanent concrete structures by 50 years or more. Note a case study in the MIT synthesis in which a parking garage in Minneapolis using BB and with actual clear cover of concrete of 1" resulted in extensive repairs within 12 years. Although other ECR structures in Canada, Florida, and Iowa still corroded over time, and the epoxy lost the chemical bond with the steel during exposure and when surface cracks were present, the predicted increase in service life was 40 years when both top and bottom reinforcing

mats of the bridge deck were ECR, compared to ECR in the top mat and BB in the bottom mat. Also note that the ECR may be damaged by aggregate when nozzles are used to pour concrete over a form; damage can be reduced and potentially eliminated by keeping the nozzle close to the form.

(3) Benefits of ECR are heavily dependent on the attention paid in construction, as noted by Dr. Hartt at FAU
(note Review_Corrosion_Performance_Epoxy_Hartt_2012.pdf). Hartt noted that all CRR structures benefit from high-quality concrete and good clear cover. Reduction in clear cover or excessive water-to-concrete ratios result in a reduced benefit of all CRR. In general, subject to the high quality concrete and clear cover as noted, CRR generally increase service life by approximately 10x with respect to simple BB.

(4) Lastly, calcium nitrite is effective in increasing the threshold of chlorine concentration at which corrosion begins to appear. It does not prevent corrosion if the chlorine concentrations are higher than the threshold. However, the service life over which this increase in concentration builds up without damage to the structure may be significant, particularly in locations such as Minnesota that does not heavily use chlorinated de-icers.

In conclusion, the use of BB in temporary barriers offers a short term increase in reinforcement-to-concrete bond strength compared to ECR, but does not offer any other short or long term benefits. In contrast, CRR does increase service life of the barrier by approximately a factor of 10 if adequate clear cover and good quality concrete is maintained. After an impact, if the concrete cracks, the benefits of the CRR will be significantly reduced. Lastly, if all bars, including loop bars, are BB, it may be appropriate to inspect the loop bars for corrosion and estimate internal damage based on the corrosion of the loop bars. This method may not be perfect as it is impossible to accurately identify which elements corrode faster with the current state of knowledge, but BB loop bar inspection is at least a minimum service inspection that could indicate if additional problems may be present.

I recommend that any barriers cast with BB only should have a date stamp indicating the casting date. and any barriers found to have corrosion with the same or similar casting date be fully inspected. Both corrosion resistant reinforcement (CRR) and black bars (BB) may be used and will develop the appropriate strength, given consideration for the increase in lap length and anchorage length for ECR.

Attachment: http://mwrsf-qa.unl.edu/attachments/f878a0d70a5f7af516f52e8e9897b68a.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/27ab659bb9ca385b368787bb710910d2.pdf

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Bridge Overlay - Concurrence requested

Question
State: NE
Date: 04-16-2015

NDOR is planning 2" overlays on Bridge structures & your concurrence is requested:

NDOR has existing concrete bridge railings at 29" across the deck of approx. 1000 bridges, these raise at the end of the bridge railing to 32" for the guardrail to attach at 31". We plan to overlay these with a thin water proof membrane and a 2" asphalt overlay across the bridge.

The FHWA has a list of acceptable bridge railings

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/bridgerailings/

Under Vertical Concrete Parapet (Open or Closed) / General [PDF 1.08 MB]; the Concrete 27" railing similar to NDORs is here. Do you concur with the below statements?

1. NDORs concrete bridge railing (open) @ 27" meets NCHRP 350 testing which is confirmed by FHWA.
2. The thrie-beam bridge approach at 29" meeting the 30" end of bridge rail, is NCHRP 350 approved.
3. The 29" thrie-beam bridge approach section will be raised to 31" over the first 75' of the guardrail run.
4. The end of the 31" w-beam will use an approved end treatment.

Response
Date: 04-16-2015

Hello Phil,

MwRSF has examined the proposed resurfacing you identified. As we understand it, the roadway will be resurfaced with a water-repelling membrane and an additional 2" of asphalt overlay. The pavement overlay would reduce the effective heights of:

- The open concrete bridge rail from 29 in. to 27 in.;
- The approach guardrail transition (AGT) from 31 in. to 29 in.; and
- The guardrail leading up to the AGT from 31 to 29 in.

In reviewing relevant research, MwRSF researchers felt that the flared distance over which the effective rail height changes is acceptable, and the 31-in. tall W-beam (e.g., MGS) end treatments are acceptable. We have some concerns with other aspects of the proposed resurfacing project. Please note below.

1. No thrie beam AGT has yet been approved at NCHRP Report No. 350 for use with a 29 in. top mounting height. All approved thrie beam transitions were designed to connect to the end of the parapet / end buttress of the concrete barrier with a top mounting height of 31 in. Researchers are unaware of any successful or unsuccessful tests with a thrie beam top mounting height of 29 in. Crash testing is recommended to confirm the adequacy of the 29-in. thrie beam AGT top mounting height according to NCHRP Report No. 350 TL-3 specifications. It should be noted that successful crash testing has been observed for some stacked W-beam with W-beam rubrail/curb approach guardrail transitions using a 29-in. top rail height.
2. Testing at TTI in the early 2000s indicated that there may be an increased propensity for rollover associated with an open concrete bridge rail with a top mounting height of 27 in.; please refer to the attached report "TTI_Report_GFRP_Bars_Concrete_Bridge_Rail_0-4138-3.pdf". As such, an 27-in. tall open concrete rail has demonstrated unacceptable behavior according to TL-3 of NCHRP Report No. 350.

These concerns may be resolved using one of the following approaches, in order of recommendation.

1. Modify the bridge rail height to be similar to what was shown in "TTI_Report_GFRP_Bars_Concrete_Bridge_Rail_0-4138-3.pdf" with a 3-in. tall tube mounted to the top of the bridge rail. Of course, other practical methods for increasing height are acceptable. Raise the height of the thrie beam transition by using modified blockouts and field-drilled holes in the posts, and re-attach the thrie beam to the end of the concrete parapet / end buttress per the original design drawing specs.
2. Modify the bridge rail height to be similar to what was shown in "TTI_Report_GFRP_Bars_Concrete_Bridge_Rail_0-4138-3.pdf" with a 3-in. tall tube mounted to the top of the bridge rail. Also, modify the AGT to be consistent with one of the stacked W-beam designs in FHWA approval letters b-65, b-77, or b-83; crash testing details may be found in the attached report "NCHRP_350_Testing_404211-F.pdf". These designs permitted the use of lower-height, W-beam transitions to the bridge rail with additional rub rails and/or curbs installed.These systems may require the use of alternative posts and structural elements in the transition region, but will not require new holes to be drilled in the end of the existing concrete parapet / end buttress.
3. Limit resurfacing projects that result in 29-in. tall AGTs and 27-in. tall vertical parapet bridge rails to TL-2 applications only.

Attachment: http://mwrsf-qa.unl.edu/attachments/98cda0b1934ac46685df767da008f72b.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/347703374d70184a40669e23bfc8e8d6.pdf

Attachment: http://mwrsf-

qa.unl.edu/attachments/dfe68beefa83b88201899b1c47121378.pdf

Concrete median barrier

Question
State: IL
Date: 04-22-2015

Greetings,

Are you aware of any TL-5 crash
tests that have been performed on 42" high non-reinforced concrete barrier
(either Jersey or F-shape)?

Response
Date: 04-27-2015

There has been testing on the Ontario Tall Wall. However, we do not promote its use do to the lack of reinforcement, the formation of shrinkage and temperature cracks over time, and the shifting ballast observed in the testing program which potentially may have reduced the impact loading. This barrier was listed in the prior versions of the Roadside Design Guide.

Mash working width values for temporary barrier

Question
State: WI
Date: 04-23-2015

I am in the process of updating the
working width information for out temporary barrier to MASH. So I have to
do some adjustment of the NCHRP test to MASH.

Could you take a look at what I have
to see if I am on the right track?

Attachment: http://mwrsf-qa.unl.edu/attachments/d4da243623f0f37878b804a3d53d076f.pdf

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Response
Date: 05-06-2015
I have looked through the detail and have the following comments. In general, they look acceptable.

1. For the free-standing barrier critical location, the MASH TL-3 working width is 8.5 ft rather than the 6'-9" shown.
2. For the asphalt tie-down, the working width shown for NCHRP 350 are based on the testing we conducted adjacent to a 3' vertical drop-off that moved a significant section of supporting asphalt and soil. If used farther from the drop-off or with a less severe drop-off, it is expected that the deflections of the asphalt pin system would only be marginally larger than that of the bolted tie-down.
3. For the asphalt tie-down, the working width shown for MASH is currently unknown. Increasing it slightly as you have to account for the higher impact severities in MASH is rational, but it is difficult to say how accurate it may be.
4. Similarly, for the bolted tie-down, the working width shown for MASH is currently unknown.

Thanks

Response
Date: 05-11-2015

If the DOTs have to go to MASH. It would probably be a good idea for MwRSF to come up with recommendations on what the working widths should be (until we test the alternatives to MASH). You are probably going to be asked the same question over and over and a consistent answer would help all the states.

I attached a spreadsheet I put together to do the calculations an pick a "rational" number. I'm not saying it is right, but this looks to be the direction I'm heading in.

Response
Date: 05-12-2015

I would agree that this probably needs some thought. Mostly along the lines of deflections for the tie-down applications. I see that you are currently scaling up the tie-down system deflections based on the free-standing MASH versus 350 deflections. I think that may be too conservative as we don't expect that kind of jump in deflection for the anchored barriers.

I will try to give this some more thought and come up with some numbers. I believe that TTI has some MASH testing of tie-down barriers from with similar 350 testing that could be looked at.

Bullnose modification

Question
State: MN
Date: 05-01-2015

Hello Michael,

The design you provided appears to be consistent with guidance provided by FHWA in approval letter CC68, which may be found at http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/term_cush.cfm. Both wider-bullnose FHWA-approved designs utilized a curved nose piece, a curved transition piece, and a length of

straight rail on the departure side of the bullnose that could be flared at a high angle. In-line with straight guardrails can produce instability and rollover, as observed during MwRSF short-radius testing. Thus it is recommended to avoid long, straight segments of guardrail extending from bullnose and short-radius systems which could be subjected to head-on impacts. The Minnesota design has two different flares on the back side of the system, which should increase the probability that an impacting vehicle will deflect the rail laterally and not subject it to potential instability and rollover. MwRSF concurs that the design is therefore consistent with FHWA-approved modifications.

Other bullnose designs provided by MwRSF are preferred in general, in part because of the concerns raised above. Preferred bullnose designs are shown in MwRSF research report on page 149 of no. TRP-03-95-00, found at http://mwrsf.unl.edu/researchhub/files/Report120/TRP-03-95-00.pdf. The designs utilize a larger, broader nose piece and variable tapers on the front and back side rails. It is believed that this design will function better when an impacting vehicle strikes parallel with the guardrail on the opposite-side rail.

The guardrails may connect to bridge rails via an approved thrie beam approach guardrail transition (AGT) after the third rail segment on each side (excluding the nose). The bullnose may be transitioned to other barrier types for connection to bridge ends using approved transitions. The guardrail on the front side may be flared at 15:1 starting at post no. 5, and back side guardrail flare rates may be larger. Note that the maximum back-side flare rate approved by FHWA is approximately 3.5:1, for FHWA Approved Wider Bullnose System (15.6-degree flare). Slopes in front of and up to 40 ft behind the barrier must not be steeper than 10:1. Design details for constructing the systems are shown in the FHWA approval letter and MwRSF report.

Let me know if you have any additional questions.

Attachment: http://mwrsf-qa.unl.edu/attachments/d61744f672b8e910af3e060aac606a1e.pdf

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Response
Date: 05-01-2015

We are updating our bullnose standard (to the USBP design) and just have a few questions to run by you.

MnDOT's current standard for a widened median (see attachment, Standard Plan 611, sheet 3 of 3) shows guardrail tapers on both the approach and the opposing sides of the median. We haven't been able to find our background information to support these tapper designs yet and though we should just ask you.

We are specifically questioning the angle turn locations at the posts (#5 & #11 on the approach side and #5 & #8 on the opposing side). We are wondering what the appropriate angles are and how best to get back to a parallel alignment with the bridge rails?

Also, the MwRSF Drawing MDN01,
Sheet 6 of 6 (see attached) shows 2 designs for wider bullnose systems.
How would these designs connect/transition into bridge rails? What are the guidelines for laying out these designs in widened medians when attaching to a bridge rail?

Your
help is appreciated.

Attachment: http://mwrsf-qa.unl.edu/attachments/d61744f672b8e910af3e060aac606a1e.pdf

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Crash Cushion Question

Question
State: IA
Date: 05-04-2015

I had a question come up on an interchange project.
Due to soil remediation they were not able to install standards W beam guardrail which would have allowed them to flare the installation. They plan to install a short section of concrete barrier and a crash cushion instead. The problem this causes is the tangent installation causes a sight distance problem. Would it be possible the flare the concrete barrier at a 20:1 rate and install the crash cushion along that same line? We could flare only the concrete portion but that would require a greater length of concrete rail to maintain the desired sight distance.

Attachment: http://mwrsf-qa.unl.edu/attachments/7e0fac2f6dee8bcff2c39e2c65000719.jpg

Response
Date: 05-06-2015

With respect to the situation below, we would not have an issue with flaring of the permanent concrete barrier as long as it falls within the guidance in the RDG for barrier flare rates based on the shy line and the design speed.

In terms of the crash cushion, we would likely recommend that the crash cushion be extended parallel to the roadway rather than in line with the flared concrete barrier due to potential concerns for impacting the crash cushion at angles and severities outside the range of its original testing. To the best of my knowledge, there has been little research or testing on crash cushions installed on flares. Minor flares have been allowed for terminals in many cases.

That said, I would recommend that you contact the crash cushion manufacturer directly in order to get their input. They likely have better insight than we do with regards to their systems in flared installations.

TCB/Guardrail Transition

Question
State: IL
Date: 05-05-2015

We are evaluating a proposal submitted by one of our
District offices regarding placement of temporary concrete barrier (TCB) across and on both ends of a bridge deck. We have some questions about options for transitioning the TCB once it leaves the bridge deck.

1.

Section B-B in the attachment complies with internal guidance to provide 2.0' between the back of TCB and the curb on the bridge deck. This scenario could be for freestanding TCB, or at most, short pins (approximately 4.5" embedment into the bridge deck) could be provided.

2.

Section A-A does not comply with internal guidance since we indicate that the face of the TCB should be between 2" and 1' from the face of the guardrail; and the underlying surface on which the TCB rests needs to be paved and in the same plane extending to the face of the guardrail.

We feel that the TCB could be shortened by using a taper of not steeper than 1:12 once the installation is off of the bridge deck. At that point a section or two could be placed parallel to the guardrail and the end units could be anchored to the underlying paved shoulder using anchor pins in all six holes. Placement of a Test Level 3 (the posted speed on the roadway is 55 mph) temporary narrow, redirective impact attenuator would be required at both ends.

A.

Are there any transition devices available that would allow another option for realigning the guardrail to attach to the TCB on both ends? We could anchor the end unit of the TCB into the underlying paved shoulder (or we could anchor multiple units, provided that they are not on the bridge deck, since our Bureau of Bridges and Structures does not allow anchoring on bridge decks). Such an arrangement would not require temporary impact attenuators on both ends; however, we are unaware of potential performance issues for TL 3 connecting guardrail to TCB.

B.

Are there other options that we might consider?

Any thoughts or guidance that you could provide would be appreciated.

Attachment: http://mwrsf-qa.unl.edu/attachments/5ca3f1a1f0ffee35ec21e4e42688ccf6.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/97fc9c09e384c50c5107c23d1ad6da2c.pdf

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Response

Date: 05-29-2015

We have reviewed you detail for the temporary barrier installation on bridges and believe that it is acceptable based on current safety practices.

The overlap of the PCB on the guardrail and the shielding of the end of the PCB with an attenuation system is currently about all that can be done for this type of installation. There currently is no tested and approved transition between TCB and guardrail. However, we currently have research underway with NDOR to address exactly this situation. The system was designed in the report below and the testing of the system is scheduled for this summer. If all goes well, the system should be sent in for FHWA eligibility before the end of 2015.

http://mwrsf.unl.edu/researchhub/files/Report299/TRP-03-300-14.pdf

The only other comment we would have is that the 2 ft offset between the bridge rail curb and the back of the barrier may need to be increased. The concern is that the motion of the TCB's during impact may cause them to strike the curb and rotate back about the rear corner of the barrier. If this happens, the propensity for vehicle climb and instability can increase. Increasing the offset another foot to 3 ft or using the steel strap tie-down system for the F-shape TCB (or other tie-down systems) could help alleviate that concern. The steel strap tie-down uses less embedment and should restrain deflections sufficiently.

http://mwrsf.unl.edu/researchhub/files/Report219/TRP-03-115-02.pdf

Thanks

W-beam attachment to Culverts

Question

State: NE

Date: 05-06-2015

The post within the weak-post w-beam attached to culverts (TRP-03-277-14) is specified as 44" long. A few situations may call for variable post lengths. What post lengths will function properly within this system

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Response
Date: 05-06-2015

Without doing more analysis, we are not too comfortable with changing the dimensions of the post, as post bending is the main provider of the systems lateral support. We could live with +/- 1", but aren't really big fans of recommending further changes without additional evaluation.

I'm not too sure why you would want a longer post anyway.Headwall and/or slab dimensions can change, but the socket has a defined length of 16.5" and a top mounting height of 2" above the top of the culvert. Thus, a 44" post will provide the specified rail mounting height of 31" above the ground/headwall. Variations to the culvert structure will not affect this rail mounting height. The only thing that would affect mounting height would be if the top of the culvert is not at ground line. However, when we reviewed each pooled fund States' culvert standards, it was common that the top of the culvert headwall was even with the groundline. Subsequently, the need for a longer post would only occur if your headwall was below the ground line. I don't know how this would occur as nothing would be preventing erosion/runoff if the headwall was not at ground line.

Note, within the conclusions section of the report it states that the system is not recommended for use with approach slopes greater than 10H:1V as the system (and the original bridge rail) were never designed for, or evaluated with, an approach slope. A steep approach slope could significantly affect the performance of the barrier system.

Response
Date: 05-06-2015

If the parapet is above the shoulder or If this is used on a bridge with a curb: is a curb over 9" too high?

Response
Date: 05-06-2015

This design has not been evaluated with a curb. As such, we do not recommended the system to be installed in combination with a curb or a headwall that extends more than an inch or two above the ground line / shoulder.

Response
Date: 05-06-2015

Is the 1' W-beam Backup Plate required at the splice joints?

Response
Date: 05-06-2015

Yes. As shown at the meeting last week, rail tearing has been evident in multiple systems utilizing S3x5.7 posts and w-beam guardrail – typically at splices. Thus, the 12" backup plate is recommended for use on all similar systems – including the original bridge rail which was only tested with 6" plates. The 12" plates will not fit between the splice bolts, so they will have to be modified to fit over/around the splice bolts. Oversized slots should do the trick.

Response
Date: 05-08-2015

So, I am stuck with only one length of post … if so, I will need to adjust most headwall parapets to meet the 4% to 6% slope of the shoulder, either cutting it to lower it or extending it to raise it? Even a few inches?

But we expect the MGS leading into this area to work at both 31" & 27.75"? why don't we think this will work properly?

Response
Date: 05-08-2015

This weak-post w-beam system was designed and tested for level terrain applications without curb. Thus, we recommend it be installed in such a manner. We have recently shown that the addition of a curb below an otherwise acceptable system can lead to rail rupture and failure (the MGS stiffness transition to thrie beam AGT). So until the system is evaluated with the addition of a curb, we don't recommend installation of the system with a curb. If the culvert headwall extends more than an inch or two above the ground, it should be cut down or the a different system should be considered. If the roadway is significantly higher than the headwall, that would mean that there is a roadside slope leading into the headwall/barrier system. Steep roadside slopes may cause vehicle instability issues and negatively affect the performance of the system. Since this system has not been evaluated to use on steep roadside slopes, it is not recommended for installation on slopes greater than 8:1.

What we are left with are culvert sights were the roadway and the headwall are level with each other or near the same elevation. I understand that there may be installation sites were the adjacent w-beam guardrail is at a height of 27.75". However, TTI has conducted recent testing of w-beam treatments for culverts and short bridge structures with this lower height w-beam and has observed rail rupture and testing failures with the MASH vehicles. As such, we recommend keeping the installation height of this system at 31" and transitioning the guardrail adjacent to this weak-post w-beam up to 31" over a distance of 25 ft on both sides of the installation.

Parapet Heights at Thrie Beam Transitions

Question
State: IA
Date: 05-08-2015

We have a project showing the following detail (77-1631-087_BridgeEnd.pdf), where it is a bridge deck overlay and they are upgrading the bridge ends from Type C (page 3 of BA-202) to a more updated Type B (page 2 of BA-202). New bridge ends are
normally specified at 34" (per BA-107) but the project in question is showing 32" to match the height of the existing bridge rail.

On past projects where we are only replacing guardrail, we've allowed the bridge side of our BTS (BA-201) to sit at 30" or 31" to match the old transition height as reconstructing new bridge ends was beyond the scope of the project.

However, since this project is updating the bridge ends, in which order are the alternatives from most preferable to least?

a) Stay at 32" to the top of the bridge end and install 32" BTS. This leaves only 2 3/8" from center of top bolt hole to top of rail and puts the top of the BTS at the top of rail.

b) Stay at 32" to the top of the bridge but lower the bolt hole pattern by 1" or 2" to gain clearance and still fall within adjusted tolerances for the BTS (30" or 31").

c) Taper the new bridge end from 32" existing up to 34" by the first bolt holes (three vertical) and install BTS at normal height. The 2" transition would have to take place over 20.5".

d) Another option?

Thanks for your assistance on this and future applicable instances.

Attachment: http://mwrsf-qa.unl.edu/attachments/1d0f83df90972c75bad80fbab0d8b6f5.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/14a87bc232568941d850c27b6aff0b29.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/2aba5128232f8afa7a5ace3cfb6aa4a5.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/085462edc6403bb933fdeb36aa6c4623.pdf

Response
Date: 05-08-2015

We had a similar discussion to this just last week at our annual Midwest States Pooled Fund meeting. At that time, multiple State DOTs had said they have transitioned the ends of the bridge parapet up a few inches to provide a few more inches of cover to the attachment bolts/hardware of the thrie beam transition. This is very similar to your Option C, and I recommend this method for use. You vertical height transition of 1/10 seems well within reasonable bounds to prevent snag and vehicle instability during reverse direction impacts.

CMB in Wide Medians

Question
State: CA
Date: 05-13-2015

I'm writing to ask if the Midwest States Pooled Fund Crash Test Program has done any research on the use of cable barriers in wide medians (greater than 75 feet). I'm conducting some research on behalf of California Department of Transportation into practices and guidance for the use of barriers in wide medians. Is that a subject that the pooled fund has investigated? I'd appreciate any information you can offer.

Response
Date: 05-13-2015

There is some available data that suggests there is a benefit to placing CMBs in medians wider than 70-75 ft, but there is a distinguishable reduction in the benefit-to-cost ratio. I have attached a report, **Reducing Median Crossover Crashes in Wisconsin**, which is abbreviated "CMC in Wisconsin.pdf". In it there is a chart showing the total cross-median crash data collected in Wisconsin by median width on Page 11. Several crashes occurred in medians of 75 ft wide or greater.

Similar analysis of crashes in medians in North Carolina shown on Page 7 of the attached PDF titled **Median Barriers in North Carolina** and denoted as "NCDOT - Summer TRB Presentation on Cable experience.pdf"

indicated that even at moderate to low traffic volumes for divided rural interstates, cross-median crashes (CMCs) still occurred when median widths were in excess of 75 ft:

Dr. Dean Sicking, Karla Lechtenberg, and Dr. F. Daniel B. Albuquerque conducted a study evaluating cross-median crashes and cable median barrier warrants based on interstate data in Kansas. That report is titled **Cable Median Barrier Guidelines** and denoted as "TRP-03-206-08-Final-Revised.pdf", and is available from the Pooled Fund website under TRP-03-206-08. Although the frequency of crashes occurring in medians wider than 70 ft was limited, there was at least a limited risk that crashes could occur in wider medians.

Likewise, TTI issued some guidance for the state of Texas in 2006 titled **Median Barrier Guidelines for Texas** and denoted as "TTI Report No. 0-4254-1.pdf". On page 33, TTI noted that the majority of TX's cross-median crash data occurred in medians larger than 60 ft wide. The disproportionate representation of wide median CMC data is partially because TX is proactive in shielding medians narrower than 70 ft, but it is reflective of the need to consider shielding even in wide medians. This was reinforced in a 2009 report titled **Development of Guidelines for Cable Median Barrier Systems in Texas.** denoted as "Development of Guidelines for CMB in Texas - TTI 2009.pdf".

Other data may also be available, but the brief synopsis suggests that for large traffic volumes, CMBs may be warranted for medians wider than 75 ft. Unfortunately there are currently no recommendations available to establish guidelines for usage, and states may determine if there are locations in which barriers placed in these wide medians are justified.

Attachment: http://mwrsf-qa.unl.edu/attachments/18e8711559c8b5570d05cb84d88c70cc.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/936f8f4d33a434ed76a316b121f8f38f.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/a854835ed12d067f5506626090266b27.pdf

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Brittle Test For Steel Bridge Rail Tubes

Question
State: WY
Date: 05-18-2015

When Wyoming's TL-3 and TL-4 Bridge Rail was approved to NCHRP 350, FHWA expressed concerns about addressing brittle failure for ASTM A 500 tubes, something they had seen in other bridge railings. To address this concern, Wyoming adopted a

requirement for testing in accordance with ASTM E 436 using criteria similar to the State of New York. The specification calls for a Drop-Weight Tear Tests and reads, "the percentage shear area shall be determined by testing six specimens from the 6-inch side or sides of the structural tube not containing a weld. If the average percent shear area falls below 50, the material represented by these tests shall be rejected."

Trinity is in the process of providing railing for a project and they observed the following results:

Of the six tests, three showed 100% shear and three tests showed 10 % shear. The average of all six tests is 55% which according to the specification would pass. We are concerned however about the spread of the results. Should this be considered a pass, or should additional criteria be applied? Any light you can shead on this mater would be helpful. We are in the process of approving the material, so time is of the essence.

Thanks!

Response
Date: 05-27-2015
ASTM E436 appears to be a shear test for evaluation of the fracture propagation in the temperatures where the steel behavior transitions from ductile to brittle. In your question, you noted that three showed 100% shear, which would indicate ductile response, and three showed 10% shear, which would indicate a brittle response. However, there is no mention of the temperatures for these tests. According to the ASTM spec, these tests should be run at varying temps to determine how the temperature is affecting ductility.

As such, in order to answer this question, we would need to look at the temperatures that the tests were run at and compare them with your operational temps in order to decide if the ductility of the bridge rail was an issue. I don't believe that you can average the results as the samples were likely run at different temps.

If you have some additional data from the testing that you can share, we can look into things further.

Thanks

Condition of Temporary Concrete Safety Barrier

Question
State: KS
Date: 05-27-2015

I
had a question come in from KDOT field personnel regarding the condition of TCSB and at what point the TCSB should be rejected on a KDOT project. KDOT doesn't currently have any published criteria, but I gave our field personnel the direction that if the shape of the barrier or the structural integrity of the barrier is compromised then it should not be allowed on the project. I talked with Scott King and he seemed to think MwRSF might have looked into this topic previously. I didn't find anything on the Pooled Fund site directly related to the condition/damage to TCSB. Do you know of any research that MwRSF has done previously on this? I have some information I've found from a few other states, but just wanted to check and see if you had anything MwRSF had done. Please give me a call to discuss if needed or just send an e-mail response.

Response
Date: 05-27-2015
There has not been any formal research in this area, but it has come up as a research need several times in the past.

As such, I don't have hard data or guidance, but I can note some areas for concern that we would consider when looking at barrier condition.

1. Deformed or damaged connections – If the barrier loops or the connection pin are significantly deformed or damaged, we would recommend replacing the barrier. Deformed loops or pins have lost some of the toughness/ductility. As such, a second impact may be sufficient to fracture those components. This would include

deformation or partial tearing of those parts. Additionally, if the loop bars are necked or decreased in cross-section. Similarly, if the loops have been pulled out of the end of the barrier face partially, this would indicate that previous impacts have moved the bars in the concrete and that there is the potential for loss of development.
2. Damage to the barrier toes or ends – We often see damage to the toes of the barrier segments due to moving and placement, especially on the ends of the barriers . This is a significant problem as the engagement of the adjacent barrier toes when the segments rotate during impact is critical for generating the forces in the joint needed to redirect the vehicle. Thus, if the toes of the barrier segments are spalled off or broken, it would be a concern.
3. Structural cracking – If you observe any through cracking of the barrier or cracks wider than 1/8", I would be concerned about barrier integrity.
4. Large sections of disengaged concrete – If large chucks or pieces of the barrier have been disengaged anywhere along the segment, it would be cause for concern. This missing concrete would degrade the structural capacity of the barrier and potentially act like asperities or snag areas along the face of the barrier that could promote vehicle instability or snag. I don't know if I have an exact size for those disengaged pieces off the top of my head.
5. Exposed rebar – Exposed rebar would be cause for concern as it would indicate large regions of disengaged concrete and it would expose the reinforcing steel to corrosion.

Again, these are not hard guidance, as that kind of effort would take more research, but these are the types of things I would look out for.

Steel Plate Grades

Question
State: WI
Date: 05-27-2015

mso-fareast-font-family:"Times New Roman"">I've once again reviewed my materials specifications.

mso-fareast-font-family:"Times New Roman"">For steel plates can I substitute ASTM A572 grade 50, or ASTM A A572 Grade 50 KSI Max. for ASTM A36?

mso-fareast-font-family:"Times New Roman"">

Response
Date: 05-27-2015

That would largely depend on the application. A36 has lower specified yield and tensile strength and marginally higher elongation. For almost all structural applications, I don't see any issues unless you desired a lower strength or slightly higher ductility. There may be some applications where this is necessary, for some kind of fracture critical or energy absorbing component.

Thanks

Temporary Concrete Barrier

Question
State: IL
Date: 06-11-2015

As a
follow-up to the response of November 25, 2013 regarding considering increasing the optional chamfer from 1/2" to 1" on all edges, we have received a suggestion regarding an additional modification in an effort to reduce the likelihood of temporary concrete barrier damage related to handling/placing/removing. The attached Standard 704001 shows a sketch of a 2" x 6" modification at the bottom of both ends of the temporary concrete barrier across the entire 22-1/2" width of the base of the barrier.

How would
this modification affect the performance of the IL F-Shape temporary concrete barrier?

[I will send the attachment via e-mail since I was having difficulty in successfully being able to provide an attachment through this method earlier this week.]

Attachment: http://mwrsf-qa.unl.edu/attachments/d04395074eceb4388930b0927e05ff90.pdf

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Response
Date: 06-12-2015
We would not recommend the removal of the 2"x6" section at the end of the TCB segment. The performance of the TCB during impact is partially dependent on the interlock of the toes of the barrier segment and development of moment continuity across the barrier joint. Removal of a portion of the toe of the barrier may reduce the effectiveness of the barrier toe contact and alter the barrier performance. Additionally removal of the concrete in that area would create more concentrated loading of the toes during impact and make them more likely to be damaged.

We do understand that the toes of the barriers get damaged during moving and placement. However, we would recommend placing more steel reinforcement in those areas rather than removal of portions of the toe near the end of the barrier.

There is potential that this alteration may still work, but it would need to be crash tested in order for us to be able to recommend its use.
