Midwest States Pooled Fund Program
Quarterly Progress Report – Third Quarter 2015
June 1, 2015 to August 31, 2015

DRAFT REPORTS – POOL FUND

Weiland, N.A., Stolle, C.S., Reid, J.D., Faller, R.K., Bielenberg, R.W., and Lechtenberg, K.A., *MGS Dynamic Deflections and Working Widths at Lower Speeds*, Draft Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-314-15, Project Nos. TPF-5(193) Supplement No. 69, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, June 2, 2015.

FINAL 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*, Final 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, June 2, 2015.

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

Putjenter, J.G., Bielenberg, R.W., Faller, R.K., and Reid, J.D., *Conceptual Development of an Impact-Attenuation System for Intersecting Roadways*, Draft Report to the Nebraska Department of Roads, MwRSF Research Report No. TRP-03-312-15, Project Nos. SPR-P1(13), Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, July 28, 2015.

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): 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): Reid, Sicking, Faller	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: RPFP-10-CABLE-3	**Other Project ID (i.e., contract #):** 2611211028001	**Project Start Date:** July 1, 2009
Original Project End Date: July 31, 2012	**Current Project End Date:** April 30, 2016	**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
$159,193	$150,944	44%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$7,459	

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 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.
The first draft of the third report will be completed, 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).

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)* TPF-5(193) Suppl. #41		**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: 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	$231,827	90%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$11,667	

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.):

Internal review of the draft report continued.

Anticipated work next quarter:

Internal review of the draft report will be completed. Draft report will be submitted to the sponsor. Final report will be completed and disseminated to the sponsor.

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): 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): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211083001	**Other Project ID (i.e., contract #):** RPFP-13-MGS-5	**Project Start Date:** 7/1/2012
Original Project End Date: 6/30/2015	**Current Project End Date:** 6/30/2016	**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
$162,896	$98,012	98%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$8,736	

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 writing the project report summarizing all design, testing, analysis, and conclusions completed as part of this project. A draft of the report has been completed and has been sent out to the sponsors for review.

Anticipated work next quarter:

Upon receiving sponsor reviews/comments, the report will be edited and finalized. The completed report will be disseminated and 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 impact 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. Thus, if a mow strip is desired that won't require pavement repairs after impacts, a 4" concrete mow strip is recommended for use in combination with the weak-post guardrail system.

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%

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 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:
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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 # 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	$75,399	43%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
$14,523 (8%)	$14,523	43%

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.):

The results from all the baseline simulations were evaluated and considered validated. Writing continued on the report to document the models and results. Fourty-two models were created with six curb types at a 0-in. offset from the face of the guardrail: 1) 2-in. tall triangular curb, 2) 4-in. tall triangular curb, 3) 6-in. tall triangular curb, 4) 2-in. tall vertical curb, 5) 4-in. tall vertical curb, and 6) 6-in. tall vertical curb. Seven different impact conditions will be conducted on each system and curb type: 1) Test no. 3-30 (Yaris) at a shallow 1/4 pt offset end-on, 2) Test no. 3-30 (Yaris) at a deep 1/4 pt offset end-on, 3) Test 3-31 (Silverado) end-on, 4) Test 3-32 (Yaris) at 5 degrees on end, 5) Test 3-32 (Yaris) at 15 degrees on end, 6) Test 3-33 (Silverado) at 5 degrees on end, and 7) Test 3-33 (Silverado at 15 degrees on end.

Anticipated work next quarter:

The results of the 42 models created will be evaluated and documented. Models with a 6-in. curb offset from the face of the guardrail will also be created. Other curb configurations, such as more gently sloping curbs may be considered depending on the results of the simulations. Writing will continue on the report.

Significant Results:

Fourty-two new models with curbs were created based upon the baseline simulations.

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:

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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. #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	$17,103	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**
	$1,446	

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)* TPF-5(193) Supplement #64	**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: 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)	$426,835 ($243,403 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
	$12,820 ($78,838 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 disseminated to the sponsors. The report containing the component testing of the shear plate brackets was disseminated to the sponsors.

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

Internal review of the draft 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) continued to be written.

Numerous methods to alleviate the floorboard penetration issue observed with the Midwest Weak Post were investigated through component testing. Review of the results was completed and disseminated to the sponsors during a conference call on August 24, 2015. In addition a summary of the conference call was sent out to all the sponsors on September 1, 2015. A brief summary of the decision made by the states able to join the conference call was MwRSF will modify the MWP to include ¾" diameter holes through the weak-axis flanges at groundline and continue to use the Bennett coupler/wedge to connect the cables and proceed with rerunning test 3-10.

Anticipated work next quarter:

Internal review of the draft report containing the full-scale crash tests (test nos. MWP-1 through MWP-3) will continue. The draft report will be sent to the member states for review. The final report will be finalized and published and will be disseminated to the sponsors.

Internal review of the draft report containing the component testing of the non-bolted connection concepts will continue. There is a potential the draft report may be sent to the member states for review during the next quarter.

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

Await feedback from the sponsors on how to proceed.

Anticipate preparing, constructing, and conducting a retest of test 3-10.

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

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
$162,518 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, $243,403 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)*		**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #66		☐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	$8,942	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**
	$414	

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):	**Phone Number:**	**E-Mail**
Reid, Faller, Lechtenberg, Bielenberg	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211099001	RPFP-14-TF13	7/1/13
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/16	6/30/16	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	$2,711	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
	$190	

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	$78,615.00	87%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$3,374.00	

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)* TPF-5(193) Suppl. #69 MwRSF Project No. RPFP-14-MGS-11		**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 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:** 6/30/2016	**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	$33798	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**
	$1,910	

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.):

The internal draft sent to sponsors was received with comments and those comments were implemented. The draft report was shifted to the publication queue.

Anticipated work next quarter:

The finalized report will be printed and copies will be sent to sponsors. The report will be loaded on the MwRSF website with relevant findings.

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 Revised and Returned to Sponsors	50%

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): Bielenberg, Faller, Reid, Rosenbaugh	**Phone Number:** (402) 472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611130087001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 2/1/2014
Original Project End Date: 7/31/2015	**Current Project End Date:** 10/31/2015	**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
$50,891.00	$49,208.00	90

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$11,409.00	

Project Description:

The research objective is to design and evaluate alternative epoxy adhesive anchorages for use in the IaDOT 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 IaDOT 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 IaDOT on April 14, 2015. At This time, MwRSF is awaiting approval of the revised scope and costs.

MwRSF asked for and received a time extension on the project to allow for completion of the research report and closing of the project using the additional funding requested in April 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 completed the summary report for this research and submitted it to IaDOT for review. We are currently waiting for comments and edits to the report from the sponsor. It is anticipated that the summary report will be completed in October 2015 to correspond with the revised project end. However, the project funding is currently depleted and the additional funding requested in April will be needed to complete the project.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will address the sponsor comments on the research report and complete the project.

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, IaDOT agreed to the revised scope and budget changes. MwRSF will work with IaDOT with regards to any changes to the scope and budget.

Currently, MwRSF is awaiting a response from IaDOT on the revised scope and budget. There are insufficient funds to complete the project as it currently stands. A time extension was granted by IaDOT to extend the project close date to October 31, 2015.

Potential Implementation:

The development of alternative epoxy adhesive anchorage systems for use in IaDOT 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	$37,714	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
	$26,547	

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 noted that recent research on cable median barriers has indicate that a potential exists for weak post sections with free edges to penetrate the floorboard of small car and sedan vehicles when these vehicles directly override the posts. MwRSF has previously developed a component testing setup with a simulated floorboard to investigate this concern. In order to investigate this potential, a dynamic test of a bogie vehicle with a simulated floorboard was conducted on the weak axis of the S3x5.7 posts proposed for use in the low-tension cable barrier adjacent to slope. The results of this test indicated significant floorboard tearing. This result was discussed with the TAC committee in a July 21st meeting in order to determine how the sponsors wished to proceed.

At the July 21st TAC meeting, MwRSF and the TAC members discussed several options for proceeding with the cable barrier adjacent to slope design in light of the potential for the S3x5.7 post to tear the occupant compartment floorboard.

1. Proceed with current S3x5.7 post, which posed the risk of 1100C test failure in the future.
2. Modify S3x5.7 post through the use of weakening mechanisms or a slip base.
3. Switch to modified MWP post in development as part of parallel research on cable median barrier systems. however, the design of the revised MWP post is not finalized at this time

The second and third options would likely require additional bogie testing adjacent to slope.

Discussion with the TAC members led to the selection of the third option as efforts to redesign the MWP post were alredy underway and the post would likely become a standard inventory part in the future. Currently, the MWP post has been redesigned with the addition of two, 3/4" holes at the based of the post in the weak axis flanges. Component testing has indicated that this will mitigate floorpan tearing. Thus, efforts to continue this project are waiting on completion of the next full-scale test of the cable median barrier system to verify that the modified MWP post works prior to continuing.

Anticipated work next quarter:

Assuming that the full-scale crash testing of the cable median barrier with the modified MWP post is successful, the research effort for the cable barrier adjacent to slope will continue with conducting the two remaining bogie tests at reduced slope offsets to determine what the minimum offset to the slope could potentially be. Testing of the strong axis capacity of the modified MWP post already exists, so the two remaining tests will focus on slope offset and any potential modifications to the MWP post in terms of embedment and/or soil plates.

Integration of the new post design into a modified cable adjacent to slope system will be required, including consideration of revised system hardware, cable tensions, cable heights, cable attachments, and anchorage. Design changes will be reviewed with the TAC members prior to determining the system configuration.

Following integration of the modified MWP post with the cable barrier adjacent to slope simulation models of the modified cable system will be conducted as originally planned to evaluate the potential for the new design to meet the MASH TL-3 criteria.

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 has caused delays in the project based on parallel development of the modified MWP post. Funding for the project tasks remains, but a time extension may be required to complete the research effort.

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	$22,809.00	45%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$16,612.00	

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.):

Previously, MwRSF completed simulation of impacts on the upstream and downstream ends of the 200 ft long barrier system to determine the length of need. It was determined that three barriers would be recommended for both the beginning and the end of length-of-need for the TCB system, until the results could be further discussed with the TAC.

The next step of the simulation analysis was to conduct 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 were evaluated using a seven barrier long TCB system. The results of these models found that the 2270P vehicle was successfully redirected for the seven barrier installation at both the beginning and end of the LON. In both cases, the reduced barrier system increased barrier deflections by approximately 16" over the full-length, 16 barrier system. Additionally, the impact at the end of the LON indicated a potential for the last barrier in the system to rotate rapidly towards the vehicle as it was redirected and impact the vehicle door. Thus, while the vehicle was redirected and the increases in deflections were manageable, the impact of the barrier with the driver side door was a concern.

These findings were discussed in detail at the July 21st TAC meeting in order to determine what the TAC concerns were and what was desired to be investigated through full-scale testing. The TAC indicated that the rotation and impact of the end barrier with the vehicle was a concern and wished to analyze the system with eight barriers, 3 for the beginning of LON, one in the middle, and 4 on the end of the LON. These models were simulated. Again both models successfully redirected the impacting vehicle. The addition of the fourth barrier on the end of LON mitigated the impact of the barriers on the vehicle door. Barrier deflections for impact at the beginning and end of LON for the 8 barrier installation were found to be 94.8 in. and 90 in., respectively. Additional, review of the models remains, but it appears that the use of an eight barrier system will be recommended for full-scale crash testing in the upcoming quarter pending approval of the

Anticipated work next quarter:

In the next quarter, MwRSF will prepare for testing and evaluation of the reduced system lengths indicated by the simulation analysis. Testing is anticipated for the 4th Quarter of 2015.

Simulations investigating the 85% impact severity on both the standard length and reduced length systems will be performed as well as simulations of intermediate system lengths under standard TL-3 impact conditions.

Significant Results:

Simulations of reduced system lengths was completed and a minimum system length of eight barrier segments was recommended for 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).

Currently, remaining tasks in the project include two full-scale crash tests, additional simulation of reduced length system deflections, and completion of the summary report. Funding for the project is adequate, but a time extension will likely be needed and requested in the 4th Quarter of 2015.

A note needs to be made regarding the budget figures noted above. For this quarter, $14,545 was charged to this project which should have been charged to TPF-5(193) Suppl#76. Additionally, $1,126 was charged to this project which should have been charged to TPF-5(193) Suppl#76 in a previous quarter. MwRSF is rectifying the accounting error and it will be corrected during next quarter.

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): Ron Faller, Bob Bielenberg, John Reid	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211108001	**Other Project ID (i.e., contract #):** RHE-11	**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**
$213,677.00	$54,758.00	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**
	$47,158.00	

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.):

In this quarter, MwRSF conducted all three of the full-scale crash tests for evaluation of the MASH TL-3 guardrail to PCB transition system. The test matrix is listed below.

1. MGSPCB-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. MGSPCB-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. MGSPCB-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.

All three of the full-scale crash tests successfully met the MASH TL-3 criteria. Thus, the system evaluation was completely successful. Currently, MwRSF is in the process of compiling the test report and recommendations for the implementation of the design.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will attempt to complete the summary research report summarizing the testing and evaluation of the guardrail to PCB transition. Additionally, the project team will prepare a technical brief as well as a summary presentation of the research results for the TAC.

Significant Results:

The guardrail to PCB transition design was successfully tested and evaluated to MASH TL-3.

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).

A note needs to be made regarding the budget figures noted above. For this quarter, $14,545 was charged to TPF-5(193) Suppl#75 which should have been charged to TPF-5(193) Suppl#76. Additionally, $1,126 was charged to TPF-5(193) Suppl#75 which should have been charged to TPF-5(193) Suppl#76 in a previous quarter. MwRSF is rectifying the accounting error and it will be corrected during next quarter.

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	$27,486	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
	$20,042	

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.):

Preliminary LS-DYNA simulations were completed to evaluate vehicle stability when traversing a simulated rock ditch liner at speeds ranging between 30 and 60 mph, and with different vehicle types. A full-scale test was conducted utilizing a Toyota Yaris small car traversing a level-terrain rock ditch liner at 50 mph. Testing was completed at the end of the quarter. Instrumentation was added to the suspension of the small car for later calibration and validation purposes.

Anticipated work next quarter:

Results of the full-scale test will be analyzed in detail. Initial vehicle calibration will be completed based on the results of the data analysis. Updated simulations with the calibrated vehicle will be performed to explore whether the rock ditch liner is safe for traversal or if modifications to the nominal design are required.

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:
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 # 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): Schmidt, Bielenberg, Faller, and Reid	**Phone Number:** (402) 472-0870	**E-Mail** jennifer.schmidt@unl.edu
Lead Agency Project ID: 2611130090001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 6/30/2014
Original Project End Date: 6/30/2017	**Current Project End Date:** 6/30/2017	**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
$95,852	$5,476	5.7%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$3,082 (3.2%)	$3,082	

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.):

More detailed Solidworks drawings were created of the concept. The development of the LS-DYNA model began. Writing commenced on the report.

Anticipated work next quarter:

The LS-DYNA model will be completed 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	40%
4. LS-DYNA Analysis and Evaluation	20%
5. Project Report	10%

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:
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) Supplement #79	**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: TL-4 Evaluation of the Midwest High-Tension, 4-Cable Barrier		
Name of Project Manager(s): Reid, Faller, Lechtenberg, Bielenberg, Rosenb	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211096001	**Other Project ID (i.e., contract #):** RPFP-15-CABLE-1	**Project Start Date:** 8/1/14
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
$408,235	$78,838 for Cable R&D	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
	$78,838 for Cable R&D	

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.

Note, in Quarter 3 of 2015, $100,000 of Project No. RPFP-15-CABLE-1 - TPF-5(193) Supplement #79, Project Title: TL-4 Evaluation of the Midwest High-Tension, 4-Cable Barrier (Yr 24 shortage) was committed to Cable R&D.

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)).

Note, in Quarter 3 of 2015, $100,000 of Project No. RPFP-15-CABLE-1 - TPF-5(193) Supplement #79, Project Title: TL-4 Evaluation of the Midwest High-Tension, 4-Cable Barrier (Yr 24 shortage) was committed to Cable R&D.

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	$41,513.00	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
	$7,345.00	

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.

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 were within 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. The initial draft of the report has been completed and the draft is currently undergoing internal review and editing.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will continue review and editing of the summary report for this research.

As part of the reporting effort, MwRSF will review the results of the full-scale crash test and provide guidance for minimum spacing between omitted posts in a run of guardrail.

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)* TPF-5(193) Suppl. #81 MwRSF Project No. RPFP-15-AGT-1		**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: Standardized Concrete Parapet for Use in Thrie Beam AGT's		
Name of Project Manager(s): Reid, Faller, Bielenberg, Rosenbaugh	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211113001	**Other Project ID (i.e., contract #):** RPFP-15-AGT-1	**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
$125,906	$13,049	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
	$6,371	

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.):

The design drawings were completed for the full-scale test installation - a thrie beam approach guardrail transition connected to a new concrete buttress. All materials were gathered and construction of the test installation has begun at the MwRSF test site.

Anticipated work next quarter:

The construction of the test article will be completed, and a single full-scale test will be conducted - a MASH 3-11 test with a 2270P pickup truck. Test results will then be analyzed.

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 bottom of the buttress (below the thrie beam) had 4"x12" chamfer to prevent tire snag, while the rest of the buttress had a 4"x4" chamfer to prevent vehicle snag. The length of the buttress was minimized at 7 ft to minimize the system length while also allowing room for geometric shape transitions to match up with various bridge rails. The height of the buttress was selected as 36" to match the height of MASH TL-4 bridge rails. The buttress height tapers down to 32" on the upstream end over a 24" length to prevent snag. 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	100%
4. System Construction	50%
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%

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	$24,893	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
	$24,266	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 (Revised from previous quarterly updates): Students with marketing expertise were hired and are brainstorming and drafting layouts for advertisements, mailers, and campaign themes for use by DOTs.

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.):

Crash data was acquired from many state DOTs in the Pooled Fund as well as some additional contributing states. Marketing students reviewed previous safety study results and provided recommendations for campaign themes and approaches, and began drafting the framework for those campaigns. Previous examples of marketing campaigns were reviewed, as well as relevant research and historical tree-related tort cases, and results were summarized. A draft report was started and is in progress.

Anticipated work next quarter:

The draft report containing work completed to date will be completed and submitted to the states for preliminary review. Crash data received from DOTs will be analyzed and results of the analysis will be summarized. It is anticipated that the crash history data will either be submitted to the Pooled Fund during 2015Q4 or 2016Q1.

Significant Results:

To date, over 150,000 tree or utility pole-related crashes have been collected over 5-year increments from state DOTs. This volume of crash data has never been analyzed in as much detail for any project known to researchers and conclusions will be significant.

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	$29,962.00	60%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$9,693.00	

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	$4,854	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
	$2,087	

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): Reid, Faller, Lechtenberg, Bielenberg, Rosenb	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211099001	**Other Project ID (i.e., contract #):** RPFP-15-TF13	**Project Start Date:** 8/1/14
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**
$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:**
TPF-5(193) Suppl. #86	☐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 Conceptual Development of an Impact Attenuation System for Intersecting Roadways		
Name of Project Manager(s): Bielenberg, Faller, Reid	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211118001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2015
Original Project End Date: 12/31/16	**Current Project End Date:** 12/31/16	**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
$256,184	$659	3%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$659	

Project Description:

The Nebraska Department of Roads (NDOR) funded the first phase of this effort (M332 – New Conceptual Development of an Impact Attenuation System for Intersecting Roadways). This Phase I effort consisted of development of design concepts, analysis of those concepts, and recommendations as to their feasibility. The project was proposed as an initial conceptual design effort, allowing NDOR to limit the research funds for this phase until a viable design was identified and a more substantial investment could be made toward compliance testing.

Following the Phase I study, a hybrid end terminal/crash cushion and net attenuator system was for additional research that had several areas in need of further development. First, dynamic component testing of the proposed Dragnet attenuator found that the current force levels were insufficient to maintain stopping distances near the desired length of 30 ft. In fact, component testing with three standard Dragnet energy absorbers on each side of the system resulted in deflections over 40 ft. Thus, redesign of the net attenuator system will be required to increase the resistive force and shorten the stopping distances. This will likely require redesign of the energy-absorbing drums, the capture net, and the anchorage of the energy absorbers. Additionally, it was desired that the hybrid end terminal/crash cushion and net attenuator attempt to accommodate moderate slopes. Thus, additional research is needed to determine what slopes can be safely used with the revised net attenuator. The first phase of the research considered a variety of end terminal and crash cushion systems, but additional research is needed to determine what other systems are optimal based on their geometry and shielding of the bridge rail end. Finally, additional research is needed to determine the exact layout of the hybrid end terminal/crash cushion and net attenuator system in order to ensure that the two systems function properly when used together.

Thus, the current research results indicated a potential for an alternative design to meet the MASH safety criteria. However, further research is needed to complete the design and prepare it for full-scale crash testing and evaluation to MASH TL-3.

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

In this initial quarter of the research project, limited work has been initiated on the first research task. MwRSF has been working and collaborating with Impact Absorption, Inc. to develop high-performance net attenuation system that incorporates increased capacity energy absorbers and an appropriate capture net. Impact Absorption, Inc. has been testing several variations of the energy absorbers to evaluate changes in materials, alteration of material dimensions such as steel tape thickness, and modification of the path of the energy absorbing tapes. MwRSF is currently working to setup a meeting for Impact Absorption, Inc. to update them on the current progress of those investigations and guide the development of the high-performance net attenuation system.

The remaining project tasks will largely hinge on the development and evaluation of the high-performance net attenuation system.

Anticipated work next quarter:

In the upcoming quarter, MwRSF hopes to obtain the design of the high-performance net attenuation system and present it to the TAC for review and comment. If the system is acceptable, we will proceed with setup for the dynamic component testing of the high-performance net attenuation system.

MwRSF will also begin work on compiling a literature review of potential end terminal and crash cushion systems for use with the high-performance net attenuation system to create the treatment for intersecting roadways.

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:

Currently, no safety treatment has been successfully crash tested using TL-3 conditions under NCHRP Report No. 350 or MASH to resolve the problems posed when intersecting roadways are located near a bridge railing. A design that can safely treat this situation along high-speed roadways is sorely needed. In addition, the development of a new design concept for an attenuation system for intersecting roadways will focus on the site and space restraints associated with intersecting roadways and adapt a design that best meets those constraints.

MwRSF will work closely with NDOR engineers and the TAC committee members throughout the concept development of a new attenuation system for intersecting roadways in order to ensure that the system is practical. This focus should ensure that the system is viable for NDOR as well as other state DOT's.

Once the new, TL-3 attenuation system for intersecting roadways has been crash tested, evaluated, and accepted by FHWA, NDOR and other State DOTs can implement the new design into its Standards and/or Special Plans for intersecting roadways. At the conclusion of this research project, it is recommended that NDOR designate an intersecting roadway location that will use this new technology in order to evaluate a "real-world" installation and make any necessary improvements.

Finally, the publication and dissemination of the research results and demonstration program, in the form of newsletters, research reports, and refereed journal papers, will aid the rapid transfer of this new technology to all interested

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. #87		**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: Guidelines for Placement of Breakaway Light Poles Behind MGS		
Name of Project Manager(s): Faller, Bielenberg, Reid	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611130094001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/10/2015
Original Project End Date: 6/30/17	**Current Project End Date:** 6/30/17	**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**
$262,603	$26	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**
	$26	

Project Description:

Light poles are a commonly found along most highways due to the need to provide proper illumination to critical areas of the road. It is not uncommon for light poles to be placed in areas where guardrail is present as well. In these situations, light poles must be placed sufficiently close to the roadway while not interfering with the performance of the guardrail system. However, several concerns exist when placing light poles in close proximity to guardrail that may affect its ability to safely contain and redirect vehicles. First, interaction between a deflected guardrail system and a pole may create unwanted stiffening or hinging of the barrier system about the pole, which may cause pocketing and increased loading to the guardrail. The pole may also present a snag hazard to impacting vehicles, which may cause increased vehicle decelerations and instabilities. Third, interaction between the guardrail posts and light pole may affect barrier performance. While the use of breakaway light poles may mitigate these concerns to some degree, the interaction between a guardrail system and a closely-positioned light pole requires further investigation.

The Illinois Tollway currently has many instances where light pole placement is desired directly behind W-beam guardrail in order to provide adequate road illumination. Illinois Tollway and Illinois Department of Transportation have recently adopted the Midwest Guardrail System (MGS) as their standard W-beam guardrail design. The current Illinois Tollway standard for light poles is to place the pole no closer than the minimum barrier clearance distance of 28" (standard 6'-3" post spacing), 23" (½-post spacing), and 14" (¼-post spacing), as shown in Figure 1. In order to accommodate poles positioned closer than the minimum barrier clearance distance, an investigation should be conducted to determine if the minimum standard distance for breakaway light poles can be reduced, and if so, determine the optimal position of the light pole with respect to the guardrail system. It is anticipated that computer simulation/modeling with non-linear finite element analysis will be conducted to reduce the number of required crash tests. Crash tests should be conducted according to the AASHTO MASH Test Level 3(TL-3) impact safety criteria.

The objective of this research effort is to develop guidance for safe placement of the Illinois Tollway standard light pole

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

In this initial quarter of the research project, effort has been focused in two areas. First, work was initiated on the literature search. The literature search has been focused on summarizing current working width and dynamic deflection guidance for the MGS based on current available MASH testing, reviewing the current Tollway light pole design and any previous testing of this pole or similar poles, reviewing current Tollway pole offset guidance, and collecting and reviewing previous, relevant research related to offset poles adjacent to roadside hardware. The literature search has been partially completed at this time and should be finished in the 4th Quarter of 2015.

Concurrent with the literature search, MwRSF has been reviewing existing models of the MGS system that have been developed at the facility in order to select the appropriate model for evaluation of the light pole offset. At this time, an appropriate version of the MGS model has been selected and will be ready to use when the simulation modeling of the pole offsets is ready to begin.

Anticipated work next quarter:

In the upcoming quarter, MwRSF plans to complete the literature search and organize and complete that section of the research report. In addition, work will be done to incorporate the Tolloway light pole standard into the simulation models of the MGS and begin the process of analyzing the pole and barrier combinations with various offsets and locations for the pole relative to MGS. The setup for the simulation analysis will depend on the review of the literature search results.

Significant Results:

The literature review for the research project has been started and an appropriate simulation model of the MGS has been selected for the analysis of pole offsets.

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 minimal offset for light poles placed adjacent to the MGS would allow the Illinois Tollway and the Illinois DOT to reduce light pole relocations in upcoming construction projects and avoid relocation in projects that are currently underway. Avoiding or reducing light pole relocations when minimum clearance distance is not met would reduce construction costs. In addition, the research could potentially reduce the need for supplemental lighting, planning, and analysis of lighting impacts due to necessary light pole relocation.

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:** 6/30/2016	**Number of Extensions:** 5

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	$828,851	84%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$45,295 (4.6%)	$45,295	84%

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 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 finalized on July 29, 2015. The fourth volume of reports, which details the results of all three full-scale crash tests, was sent for sponsor review on September 9, 2015. Writing also continued on a fifth report, which details the initial background and development of a future stiffness transition to a rigid concrete parapet.

The joint between the upper steel tube was redesigned to align the tube splices with the splices in the concrete beams for ease of installation. This joint was made more robust to transfer the moment across the splice when impacted.

Design continued on the stiffness transition between the deformable barrier and a TL-4 rigid concrete parapet end or buttress. The design was completed on a pinned-end connection and initial evaluation of the concept was completed using the LS-DYNA barrier model developed previously.

Anticipated work next quarter:

The fourth report will be finalized. The stiffness transition design concepts will be further evaluated according to the design criteria, including consideration for snag mitigation with simulated impacts with 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 needs for additional project funding and include 1100C, 2270P, or 10000S vehicles.

Significant Results:

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.

Report TRP-03-318-15 documenting phase 4 of this project was sent to sponsor for review on September 9, 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.

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

06-10-2015 to 09-09-2015

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.

Extra Blockouts / Bridge Guardrail Near Side Roads

Question
State: IA
Date: 06-15-2015

Extra Block outs

http://mwrsf-qa.unl.edu/view.php?id=205

On the link above it discusses the use of double and triple block outs. I read it that double block outs are OK for any number of posts. I thought that would be for the standard 12" block out in the W beam, but it seems to indicate 8". Would the 8" block out, only apply to the Bridge transition section? Are there areas of bridge guardrail that double block outs should be avoided?

Restricted Length Bridge Guardrail

A question that arises often is one related to placing guardrail that conflicts with a side road or entrance. We have developed a document for guidance, Short Radius Guardrail, and would like your input. We realize some of the shorter choices are less desirable but thought they were better than not doing anything. This is a tough subject that should probably require research and analysis, but we really just want to make sure we are not giving some blatantly bad direction to designers. Any input would be greatly appreciated.

Attachment: http://mwrsf-qa.unl.edu/attachments/8eb8ee9b0fc3bae65990600d82f3dbf8.docx

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Response
Date: 06-17-2015

First, the blockouts guidance below is based on 8" blockouts. Thus, we believe that 6" blockouts are acceptable as we have used them in certain special applications without a problem. 24" blockouts are allowed in limited locations as noted in the response.

This holds true for the standard MGS system as well.

http://mwrsf-qa.unl.edu/view.php?id=267

For the short-radius document, I have a couple of comments.

1. We have provided guidance for attachment of terminals and minimum system lengths for the approach guardrail system and terminals. I would review that relative to the guidance on the first page, as I believe that some of them may be in conflict.

   "Thus, the following implementation guidelines should be followed:

   1. A recommended minimum length of 12 ft – 6 in. (3.8 m) for standard MGS is to be installed between the upstream end of the asymmetrical W-beam to thrie beam transition section and the interior end of an acceptable TL-3 guardrail end terminal. This segment includes one half-post spacing for Design K and three half-post spacings for Design L.

   2. A recommended minimum barrier length of 46 ft – 10½ in. (13.3 m) is to be installed beyond the upstream end of the asymmetrical W-beam to thrie beam transition section, which includes standard MGS, a crashworthy guardrail end

terminal, and an acceptable anchorage system. This segment includes one halfpost spacing for Design K and three half-post spacings for Design L.

3. For flared guardrail applications, a minimum length of 25 ft (7.6 m) is recommended between the upstream end of the asymmetrical W-beam to thrie beam transition section and the start of the flared section (i.e. bend between flare and tangent sections). This segment includes one half-post spacing for Design K and three half-post spacings for Design L."

http://mwrsf.unl.edu/researchhub/files/Report38/TRP-03-210-10.pdf

2. When discussing the radius options for the short-radius guardrail, we would suggest a minimum radius of 8'. No radius smaller than that has ever been crash tested.

3. It appears that you are using the Washington short-radius design. This is likely based on the FHWA memo that previously recommended that design for use until a better, crash-tested system is developed. Recently, TTI got TL-2 approval for the Yuma County short-radius design. Some states have moved to this design, and I just wanted to bring it up in case you were unaware.http://www.roadsidepooledfund.org/files/2010/11/T-Intersection-final_2010-08-17.pdf

4. TTI has also done some recent research into a MASH TL-3 short-radius system. The system did meet the crash test criteria, but we have some concerns about impacts on the system in locations not specified in the crash test matrix. I thought you might want to look at that information as well.

   http://tti.tamu.edu/documents/0-6711-1.pdf

   http://tti.tamu.edu/documents/0-6711-S.pdf

5. On page three, you discuss an area for breakaway posts for capture of errant vehicles. You have chosen an area from 5-15 degrees. We have recently been doing research with NDOR on a new safety treatment for intersecting roadways and have looked into similar issues of necessary capture area. We believe that the angle of impact in the capture area may vary from 0-25 degrees. We defined the potential impact area for errant vehicles based on a runout length calculation. NDOR liked this approach because it provided for a more justifiable definition. The report on this research should be out in a month, but I have attached a draft of the chapter describing this for your review.

Thanks

Attachment: http://mwrsf-qa.unl.edu/attachments/e2d3281ac681d0ecdc4a939be383a1f4.pdf

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Curb in front of thrie-beam transition

Question
State: IA
Date: 06-22-2015

I'm looking for guidance for the following situation regarding the length of 4" curb placed through the end of the nested w-beam of a typical 37.5' Barrier Transition System (BA-201).

As you can see on BA-201, we show possible curb running through the end of the BTS as report 03-291-14 *Dynamic Evaluation of MGS Stiffness Transition with Curb* suggests in the second full paragraph on page 136. We denote this 4" curb via circle note 2, which states to see project plans. Project plans in this case typically refer to our Bridge Approach Standards (BR Series), and therein lies the problem. On the Bridge Approach Standards that show abutting pavement (BR-102, 103, 104, 105, 106, 107, 112, 205, 211, 212, 231), we have a circle note that states something to effect of "Build 4 inch Sloped Curb to end of Double Reinforced Section." This note has been shown on our approach standards since April 1999 when we switched to the 4" curb. A typical double reinforced section extends 20' out from the center of the roadway (see image below). I would say that in almost no case would the double reinforced section extend 37.5' and meet the report's suggestion. What I would like to know is which of the following is the real issue with curb location:

1) If curb is present along any length of the thrie-beam portion, asymmetric transition portion, or nested w-beam, it must be run from the bridge end out to at least 37.5', and thus typically ending at the nested-to-single w-beam splice, or

2) If curb is present under the 7' (approx.) asymmetric transition, it must be run out to the nested-to-single w-beam splice.

The first option forces a 37.5' minimum install length of curb. The second option says to end the curb before the asymmetric transition (somewhere in the first 18' or so) ***OR*** carry it out to the nested-to-sing w-beam splice (at least 37.5').

I ask because both our "old" Barrier Transition Section standard (older BA-201) and "new" Barrier Transition System (BA-201) have the asymmetric transition ending 25' away from the bridge end. With a typical bridge end section of 7' (BA-107). that placed the asymmetric transition 25' to 32' from the edge of the deck/beginning of double reinforced section. Perhaps on the long side of a strong skew we could have seen the edge of the double reinforced be in line with the asymmetrical transition, but it was likely a rare occurrence, which is great if #2 above is what was meant. If #1 is the real issue, then I'll have a follow up email about the immediacy of change for our current standards.

Attachment: http://mwrsf-qa.unl.edu/attachments/615314ed3792e3351fb4e9051968de56.jpg

Response
Date: 06-22-2015

Your option 2 is more accurate. If you wish to have curb extend from the bridge rail/buttress and terminate prior to the asymmetric rail section, this would be acceptable. In fact, prior to the success of the full-scale test you are referencing, we had recommended terminating the 4" curb within the thrie beam section of the approach guardrail transition. I apologize for this not being clearer in the report.

Response
Date: 06-23-2015

Given that clarification, here is what I plan to propose to designers. Please let me know if this is incorrect.

Using BA-201 as an assumed Barrier Transition Section and a standard 5' curb transition as shown on page 2 of PV-102 (which meets your 3' min curb transition recommendation on page 136 of TRP-03-291-14):

A) If any part of the 4" sloped curb (including the curb transition) extends into the asymmetrical transition section, the minimum curb length must be extended to 37.5' and they are to use the new 37.5' BA-201 showing the nested w-beam and also meet the general layout requirements as shown on page 137 of TRP-03-291-14 *Dynamic Evaluation of MGS Stiffness Transition with Curb*:

B) If the 4" sloped curb (including the curb transition) is terminated prior to the asymmetrical transition section, the older BA-201 (25' instead of 37.5') may be used but must also meet the general layout requirements as shown on page 154 of TRP-03-210-10*Development of the MGS Approach Guardrail Transition using Standardized Steel Posts*:

I ask for confirmation because the potential installation length differences between the two are significant. Assuming all other things equal, the first has a minimum install of (37.5 BTS+50.0 w-beam+3.125 connection+50.0 terminal) 140.625'. The second has a minimum install of (25.0 BTS+12.5 w-beam+3.125 connection+50' terminal) 90.625', or a 50' installation length increase for not terminating the curb early. This may not matter on the interstate or higher volume roadways where the runout length (according to Roadside Design Guide) is well beyond that, but certainly would come into play on our lower volume roadways and especially our county/local roadways. It may also cause us to rethink requiring the curb to extend to the end of the double reinforced section (discussed below) as this would essentially guarantee the longer installation.

Another situation we run into frequently is having to drop down from a TL-3 Barrier Transition Section to a TL-2 where we essentially eliminate the thrie-beam downstream of the asymmetrical transition and attach the asymmetrical transition piece to the Bolted End Anchor (BA-202). This TL-2 system was tested at TTI (available here with detail attached). This typically comes into play when we have an entrance/side road within the normal guardrail installation. Since I wouldn't expect for you to speak for another research facility, TTI in this case, I will make the following statement and ask that you agree or disagree based on the general principles at play.

A) Since the failure in TRP-03-291-14 was due to the existence of curb in the asymmetrical piece, any curb coming off of the bridge end would extend into that section and thus a 12.5' section of nested w-beam should be added to the upstream end of the transition, along with w-beam equal to the length of the end terminal (25' TL-2 typically).

B) If there is no curb, no nested w-beam is needed but a length of w-beam equal to the length of the end terminal should be included, OR

C) If there is no curb, no nested w-beam is needed but a 12.5' section of w-beam should be included before the end terminal.

Again, please confirm my understanding on both points. And as always, your assistance is appreciated.

Attachment: http://mwrsf-qa.unl.edu/attachments/1f0350b249e192392307be9bd1da7a8e.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/119a1b57e82737ead02789dbd7bd8964.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/f7aa283ca4a3b630eb26f906b0490a0b.pdf

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Response
Date: 06-24-2015

I have commented below in RED

Given that clarification, here is what I plan to propose to designers. Please let me know if this is incorrect.

Using BA-201 as an assumed Barrier Transition Section and a standard 5' curb transition as shown on page 2 of PV-102 (which meets your 3' min curb transition recommendation on page 136 of TRP-03-291-14):

A) If any part of the 4" sloped curb (including the curb transition) extends into the asymmetrical transition section, the minimum curb length must be extended to 37.5' and they are to use the new 37.5' BA-201 showing the nested w-beam and also meet the general layout requirements as shown on page 137 of TRP-03-291-14 *Dynamic Evaluation of MGS Stiffness Transition with Curb*:

B) If the 4" sloped curb (including the curb transition) is terminated prior to the asymmetrical transition section, the older BA-201 (25' instead of 37.5') may be used but must also meet the general layout requirements as shown on page 154 of TRP-03-210-10*Development of the MGS Approach Guardrail Transition using Standardized Steel Posts*:

I ask for confirmation because the potential installation length differences between the two are significant. Assuming all other things equal, the first has a minimum install of (37.5 BTS+50.0 w-beam+3.125 connection+50.0 terminal) 140.625'. The second has a minimum install of (25.0 BTS+12.5 w-beam+3.125 connection+50' terminal) 90.625', or a 50' installation length increase for not terminating the curb early. This may not matter on the interstate or higher volume roadways where the runout length (according to Roadside Design Guide) is well beyond that, but certainly would come into play on our lower volume roadways and especially our county/local roadways. It may also cause us to rethink requiring the curb to extend to the end of the double reinforced section (discussed below) as this would essentially guarantee the longer installation.

I agree with the installation options A) and B) above. However, the minimum total lengths of the systems should be identical. The only difference between the installation length recommendations was the reference point. The Option A reference point is the upstream end of the W-beam section, while the reference point for Option B is the upstream end of the asymmetrical segment. Since the nested region is 12.5 ft long, the lengths should add up:

Requirement #1

A: 37.5 ft (end shoe through nested w-beam) + Terminal = 37.5 ft + Terminal length

B: 25 ft (end shoe through w-to-thrie segment) + 12.5 ft (standard MGS) + Terminal = 37.5 ft + Terminal length

Requirement #2

A: 37.5 ft (end shoe through nested w-beam) + 34.38 ft (w-beam) = 71.88 ft

B: 25 ft (end shoe through w-to-thrie segment) + 46.88 ft (standard MGS) = 71.88 ft

Requirement #3

A: 37.5 ft (end shoe through nested w-beam) + 12.5 ft (MGS) + Flared Terminal = 50 ft + Flared Terminal

B: 25 ft (end shoe through w-to-thrie segment) + 25 ft (MGS) + Flared Terminal = 50 ft + Flared Terminal

Another situation we run into frequently is having to drop down from a TL-3 Barrier Transition Section to a TL-2 where we essentially eliminate the thrie-beam downstream of the asymmetrical transition and **attach the asymmetrical transition piece to the Bolted End Anchor** (BA-202) **There should be 37.5" of either 10 ga. thrie beam (as tested) or nested 12 ga. thrie beam between the asymmetrical segment and the end shoe**. This TL-2 system was tested at TTI (available here with detail attached). This typically comes into play when we have an entrance/side road within the normal guardrail installation. Since I wouldn't expect for you to speak for another research facility, TTI in this case, I will make the following statement and ask that you agree or disagree based on the general principles at play.

A) Since the failure in TRP-03-291-14 was due to the existence of curb in the asymmetrical piece, any curb coming off of the bridge end would extend into that section and thus a 12.5' section of nested w-beam should be added to the upstream end of the transition, along with w-beam equal to the length of the end terminal (25' TL-2 typically).

B) If there is no curb, no nested w-beam is needed but a length of w-beam equal to the length of the end terminal should be included, OR

C) If there is no curb, no nested w-beam is needed but a 12.5' section of w-beam should be included before the end terminal.

Since we do not have testing of the TL-2 system with curb, it would be conservative to add the nested section of W-beam upstream of the asymmetrical segment to prevent possible rail tearing when a curb is present. As such, I agree with these installation configurations and lengths.

Response
Date: 06-25-2015

Two additional questions for you then.

I agree that requirements 2 and 3 would produce installations that are identical in length. Makes sense that you're simply turning a piece of standard w-beam into nested. What I'm perhaps more confused with now is how requirement 1 is bringing me to the same length for each situation.

Part A

BTS = 37.5'

W-beam upstream of nested to be greater than or equal to end terminal = 50' (or 37.5' for cable connection)

End terminal = 50' (or 37.5' for cable connection)

Total install = BTS + 2 times end terminal length = 37.5' + 2(50') = 137.5'

Part B

BTS = 25'

w-beam = 12.5'

End terminal = 50' (or 37.5' or 25')

Total install = 87.5'

The other question is in regards to the 12.5' section of standard w-beam between the asymmetrical transition piece and the end terminal (requirement B,1 below). What was the underlying concern that introduced this section? We have plenty of existing installations where it is simply a BTS to End Terminal.

Sorry for all the questions. I'm just trying to understand the underlying principles in order to make correct modifications as needed.

Response
Date: 06-26-2015

For requirement 1, the length upstream of the nested w-beam section is to include the terminal itself. Thus, you only need your BTS length (37.5 ft) plus the length of the terminal (50 ft), for a total of 87.5 ft – same as option B. Sorry for the mix up there, we probably could have worded that better.

Concerning the 12.5 ft for requirement B-1:

The overlying reasoning is to separate any transition elements from the end terminal so as not to affect the performance of the end terminal. A different rail segment could easily affect performance, so we need to keep the stroke length of the terminal upstream of the 10 ga. w-to-thrie segment. Additionally, there is a post at ½ post spacing (37.5") upstream of the w-to-thrie segment. Depending on the specific terminal, utilizing a different post spacing (or different post altogether) may also affect the performance of the terminal. Thus, we wanted to stay upstream of the ½ post spacing portion of the transition as well. We could have used a 6'-3" distance in this recommendation (B-1), but many states don't stock 6'-3" segments of w-beam guardrail. Therefore, the length was conservatively extended to 12'-6". If you desire to use the shorter 6'-3" distance for plans, I couldn't argue against it.

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what is the purpose of beam guard in the photo attached

Question
State: WI
Date: 07-01-2015

The RDG indicates that the guardrail shown on the attached file should be used near a short radius system. Any idea on why?

Attachment: http://mwrsf-qa.unl.edu/attachments/53690234fd13a4c0fbf7cfe65ff5dbb9.docx

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Response
Date: 07-02-2015
I would assume that the guardrail shown upstream of the short-radius system in the attached figure is based on two related concerns.
1. All previously developed and tested short-radius systems have focus only on impact locations ranging from the center of the nose of the system and towards the primary roadway. Thus, the behavior of the system farther up on the secondary roadway is unknown.
2. Based on potential vehicle trajectories and runout length calculations, current short-radius systems may potentially be insufficient to shield the range of potential impacts.

Placement of the additional barrier on the upstream side of the primary roadway limits the potential for these concerns. We have currently been working on a research project for NDOR to develop a treatment for intersecting roadways that better addresses the hazard area and has significantly higher capture capabilities. The Phase I report for that should be out this month and Phase II started July 1.

Guardrail flare rate with Bullnose

Question
State: NE
Date: 07-01-2015

With w-beam tested on a 7:1 taper rate, would you expect thrie-beam to redirect a MASH vehicle properly on a 7:1 taper?

What about thrie-beam on a 8:1 placed in a 45 mph median?

This is attached to a bullnose.

Response
Date: 07-06-2015

We have not recommended increased flare rates on thrie beam at this time. While the work done with the MGS system would indicate that the potential for increased flares with thrie beam exists, there are too many unknowns. The thrie beam system would have different capture, post stiffness, and dynamic deflections as compared to the MGS. As such, it is difficult to ensure that the performance would be similar. Certain design changes might need to be made regarding the post embedment, splice location, and the blockout geometry to ensure that it would work.

As far as the bullnose system goes, we have recommended standard flare rates as recommended by the RDG beginning at post no. 9 on the oncoming traffic side. Flaring prior to post no. 9 may affect the performance of the bullnose. On the reverse direction traffic side of the system, we have allowed more aggressive flares as the guardrail would be flaring away from oncoming traffic.

The RDG list 8:1 flares as acceptable for 40 mph and 10:1 for 45 mph.

Thanks

Curb Offset Behind Guardrail

Question
State: KS
Date: 07-07-2015

When you have time could you please give me a call to
discuss the attached? My calendar is full today, but I have some time tomorrow from 11:00 am to 1:00 pm or anytime Thursday works well.

Attachment: http://mwrsf-qa.unl.edu/attachments/8d0fb26a6d0eca56a2fb1a16eeb4799f.pdf

Response
Date: 07-09-2015

I reviewed the schematic you sent regarding a curb offset behind a guardrail system to help control erosion. You had asked about our thoughts on the offset of the curb behind the barrier and the height of the curb. We have several comments on this setup for your consideration.

1. We would assume that this setup would be made with the MGS system rather than the previous metric height G4(1S) system. Thus, all of the remaining comments are made with respect to the MGS.
2. As you noted, the guardrail posts will be installed in a 4" thick concrete pad with leave outs filled with grout. I assume that this is based on the TTI research on mow strips and leave outs. We would recommend using that research for the leave out details.
3. The main concern with this type of system is the interaction of the vehicle with the curb during deflection of the guardrail system. For an MGS system, that deflection is typically in the 4' range for TL-3. We have seen that vehicle

interaction with curbs can increase rail loads and increase the potential for vehicle instability. However, we believe that the curb can be placed in the later portion of the barrier deflection and still maintain safe performance as the overall barrier stiffness will be lower at that point in the impact.

4. With regards to the barrier offset, the MGS with an 8" or a 12" blockout is approximately 18" to 22" deep, respectively. A 24" offset from the back of the post to the curb would make the offset to the curb 42"-46" depending on the blockout size. This would be at the latter region of the MGS deflection. Thus, placement of the curb at the 24" offset should have minimal effect on the barrier performance.

5. As far as curb height, we believe that a 4" curb would be a more forgiving setup in terms of its effect on barrier performance. However, we believe a 6" curb will work given the 24" offset and the limited vehicle interaction with the curb.

Let me know if that answers your questions or if you need anything else.

Thanks

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top mounted Guardrail to culvert attachments

Question
State: KS
Date: 07-22-2015

I've attached KDOT's current Standard Drawing (RD617E) for attaching MGS to low fill culverts as well as a sketch (Attachment to Low Fill Culverts) from a project currently being constructed. The design engineer on the project has run into an issue where the steel plate that rests on the ceiling of the box is conflicting with the fillet in the waterway opening (this is occurring at several locations). The sketch in the second attachment depicts the issue. We've investigated shifting the guardrail installation to avoid the conflict with the fillets, but unfortunately we are unable to avoid them given the needed post spacing. I'd like to discuss whether or not we could

include washers between the steel plate and the culvert ceiling to shim the plate down an inch or so to avoid the conflict. I marked on the second attachment where the washers would be included.
Attachment: http://mwrsf-qa.unl.edu/attachments/4dd0c01034511e5febc1e90c7dbc5297.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/dee23cc9cc5a36c8c28ab6ba30cb993d.pdf

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Response
Date: 07-22-2015

. I do not see a problem with utilizing washers underneath the culvert top slab. In fact, a similar attachment scheme was full-scale crash tested back with the original evaluation of this system – see report no. TRP-03-114-02 page 111 (available on MwRSF website/research hub). The tested configuration utilized only rectangular plate washers in the attachment of the through bolts to the underside of the culver slab. You could use this concept too, if desired. If you utilize washers of a similar size, you would not need to include the full-size washer plate in addition to the enlarged washers. The individual washers alone would suffice.

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fall protection on parapets

Question
State: WI
Date: 07-22-2015

We have had our contractor's mount hardware on top of our 32" bridge parapets to comply with OSHA fall requirements.

Here is one example.

I have concerns from a roadside design perspective that:

- Vertical struts are snag issue
- cables may interfere with vehicle once it leans over the barrier.

I have heard of 2x4 being used on our parapets and temporary barrier as well.

I wanted to get MwRSF's impression of what our contractors are doing.

Thanks

Attachment: http://mwrsf-qa.unl.edu/attachments/beb3b76612f4a35076adcb4b0a121ff1.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/8e95b8975d4000173df1f12e99ff05fc.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/450f13ee326c40d54504e4b3f3edd5fe.jpg

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Response

Date: 09-03-2015

The concern with the addition of structures on existing barrier systems would be similar to those concerns with barrier performance raised in previous studies regarding pedestrian rails, combination bridge rails, and the Zone of Intrusion (ZOI) study. Additional structure on top of a barrier may pose a snag hazard, adversely affect vehicle stability, potentially create dangerous debris, and pose a hazard for partially ejected occupants or occupant heads among other concerns.

Thus, while there is a need for fall protection in critical areas, we would recommend that the fall protection concern be weighed against concerns for the effect on the safety performance of the barrier.

Development of safe fall protection hardware would likely require further research, design, and potential evaluation testing. additionally. the design of the fall protection may differ significantly depending on the type of barrier it is used on.

Tie-Down Anchor Bolt - Length Change

Question
State: MO
Date: 07-29-2015

Ivan Schmidt at MoDOT has raised a question regarding the anchor bolt length that was used to tie-down the steel straps. The built-up strap material at the hole locations was ½ in. thick. In the original report, a 57-mm (2¼-in.) long bolt was used. Original report link is provided below.

Original Report

http://mwrsf.unl.edu/reportresult.php?reportId=219&search-textbox=tie

In the letter report to NDOR, the CAT anchorage testing program utilized a 1¾-in. long bolt with the RedHead Drop-In anchors. Letter report link is provided below.

Letter Report

http://mwrsf.unl.edu/reportresult.php?reportId=266&search-textbox=tie

Do you know why the hex head bolts were shortened by ½ in. and did not use the original bolt length of 2¼ in.? I have quickly looked through the original and letter reports as well as current RedHead anchor information. I was unable to find the published threaded distance within the anchor cavity. Let me know if you recall as to why this both length was reduced. Thanks!

Response

Date: 07-29-2015

The bolt was shortened based on concerns that the longer bolt could bottom out in the drop in and cause it to break the tabs that expand at the base.

Response
Date: 07-30-2015

So, then why was the original report not revised? Also, the 2007 letter reports that the ultimate tensile capacity 17.3 k of the red head anchor is based on "limited testing and review of manufacturer test data of the drop in anchor conducted during the development of the steel strap." Seems like the tensile capacity would be a pretty big deal since these anchors are pulled out of the holes in barriers directly impacted.

And, if the tensile strength is actually based on a 2 1/4" long bolt, then the alternatives would be overdesigned.

Where and when was this change in bolt length documented so we can have for our records and should MoDOT immediately change the 2 ¼" long grade 5 bolt to 1 ¾"? If the 2¼" long bolt was crash tested and worked why change to 1¾"?

Response
Date: 07-31-2015

See my comments below!

So, then why was the original report not revised?

**There was not a problem with the original configuration. The RedHead anchors were used with 2¼" long bolts, and the barrier system performed well. The original report documents the successful crash test and installation details. No hardware problems were encountered in the crash test. As such, there was no consideration to prepare a revised version of the report. However and based on your inquiry, we are wondering whether a notice should be posted to better indicate this bolt length change.

Also, the 2007 letter reports that the ultimate tensile capacity 17.3 k of the red head anchor is based on "limited testing and review of manufacturer test data of the drop in anchor conducted during the development of the steel strap." Seems like the tensile capacity would be a pretty big deal since these anchors are pulled out of the holes in barriers directly impacted.

**Per Bob, the RedHead anchor socket has an internal threaded length of 1¼". Thus, the original longer bolt penetrated farther into the void region below where the internal threads ended within the socket. Those extra threads did not engage the socket and did not provide additional tensile capacity. The new 1¾" long bolt with full threads engaged the entire threaded region of the socket when considering the strap thickness and welded washer plate thickness. Thus, the tensile capacity of the anchor was not changed. The anchor socket behavior was controlled by concrete fracture and/or bond failure.

**If bolts are excessively long, there could be a potential for really long bolts to contact and rupture the deformed tabs at the bottom socket. We do not recall that scenario occurring in our actual field installation that was used in the crash test.

**With additional information from the manufacturer, we chose to use a 1¾" bolt length in the follow-on study that evaluated alternative mechanical anchor hardware. Again, the tensile capacity of RedHead socket was controlled by concrete strength. Both bolt lengths would provide equivalent tensile capacities when considering a 1¼" threaded length within the socket.

And, if the tensile strength is actually based on a 2 1/4" long bolt, then the alternatives would be overdesigned.

**See comments above.

Where and when was this change in bolt length documented so we can have for our records and should MoDOT immediately change the 2 ¼" long grade 5 bolt to 1 ¾"? If the 2¼" long bolt was crash tested and worked why change to 1¾"?

**The 2007 letter report documented this change. Drawings were also prepared for AASHTO Task Force 13 Roadside Barrier Hardware Guide. The latest drawings are attached. Note that the anchor socket did not change. The 2¼" long bolt met crash testing requirements. The 1¾" long bolt will also meet crash testing standards as all bolt threads are engaged in 100% of socket threads. The shorter bolt length can reduce any potential concerns if an excessively long bolt would contact deformed tabs and cause damage. Although we did not have that occur, we took advise and reduce the risk of it occurring.

**It does appear that the original 2003 FHWA eligibility letter, B-112, still depicts the 2¼" long bolt for use in the socketed anchors.

**Alternatively, the online AASHTO TF13 Hardware Guide provides a 2007 SWC10 detail (8/31/2007) that shows the 1¾" bolt length. The link is provided below. However, the latest version of the SWC10 drawing that is located on our internal server is dated, 10-22-2008. Thus, the different dates causes me to raise the question as to why the online hardware does not depict the most current version of the detail that remains on our server as it should. As such, I need to speak to my colleagues to better understand how often revised details are forwarded to TF13 for replacement in the online guide.

http://guides.roadsafellc.com/hardwareGuide/index.php?action=view&hardware=124

**Please let me know if you have further questions regarding my responses to the items noted above. Thanks!

Temporary Barrier on Bridge 9123

Question
State: MN
Date: 08-04-2015

I need your help with this one (See specifics below).

We use the Iowa F-Shaped Temporary Concrete Barrier System (SWC09), and we do have the Tie-Down Strap System for the F-Shape Concrete Barrier in our standards (SWC10).

We essentially will have TL-2 conditions (45 mph Posted Speed).

Is there a configuration/location that would not require anchorage of the barrier for these TL-2 conditions. I realize that a barrier pushing up against the curb would easily tip over as the curb would act like a hinge, but how close is too close?

Is the top of the sidewalk an option at
all? I can visualize barrier deflection followed by vehicle vaulting on the curb (assume an 8" curb).

If we place a system with the Tie-Down Strap on
the shoulder, How close to the curb could it be placed? In the Tie-Down test FHWA letter, I believe that I saw 12 " (305mm) of dynamic deflection for the area of impact, with a TL-3 test. Could we go 6" with TL-2 conditions? We would like to give some room to the vehicles (the barrier is 22.5" wide).

Of course the designers need an answer asap.

Please give me a call if you need more information.

Thanks

I left you a voicemail, but I thought I would follow up with a clearer view of what was needed.

Some information about the site:

- TH 21 over UPRR (Bridge 9123)

- 45 mph on the bridge

- Expect that this condition will last for approximately 5 years until the bridge is replaced

We are looking for guidance on the following questions:

- Can we place temporary barrier on the shoulder or on the sidewalk?

- If so, how far from the edge of the sidewalk or from the gutter line does it have to be?

- What sort of anchoring is needed?

- Any other guidance we need?

Attachment: http://mwrsf-qa.unl.edu/attachments/ec81acdbe36a98bfbf5393571fd8a16a.jpg

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Response
Date: 08-06-2015

I will try to provide my thoughts and be as brief as possible due to MnDOT's time constraints.

First, the duration of the work zone is noted to be five years, which is a long duration . Thus, a conservative approach may be justified using best available information.

Second, the placement of a single row of F-shape PCBs on top of the sidewalk may create some concerns. Although the F-shape PCBs will displace laterally, I wonder whether impacting passenger vehicles will reach a higher effective climb height on the barrier face relative to the lower bridge deck surface, thus potentially leading to slightly greater vehicle instabilities. Granted, I believe that this risk would be much reduced at TL-2 conditions as compared to TL-3 conditions. However, I just want to denote this low to moderate potential safety concern.

Third, the laterally-deflecting PCB on the sidewalk could create a scenario where a partially-redirected vehicle allows for a wheel to catch on the sidewalk, thus leading to increased roll or yaw behavior and increased vehicle instabilities. Although this behavior and risk is uncertain, I still need to raise this potential concern.

Fourth, a free-standing PCB at TL-2 of NCHRP 350 would result in reduced dynamic deflections as compared to TL-3. Unfortunately, we have not previously conducted testing nor simulations at the TL-2 conditions. Instead, MwRSF conducted a study to evaluate conditions at the 85% impact condition – 2000P pickup truck, 36 mph, and 27.1 degrees. Details of this R&D is provided using the link below. Note that the TL-2 impact condition provides approximately 35% more impact severity than the 85% impact condition used for the noted study. Thus, the anticipated free-standing deflection for F-shape PCBs would range between 24 and 43 in for NCHRP 350 TL-2 impact conditions. One might estimate between 32 and 36 in. for TL-2.

http://mwrsf.unl.edu/reportresult.php?reportId=243&search-textbox=concrete%20barrier

Next, I agree with you that free-standing PCBs on the bridge deck and adjacent to the sidewalk would laterally deflect backward and strike the sidewalk. Once the PCBs had bottomed out against the raised sidewalk edge, the PBCs would be prone to rotation without translation, which could increase vehicle climb and subsequent roll and pitch angles as well as vehicle instabilities. As such, adequate space would be necessary between a free-standing PCB and the raised sidewalk, even for TL-2 conditions.

Based on this information, I believe that a reduced-deflection PCB system may be worth considering for your application and located on the bridge deck. There exists the (1) tie-down strap system, (2) vertical through-bolt tie-down system, and (3) WisDOT steel tube and saddle system for use with the F-shape PCB system. All three systems alone, or in combination with one another, may provide a workable solution, especially where you have limited width for PCB placement. If you can accept deeper holes drilled into the bridge deck for either through-anchor bolts or rods epoxied into partial-depth holes within the deck, the through-bolt system offers a low-deflection system, especially at TL-2. If that option is not acceptable, the tie-down strap system could be used with a larger gap between the back of barrier base and face of raised sidewalk, say 6 to 9 in. and at TL-2. Finally, it might seem reasonable to use a combination of the tie-down strap system and the WisDOT tube/saddle system at an even closer offset to front face of sidewalk, say 3 to 6 in., for TL-2 impact conditions of NCHRP 350. Actually, I might consider the latter option more preferred when considering the 5-year work-zone time period. Of course, it should be noted that these options have not been tested under TL-2 conditions and/or when positioned this close to a raised sidewalk edge.

Finally, one last consideration would be to further reduce posted speed limits from 45 mph to 35/40 mph to help control potential impact speeds.

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

Steel Posts in the Bridge Transition Section

Question
State: IA
Date: 08-06-2015

We received a call from a contractor asking if they could use a longer 6'9" for posts 8-13 in that attached modified road standard. This would keep the same length of embedment but would allow the top of the post to be flush with the blockout. It sounds like they are having trouble getting the post installed correctly with the method they typically use. The other reason they sighted, for the longer posts, is that the dies their manufacture have need 7 inches at the top of the post to punch the holes. The shorter posts shown are requiring custom punching of the posts and driving costs up. Do you see an issue with allowing the post to be 3 inches longer? They are waiting to order some posts, so a quick response would be greatly appreciated.

Attachment: http://mwrsf-qa.unl.edu/attachments/6668147e0cd2bef85398813a1ac55ad0.jpg

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Response
Date: 08-07-2015

Brian:

I have reviewed our prior research studies that pertain to this issue. These include:

System No. 1 - ITNJ Test Series – nested thrie-beam AGT with steel posts on ¼-spacing near buttress end

Report can be accessed at:

http://mwrsf.unl.edu/reportresult.php?reportId=61&search-textbox=transition

Test ITNJ-2 on an improved design consisted of successful 2000P pickup truck test at TL-3 impact conditions. The six ¼-spaced posts were installed with a 49" embedment depth and a 2" recess for top of post below top of 31" tall thrie beam rail. The distance between the buttress end and the center of the first post was 11.5". The top of posts were recessed 2" in this stiffer transition region due to concerns for engine hood and quarter panel contact and snag that may lead to instabilities and even rollover. This snag behavior was observed and deemed a contributing factor in the rollover of a pickup truck in a R&D study performed on a Missouri transition system. See System No. 2 discussion below. This testing was performed under NCHRP Report No. 350.

System No. 2 – MTSS Test Series – dual 10-gauge thrie-beam median AGT with steel posts on ¼-spacing near buttress end

Report can be accessed at:

http://mwrsf.unl.edu/reportresult.php?reportId=84&search-textbox=transition

Test MTSS-2 on a modified design consisted of successful 2000P pickup truck test at TL-3 impact conditions. The six ¼-spaced posts were installed with a 43" embedment depth and a 2" recess for top of post below top of 31" tall thrie beam rail. The distance between the buttress end and the center of the first post was 11.5". Following the first failed test, the top of posts were recessed 2" in this stiffer transition region due to engine hood and/or quarter panel contact and snag on top of the median posts and on the upper sloped end of concrete buttress. This testing was performed under NCHRP Report No. 350.

System No. 3 – Test 2214T-1 – nested thrie-beam AGT with steel posts on ¼-spacing near buttress end

Report can be accessed at:

http://mwrsf.unl.edu/reportresult.php?reportId=148&search-textbox=transition

Test 2214T-1 consisted of same system evaluated under System No. 1 above and included a successful 2270P pickup truck test at TL-3 impact conditions. The six ¼-spaced posts were installed with a 49" embedment depth and a 2" recess for top of post below top of 31" tall thrie beam rail. The distance between the buttress end and the center of the first post was 11.5". The top of posts were recessed 2" in this stiffer transition region due to concerns for engine hood and quarter panel contact and snag that may lead to instabilities and even rollover. This testing was performed under MASH.

System No. 4 – nested thrie-beam AGT to T131RC using steel posts on ¼-post spacing **[no recessed posts]**

Report can be accessed at:

http://tti.tamu.edu/publications/catalog/record/?id=38552

Two tests - 2270P and 1100C - were successfully run under MASH TL-3. The six ¼-spaced posts were 7-ft long but did not utilize a recessed top of posts relative to the top of the rail. As such, this testing may suggest that the recessed region may not be needed under MASH.

**At this time, I have requested two other crash test reports from TTI. I want to review these tests and determine whether those successful thrie beam AGT systems utilized recessed tops for posts relative to top of rail. I should have those reports by next week. In closing, I believe that there is strong potential for the tops of closely-spaced, steel transition posts to incorporate the same height as the blockouts under MASH testing. However, I want more evidence from a few more cases for confirmation, and then I will get back to you with an updated response.

Thanks again and feel free to contact me with any additional questions or comments!

Response
Date: 08-27-2015

Hi Ron,

Sorry for the delay in getting you this information. It is amazing how quickly things get buried these days. I appreciate the reminder. ☺

The first test was run under NCHRP Report 350. It did not have a curb, and the end shoe was rotated into the slope of the concrete bridge rail parapet to which it was attached. The link to the report for this test is:

http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/4564-1.pdf

The second test was run under MASH. It also did not have a curb. However, in this case, a special adaptor block was fabricated for use under the end shoe to keep the thrie beam rail in a vertical plane throughout its length. The link to the report for this test is:

http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/9-1002-12-3.pdf

Please let me know if you have any questions or need any additional information. We can forward video, etc. as needed.

Best regards,

Roger

Response
Date: 09-09-2015
I believe that the recess may not be needed based on System No. 4 noted below. Thus, an increase in post length without the use of top recess may seem reasonable.

I agree that you could move forward with the longer post that no longer includes a recessed top region.

NHSX-52-5(31)--3H-96 Curved Guardrail

Question
State: IA
Date: 08-07-2015

As we discussed please see the
curved guardrail layout. I have include the MicroStation files so you can do more detailed measurements.

As I eluded to
below and again on the phone, I think a radial guardrail design needs to be used for both the Pulpit and Madison roadways. Looking at the attached Google Earth image, one can see the (no longer) existing layout changes from steel to wood posts around the curve. We need to effectively mimic that design this time around.

I contacted
WHKS to get their design file as the plan sheets leave a lot to be desired.
Attached is their reply. Those files and all workup files are available at W:HighwayDesignMethodsSectionMethods-SubjectAreasBarriers_DesignModificationsGuardrail_RadiusGuardail_US52

Model
'Guardrail Details' inside **7288.14.dgn** shows that the proposed paved shoulder at Pulpit has an inside radius of 46' (attached image). Using that as the design radius (as it is already poured is effectively becomes the radius), the curved portion of the guardrail layout is shown in attached CurvedDimensions.pdf.

With an Lg of
75, you'll need (75/6.25) + 3 = 13 CRT posts and (75/12.5) = 6 curved w-beam pieces. You'll also need to add a 12.5' VT section between the end of the last curved section and the beginning of the End Terminal. The 3 posts that are used in that section are the 3 added in the sentence above.

Using model
'Guardrail Detail Shading', the guardrail splits should look something like this:

BTS= 28.125

VF = 75

VT1 = 250

Curved VT = 75

VT2 = 12.5

ET = 50

I'm not
entirely confident in the precision of the first VT as the paved shoulder and guardrail don't seem to run parallel to each other in **the 7288.14.dgn**, but since the paved shoulder is already constructed, drill the holes at 6.25' increments and begin placing CRT posts at the junction of the ~250' VT and the curved VT, continuing through the curve and final VT, ending at the end terminal. The posts in the BTS and the VT1 may be changed to steel as requested as I don't believe that change impacts the radial component.

For the Madison
Road curve, since it is only a partial layout, I can't really design it. The same approach would apply though. Basically, the CRT posts begin at the connection of the VT and the curved w-beam and continue through the curve. Since the guardrail doesn't terminate near the intersection, continue the CRT posts for two posts beyond where the curved pieces flatten out. You'll have to count up the number of CRT posts in the field.

Attached
US52_CurvedGuardrailAtSideRoad.pdf is a highly modified detail of past installations. Most of the information has been stripped out as the tables didn't cover this large of a radius. The CRT hole spacing is borrowed from the current BA-211.

You mentioned
over the phone that because of the severe drop off, additional actions were being added in an attempt to extend the 10:1 grading at least 3' behind the face of guardrail, with the potential of 4' before it broke to 2:1 or steeper. Normally we would introduce longer posts for that situation, but since these are CRT posts, I don't think that makes sense to do so. Brian and Dan may have a comment on this.

I'm out of the
office tomorrow and on the road Monday, so I'll be happy to check back in on Tuesday to see what Brian, Dan, and yourself decided to do for these installations, including any necessary changes to the curved and VT lengths.

Image 806 is where we plan to begin the ET. which is 802 plus 25' as you note. The side road this is at is Pulpit. This is an area that rock drilling needs to occur, and Lovewell is marking out the post locations today so yes we need to know shortly if the post spacing changes.

I would much prefer starting the end terminal from the end of the rail shown on the attached 806 than the attached 802. It doesn't appear the end terminal even terminates within the shoulder if starting from the 802 measuring tape. I would concur that adding the additional 25' from the 802 to end up at the 806 and then start the end terminal would be the preferred option.

The trailing back around the radius of the side road throws me a bit here. Looking at page D.3 of the plans, it appears that they are running normal guardrail around the corner of Pulpit Rock Road, if that is the location of these images, but I don't see a detail in the plans for laying out guardrail on that tight of a radius. We typically use a short radius guardrail detail that has different posts and spacing at that kind of a radius.

I'm sure you're waiting on an answer, so I'll talk with Brian this afternoon. In the meantime, can you provide the side road these pictures were taken at if it isn't Pulpit/Madison, both of which have potentially the same issue.

The guardrail layout is a long section that extends from a bridge endpoint on the trailing end back around a radius of a side road. The section shown in the attachments is within the VT-2 section with an additional 25' added. If we didn't add the 25' the ET section would end up flaring toward the side road. Is this acceptable?

These pictures show the last two sections extending the VT-2 by 25'.The ET would then be in the tangent paved shoulder area.

Attachment: http://mwrsf-qa.unl.edu/attachments/16a1a95a1f8989713108148145 69c13c.zip

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Response
Date: 08-07-2015

A few years ago, MwRSF conducted a research study for the Wisconsin DOT. This effort explored the performance of W-beam short-radius guardrail systems under TL-2 impact conditions with larger radii. See the link to access a copy of the report. Also, note the Chapters & Sections that are recommended for reading.

http://mwrsf.unl.edu/reportresult.php?reportId=288&search-textbox=radius

See page 199 or PDF page 213!

See Chapter 12 – page 205 – PDF page 219!

See Chapter 13 – page 223 – PDF page 237!

See Chapter 14 – page 227 – PDF page 241!

From this simulation effort, it was determined that rail heights greater than 27 in. and up to 31 in. would improve barrier performance for pickup truck impacts. Although no small car simulations were performed, there is concern that a 31 in. rail height could accentuate small car underride. As such, it was believed that a 29 in. rail height may still provide improved performance for pickup truck impacts but reduce concerns for small car underride. In the absence of an actual crash testing program at TL-2, MwRSF personnel would lean toward the use of a 29 in. rail height versus a 27 in. rail height based on the best available information and results from this study. Of course, the only true evaluation of safety performance would be through full-scale crash testing.

Second, the study noted that blockouts on posts around the radius contributed to improved vehicle capture by better maintaining adequate rail height. Blockouts also showed an ability to reduce vehicle to post contact. Further, CRTs were simulated around the nose through the tangent sections. As such, it would be recommended to maintain the CRTs throughout the entire curve and into tangent for any larger radius system that is implemented.

It should also be noted that the simulation effort was performed with level terrain behind the barrier system. Your real-world scenario will likely feature a gradual slope behind the barrier system for some distance, followed by a steeper slope. Barrier performance can be greatly affected by the presence of various slopes behind the actual barrier. Thus, it is recommended to provide a gentle slope behind the barrier using as much lateral distance as feasibly possible.

Again, these thoughts are provided based on our best available information as well as the research findings from the recent simulation effort. If you have any questions regarding this information, please feel free to contact either myself or my included colleagues at your convenience. Thanks!

Non-Proprietary Bullnose Thrie-Beam System

Question
Date: 08-17-2015

I was in Virginia a week ago and saw the Bullnose Thrie Beam in a gore. They had several.

While I have seen several in medians, this was the first time I saw one in a gore.

Attached are some pictures from Google of the location.

Are the Midwest states doing this design in gores.

Any pointers for this application, concerns?

What are your thoughts?

Response
Date: 08-17-2015

Thanks for the information. I want to give some background. As you know, MwRSF developed and tested this system in the late 90s. At that time, we tested a narrow system with parallel sides and requested eligibility of two wider alternatives with parallel sides to accommodate different median/hazard widths. During the review process, Dick Powers suggested an alternative design that included non-parallel sides (i.e, the back-side rail flaring away from the front rail that runs parallel with the traveled way. As such, the FHWA letter included an alternative layout that included Dick's suggested variation that is similar to the front of the system contained in your photographs.

Again, the as-tested configuration utilized parallel sides. The as-tested design could be used to shield the hazards shown therein and would result in shallower impact angles along the sides of the bullnose. The currently-depicted dual flares would seem to potentially increase approach angles for 1 or both sides.

In such scenarios, I would always prefer to use the bullnose in a parallel configuration if site conditions allow. However, the Power's alternative may allow for a flared version to be used in these settings when traffic is on both sides. One potential item to consider is the effect of flare angle on sides and resulting increased I.S. Historically speaking, there has not been considerable crash testing performed on crashworthy systems that are now installed with the maximum allowable flare angle provided in the AASHTO RDG for highway and WZ applications. We performed some testing on a flared MGS many years ago. However, PCBs/TCBs and some other devices may not always have had the allowable flare built into the testing program on the front end. That topic may be something to reconsider moving forward under MASH.

I have also copied Bob on this reply as he was largely responsible for the original bullnose system. He has fielded the majority of the bullnose implementation questions and may be able to provide additional input into this special scenario. Please let me know if you have any questions regarding the information provided thus far. Thanks!

Response
Date: 08-18-2015

Ron made most of the good points on the bullnose in gore areas, but I have a couple more.

As Ron noted, there are concerns with flaring the bullnose sides on a couple of levels. First, is the increased IS issue Ron noted below. Second, is that we don't want the flaring of the bullnose to negatively affect the capture and energy absorption of the system. Thus we have typically not recommended flaring of the bullnose prior to post no. 5 on each side. Dick Powers did approve a flared version as noted below, but that was intended for medians and not necessarily gore areas where the traffic on both sides of the bullnose is in the same direction.

Also because the system in this application would have traffic in the same direction on both sides, the guardrail splicing would be different than a median bullnose installation in that the overlap of the splice on the left side of the system would be reversed.

We have addressed this issue in the past through our Pooled Fund Consulting efforts and I have attached those responses as well for you to review as they contain some additional thoughts.

http://mwrsf-qa.unl.edu/view.php?id=927

http://mwrsf-qa.unl.edu/view.php?id=909

As Ron noted, if you have any questions, let us know.

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grading behind a MGS transition

Question
State: WI
Date: 08-21-2015

If we have the 2' of relative flat grading behind the post of the MGS thrie beam transition, How steep can the slope behind the 2' of flat grading? I assume a 2:1 would be acceptable.

Response
Date: 08-21-2015
A 2:1 slope located 2 ft behind the posts (on level grading) should not cause any adverse affects to the performance of the guardrail transition.

Vertical Taper Rate for Concrete Barrier

Question
Date: 08-26-2015

I have been
searching through various standards and reports trying to find documentation on acceptable vertical flare rates when transitioning from 32" high safety shape barrier to 42" safety shape barrier, or adjacent to thrie beam structure connections to 42" bridge rail . As you will appreciate, many different slope ratios are used by various agencies ranging from 1.5H:1V to 10H:1V. While reviewing TRP-03-300-14, I saw the photo below of the TCB to permanent concrete barrier, which referenced TRP-03-208-10.

Based on
dimensions of the steel cap rail transition in TRP-03-208-10, the slope is 4.97:1 (1262mm run over 254mm rise), or say 5H:1V. Can you offer any comments on the rationale for this ratio to minimize snagging potential for the vertical transition from a 32" PCB (pinned) to 42" permanent barrier, and whether using 5H:1V transition for a MASH thrie beam connection to 42" bridge rail would be acceptable (ie 32" at end of bridge rail where nested thrie beam overlaps the concrete, and immediately transitioning the top of concrete upward at 5H:1V to 42" bridge rail)?

Attachment: http://mwrsf-qa.unl.edu/attachments/49c33a8d68c89e96f5eac8697b32ec40.png

Attachment: http://mwrsf-qa.unl.edu/attachments/71e2ebccb8564ba33ea8c5563e7613e3.png

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Response
Date: 08-26-2015

You are correct that in TRP-03-208-10 we utilized a 5:1 vertical taper to go from 32" to 42". The 5:1 height transition slope that we tested with the PCB transition used a steel cap to create the vertical transition flare. There is some concern that using concrete to create the 5:1 flare may increase friction and or gouging of vehicle components in the flared region. Thus, the 5:1 is an aggressive approach with some concerns for its use. However it has been adopted by many states. Use of an 8:1 slope has been commonly used as a more conservative approach.

Based on the performance of the this 5:1 flared cap, it would seem reasonable to use slopes as high as 5:1 when transitioning from 32" tall barriers up to higher heights. We could not recommend the use of these higher flares for shorter barrier heights below 32" as the potential for the vehicle to climb the flared section may increase if the starting height of the flare is lower.

For transition from heights lower than 32", the recommendation would be an 8:1 slope. We would recommend this based on the concerns noted above regarding the difference in the slope materials. In addition, we would not want to go to steeper slopes for barrier heights below 32" on the low side due to concerns for increased vehicle exposure to the slope and climb.

Response
Date: 08-27-2015

I note in the package you just sent me that the proposed Standardized AGT Buttress uses all W6x8.5 posts (with last 6 posts immediately adjacent to the concrete rail being 78" long and spaced at 18-3/4"). We are currently using the simplified steel post MGS stiffness transition with three W6x15x84" posts immediately adjacent to concrete rail spaced at 37-1/2" with next four W6x9x72" at 14-3/4", etc (per MWTSP similar to Missouri Transition to Single slope in TRP-03-210-10). Has the post configuration in the proposed Standardized AGT Buttress with all W6x8.5 posts been crash tested before? Were there concerns with the performance of the MWTSP design using the W6x15 posts, or is the proposed change to all W6x9 posts in the proposed AGT buttress being primarily driven by desire to only use one size of posts (albeit two different lengths)?

Response
Date: 08-28-2015

I have a some answers to your questions.

First , the upstream stiffness transition that was developed in TRP-03-210-10 was designed to work with a wide range of AGT designs that were tested on only the downstream end in NCHRP 350. When we conducted the crash tests of that upstream transition, we selected a very stiff AGT design adjacent to the bridge rail. The system that was selected was a Missouri AGT to a steel bridge rail with a cap rail because it was a very stiff design that would accentuate any issues with the upstream end of the transition.

That said, that Missouri AGT with W6x15 posts at 37.5" spacing was never tested and evaluated with a concrete parapet. However, you are connecting to a concrete parapet. Thus, you may want to consider designing the downstream end of the transition to comply with a previously tested and approved transition for the downstream end. We provided guidance for adapting existing transitions for use with the upstream end that we developed in the project report (TRP-03-210-10). Thus you could adapt one of those designs, or we could assist you in adapting something else that you prefer to use.

Another potential option would be to use the W6x15 posts at half post spacing that you originally had and connect to a concrete parapet. I went through some old correspondence that we had with Iowa. They requested guidance on using the W6x15 posts at half post spacing and connecting to a vertical concrete parapet. We had replied then that the system was likely to work, but that there were concerns with slightly more thrie beam deflection relative to the more rigid bridge system. However, we believed that the increased deflection would pose minimal risk for wheel snag.

excessive barrier deflections, or vehicle pocketing. This design would also require flaring of the end of the parapet to prevent snag. Use of this design would likely require further investigation into the relative deflection and snag potential of similar systems to justify its use. We recommended to Iowa to run this by FHWA as well. The upcoming testing on the standardized parapet may shed light on that as well.

http://mwrsf-qa.unl.edu/view.php?id=676

The transition being used for the standardized parapet is a previously NCHRP 350 tested AGT design (with a curb) that was done for Iowa for connection to concrete bridge rail. It was selected for evaluation of the standardized parapet because it is among the least stiff of the approved transitions and it has been shown to be sensitive to use without or without a curb. Thus, we believed it will provide a critical test of the standardized parapet such that we can use it with all previously tested AGT's. The Iowa transition was also tested to MASH with the curb and passed during NCHRP 22-14.

http://mwrsf.unl.edu/researchhub/files/Report148/TRP-03-175-06.pdf

http://mwrsf.unl.edu/researchhub/files/Report61/TRP-03-69-98.pdf

So the Iowa transition has been around for a while, and the use of the W6x9 posts was not originally intended for simplification of inventories. However, during the development of the upstream stiffness transition, we were asked to considered simplified post configurations to limit inventories, and the Iowa transition was part of that thought process.

Minimal guardrail lengths to develop tension over culvert

Question
State: IA

Date: 08-26-2015

We have a
situation where guardrail is being attached to a short bridge and is acting as the bridge rail, though we also see similar issues with culverts, and there is a question regarding how long of an installation is needed on either side of the bridge or culvert to develop enough tension in the system. I can somewhat gather that for a TL-3 system, 62.5' is the minimum needed on the upstream and downstream ends beyond the obstacle, assuming a typical end terminal as shown in the attached standards. Please confirm or provide guidance.

The project in
question is leaning towards a TL-2 installation (gravel road, very low volume) and the same question remains; what would the minimum combined length of w-beam and end terminal typically need to be to correctly anchor and tension the system for a TL-2 installation?

For a very
generic layout, see attached.

Thanks for your
assistance!

Attachment: http://mwrsf-qa.unl.edu/attachments/d0b01a764b637e917d16273edb2ea2f7.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/3747c7df94a35634eec4259539f29241.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/d2ed67ce4498074a7b14264d3d3d3d6a.pdf

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Response
Date: 08-26-2015

We have looked into minimum system length for the MGS in the past as well as made recommendation regarding minimum system lengths for long span guardrails over culverts with reduced span lengths from the 25 ft unsupported span that was crashed tested. There are three factors that come into play.

1. Lateral Extent of the Area of Concern, the Guardrail Runout Length, and length-of-need (LON) as determined by the Roadside Design Guide (RDG) must be considered when factoring in minimum system lengths. Often a guardrail system may be able to redirect vehicles at lengths less that that required to adequately shield the hazard. As such, determination of length should start here. If the runout lengths are short enough to consider s shorter barrier system, then a couple of other factors need to be considered.

2. Minimum system length required for capture and redirection.

The MGS Long-Span Guardrail System over culverts was successfully crash tested and evaluated according to the Test Level 3 (TL-3) safety performance criteria found in MASH. For this testing program, the overall system length was 175 ft, including 75 ft of tangent rail upstream from the long span, a 25-ft long unsupported length, and 75 ft of tangent rail downstream from the long span. As part of the final recommendations, MwRSF had noted to provide a minimum "tangent" guardrail length adjacent to the unsupported length of 62.5 ft. While your installation does not appear to use the long span system, similar logic may apply.

A recent MASH crash testing program on a minimum length version of the MGS suggests that there may reason to consider potentially reducing the 75-ft total guardrail length on the upstream and downstream ends of MGS Long-Span Guardrail System.

In the minimum length study, computer simulation and full-scale testing indicated that a 75' long MGS system would be capable of redirecting a 2270P vehicle under the MASH TL-3 impact conditions. Test no. MGSMIN-1, was performed on the 75-ft long MGS with a top rail mounting height of 31 in. A 4,956-lb pickup truck impacted the barrier system at a speed of 63.1 mph and at an angle of 24.9 degrees. The test results met all of the MASH safety requirements for test designation no. 3-11. The tested system had a total of 13 posts.

A performance comparison was conducted between 75-ft MGS (test no. MGSMIN-1) and 175-ft MGS. The dynamic deflection for the 175-ft (53.3-m) MGS was slightly higher than observed for the shortened system, but this difference could be due to variations in soil compaction between tests. The working width was nearly indistinguishable. In general, the 75-ft MGS in test no. MGSMIN-1 performed as desired and closely resembled the standard 175-ft MGS.

A second study regarding downstream anchoring of the MGS found that the MGS would successfully redirect 2270P vehicles impacting at 6 posts or more upstream of the end of the system for a MASH TL-3 impact on a 175-ft long MGS system.

Based on previous testing and the results of test no. MGSMIN-1, MASH TL-3 vehicles impacting between post nos. 3 and 8 of the 75-ft long system should be redirected. Vehicles impacting downstream of post no. 8 may be redirected, but the system would also be expected to gate based on the downstream anchor research.

Based on the MASH 2270P test into the MGS Minimum Length System, we believe that the MGS Long-Span Guardrail System would likely have performed in an acceptable manner with 62.5 ft of rail on the upstream and downstream ends, thus resulting in an overall system length of 150 ft. A 62.5-ft long tangent length adjacent to the unsupported length would still provide adequate space to incorporate a 37.5 ft or 50 ft long energy-absorbing guardrail end terminal.

For unsupported lengths of 18.75 ft and 12.5 ft, it would seem reasonable to consider a reduction in the required guardrail length both upstream and downstream from the unsupported length using the test information and arguments noted above. For two missing posts or an unsupported length of 18.75 ft, we believe that the upstream and downstream guardrail lengths likely could be 56.25 ft each with a minimum overall system length of 131.25 ft. For one missing post or an unsupported length of 12.5 ft, we believe that the upstream and downstream guardrail lengths likely could be 50 ft each with a minimum overall system length of 112.5 ft. However, we believe that the three CRT posts still would be required on the upstream and downstream ends of the 18.75 ft and 12.5 ft long unsupported lengths. In addition, one would need to discuss with and likely obtain approval from the manufacturers as to whether they would allow three CRTs to be used within the last 12.5 ft of a 50-ft long guardrail terminal.

If one were to follow the logic used above and consider the situation of no missing posts (i.e., 6.25 ft post spacing throughout), the upstream and downstream ends would be reduced by 6.25 ft each and include the interior 6.25 ft long span in the middle of the system. As a result, the overall system length would be 43.25 ft + 6.25 ft + 43.25 ft for a total of 92.75 ft. As noted above, MwRSF recently crash tested a 75-ft long version of the MGS with satisfactory results, effectively configured with two 37.5-ft long guardrail segments with tensile anchorage devices and placed end-to-end. This corresponds to the situation in the schematic you sent and would provide conservative guidance on minimum length for the guardrail system over the culvert. Thus, this would correspond to 43.25 feet of barrier on the upstream and downstream end of the system. However, some terminals may require a 50 ft length for installation.

Of course, it should be noted that these design modifications are based on engineering judgment combined with the unpublished results from the MGS Minimum Length System crash testing program. In addition, the opinions noted above are based on the assumption that the currently-available proprietary guardrail end terminals would provide comparable tensile anchorage for the MGS as provided by the common tensile anchorage system using in the MwRSF crash testing program (i.e., two steel foundation tubes, one channel strut, one cable anchor with bearing plate, and BCT posts at positions 1 and 2 on each end). Although we are confident that the modifications noted above would provide acceptable performance, the only sure means to fully determine the safety performance of a barrier system is through the use of full-scale vehicle crash testing.

3. Sufficient length for compression based terminal operation must be considered as well.

To the best of our knowledge, the shortest installation lengths for compression based terminal testing was conducted on 131.25-ft long system. We believe that this length could be shortened some based on our current knowledge of guardrail compression forces. We have used a reduction in longitudinal rail force of approximately 1-1.2 kips at each post in a guardrail due to the connection between the post and the rail. Current terminal designs tend to have impact head compressive forces that average about 15 kips. This would mean that a minimum of 12-13 posts would be needed to develop the compression load. Of course the end terminal takes out some posts during its compression. However, most of the velocity drop occurs in the first 25-31.25 feet of the compression. Thus, we can assume that if we allow for 31.25 ft of compression and 13 posts to develop the compressive load, an estimated minimum system length for the development of the end terminal compressive loads would be 112.5 ft (13*6.25+31.25).

Because we did not have additional funds or terminal testing and evaluation in the above research, we would recommend minimum system lengths of 112.5 ft in order to be conservative.

One last factor to consider with the use of terminals on these short systems is the deflection of the terminal when impacted on the end relative to the hazard. As noted above, we believe that the system will redirect the vehicle beginning at post no. 3 in the system. However, in an end on impact of the terminal, the vehicle may deflect down the rail between 37.5 ft – 50 ft. Thus, hazards near the back of the guardrail may still be impacted by end terminal impacts even when they are in the redirective area of the guardrail system. As such, you have to consider both the deflection of the terminal, the redirective region of the LON, and the runout length considerations when designing the placement of short guardrail system.

Thus, based on the analysis and review of previous research, it seems that the minimum length of the installation may be limited to 112.5 ft based the function of the compression terminals. In answer to your question with respect to guardrail over culvert, we would recommend that the overall system length be at least 112.5 ft, and that a minimum of 43.25 ft be required on the upstream and downstream ends of the system. Again, consideration of Lateral Extent of the Area of Concern, the Guardrail Runout Length, and length-of-need (LON)may trump this guidance.

Thanks