Midwest States Pooled Fund Program
Quarterly Progress Report – Fourth Quarter 2015
September 1, 2015 to November 30, 2015

DRAFT REPORTS – POOL FUND

Lingenfelter, J.L., Rosenbaugh, S.K., Bielenberg, R.W., Lechtenberg, K.A., Faller, R.K., and Reid, J.D., *Midwest Guardrail System (MGS) with an Omitted Post*, Draft Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-326-15, Project Nos. TPF-5(193) Supplement No. 80, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 24, 2015.

Rosenbaugh, S.K., Faller, R.K., Lechtenberg, K.A., Reid, J.D., and Bielenberg, R.W., *Development and Evaluation of Weak-Post W-Beam Guardrail in Mow Strips*, Draft Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-322-15, Project Nos. TPF-5(193) Supplement No. 57, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, August 31, 2015.

FINAL 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*, Final 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, September 29, 2015.

Bielenberg, R.W., Rosenbaugh, S.K., Faller, R.K., Humphrey, B.M., Schmidt, T.L., Lechtenberg, K.A., and Reid, J.D., *MASH Test Nos. 3-17 and 3-11 on a Non-Proprietary Cable Median Barrier*, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-303-15, Project Nos. TPF-5(193) Supplement Nos. 44 and 64, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 3, 2015.

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

Lechtenberg, K.A., Schmidt, J.D., Faller, R.K., Guajardo, A.L., Bielenberg, R.W., and Reid, J.D., *Development of a Crashworthy Pedestrian Rail*, Draft Report to the Wisconsin Department of Transportation, MwRSF Research Report No. TRP-03-321-15, Project Nos. TPF-5(193) Supplement No. 41, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 24, 2015.

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

Bielenberg, R.W., Reid, J.D., Rosenbaugh, S.K., Haase, A.J., and Faller, R.K., *Attachment of a Combination Bridge Rail to Concrete Parapet Utilizing Epoxy adhesive Anchors*, Draft Report to the Iowa Department of Transportation, MwRSF Research Report No. TRP-03-325-15, Project No. TPF-5(193) Supplement No. 73, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 3, 2015.

Putjenter, J.G., Bielenberg, R.W., Faller, R.K., and Reid, J.D., *Conceptual Development of an Impact-Attenuation System for Intersecting Roadways*, Final 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, September 30, 2015.

DRAFT REPORTS – FHWA PROJECT

None

FINAL REPORTS – FHWA PROJECT

Schmidt, J.D., Schmidt, T.L., Rosenbaugh, S.K., Faller, R.K., Bielenberg, R.W., Reid, J.D., Holloway, J.C., and Lechtenberg, K.A., *MASH TL-4 Crash Testing and Evaluation of the RESTORE Barrier*, Final Report to the Nebraska Department of Roads and Federal Highway Administration, MwRSF Research Report No. TRP-03-318-15, Project No. NDOR DPU-STWD (94), Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, November 3, 2015.

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

Project Title:

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$159,193	$151,121	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
	$127	

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. Little progress was made this quarter due to other priorities, but the report will be finished soon.

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.

*Note on the 3rd Quarter, 2015 Progress Report, the "Total Cost to Date for Project" was reported as $150,944, and should have been reported as $150,994.

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	$267,019	97%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$35,192	

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 was completed. Draft report was submitted to the sponsor. Sponsor comments and edits were implemented. Revised draft report resubmitted to sponsor. Awaiting sponsor final approval on revised draft report.

Anticipated work next quarter:

Anticipate the 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): 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. #51		**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Annual LS-DYNA Modeling Enhancement Support		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: RPFP-12-LSDYNA	**Other Project ID (i.e., contract #):** 2611211071001	**Project Start Date:** July 1, 2011
Original Project End Date: June 30, 2014	**Current Project End Date:** September 30, 2016	**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
$36,543	$29,391	80%

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	$1,683	0

Project Description:

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

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

A reduced model of the Toyota Yaris (1100c vehicle) was obtained from CCSA, converted to MwRSF format for use in simulations, and then used in several baseline roadside applications. Unfortunately, the model had some serious difficulties in completing the MGS simulation - further investigation is needed.

Anticipated work next quarter:

A two-hour discussion on friction in LS-DYNA roadside safety simulations will be conducted by MwRSF researchers at the January 2016, TRB meeting in Washington D.C. Information used in this discussion has been accumulating for many years during various LS-DYNA projects.

Work will continue on developing a stable version of the 2015 reduced Yaris model.

The 2012 detailed Yaris model will be fitted with the MwRSF developed detailed tire model. The detailed tires will significantly improve tire interaction on several projects including hitting curbs and rock ditch liners. This effort is much more complicated than it might appear. The detailed tire model MwRSF developed was for a pickup truck, the Yaris has considerably different type and size of tires. The model cannot simply be scaled to fit.

Significant Results:

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

Due to the nature of this project, this project is worked on when the need arises or when there is a slack in other project priorities. Thus, the funds were not expended in the original project period.

Potential Implementation:

- see Significant Results

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. #56		**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: Increased Span Length of the MGS Long Span		
Name of Project Manager(s): Reid, Sicking, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: RPFP-13-MGS-3	**Other Project ID (i.e., contract #):** 2611211082001	**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
$212,730 + suppl $36,605	$174,532	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$5,695	

Project Description:

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

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

Objectives / Tasks

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

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

Task 5.
Data and video analysis were completed.

Task 6.
Test report was initiated.

Anticipated work next quarter:

Task 5.
More detailed evaluation of both tests should be completed to determine exactly what went wrong with the unsuccessful test.

Task 6.
Test report writing will continue.

Significant Results:

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

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

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

Objectives / Tasks	% Complete
1. Literature review of previous long-span systems	100%
2. Simulation of both original and any new long-span system designs	100%
3. Design modifications to extend unsupported length	100%
4. Full scale crash testing of new design (two MASH 3-11 tests)	100%
5. Data analysis and evaluation	75%
6. Written report documenting all design work, simulation, testing, and conclusions	40%

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

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

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #57		**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: 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	$106,134	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**
	$7,122	

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.):

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 was sent out to the sponsors for review. The report was then edited according to the sponsor comments. The report was then sent to MATC for review as they provided $60,000 of additional funding to conduct extra component tests of posts within various mow strips.

Anticipated work next quarter:

Upon receiving MATC reviews/comments, the report will be edited, finalized, and disseminated. An eligibility letter will be written and submitted to FHWA for qualify for federal reimbursement. Upon completion of the report and FHWA letter, the project will be closed.

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 the original schedule.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

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

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

Project Title:
Safety Investigation & Design Guidance for Curb & Gutter Near Energy-Absorbing Terminals

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Schmidt, Bielenberg, Faller, Reid	(402) 472-0870	jennifer.schmidt@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211094001		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
$173,716	$90,452	52%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$15,053 (9%)	$15,053	52%

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.):

Writing continued on the report to document the models and results. Fourty-two models were created with different curb configurations. However, upon running the simulations, the tire on the Silverado and Yaris vehicle models did not produce realistic curb traversals. A more detailed tire model was implemented on the Silverado model. A more detailed tire model is being developed for the Yaris. Of the 42 models that were created, all but 14 of them have been run.

Anticipated work next quarter:

Models with a 6-in. curb offset from the face of the guardrail will be created. A meeting will be held with the sponsor to determine if other curb configurations, such as more gently sloping curbs or with a flared end terminal, may be considered depending on the results of the simulations. Writing will continue on the report.

Significant Results:

Baseline simulations were completed.

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

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

None.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$59,946	$20,652	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$3,549	

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 were completed. The request for FHWA eligibility was submitted.

Anticipated work next quarter:

All work has been completed. The remaining funds will be requested to be moved to contingency.

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	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).

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.

All work was completed on the project in the fourth quarter of 2015. Remaining funds were requested to be moved to contingency. $2,895 was charged to Cable R&D.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

Project Title:

Continued Development of the Midwest Four-Cable, High-Tension, Median Barrier (Continuation Funding)

Name of Project Manager(s):	**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:**
2611211096001	RPFP-14-CABLE1	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
$375,513 (+$264,372 from Yrs 20 & 22)	$482,260 ($267,460 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
	$55,425 ($24,057 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 full-scale crash tests (test nos. MWP-1 through MWP-3) was disseminated to the sponsors.

Internal review of the draft report containing the component testing of the non-bolted connection concepts was initiated.

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

Construction of the modified system with MWP to include ¾" diameter holes through the weak-axis flanges at groundline with rounded corners and continue to use the Bennett coupler/wedge to connect the cables.

On October 19th, the redesigned high-tension cable median barrier on level terrain was subjected to AASHTO MASH TL-3 test conditions using a 1100C small car vehicle (test designation 3-10). This system include modified weak posts with the rounded corners and weakening holes at groundline. In test no. MWP-8, the small car impacted the system at a speed and angle of 63.0 mph and 25.7 degrees, respectively, resulting in an impact severity of 64.5 kip-ft. The system adequately contained and safely redirected the small car. The occupant impact velocities and occupant ridedown accelerations were within the preferred limits provided in MASH. The working width of the system was 86 in. Following the test, inspection of the test vehicle revealed longitudinal lacerations of the vehicle floorboard. MwRSF believes that the laceration of the floorboard were caused when the vehicle redirected back into the system. Penetration of the occupant compartment by the post is not permitted under the MASH safety requirements and the test was judged to be unacceptable.

On November 9th, a conference call was held with the member states. During that meeting, it was decided that two

Anticipated work next quarter:

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.

Internal review of the draft report containing the full-scale crash tests (test nos. MWP-4, MWP-6, and MWP-7) will continue. There is a potential the draft report may be sent to the member states for review during the next quarter.

Determine fixes for the current system to eliminate the floorboard cutting issue seen in test no. MWP-8. Anticipate preparing, constructing, and conducting a retest of test 3-10.

Initiate the R&D path of a complete redesigned system.

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, $267,460 has been posted to the contingency funds for Cable R&D and Cable Reporting.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$11,519	$11,519	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,577	

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 through the fourth 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 was sent to the states. The Pooled Fund page was added to the mwrsf site.

All funds from this project have been exhausted, all remaining work and progress will be reported under Project No.: RPFP-15-PFCHS – TPF-5(193) Supplement #84, Project Title: Pooled Fund Center for Highway Safety

Anticipated work next quarter:

None as all funds have been exhausted, all remaining work and progress will be reported under Project No.: RPFP-15-PFCHS – TPF-5(193) Supplement #84, Project Title: Pooled Fund Center for Highway Safety

This project will be closed.

Significant Results:

Several newly completed projects were added to the research archive.

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$3,695	$3,294	85

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$582	

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 4:
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	$79,606.00	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**
	$991.00	

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 has been completed, and the report is going through internal review and edits at MwRSF prior to being submitted to the Midwest Pooled Fund states for comment. The final task prior to submitting the draft report to the states is development of implementation recommendations for the standard MGS system installed adjacent to 2H:1V fill slopes. These recommendations are currently being compiled by the engineering staff and will be implemented into the draft in the upcoming quarter.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will complete the internal reviews and edits of the summary report and finish the development of implementation recommendations for the standard MGS system installed adjacent to 2H:1V fill slopes. Once the implementation recommendations are completed, the researchers will submit the report to the MwRSF Pooled Fund members for comments next quarter. Following review and implementation of the state comments, the summary report will ne finalized and 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	$35,498	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,700	

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 draft report was finalized and sent to sponsors on November 12, 2015.

It will be requested from the states to convert remaining project funds to contingency funds during 1Q 2016.

Anticipated work next quarter:

None (N/A)

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	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).

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)* TPF-5(193) Suppl. #73		**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: Attachment 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:** 11/30/2015	**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
$50,891.00	$50,891.00	100

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,683.00	

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 received 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. IaDOT was unable to complete the report review by the end of October 2015 to correspond with the revised project deadline. As such, a second no-cost extension of the project was provided until November 30, 2015.

Additionally, the project funding was depleted and the additional funding requested in April was needed to complete the project. MwRSF received the supplemental funds as part of a second project, Attachment of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase IB.

The summary report was completed and the project was closed using those supplemental funds. A separate progress report has been submitted detailing that funding.

Anticipated work next quarter:
The project has closed.

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.

IaDOT provided additional funds through a supplemental research effort, Attachment of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase IB, to address the revised scope and budget. A time extension was granted by IaDOT to extend the project close date to November 30, 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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #74	☐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):	**Phone Number:**	**E-Mail**
Faller, Reid, Bielenberg	402-472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211106001		7/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
12/31/15	12/31/2016	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
$124,345	$39,063	37%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,349	

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 was redesigned with the addition of two, 3/4" holes at the based of the post in the weak axis flanges. Component testing indicated that this will mitigate floorpan tearing.

Full-scale testing of the MWP post in test no. MWP-8 found that the modified MWP post mitigated tearing initially.

Anticipated work next quarter:

Because the full-scale crash testing of the cable median barrier with the modified MWP post was not successful, the research effort for the cable barrier adjacent to slope is awaiting to see how the MWP post will be modified for the high-tension cable median barrier. If the MWP post design issues are resolved, MwRSF 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. 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. The use of the S3x5.7 post was negated due to floorboard penetration concerns and the project is currently awaiting modifications to the MWP post before proceeding.

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 was requested and received this quarter that extends the project completion date to 12/31/16.

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:** 12/31/16	**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
$189,820.00	$9,907.00	47%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	-$12,902.00	

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. These results were given to the TAC in a meeting on 10-15-15. They concurred that testing should proceed on the 8 barrier installation.

Anticipated work next quarter:

In the next quarter, MwRSF potential conduct the full-scale crash testing and evaluation of the reduced system lengths indicated by the simulation analysis. Two full-scale crash tests will be conducted.

1. Test designation no. 3-35 at beginning of LON
2. Test designation no. 3-37 at end of LON

Testing is anticipated for the 1st Quarter of 2015, but is dependent on other testing needs and maybe moved back.

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 were completed and a minimum system length of eight barrier segments was recommended for testing.

CAD details were developed and system hardware is ready and waiting in test queue.

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 tasks remains, but a time extension was requested and received this quarter that extends the project completion date to 12/31/16.

A note needs to be made regarding the budget figures noted above. In the 3Q of 2015, $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 rectified the accounting error and the revised total expenditures are noted above.

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #76	☐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 Guai

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Ron Faller, Bob Bielenberg, John Reid	402-472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211108001	RHE-11	7/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
12/31/15	12/31/16	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
$213,677.00	$118,361.00	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
	$63,603.00	

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.):

Previously, 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. MwRSF was unable to complete the summary report prior to the original project end date of 12/31/15. Thus, a no-cost project extension was requested and granted.

A TAC meeting was held on 10-15-15 to update the project status and review the full-scale crash test results.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will continue efforts to complete the 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).

Due to having insufficient time to complete the summary report, MwRSF was not able to complete the research project within the original time frame. Funding for the project tasks remains, but a time extension was requested and received this quarter that extends the project completion date to 12/31/16.

A note needs to be made regarding the budget figures noted above. For 3Q of 2015, $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 rectified the accounting error and the revised total expenditures are noted above.

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	$68,235	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**
	$40,749	

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.):

A full-scale 1100C small car test was conducted on September 2, 2015 at 50 mph into a simulated rock ditch liner, installed on level terrain. The small car was able to safely traverse the rock ditch liner for a distance of 150 ft. Minor wheel turning was observed due to contact with the rocks but the vehicle did not redirect until departing the end of the rock ditch liner. The right-front tire was deflated during impact.

Initial simulation results were compared to test results and excellent agreement was observed overall, although modeling tire deflation could not be accurately predicted due to modeling limitations. A 3-dimensional spatial/terrestrial scan of the rock ditch liner was completed and results were exported to XYZ coordinates. An attempt is underway to convert spatial geometry of the rock ditch liner into an exact LS-DYNA representation of the constructed rock ditch liner.

Anticipated work next quarter:

The spatial geometry of the rock ditch liner will be implemented into an LS-DYNA model and final computer simulations will be conducted. In addition, higher-risk maneuvers, such as steering, sliding, and traversing rock liner placed on a sloped ditch will be investigated to determine if additional simulation and/or full-scale testing is required to certify the crashworthiness of the rock ditch liner. A draft report will be started.

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)* TPF-5(193) Suppl # 78	**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:		
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	$10,869	11.3%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$5,393 (5.6%)	$5,393	

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.):

The LS-DYNA model of the first concept of the transition from the reduced deflection PCB system to freestanding PCB system was completed. Eight impact points were simulated within the transition region with the 2270P vehicle. In each case, the 2270P vehicle model was captured and redirected. Results from the simulations including ORAs, OIVs, roll, pitch, yaw, and dynamic deflection were calculated and compared to the results of the simulation of test RDTCB-2 (reduced deflection system) and the simulation of test 2214TB-2 (freestanding PCB system). Some simulations showed elevated lateral ORAs and increased roll values, although it is not anticipated that they should be problematic. However, the results of the simulations will be further evaluated. Writing continued on the report.

Anticipated work next quarter:

The results of the simulations will be further evaluated. Additional impact points may be simulated. An internal meeting will be held to discuss the results and proposed course of action. Recommendations about the initial concept with the tube taper will be provided and modifications or additional concepts may be proposed.

Significant Results:

Initial simulations appear to have an acceptable performance.

Main Objectives/Tasks	% Complete
1. Literature Review	100%
2. Concept Development	40%
3. Selection of Transition Design	40%
4. LS-DYNA Analysis and Evaluation	60%
5. Project Report	12%

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #79	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$408,235	$100,000 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
	$21,162 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.

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	$47,996.00	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$6,483.00	

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 draft of the report has been completed and sent to the state DOTs for review and comment. Recommendations were developed for the number and spacing of omitted posts in an MGS guardrail system as well as how close omitted posts can be to special applications of guardrail such as transitions and end terminals.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will review the comments and edits from the sponsors, implement those comments, and complete the summary report for this research.

Significant Results:

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

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

None.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*		**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #81 MwRSF Project No. RPFP-15-AGT-1		☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Standardized Concrete Parapet for Use in Thrie Beam AGT's		
Name of Project Manager(s): 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	$27,265	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
	$14,216	

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 test installation was constructed at the MwRSF test site, and the vehicle was prepped for the test.

Anticipated work next quarter:

The full-scale test will be conducted - a MASH 3-11 test with a 2270P pickup truck. Test results will then be analyzed, and work will begin on the project summary report.

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	90%
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).

The test installation was originally built in November. However, heavy precipitation caused the soil around the transition to become too saturated and weak. Thus, the critical area of the transition had to be pulled out and reconstructed in mid-December.

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl.#82	☐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):	**Phone Number:**	**E-Mail**
Reid, Faller, Lechtenberg, Bielenberg	402-472-6864	rfaller1@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
RPFP-15-TREE-1	26112110114001	August 1, 2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
July 31, 2017	July 31, 2017	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$80,815	$44,135	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
	$19,242	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.):

Survey results were collected and analyzed. Crash data from 13 states were collected, tabulated, analyzed, and results were plotted. Trends were identified. A draft report summarizing the results of the literature review, litigation, crash data, survey results, marketing approaches and sample marketing plans was continued and expanded.

Anticipated work next quarter:

The draft report will be completed and sent to sponsors during 1Q 2016. Sponsor feedback will be sought and the report will be revised. Depending on available budget and sponsor interest, a conference call may be set up with all of the state DOTs who wish to participate to discuss report results, marketing efforts in the future, and how state DOTs can work together in the future to make progress on safer tree placement guidelines.

Significant Results:

To date, over 450,000 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. In addition, 25 state DOTs responded to the request for survey.

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #83	☐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):	**Phone Number:**	**E-Mail**
Ron Faller, John Reid, Bob Bielenberg	402-472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211115001	RPFP-15-CONSULT	8/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/17	7/31/17	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$50,001.00	$46,500.00	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
	$16,538.00	

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. #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: 2611211116001	**Other Project ID (i.e., contract #):** RPFP-16-CONSULT	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/18	**Current Project End Date:** 9/30/18	**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
$51,029.00	$0.00	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
	$0.00	

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.):

This project just became active in the past quarter. Consulting inquiries over the last quarter were addressed using funds from project RPFP-15-CONSULT. Once the funds in RPFP-15-CONSULT are depleted, MwRSF will charge time and costs to this project.

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	$8,413	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
	$3,559	

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 through the fourth 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 was sent to the states. The Pooled Fund page was added to the mwrsf site.

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.

Complete the development of the dedicated Pooled Fund page.

Significant Results:

Several newly completed projects were added to the research archive.

Section devoted to the Pooled Fund was developed.

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: 2611211117001	**Other Project ID (i.e., contract #):** RPFP-15-TF13	**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
$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)* TPF-5(193) Suppl. #86		**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: 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	$2,608	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
	$1,949	

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 quarter of the research project, 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.

Attempts by Impact Absorption, Inc. to modify their existing Dragnet energy absorber to generate higher loads have failed due to either not reaching desired loads or overloading of the steel tape causing it to fracture. As such, Impact Absorption, Inc. efforts have shifted to investigation of a higher capacity energy absorber they developed previously for high-severity impacts and military applications. This system uses a much thicker tape that plastically deforms to absorb energy and generates approximately 17 kips of force per absorber, which is close to the design target value of 18-25 kips. However, this system has some drawbacks due to its size, and its performance is unknown when the energy absorber and tape are loaded out of plane. Thus, Impact Absorption, Inc. is fabricating a prototype and shipping it to MwRSF for evaluation.

Due to the difficulties that have been found in modifying existing energy absorbers, MwRSF also developed a concept for an energy absorber based on capstan friction using a cable that passes around a series of pins. Basic calculations found that the target design loads can be reached with this concept, but additional developmental testing and design efforts would be required. This concept will be placed on hold for now, but may be further developed based on the evaluation of the Impact Absorption, Inc. high-performance energy absorber.
A TAC meeting was held 11-24-15 to review current progress and get feedback from the ccommittee.

Anticipated work next quarter:

In the upcoming quarter, MwRSF hopes to review the prototype, high-performance energy absorber supplied by Impact Absorption, Inc. and perform a dynamic component test of the high-performance net attenuation system to evaluate its feasibility. This will include review of the design, development of a test setup, conducting the component test, and analyzing the results.

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:

Fabrication of high-performance energy absorber for feasibility testing and development of a second potential energy absorber concept.

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #87	☐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):	**Phone Number:**	**E-Mail**
Faller, Bielenberg, Reid	402-472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130094001		7/10/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/17	6/30/17	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$262,603	$2,832	10%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,806	

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 quarter of the research project, the literature search was completed 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.

Following the literature search, a CAD model of the Illinois Tollway light pole and based was developed and the CAD model was then meshed made developed into a finite element model for use in the simulation analysis.

MwRSF has been selected models of the MGS system for evaluation of the light pole offset and the light pole has been inserted into those models.

Anticipated work next quarter:

In the upcoming quarter, MwRSF plans to begin the process of analyzing the pole and barrier combinations with various offsets and locations for the pole relative to MGS. The first step will be development of a simulation matrix of various impact points and pole offsets to evaluate the effect of the pole placement on MGS performance. MwRSF will evaluate a variety of metrics to analyze the pole offsets including vehicle snag on the pole, pocketing, and interaction of the W-beam element and/or system posts with the pole among other factors.

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): New Jersey 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. #88		**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: Evaluation of New Jersey TCB Performance under MASH TL-3		
Name of Project Manager(s): Faller, Lechtenberg, Bielenberg, Rosenbaugh,	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611130095001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 4/1/2015
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
$702,369	$32,271	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
	$32,271	

Project Description:

The New Jersey Department of Transportation (NJDOT) currently uses a New Jersey shape temporary concrete barrier (TCB) design with a I-beam connection piece in their work zones and construction areas. The New Jersey Roadway Design Manual provides guidance on allowable barrier deflections for various classes of TCB joint treatments. The guidance provided in the Roadway Design Manual was based on test data from previous testing standard and needs to be updated to be consistent with current testing standards and the vehicle fleet. MASH TL-3 testing of other TCB systems has indicated that dynamic barrier deflections of these types of barriers can increase significantly when compared to deflections based on older crash test data. Thus, a need exists to investigate the performance of the NJDOT TCB design in its various configurations and provide guidance for updating current design guidance for these systems.

The objective of this research effort is to investigate the performance of the NJDOT TCB design in various configurations in order to evaluate the barrier to the MASH TL-3 safety requirements and to develop information on the barrier performance that can be used by the NJDOT to developed updated and improved guidance for the use of the TCB system.

Objectives / Tasks

1. Test no. 1 - Full-scale crash testing (MASH 3-11)
2. Test no. 2 - Full-scale crash testing (MASH 3-11)
3. Test no. 3 - Full-scale crash testing (MASH 3-11)
4. Test no. 4 - Full-scale crash testing (MASH 3-11)
5. Test no. 5 - Full-scale crash testing (MASH 3-11)
6. Test no. 6 - Full-scale crash testing (MASH 3-11)
7. Test no. 7 - Full-scale crash testing (MASH 3-11)
8. Test no. 8 - Full-scale crash testing (MASH 3-11)

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

Project planning.

Preparation of system CAD details for test no. 3. Drawings sent to sponsor for review and approval.

Procurement of barriers for five crash tests.

Anticipated work next quarter:

Procurement of remaining materials for test no. 3. Setup system and conduct crash test no. 1 (which is actually test no. 3 from the proposal).

Documentation of crash test no. 1.

Preparation of CAD details for test no. 4 and test no. 1.

Significant Results:

None

Objectives / Tasks	% Complete
1. Test no. 1 - Full-scale crash testing (MASH 3-11)	
2. Test no. 2 - Full-scale crash testing (MASH 3-11)	
3. Test no. 3 - Full-scale crash testing (MASH 3-11)	
4. Test no. 4 - Full-scale crash testing (MASH 3-11)	
5. Test no. 5 - Full-scale crash testing (MASH 3-11)	
6. Test no. 6 - Full-scale crash testing (MASH 3-11)	
7. Test no. 7 - Full-scale crash testing (MASH 3-11)	
8. Test no. 8 - Full-scale crash testing (MASH 3-11)	
9. Test no. 9 - Full-scale crash testing (MASH 3-11)	
10. LS-DYNA simulation test no. 1	
11. LS-DYNA simulation test no. 5	
12. LS-DYNA simulation reduced system lengths	
13. Written report documenting design, testing, and conclusions	
14. Hardware Guide drawings	
15. FHWA eligibility application	

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).

In August 2015, MwRSF received authorization to begin work on the project. However, the NJDOT provided $219,500 of project funding initially. In October 2015, NJDOT anticipates providing additional funds to reach $350,000 in total funding. In the fall of 2016, NJDOT anticipates providing the remainder of the funds to reach the $702,369 total project budget. Therefore, the project plan was adjusted to accommodate the staged funding and delayed authorization to proceed.

Note: additional funds to reach the initial $350,000 have not been received as of December 15, 2015. Therefore, the project only has enough funds to conduct 3 tests at this time.

Potential Implementation:

Investigation and evaluation of the proposed NJDOT TCB configurations would provide for MASH TL-3 acceptance of the current NJDOT barrier standard. In addition, the testing and proposed simulation analysis would provide improved data for NJDOT design guidance and standards.

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl.#89	☐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 Midwest High-Tension, Cable Barrier End Terminal - Phase I		
Name of Project Manager(s): Schmidt, Reid, Faller	**Phone Number:** 402-472-0870	**E-Mail** jennifer.schmidt@unl.edu
Lead Agency Project ID: 2611211119001	**Other Project ID (i.e., contract #):** RPFP-16-CABLE-4	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/2018	**Current Project End Date:** 9/30/2018	**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
$41,230	$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:

MwRSF has been conducting research for the Midwest States Pooled Fund Program to develop a non-proprietary, high-tension, four-cable median barrier. A separate effort was funded in parallel to develop a crashworthy end terminal for that cable barrier design. Previous research efforts resulted in two non-proprietary, high-tension, cable barrier end terminal designs that were subjected to dynamic bogie testing. However, the bogie testing indicated that the two systems did not meet all of the design goals and further design modifications and investigation was deemed necessary. Additionally, during the development of the high-tension, four-cable median barrier, several design modifications were implemented that will likely affect the design of the end terminal, including the post section, the cable height and spacing, cable tension, and the cable-to-post connection hardware. It is desired that the end terminal system be designed to integrate with the high-tension, four-cable median barrier design as seamlessly as possible. Thus, additional effort is needed to update the terminal to the current high-tension, cable median barrier configuration.

The research objective is to continue the development, dynamic component testing, and evaluation of a crashworthy, four-cable end terminal. The system is desired to meet the TL-3 safety performance criteria found in MASH.

Major Task List -

1. LS-DYNA Simulation
2. CAD Drawings
3. Construction of End Terminal
4. Two Bogie Tests and Data Analysis
5. Summary Report

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

Discussion continued throughout November about the funding of this project due to one State DOT not being able to contribute to Year 26. This project was originally funded in Year 26 with a total budget of $106,230. In the November 9 Pooled Fund meeting, it was decided that $65,000 would be reduced from this project RPFP-16-CABLE-4, so the currently funded budget is $41,230 as reflected in 'Total Project Budget' on page 1. It is anticipated that the $65,000 deficit will be made up in Year 27. Otherwise, all tasks in this project will not be completed.

Anticipated work next quarter:

At the completion of the previous end terminal simulation project, several ideas were brainstormed to improve the cable end terminal during vehicle impacts, especially to improve performance in reverse direction impacts (MASH test designation no. 3-37). Further ideas will be brainstormed and/or the most feasible concepts will be fleshed out.

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).

Note: This project was originally funded in Year 26 with a total budget of $106,230. In the November 9 Pooled Fund meeting, it was decided that $65,000 would be reduced from this project RPFP-16-CABLE-4, so the currently funded budget is $41,230 as reflected in 'Total Project Budget' on page 1. It is anticipated that the $65,000 deficit will be made up in Year 27. Otherwise, all tasks in this project will not be completed.

Potential Implementation:

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

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. #90		**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: Portable Concrete Barrier–Steel Cover Plate for Large Open Joints		
Name of Project Manager(s): John Reid, Ron Faller, Bob Bielenberg, Karla [	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211120001	**Other Project ID (i.e., contract #):** RPFP-16-CONC-4	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/18	**Current Project End Date:** 9/30/18	**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**
$118,925.00	$0.00	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**
	$0.00	

Project Description:

Temporary concrete barriers (TCB) are commonly used to protect work zones and to shield motorists from hazards in construction areas. During setup or contractor operations in work zone areas, it is not uncommon to layout, construct, and connect free-standing TCB installations from different ends or to install barriers with a longitudinal gap between adjacent barrier segments. Longitudinal gaps can also be created due to tensioning issues following an impact event. These gaps can range from 6 in. to as long as a full barrier segment length, or 12.5 ft. Gaps in the barrier system pose a serious safety concern, but limited guidance is available for this situation. Overlapping two runs of barriers has been recommended in the past. However, the length of barrier overlap is relatively large and also requires significant lateral offset between the overlapped segments, which reduces available space in constricted work zones. Thus, a need exists to develop crashworthy and efficient methods for treating longitudinal gaps in adjacent runs of free-standing TCBs.

Previous research efforts to investigate gaps between adjacent TCB installations have focused on gate designs for providing emergency or maintenance access through temporary barriers. These devices include the ArmorGuard Gate, the BarrierGuard Gate, and the Vulcan barrier system. All of these gate systems are proprietary with fixed lengths that can be attached to permanent and temporary concrete barrier systems. While these systems have been crash-tested and demonstrated to function adequately, they are fixed-length solutions that would not be effective at spanning variable length gaps. In addition, these gates can be relatively costly to install.

For a more general solution to variable length gaps, the current guidance is to longitudinally overlap two adjacent barrier runs with a minimum of eight TCB segments and provide a minimum lateral offset of 2 ft between adjacent barrier runs. While this solution is adequate in terms of crashworthiness, it is not always manageable in terms of available space in the work zone. A more efficient solution would involve some form of gap-spanning hardware that could be adjusted for a variable gap length, would be easy to install and remove, and would be crashworthy. Crashworthiness of any design solution would require development of continuity (shear, tensile, and flexural loads) across the variable gap length and

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

MwRSF has made no progress to date on this research effort. During the 4 Quarter of 2015, one of the Midwest Pooled Fund State members was unable to allocate funds from their state for support of the Year 26 research projects. As such, the Midwest Pooled Fund States discussed funding options during this quarter. One option was to delay funding on this project. However it was decided in mid-November that funding for this project would be allocated in full.

Thus, MwRSF plans to begin this research effort in the upcoming quarter. The amount of progress in the upcoming quarter will be dependent on the status of existing projects and staff commitments.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will begin to compile the literature search to review joint spanning systems for concrete barriers (permanent and portable). Once that literature has been compiled and reviewed, MwRSF will begin the process of developing concept designs.

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:

Development of a crashworthy system for spanning variable gaps in adjacent runs of TCBs would provide states with increased safety through removal of the hazard posed by interruption of the barrier continuity and would improve the flexibility of work zone operations by making it easier to move or coordinate TCB installations.

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. #91		**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: Design Guidance for MGS Placed on or near Slopes		
Name of Project Manager(s): John Reid, Ron Faller, Bob Bielenberg, Karla	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211120001	**Other Project ID (i.e., contract #):** RPFP-16-MGS-2	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/18	**Current Project End Date:** 9/30/18	**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
$54,309.00	$0.00	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
	$0.00	

Project Description:

The MGS has shown to be a high performance, adaptable system that can be installed on or near slopes. Variations of the MGS have been tested under these conditions, with differing post spacing, post lengths, and blockout depths, depending on the degree of the slope and the guardrail offset in front of the slope. However, gaps in the guidance still exist for some ranges of slopes and offsets, and existing guidance is contained in various documents as well as on the Midwest Pooled Fund Q/A website.

The need exists to fill the gaps in guidance regarding MGS installed near slopes. For example, there is currently limited guidance for: (1) posts installed 1 ft to 2 ft adjacent to a 3H:1V or steeper slope; (2) posts installed less than 1 ft adjacent to a 3H:1V to 6H:1V slope; and (3) posts installed less than 1 ft adjacent to a 6H:1V or flatter slope. In addition, a single document that provides clear, concise guidance on all options available to designers when installing MGS near slopes would be extremely valuable.

The research objectives are to: (1) develop recommendations for MGS installed with slopes and offsets that have not been provided previously and (2) combine all recommendations regarding MGS installed near slopes into a selection guide which clearly presents all options available to designers when placing MGS near slopes.

Major Task List

Literature Review: Review literature pertaining to MGS in combination with slopes.

Selection of Options: Determine slope and barrier combinations requiring guidance, followed by sponsor review and feedback

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

MwRSF has made no progress to date on this research effort. Current project workload and efforts to close existing project to meet deadlines prevented the start of this effort.

MwRSF plans to begin this research effort in the upcoming quarter. The amount of progress in the upcoming quarter will be dependent on the status of existing projects and staff commitments.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will begin to compile the literature search to review the performance of the MGS adjacent to slopes. Once that literature has been compiled and reviewed, MwRSF will begin the process of developing guidance for intermediate slopes and barrier offsets.

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:

This research would develop a selection guide that presents installation options of the MGS placed near a slope. It would be slope-based such that for a given slope, all allowable variations and locations of the MGS would be presented.

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. #92 MwRSF Project No. RPFP-16-MGS-3		**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: Steel Post Version of Downstream Anchorage System		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211122001	**Other Project ID (i.e., contract #):** RPFP-16-MGS-3	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/2018	**Current Project End Date:** 9/30/2018	**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
$162,219	$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:

Component testing has shown that the performance of the new Universal Breakaway Steel Post (UBSP) compares very well with that of the wood CRT post. As a result, the MwRSF concluded that the UBSP may be a viable option to replace CRT posts in various systems including bullnose systems, long-span guardrail systems, and guardrail end terminals. Although most guardrail end terminals are proprietary, MwRSF has recently developed a non-proprietary downstream anchorage system for the MGS that utilizes two wood Breakaway Cable Terminal (BCT) posts. For state DOTs that primarily utilize steel posts, it is desirable to find a steel post alternative for BCT posts utilized in the MGS downstream anchorage. Although BCT posts differ in function and design from CRT posts, they have similar cross sections and weakening holes at groundline. Thus, modifications to the UBSP may result in performances similar to that of a BCT post. Therefore, an adaptation of the UBSP is desired for use in a new steel post version of the MGS downstream anchorage system.

The objective of this research effort is to develop a steel post version of the MGS downstream anchorage system that satisfies the MASH TL-3 safety performance requirements. Note, this project was divided into two phases. Phase II has yet to be funded, and only Phase I is shown herein.

Objectives / Tasks:

1. Literature Review
2. Development of Design Concepts
3. Design and Analysis
4. CAD Details
5. Component Fabrication
6. Component Testing
7. Data Analysis
8. CAD Details of Recommended System Design

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

Work has not yet begun on this project

Anticipated work next quarter:

Work will begin on the literature review and the development of design concepts.

Significant Results:

Objectives / Tasks:	% Complete
1. Literature Review	0%
2. Development of Design Concepts	0%
3. Design and Analysis	0%
4. CAD Details	0%
5. Component Fabrication	0%
6. Component Testing	0%
7. Data Analysis	0%
8. CAD Details of Recommended System Design	0%
9. Summary Report	0%

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

None

Potential Implementation:

The successful development of a steel post downstream anchorage system would provide states with a second non-proprietary option for the downstream anchorage of MGS. State DOTs that regularly use steel posts instead of wood posts would find implementation of the new system much easier than having to justify wood post use for this special application.

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. #93 MwRSF Project No. RPFP-16-MGS-4	☐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: Top Mounted Socket for Weak Post Bridge Rail		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211123001	**Other Project ID (i.e., contract #):** RPFP-16-MGS-4	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/2018	**Current Project End Date:** 9/30/2018	**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
$130,538	$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:

Numerous box culverts across the country utilize low-fill soil above the top slab, typically in the range of 1 to 3 ft. Because these fill heights do not permit full guardrail post embedment (i.e., 40 inches), alternative post attachment/anchorage options are required to protect the culvert drop-off. Top-mounted post systems have been developed to bolt to the top culvert slab. Unfortunately, when the guardrail system is impacted and posts need to be repaired and/or replaced, maintenance personnel are required to dig up the roadway and/or fill soil to access the attachment bolts and base of posts. This effort adds significant time and costs to system repairs.

Recently, a side-mounted socket system for weak-post MGS was developed for attachment to the outside face of culvert headwall. The system posts are inserted into steel sockets that remain undamaged during impacts. Thus, damaged posts can be replaced without any soil removal or the need for a post driver. However, there are many installations where the culvert or roadway geometry is not compatible with this side-mounted system. For example, the culvert headwall may be farther from the roadway than the adjacent guardrail system. Additionally, there may be a fill slope between the edge of the roadway and the culvert headwall, and the side-mounted guardrail system was only recommended for level terrain applications. The ideal guardrail system for use on low-fill culverts would combine the benefits of a top-mounted system with that of a socketed system. Utilizing sockets would allow for quick and easy repairs to damaged posts, while mounting the sockets to the top of the culvert slab would allow the system to be installed on virtually all culverts.

The objective of this project is to develop a top-mounted socket to attach the weak-post W-beam guardrail system to the top slab of low-fill (1-3 ft) box culverts.

Objectives / Tasks:

1. Literature Review
2. Conceptual Design and Analysis

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

Work has not yet begun on this project

Anticipated work next quarter:

Work will begin on the literature review and the development of design concepts.

Significant Results:

Objectives / Tasks:	% Complete
1. Literature Review	0%
2. Conceptual Design and Analysis	0%
3. Selection of Preferred Concepts	0%
4. CAD Details	0%
5. Component Fabrication and Construction	0%
6. Dynamic Component Testing	0%
7. Data Analysis	0%
8. Removal and Disposal	0%
9. TF 13 Hardware Guide Drawings	0%
10. Project Summary Report	0%
11. FWHA Eligibility Letter	0%

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

None

Potential Implementation:

With the successful completion of this project, state DOTs will have a crashworthy, top-mounted, socketed guardrail system for use on low-fill culverts. The use of sockets to support the guardrail posts will minimize maintenance and repair costs, while having a top mounted system will allow the guardrail system to be placed anywhere on the culvert.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): NDOR

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 # 94	☐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 Generic Energy-Absorbing, Approach End Terminal for MGS

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Schmidt, Reid, Faller	(402) 472-0870	jennifer.schmidt@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211124001	RPFP-16-TERM-1	10/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2018	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
$70,000	$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:

Several crashworthy end terminals exist for W-beam guardrail, including energy-absorbing and non-energy absorbing options. According to the FHWA resource charts for roadside terminals, the currently available generic W-beam guardrail end terminals are all classified as non-energy absorbing [1]. Seven proprietary, energy-absorbing, end terminals exist for W-beam guardrail. However, only one of those systems has been evaluated according to MASH safety performance criteria. Several of the other end terminals were evaluated with 27¾-in. high guardrail and had limited full-scale crash testing with 31-in. high MGS. Only one proprietary, energy-absorbing W-beam guardrail end terminal has been evaluated according to MASH safety performance criteria. Therefore, state DOTs desire a generic, energy-absorbing, tangent end terminal for the MGS that meets the MASH TL-3 safety performance criteria.

The research objective is to synthesize information regarding existing end terminal designs and begin development of design concepts for a generic, tangent, energy-absorbing end terminal for use with the MGS.

Major Task List

1. Literature Review
2. Brainstorming
3. Concept Development and Preliminary Design

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

No progress has been made on this project as much discussion occurred throughout October and November as to which project $65,000 in funding would be eliminated, as one State DOT could not longer contribute funds to Year 26 Pooled Fund.

Anticipated work next quarter:

Patents and other end terminal literature will be reviewed and documented.

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:

At the completion of this multiple phase project, State DOTs will have a tangent approach end terminal for MGS that is generic,energy-absorbing, and meets MASH safety performance criteria. Additionally, State DOTs will better understand the performance of energy-absorbing end terminals, will have an alternative to proprietary products, and could easily explore special applications (i.e. with a curb) that are beyond the current state-of-the-practice.

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. #95	☐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):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211125001	RPFP-16-WEB-1	10/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2018	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
$30,102	$0	0%

Quarterly Project Statistics:

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

Project Description:

The Midwest States Pooled Fund states sponsored the development of a Pooled Fund Center for Highway Safety website. This project has allowed for the development of the website and archiving of materials on the website. Previously, a website for the Midwest States Pooled Fund consulting questions and responses was developed and made available. The website 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 website, 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 created. The research archive contains all of MwRSF's archived research reports in a searchable format. The archive of the CAD details for the research efforts has been generated and is currently being uploaded beginning with newer projects and proceeding to older research. Additionally, Midwest Pooled Fund members have requested inclusion of videos files from full-scale crash testing to the archive. These are currently being added to the site for the newer projects and as requests for older videos are made. The research archive as well as the Midwest States Pooled Fund consulting website is integrated with the main MwRSF website.

Tasks

(1) Identify projects needing wmv videos uploaded to the Research Hub
(2) Locate full-scale crash test videos for publicly funded projects completed at MwRSF
(3) Convert videos to wmv format
(4) Upload the wmv videos to the Research Hub and archive converted videos with the original videos
(5) Verify videos have been uploaded

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

Work has not begun on this project.

Anticipated work next quarter:

Identify projects with videos that need converting. Create a tracking list.

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:

Making the videos available in wmv format will benefit the DOTs involved in training designs, field inspectors, and maintenance personnel on the various roadside safety concepts and devices.

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. #97		**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, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211127001	**Other Project ID (i.e., contract #):** RPFP-16-PFCHS	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/2018	**Current Project End Date:** 9/30/2018	**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
$11,848	$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:

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.):

Work has not begun on this project.

See progress in Project No.: RPFP-15-PFCHS – TPF-5(193) Supplement #84, 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; 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. Funding from Project No.: RPFP-15-PFCHS – TPF-5 (193) Supplement #84, 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 #98		☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☑Quarter 4 (October 4 – December 31)
Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Lechtenberg, Bielenberg, Rosenb	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211128001	RPFP-16-TF13	10/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2018	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
$3,686	$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-15-TF13 – TPF-5(193) Supplement #85, 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-15-TF13 – TPF-5(193) Supplement #85, 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): 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. #99		**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: LS-DYNA Modeling Enhancement Support		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: RPFP-16-LSDYNA	**Other Project ID (i.e., contract #):** 2611211129001	**Project Start Date:** October 1, 2015
Original Project End Date: September 30, 2018	**Current Project End Date:** September 30, 2018	**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
$41,114	$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	$0	0

Project Description:

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

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

This is a continuation of TPF-5(193) Suppl. #51, "Annual LS-DYNA Modeling Enhancement Support" and thus, no progress to report until funds are exhausted in that project.

Anticipated work next quarter:

Significant Results:

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

Potential Implementation:

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. #100	☐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:

Attachment of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase IB

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Bielenberg, Faller, Reid, Rosenbaugh	(402) 472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130097001		9/23/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
11/30/2015	11/30/2015	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$33,488.00	$784.00	100

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$784.00	

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.):

This project is supplemental funding provided by IaDOT to account for a revision in project scope and a need for additional funding in project Attachment of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase I.

As noted in the previous progress reports for Attachemnt of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase I, 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. IaDOT was unable to complete the report review by the end of October 2015 to correspond with the revised project deadline. As such, a no-cost extension of the project was provided until November 30, 2015.

Additionally, the project funding was depleted and the additional funding requested in April was needed to complete the project. MwRSF received the supplemental funds as part of a second project, Attachment of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase IB.

The summary report was completed and the project was closed using the supplemental funds.

Anticipated work next quarter:

The project has closed.

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 original research to some degree. However, IaDOT agreed to the revised scope and budget changes.

IaDOT provided additional funds through a supplemental research effort, Attachment of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase IB, to address the revised scope and budget. A time extension was granted by IaDOT to extend the project close date to November 30, 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)*	**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	$855,903	86%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$27,053(2.7%)	$27,053	86%

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 fourth volume of reports, which details the results of all three full-scale crash tests, was finalized on November 3, 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.

Design continued on the stiffness transition between the deformable barrier and a TL-4 rigid concrete parapet end or buttress. The pinned-end connection was implemented into the LS-DYNA barrier model developed previously, and initial simulations were completed with the 2270P vehicle.

Refinements to the barrier were explored to mitigate damage seen in the crash tests, to address maintenance concerns, and to allow for easier installation without affecting the performance of the barrier. A comprehensive list of potential refinements was reviewed, and mitigating damage to the concrete beams was a top priority. A series of four component tests was proposed to evaluate the damage that occurs at the current concrete beam splice, if an elastomer padding is added at the splice, if normal strength concrete is utilized, and if a steel end cap is added at the ends of the concrete beams.

Anticipated work next quarter:

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

In lieu of the four component tests that were anticipated to evaluate the performance of posts with damage and in cold temperature, four new component tests to evaluate potential barrier modifications will be further explored. The test setup and acquisition of materials will begin soon.

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

Significant Results:

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 rubber 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 published on November 3, 2015.
Report TRP-03-317-15 documenting phase 3 of this project was published on July 29, 2015.
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.

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.

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 project has received multiple extensions. 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

09-11-2015 to 12-11-2015

Guardrail deflection for non-TL-3 situations

Question
State: IA
Date: 09-14-2015

We've had the following issue come up recently and I'm wondering if you can provide some guidance as to what to use for design deflection distances.

The attached Table 5-6 Summary of Maximum Deflections from 2011 Roadside Design Guide provides design deflections for TL-3 impacts. What I'm wondering is what should we be using for deflection distances on a TL-2 situation, commonly an urban 35mph roadway? This question comes up when protecting a railroad lighting/crossbuck pole just off the traveled way, see attached. We currently use the attached BA-204 as the downstream anchor and the attached BA-253 as the general layout. Since the BA-204 utilizes a cable, introducing half post spacing is likely not preferred. That would leave us with nesting the thrie-beam if we felt it was needed.

Are there any reports that might give an indication if we should stay conservative and use the 19.2" number, as I think a 25 impact angle is highly unlikely, or use something more towards the 13.1" number? I'm trying to generate a balance between being far enough away from the railroad pole but not get too close to the roadway to introduce unnecessary impacts.

As always, I appreciate your assistance and insight.

Attachment: http://mwrsf-qa.unl.edu/attachments/c0ce28319a79f5948119e30f27f5321e.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/bd8b0eef399bf06ad91cfe111d87a5dc.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/4f4b2d63eddeb0ad9ae6aa2923b0bfe4.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/6a60e5ef20a3f7cc906617ff1110222c.pdf

---

Response
Date: 09-14-2015

I have looked at the details that you sent and have concerns over the function of the shielding of the pole outside of the allowable deflection.

As it is laid out in your detail, the signal pole is directly adjacent to the end anchorage for the thrie beam. Vehicle impacts in that area would likely release the end anchor through fracture of the BCT and allow the vehicle to impact the pole with little appreciable drop in velocity. Thus, shielding of the pole in this manner may not be effective.

That leaves a variety of options.

1. Moving the pole upstream of the end of the thrie beam and away from the anchorage may help somewhat, but the longitudinal offset may not be allowable based on where the signal needs to be placed.

2. Offsetting the pole more laterally may be the simplest answer, but I don't know what space restrictions you have for lateral offset. A pole with an L-shaped top that allows the pole offset to increase while maintaining signal position might be an option too, but I don't know if such an option exists.

3. A more effective post shielding could be done using a short concrete parapet with a TL-2 AGT and end terminal. This may increase the system length, but it would alleviate concerns for interaction with the signal pole.

4. Install a breakaway base on the pole to make the signal similar to a breakaway luminaire pole.

Take a look at these options and let me know what you think. I may have missed something.

---

travesable cuvert grates

Question
State: WI
Date: 09-02-2015

We had some field staff have a problem installing a steel traversable culvert grate on a concrete pipe (see photo).

We and a number of other states allow the use of an adapter to connect the steel traversable culvert grade to concrete pipe.

I was wondering if MwRSF has seen similar problems in the past or has come up with other possible solutions (e.g. traversable concrete grate comes to my mind...).

I know that the 4" object standard is difficult to apply on a slope, but it is the best published guidance I know of

Attachment: http://mwrsf-qa.unl.edu/attachments/2a74b49be0867b63be4149f6a5867240.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/35392f576bbdd3346a8bb66f4b2f947e.pdf

---

Response
Date: 09-14-2015
I have a couple of comments regarding the attached detail.

1. I assume that the detail is for parallel drainage structures based on the pipe alignment which is why you are concerned with the step up at the attachment to the culvert pipe. If so, I would note that the detail shows 4:1 slopes for certain configurations. Currently, the best available guidance for traversable parallel drainage in the RDG recommends maximum slopes of 6:1 at speeds up to 80 km/h.
2. With respect to the step up in height at the top of the culvert, the current best guidance for traversable parallel drainage would suggest that this is acceptable. Currently, the RDG recommends that the height of the first pipe on the culvert be mounted 4-8" above the culvert invert. Thus, if the slope grading remains consistent with the traversable culvert grate, then the step of of 6-8" at from the top pipe of the grate to the lip of the concrete pipe should present a similar traversable step.

Let me know if you have further comments or questions.

Thanks

MGS Thrie Beam AGT with Curb

Question
State: OH
Date: 09-15-2015

I have a question about our MGS-3.1 Bridge Terminal Assembly, Type 1 that I hope you can answer. The standard drawing states that "Where curb must extend upstream of Post No. 11 for drainage purposes, an extra 12'6" panel of 12 gauge w-beam must be nested prior to the transition (upstream of Post No. 13). This added component shall be included as incidental to the cost of the BTA."

http://www.dot.state.oh.us/Divisions/Engineering/Roadway/DesignStandards/roadway/Standard%20Construct%20Drawings/MGS-3.1_7-18-2014.pdf

Is this still required if the curb is asphalt and not concrete? The Ohio Turnpike constructs concrete curb from structures to BTA post 11 and then changes to asphalt.

Response
Date: 09-21-2015

The need for the nested rail section is based on additional loading of the rail due to the curb geometry affecting the vehicle as it impacts the barrier. Thus, the material that the curb is constructed of should not make a difference, and the nested section should still be required for an asphalt curb section.

Please feel free to contact me with additional questions or comments.

Guardrail Connector Plate

Question
State: MN
Date: 09-16-2015

MnDOT, is in the final phases of developing a new AGT standard. It's the thrie-beam version with the first three larger posts (sized at 84" – W6 X 15) before the concrete end parapet connection. See the attached proposed standard plan (694_AGT_type31_SingleSlope.pdf).
Most newer bridge designs will have an integral abutment with the approach panel. The expansion/contraction joint will be as the end of the approach panel and the parapet.
A concern has been brought to our attention concerning the thrie-beam anchorage plate (see attached standard 8350A). The concern is that the 1 1/8" slotted holes will not allow enough room for expansion/contraction and that the guardrail will be push back and forth, which would move the posts out of vertical. While we do not know if this is a valid concern, we do have an existing standard for a w-beam rail anchorage plate with 3" slots (see attached standard 8318C).
Our question; would a modification of our 8350A standard, to include a 3" (or less) slot, be acceptable for our proposed 694_AGT_type31_SingleSlope.pdf design?
I look forward to your response. Please feel free to give me a call if you have any questions or need additional information.

Attachment: http://mwrsf-qa.unl.edu/attachments/00f9e32d43bc9b3555499917fc3885e5.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/575de1d94ad6db47b4300e40ddf86c7c.pdf

---

Response
Date: 09-17-2015

I have accumulated some feedback from my colleagues. Here are a few thoughts.

Karla Summary:

In the hardware guide, RWE02a-b is the W-beam Terminal Connector. When comparing the RWE02a-b slots to the slots in MNDOT's standard 8318C, they are similar. The hole diameter in the MNDOT drawing is a little smaller. Slot dimensions for RWE02a-b is 31/32" x 3", while slot dimension for MN 8318C is 29/32" x 3".

RTE01b is the Thrie-Beam Terminal Connector. When comparing the RTE01b slots to the slots in MNDOT's standard 8350A, they are different. The RTE01b shows the slots at a 50-degree angle, and they are 31/32" x 1¾". However, it is noted that the slots could be oriented parallel to the longitudinal axes rather than at the 50-degrees. MNDOT's standard has a smaller diameter and a shorter length, 13/16" x 1⅛".

Therefore, I would say MNDOT could at least increase the slot size to what the hardware guide shows without any concerns. I know that this doesn't get to 3".

Scott Summary:

First thoughts – a 3" slot is large. During impacts, it may take quite a while for the rail to shift enough, develop tensile loads, and create the membrane action typically associated with guardrail redirections. This shift could lead to pocketing/snag issues. On the other side of the argument, transitions rely more on lateral force loads provided by posts and rail bending. So maybe enlarged slots don't cause any issues. Without tests, I'm unsure what effect this has on performance.

An idea to strengthen their transition with 3" slots may include shortening the unsupported length of the thrie beam between the concrete parapet and Post 1 (shift the guardrail system DS). Reduce this length from 29" to say 15"-18". I would feel better about reduced snag concerns on the concrete end with a reduced distance.

I would be more comfortable if the expansion/contraction joint had concrete on both sides of it – which I believe is more common amongst our Pooled Fund States.

Ideally, the 7-ft long standardized buttress would be on the upstream side of the joint. However, they may be trying to shorten the length of the transition system and thus, have spanned the thrie beam across the joint. Not sure they want to add an additional 7 ft.

Last thought, I hope that any potential enlarged slots would be punched into the end shoe during fabrication, not cut by hand just prior to installation. Are they working with a manufacturer to produce the part?

****

Based on the above feedback, there are some concerns with extending slots more than used in historical crash-tested systems. Increased slot length could lead to increased lateral deflection in advance of the rigid end. With a longer slot at the end shoe splice location, the rail tension will not develop as quickly. I concur with Scott on this issue. Instead, the rail may more easily move back even though resisted by posts and rail bending capacity due to overlap on parapet. At this time, we unfortunately do not know how much longitudinal shift is acceptable before rail tension is developed. I am aware from prior BARRIER VII modeling efforts that rail tension can be greater than some expect and near the buttress end, say up to 80 to 90 kips during high-energy impact events. Excess rail deflections can lead to pocketing and/or wheel snag as well as increased propensity for vehicle instabilities.

Unfortunately, I cannot easily determine the exact slot lengths, and bolt positions within those slots, that were used in prior crash test efforts of AGTs. What we can say is that standard thrie beam end shoes were used with the commercially-available, industry-accepted slot patterns and sizes, including some variations denoted in hardware guide.

Finally, if I had a choice, I would rather locate the expansion gap between the concrete rail end and the buttress end. However, it may be possible that the 3-in. slot length will not cause any problems in a crash testing program. Unfortunately, I am less certain regarding the system's safety performance with a change under MASH.

Please let me know if you want to further discuss this issue! Also, I need to look at a few other dimensions in the near future. Thanks!

Response
Date: 09-23-2015

We appreciate your (Karla and Scott, also) information and insight.

We are looking into using the TF-13 design RTE01b, and have a few questions.

Was the RTE01b version used in your research outlined in the Transition Report TRP-03-180-06? We have this as one of our standard options, but could not tell from the report.

I have seen both versions on other state standards, one similar to ours and the RTE01b.

Also, I am interested in the number of attachment holes for attachment to the barriers on the end. Ours has five 1" diameter holes and RTE01b has 9 (two ¾" and seven 1").

Why is there a difference. When would we ever need more than the five 1" holes?

You help is appreciated.

Response
Date: 10-01-2015

Hello Mike!

I will respond to your questions below. I have also provided a photograph from the noted reported to inform you of what bolt hole pattern was used in this test series. The end show have 5 bolt holes versus nine.

Photo from test 2, page 71, figure 46 of TRP-03-180-06.

Ronald K. Faller, Ph.D., P.E.

Director and Research Associate Professor

Midwest Roadside Safety Facility (MwRSF)

Nebraska Transportation Center

University of Nebraska-Lincoln

130 Whittier Research Center

2200 Vine Street

Lincoln, Nebraska 68583-0853

(402) 472-6864 (phone)

(402) 472-2022 (fax)

rfaller1@unl.edu

From: Elle, Michael (DOT) [mailto:michael.elle@state.mn.us]
Sent: Wednesday, September 23, 2015 11:39 AM
To: rfaller1@unl.edu
Cc: Brown, Timothy (DOT) <timothy.j.brown@state.mn.us>
Subject: RE: Guardrail Connector Plate

Rom,

We appreciate your (Karla and Scott, also) information and insight.

We are looking into using the TF-13 design RTE01b, and have a few questions.

Was the RTE01b version used in your research outlined in the Transition Report TRP-03-180-06? We have this as one of our standard options, but could not tell from the report.

**As shown above, the as-tested end shoe part used 5 mounting holes. It does appear as though the CAD details in figure 45, page 70, shows extra holes in the end shoe.

I have seen both versions on other state standards, one similar to ours and the RTE01b.

**The previously-provided TTI report revealed static testing on multiple versions of end shoes.

Also, I am interested in the number of attachment holes for attachment to the barriers on the end. Ours has five 1" diameter holes and RTE01b has 9 (two ¾" and seven 1").

Why is there a difference. When would we ever need more than the five 1" holes?

**Thrie beam end shoes are anchored with 5 bolts – three in column 1 and two in column 2 located 8 in. away from vertical centerline of column 1. Unfortunately, I do not know the history as to why some end shoes have 9 holes. I would suspect that a greater number of holes spaced close to one another could potentially lead to part fracture at slightly lower loads. At any rate, we use only 5 anchor bolts for these parts.

Let me know if you have any further questions regarding this information.

Bridge Approach Section

Question
State: NE
Date: 09-17-2015

I have questions about the use of 29" bridge rail & 28"Bridge Approach Section (BAS) taper to 31" over 50'

Has any thrie-beam BAS been tested at 28"?
Should it work properly?

Response
Date: 09-18-2015

We have been asked previously about reduced height transitions. We would expect that a slightly lower transition height would allow for redirection of the vehicle. However, all thrie beam transition testing that I have seen was conducted at 31" or at the metric height of 31 5/8". In addition, lower transition heights typically would expose more of the concrete barrier at the downstream end of the transition and create a potential snag hazard. This would not be an issue for you as you are using lower bridge heights as well.

With respect to transitions, the issue has not been adequately addressed with respect to the current MASH vehicles and impact conditions.

We cannot say with certainty that reducing the rail height of the MGS transition will not affect its performance. Reducing the height of the transition 2"-3" will increase the impact load height on the post and the relation of the vehicle front to the barrier. This in turn could increase the moment on the posts and affect the lateral deflection and stiffness of the system. In addition, there would be concerns for vehicle stability as well as an increased potential for wood posts in the transition to fracture. Thus, we would generally recommend a height of 31" for the MGS transition as well.

We have noted that for TL-2 applications, there is increased potential that a reduction in the rail height for the transition of two inches would likely be acceptable.

Let me know if you need anything else.

MGS Stiffening

Question
State: WV
Date: 09-18-2015

Do you know of any research and results of stiffening MGS with double nested beams or reduced post spacing.

Of course with added post it becomes a splice on the post system, but I was interested in the transition from MGS to the changed section. I was looking at the RDG, Table 5-6 on Page 5-34 and the maximum deflection of a Double W-Beam and 38 in post spacing looks desirable.

I am protecting High Mast lighting in the median that has a 4' dia. foundation 2' above grade and a poles that will not break. I really want some solid protection and bullnose can't be graded in due to the bifurcated typical.

Response
Date: 09-22-2015

We have looked at stiffening methods for the MGS system in the past. We have not evaluated nested rail applied to the standard MGS system at this time. We have used nesting in a couple of special applications for transitions, but we have not done it for a standard length of need system.

That said, we have looked at the use of reduced post spacing for the MGS. The report for this work can be found at the link below. In the report, we tested ¼ post spacing and developed guidance for ½ post spacing deflections as well.

http://mwrsf.unl.edu/researchhub/files/Report162/TRP-03-139-04.pdf

Historically, common W-beam guardrail systems have been easily transitioned between full and half-post spacing variations as well as half- and quarter-post spacing configurations without changes to post lengths or rail configurations. When the MGS with quarter-post spacing is deemed necessary to shield hazards closer to the traveled way, the needs exists to connect full-post spacing MGS to quarter-post spacing MGS. Under this scenario, MwRSF has previously suggested that an intermediate stiffness transition be utilized to more gradually blend the varied lateral stiffness of the two systems. More specifically, MwRSF suggested that a 12-ft 6-in. long MGS segment with half-post spacing be used to gradually transition the lateral barrier stiffness and strength, thus resulting in four spans of half-post spacing between the two systems.

Although the standard MGS utilized mid-span locations for rail splices, it would be expected that rail splices would occur at post locations for the MGS variations which utilized a reduced post spacing. Thus, MwRSF has suggested that rail splices be configured to occur a minimum of 1 reduced span (3 ft - 1½-in.), and preferably 2 reduced spans (6 ft " 3in.), beyond the last or first MGS full-post spacing.

The stiffness transition noted above is suggested for situations where impacting vehicles first contact the full-post spacing MGS and subsequently engage the quarter-post spacing MGS. Therefore, it would not be necessary to apply a similar stiffness transition to the downstream ends of quarter-post spacing MGS unless prone to reverse-direction impacts.

As a side note, we currently have a research project with the Illinois Tollway to evaluate the minimum offset for luminaire poles behind the standard MGS system. We can keep you up to date on the outcomes of that study if you are interested.

Lateral Placement Tolerance for Guardrail Posts

Question
State: OH
Date: 09-22-2015

I'm not sure how familiar you are with our old Type 5 guardrail, but I have a question regarding its installation. Over a long run of guardrail, we have one location where, because of an obstruction, the post spacing was changed in the field to 6' on one side and 6'6" on the other versus the standard 6'3" and holes punched into the rail to secure the rail to the post. Is there a tolerance for lateral placement of guardrail posts and if so, what might that be?
Attachment: http://mwrsf-qa.unl.edu/attachments/edf447ad82342663d5c9e53393628e2a.png

---

Response
Date: 09-23-2015

For the older G4(1S) or G4(2W) systems installed at the original metric height (27.75") we don't believe that a 6" offset of a post should make a substantial effect on barrier performance. However, at some point, the alternation of the post spacing may become more of an issue due to the potential for pocketing, vehicle snag on the posts, and vehicle instability.

We believe that a 1 ft offset tolerance on guardrail post longitudinal placement is acceptable in discrete locations. We would not recommend throughout a system. Typically, we would expect the posts to be placed such that the tolerance provided by the rail slots would be sufficient for attachment of the guardrail. However, a single post offset 1 ft or less should not pose an issue in our opinion.

It should be noted that some care should be taken when field cutting a new post bolt hole such that stress concentrations that may reduce the rail capacity do not arise. Thus, the post bolt hole should be cut smoothly and correspond with typical post bolt hole dimensions. Additionally, we would recommend spray galvanizing the hole to prevent corrosion.

For the MGS system, we have successfully tests a single omitted post at standard post spacing under the MASH TL-3 impact conditions. Thus, for the MGS system, the tolerances and may be larger and/or the post may be simply omitted in that area. The report on that research should be out shortly.

Expansion and contraction of the guardrail connection to a bridge parapet

Question
State: MN
Date: 09-24-2015

Two questions;

1. How concerned should we be with expansion and contraction of the guardrail connection to a bridge parapet.
As you know from our recent questions, this has become a hot discussion issue, but I would think that each post connection must allow some movement with the bolt and slot design, otherwise we would be seeing problems on long runs.

2. If we do move the parapet/end post off the integral approach panel abutment, then how much of a gap can we allow before we have to start considering a cover plate. Attached is a consultant concept that illustrates the concept. Note that I told the consultant that they would not be able to use this concept without an acceptance letter from the FHWA.

Attachment: http://mwrsf-qa.unl.edu/attachments/98fa5fe4ed0dc09322d28201dc2d80d8.pdf

---

Response
Date: 10-01-2015

I will try to respond to your questions noted below.

First, I will begin with question No. 2. We re-examined the issue of a critical gap size or length. When considering 25-degree approach angles for passenger vehicles, we believe that excessive gap length could lead to increased vehicle snag at open joints of rigid parapets. Historically, we have used a 2 in. limit for allowable wheel overlap on the upstream end of rigid buttresses when associated with acceptable snag under thrie beam attached to approach guardrail transitions. The affiliated gap length would be around 4.3 in. Thus, I might suggest holding the gap length to 4 in. maximum.

I recall that this issue was raised many years ago following our testing of an open concrete bridge railing for the State of Nebraska. I looked through our old Pooled Fund Consulting Q&A site and found the following inquiry and response. Years ago, we also recommended a maximum gap length of 4 in. and the use of chamfered corners/edges.

http://mwrsf-qa.unl.edu/view.php?id=386

With regard to question No. 1, we are somewhat concerned with large longitudinal movements in the steel guardrail near the bridge end. If bolts are located at the ends of rail slots, would it be possible for the rail to pull over posts in the same direction of weak-axis bending. Of more concern, we believe that excessive slot length at the buttress and end shoe location could allow for increased vehicle pocketing/snag on the buttress end as well as greater risk for vehicle instabilities during close impacts near the bridge but in AGT.

Please let me know if you have any further questions regarding the information noted above.

KDOT Thrie-Beam Standard Drawing

Question
State: KS
Date: 09-24-2015

I was doing some research on the pooled fund site on a separate topic and came across a detail showing a wood post alternative for the MGS thrie-beam (see attached .png file). I thought this was still in development/hadn't been finalized yet. Can you confirm the "recommended wood post design for Tested MWTSP approach transition" details shown in the attachment would apply to KDOT's current MGS thrie-beam (standard drawing RD613A, also attached)? If we can have this as a wood post option can you confirm the blockouts for the thrie-beam are still 6" wide for the 8" wide x 10" deep 7'-0" long posts? Depending on your response I may put together some draft standard drawings for MwRSF review before KDOT implements them.
Attachment: http://mwrsf-qa.unl.edu/attachments/f01237c4703077f67a9c2c4d25be773e.png

Attachment: http://mwrsf-qa.unl.edu/attachments/6d6ae8f470f23cfc79cbd6def13bfe96.pdf

---

Response
Date: 09-25-2015

A few comments:

The drawing for "Recommended Wood Post Design for Tested MWTSP Approach Transition" (bottom sketch on the drawing page you forwarded) appears to be very similar to the steel post transition from RD613A. You would just need to swap the 3 larger steel posts on the downstream end for the larger 8"x10"x6.5-ft wood posts shown in the drawing. The blockouts can remain the same size – 6"x8"x19" (your email had a 10" height, but I assume that was a typo).

Just a comment/question on your current steel post transition... What size posts are you utilizing for the three 7-ft long posts adjacent to the buttress? I don't see a section note for the posts on the drawing set (other than on section C for the w-to-thrie transition element). Nearly all transitions with 37.5" post spacing adjacent to the rigid buttress require increased post sections, e.g., W6x15's, W6x25's, etc.). I am unaware of any transition being designed and tested utilizing only W6x9 posts with a 37.5" post spacing.

Response
Date: 09-26-2015
Thanks for the quick reply. I'm going to use TRP-03-243-11 as a reference to put the details together for a wood post option. KDOT's 7'-0" posts are W6 x 15 posts. That information is shown on a post details sheet, which I didn't send over yesterday. Once I have the draft drawings put together can I send them onto you for review?

Curb (4") in front of Concrete Barrier

Question
State: MN
Date: 09-28-2015

We would like your input regarding on 4" high curbs, particularly with respect to potential vehicle redirection. There is general language in AASHTO Green Book, the Roadside Safety Guide and the Safety Manual, along with the MnDOT RDM, but nothing that I would consider definitive.

Many Trunk Highway and Interstate projects have included these raised curb sections adjacent to shoulders, in order to manage snow storage. Typically, these configurations will have a concrete barrier located behind the minimally raised curb section. It has been *my understanding* that a 4" curb has not been considered to be vertical curb (with the definition provided in the AASHTO Greenbook) and the MnDOT Geometrics and/or Safety Office has not identified these as a significant re-directional hazard to vehicles.

I would appreciate your insight.

Thank You.

Minnesota DOT

Attachment: http://mwrsf-qa.unl.edu/attachments/4f0e8940a317b0076a3b59efc8bd2217.pdf

---

Response
Date: 09-30-2015
With respect to the 4" curb alone, there are no issues with traversability or vehicle redirection. Various tests of curbs have been performed that have shown curb heights of 4" are not sufficient to redirect a vehicle nor do they tend to cause vehicle instability on their own.

That said, the use of the 4" curb may affect the performance of concrete barrier designs depending on the offset of the curb and geometry of the concrete barrier as curbs adjacent to the barrier may increase vehicle climb and the potential for vehicle instability.

31

Question
State: KS
Date: 09-29-2015

Bob – I called and left a voicemail earlier today in reference to the following and attached: KDOT has had several discussions on this topic with MwRSF previously and it recently occurred to me there may have been a miscommunication. Previously KDOT has asked whether there is an MGS installation for this type of short radius guardrail installation, which there is not. The MGS terminology is a little misleading. I think what we really wanted to know was; is there a 31" tall version of this type of short radius guardrail installation? I think NDOR has details for this, but I wasn't able to find them on their website. I did some searching on the Pooled Fund Site, but didn't find an answer to my specific questions. I know you and Cody Stolle did some investigating on this topic through a Wisconsin funded study in 2014 and found the short radius installation performed acceptably, or maybe even better in some regards, at a height of 31" compared with the 28" height.

As a result I wanted to revisit this topic again. I've attached several draft standard drawings. RD619 is the current short radius guardrail installation KDOT uses for a mounting height of 28". RD619A is a modified version of that drawing keeping the hardware through the curved section the same, but transitioning to MGS on either side of the curved portion. To avoid confusion I'm referring to RD619A as a modified short radius guardrail installation mounted at 31". This is not an MGS installation, but transitions to MGS hardware on either side of the curved section.

My goal is to develop something that will allow KDOT to avoid height transitions within an installation and minimize the different types of hardware we are using in our guardrail installations while still maintaining performance comparable to other TL-2 configurations for similar systems. Currently our practice is to use the old 4G1S AGT with the old 4G1S posts and hardware all mounted at 28" (shown on RD619) when a short radius installation cannot be avoided. As a result we have locations where 3 quadrants of the bridge is all MGS hardware and one quadrant that is 4G1S, which KDOT refers to as the Conventional Guardrail System (CGS). The other approach we've taken where we have space is to install the MGS and then transition to a lower height of 28" over 50 feet up to the curved section of the short radius installation. At that point the hardware switches back to the short radius hardware for the remainder of the installation unless there is room on the end terminal side (along the minor roadway) to transition the height and hardware back to MGS. For additional information I attached the updated post details and the MGS AGT details, which I reference on RD619A.

Just to cover what I found on the Pooled Fund Site during my search I included a short summary below:

1. Response to IA dated June 26, 2012 not recommending the short radius mounting height be raised to 31". A height transition over 50'-0" from 31" to 28" was suggested. The issue we've run into at KDOT is these systems are used only when an intersection is in close proximity to a bridge or a needed guardrail installation. In the case of the bridges there often is not enough room (less than 50'-0") to transition the height so you end up with one quadrant using the old hardware.
2. I found a similar response to NDOR dated January 2, 2012 regarding the 31" mounting height.
3. I also read through TRP-03-296-14 Extending TL-2 Short-Radius Guardrail to Larger Radii. That report seemed to suggest, if I understood it correctly, mounting the short radius at 31" was acceptable for the configurations shown in the report.

The details I've attached are yet another variation on the details shown in the report I referenced in number 3 above. I'd like to discuss this over the phone at your earliest convenience before any thorough review is completed. We coordinated the height transition option we currently use when there is space available with MwRSF previously. The new attached proposed drawings would be identical to that type of installation with the height transition omitted since it would not be needed with everything mounted at 31".

Attached is a detail I was able to track down that NDOR is using.
Attachment: http://mwrsf-qa.unl.edu/attachments/d613681324be40e5cea7cd9191e909b0.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/45a91280348fe5d285948504b9e5a219.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/339eae51de9991bb0bd500d732d34bcb.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/792b63264dac3443e1b558abdcdfd27d.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/370a3f204f2ccd08c7d3ae40e30c8951.pdf

---

Response
Date: 09-30-2015

We currently are limited in what recommendations we can provide regarding short-radius type barrier systems. As you are aware, no short-radius system has met the crash testing criteria for MASH or NCHRP 350 at this time. TTI has recently done research on a MASH TL-3 thrie beam short-radius system, but to my knowledge that has not been approved by FHWA and we have some concerns regarding the test matrix and impact points used to evaluate that system. Thus, we are left with trying to make the best of the situation at hand.

The only short-radius system that has met FHWA eligibility is the 27" high TL-2 version of the Yuma county short-radius system that was analyzed by TTI. This is the system that has been implemented most recently by several states. Your system seems to vary from this design somewhat as it included additional cable anchorages near the nose section. I am not sure of the function of these additional anchorages, but you may want to reconsider them as they may not be consistent with any currently approved design.

Subsequent to that research at TTI, we conducted a simulation analysis for WisDOT regarding the performance of short-radius guardrail for larger radii under NCHRP Report 350. This study started with the Yuma county design and extended it to larger radii (over 25') This study found that the performance of 27" high short-radius guardrail was potentially limited in terms of capturing the 2000P vehicle and that 31" high larger radii short-radius systems had improved potential for pickup truck and high CG vehicle capture. The report also noted that the simulation analysis did not investigate small car interaction with the large radii short-radius systems at either 27" or 31" mounting heights. Passenger cars may underride the rail if a 31-in. mounting height is used despite a beneficial interaction with pickup truck vehicles. Previous thrie beam short-radius systems with 31-in. mounting heights culminated in small car underride and roof or windshield crush. No W-beam short-radius system has been tested and approved with a top mounting height higher than 27 in. Nonetheless, tangent guardrails as tall as 36 in. have redirected small cars at MASH TL-3 impact conditions. Based on these concerns, full-scale testing was highly recommended if a 31-in. (787-mm) tall system is to be used. Thus, while 31" rail height was shown to work acceptably in the study for a limited range of speeds and impact conditions, concerns were noted for small car capture that prevented us from fully endorsing a shift to 31". We did note that a 29" system may be a compromise between the two alternatives until further research is available.

As you noted in your email, we have made similar responses to Iowa and Nebraska regarding the height issue and have recommended limiting the height to the approved 27" for now even though we have some data that suggests that it may pose problems with high CG vehicle capture. This is due to concerns that the small vehicle capture may suffer. Thus we are currently limited to that guidance until further investigation or crash testing of the increased height short-radius systems are undertaken.

From your email, it appears that this is an issue because you are converting to the MGS system and the 27" height of the Yuma county system likely conflicts with some of the approach transition hardware for the MGS. Unfortunately, for the time being, we can only recommend the TTI/Yuma county system as it was granted eligibility at this time because we do not have sufficient information raise the height based on the concerns noted above. Thus, one may be forced to implement the current Yuma system and keep use older hardware.

Let me know if answers your question. I understand that this may not help much. The short-radius issue has been a big problem for several years and will continue to be until we can resolve it. We currently have and R&D effort with NDOR to evaluate a different treatment for intersecting roadways, but that work is still in the developmental phases.

Attachment: http://mwrsf-qa.unl.edu/attachments/b2308bea4ad6c813fde235052ea0dde1.pdf

---

Response
Date: 09-30-2015

I will revisit our existing design and compare it to the TTI design you provided in the attachment. Is there anyone at MwRSF who might be able to do a quick review of the details once I have them put together just to get another set of eyes on them in case I missed anything?

Response
Date: 10-01-2015

Attached are the revised details. I removed all the details for the cable anchor assemblies, soil plates, etc. Since the TTI report noted any tested AGT/End Terminals meeting NCHRP 350 TL-2 or higher could be used outside the curved section I left the 4G1S AGT/End Terminals in the drawing. I attached the original drawing for comparison (RD619_Original). I also attached the other standard drawings I reference on the sheet for information. I did have a couple of questions:

1. I didn't see this in the TTI report, but I know there was some discussion of this in the work you and Cody did for Wisconsin. Can the STYP posts be used in lieu of the wood CRP posts?
2. I left the mounting height detail showing 28" rather than 27" since that is how tall KDOT's typical 4G1S w-beam is mounted. Is that acceptable?

3. Are the radii listed shown on KDOT's version of the drawing ok? I know from the TTI report it had a radius of 8'-0" (shown as 7.96' on KDOT's version to give a length of 12'-6" for the rail, which is evenly divisible by the post spacing). From the work you and Cody did it looks like radii of 23'-10.5", 47'-9", and 71'-7.5" is also ok. Are radii increments between these radii acceptable? Can those radii be adjusted slightly to give lengths of w-beam rail that are evenly divisible by the typical post spacing (i.e. 23'-10.5" would be ok shown as 25'-0")?

Thanks for your help on this.

Attachment: http://mwrsf-qa.unl.edu/attachments/240e25b1dad7a78be175f1f569a629a4.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/fa1c06ec75ed9f118885f4df7c96edc0.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/9c6836d43c5f02d44ac420444796724b.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/414a5f15d82b26d488930407414fe5b9.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/0cf111e0c0400832e80830d739b72e7b.pdf

---

Response
Date: 10-02-2015

I had another question that crossed my mind this morning after sending this info to you yesterday. Can the MGS guardrail and AGT be used instead of the 4G1S system outside the short radius installation if it is mounted at 27" or 28"?

Response
Date: 10-03-2015

I have commented to the questions below in red.

Comments are listed here with respect to the details you sent.

1. You details show a 2:1 slope starting 3' behind the short radius system. While I understand the reality of these slopes, no short-radius system has been successfully tested with these types of slopes and the approval of this system was based on level terrain testing. Based on previous testing and simulation done at MwRSF, we believe that the performance of the system will be degraded significantly with the presence of the steep slope behind the system in terms of vehicle capture and stability.

2. I saw no other significant deviations from the TL-2 approved Yuma County system.

I had another question that crossed my mind this morning after sending this info to you yesterday. Can the MGS guardrail and AGT be used instead of the 4G1S system outside the short radius installation if it is mounted at 27" or 28"?

I don't see any reason why the MGS cannot be used mounted at the lower height for this application. The midspan splices should improve the performance and the deeper blockouts should aid in vehicle capture as well. Obviously the benefits of the reduced post embedment would not be included as the height would not increase. Cody's work for WisDOT indicated that the blockouts may improve vehicle capture for the higher CG vehicles. The effect of the blockouts on small car capture is unknown, but TTI noted in the Yuma

TL-2 system report that blockouts could be used even in the curved section. However they did not make a recommendation towards the larger blockout in the MGS.

With respect to the AGT, I think you would need to stay with the NCHRP TL-3 approved transitions noted in the TTI report. The MASH tested MGS transition essentially uses NCHRP 350 approved transitions on the downstream end adjacent to the bridge, so that part of the transition would not be different. The upstream end of the transition was designed to convert between the stiffness between the standard MGS and the AGT. It also used a asymmetric W-thrie transition piece. The upstream end of that transition has not been evaluated at the lower height, and if you recall, we experienced a rail rupture of that transition near the asymmetric W-thrie transition piece when we tested it with a curb and a 1100C vehicle, which forced us to nest the w-beam ahead of the asymmetric W-thrie transition piece when the AGT was used with a curb. Thus, a lower system may be sensitive to near the asymmetric W-thrie transition piece. Additionally, the asymmetric W-thrie transition piece would not allow for the correct thrie beam height for the AGT connection at the bridge.

Attached are the revised details. I removed all the details for the cable anchor assemblies, soil plates, etc. Since the TTI report noted any tested AGT/End Terminals meeting NCHRP 350 TL-2 or higher could be used outside the curved section I left the 4G1S AGT/End Terminals in the drawing. I attached the original drawing for comparison (RD619_Original). I also attached the other standard drawings I reference on the sheet for information. I did have a couple of questions:

1. I didn't see this in the TTI report, but I know there was some discussion of this in the work you and Cody did for Wisconsin. Can the STYP posts be used in lieu of the wood CRP posts?

I am assuming that you are referring to replacement of the timber CRT posts used in the approved system with Steel Yielding Posts (SYP) developed by TTI. We did not comment on this in the WisDOT study, but we do not recommend replacement of the timber CRT posts with any of the steel breakaway posts at this time. The SYP post is a yielding post that bends at a lower load that the standard W6x8.5 section rather than breaking away at the base like a CRT. This behavior may create a ramp for the vehicle to climb in the nose section which could increase the propensity for override of the rail and vehicle instability. The UBSP post that was developed through the Midwest Pooled Fund is likely a better option as it was used successfully in the bullnose and tends to break way at the base. Component testing of that post compared well with CRT's. However, we have not recommended the use of that section in any system without full-scale testing as it may be sensitive to applications outside of the bullnose. In the case of the Yuma county short-radius system, it is unlikely that it will ever be subjected to a full-scale crash test to evaluate that potential application.

2. I left the mounting height detail showing 28" rather than 27" since that is how tall KDOT's typical 4G1S w-beam is mounted. Is that acceptable?

I will leave the mounting height decision up to you and KDOT, because the guidance in this area is mixed. TTI received approval on the Yuma county system based on the 27" height. Thus, from the standpoint of FHWA eligibility, the 27" height has been recommended by both TTI and FHWA. As I noted in the previous email, the simulation effort we did for WisDOT showed found mixed results for the varying rail heights. Cody's simulations of a 5,000 lb pickup truck on the 27" high Yuma county system with an 8' radius that were conducted to validate the modeling effort found that the pickup was captured. However, a simulation of the a 4,409 lb pickup truck under the same impact conditions overrode the rail. Additionally, as we simulated larger radii at the 27" height, the 2000P vehicle vaulted over the guardrail in 100, 100, and 80 percent of impact conditions simulated for 24, 48, and 72 ft radii, respectively. Blockouts were added to the CRT posts, and the vaulting override rates were reduced to 80, 36, and 50 percent of simulated impact conditions for 24, 48, and 72 ft radii, respectively. Thus, while the 27" height was listed in the TTI report, our study found that it potentially may have capture issues with the higher CG vehicles. We also simulated 29" and 30" rail heights and found much better capture of the 2000P vehicle. However, increasing the rail height leads to concerns for small car underride which were not investigated in the WisDOT study. Thus, we noted that a 29" rail height might be a compromise, but further study was needed to ensure that small car underride was not an issue.

For you, the decision will be what level of variation from the TTI approved system you can tolerate. The work Cody did seems to suggest that increased rail heights are better for higher CG vehicles, but the concerns for small cars exist. That said, the TTI study was a paper study that did not test the Yuma system under the TL-2 impact conditions. So neither of the current guidance is founded in a solid crash test. I would think that the 28" height you propose is a minimal variation from the TTI system and may improve the high CG vehicle performance based on what we currently know.

3. Are the radii listed shown on KDOT's version of the drawing ok? I know from the TTI report it had a radius of 8'-0" (shown as 7.96' on KDOT's version to give a length of 12'-6" for the rail, which is evenly divisible by the post spacing). From the work you and Cody did it looks like radii of 23'-10.5", 47'-9", and 71'-7.5" is also ok. Are radii increments between these radii acceptable? Can those radii be adjusted slightly to give lengths of w-beam rail that are evenly divisible by the typical post spacing (i.e. 23'-10.5" would be ok shown as 25'-0")?

In the TTI report on the Yuma county short-radius, they do not note changing of the radius of the system as one of the acceptable system modifications. This is likely because alteration of the radius may affect capture of the vehicle and energy dissipation. As noted above, Cody's study indicated that larger radii may be an issue as well (however, some of that may have been tied to the height of the rail). Previous recommendations by FHWA have allowed short radius with radii up to 35'. However, that has not been formally verified through a crash test. Thus, it is difficult to recommend larger radii for the Yuma County system. TTI and our research don't seem to suggest that it should be done, but the previous FHWA memo allowed it, so I am sure many states still have the larger radii in their standard. The best option may be to stick with the 8' radius and extend the tangent sides of the system. If you chose to allow the larger radii, the intermediate values should be acceptable.

Cable Barrier Heights

Question
State: WI
Date: 10-01-2015

We have a number of resurfacing project near previously installed cable barriers.

These project likely will change the cable height of the proprietary systems being used.

Does MwRSF know of acceptable variation in height for proprietary systems?

Does MwRSF know of acceptable modification to existing proprietary systems to get the cables at the appropriate height?

Has MwRSF had similar conversations with other states about this topic?

Thanks

Response
Date: 10-01-2015
Our current experience with development and testing of the non-proprietary, high-tension cable median barrier for the Midwest Pooled Fund has shown that cable median barriers can be sensitive to cable heights along with other factors. With respect to overlays, the greatest concern would lie with override of the cable barrier system. As the overlay increases the height of the roadway with respect to the barrier, the potential for the vehicle to impact higher relative to the cable locations increases and thus increases the potential for vehicle capture to be compromised and override the barrier. Additionally, the cable interaction and interlock height with respect to the vehicle will be affected even if the vehicle is captured which could promote increased vehicle instability.

We are not able to directly comment on specific proprietary cable barrier systems and what level of overlay they may be able to tolerate as these systems vary in cable height, cable position on the post, cable attachment to the post, and other factors. Additionally, testing of the Midwest cable median barrier system has largely been conducted to MASH according rather than NCHRP 350. But in a general sense, one would expect that the additional of a pavement overlay would degrade vehicle capture and increase the potential for barrier override and vehicle instability.

In terms of retrofitting the existing cable barrier systems, there is not simple answer. There may be potential means for adjusting the height of the cables in these systems without a complete re-install, but it is largely system dependent. A simple lifting of the post is not likely a good solution as this would raise all of the cable heights and may degrade vehicle capture and barrier performance for backside impacts or low angle hits that compress the vehicle suspension and cause the vehicle to engage the lower cables on the system. Similarly, retrofits that increased the height of the top cable to compensate for the overlay might help with override mitigation, but the increase in the cable spacing on the post could increase the potential for vehicle penetration.

At this time, MwRSF does not know of any acceptable height tolerances and/or potential retrofits for cable barrier systems to compensate for overlays. However, as noted above, there are concerns with the effects on barrier performance, and it seems be be a topic worthy of further consideration.

Concrete Median Barrier re-bar questions

Question
State: MN
Date: 10-09-2015

this has become an urgent constructability question that I need some answers for before a meeting on Monday morning.

Two Questions:

1. Two our three primary concrete contractors are claiming that their slip forming operations would go much better if the rebar clearance from the face of the barrier

was more than two inches. I have seen other states with 2" or 2.5" minimum listed, but never a maximum. What should the maximum clearance be? Could we state 2" min and perhaps 3" or 4" maximum.

2. The current design allows for two vertical 8" bars on the base (every two feet) if the footing is poured separately. Could these be placed closer to the center to help in slip form operations? Better yet could they be placed one every foot, on center or perhaps 4" just off center alternating from side to side every foot?

Our draft standard single slope plan is attached. It is very similar to the Wisconsin, Washington, California and Texas designs (as well as our current f-shape footing design).

Differences of opinion are ok. We, as a state agency, will make the final determination (which sometimes can be polical decision as you know), but I just want to make sure we have your input before the decisons are made.

Thanks for prompt attention to this issue.

Attachment: http://mwrsf-qa.unl.edu/attachments/63455256baa778705f2bb3acb804b217.pdf

---

Response
Date: 10-10-2015

I will provide my general comments below under the individual questions and realizing that Roger has already done a great job in addressing each item.

Ron

From: Elle, Michael (DOT) [mailto:michael.elle@state.mn.us]
Sent: Friday, October 09, 2015 10:13 AM

To: Bligh, Roger <RBligh@tamu.edu>; Ronald K. Faller <rfaller1@unl.edu>
Subject: Concrete Median Barrier re-bar questions

Roger and Ron,

I am sending this to both of you, as this has become an urgent constructability question that I need some answers for before a meeting on Monday morning.

Two Questions:

1. Two our three primary concrete contractors are claiming that their slip forming operations would go much better if the rebar clearance from the face of the barrier was more than two inches. I have seen other states with 2" or 2.5" minimum listed, but never a maximum. What should the maximum clearance be? Could we state 2" min and perhaps 3" or 4" maximum.

**Per my recollection, we have not experienced significant discussions on clear cover, except when developing the TL-5 barrier depicted in the attached report. This barrier was planned for implementation under slip-forming operations. For it and based on contractor feedback, we settled on a general clear cover of 2.5 in. I have not considered or recall seeing a maximum clear in standard plans. However, if both maximum and minimum clear covers are desired, the barrier capacity should be based on a maximum clear cover during testing or with design calculations. I am not overly found of clear covers of 4". I would be more supportive of a 3" maximum clear cover as long as adequate structural capacity is provided.

2. The current design allows for two vertical 8" bars on the base (every two feet) if the footing is poured separately. Could these be placed closer to the center to help in slip form operations? Better yet could they be placed one every foot, on center or perhaps 4" just off center alternating from side to side every foot?

**Without some additional analysis, it is somewhat difficult for me to make further guidance pertaining to number of shear bars, resistance to overturning, placement, etc. Shear bars provide some overturning resistance, but the short length reduces effectiveness. Asphalt keyways on front and back can provide similar resistance to shear. I personally like to see vertical stirrups in barriers. Although the current plans show a particular dowel size, length, and spacing, it is unclear as to the background of these selections. I could further investigate next week if needed. I seem to recall that this configuration may have evolved from the results obtained in the SwRI 1976 barrier study.

I am sorry for the short response and can provide more thoughts next week if needed.

From: Bligh, Roger [mailto:R-Bligh@tti.tamu.edu]
Sent: Friday, October 09, 2015 12:33 PM
To: Elle, Michael (DOT) <michael.elle@state.mn.us>; Ronald K. Faller <rfaller1@unl.edu>
Subject: RE: Concrete Median Barrier re-bar questions

Hi Mike,

A few comments for your consideration in regard to your questions.

1). We noted on your current drawings that your clear cover is currently specified to be 2" +/- ½". Increasing the clear cover will slightly reduce the moment capacity of the barrier because it reduces the "d" distance to your tension steel. However, you may get some contribution from your compression steel that could counter some of this loss. You also have a relatively wide barrier section that helps provide capacity. For example, the 36 inch barrier is probably wider and stronger than it needs to be for TL-4 impacts. With all this in mind, we would be comfortable with a 3 inch clear cover. One note -- with increased clear cover (e.g., 3 inches) on the side and top of the barrier, there is an increased chance of having chunks of concrete lost at the top corners of the barrier during severe impacts.

2). Having a continuous slip-formed barrier helps tremendously in developing required barrier capacity due to the inertial resistance offered by the large barrier mass. There is also a good deal of adhesion strength that exists between the two pours (footing and barrier) that is not accounted for in the design process. This being the case, either of your alternate anchorage options are likely o.k. However, it should be noted that the short 4" embedment will not come close to developing the strength of the #8 bars dowel bars. A better detail would be to use an "L" shaped bar with the leg of the "L" bar in the footer and with a taller vertical projection into the barrier. The size of the anchor bars can be reduced to something like a #6 bar and they could be placed along the center of the barrier at a wider spacing. I suspect that your contractors my simply "stab" the #8 dowel bars into the concrete footer after it has been placed. The "L" bars could still possibly be stabbed into the footer and perhaps tied together (if needed) using a #3 bar along the vertical leg. I noted that TxDOT is using #6 "L" bars on 8-ft centers when a single slope barrier is cast onto a concrete deck or pavement. They use a few bars at 2-ft spacing near the ends of the barrier run. I have attached a detail sheet for your reference.

Please note that these are general comments. Analyses can be performed to be more precise with recommendations, but this would require more time to complete. Please let me know if you have any additional questions or if we can be of any additional service.

Have a great weekend.

Best regards,

Roger

Approach Transition Posts Obstructed by Inlet

Question
State: NE
Date: 10-15-2015

What options to move posts do we have in this location?

Phil,

On the #1095Y Peru Spur project we have a conflict with a flume inlet and the new guard rail installation. I'm attaching a plan with an approx. area where the flume inlet is going to go in relation to guard rail post installation. I spoke with Curt M. & Tyler Chicoine regarding this issue yesterday. I wanted to run this issue by you to see what resolution would be availabble to make this work and still be compliant with the guard rail installation?

Attachment: http://mwrsf-qa.unl.edu/attachments/7cc876fbc27932d617bdb181733a7537.pdf

---

Response
Date: 10-19-2015

We looked over the detail you sent. There are not a lot of good options with this setup, but we can give our best modification with the caveat that this has not been tested and represents only what we believe you can do to best fit the situation you have. If this installation has not been put in, the best option would be to shift the inlet to the region with 6'-3" post spacing where the inlet can be installed without concerns for the barrier performance.

The concern with the inlet as shown is that the obstruction of the two posts will change the AGT stiffness transition considerably and would likely lead to pocketing and poor safety performance. The best alternative installation we can consider is to offset the two obstructed posts longitudinally such that both posts are at least 6" from the sides of the inlet. This should allow for placement of the posts within 1' or so of their intended position. This will likely have the least drastic effect on barrier performance of any alternative we could devise. Relocation of these posts will require field fabrication and spray galvanizing of new holes. We would recommend that we make sure that the new holes land outside of the rail splice overlap.

We would also recommend adding an additional post on the upstream end of the transition. During the design of the AGT, we developed two designs for the transition. The design you have shown is the design we tested, Design K, which was more aggressive. We also had a Design L for the transition that had one additional post at ½ post spacing on the upstream end of the transition. This improved performance of the transition in our simulation models, but we chose the more aggressive version for testing. Because we are modifying the post spacing in this transition, we would recommend adding that additional post back into the system to make the design slightly more conservative. Additionally, the added post may stiffen the upstream end of the transition somewhat and help mitigate the effects of the increased post spacing near the inlet.

So, the options are as follows.

1. The best option would be to move the inlet to a less critical location.

2. A second option would be the modified post spacing and the addition of an additional upstream post as noted above. Again, this is not a tested or evaluated modification, but it represents our best current alternative for an inlet in that location. There are some concerns that the offsetting of the posts longitudinally may affect the stiffness of that region of the transition which may degrade system performance. However, the degree of the effect and the overall performance of the system with the modification is not something we can gauge without further study.

Thanks

Attachment: http://mwrsf-qa.unl.edu/attachments/aa43a52a1de4ea9c1b2117c1f31a3df2.jpg

---

Response
Date: 10-20-2015

The inlet is built, the contractor is building the guardrail.

If we extend the thrie beam or nested thrie beam past the inlet … What post spacing would be needed to allow this inlet to stay in place?

Would using w8x15 posts thru this area help or spacing/ gap at the inlet?

Response
Date: 10-21-2015

If the inlet is in place, then the best option is the one noted below. This was to offset the two obstructed post so that they land just to each side of the inlet and add the additional post upstream from the Design L option.

Using W6x15 posts or extending the nested rail would likely stiffen the downstream end of the transition and increase the effect of the offset posts. Thus, it would not be preferred over the option below.

Thanks

Short Radius Questions

Question
State: WI
Date: 10-19-2015

Here are some questions I have about the short radius.

When we indicate that there is a radius in our plans, how accurate should be the radius (nearest ft, 2 ft 5 ft quarter of an inch)?

As I look at the FHWA drawings, it appears that there are two cables shown. One being 9' long and no information about the other cable.

1. Am I looking at this wrong?
2. Is the other cable just a standard BCT cable (see attached)? I have done some searching around and have not had much luck in finding that cable labeled.

Attachment: http://mwrsf-qa.unl.edu/attachments/9eb8ea2a2bf3ea353a7eeab3649acb66.pdf

---

Response
Date: 10-19-2015

(1) Radii accuracy are dependent on construction tolerance etc. There is some leeway for radii between 8 and 16 ft, but whatever leeway you give you will end up stretching the rail a bit if the radius isn't close because you won't get the rail to exactly 90 degree turn. I think your tolerance is more on your rail curvature, so the total radius tolerance might be nearest foot, maybe less.

(2) The second cable he described is a normal BCT cable.

Concrete Pier Protection AGT attachment

Question
State: NE
Date: 10-22-2015

This installation problem has control bolts that will miss the bottom of a concrete rail along our piers.

Proposed solution; Can the control bolts be eliminated if we run the thrie-beam continuously along the face of the concrete rail 40' to 45'?
I would connect the trie-beam to the bridge approach section on each end of the concrete rail.
Reason this would give us tension in the rail, and only be connected to the wall at the 6'-3" post spacing's(one button head bolt … or not).
This would allow for easy resetting of guardrail when it will be overlaid 20 years from now.

What else is possible other than rebuilding the concrete?

Attachment: http://mwrsf-qa.unl.edu/attachments/07b072a589fceb3c9002878a0419a2b0.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/9d8d98fd45a95fec776d42e86a5be690.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/ea07e20c8327025058efe994d8978b03.pdf

Response
Date: 10-22-2015

If the five anchorage/control bolts are eliminated, then there may be excessive slack available from the downstream guardrail, splices and soil anchorage system that may possibly increase pocketing/snag on the upstream side of the buttress. It may not be an issue, but I am uncertain at this time. Is it possible to construct a taller parapet in the future that allows for two sets of threaded inserts for bolt placement?

Response
Date: 10-23-2015

taller parapet?

It is already tooo tall.

Shouldn't the tension from the upstream & downstream anchors & the bridge approach section posts - keep the vehicle from pocketing/ snagging?

Response
Date: 10-24-2015

Approach guardrail transitions are rigidly anchored to the buttress end. There is only one guardrail joint at this location between the thrie beam end shoe and the nested thrie beam rails. The only joint slip downstream of this location occurs at the one splice location on the face of the buttress.

For a long run of guardrail downstream of this location, there would be multiple joints plus another anchorage. Additional slip could occur that could potentially allow for more rail deflection upstream of rigid buttress. I do not know how significant that this may be but only pointing out that we would not have exactly the same scenario as most testing programs. More rail rotation may occur when the rail is not clamped down to buttress face as well. That could potentially increase pocketing/snag as well; since, one bolt every 6 ft – 3 in. may not replicate the end shoe clamped behavior.

When I noted taller parapets, I was referring to future height to allow for an overlay with second set of 5 bolts.

Again, the long run of thrie beam may be okay. However, I am not as certain that other issues will not crop up.

Response
Date: 10-25-2015

Can the five bolt pattern be adjusted to keep them in the concrete.

Can the 5 bolts be in the top ¾ of the end shoe?

Response
Date: 10-26-2015

Today, Scott and I were able to further discuss this immediate need involving pier protection adjacent roadway reconstruction. As we understand, the roadway adjacent to numerous bridge piers and concrete/guardrail protection systems was milled/removed and reconstructed. During this process, the new roadway is much lower than originally used relative to the barriers. As such, there are concerns with the replacement of the barriers as well as safety concerns regarding roadway elevation changes.

To effectively address these concerns, we believe the best solution involves the downward extension of the RC parapet below the existing parapet. Second and due to such variability between sites, it would be best to just extend the parapet to the current ground elevation. The RC parapet would be supported against the piers in a similar manner to that used for the existing parapet. If desired, one could utilize minimal attachment to the concrete ground surface, although not required. New anchorage hardware would be either cast into the new parapet or placed into old/new concrete with epoxy anchors. The old exposed anchors could be cut off to reduced snag hazards. On the upstream end of the flared buttress, you will likely have the concrete end extend above the thrie beam, which provides some snag hazard for vehicles extending over the thrie beam. If possible, we would prefer to have a top taper on this region to reduce snag risk. However, a taper could provide challenges in the future when the rail needs to be raised. We may want to further discuss options here and note that some risk would exist if you do nothing here.

Please let us know if you have further questions regarding the enclosed information or want to discuss other options. Thanks!

Attachment: http://mwrsf-qa.unl.edu/attachments/b00885d34b8bf4f2d3081dcbb8705775.pdf

---

Response
Date: 10-26-2015
I would suggest not changing the 5-bolt pattern away from that used in the standard steel end shoe. Such changes may potentially cause different failure patterns or capacities to occur in the end shoe. The 5 bolts were likely placed to maximize tensile capacity and provide even distribution within the end shoe.

MGS barrier in a TWLTL

Question
State: OH
Date: 10-23-2015

Because of a crash problem, we would like to install an MGS barrier rail in the center

of the two way left turn lane shown below. A guardrail contractor recommends removing 1' of pavement width, back filling and using steel posts. How much pavement should we remove to allow the guardrail posts to rotate properly?
Attachment: http://mwrsf-qa.unl.edu/attachments/87c31abd4b3f527315d5db2aed95e5bf.jpg

---

Response
Date: 10-28-2015

With regards to the installation below, I am assuming that you are installing the MGS as a strong post median barrier system. This has been approved by FHWA with 12" blocks, and was subsequently tested at TTI using 8" blocks.

Installation of the strong guardrail posts in asphalt can be problematic as it limits the ability of the post to rotate in the soil and absorb energy. MwRSF and TTI have both conducted research related to this issue in the past.

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

http://tti.tamu.edu/documents/0-4162-2.pdf

In the MwRSF research, the researchers designed an evaluated a system for installation of guardrail posts in rock where full embedment was not possible and backfilled cavities were placed in the rock to allow for post rotation. As part of this effort, MwRSF also made recommendations regarding the placement of posts in road paving. If guardrail posts are to be installed in pavement, such as in shoulders alongside the roadway, it was recommended to blockout a portion of the pavement so that the post would have room to rotate backwards. This could be done for both W6x9 steel and 6-in. x 8-in. timber posts. The size of the blocked out portion of the pavement for the post was recommended by assuming the post would rotate around a point two-thirds the depth of full embedment, and the post would be allowed to deflect backwards 18 in. at the rail midpoint height before contact with the pavement. The figure below shows possible geometries for blockout portions of pavement. Backfill with confined compression properties similar to ASTM C33 coarse aggregate, size no. 57, would possibly be acceptable for this application, but it was noted that further testing should likely be conducted. Thus, based on this research a 18" wide portions of roadway would be recommended for a roadside system (with the post located 1" from the front of the removed pavement). If you have median traffic and impacts, the post would need to rotate both ways, so the blocked out pavement would need to be 28" wide to allow for the same motion of the post in both directions with the post in the center of the removed pavement.

Subsequent research at TTI looked at grout filled leavouts for mow strips. Both steel and wood post systems were tested with 18 in. × 18 in. square leave-outs. It was noted that a 18 in. diameter round leave-out provides approximately the same area of leave-out material around the post and was considered to be an acceptable alternative to the square leave-out. Without further testing, these were considered to be the minimum acceptable dimensions for the leave-outs. The material used to backfill the leave-outs was a standard two-sack grout mixture. Tests indicated a maximum 28-day compressive strength of 0.85 MPa (120 psi) for this material. Other leave-out backfill materials (e.g. foams) may be accepted as alternatives to the two-sack grout provided their compressive strength does not exceed that of the grout.

Thus, the TTI work came to a very similar conclusion regarding the size of pavement removed. Thus, we would likely recommend a 28" wide pavement removal with the posts installed in soil in the middle. If you wanted to use a leaveout backfill material in that area, the TTI recommendations for that material should be followed.

Let me know if that answers your question or if you need further information.

Attachment: http://mwrsf-qa.unl.edu/attachments/a04b6cf5e65c7945cc564da423b716b8.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/64ece7e8fd9a760651f2096226ae5e09.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/c7c9d6cafbe589a9c9eb76b1c1b39173.jpg

---

Double thrie beam to two single faced thrie beams

Question
State: WI
Date: 10-28-2015

I did some stumbling around looking for double faced thrie beam to two single faced thrie beam. The details that I did find typically had one post with extra blocks. The next post had two steel posts very close together.

I'm worried that one steel post will interfere with rotation of the steel post struck. How much room between two steel posts is adequate?

I was thinking 2 feet when I drew up my PDF.

I don't know if there is a right answer. I know that adding a bunch of blocks has not be tested either.

Attachment: http://mwrsf-qa.unl.edu/attachments/edea01b9839370a30eaf2a9a254e2112.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/91805cb37d9706c715a60310b56926c5.jpg

---

Response
Date: 10-28-2015

As a quick conservative thought, I might consider that the rail could deflect around 30 in. or more. We may not want the back of an impacted rail to deflect into the back side of an opposite-side steel post.

A single post with 12-in. blocks on each side would result in a gap of 30 in. (two 12-in. blocks plus 6 in. steel post). However, a dual-post system with 8-in. blocks would require a 44-in. gap to not allow posts to contact the backside of second rail using a 30-in. clear region.

If we extend two 8-in. blocks on each side of a single post, we end up with a 38-in. gap. This gap size still falls short of the 44-in. gap, or point where one may consider transition from 2 posts to 1 post.

I am less certain about using three 8-in. blocks on each side.

Note that these quick thoughts have not been tested/evaluated and may also be overly conservative.

As a second thought, another option would be to stager post pattern on dual-side region and use blockouts on both sides of dual posts. This options would mitigate concerns for rail rupture and may allow for narrower gap.

---

post placement for long spans

Question
State: WI
Date: 11-10-2015

We have a project where if the MGS Long-span is installed as crash tested will reduce the shoulder down to 1'.

We have room to install a longer MGS system (box is only a 6' 4" wide).

Could we install a longer span box culvert and have the face of rail closer to the head wall?

We would not have to worry about post rotation issues.

The only potential issue I do see is that we may allow more of the vehicle to extend over the box culvert during a crash. Extending how much the vehicle is over the culvert may increase the likelihood of the vehicle interacting with the wing walls.

The head wall does not extend above the ground line.

I have some photos of the culvert in question. They look pretty bad, but I understand that the culvert had some repair work done on it after it got hit.

Attachment: http://mwrsf-qa.unl.edu/attachments/bef5496cda33e22847f62afcbe33e9b5.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/8f13cd7cf8be17afeec0268ed4912323.docx

---

Response
Date: 11-17-2015
After reviewing the proposed installation, we have concerns with respect to extending the long span an moving the system closer to the culvert. At this time, we have not performed any analysis or or testing that would shed light on the effects of moving the system closer to the edge of the culvert. The concern would lie mostly with the extension of the vehicle over the culvert and the potential for this to compromise the safety performance of the barrier. Keeping the the unsupported length less than the 25' that was full-scale crash tested may limit the extension somewhat, but the amount of the reduction is not quantified.

A better solution in this case my be to use the MGS mounted to culverts with the side mounted sockets for the S3x5.7 post. Note that we would recommend the extended backup plates on this design based on the results of the MGS in mow strip testing.

http://mwrsf.unl.edu/researchhub/files/Report293/TRP-03-277-14.pdf

---

AGT Post Obstruction

Question
State: NE
Date: 11-12-2015

Post # 6 has a footing blocking the placement.
The footing is 2' below the ground.
What can be done with other post spacing to alleviate this?

Attachment: http://mwrsf-qa.unl.edu/attachments/5653f0cd4c2b3e9f93eea3f526e8da18.pdf

---

Response
Date: 11-19-2015

I am not a big fan of moving either post #5 or post #6 approximately 8" or more when only placed within a span of 18.75" due to the potential for increased pocketing when striking just upstream from this location and near asymmetric transition segment. Instead, I would rather use the dual-post straddle and beam system that was developed for Erik Emerson and the Wisconsin DOT in a recent research study. Have you considered this system?

Now, as a last resort, I maybe could live with the post shift method if the transition were extended more upstream to include another thrie beam panel (6 ft – 3 in.) and more ¼-post spacings to mitigate any concerns with a shifted post of 8".

I will ask that Bob/Scott comment as well. Please let me know if you have any questions related to the information noted above. Thanks!

Response
Date: 11-20-2015

What about 2 more W6x15's @ 37.5" as in the clip – in the place of the standard posts at ¼ space.

For post 5 of our original sketch fix: the below would span the footing but we would use an additional 6'-3" of thrie beam & the 31" rail to the right as in our original sketch.

For post 6 fix: this would require moving the last W6x15 8" which would be behind the 6-'-3" thrie beam
Attachment: http://mwrsf-qa.unl.edu/attachments/819e9d230bf605f68a2a04526d6b6929.jpg

---

Response
Date: 11-21-2015

The noted transition below does not have include the transition to the standard AGT that is now used. However and in terms of our prior discussion, one could add a few more ½-post spacings of W6x15, another 6 ft 3 in. segment of thrie to include 12 ft 6 in. of single thrie, then the asymmetric segment, etc. The 37.5 in. span would straddle the hazard. You would still then have Scott's stiffness transition with 18.75" spacings and design K or L of prior report. Let me know if this makes sense. If not we could sketch on paper a few versions.

adding wood planks to back of posts

Question
State: WI
Date: 11-23-2015

We have a number of installations of approach transitions to rigid barrier and beam guard where the sidewalk is directly or in close proximity to the back of post.

Some of our project teams have installed wood planks at about rail height at the back of post to prevent pedestrians or bikes from snagging into the posts.

It may stiffen up the system a little, but I don't see a problem with this so long as it is not within an end terminal.

There could also be some additional debris from an impact as well.

Many of these locations are 45 mph or less posted speed.

I'll try to find a drawing or photos of what they are doing.

What is your thoughts?

Attachment: http://mwrsf-qa.unl.edu/attachments/1316bd5112e89920e1414a022cedab1b.jpg

---

Response
Date: 11-24-2015
In reviewing this type of installation, there are some concerns about debris and the potential for the backside 2x10 rail to detach from the back of the post during impact and become a hazard to the impacting vehicle.

As such, we would likely recommend that this type of installation be evaluated through full-scale crash testing for TL-3 applications. For TL-2 applications like the ones you note above, the concerns with debris and interaction of the rail with impacting vehicles is much lower. Thus, we believe that the timber railing has the potential to be used in lower speed applications without adversely affecting the safety performance of the guardrail or AGT.

TL-4 Thrie Beam Barrier

Question
State: WV
Date: 11-25-2015

I'm trying to contain a perpetual problem of tractor trailers with nested Thrie beam, reduced post spacing and anything short of a concrete barrier wall. The location is about 1900LF so cost isn't a primary concern, we're after TL-4 performance or better.

Was there any nesting of Thrie Beam considered in the development of the Bullnose? Or do You know of anyone testing these applications?

From the RDG, pasted below, is a summary of deflections from simulations for my interest. I would like to propose Run number 14 but sure wish I had actual testing to base it on. Run 18 doesn't produce much benefit for twice the post.

Any info on testing or other input would be much appreciated.

Attachment: http://mwrsf-qa.unl.edu/attachments/206eef5f0918922110886284412 8c2cf.png

---

Response
Date: 11-26-2015

To the best of my knowledge, no one has evaluated any thrie beam barriers to MASH TL-4. TTI previously tested a 34" tall modified thrie beam system to NCHRP 350 TL-4. See attached. I believe that NUCOR had and NU-Guard W-beam barrier and Trinity had a T-39 barrier that were tested to NCHRP 350 TL-4.

NJDOT has contacted us regarding evaluation of the 34" tall modified thrie beam system to MASH TL-4, but it has not been formally put into a proposal. Additionally, we have had some interest from several states regarding adopting the MGS into a TL-4 system that potentially used thrie beam. However, that has not gotten priority for funding yet. We think the potential to do this exists.

TTI did test the standard G9 thrie beam system to MASH under 22-14(3). The system failed to meet MASH in that test with a 2270P vehicle due to rollover. This system used full length timber blockouts. We believe that the use of shortened timber blockouts would have improved the performance of that system. Our previous research on the bullnose and other transition has shown that the shorter thrie beam blockouts improve capture and stability.

In terms of the barrier in Run 18 below, this system would represent a very stiff thrie beam barrier system based on the post spacing and nested rail. This would essentially be as stiff as some of the thrie beam AGT's. That said, we would recommend the use of the shorter blockouts mentioned above for this system as well.

Attachment: http://mwrsf-qa.unl.edu/attachments/cd455ef0c794883dd579a47d948322a8.pdf

---

Triple Blockouts

Question
State: OH
Date: 12-01-2015

We have a guardrail replacement project that is wrapping up on Interstate 70 in Columbus. Because of an inlet, the contractor has used triple 12" blockouts at several approach locations to a structure. The inlet is in poor condition and the project engineer is concerned that the structure is too weak to properly support the load of an impact. From past questions I see that a triple 8" blockout can be used under certain conditions. Is a triple 12" blockout ever an option? If so, can it be used at a transition section such as this? Could some combination of triple blockout and steel post attached to the inlet be used? Is the only option in this case to remove the old inlet

and use steel posts attached to the top of the new inlet? Thanks!
Attachment: http://mwrsf-qa.unl.edu/attachments/cb4b50311442ec93e99e898dbcb36188.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/acd0ce95fff7f85ff91908655a94eceb.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/2134370d30a7a9f7d5859cff9cac2a9e.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/cd11ed3a2b8e7b5f549c8b978ca7078d.JPG

Attachment: http://mwrsf-qa.unl.edu/attachments/c5c6cc210086ce2a99b5771a37c00c48.JPG

Response
Date: 12-10-2015

The issue of placing posts across drainage structures has been brought up several times in the past. We addressed this issue to a limited degree in research for WisDOT in the report below.

http://mwrsf.unl.edu/researchhub/files/Report5/TRP-03-266-12.pdf

One method for traversing drainage structures that has been proposed was to use extended blockouts in that region or attachment of posts to the drainage structure. As you noted, attachment of posts to the drainage structure can be difficult and may not work well because the drainage structure is not designed to structurally handle the loads from the posts.

Similarly, there are concerns with extended blockouts. In the past, we have considered the use of deeper blockouts in limited cases dependent on system in question. We have used 16" deep blockouts in certain systems, and have allowed triple 8" deep blockouts in a transition system. However, there are concerns that the additional blockout depth may begin to affect the way the guardrail post is loaded and may increase the potential for later-torsion buckling of the post rather than the desired post loading modes of strong axis bending and rotation of the post through the soil. As such, we have tried to limit these extended blockouts to a single post in a run of standard guardrail in order to deal with obstacles or other issues.

For transitions, we have previously discussed triple 8" blockouts for three posts as a last resort type of implementation, but did not recommend it as a common practice. The concern for altering the post loading is less prevalent for the transition posts as they tend to be closer spaced and deflect less, which lowers the concern for buckling or improper loading of the post.

In your case, the use of three 12" deep blockouts increases the concerns with post loading. Additionally, there is concern that the extreme length of the blockout will cause the blockouts to disengage during an impact without effectively transferring load to the post. That said, the use of these in a transition reduces the concerns somewhat, and there may not be a better solution for the situation at hand.

The issue of these drainage structures probably deserves its own research effort. A problem statement related to this issue is listed on the Pooled Fund Year 27 ballot that was sent out last month.

Buttress Shape for NE Transition

Question
State: UT
Date: 12-08-2015

My question is in reference to TRP-03-210-10 report and the adapted Nebraska transition. For reference I have attached the Nebraska Std. Dwg.

Within the drawing they show the end of the concrete rail placed at a flare. My question is, can this transition be used on a constant slope barrier end with no flare? Second, as I understand the report this transition would not be used on New Jersey shape barrier?

Attachment: http://mwrsf-qa.unl.edu/attachments/60f4e37b8d887c1c643f69c1f33ed4bc.PDF

Response
Date: 12-08-2015

We recommend utilizing the same concrete buttress geometry as the tested and approved system. We do not recommend altering the concrete barrier design adjacent to the transition region as geometric changes can lead to vehicle snagging and/or instabilities. Numerous full-scale crash tests has shown that altering the geometric shape of the buttress can be the difference between passing and failing a crash test. Therefore, the taper/flare of the front edge of the concrete buttress should remain in place to prevent vehicle snag issues. Also, the buttress shape should remain as a vertical faced barrier in the transition region.

That being said, you could utilize a shape transition between the vertical faced buttress and a New Jersey shaped bridge rail. The shape transition could begin just downstream of the thrie beam end shoe and may be completed over a 7-8 ft distance. Thus, the total length of the concrete rail be get a little longer (due to the shape transition), but you could utilize this approach guardrail transition and buttress in combination with a New Jersey shaped bridge rail.
