Midwest States Pooled Fund Program
Quarterly Progress Report – First Quarter 2015
December 1, 2014 to February 28, 2015

DRAFT REPORTS – POOL FUND

Bielenberg, R.W., Schmidt, T.L., Faller, R.K., Rosenbaugh, S.K., Lechtenberg, K.A., Reid, J.D., and Sicking, D.L., *Design of an Improved Post for Use in a Non-Proprietary High-Tension Cable Median Barrier*, Draft Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-286-15, Project Nos. TPF-5(193) Supplement Nos. 44 and 45, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 23, 2015.

Rosenbaugh, S.K., Schmidt, T.L., Faller, R.K., and Reid, J.D., *Development of Socketed Foundations for S3x5.7 Posts*, Draft Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-293-15, Project Nos. TPF-5(091) Supplement No. 2 and TPF-5(193) Supplement No. 19, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, February 4, 2015.

FINAL REPORTS – POOL FUND

Weiland, N.A., Reid, J.D., Faller, R.K., Bielenberg, R.W., and Lechtenberg, K.A., *Increased Span Length for the MGS Long-Span Guardrail System*, Final Report to the Midwest States Regional Pooled Fund Program, MwRSF Research Report No. TRP-03-310-14, Project Nos. TPF-5(193) Supplement No. 56, Midwest Roadside Safety Facility, University of Nebraska-Lincoln, Lincoln, Nebraska, December 17, 2014.

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

None

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

None

DRAFT REPORTS – FHWA PROJECT

None

FINAL REPORTS – FHWA PROJECT

None

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$92,207	$74,439	99%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$3,591	

Project Description:

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

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

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

Objectives/Tasks:

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

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

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

This quarter, a draft of the report concerning foundation designs for S3x5.7 posts was completed. The draft has gone through internal reviews and was sent to the sponsor states in February for review and comments.

Anticipated work next quarter:

Once reviews and comments from sponsoring states are recieved, the S3x5.7 post foundation report will be edited, finalized and sent to the sponsors. The project is set to close April 30, 2015.

Significant Results:

Phase I of this project included the evaluation of 4 new socketed foundation designs. All 4 of these first round designs experienced heavy damage in the form of concrete fracture and plastic deformation of the reinforcing steel. As a result, 4 new reinforcement designs were configured to provide additional strength to the socketed foundation.

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

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

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

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

Objectives/Tasks:	% Completed (Phase II)
1. Design new socket foundations for barrier posts.	100%
2. Fabrication and dynamic testing of socketed foundations.	100%
3. Analysis of test data and evaluation of socketed foundation designs.	100%
4. Written report documenting all work and conclusions.	98%

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

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

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl.#21	**Transportation Pooled Fund Program - Report Period:** ☑Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Additional Funding to Complete Development of a Crash-Worthy Terminal for Midwest Four-Cable, HT, Barrier System		
Name of Project Manager(s): Reid, Sicking, Faller	**Phone Number:** 402-472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: RPFP-10-CABLE-3	**Other Project ID (i.e., contract #):** 2611211028001	**Project Start Date:** July 1, 2009
Original Project End Date: July 31, 2012	**Current Project End Date:** April 30, 2015	**Number of Extensions:** 3

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$159,193	$136,758	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
	$1,940	

Project Description:

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

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

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

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

Task 4.
Further simulation continued on the end terminal model with a reverse 25-degree impact with both 820C and 1100C vehicles. The line post spacing was 16 ft. An impact point was selected between post nos. 2 and 3, at a point where it is unknown whether the barrier will gate or redirect the car. The top cable releases from the cable anchor bracket when impacted by the 1100C vehicle. However the other 3 cables when impacted by 820C vehicle and all 4 cables when impacted by the 1100C vehicle, remain intact with the cable anchor bracket and interlock with the car's bumper. Several modeling techniques were used to improve the cable contact with the vehicle, but the simulations still had an error before it could be determined if the vehicle would be redirected or if the system would gate.

The research engineers had a meeting to discuss a course of action. The current non-proprietary, low-tension cable end terminal system is of a similar design to what was used by the Gibraltar 3-cable end terminal system. During NCHRP Report 350 modified test designation no. 3-39 (now MASH modified test designation no. 3-37, reverse direction impact) on that system, the 820C vehicle did not exit the system, and had a very rapid deceleration, although it passed all occupant risk criteria. However, it is believed that the current high-tension cable end terminal design is similar enough to this test that it may pose the same concerns if the cables don't release quickly enough. Therefore, simulation will be used to explore some design concepts that will allow the cables to release when impacted in the reverse direction. The design will eventually need to be verified with full-scale crash testing.

Anticipated work next quarter:

Task 4.
Simulation of the reverse direction impact will continue to be evaluated. A detailed evaluation of the current performance of the cable end terminal system will be summarized and changes may be made if warranted. Other CIPs will need to be evaluated. Writing will continue on the third report which will summarize the cable end terminal design, simulation, and evaluation. The MWPs and post spacing that are part of the cable end terminal will be updated as needed to reflect the changes made to the cable median barrier length of need system. While it is desired that the end terminal posts adjacent to the cable anchor bracket are the same as the length of need system, the post spacing and/or base of the post may need to be varied to allow the posts to deform easily when impacted in the weak axis.

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.

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".

Potential Implementation:

The revised terminal will provide a non-proprietary end terminal for high tension barrier cable systems.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Project Title:		
Crashworthy Pedestrian Rail		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Bielenberg, Lechtenberg	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211061001		7/1/2011
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2014	3/31/2015	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
$234,629	$213,923	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
	$30,327	

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.):

Discussions with FHWA regarding the numbers obtained from the two different accelerometer units straddled the maximum limits in MASH for the 1100C small car vehicle (test designation 2-90) in test no. APR-2 were held. Since there is no existing policy for comparing accelerations from different transducer units on the same test, FHWA feels it is best to recognize the implication of a higher value. Thus, the occupant ridedown accelerations were not within the suggested limits provided in MASH and the test was unacceptable according to the safety performance criteria of AASHTO MASH for test designation no. 2-90.

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

Anticipated work next quarter:

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

Significant Results:

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

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

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

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

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

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #43	☑ 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:		
Roadside Grading Guidance - Phase II		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Sicking, Faller, Bielenberg, Lechtenberg	402-472-6864	rfaller1@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211063001		7/1/2011
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2014	3/31/2015	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
$199,502	$121,821 ($34,149 for Suppl. #40, $2	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
	$415 ($108 for Suppl. #40)	

Project Description:

Currently, it is difficult for designers to quantify the safety benefits of flattening roadway slopes. Consequently, a designer may not choose the most cost-effective roadside treatment for a given location. There are some tools to assist designers, however, these tools are difficult to use, time consuming, require training, and would be difficult to implement in a statewide policy. Therefore, there was a need to develop a tool (e.g. a series of graphs or charts) to help designers choose if flattening a slope for a given project is cost beneficial and, if so, identify the most appropriate method for providing slope flattening.

Previously, WisDOT funded a research study with the Midwest Roadside Safety Facility (MwRSF) to examine and update the severity values of roadside slopes, determine the range of slope conditions to be considered, and perform a benefit cost analysis to determine appropriate grading guidance. The total accident database contains approximately 20,000 accident cases, but the previous project analyzed only 1,500 of them due to budget limitations. The preliminary analysis of the data has only provided the average severity of slopes on rural arterials. These data cannot provide accurate correlation with speed limits and the depth of slope without expansion of the number of accident cases. It is believed that analysis of more accident data would allow determination of corresponding speed limits and slope depths. Thus, there is a need to expand this study with a second phase in order to improve the quality and accuracy of the slope grading guidance through analysis of as many of the available accident cases as possible.

Objectives / Tasks
1. Accident data collection
2. Data analysis and determination of critical elements
3. RSAP analysis
4. Written report documenting all analysis and conclusions

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

TRB paper presented in poster session at the Transportation Research Board's annual meeting.

All work has been completed. This project will be closed.

Anticipated work next quarter:

None

Significant Results:

Objectives / Tasks	% Completed
1. Accident data collection	100%
2. Data analysis and determination of critical elements	100%
3. RSAP analysis	100%
4. Written report documenting all analysis and conclusions	100%

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

A subcontract was established for Dr. Dean Sicking in the amount of $25,649 in order for him to review and make edits on the report.

Due to the amount of work remaining, this project is projected to have extra funds remaining at the time the project is complete. The funds in Project Nos. TPF-5(193) Suppl. #40 and TPF-5(193) Suppl. #42 were exhaust prior to the completion of the project. Therefore, the overrun budgets for Project Nos. TPF-5(193) Suppl. #40 and TPF-5(193) Suppl. #42 are being posted to this project. To date, $34,149 has been posted for Project No. TPF-5(193) Suppl. #40 and $2,813 has been posted for Project No. TPF-5(193) Suppl. #42.

Potential Implementation:

This research will provide designers with a tool that simplifies and expedites the process of designing roadside slope geometry. In addition, the guidelines developed herein will provide a uniform policy for roadside design throughout the state of Wisconsin, thus improving the consistency and safety of the roadside slope geometries in the state. A recent implementation was developed wherein the highway classification process can be improved through objective reasoning, divorcing the process from federal aid requirements and antiquated classification traditions, thus providing accurate measures of classification for use in the roadside safety community. Finally, this research should provide for more cost effective use of limited state highway funds by defining the most cost effective slope designs.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Project schedule status:

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

Overall Project Statistics:

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

Quarterly Project Statistics:

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

Project Description:

The objective of this research effort is to set up an annual 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.):

Due to project priorities, no effort was spent on this project during this quarter.

Anticipated work next quarter:

A review of the usage of LS-Dyna at MwRSF is planned. From that review, specific project goals for the remainder of this year will be determined.

Significant Results:

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

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

Potential Implementation:

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$212,730 + suppl $36,605	$81,184	30%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$4,946	

Project Description:

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

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

Objectives / Tasks

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

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

Task 4.

No progress - the full-scale tests for this project are in the testing queue waiting for higher priority projects to be completed first.

Task 6.

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.

Anticipated work next quarter:

Task 4.

It is predicted that full-scale crash testing will begin this quarter.

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)	15%
5. Data analysis and evaluation	0%
6. Written report documenting all design work, simulation, testing, and conclusions	35%

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

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$162,896	$84,261	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
	$51,649	

Project Description:

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

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

Objectives / Tasks

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

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

Previously, a full-scale crash test on the weak post guardrail system installed within a 6-in asphalt mow strip. The S3x5.7 posts were spaced at 37.5" and installed within 4"x4" steel sockets measuring 30" deep. these sockets were driven into the center line of a 4' wide, 6" deep asphalt mow strip. Although the system successfully captured and redirected the 2270P vehicle, the asphalt behind the system fractured. A 2-3 inch wide crack ran along the post line throughout the impact area as the back half of the asphalt translated. Additionally, the tops of the sockets translated up to 2 inches.

Subsequently, asphalt mow strips were deemed too weak to prevent damage to the weak post system during severe impacts. A dynamic component test was conducted on dual S3x5.7 posts spaced 37.5" apart within a 4" thick concrete mow strip. During the test, the posts bent over and the bogie eventually overrode the posts. Minimal spalling behind the posts was the only damage to the concrete pad. Thus, the concrete mow strip should be able to support the weak post system without risk of damage during impacts.

Anticipated work next quarter:

Work on the summary report documenting all design, component testing, and full-scale testing will continue in an effort to close the project on time (June 30th).

Significant Results:

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

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

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

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

Objectives / Tasks	% Complete
1. State survey of existing mow strip practices	100%
2. System design and analysis	100%
3. Dynamic bogie component testing	100%
4. Full scale crash testing (MASH 3-10 and 3-11 tests)	100%
5. Data analysis and evaluation	85%
6. Written report documenting all design work, simulation, testing, and conclusions	20%

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:

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

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

Project Title:		
Safety Investigation & Design Guidance for Curb & Gutter Near Energy-Absorbing Terminals		
Name of Project Manager(s):	**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	$48,520	28%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$6,848 (3.9%)	$6,848	28%

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.):

Modification and validation began on the 31" tall end terminal model. Simulations of NCHRP Report 350 test 3-30 impacts were completed at the shallow 1/4 point offset and seem reasonable. Simulations of MASH test 3-31 impacts were nearly completed. Several modeling techniques were applied to assist the CRT post bolts to "tear" the W-beam and release the rail from the posts, and a path was selected for bolt release for the rest of the study. Validating the model against test 3-31 may prove difficult when comparing test article deflections, as the average force applied by similar end terminals (i.e. SKT and ET-Plus) are quite different. As established at the beginning of this project, only one average, representative force will be used. Other force values were applied to model to select a model with the best average of all the end terminals.

A meeting was held with the ET-Plus and SKT manufacturers, TTI, and FHWA representatives in January 2015 in Washington D.C. Overall results were discuss, and the progress of the project thus far was satisfactory thus far.

Anticipated work next quarter:

A final model of the 31" tall system will be completed including impacts :
3-30 820C at 62mph, 0 degrees, end-on at (shallow ¼ pt offset) @ 31" height
3-30 1100C at 62mph, 0 degrees, end-on at (shallow ¼ pt offset) @ 31" height
3-30 820C at 62mph, 0 degrees, end-on at (deep ¼ pt offset) @ 31" height
3-31 2270P at 62 mph, 0 degrees, end-on at centerline@ 31" height
3-31 2000P at 62 mph, 0 degrees, end-on at centerline@ 31" height

The model will then be changed to 27 3/4 in. tall guardrail and impacted end-on with the 820C and 2000P vehicles.
3-30 820C at 62mph, 0 degrees, end-on at (shallow ¼ pt offset) @ 27 3/4" height
3-30 820C at 62mph, 0 degrees, end-on at (deep ¼ pt offset) @ 27 3/4" height
3-31 2000P at 62 mph, 0 degrees, end-on at centerline@ 27 3/4" height
Explore tests 3-32 and 3-33 with 820C and 2000P vehicles

A complete validation of the end terminal model will also begin.

Significant Results:

Met with end terminal manufacturers and TTI to obtain approval on research completed thus far and anticipated research to be completed. An end terminal model was developed. The 31" tall end terminal system has been evaluated with 820C and 2270P end-on impacts.

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

None.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

Project Title:

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$59,946	$15,640	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
	$3,530	

Project Description:

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

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

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

Objectives & Tasks

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

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

The hardware guide drawings are undergoing internal review and edit.

Anticipated work next quarter:

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

Significant Results:

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

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

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

Objectives/Tasks	% Complete
1. Full-scale crash testing (MASH test designation nos. 3-20 and 3-21).	100%
1a. Full-scale crash test of modified transition (MASH test no. 3-20)	100%
2. Data analysis and evaluation.	100%
3. Report documenting R&D effort, including redesign, crash testing, and conclusions	100%
4. TF-13 Hardware Guide Drawings	85%

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

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

Project Title:		
Continued Development of the Midwest Four-Cable, High-Tension, Median Barrier (Continuation Funding)		
Name of Project Manager(s):	**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)	$360,416 ($100,911 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
	$71,447 ($12,734 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.):

Internal review of the draft report containing the folded C-channel posts and Midwest Weak Posts was completed. The draft report was submitted to the Pooled Fund members for review and comment.

Internal review of the draft report containing the component testing of the shear plate brackets was initiated. The report containing the full-scale crash tests (test nos. MWP-1 through MWP-3) continued to be written.

Construction of the modified Midwest high-tension cable median barrier system on level terrain with 8' post spacing, 38" top cable height, 15.5" bottom cable height, and 7.5" cable spacing in between was completed. On January 8, 2015, MwRSF conducted one small car crash test (test no. MWP-5) into the modified Midwest high-tension cable median barrier with the Midwest Weak Post using a 1100-kg Kia Rio according to the TL-3 safety performance guidelines of MASH, specifically test designation no. 3-10. However, the system was not impacted as intended due to a failure in the guidance system rather close to the system. As a result, the cable barrier system was impacted with the vehicle traveling in a non-tracking scenario, positioned nearly parallel to the system, and with a yaw velocity. While test no. MWP-5 safely redirected the vehicle, the impact conditions were not consistent with the MASH requirements for test no. 3-10.

Consequently, the system was rebuilt. On January 16th, 2015 a retest was conducted at MwRSF's expense. The retest consisted of one small car crash test (test no. MWP-6) into the modified Midwest high-tension cable median barrier with the Midwest Weak Post using a 1100-kg Kia Rio according to the TL-3 safety performance guidelines of MASH, specifically test designation no. 3-10. The 1100C vehicle was safely and smoothly redirected through parallel with the vehicle securely captured with the second cable from the ground. Maximum dynamic deflections were estimated to be approximately 8'. After exiting the system, the vehicle came to a rest in a stable manner downstream. Following the test, inspection of the test vehicle interior found two longitudinal lacerations of the vehicle floorboard, one on each side of the

Anticipated work next quarter:

The report containing the folded C-channel posts and Midwest Weak Posts will be finalized and disseminated to the sponsors.

The report containing the component testing of the shear plate brackets will continue to be written. It is anticipated that internal review of the draft report will be initiated. There is a potential the draft report may be sent to the member states for review toward the end of the next quarter.

The report containing the full-scale crash tests (test nos. MWP-1 through MWP-3) will continue to be written.
The results of the testing of the non-bolted connection concepts will be presented to the states to determine if any of the options seem promising and further work is desired. Documentation of the test results in a formal report will be initiated.

Further investigating the cause of the floorboard penetration and determining potential methods to alleviate the issue prior to further full-scale crash testing will take place. One method that is being investigated is rounding of the free edges on the MWP post instead of just the upper corners. The other options have been previously sent to the sponsors in an email from Bob Bielenberg dated February 3, 2015 following the MWP-6 test, which I have added as an attachment for reference.

Potentially construction of the modified cable system placed on level terrain will be completed.

Significant Results:

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

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

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

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

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

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

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

To date, total funds spent are from the following project funds:
$64,736 from Project No.: RPFP-10-CABLE-3 – TPF-5(193) Supplement #21
$199,626 from Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #46
$96,099 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, $100,911 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	$5,816	50%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,856	

Project Description:

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

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

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

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

Maintenance, repair, and upkeep of the website continued.

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

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

Anticipated work next quarter:

Continue maintenance, repair, and upkeep of the website.

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

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

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

Significant Results:

Several newly completed projects were added to the research archive.

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$3,695	$2,214	55

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$153	

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 of Barrier Drawing through 2014 Quarter 3:
31 systems - 31 approved
41 components - 41 approved
2 systems submitted to Bridge Rail Guide
1 component submitted to Luminaire Guide

Task	% Complete
1. Prepare CAD details for Hardware Guide	55%

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #68	☑ 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):	**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:**
2611211100001	RPFP-14-MGS-8	7/1/2013
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
$89,991.00	$72,804.00	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
	$913.00	

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 has been underway. At this time, the initial draft report for the research is almost complete. Once the initial draft is complete, it will go through internal review and edits at MwRSF prior to being submitted to the Midwest Pooled Fund states for comment.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will complete the initial draft of the summary report and place the report in internal review and editing.

Significant Results:

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

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

None.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$49,044	$12,400	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
	$4,744	

Project Description:

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

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

Objectives / Tasks:

Phase I - Evaluation of Standard MGS (Completed)

1. LS-DYNA computer simulation
2. Summary Report

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

1. LS-DYNA computer simulation
2. Summary Report

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

Simulations were completed for the scenarios of MGS installed in conjunction with a 6-in. AASHTO Type B curb. Results were tabulated and analyzed, and alternative applications to reduce MGS working widths were explored and considered. An internal draft of the report was completed and revision and modification is in progress.

Anticipated work next quarter:

The draft report will be submitted to the Midwest Pooled Fund States for review, revised, and finalized.

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	80%

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

None

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Iowa DOT

INSTRUCTIONS:

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

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

Project Title:
Attachemnt of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase I

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Bielenberg, Faller, Reid, Rosenbaugh	(402) 472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130087001		2/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/2015	7/31/2015	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$50,891.00	$36,121.00	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
	$713.00	

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 has yet to send the updated research costs reflecting the revised project scope as denoted in previous progress reports to IaDOT. They will be submitted this quarter or second quarter of 2015.

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

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

Anticipated work next quarter:

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

MwRSF will also provide the updated budget for the research effort to laDOT.

Significant Results:

None.

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$124,345	$7,678	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
	$4,019	

Project Description:

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

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

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

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

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

This quarter, a component testing matrix was constructed and detailed drawings were completed. The drawings were sent out to MwRSF's test site and the component tests are currently in queue. Component testing will begin with two baseline tests with posts installed on level terrain. Subsequent post tests will be conducted with the posts incrementally shifted toward a 1.8:1 slope break point until a significant loss of resistance is observed. Additionally, the post's soil plate will be redesigned to better optimize strength. The results of this testing will be utilized in assembling the LS-DYNA model of the system.

Anticipated work next quarter:

Bogie testing shall begin on S3x5.7 posts on level terrain and adjacent to a 2:1 slope break point. The testing shall be used to determine an optimized soil plate design as well as the relationship between post offset (from the slope) and the resistance provided by the post.

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

Significant Results:

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

Major Task List	% Complete
1. Literature review of cable barrier on/adjacent to slopes	100%
2. Concept Design	75%
3. Component Testing of Post Configurations	0%
4. LS-DYNA model development, validation, and calibration	0%
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).

none

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #75	**Transportation Pooled Fund Program - Report Period:** ☑ Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☐ Quarter 4 (October 4 – December 31)

Project Title: Length of Need for Free-Standing, F-Shape, Portable 12.5' Concrete Protection Barrier		
Name of Project Manager(s): Ron Faller, Bob Bielenberg, John Reid	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211107001	**Other Project ID (i.e., contract #):** RHE-08	**Project Start Date:** 7/1/2014
Original Project End Date: 12/31/15	**Current Project End Date:** 12/31/15	**Number of Extensions:** 0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$189,820.00	$4,719.00	30%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,689.00	

Project Description:

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

Phase I

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

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

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

During this quarter, MwRSF completed simulation of impacts on the upstream and downstream ends of the 200 ft long barrier system to determine the length of need. Simulations were conducted at seven impact points on the upstream of end of the barrier system and eight impact points on the downstream end of the barrier system. These simulations are currently being reviewed to determine where the length of need starts and ends for the long system. At this time the models of the upstream end of the system have been evaluated and documented. Additional models may be simulated with intermediate impact points to further refine the results. Once all of the results are fully analyzed, the results will be used to determine the beginning and end of length of need based on several factors, including barrier displacement, pocketing, occupant risk measures, and vehicle trajectory and stability.

The results of the friction testing of the F-shape PCB on asphalt were analyzed this quarter. The results of that analysis found that the dynamic friction coefficient between the concrete barriers and asphalt pavement was 0.51. Previous testing of the concrete barrier on concrete pavement yielded a friction value between 0.40 and 0.44. The concrete on concrete values are being used in the current simulation models. The results of the friction testing on asphalt indicated that barrier friction on asphalt surfaces is potentially higher than on concrete. Thus, analysis performed with the concrete-to-concrete friction values should provide conservative estimates for barrier restraint and deflection.

Anticipated work next quarter:

In the next quarter, MwRSF will continue the simulation effort for determining minimum system length and the number of barriers required for the beginning and end of the length of need. The researchers will continue evaluation of the simulation models of impacts at various points near the beginning and end of the PCB system. These models will provide determination of the number of barrier segments needed on the upstream and downstream ends of the full length barrier system to safely redirect errant vehicles.

Once the beginning and end of the length of need is determined for the long PCB system, the length of the system will be reduced and the length of need points will be re-evaluated through computer simulation to determine the minimum system length. The simulations will also be used to determine deflections for the reduced system lengths.

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

Significant Results:

Simulations of various impact points on the upstream and downstream end of the PCB system for determining the length of need were completed and are being evaluated.

Friction testing of PCB on asphalt analyzed and documented.

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

None.

Potential Implementation:

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

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

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$213,677.00	$770.00	12%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,896.00	

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.):

During this quarter, MwRSF submitted the final CAD details for the first full-scale test of the guardrail to PCB transition system to the field crew at the MwRSF Outdoor Test Facility for placement into the testing que.

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

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

Anticipated work next quarter:

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

Significant Results:

None.

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

None.

Potential Implementation:

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

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

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl # 77	**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 IIA Vehicle Dynamics Testing, Validation of Vehicle Models & Computer Simulation of Rock Ditch Liners		
Name of Project Manager(s): Reid, Bielenberg, Faller, and Lechtenberg	**Phone Number:** (402) 472-3084	**E-Mail** jreid@unl.edu
Lead Agency Project ID: 2611130089001	**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
$110,000	$1,339	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
	$374	

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.):

An initial investigation on how to model a 1:1 sloped ground rock ditch liner was performed. This included LS-Dyna simulations with the Toyota Yaris 1100c and the Chevrolet Silverado 2270P models, with different tire models and impact speeds. SolidWorks was used to create two different 3D models of the rip rap that makes up the rock ditch liner. Simulation results showed promising behavior but it is recognized that the 3D surface models of the rip rap are just an approximation of the real thing. Once an actual ditch liner is constructed, we will have a much better example of what one actual should look like. This should help in maturing and developing a more realistic LS-Dyna model.

Anticipated work next quarter:

A brief survey will be conducted to determine which state DOTs utilize rock ditch liners, and obtain details of the liners in use. Additional simulations will be conducted to evaluate alternative configurations of rock ditch liners with varying properties and rock sizes. Based on simulation results and discussion, a full-scale test speed will be determined. The speed will be 30, 45 or 60 mph. Design drawings for the full-scale test will be initiated.

Significant Results:

None to date.

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

None

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* 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	$1,517	2%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$489 (0.5%)	$489	

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 initial literature review was completed on this project including examining existing transitions between temporary concrete barriers and other temporary and permanent concrete barriers and existing methods to taper down box beam sections.

Brainstorming began of the simplest ways to connect free-standing and reduced deflection TCBs.

Anticipated work next quarter:

Further brainstorming will continue on transition designs. The sponsor will be contacted to discuss and rank possible options.

Significant Results:

None to date.

Main Objectives/Tasks	% Complete
1. Literature Review	100%
2. Concept Development	10%
3. Selection of Transition Design	0%
4. LS-DYNA Analysis and Evaluation	0%
5. Project Report	0%

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

None

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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): Reid, Faller, Lechtenberg, Bielenberg, Rosenb	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211096001	**Other Project ID (i.e., contract #):** RPFP-15-CABLE-1	**Project Start Date:** 8/1/14
Original Project End Date: 7/31/17	**Current Project End Date:** 7/31/17	**Number of Extensions:** 0

Project schedule status:

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

Overall Project Statistics:

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

Quarterly Project Statistics:

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

Project Description:

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

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

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

None.

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

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

Anticipated work next quarter:

None

Significant Results:

None

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #80	**Transportation Pooled Fund Program - Report Period:** ☑ Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☐ Quarter 4 (October 4 – December 31)

Project Title: MGS Guardrail with an Omitted Post		
Name of Project Manager(s): Ron Faller, John Reid, Bob Bielenberg	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211112001	**Other Project ID (i.e., contract #):** RPFP-15-MGS-5	**Project Start Date:** 8/1/2014
Original Project End Date: 7/31/2017	**Current Project End Date:** 7/31/2017	**Number of Extensions:** 0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$99,973.00	$1,529.00	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
	$343.00	

Project Description:

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

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

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

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

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

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

CAD details for the tested system were completed and the details were sent to the MwRSF Outdoor Test Facility for placement in the test que during the 4th Quarter of 2014. The test will be conducted as soon as resources and priority are available.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will prepare testing of this system if it reaches a high enough priority in the test que. The testing of the MGS with a single omitted post will be conducted as soon as resources are available. However, completion of the testing is dependent on the schedule of existing crash testing commitments and may not occur if projects with higher priority in the testing que prevent the test from being completed.

Significant Results:

None.

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

None.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$125,906	$4,531	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
	$3,264	

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.):

A preliminary design was discussed at the Dec. 17th meeting of the Pooled Fund States. The buttress design includes:

a vertical front geometry to maximize vehicle stability and eliminate any vehicle interaction with a barrier toe
a 32" barrier height to match the top of the thrie beam guardrail without snag potential
a 4"x4" chamfer along the US-front corner of the buttress behind the thrie beam to minimize vehicle snag
a 4"x12" chamfer along the lower 12" of the same corner to minimize vehicle tire snag

A few of the states were concerned that the dual taper design was too difficult to construct in the field. As such, sketches of both a single and dual tapered design were completed and sent out to the states to vote on preference. The dual taper was selected with 7 out of 11 states voting for it.

Work has since continued to completed the drawing set for the dual tapered buttress and thrie beam transition system.

Anticipated work next quarter:

The CAD drawings of the buttress design and the weak AGT system will be completed and sent to the MwRSF test site for construction and full-scale testing.

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.

Objectives / Tasks:	% Complete
1. Literature Review	100%
2. Parapet Design and Analysis	90%
3. System CAD Details	80%
4. System Construction	0%
5. Full-scale Crash Test	0%
6. System Removal	0%
7. Data Analysis	0%
8. Design Recommendations	0%
9. Written Project Report - First Draft	0%
10. Written Project Report - Edits and Finalization	0%
11. Hardware Guide Drawings	0%
12. FHWA Approval Letter	0%

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

None

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$80,815	$395	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
	$133	0%

Project Description:

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

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

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

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

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

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

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

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

A literature review was initiated regarding studies involving roadside tree safety, tree-related motor-vehicle crashes, treatment of roadside tree hazards, etc. MwRSF continued internal discussions regarding potential marketing approaches for addressing roadside tree safety. MwRSF staff also brainstormed options for hiring new undergraduate students with different skill sets, such as marketing and advertising, to potentially participate in this research study.

Anticipated work next quarter:

MwRSF will attempt to hire UNL undergraduate students with non-engineering backgrounds to support the research study. The literature review will be continued.

Significant Results:

None

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

None

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**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	$9,602.00	20%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$7,497.00	

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)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #84	☑ 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, Lechtenberg, Bielenberg, Rosenb	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211116001	RPFP-15-PFCHS	8/1/2014
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
7/31/2017	7/31/2017	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$11,468	$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.):

None.

This project will not be started until the completion of Project No.: RPFP-14-PFCHS – TPF-5(193) Supplement #66, Project Title: Pooled Fund for Highway Safety.

Anticipated work next quarter:

None

Significant Results:

None.

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

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

Project schedule status:

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

Overall Project Statistics:

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

Quarterly Project Statistics:

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

Project Description:

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

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

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

Tasks:

1. Prepare CAD details for Hardware Guide

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

None

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

Anticipated work next quarter:

None

Significant Results:

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

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

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

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

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

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

Project Title: Adaptation of the SAFER Barrier for Roadside and Median Applications		
Name of Project Manager(s): Ron Faller, John Reid, & Jennifer Schmidt	**Phone Number:** 402-472-6864	**E-Mail** rfaller1@unl.edu
Lead Agency Project ID: 2611211036001	**Other Project ID (i.e., contract #):** DPU-TWD(94)	**Project Start Date:** 7/1/2009
Original Project End Date: 6/30/2011	**Current Project End Date:** 6/30/2015	**Number of Extensions:** 4

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$990,000.00	$688,738	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
$35,707 (3.6%)	$35,707	70%

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 system installation and single-unit truck preparation were completed for upcoming SUT test. MASH test designation 4-12 (test no. SFH-3) was conducted on March 13, 2015 with a 22,000-lb (10,000-kg) single-unit truck impacting the barrier at the target conditions of 56 mph and 15 degrees. From a quick review, the test appeared to be successful as the the truck was safely contained, redirected, and stable throughout the entire event.

The first draft of the third volume of the research reports, which details all system design and simulation as well as further component tests leading up to the first full-scale crash test, has almost completed the MwRSF review process. The first draft of the fourth volume of research reports, which details the first two full-scale crash tests, is currently within MwRSF's internal review process. Writing also continued on a fifth research report, which details the initial background, brainstorming, and development of a future stiffness transition between the energy-absorbing barrier and a rigid concrete buttress.

As noted above, several concepts were brainstormed to help with the eventual development of a stiffness transition between the AASHTO MASH TL-4 energy-absorbing barrier and a rigid concrete parapet end or buttress. A pinned end connection between barrier types is being evaluated for impacts near the end of the system using the LS-DYNA barrier model development previously.

Anticipated work next quarter:

Test no. SFH-3 will be analyzed, and a report will be prepared summarizing the test results. The results from all three crash tests will then be evaluated to determine if the barrier system provides: satisfactory safety performance according to the MASH TL-3/4 evaluation criteria; a desired reduction in lateral acceleration; and a permissible level of barrier damage. The results will be analyzed to determine what modifications and refinements are necessary, followed by any additional analysis, design, and LS-DYNA computer simulation if warranted.

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. The third and fourth reports will be sent to the sponsor for review. 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.

Significant Results:

Report TRP-03-281-13 documenting phase 1 of this project was published July 16, 2013.
Report TRP-03-280-13 documenting phase 2 of this project was published February 6, 2014.
Test no. SFH-1 was conducted on July 2, 2014 and was successful.
Test no. SFH-2 was conducted on August 11, 2014 and was successful.
Test no. SFH-3 was conducted on March 13, 2015 and appeared to be 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 additional investigation will not be completed by the current project end date. The budget of the project has not been affected.

Potential Implementation:

Study findings on rubber material models under high-velocity impacts are available to future researchers to use in other investigative efforts. The shear-fender, open concrete median barrier concept has demonstrated a significant reduction in lateral vehicle accelerations and occupant risk values for passenger vehicles in numerical simulations. The barrier also has demonstrated the ability to contain simulated TL-4 single-unit truck impacts under MASH test conditions. The current barrier design has a top steel rail that can be removed and easily replaced if a single-unit truck cause significant damage. The barrier should otherwise be restorable and virtually maintenance free for impacts with passenger vehicles ranging from small cars to light trucks. It is anticipated that severe injuries and fatalities could be reduced with the shear-fender, open concrete median 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

12-09-2014 to 03-15-2015

MGS Box Culvert Mounting

Question
State: NE
Date: 10-24-2014

Implementation of MGS mounted to culvert parapet.
I need to shorten the top mount.
The NDOR typical parapet is only 8" wide.
There should be more concrete behind this threaded rod from the top.
What should the strap length be?
Should the cover over the threaded rod be 2"? or centered in the parapet

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Response
Date: 12-09-2014
For the culverts in which the headwall is narrow (yours are 8"), I would not utilize the top-mounted, single-anchor design to attach the socket to the outside of the headwall. For that design, it's important to maintain the 7" anchor offset from the outside face to prevent concrete damage. Unfortunately, that will not leave you enough concrete cover on the inside of the anchor, 2 inches is recommended. We never designed the top mounted attachments for offsets less than 7".

However, you could utilize either the wrap-around design, or the side-mounted design (through bolt). See pages 36-41 of the report (TRP-03-277-14) for the design details of these attachment options. The only difference you would need to make is the length of the strap or bolts to reflect the correct headwall width.

Note, although only 2 of the 5 design concepts were included in the final drawing details, MwRSF has confidence that all five of the concepts provide adequate strength to support the system. Thus, any of the five concepts can be utilized to satisfy the

installation needs of existing culverts.

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54 Inch Concrete Barrier

Question
State: WY
Date: 12-10-2014

We have a single slope barrier from Caltrans that is 56" tall. But I don't believe that it has the vertical reinforcement required for pier protection.

In most cases, we have convinced our structures department and FHWA to hardened new structures for the large truck impact loads. It is cheaper to do and less of a hazard to the driving public.

Response
Date: 12-10-2014

Does anyone
have any details for a 54 inch single slope barrier they would care to share with me?

Response
Date: 12-10-2014

It's not quite a single slope barrier, but here are details for the (almost) vertical shape with head ejection criteria that we've used.

Attachment: http://mwrsf-qa.unl.edu/attachments/b8f0046bda78516614b3c49b61bda646.pdf

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Response
Date: 12-10-2014

I would like this information as well, as we are looking to create a 54" (TL-5) single slope bridge pier protection design for Ohio...

Florida has a 54" safety shape design. http://www.dot.state.fl.us/rddesign/DS/10/IDx/411.pdf

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Response
Date: 12-10-2014

I have attached a link to a previous question on this topic from the Q&A website (ID #360). The drawings are of a 54" F-shaped concrete barrier with a footing for both interior and exterior sections. It was designed specifically for pier protection appilications (hence the footer). This could easily be converted to a single sloped shaped as long as the reinforcement remained the same (bar size, number of bars, and stirrup spacing) and the top with remained the same. I will caution against using this design as a vertical-faced barrier as the base would be narrow and may not provide enough over-turning moment strength.

http://mwrsf-qa.unl.edu/view.php?id=360

Response
Date: 12-10-2014

Our median barrier meets the criteria, but we were looking for a roadside version. Our structures folks also plan to reinforce new structures to avoid the need for such a barrier, but we do still have bridges that don't have redundant piers, so those will require the protection.

Response
Date: 12-10-2014

What is the intended purposed for the 54" barrier? Is it for pier protection or glare screen/barrier combination?

We are currently working on new standards for single slope barriers and bridge rails. We are using the Texas (10.8 - 11 degree) sloped barrier. The heights will be 36", 42" and either a 54" or a 56".

The purpose of the 54" or 56" height is for a permanent glare screen on top of a barrier, not pier protection. Our current f-shaped concrete median barrier is 56" and our bridge version is 54", so we are currently trying to reconcile the two.

Bottom line, we will have (54" or 56") single slope, bridge rail and median barrier designs to share soon, but they will not be designed for pier protection. We will likely be considering them all MASH TL-4 barriers.

Response
Date: 12-10-2014

Thank you all for your valuable input. I may have a few questions as the day goes on, but want to answer Mike's question first. This barrier is intended for bridge pier protection. In general, our bridge designers are designing to the LRFD loading (600 Kips I think), but as Maria said, we have many existing structures which are not and some are in vulnerable locations. We have used 42 inch single slope barrier in the past with the Texas slope design, but we are curious if we should switch to either the steeper Caltrans design (9% ??) or Iowa's more vertical face with head ejection criteria. I am not aware of head ejection being an issue with the Texas Design, at least for a 42 inch high barrier, but am curious if the Caltrans design is more at risk for head contact. Maybe **Scott** could weigh in on this. I am a little concerned about the Iowa design being more difficult to construct, and also if the second, flatter face may allow tankers to slide up over the barrier? Also, it may be harder to transition down to 31 or 32 inches to connect to a crash cushion or MGS barrier. Maybe **Scott and Chris** could weigh in on these issues.

Response
Date: 12-10-2014

I would agree that Iowa's vertical-faced barrier is probably more difficult to construct than a single-slope shape due to the multiple angles. For this same reason, it may be slightly more difficult to transition down to a shorter height barrier. Having said that, however, the contractor on our first installation was able to construct the barrier and the transitions in accordance with our plans, and the end result looks good. I can't really comment on the barrier's ability to redirect a tanker truck, as it's my understanding that 90 inches is the minimum height needed to redirect such a vehicle.

Response
Date: 12-10-2014

Head ejection with the Texas version of the single slope barrier is tough to estimate. Some tests have the vehicle ride a bit up the slope and cause the vehicle to roll away from the barrier. Other tests show the vehicle tires staying down and the vehicle rolling slightly toward the barrier. The risk of head slap is definitely less with the Texas single slope than it would be for more vertical shapes. The magnitude of this reduction... I don't have a good answer for.

Response
Date: 12-10-2014

Was vehicle stability good in all of the tests you saw as the vehicle comes off the barrier (Texas design)?

Response
Date: 12-10-2014

I don't recall any vehicle rollovers, only a couple of pickup tests that had >25 degree roll angles. Textured single slope barriers have caused vehicle instabilities for the CA single slope. I would assume the same results would occur for textured TX single slopes.

Response
Date: 03-05-2015

I am a little late on the response but we do not have the single slope barrier. Below is what our bridge staff uses.

Attachment: http://mwrsf-qa.unl.edu/attachments/240da23d56e5b3c6c15bdea36494be54.png

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54" Concrete Barrier

Question
State: IA
Date: 11-30-2009

IADOT needs the following:

- 54-in. tall, single-face, reinforced concrete parapet with foundation system for use in shielding bridge piers according to AASHTO 3.?.?
- reinforcement design for the interior and end locations of wall and foundation
- design based on WsDOT report and other more recent TL-5 barriers with reinforced footings/grade beams/slabs

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Response
Date: 11-30-2009

See the attached PDF file for a simplified drawing for a 54" tall, F-shape, TL-5 barrier. A few notes:

1. The only difference between the interior and ends sections for the barrier is the reduction of stirrup spacing from 9" to 6".
2. All longitudinal steel should be evenly spaced
3. 10 of 12 longitudinal steel bars in the interior footing can continue through the end section footing as well. The remaining two bars should be extended at least 2 feet into the end footing.
4. The end section shows the barrier positioned on the front of the footing, but it could be placed on the backside of the footing as well.

5. Other footing dimensions can be created to provide adequate strength, however the steel reinforcement may need to be reconfigured.

Attachment: http://mwrsf-qa.unl.edu/attachments/6b056c85523dc7c21fc7aa48f145d9f8.pdf

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Response
Date: 12-11-2014
here is a related 54" concrete barrier, near vertical shape with head ejection considerations
Attachment: http://mwrsf-qa.unl.edu/attachments/f9593b049273d48b9b9700edeeb06476.pdf

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2" lip on bridge rail

Question
State: NE
Date: 12-11-2014

Is there a good solution to updating the 2" concrete lip on bridge rail?

Could This be filled with grout? Or steel plates? Cardbored?

Attachment: http://mwrsf-qa.unl.edu/attachments/7d0ee28e522b4f7def0d2f5c9b204503.jpg

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Response
Date: 12-15-2014

When one raises the thrie beam end shoe off of the concrete surface and depending on the method, the threaded bolts could be loaded to a higher stress level due to combined bending and shear. I believe we have in the past used a higher grade of steel when using fabricated steel offset plates on sloped parapets. An offset late could be used but one would want to consider higher grade bolts and hardware that reduces bolt bending and maintains more shear loading. A concrete fill region could be used but may be difficult to cast/bond to old concrete. Reinforcement should be used in this scenario to help anchor the new concrete surfacing. I am not sure how successful this option would be for long-term durability and impact loading that may shatter off concrete patch. The cardboard option is not acceptable.

For new construction, I would eliminate the recessed region.

Review of Standard drawings: 7470 - Guardrail Attached to Culvert

Question
State: NE
Date: 12-19-2014

We have developed a new standard for guardrail attached to culvert based on recent MwRSF research. Can you please review the details and provide comments.
Attachment: http://mwrsf-qa.unl.edu/attachments/dd6aefdf4b4d86c4724ceadf335f9a10.pdf

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Response
Date: 12-22-2014

I have reviewed the attached drawings and have the following comments/edits.

Sheet 1:

- The spacing between the first S3x5.7 post (in socket on culvert) and the adjacent W6x9 post (standard line post in soil) can be either 37.7" or 75". The wider spacing may allow installations to avoid conflicts with W6x9 posts and concrete structures such as wing walls.

- The cross section view shows a standard line post and blockout configuration, but is labeled as an S3x5.7 post. The line posts (in soil) should remain the standard W6x9 posts. The S3x5.7 posts are placed in sockets which are attached to the culvert, and do not utilize blockouts.

- The notes section call out guardrail bolts for standard line posts. The rail attachment bolts for the bridge rail (and this culvert attachment) are 5/16" dia. A307 bolts. Further a 1.75" square washer (1/8" thick) is utilized between the bolt head and the face of the rail.

- The weak-post bridge rail should have backup plates between the posts and the rail. The original bridge rail was tested with 6" backup plates (6" long sections of W-beam). However, as discussed during the Dec. 17th pooled fund meeting, MwRSF will be recommending utilizing 12" long backup plates for all weak-post guardrail variations due to the consistent occurrence of rail tears forming during crash testing at both TTI and MwRSF. Oversized holes/slots will need to be cut into these 12" backup plates to fit over the splice bolts for the post locations that coincide with rail splices.

- Note section should also indicate that any of the 4 designs on sheets 3-6 are acceptable for use. All utilize the same post, just the attachment to the culvert is different.

- A note should be added to specify an epoxy with a minimum bond strength of 1,300 psi.

Sheet 2:

- The post length should be 44", not variable

- The post details on the right again show a standard line post to guardrail attachment (12" blockout and 5/8" bolt). This detail needs to be replaced with the 5/16" bolt, square washer, and 12" backup plate as discussed above.

Sheet 4:

- May want to add total length dimension of 9" (top to bottom) for top mounting plate.

Sheet 5:

- The 5-13/16" dimension should be from the bottom of the top plate to the center of the hole. The dimension as drawn (bottom of top plate to absolute bottom of plate) should be 7-5/16"

Sheet 6:

- The welds on the top plate gussets (shown on "top view") should be ¼" fillets. 3/8" welds are too large for ¼" thick plate.

Low Tension Cable - Post no 2/ Slip Base

Question
State: NE
Date: 12-22-2014

I suggest a change to the bolts on post no 2 on the low-tension cable system.

Could we install the bolts with the nuts on the top side of the "slip Base" plates?

This would help with replacement when damaged.

Attachment: http://mwrsf-qa.unl.edu/attachments/5b149816c81a3d387134a1a3e6e7d2e6.jpg

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Response
Date: 12-22-2014

I do not see a difference with the bolts oriented 180 degrees from the current configuration as this change should not affect their ability to slip out of the base.

RE: G-4 Guardrail: Clear Spanning of shorter distances, 18'9" & 12'

Question
State: UT
Date: 01-06-2015

I have been asked to research
possible solutions to the the NCHRP 350 testing failure of the 18' 9"
clear span using w-beam,TTI Report/Test #405160-1-1, dated May 24, 2006.

UDOT currently uses 18'9" & 12'6"spanned guardrail systems that were approved using the 230 testing criteria. UDOT currently also uses the 25' span as tested and accepted under NCHRP-350, acceptance #B-58.

I am asking if the posts immediately prior to the span and after the span were replaced using CRT post with 2 blocks would that be an acceptable alternative to the current design of standard posts? I have modified 2 of the details to show my proposal using crt posts and 2 blocks for your review. See attached Span Proposal.pdf drawing.

Std. Dwg BA 4H1 has 3 details, Std. Dwg BA 4H2 has 2 details, if I'm remembering the discussions with Don Gripney correctly the splice location appeared to be an issue during 230 testing. I have also included BA 4HI and BA 4H2 for reference.

Under the 350 testing of the 25 ft. span using CRT post and 2 blocks, the splice joint did not appear to be an issue where it was placed in the run..

If these are not acceptable changes can you offer any suggestions that may work in these situations?

Thanks for any assistance you can provide.

Attachment: http://mwrsf-qa.unl.edu/attachments/b23f6339025e71285277dad6d2245ea0.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/2220e3e28c55474da4bfec79251027bb.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/4151abd21caca59efe14f5fb90988ac6.pdf

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Response
Date: 01-06-2015

We have some comments regarding the use of omitted posts in G4(1S) guardrail systems.

We have addressed this topic with the states in the past and have a current project underway to investigate the omission of a single post in the MGS system. Previous research into G4(1S) long span guardrail systems with various lengths have found that the G4(1S) system require nested guardrail if posts are removed from the system, as noted in the TTI research you reference. As such, we have typically recommended that all G4(1S) systems with unsupported spans use nested rail. We have provided recommendations as to the length required nested rail. This can be found in the link below.

http://mwrsf-qa.unl.edu/view.php?id=493

With respect to the use of CRT posts in the G4(1S) system, we have typically recommended that the three CRT posts be used on each side of the unsupported span to reduce the potential for snag and pocketing when posts are omitted. It is possible that the use of CRTs could be eliminated for shorter spans or that fewer CRTs could be used. However, there is not sufficient research to fully support that at this time. Thus, we have taken a conservative approach with the recommendation.

http://mwrsf-qa.unl.edu/view.php?id=836

Thus, we would recommend that you modify your proposed installation to include the nested rail and three CRT posts adjacent to each side of the unsupported span. We do not believe that the location of a splice in the unsupported region is cause for concern.

Let me know if you have further questions.

Inertial Barrier System

Question
State: KS
Date: 01-16-2015

KDOT
is planning to simplify our Inertial Barrier Standard Drawing (current drawing attached) to have only two options for IBS layouts; one for low speed (less than or equal to 45 mph TL-2) and one for high speed (greater than 45 mph TL-3). Through conversations with Scott, he indicated MwRSF may have a program or spreadsheet to evaluate different configurations. Can you take a look at the current layouts we have shown for 45 mph, 65 mph, and greater than or equal to 70 mph and let me know if the current configurations are sufficient for a TL-2 (45 mph) or TL-3 (65 or greater than or equal to 70 mph) type hit? If you have any questions or want to discuss further let me know or give me a call.

Attachment: http://mwrsf-qa.unl.edu/attachments/3cf5953cc69f990d0637cfcdcb768fd1.pdf

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Response
Date: 01-23-2015

We have done an analysis on the sand barrel array configurations that you sent us. The analysis consisted of the following NCHRP Report 350 configurations.

1. We analyzed each system at its design speed shown in the following cases. The 40 mph array was evaluated at 40mph, the 45 mph array was evaluated at 45 mph, and so on… We ran all of the analyses with the barrels oriented parallel to the roadway rather than the 0-10 degree orientation shown as an option in the detail. It was believed that the 0 degree orientation parallel to the roadway was more critical.

    a. Test no. 3-40 using an 820C vehicle centered on the end of the array rather than the ¼ point offset as the center impact would maximize the decelerations.

    b. Test no. 3-41 with the 2000P vehicle

    c. Test no. 3-42 using an 820C vehicle

    d. Test no. 3-43 with the 2000P vehicle

e. Test no. 3-44 with the 2000P vehicle

2. We also ran the reverse direction impacts along the barrier with the 820C and 2000P vehicle to evaluate its performance for that type of impact.

3. We also analyzed the 65 mph configuration under the TL-3 impact speed – 62.1 mph.

From these analyses, we found the following.

1. Almost all of the arrays were acceptable under the required NCHRP 350 impact tests for the design speeds listed.

2. For the 65 mph array, our analysis found that the array was not quite long enough to bring the 2000P vehicle below a critical velocity prior to the end of the concrete parapet for test no. 3-41. Typically we design the arrays to drop the vehicle velocity below 10 mph and then place a final row of barrels beyond that point to ensure safe vehicle deceleration. In the case of the 65 mph array, the vehicle velocity was still slightly above the 10 mph cutoff when it reached the last row of two 2100 lb barrels. Thus, you may consider modifying this array slightly to alleviate this issue by changing rows 4 and 5 from 200 lbs and 400 lbs to 400 lbs and 700 lbs, respectively. See attached. The addition of one additional row of barrels past the 10 mph velocity point is not necessarily required, but is mentioned as an option in the RDG and is recommended by some of the manufactures.

3. Analysis of the 65 mph at the TL-3 impact speed of 62.1 mph found that the array was acceptable under the required NCHRP 350 impact tests.

4. Analysis of the 60 mph array under the 60 mph design found a similar issue to the above 65 mph case in that the array was not quite long enough to bring the 2000P vehicle below a critical velocity prior to the end of the concrete parapet for test no. 3-41. Depending on your preference, we could attempt to adjust that array as well.

5. The 55 mph array analysis found that the acceleration limits were exceeded for test no. 3-44 with the 2000P vehicle. This is a function of the length of the array changing the impact point for the test to a more critical location. The impact point for test no. 3-44 is the length of the array divided by two. Thus, the shorter array used here places the impact point further down the array. Again, we can look into adjustment of that array if you desire.

Take a look at this information and let me know what you think. I also have some additional thoughts that we can discuss on the phone if you want to give me a call.

Attachment: http://mwrsf-qa.unl.edu/attachments/d8503d8297e74dd06d9fbcd8848f18b6.jpg

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spanning an old culvert

Question
State: WI
Date: 01-20-2015

We have a minor project were a very old box culvert is near a roadway. The overall roadway is in poor condition and in the next 5 years the roadway, box culvert and near by intersections will be worked on.

In the interim, the existing beam guard does not have the correct height, is in poor condition, lacks sufficient grading and uses down turned end terminals.

The box culvert is very narrow and only a few feet high (making it almost impossible to get into). Making using a top bolted not viable. In addition given the age of the box culvert the culvert itself may not be in good condition or have the strength required

A long span will not properly fit in at this location because of grading/right-of-way/environmental concerns.

Note that the web page will not let me attach 2 other photos

Attachment: http://mwrsf-qa.unl.edu/attachments/110ae138e9d766e1951c592fbbac92ff.pdf

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Response
Date: 02-03-2015

We looked through this and the proposed detail. We believe that the proposed detail is a little too complicated and that the reduced spacing adjacent to the culvert doesn't improve things.

Instead, we would recommend that you treat the box culvert obstruction as a small long span system with the MGS and place 3 CRT posts on each side of the culvert. This should alleviate the potential for degradation of the performance over the culvert.

You may not need the long span CRT's at all if you can get the posts to straddle the culvert at standard spacing.

Minimum length of guardrail

Question
State: IL
Date: 01-25-2015

At TRB I mentioned that we would like to revise our criteria concerning the minimum length of guardrail for a free-standing run.

This is an excerpt from the IL Tollway Traffic Barrier Guidelines:

The 168.75' minimum length of a "free-standing" run of guardrail is based on the system length that has been crash tested. If using a Type T1 (Special) Terminal on the upstream end, 34.38' can be applied toward the 168.75' requirement. For example, a typical free-standing installation usually includes a Type T1 (Special) Terminal on the upstream end and a Type T2 Terminal on the downstream end. For this example, the minimum length of guardrail required between these two terminals is 137.5'.

I would love to reduce the minimum length shown in yellow. What is the minimum that you are comfortable with? Can it be 75'?

Thanks again.

Response
Date: 01-26-2015

Previously, MwRSF has done two research studies that relate to this issue. The first was a study for the MGS system that investigated potential minimum system lengths for the system under MASH TL-3 impact conditions (http://mwrsf.unl.edu/researchhub/files/Report281/TRP-03-276-13.pdf). The second was a study that investigated the crashworthiness and redirective length of the downstream anchorage that is typically used with the MGS (http://mwrsf.unl.edu/researchhub/files/Report279/TRP-03-279-13.pdf).

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

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

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

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

Although the 75-ft (22.9-m) MGS performed successfully, several factors, including Lateral Extent of the Area of Concern and the Guardrail Runout Length, must be considered when determining the overall barrier length for shielding a roadside hazard. Only a few roadside hazards can be properly shielded by short guardrail installations. Thus, longer guardrail installations are still required for shielding many hazards.

In order to estimate the actual redirective lengths of the shortened system, it was assumed that the shorter 75' system would potentially continue to redirect errant vehicles impacting at 6 posts or more upstream of the end of the system similar to the 175-ft long system. This has not been proven through testing, but we believe that the performance should be similar. In addition, the beginning of the length of need is typically identified as post no. 3, or 12.5 ft from the upstream end for most terminals. Thus, redirection was assumed for MASH TL-3 vehicles impacting between post nos. 3 and 8 of the 75-ft long system for a length of 31.25 ft. This limits the use of the system to relatively narrow, discrete hazards where proper runout length and length of need can be achieved.

Similar analysis was done for 62.5-ft and 50-ft long systems, as noted in the reports. However, that worked is based only on simulation and has not been tested.

The scope of the research did not include evaluation of the performance of end terminals on a reduced-length guardrail system. Further study may be needed to evaluate reduced system length in conjunction with guardrail end terminals in redirective impacts as well as end-on terminal impacts. Guardrail end terminals may have weaker post sections and/or anchorage than what was utilized in test no. MGSMIN-1. Thus, shorter guardrail lengths may not have the same redirection envelope found in this study and the posts may not resist the rail forces in end-on

impacts. Since guardrail end terminals are mostly proprietary, they were not evaluated in this study.

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

Because we did not have additional funds or terminal testing and evaluation in the above research, we would recommend minimum system lengths of 112.5 ft in order to be conservative. This would extend the redirective length for the system using the assumptions above to 68.75 ft.

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

Let me know if that answers your questions.

Attachment: http://mwrsf-qa.unl.edu/attachments/d4fdd711c8ce309d56fe55a969312246.jpg

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Guardrail Height

Question
State: NE
Date: 01-26-2015

FHWA web site

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/ctrmeasures/wbeam/

First Sentence:

Recent research on standard 27-inch strong steel-post W-beam guardrail shows that it does not meet NCHRP Report 350 Test Level 3 criteria.

Do you know what are they referring to?

Response
Date: 01-26-2015

There were a number of historical crash tests that demonstrated problems with many versions of 27" tall W-beam guardrail. In addition, some variations even had problems at a 27¾" height. This discussion has been ongoing for the last 8 or more years. Over the last 3 or 4 years, FHWA has been discussing and presenting options for raising guardrail height. I believe that they raised this issue at our Pooled Fund meeting, the joint meeting between the Pooled Fund and AASHTO TF13, and several AASHTO TF13 meetings. We had a NCHRP 22-14 crash test on the G41s that showed it marginally met AASHTO MASH at 27¾" height under Test Level 3.

FHWA prepared and released a lengthy memo on this topic many years ago. I can send a copy of this memo after locating if desired. Also, I can send a copy of a 2007 TRB paper that we prepared after doing the AASHTO MASH update study.

Missing Post in Double Faced Run of 8" Blockout MGS

Question
State: NH
Date: 02-04-2015

Good afternoon. I hope that all is well with you and yours.

Keith Cota suggested that I contact you as I have a question regarding the MGS system with an 8" offset block. We have a project with a gas transmission line that we must avoid while installing median guardrail. This is a double faced installation. We need to omit one post if possible. In the past I would have been inclined to say no problem and just do it but as I have seen the MASH tests with existing systems I am more wary of this simple approach. I do not know how introducing a more flexible area in the midst of a run that is otherwise more semi-rigid could affect the behavior of the impacting vehicle. I would hate to think of it somewhat acting like a slingshot, with the vehicle overturning. And I am talking a MASH TL-3 scenario. I am thinking of a 12'-6" span but could reduce that to 9'-4"? Any thoughts that you would care to share with me?

Oh yes, I should state that the Department is not using high tension cable guardrail so that is not an alternative.

Response
Date: 02-04-2015

I have thought some of your situation and further discussed with my colleagues.

My simple response would be to treat the situation using the same philosophy that is used for roadside obstructions. We typically recommend that when 1 to 3 posts cannot be installed due to subsurface obstructions, use the MGS Long-Span System. For the 31" tall MGS LS, three timber CRT posts are installed on both the upstream and downstream sides of the longer unsupported length, for a total of six CRT posts. We also use 12" blockouts, which were part of the original design. As such, I would

expect that the MGS median system with 12" blocks could also be modified to accommodate at least 1 missing post as long as three CRT are placed on each side of longer span.

Further and based on significant MGS R&D as well as knowledge of other median guardrail tests on proprietary systems, we sought eligibility of a median version of the MGS, which utilized 12" blocks. I have attached the link and a pdf copy of this letter.

MwRSF Eligibility Request w/ 12" Blocks

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/listing.cfm?code=long

When using 12" blocks for a median variation of MGS, it should be manageable to replace six W6x9 posts with six CRT posts. You will have lost 2" of internal space that needs to be addressed. One thought would be to adjust blockout depth over the 12 to 18 ft on each side of span using 10", 11", and 12" special blocks with 3 CRT posts.

Now, if you do not have the MGS median system with 12" blocks but rather the 8" blocks shown in the TTI report below, I might also suggest the use of a stepping of blockouts over the 3 CRT posts. I understand that this solution requires a few special blockout sizes and varied bolt lengths. However, it provides a reasonable solution for these special circumstances. For me personally, I am more comfortable with the use of 12" blocks in combination with CRT posts in combination with increased span systems. Unfortunately, it may be more difficult to integrate 12" blocks when one started a median system with 8" blocks, unless one starts a blockout stepping process much farther away from span with omitted post.

TTI Report – Median MGS w/ 8" Blocks

http://tti.tamu.edu/publications/catalog/record/?id=39225

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

Attachment: http://mwrsf-qa.unl.edu/attachments/319090c54ab5c34005881d5f10a24009.pdf

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Response
Date: 02-05-2015

Your response is very, very much appreciated! Your guidance and that of your colleagues really helps.

I certainly agree that a few custom offset blocks should not be a big deal.

NHDOT is trying to avoid the use of wood posts as much as is practical for the reasons that follow. We have had posts appear sound above ground and practically had no post 6" below ground. Some posts have been found to not be treated as advertised and have been eaten by insects in the central section of the posts. Those conditions are not always readily discernible. I won't even speculate about how often they may be "field shortened" where the soil conditions make driving difficult. They are considered a solid waste requiring disposal at specific (expensive) sites. Which leads to my subsequent question.

Regarding the wood CRT posts, I know that the TRP-03-288-14 report (Universal Breakaway Steel Post for Other Applications) indicated great promise for the universal breakaway steel post. Has any further testing been done to "prove" the design. And if so, has a letter gone to FHWA?

I do not mean to take more of your and your colleagues' time but the long span solution using CRT wood posts prompts the question. If I wood is the answer, fine. But if the other post could be used, that would be great as well.

Response
Date: 02-06-2015

You are doing very well in moving thoughts on to the Universal Breakaway Steel Post (sometimes noted as Universal Steel Breakaway Post). We already demonstrated its viability in the thrie beam bullnose system. Based on its prior success as well as the results from another MGS Long-Span study (system with CRTs showed potential promise during simulated impacts on span lengths greater than 25 ft), our Pooled Fund agreed to test and evaluate longer unsupported lengths under MASH with UBSP posts in lieu of CRTs. However, we are at the stage of programing construction/testing within our overall field project queue. This year, we will be testing UBSP posts in combination with a 31.25-ft long-span system.

Again and based on dynamic component testing, we believe that the UBSPs compare well to CRT posts and can likely serve as a surrogate in other designs (i.e., MGS Long Span, MGS Downstream Anchorages/Trailing Ends, etc.). However, we want to further demonstrate acceptable performance in actual crash testing, similar to what was done on the bullnose and currently planned for MGS Long-Span.

For your particular scenario and if all goes well, the UBSP post would not create any dimensional issues for median systems as the depth for the upper portion of the post is identical existing steel guardrail posts.

I have attached the FHWA Eligibility Letter for the thrie beam bullnose with UBSP posts as well as the AASHTO TF13 details for the roadside hardware guide. See below for additional information regarding other attachments.

Ron,

I went through the components list in SET03a-b (which is the system drawing for both the wood and UBSP versions) and tried to include all the new component drawings that would not have been in the printed version of the Hardware Guide. If you need the already existing ones that were in the printed version of the Hardware Guide we will have to have a student scan them into a PDF. Let me know.

Karla

Attachment: http://mwrsf-qa.unl.edu/attachments/b25db039d17db1e07b0009b9063557fe.zip

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TXDOT TL-3 Transition Crash Test Report

Question
State: LA
Date: 02-04-2015

I have been talking with Paul
Fossier over at Louisiana DTOD about their TL-3 transition design.

They would like to review the
crash test report on the TXDOT TL-3 transition with the curb.

Did you guys crash test the
TXDOT Design (see attached TXDOT Details).

This transition uses a curb.

If so, could I get a copy of the
crash test report?

Please let me know.

Response
Date: 02-04-2015

MwRSF did crash test this AGT back in the mid to late 90s under NCHRP 350 using both steel and wood posts. This testing was completed prior to the development of the asymmetric W-beam to thrie beam transition segment. In addition, this testing was conducted prior to the design and testing of the simplified stiffness transition to the AGT. Later, this AGT was successfully crash tested under AASHTO MASH. Further, two different stiffness transitions were designed and tested on the upstream end of this AGT, thus future variations should integrate both regions. I will acquire links to the reports and forward those to you.

Response
Date: 02-05-2015

Here are the links to the noted systems described below.

Original Crash Testing – NCHRP 350

http://mwrsf.unl.edu/reportresult.php?reportId=61&search-textbox=transition%20iowa

Follow-Up Crash Testing – NCHRP 22-14(1) Update to NCHRP 350 (AASHTO MASH)

http://mwrsf.unl.edu/reportresult.php?reportId=148&search-textbox=transition%20iowa

Original Stiffness Transition to AGTs with Three Steel Post Types (350)

http://mwrsf.unl.edu/reportresult.php?reportId=108&search-textbox=transition

Simplified Stiffness Transition to AGTs with Standardized Steel Posts (MASH)

http://mwrsf.unl.edu/reportresult.php?reportId=38&search-textbox=transition

Wood-Post Alternative Stiffness Transition to AGTs (Bogie Testing)

http://mwrsf.unl.edu/reportresult.php?reportId=32&search-textbox=transition

Recent AASHTO MASH Testing of Stiffness Transition to Crashworthy Transitions with Curb (Led to nested segment of W-beam upstream from asymmetric setion)

http://mwrsf.unl.edu/reportresult.php?reportId=295&search-textbox=transition%20iowa

I have attached a copy of a paper that corresponded to the last research study. One should note that the upstream stiffness transition should be integrated onto the upstream end of prior, short, relatively stiff, crashworthy AGTs. Let us know if you have any further questions.

Attachment: http://mwrsf-qa.unl.edu/attachments/a94cfa0760d895448696f06945ad6a35.pdf

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Short Radii Other than Tested - Bolts on Posts in Radius

Question
State: WI
Date: 02-06-2015

Previously, MwRSF performed research related to the use of short radius guardrail with larger radii. Previously tested short-radius systems did not use guardrail to post connection bolts. Can you comment on this?

Response
Date: 02-06-2015

I had a chance to discuss the bolts on posts topic with Bob and Dr. Faller and we seem to be in agreement here. All the tested systems did not utilize a post with a bolt in the radiused section for concern that the post would remain attached to the rail for too long and drag the rail down. There doesn't appear to be a pressing need to add a bolt to those posts on the radius if the radius increases. Thus, we concur with omitting post-to-rail bolts for posts within the curved rail section. Please note that there should be adequate upstream length of rail on the secondary side of the system (and primary side too, if not anchored to a stiff structure or rail) to develop the required tension in the rail. According to what I found from the Wisconsin larger-radius guardrail simulations, the first point on a guardrail system that can capture or redirect a truck impacting with TL-2 conditions was 6 posts downstream from an anchor, or the 8^{th} post from the upstream end of the rail. I recommend that this point be approximately aligned with the beginning of the length of need.

Dr. Faller indicated he is more inclined toward the use of a small shelf bracket on the CRTs in lieu of a screw on the front of the post. I believe the bracket is more helpful to support the post because (1) it is easier to mount the rail and (2) to reduce the propensity for stress concentration and possible rail tear initiation at the screw. Nonetheless, mounting hardware is up to your determination.

Let me know if you have any additional questions.

Guardrail end terminals with raised curbs

Question
State: FL
Date: 02-09-2015

We have a question regarding the performance of end terminals in conjunction with raised
curbs.

Currently, we understand that a
typical run of guardrail set at 6" behind the face of curb is acceptable. However, this curb configuration causes several issues near an end terminal and conflicts with the Roadside Design Guide's recommendations for flat grading surrounding the end terminal. Unfortunately, dropping the curb at the end terminal location is not always feasible when drainage issues are considered, so we're actively looking for solutions where curbed sections are needed (a frequent scenario).

Do you know of any recent
studies or criteria that address this topic of end terminals working in
conjunction with raised curbs?

We really appreciate your help!

Response
Date: 02-09-2015

At this time, no research has been performed on curbs used in conjunction with guardrail end terminals. Nonetheless, previously performed studies related to the interaction between curbs and crash cushions or barriers may provide useful information about the influence that a change in the vehicle trajectory may have on the safety of roadside hardware.

Several years ago and in 1979, CALTRANS researchers investigated the safety performance of sand barrel crash cushions in conjunction with 6-in. high curbed gores. In this study, eight live-driver, crash tests were conducted with small car and large passenger vehicles. These crash tests were performed head-on into curbed gore areas at speeds of 40 and 60 mph. These tests indicated that the highest rise in vehicle trajectory occurred with the small vehicle traveling at 40 mph. This peak rise was 9.5 in. above the top of the gore at a distance of 14.5 ft beyond the nose of the curbed

gore. The performance of a sand barrel crash cushion, placed 5 ft back from the nose of the curbed gore, was not appreciably affected. This result was observed when evaluated by a vehicular impact which was deemed to produce the greatest potential for vehicle vaulting (i.e., small car at 40 mph and head-on). For both parts of this study, the raised asphalt concrete gore surface was bounded by a 6-in. high, sloping-face concrete curb, forming a gore about 50 ft long and having a nose radius of 5 ft.

Research has also been conducted to investigate the performance of guardrails placed in front of curbs. Barrier offset away from the curb has been shown to effect system performance through computer modeling and crash testing. Previous work with steel-post, nested W-beam guardrail has shown that a 4-in. high sloped curb with the toe of the curb placed at the front face of the W-beam guardrail is capable of meeting NCHRP Report No. 350 safety requirements. Further research with standard wood-post, W-beam guardrail has shown that a 4-in. high sloped curb with its toe set out 1 in. from the front face of the guardrail is also capable of meeting TL-3 requirements.

Investigation of curb-barrier combinations was also investigated in NCHRP Report No. 537, Recommended Guidelines for Curbs and Curb-Barrier Combinations. This study developed guidelines for the use of curbs and curb-barrier combinations on roadways with operating speeds greater than 37.3 mph. The study recommended that guardrail be installed flush with the face of the sloped curb or offset more than 8.2 ft behind the curb for operating speeds in excess of 37.3 mph. In addition, the study recommended that guardrail should not be offset behind sloped curbs for speeds greater than 62.1 mph.

The recent development and testing of the Midwest Guardrail System (MGS) has demonstrated that this system can be used with a 6-in. (152-mm) tall, American Association of State Highway Transportation Officials (AASHTO) Type B curb positioned 6 in. forward from the front of the face of the guardrail element. Additional research was conducted with respect to TL-3 impacts on the MGS system with larger curb offsets. This research did not yield clear guidance on larger curb offsets for the MGS under TL-3 impact conditions. Thus, the current guidance regarding curb placement near the MGS on high-speed facilities remains the 6-in. offset noted above. This limitation on curb placement is critical as installation of a tangent end terminal within 6 in. of a curb would likely result in the impact head hanging into the roadway. Thus, placement of tangent end terminals adjacent to curbs may require some flaring

of the terminal (flares of 1 ft over 50 ft are relatively common in Texas and other states).

We currently have a project at MwRSF to begin the study of curbs and energy-absorbing terminals that was sponsored by the Wisconsin DOT. The objective of this research effort is to develop guidance for the safe placement of curbs adjacent to energy-absorbing guardrail end terminals. Initially, computer simulation will be used to identify potential safety hazards, define critical curb and terminal impact scenarios, and select optimal curb placement. 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.

Thus, there is currently very little hard guidance one can give regarding curbs and end terminals. In general, shorter, wedge shaped curbs will likely be more forgiving based on previous research with curbs and other barrier types.

Let me know if you need any further information.

Response
Date: 02-09-2015

We greatly appreciate your response and input. I think that we should be able to work with the past practices you've mentioned with possible limitations added.

In the future, we recommend further considering topics of:

1. Soil heights being raised at the terminal assembly posts as a result of the curb height
2. Curb effects on vehicle vaulting and stability for end terminal nose impacts at a shallow angle (head-on, moving near-parallel to curb)

Again, thank you for the background and input! As always, we look forward to learning the results of your next study.

Thank you,

W Beam Cable transition

Question
State: IA
Date: 02-12-2015

We have a request from the district to narrow the w beam terminal section on a cable to w beam transition. The project falls within a lager water shed and they are trying to stay within the existing footprint. We have our standard BA-206 (4 foot offset) designated for this transition. They are asking if they can use the BA-205 (2 foot offset). They are mainly trying to minimize the grading foot print.
I looked at the two terminals we have for the BA-206 and they are the FLEAT-MGS and the SRT-31. According to the manual I found the Fleat can go down to a 2'6" offset and the SRT can go down to 3 foot offset. To me it looked like we could easily go down to 3 feet of offset but did not know how that would affect the interaction of the cable and w beam.

If they really wanted to go down we could use the Fleat only and go go down to 2'6" but again did not kown how that would affect the interaction between the two. Any input would be greatly appreciated.

http://www.iowadot.gov/design/SRP/IndividualStandards/eba206.pdf

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Response
Date: 02-13-2015

You are correct that we have tested two versions of the cable to W-beam transition system. The first test was conducted using the standard low-tension cable system transitioning to G4(1S) guardrail. The original cable to W-bean transition was tested with both a BCT end terminal and a the second test used a FLEAT end terminal. The cable heights for the original system used a 27" top cable height with 3" cable spacing. This cable height and spacing correlated well with the W-beam barrier height used in the design and allowed the top cable to be run along the top of the W-beam and the bottom two cables to be run along the bottom of the W-beam as they were transitioned from one system to another.

http://mwrsf.unl.edu/researchhub/files/Report164/TRP-03-80-98.pdf

In both tested systems, the terminals were offset 4' laterally from the cable barrier. For both systems the testing of the 2000P vehicle showed the potential for vehicle instability when the system was impacted such that the vehicle contacted the terminal end and the cable system simultaneously. Thus, there is concern that moving the terminal ends closer to the cable barrier may increase the vehicle instability further. In addition, the vehicle could deflect the cable system ahead of the terminal end allow the vehicle to get behind the end of the terminal at the shorter offset. This may further

degrade the system performance. As such, we have allowed the end terminal systems to be extended to larger offsets in the past, but we have not allowed shorter offsets as we believe that they would potentially adversely affect the transition.

Let me know if you need anything else.

Thanks

Short Radius Controlled Releasing Post on Concrete Box Culvert

Question
State: NE
Date: 02-13-2015

MwRSF Report No. TRP-03-288-14

What are your thoughts on the short radius being placed over a box culvert;

When one post(at the 6'3" spacing) would land on the box culvert:

Could the UBSP steel post be used?

Could the wood post be attached to the top of the culvert?

Could the steel breakaway post be used?

Here it is.

https://maps.google.com/maps?q=Scribner,+NE&hl=en&ll=41.669472,-96.672665&spn=0.001685,0.002411&sll=39.609127,-106.370444&sspn=0.027806,0.038581&oq=scribner&t=h&hnear=Scribner,+Dodge+County,+Nebraska&z=19

Attachment: http://mwrsf-qa.unl.edu/attachments/e365c518ba66c86529ddc1a3f4faa700.png

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Response
Date: 02-13-2015

I have briefly looked over the materials and will make a few comments below.

What are your thoughts on the short radius being placed over a box culvert;

** I have reservations about the placement of a SRG over culvert hazard. Per the draft sketch, an impacting vehicle would likely deform the system and travel far more than the 6 to 7 ft distance to the obstacle being shielded. The accepted Yuma County system and grandfathered/modified TTI system have secondary lengths longer than that shown as I recall. For Yuma County, the pickup truck appears to have traveled up

to 20+ ft into system at TL-2 conditions. For SRG designs, CRT posts are around and/or behind the nose section. These posts are founded in soil. A concrete box culvert would likely obstruct post placement as you noted, thus potentially altering its safety performance from what was observed many years ago. In summary, hazard seems close and barrier cannot be installed in similar manner to that tested previously.

When one post (at the 6'3" spacing) would land on the box culvert:

Could the UBSP steel post be used?

**We have verified the use of UBSPs in bullnose applications in lieu of CRTs. We are getting ready to verify their use in long-span guardrail systems. We do not know how they will perform in SRG systems. As we continue to investigate their use in barrier systems, we may eventually try UBSPs in such designs. However, some post rotation and energy dissipation occurs when placed in soil. When mounted to culvert slab, the behavior may not match that of CRTs in soil. In summary, we cannot justify its use in an alternative manner without adequate R&D. I guess one needs to know how much soil is over culvert slab.

Could the wood post be attached to the top of the culvert?

**I do not currently see how this attachment would be accomplished and provide similar behavior to CRTs in soil.

Could the steel breakaway post be used?

**I discussed the UBSP above.

Guardrail Length Adjacent to AGT

Question
State: IA
Date: 02-18-2015

We have been trying to upgrade
some of our W beam guardrail with the minimal impact to the foot print possible. For a very long time we place 56 feet of rail on the end of our bridges. Now as we go back to update them we are trying to update the systems to our current standard. Our newer system is much long and can require significant grading in environmentally sensitive areas near bridges. One of our designers asked if we could use the BA-201(25') with the BA-206 (37.5') for and overall length of 62.5'. I know it is desirable to have another 25' of tangent between the 2 pieces but wondered on a special situations if we could go to that minimum length

http://www.iowadot.gov/design/SRP/IndividualStandards/eba201.pdf

http://www.iowadot.gov/design/SRP/IndividualStandards/eba206.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/09bbf8ee2261bd591f622bfa061e8fa6.pdf

Response
Date: 02-19-2015

First, in the BA-201 drawing there should be 1 more 6-ft long post upstream of the w-to-thrie transition piece at a 37.5" spacing. This also moves the post locations away from splices for the MGS. Don't know if that post is considered a part of the standard MGS (so it's on another drawing set), but I figured I would mention it.

Your BA-601 plan shows the option for a curb under the transition. Recall, if a curb is present, then the guardrail placed immediately upstream of the w-to-thrie transition segment nested needs to be nested for 12.5 ft (refer to report TRP-03-291-14). You should note that in your drawing set.

Finally, there are recommendations for the necessary length of guardrail upstream of the transition within the conclusion sections of reports TRP-03-291-14 (page 137) and TRP-03-210-10. These reports are available on our website (mwrsf.unl.edu). Note, the recommendations are identical in reference to the W-to-thrie transition segment. Please refer to these recommendations as there are different criteria for (1) total length, (2) terminal length, and (3) length prior to a guardrail flare.

Let me know if you have further questions.

Bolt Specifications for Steel Strap TCB Tie-Down

Question
State: KS
Date: 03-03-2015

We have a question
submitted by one of our contractors regarding which bolts are acceptable for use in concrete safety barrier anchorage applications with tie down straps. Can you take a look at the attached information submitted to KDOT and the highlighted version of our Standard Drawing and let us know if you would have any concerns

using ASTM A325 bolts in lieu of ASTM A449 bolts? I quickly reviewed the properties and they look virtually identical to me, but Scott King pointed out the different materials can sometimes be sensitive to temperature or may have different shear strengths so I wanted to check with you and get your thoughts.
Attachment: http://mwrsf-qa.unl.edu/attachments/e2cc67a762a5048f5bdd016abcf55b96.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/07a787587f17b853f12bec43f653e90d.pdf

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Response
Date: 03-04-2015

Maximum fiber stress in bending for beam guard posts

Question
State: WI
Date: 03-05-2015

We have a requirement that our beam guard post have a maximum fiber stress F_b of 1,200. I believe that AASHTO has a similar requirement (AASHTO M168-6 is below).

Guardrail Posts-Guardrail posts shall be a stress grade of 8.2 MPa (1200 psi) or more,

conforming to the applicable standards contained in AASHTO-ARTBA-AGC, *A Standardized*

Guide to Highway Barrier Hardware. When a preservative is required, framing and boring shall

be completed prior to treatment in accordance with M 133.

What is the F_b of white pine?

If the F_b of white pine is lower than 1,200 do we need to be concerned about this even if there is a passing crash test?

Response

Date: 03-05-2015

The fiber stress requirements noted exist to help ensure that timber posts used in guardrail systems possess sufficient capacity to deflect through strong soils and absorb energy during impact as intended. Posts with insufficient capacity pose the risk of fracturing prematurely and degrading the safety performance of the barrier system.

With respect to the MGS system, MwRSF conducted previous research with the white pine post (http://mwrsf.unl.edu/researchhub/files/Report41/TRP-03-241-11.pdf). In this research, it was noted that there were two approachesto implementing the white pine post, which has lower strength than the typical southern yellow pine post,. One approach was to revise the geometry of the post cross-section to provide similar capacity to the standard 6"x8" SYP post. The other approach was to full-scale crash test the standard post geometry with the white pine post to investigate its performance. The study chose to evaluate the white pine post with the standard geometry. The full-scale test of the white pine MGS system was successful according to MASH. Because the white pine post version of the standard LON system of the MGS was successful, there would be no reason not to use the system with white pine posts, even if the fiber strengths were lower than to specified values.

There would only be a couple of caveats.

1. Use of other reduced strength wood species than white pine with the MGS would likely need to be evaluated. MwRSF has done some previous research on alternative species which can be found here.
http://mwrsf.unl.edu/researchhub/files/Report220/TRP-03-154-04.pdf
http://mwrsf.unl.edu/researchhub/files/Report125/TRP-03-179-07.pdf
2. The use of white pine would be for the MGS system and not previous metric height G4(2W) systems.
3. The report above provides recommendations for the use of white pine posts for special applications of the MGS that should be followed due to these systems potentially being more sensitive to variation of the wood strengh..