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:** 2/28/19	**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
$124,345	$73,311	65%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$7,734	

Project Description:

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

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

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

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

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

At the July 21st TAC meeting, MwRSF and the TAC members discussed several options for proceeding with the cable barrier adjacent to slope design in light of the potential for the S3x5.7 post to tear the occupant compartment floorboard.
1. Proceed with current S3x5.7 post, which posed the risk of 1100C test failure in the future.
2. Modify S3x5.7 post through the use of weakening mechanisms or a slip base.
3. Switch to modified MWP post in development as part of parallel research on cable median barrier systems. however, the design of the revised MWP post is not finalized at this time

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

Discussion with the TAC members led to the selection of the third option as efforts to redesign the MWP post were alredy underway and the post would likely become a standard inventory part in the future. Currently, the MWP post was redesigned with the addition of two, 3/4" holes at the based of the post in the weak axis flanges. Component testing indicated that this will mitigate floorpan tearing.

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

Anticipated work next quarter:

In the upcoming quarter, MwRSF will work on simulation of variations of the proposed cable barrier adjacent to slope in order to determine the optimal design configuration. Variations may include posts spacing, cable heights, offset from slope, and cable-to-post attachments. Simulation models of the modified cable system will be conducted to evaluate the potential for the new design to meet the MASH TL-3 criteria.

The simulation will focus on increasing stability and evaluating several potential system modifications.

1. Further investigation of the propensity of the cable hook bolt to cause cable pull-down.
2. a. Increase the slope offset of from 1' to 2' and 3' with the same cable heights (22", 28", and 34").
3. Increase the cable heights to 24",30",36" for slope offsets of 1', 2', and 3'.
4. If none of those options are successful we will examine reduced post spacing under the variables above to see if that helps stability.

Significant Results:

The literature review of all full-scale tests on cable barrier systems adjacent to or within slopes was completed and summarized in a table. A preliminary design was established, and a component testing methodology was determined. The use of the S3x5.7 post was negated due to floorboard penetration concerns and the project has shifted to a tubular steel post. Simulation of proposed designs is underway.

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	100%
4. LS-DYNA model development, validation, and calibration	80%
5. LS-DYNA simulation of various cable barrier modifications	25%
6. CAD details of proposed cable system designs	0%
7. Preparation of research report and recommendations for future research	15%
8. Preparation of Technical Brief for NDOR.	0%

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

The results of the floorboard testing of the S3x5.7 posts caused delays in the project based on parallel development of the modified MWP post.

A no-cost extension was requested and received extending the project end date to 2/28/19 to deal with additional cable modeling needed to develop a proposed design.

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:

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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. #86	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Phase II Conceptual Development of an Impact Attenuation System for Intersecting Roadways		
Name of Project Manager(s): Bielenberg, Faller, Reid	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211118001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/1/2015
Original Project End Date: 12/31/16	**Current Project End Date:** 8/31/2019	**Number of Extensions:** 2

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$256,184	$151,101	65%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$20,331	

Project Description:

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

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

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

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

Previously, MwRSF tested the high-capacity energy absorber prototype and capture net supplied by Impact Absorption in late March of 2016.

In test no. DBT-1, MwRSF impacted the net attenuator with one high-capacity energy absorber on each side of the net mounted near the center of the net height on rigid frames. The 4,908 heavy bogie vehicle impacted the center of the net at an angle of 90 degrees and a speed of 56.5 mph. The net attenuator captured the bogie and brought it to a controlled stop approximately 34 ft from impact. Peak deceleration forces were 23.6 kips, which correlated to a peak deceleration of 4.81 g's. The longitudinal OIV and ORA values were calculated to be 5.8 m/s and 4.7 g's, respectively. Lateral OIV and ORA values were negligible.

The tape feed length on the left and right side were 148.25 in. and 153.75 in., respectively. MwRSF also ran an analysis to check the estimated deceleration levels for the 1100C small car vehicle. Estimated longitudinal OIV and ORA values were calculated to be 7.5 m/s and 8.5 g's, respectively. These values are well within the MASH limits.

The results from the test showed that the high capacity absorber and net had promise, but that higher force levels were needed. In addition, future versions must be ground mounted to work in the hybrid end terminal/crash cushion and net attenuator system while meeting stub height requirements of 4" or less.

For the next step, MwRSF plans to evaluate the system with higher force levels and ground mounted to determine if the system can be setup and function properly when mounted at grade. Impact Absorption is working on supplying an energy absorber with 17 kip sustained pull force. Additionally, MwRSF is working on mounting the system at ground line and low enough to meet stub height requirements. A subsequent test is planned to evaluate the increased capacity energy

Anticipated work next quarter:

In the upcoming quarter, MwRSF will meet with NDOT and present the recent net attenuation testing to NDOT. NDOT will be asked to select which net system they would like to proceed with. Additionally, the meeting will discuss potential changes to the project scope.

Progress will also continue on the summary report.

Significant Results:

Fabrication of high-performance energy absorber for feasibility testing and development of a second potential energy absorber concept. Eight dynamic component test were conducted on two net attenuation systems and the results were used to push for a revised designs that will be evaluated next in two subsequent bogie tests.

A literature search of existing terminal and crash cushion designs was completed and preliminary review of the available system was done to consider potential options for use with the hybrid end terminal/crash cushion and net attenuator system. Further recommendations on potential systems will be based on NDOR input and will be dependent on the parameters of the final net attenuator design.

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 complications arising from the timing and response of the private industry partners in this effort, the development of the new treatment for intersecting roadways is currently behind schedule. This was discussed with the TAC in the October 2016 meeting and it was agreed that it was worthwhile to extend the research effort to allow for further net attenuator development and the use of potential Zodiac Aerospace technologies. Thus, a no-cost time extension was requested and received for this project prior which extended the end date to 8/31/2019.

Potential Implementation:

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

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

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

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): New Jersey 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. #88	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:

Evaluation of New Jersey TCB Performance under MASH TL-3

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Faller, Lechtenberg, Bielenberg, Rosenbaugh,	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130095001		4/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2016	7/31/2019	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**
$702,369	$637,451	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**
	$6,872	

Project Description:

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

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

Objectives / Tasks

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

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

Summary finding and recommendations for improved system performance for the system configurations tested in test nos. NJPCB-8 and NJPCB-9 submitted to sponsor.

Anticipated work next quarter:

Receive feedback from sponsor.

Finalize reports for test nos. NJPCB-1, NJPCB-2, NJPCB-3, NJPCB-4, NJPCB-5, NJPCB-6, NJPCB-7, NJPCB-8, and NJPCB-9.

Significant Results:

None

Objectives / Tasks	% Complete
1. Test no. 1 - Full-scale crash testing (MASH 3-11) - NJPCB-3	100%
1a. Test no. 1 Report - NJPCB-3	95%
2. Test no. 2 - Full-scale crash testing (MASH 3-11) - NJPCB-4	100%
2a. Test no. 2 Report - NJPCB-4	95%
3. Test no. 3 - Full-scale crash testing (MASH 3-11) - NJPCB-1	100%
3a. Test no. 3 Report - NJPBC-1	95%
4. Test no. 4 - Full-scale crash testing (MASH 3-11) - NJPCB-2	100%
4a. Test no. 3 Report - NJPBC-2	95%
5. Test no. 5 - Full-scale crash testing (MASH 3-11) - NJPCB-5	100%
5a. Test no. 5 Report - NJPCB-5	95%
6. Test no. 6 - Full-scale crash testing (MASH 3-11)	100%
6a. Test no. 6 Report - NJPCB-6	95%
7. Test no. 7 - Full-scale crash testing (MASH 3-11)	100%
6a. Test no. 6 Report - NJPCB-7	95%
8. Test no. 8 - Full-scale crash testing (MASH 3-11)	100%
6a. Test no. 6 Report - NJPCB-8	95%
9. Test no. 9 - Full-scale crash testing (MASH 3-11)	100%
6a. Test no. 6 Report - NJPCB-9	95%

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

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

Note: additional funds to reach the initial $350,000 have not been received as of April 30, 2016. Therefore, the project only has enough funds to conduct 3 tests at this time.

A no-cost extension will be requested to continue the project since funding has been delayed.

The additional funds to reach the $702,369 total project budget was received in September 2016. Therefore, the project plan may be shifted 6 months to account for the delay in funding.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): 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. #81 MwRSF Project No. RPFP-15-AGT-1	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Standardized Concrete Parapet for Use in Thrie Beam AGT's		
Name of Project Manager(s): Reid, Faller, Bielenberg, Rosenbaugh	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211113001	**Other Project ID (i.e., contract #):** RPFP-15-AGT-1	**Project Start Date:** 8/1/2014
Original Project End Date: 7/31/2017	**Current Project End Date:** 7/31/2018	**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
$125,906	$125,906	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$3,512	

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.):

Work continued to complete the summary report, which will detail all design and testing of the standardized buttress along with guidance for installing the buttress in real world AGTs. Specifically, details concerning the implementation of the buttress were developed with sketches illustrating how to transition the buttress to various bridge rail shapes.

This Phase I project was closed at the end of July 2018. However, a singular report is being written for both this project as well as the Year 27 continuation project. As such, the report will be finalized after the this individual project is closed and will be completed with funds from the continuation project.

Anticipated work next quarter:

The current project was closed at the end of July 2018. However, a singular report is being written for both this project as well as the Year 27 continuation project. As such, the report will be finalized after the this individual project is closed and will be completed with funds from the continuation project (Project no.TPF-5-(193) Supplement #3 or RFPF-17-AGT-3).

Significant Results:

An extensive literature review of all AGTs to concrete parapets was summarized in a reference table. The table was utilized during the design process to develop a buttress that minimizes snag while maximizes vehicle stability. Through a voting process, the states selected a dual taper design over a single taper design. The bottom of the buttress (below the thrie beam) had 4"x12" chamfer to prevent tire snag, while the rest of the buttress had a 4"x4" chamfer to prevent vehicle snag. The length of the buttress was minimized at 7 ft to minimize the system length while also allowing room for geometric shape transitions to match up with various bridge rails. The height of the buttress was selected as 36" to match the height of MASH TL-4 bridge rails. The buttress height tapers down to 32" on the upstream end over a 24" length to prevent snag. Design details for the system including geometric shape and reinforcement were completed.

A test installation was constructed at the MwRSF test site and was subjected to 1 full-scale crash test in accordance with MASH test 3-21 with a 2270P. During the test, the pickup was contained and redirected. However, the vehicle floor pan and seat were displaced during the impact event - not enough to exceed occupant compartment deformations, but enough to cause erroneous data to be recorded by the accelerometers (which mount to the seat frames). Thus, a -30 g pulse was recorded in the longitudinal direction which exceed MASH ORA limits. The on board ACM recorded only a -20 g pulse, but it too was affected by the motion of the vehicle floor pan. Efforts were made to compare the data trace to high-speed video, but vehicle roll and pitch made tracking of the actual vehicle c.g. very difficult. Consequently, it could not be proven that the ORAs were below the 20.49 g limit in MASH.

Following the unsuccessful full-scale crash test, the geometry of the standardized buttress was redesigned to improve the performance of the system. The size of the lower taper was increase from a 4"12" taper to a 4.5"x18" taper. Also, the height of this lower taper was increased from 11" to 14". these changes were done to reduce wheel snag and loads into the axle of the vehicle. the upper taper was changed from 4"x4" to a 2"x4". this reduction in slope was intended to

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Extra data analysis was conducted in an attempt to validate the differing data traces obtained from the accelerometers and the high speed video for test no. AGTB-1. Unfortunately, none of the analysis methods converged.

A continuation study/project was funded in 2016 as part f the Year 27 Pooled Fund Program. This new project was aimed at redesigning the buttress and re-testing the system (MASH 3-21). As this effort is advanced, labor and materials will be charged to this Year 25 project until the funds are exhausted. The test charges were still applied to the YR 27 project instead of the original YR 25 project.

A singular report is being written for both this project as well as the Year 27 continuation project. As such, this project was closed in July 2018, and the report will be finalized with funds from the continuation project.

After the project had begun, FHWA issued a new memo/policy stating that it would only grant eligibility letters to systems that had completed the full test matrix as recommended in MASH. Since the project did not include testing with the small car (deemed non critical), the standardized buttress will not meet the criteria for FHWA eligibility letters. Thus, a submission will not be completed. Instead, MwRSF's opinion on the crashworthiness of the buttress will be explicitly written in the report and supported with details and references.

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): Nebraska Department of Roads

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #91	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: Design Guidance for MGS Placed on or near Slopes		
Name of Project Manager(s): John Reid, Ron Faller, Bob Bielenberg, Karla I	**Phone Number:** 402-472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611211120001	**Other Project ID (i.e., contract #):** RPFP-16-MGS-2	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/18	**Current Project End Date:** 9/30/19	**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
$54,309.00	$20,370	48%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$187	

Project Description:

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

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

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

Major Task List

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

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

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

Previously, MwRSF conducted a literature search to compile and summarize research related to the MGS adjacent to slopes. This effort collected information regarding:

1. Collect all previous MASH testing of the MGS adjacent to slopes including MwRSF 2:1 slope testing, MwRSF gabion wall testing on 3:1 slopes, and TTI testing of 31" tall guardrail on 2:1 slopes.
2. Collect bogie testing efforts at MwRSF and others related to guardrail adjacent to slopes.
3. Review current research related to guardrail on slopes including ongoing projects.
4. Review previous guidance on guardrail adjacent to slopes provided by MwRSF through the Midwest Pooled Fund Consulting efforts.

The data from the literature search was reviewed and additional research related to barrier placement adjacent to slopes was added included additional bogie testing of posts on both level terrain and slopes. The literature review was reviewed and edited for use as part of the final report.

In November of 2016, MwRSF had a Midwest Pooled Fund progress update meeting. In that meeting, the scope of this project was reviewed in light of the MGS successfully meeting MASH TL-3 criteria when installed in its standard configuration adjacent to a 2:1 slope. In that meeting, it was decided that the use of standard post length MGS systems on 2:1 slope would greatly simplify the required guidance and scope of this report. Thus, it was agreed to simplify the guidance to denote the allowable configuration under MASH and provide relevant implementation guidance in terms of issues such as working width, special MGS applications, and soil strength considerations. Thus, the scope has been revised to a more simple approach.

MWRSF has developed simplified guidance for the MGS placed adjacent to slopes. Additionally, estimated deflections

Anticipated work next quarter:

In the upcoming quarter, MwRSF will work on completion of the summary report.

Significant Results:

State survey completed and the literature search was completed.

Scope of project guidance simplified based on recent MASH testing.

Simplified guidance for the MGS adjacent to slope was developed.

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

Year 26 of the Midwest Pooled Fund Program has been extended to 9/30/2019 to allow for completion of existing research efforts within that year.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #92 MwRSF Project No. RPFP-16-MGS-3	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:

Steel Post Version of Downstream Anchorage System

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211122001	RPFP-16-MGS-3	10/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2018	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$162,219 (+$39,100 Yr 28 Contingency)	$162,186 (+$39,925 Yr 28 Continger	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
	$18,521	

Project Description:

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

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

Objectives / Tasks:

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

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

Internal review of the literature review, patent search, concept development, and component test documentation continued.

Acquired materials for the first systems. Constructed the first system.

On July 31, 2018, MwRSF conducted test no. SPTA-1 on the steel post version of the downstream anchorage according to a modified MASH 2016 test designation 3-37a with the intent of assessing the end of the length of need rather than maximizing vehicle snag and instability. We impacted the system at the sixth post upstream from the downstream end of the barrier because we wanted the same impact location as the wood post version of the downstream anchorage system. The pickup truck impacted at a speed of 62.1 mph and an angle of 25.0 deg. There was minor roll of the vehicle, but the vehicle remained upright and the system safely redirected the vehicle. Essentially no occupant compartment deformation was found. All occupant risk values were found to be within the limits. Therefore, test no. SPTA-1 was determined to be acceptable according to the MASH 2016 safety performance criteria for modified test designation no. 3-37a.

After analysis and documentation was completed, minor modifications were made to the breaker bar length and attachment to the post as well as gussets were added to the breakaway steel posts to prevent post deformation and twisting. New material was acquired to construct the second system. Constructed the second system.

On September 12, 2018, MwRSF conducted test no. SPTA-2 on the steel post version of the downstream anchorage according to modified MASH 2016 test designation 3-37b with the intent of maximizing vehicle snag and instability. We impacted the system at the midspan between the second and third posts upstream from the downstream end of the

Anticipated work next quarter:

None,

The project funds were depleted this quarter and the project was closed. All further project progress will be reported under the Phase II project (Project No. TPF-5(193) Supplement #120 - RPFP-18-MGS-1, Project Title: Steel Post Version of Downstream Anchorage System - Phase II).

Significant Results:

Five design concepts were developed and component tested.

Objectives / Tasks:	% Complete
1. Literature Review	100%
2. Development of Design Concepts	100%
3. Design and Analysis	100%
4. CAD Details	100%
5. Component Fabrication	100%
6. Component Testing	100%
7. Data Analysis	100%
8. CAD Details of Recommended System Design	100%
9. 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:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #93 MwRSF Project No. RPFP-16-MGS-4	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:

Top Mounted Socket for Weak Post Bridge Rail

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211123001	RPFP-16-MGS-4	10/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2019	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
$130,538	$78,710	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
	$908	

Project Description:

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

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

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

Objectives / Tasks:

1. Literature Review
2. Conceptual Design and Analysis

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

Minimal work was conducted on this project as MwRSF focused on other high-priority Pooled Fund projects. The work that was conducted was to continue assembling the project summary report.

Anticipated work next quarter:

The draft of the project report will be completed.

Significant Results:

A literature review was completed covering all previous crash-testing of related weak-post systems and top-mounted culvert guardrail systems. Following some initial conceptual designs, discussions with the project sponsors led to the selection of 3 socket design options for evaluation: 1) a steel socket, 2) a cylindrical concrete foundation, and 3) sockets encased in a concrete slab.

The reinforced steel socket option was evaluated through both the strong and weak axis of the post at impact heights of 25" and 12", respectively. The sockets were placed on the slope break point of a 2:1 slope, and the culvert soil fill depth was at its maximum of 36 inches. This configuration was considered critical to maximize the potential for socket damage and displacement. Both tests resulted in virtually no damage to the socket, and permanent deflections of the socket was less than 0.5" (as measured at the top of the socket.

A dynamic component test was also conducted on the cylindrical concrete foundation. Since this concept has already proven to resist movement in soil with a 30" embedment depth, the shallowest embedment depth (12') was selected as the critical soil depth to evaluate the anchorage of the foundation to the top of the culvert. The test was conducted through the strong axis of the post with a 25" impact height. The test resulted in virtually no damage or displacement of the concrete foundation. A second cylindrical concrete foundation was installed at the maximum fill depth of 36" and subjected to a weak-axis impact at a height of 12" above ground line. The post bent over and the bogie eventually overrode the top of the post. the foundation sustained no damage and had only 1/16" of permanent displacement.

A 9-ft long x 3 ft wide x 4" thick concrete slab was poured with its back edge at the slope break point of a 2:1 slope. Two sockets spaced 27.5" apart were placed within the concrete slab 24" from the back edge of the slab. The test was

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

In May 2017, the FHWA issued a memo that stated that only systems that had been evaluated to the entire suite of tests within the MASH crash testing matrix would receive an eligibility letter. Since this project incorporated only component testing, these socketed designs will not have the opportunity to receive letters. Thus, an application for an FHWA letter will not be submitted.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): NDOR

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl # 94	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title:		
Development of a Generic Energy-Absorbing, Approach End Terminal for MGS		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Schmidt, Reid, Faller	(402) 472-0870	jennifer.schmidt@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211124001	RPFP-16-TERM-1	10/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2018	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$123,057	$123,057	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,171	

Project Description:

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

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

Major Task List

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

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

The second report was published on July 17, 2018. All remaining charges were posted to the project and the project was closed.

Anticipated work next quarter:

This is the last progress report. Project is closed.

Significant Results:

The background and patents on all current end terminals has been documented. Several concepts have been brainstormed. The States voted to pursue the path of a new end terminal design. The new end terminal impact head was designed and preliminary simulation with LS-DYNA was completed.

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).

Initially, $70,000 was funded to begin the project and determine the course of direction. In December 2016, the majority of the Pooled Fund States voted to utilize $53,057 in Year 23 contingency funds from TPF-5(193) Suppl #57 to continue with component testing and possibly simulation in this Phase I effort. Thus, the total project budget was increased from $70,000 to $123,057 in the 2016 Quarter 4 quarterly progress report.

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #95	**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: Enhancements to MwRSF Hub Website		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211125001	**Other Project ID (i.e., contract #):** RPFP-16-WEB-1	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/2018	**Current Project End Date:** 9/30/2019	**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
$30,102	$23,789	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
	$724	

Project Description:

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

In addition to the consulting website, a searchable online listing of downloadable research reports and a searchable archive of CAD details for crash-tested and/or approved systems and features has been created. The research archive contains all of MwRSF's archived research reports in a searchable format. The archive of the CAD details for the research efforts has been generated and is currently being uploaded beginning with newer projects and proceeding to older research. Additionally, Midwest Pooled Fund members have requested inclusion of videos files from full-scale crash testing to the archive. These are currently being added to the site for the newer projects and as requests for older videos are made. The research archive as well as the Midwest States Pooled Fund consulting website is integrated with the main MwRSF website.

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

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

Uploading videos to the research hub and archiving the converted videos with the original videos continued. All have been uploaded and archived.

Continuing to verifying that all videos, CAD, and reports have been uploaded for each Pooled Fund report on the research hub.

Anticipated work next quarter:

Continue the verification process of verifying that all videos, CAD, and reports have been uploaded for each of the Pooled Fund reports located on the research hub.

Significant Results:

Task	% Complete
1. Identify projects needing wmv videos uploaded	100%
2. Locate full-scale crash test videos	100%
3. Convert videos to wmv format	100%
4. Upload the wmv videos and archive converted videos	100%
5. Verify videos have been uploaded	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).

None

Potential Implementation:

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

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #99	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)	
Project Title: LS-DYNA Modeling Enhancement Support		
Name of Project Manager(s): Schmidt, Reid, Faller, Bielenberg, Lechtenberg	**Phone Number:** 402-472-3084	**E-Mail** jennifer.schmidt@unl.edu; jreid@unl.e
Lead Agency Project ID: RPFP-16-LSDYNA	**Other Project ID (i.e., contract #):** 2611211129001	**Project Start Date:** October 1, 2015
Original Project End Date: September 30, 2018	**Current Project End Date:** September 30, 2019	**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
$41,114	$19,531	48%

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	$5,955	0

Project Description:

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

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

An approach guardrail transition (AGT) incorporating the standardized buttress developed by the Pooled Fund program was created. Part of the model was developed under another project, but LS-DYNA modeling techniques were also explored under this project. This AGT model will serve as a the baseline model to be used in the current Pooled Fund project on exploring flare rates for AGTs.

Anticipated work next quarter:

Work will continue on the AGT model. Enhanced soil modeling and incorporating steel fracture into guardrail models may also be explored in more detail.

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).

The project was extended by a year to allow more work to be conducted on LS-DYNA-related problems as they arise.

Potential Implementation:

Once a validate AGT model is completed, it will serve as a the baseline model to be used in the current Pooled Fund project on exploring flare rates for AGTs and will be useful to many other future projects as well.

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. #101	☐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: Iowa DOT Combination Bridge Separation Barrier with Bicycle Railing		
Name of Project Manager(s): Faller, Bielenberg, Reid, Rosenbaugh	**Phone Number:** (402) 472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611130099001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 7/01/2016
Original Project End Date: 12/31/2018	**Current Project End Date:** 5/31/2019	**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
$254,445.00	$160,572	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
	$54,259	

Project Description:

The objective of this research is to develop a MASH TL-2 crashworthy, low-height, vertical-face traffic barrier with an attached crashworthy bicycle railing. It is desired that the low-height, vertical-face traffic barrier be applicable for standard applications and that the crashworthy bicycle railing attachment can be added as desired. The barrier system should minimize the height of the concrete barrier portion of the system and provide improved visibility and sightlines, including when the bicycle railing attachment is used. In addition, the new railing system should comply with current AASHTO LRFD guidance for bicycle railings with respect to the parapet and/or the parapet and combination railing.

The research effort to develop a MASH TL-2 crashworthy, low-height, vertical-face traffic barrier and attached crashworthy bicycle railing will proceed in two phases. Phase I will consist of the development and analysis of design concepts, and Phase II will consist of evaluation and full-scale crash testing of the proposed design.

Phase I

The Phase I research effort will begin with a literature search to review crash tested vertical parapets and bicycle/pedestrian rails. The information will be reviewed to suggest potential vertical concrete parapet geometries and designs as well as provide background information on existing crashworthy combination railings. Following the literature search, the researchers will estimate the lowest vertical-faced concrete barrier height that is sufficient to meet AASHTO MASH TL-2 crash testing requirements and can also be used with a pedestrian/bicycle railing. A 24-in. minimum height will be the lowest potential parapet height based on the AASHTO LRFD guidance for a pedestrian separation barrier, as noted previously. However, no rigid parapets have been evaluated at that height under the MASH TL-2 criteria.

LS-DYNA simulation with the 2270P vehicle will be used to evaluate potential minimum rail heights for the vertical parapet of 24 in. or greater. A baseline simulation model will be created and validated against the best available relevant crash

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

To date a literature search has been performed on previous crash testing and development of TL-2 and TL-3 vertical concrete parapets as well as combination bridge rails. Information has also been collected regarding low-height TL-2 and TL-1 barriers that includes portable concrete barriers as well. Information on the Zone of Intrusion and occupant head ejection that may be relevant to the project was collected as well.

The researchers used the materials from the literature search to begin simulation analysis of the minimum TL-2 parapet height. MwRSF has developed models of recent vertical parapet tests for calibration and is conducting the height analysis. The researchers also reviewed critical vehicle components relative to the barrier height in existing tests to help establish the minimum barrier height. The literature review data and simulation will then be applied to select the minimum height.

The effort to determine the minimum TL-2 concrete parapet height was continued. Simulation of a MASH TL-3 test of the Texas T-222 vertical bridge rail was conducted to validate simulation of the 2270P vehicle into a vertical concrete parapet. Analysis of the simulation results found that the simulation tended to overestimate vehicle pitch and roll values. Attempts were made to adjust vehicle to barrier friction and the deflection of the barrier to better match the physical crash test, but improvement was minimal. Further analysis simulated TL-2 impacts of the 2270P vehicle into extremely low height parapets with heights of 14 in. and 18 in. The simulation models tended to suggest vehicle redirection for both of these impacts, but previous testing has indicated that 18 in. barrier heights are not sufficient to redirect pickup trucks. Thus, it was determined that the tire and suspension models for the 2270P vehicle may not be sufficient to predict vehicle interaction with the low height parapet.

A second analysis of existing vehicle testing on low height parapets was undertaken that compared critical points on the

Anticipated work next quarter:

The summary report for the bridge rail design will be completed in the 4th quarter of 2018.

Summary report for the full-scale testing will be worked on during the 4th quarter of 2018.

Significant Results:

The Iowa TL-2 Combination Bicycle Railing was tested and found acceptable under the MASH TL-2 criteria.

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

Currently, Phase I design of the combination rail is approximately 3-6 months behind the intended project plan. Funding is not an issue.

Due to these delays, MwRSF requested and received a no-cost time extension for the project with a revised end date of 5/31/2019.

Potential Implementation:

Investigation and evaluation of a MASH TL-2 crashworthy, low-height, vertical-face traffic barrier and an attached crashworthy bicycle railing will provide IaDOT with a safe option for shielding bicycle facilities and also may be used without a railing for pedestrian separation.

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. #103	**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: 34" Tall Thrie-Beam Approach Guardrail Transition		
Name of Project Manager(s): Rosenbaugh, Faller, Faller, and Reid	**Phone Number:** 402-472-9327	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611130101001	**Other Project ID (i.e., contract #):** RHE-17M	**Project Start Date:** 9/7/2016
Original Project End Date: 3/31/18	**Current Project End Date:** 3/31/19	**Number of Extensions:** 2

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$179,936	$156,185	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
	$20,795	

Project Description:

A taller rail height approach guardrail transition (AGT) is desired to allow for future roadway overlays without modifications or retrofits to the thrie beam AGT. Ideally, a 3" overlay could be placed in front of a 34" tall AGT, thereby making it a standard 31" tall AGT. Thus, the objective of this research is to evaluate the safety performance of NDOR's approach guardrail transition (AGT) with the top mounting height of the thrie beam increased from 31" to 34". The 34" tall AGT will be evaluated according to MASH TL-3 safety performance criteria. The concrete buttress at the downstream end of the the transition will be selected to fit the needs of NDOR and ensure a crashworthy system after a 3" overlay. Finally, connection details for the MGS upstream of the thrie-beam AGT will be developed for both pre- and post-overlay situations.

Major Task List:

1. Project Planning and Correspondence
2. Design/Selection of Concrete Buttress
3. Design of MGS to 34" Transition
4. CAD Details
5. Construction of Test Article
6. Full-Scale Crash Testing - MASH 3-20
7. Full-Scale Crash Testing - MASH 3-21
8. System Removal
9. Data Analysis
10. Summary Report
11. Technical Brief and Presentation for NDOR
12. Submission of FHWA Eligibility Letter

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

Work this quarter consisted of completion of a journal paper and an LSDYNA transition model. The journal paper was written and submitted to the Transportation Research Board. It was accepted for both presentation at the 2019 annual meeting in Washington D.C. and for publication in the Transportation Research Record.

The individual components and materials for the LS-DYNA transition model have been completed. The model was then compared to multiple full-scale crash tests as part of the validation process. The comparisons included both small car and pickup truck impacts, as well as impacts both near the rigid buttress and the upstream MGS stiffness transition. The model has been modified to better replicate the physical crash tests.

Anticipated work next quarter:

Work will continue to complete the project summary report documenting all testing and implementation guidance. Additionally, a presentation will be assembled for the TRB paper.

Significant Results:

Through multiple meetings and discussions between MwRSF and NDOR, the concrete buttress design and the upstream transition from 31" MGS to 34" AGT were finalized. The concrete buttress is a taller version of the Standardized Transition Buttress being developed through the Midwest States Pooled Fund (39" instead of 36"). The upstream MGS will connect to a symmetrical W-to-thrie transition segment that will take the top rail height from 31" to 34". Once an overlay is paved, the symmetric segment will be replaced with an asymmetrical W-to-thrie segment, and the W-beam rail and blockouts upstream of the the transition will be raised 3" to match the top rail height of the AGT (was 34" now 31" relative to the top of the roadway). Extra bolt holes were placed in the posts to accommodate the different transition segments and the raising of the W-beam.

CAD details for the system were developed and the 34" AGT system with 39" standardized buttress was constructed at the MwRSF test site. The first full-scale crash test, 34AGT-1, resulted in the 2270P being smoothly redirected with only minor contact between the vehicle and the buttress. All occupant safety criteria was satisfied, so the test passed all saftey performance criteria of MASH 3-21.

The second full-scale test, test no. 34AGT-2, was conducted on the transition system according to MASH 3-20. The small car was contained and redirected, but the front tire extended under the thrie beam rail and snagged on the upstream face of the buttress. This snag resulted in significant crush to the floorpan and toe pan. However, these deformations were within the MASH limits. The windshield was cracked and torn, which is not allowed under MASH criteria. However, the windshield damage was the result of deformations of the vehicle hood, fender, and A-frame. The test article never contacted the windshield, so the potential for penetration is negligible. Thus, this tearing was not deemed a safety hazard. Finally, the driver side door opened during the test as a result if the contact between the door and the thrie beam. MASH

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 initial project proposal was written with an end date of June 2018. However, the timeline listed on the agreement between NDOT and UNL had shifted the completion date forward to March 31, 2018, thus resulting in 3 months of lost time to complete the study and finalize all project deliverables. Additionally, the MwRSF wanted to prepare a technical journal paper on the project to disseminate the project's findings and conclusions throughout the country. As such, a 6 month, no-cost extension was granted to this project.

Through discussions Phil TenHulzen, NDOR expressed interest in using the test data to construct and validate a computer model for use in further study of AGTs. Specifically, an LS-DYNA model of an approach guardrail transition could aid in the study of other guardrail heights, various transition post and post spacing configurations, and transition flare rates. After the full-scale crash testing and evaluation of this project was completed, there were significant funds remaining in the project budget. Therefore, LS-DYNA modeling was added to the project scope, and a validated AGT model will be constructed as part of this project.

Potential Implementation:

The successful testing of the 34" tall AGT will allow NDOR to install both their bridge rails and their adjacent AGTs in anticipation of future overlays. Both of these barrier types will now be crashworthy at the time of initial installation as well as after a 3" roadway overlay. Not having to remove and replace the AGTs after an overlay should result in significant savings in both cost and labor.

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 #104	☐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:		
Optimized TL-4 Concrete Bridge Rail		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211133001	RPFP-17-CONC-2	10/1/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2019	9/30/2019	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
$247,654	$236,588	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
	$80,797	

Project Description:

Historically, rigid concrete barriers satisfying TL-4 criteria have typically been 32 in. tall. However, with the adoption of MASH and an increase in both mass and impact speed for the single-unit truck, TL-4 tests on 32-in. tall barriers have repeatedly resulted in the 10000S vehicle rolling over the barrier. As such, barriers taller than 32 in. are now required to meet the MASH TL-4 criteria.

Past research has indicated that certain barrier shapes, such as safety-shapes, increase the propensity for vehicle climb, instability, and rollover. An optimized barrier shape would minimize vehicle instabilities by utilizing a flat, near vertical face. However, tall vertical faced barriers pose the risk of occupant head slap during impact events. Thus, an optimized geometric shape that considers vehicle containment, vehicle stability, and occupant head ejection is desired for new taller TL-4 barriers. Additionally, the increased impact severity associated with MASH TL-4 criteria will increase impact loads to the deck and could lead to deck damage. Retrofitting stronger barriers onto existing bridge decks not designed for these increased loads may lead to deck damage during severe impacts.

The objective of this research effort is to develop a MASH-compliant TL-4 bridge railing. The railing will be optimized for strength, vehicle stability, installation costs, and head slap mitigation. Efforts will also be made to minimize load transfer into the deck and determine the minimum deck capacity, thereby minimizing the risk of deck damage.

Objectives / Tasks:

1. Literature Review
2. State Survey of TL-4 deck designs
3. Barrier Design and Structural Analysis
4. Deck Design and Structural Analysis
5. CAD Details
6. Development of Barrier End Sections and Transitions

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

Construction was complete on the test article, which consisted of the optimized, 39-in. tall, single slope concrete bridge rail placed on a simulated 5-ft cantilever, 8-in. thick bridge deck. A 3-in. asphalt overlay was applied to the deck surface, effectively bringing the height of the bridge rail to 36". A full-scale crash test was conducted on the bridge rail with the 10000S single-unit truck in accordance with MASH test 4-12.

During the test, the vehicle was captured and redirected by the bridge rail. The vehicle remained stable during redirection and stayed in contact with the bridge rail for approximately 112 ft downstream of impact. The maximum dynamic deflection of the bridge rail was 1.0 in., while the working width of the system was 54.7 in. (top edge of the truck box as it leaned over the barrier). The truck had a maximum roll of 35 degrees during redirection, which was limited due to the box contact the top surface of the bridge rail.

Damage to the barrier was limited to contact marks, gouging into the barrier, and minor cracking of the barrier. The barrier cracks were limited to a few locations on the front and back faces of the barrier and ranged in thickness from hairline to 1/32". Contact from the vehicle wheels resulted in gouging to the face of the barrier (typical of all concrete barrier impact tests), while additional gouging to the top front edge of the barrier wa the result of the box leaning on top of the barrier. No visible damage was observed to the bridge deck – even after the 3" overlay was removed.

Test 4CBR-1 satisfied all MASH requirements for test 4-12. This MASH 4-12 test was the only proposed test for this bridge rail, as both the small car (MASH test no. 4-10) and pickup truck (MASH test no. 4-11) tests were deemed non-critical due to the bridge rail's similarities to previously MASH tested barriers. As such testing for this project has been completed.

Work has also begun to write the project summary report which will document all design and testing of the new optimized TL-4 barrier.

Anticipated work next quarter:

Work will continue on the project summary report. Also, an update presentation will be given to the project sponsors are the Midwest Pooled Fund mid-year meeting in November.

Significant Results:

Multiple contractors and slipformers were contacted and surveyed concerning the cost to install concrete bridge rails. Specifically, the material and labor costs for the steel rebar and concrete were obtained. Average values for these costs will be utilized to optimize the barrier design.

A single slope barrier shape measuring 2-3 degrees from vertical was selected for the bridge rail to maximize vehicle containment and stability while also remaining constructible through slipforming. General reinforcement patterns were selected to provide cage stability during casting/slipforming and efficiently strengthen the barrier. Various barrier width and rebar configuration combinations were first analyzed using Yield Line Analysis to ensure a minimum strength capacity of 80 kips to satisfy MASH TL-4 impact loads. The material and labor costs associated with both concrete and the steel reinforcement were estimated for each barrier configuration. A table of the lowest cost configurations to satisfy the 80 kip capacity was created for selection of the optimized system. This analysis was completed twice, once for a single slope barrier configuration, and a second time for a barrier shape which contains large chamfer on the top-front corner to minimize the risk of head slap.

An update meeting was held in October 2017 with the project sponsors. At this meeting, various barrier design configurations that satisfied the design criteria were discussed. The states were then asked to vote for their most desired barrier configurations. The selected configuration incorporated a single slope front face angled 3 degrees from vertical, an 8" top width, and an installation height of 39". The barrier was reinforced with (8) #5 longitudinal rebar and #4 stirrups spaced at 12" intervals.

A bridge deck was also configured for the full scale test based on existing deck designs from the sponsor DOTs. Details

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

In a May 2017 memo, the FHWA declared that eligibility letters will now only be granted to systems that have completed the entire suite of tests within the MASH testing matrix. Since the small car and pickup truck tests (MASH 3-10 and 3-11) were previously deemed non-critical by MwRSF and the Pooled Fund States, they will not be conducted as part of this project. Thus, the concrete bridge rail will not meet FHWA's new criteria to qualify for a letter, and an application for a letter will not be submitted.

Potential Implementation:

Successful development of this optimized bridge railing would provide states with a MASH TL-4 bridge rail option when constructing new bridges or upgrading existing bridges. The barrier will provide unique benefits in that it will be optimized for vehicle containment and stability, load distribution into the deck, head slap mitigation, and cost while also allowing for future roadway overlays.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #106	☐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 with Curb		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-9324	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211135001	**Other Project ID (i.e., contract #):** RPFP-17-MGS-2	**Project Start Date:** 10/1/2016
Original Project End Date: 9/30/2019	**Current Project End Date:** 9/30/2019	**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
$161,926	$80,327	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
	$6,307	

Project Description:

Curbs located along roadways can adversely affect the interaction of errant vehicles with roadside barriers. Although the two are commonly used in combination, when curbs are placed near guardrail systems, the propensity for vehicle underride, override, and instability increases. The MGS with a curb offset 6 in. from the front face of the guardrail was successfully crash tested to NCHRP Report No. 350 TL-3 requirements. However, the MGS with curb has not yet been evaluated to MASH TL-3.

Thus, the objective of this research is to evaluate the performance of the MGS installed with the face of the rail offset 6-in. from the face of the 6-in. tall AASHTO Type B curb. The evaluation of the barrier system behind curb will be undertaken according to the MASH TL-3 safety criteria through two full-scale crash tests with both the 1100C and 2270P vehicles.

Objectives / Tasks:

1. CAD Details
2. Construction of test article
3. Full-Scale Testing - MASH 3-10
4. Full-Scale Testing - MASH 3-11
5. Data Analysis
6. System Removal
7. Summary Report
8. TF13 Hardware Guide Drawings
9. FHWA Eligibility Letter

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

A draft of the project summary report was written documenting both of the MASH full-scale crash tests. This draft report is currently under internal review. Additionally, implementation guidance pertaining to various combinations of the MGS in combination with curbs was developed and will be included in the test report.

Anticipated work next quarter:

The summary report will be completed. Additionally, work on the Hardware Guide drawings and/or the FHWA eligibility letter will begin.

Significant Results:

Two full-scale crash tests were conducted on the MGS with curb test installation. The first test, test no. MGSC-7, was conducted according to MASH 3-10 with the 1100C small car. During the test, the barrier captured and redirected the vehicle with controlled system deflections. The W-beam rail was partially torn at the location of the critically loaded splice. This is the same location as the complete rail rupture observed during testing of the MGS with curb and an omitted post. Thus, the standard system (i.e., no omitted posts) provides enough support and strength to prevent the tearing previously observed.

The second full-scale test, test no. MGSC-8, was conducted according to MASH 3-11 with the 2270P pickup truck. during the test the vehicle was captured and smoothly redirected. The impact event caused the guardrail to detail from every post downstream of impact, though the cable anchorage was still intact. After the vehicle lost contact with the the system, it steered back toward the system eventually coming to a stop on top of the downstream anchorage. Although the front tires overrode the guardrail, this was not seen as grounds for failure of the system for multiple reasons. 1) the vehicle had already safely exited the system, so the tire rolling over the downstream end would be a secondary impact on a damaged system. 2) the trailing end anchorage utilized during the test is expected to gate for impacts located downstream of the 6th post form the downstream end, and the secondary impact clearly impacted near post 3. Thus, the system is supposed to gate at this location. 3.) rail release from posts all the way through the anchor posts has been observed in other successful tests on versions of the MGS. This was just the first occurrence of a secondary impact. Thus, test MGSC-8 was deemed a PASS to be consistent with previous testing evaluations.

Objectives / Tasks:	% Complete
1. CAD Details	100%

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

This project was waiting for the testing results of a related project - TPF-5(193) suppl. #105: Testing of the MGS Omitted Post with Curb. The omission of a post is thought to increase the risks of vehicle instabilities and possible capture issues. Thus, it was deemed the more critical of the system installations. If the MGS with Omitted post with curb was successfully tested, this project would likely not be necessary. However, a failure occurred during the evaluation of the omitted post installation. Thus, this project became active after being delayed to observe the results from the related project, TPF-5(193) suppl. #105: "Testing of the MGS Omitted Post with Curb." However, the full-scale crash testing was conducted in a very timely manner, so the project will be completed on time.

Potential Implementation:

The successful testing and evaluation of the MGS guardrail system offset from a 6-in. tall Type B curb would provide state DOTs with a MASH-tested option to install curb adjacent to the MGS. Evaluation of the MGS with curb will allow state DOTs to continue to use this hardware on their roadways and will ensure that its safety performance remains adequate with respect to the current vehicle fleet.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #105	☐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 with Curb and an Omitted Post		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211134001	RPFP-17-MGS-1	10/1/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2019	9/30/2019	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
$164,855	$103,900	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
	$6,109	

Project Description:

Curbs located along roadways can adversely affect the interaction of errant vehicles with roadside barriers. Although the two are commonly used in combination, when curbs are placed near guardrail systems, the propensity for vehicle underride, override, and instability increases. The MGS with a curb offset 6 in. from the front face of the guardrail was successfully crash tested to NCHRP Report No. 350 TL-3 requirements. However, the MGS with curb has not yet been evaluated to MASH TL-3.

In addition, roadside obstructions may frequently occur that prevent proper post placement within a run of guardrail. To avoid small obstructions, a single post may be left out of system creating a single enlarged span length of 12.5 feet. The MGS with an omitted post was crash tested to MASH test no. 3-11 and adequately redirected the 2270P pickup truck. However, the introduction of a curb below to the elongated span of an omitted post length may lead to vehicle capture and/or stability issues. omitted posts has never been crash tested to the safety performance criteria of MASH.

Thus, the objective of this research is to evaluate the performance of the MGS with a single omitted post installed with the face of the rail offset 6-in. from the face of the 6-in. tall AASHTO Type B curb. The evaluation of the barrier system behind curb will be undertaken according to the MASH TL-3 safety criteria through two full-scale crash tests with both the 1100C and 2270P vehicles.

Objectives / Tasks:

1. Determination of CIPs
2. CAD Details
3. Construction of test article
4. Full-Scale Testing - MASH 3-10
5. Full-Scale Testing - MASH 3-11
6. Data Analysis
7. System Removal

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

Work this quarter focused on writing the project summary report. A draft report was completed and is now in internal review.

Anticipated work next quarter:

The summary report documenting both MASH 3-10 tests will be reviewed and edited.

Additionally, a continuation project proposal which incorporated the MASH 3-11 pickup truck test was selected for funding as part of the 2018 Midwest Pooled Fund program. This project will begin in October 2018.

Significant Results:

BARRIER VII analyses were utilized to determine the CIPs for MASH TL-3 impacts on the MGS placed 6" behind a 6" curb and with an omitted post. The CIP for the 1100C was determined to be 122" upstream of the first post downstream of the elongated span, while the CIP for the 2270P was determined to be 131" upstream of the first post downstream of the elongated span.

Full-scale crash test, test no. MGSCO-1, was conducted on the MGS with an omitted post placed 6" behind a 6" curb. The test was conducted in accordance with MASH test 3-10 with the 1100C small car. During impact, the W-beam rail was torn at the splice located within the elongated span length created by the omitted post. As a result, the vehicle was not captured, but instead penetrated through the barrier system.

A number of possible retrofits for the system were discussed with the sponsoring DOTs. Through a survey of the Pooled Fund members, the project scope was changed to include a second MASH 3-10 test on the MGS with curb and an omitted post - only this time nested W-beam rail would be placed in the region of the omitted post. The damaged system was then rebuilt with 37.5-ft of nested rail around the omitted post location.

The second full-scale crash test, test MGSCO-1, was conducted according to MASH TL-3 with the 1100C car impacting the MGS with an omitted post placed 6" behind the face of a 6" tall curb. The MGS included 37.5 ft of nested guardrail encompassing the unsupported span length and 2 adjacent posts on each side. During the test, the vehicle was captured and redirected without any evidence of guardrail tearing. Thus, the test passed MASH 3-10 evaluation criteria.

Objectives / Tasks: % Complete

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

Due to the failure of test MGSCO-1, the project scope was changed. The second budgeted crash test (MASH 3-11 with the 2270P) was changed to a 2nd MASH 3-10 test on the nested rail retrofit to the system. To complete the evaluation of the MGS with curb and an omitted post (pickup truck test), a continuation project was funded as part of the Year 29 (2018) Midwest States Pooled Fund Program. Since the MASH 3-11 test will not be conducted as part of this project, hardware guide drawings and an FHWA eligibility letter will not be completed as part of this project, but will take place as part of the Year 29 continuation project.

Potential Implementation:

The successful testing and evaluation of an MGS guardrail system with curb and omitted post will allow state DOTs to eliminate one post to avoid an obstruction in a guardrail run installed adjacent to curbs and ensures that its safety performance remains adequate with respect to the current vehicle fleet.

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 #107	☐ Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☑ Quarter 3 (July 1 – September 30) ☐ Quarter 4 (October 4 – December 31)

Project Title:		
Top Mounted Socket for Weak Post Bridge Rail		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211132001	RPFP-17-AGT-3	10/1/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2019	9/30/2019	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**
$128,145	$42,831	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**
	$3,528	

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. A prior project (Pooled Fund YR 25 - TPF-5(193): Development of a Standardized Concrete Parapet for AGTs) ultimately resulted in an unsuccessful full-scale crash test. This project is a continuation of that effort and will utilize the knowledge obtained from the previous crash test.

Objectives / Tasks:

1. Redesign of Standardized Parapet
2. CAD Details
3. Construction of Test Article
4. Full-Scale Crash Testing - MASH 3-21
5. Data Analysis

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

Work continued to complete the summary report, which will detail all design and testing of the standardized buttress along with guidance for installing the buttress in real world AGTs. Specifically, recommendations for shape transitions within the buttress to match up with adjacent concrete barriers and bridge rails were developed and drawings were created detailing these recomendations.

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 large portion of this effort was charged to the original design project form Year 25 of the Midwest Pooled Fund Program (TPF-5(193) Suppl. #81). All labor costs were charged to the original project (Pooled Fund YR 25 - TPF-5(193): Development of a Standardized Concrete Parapet for AGTs) until those funds were exhausted and teh Phase I project was closed in July 2018. Labor charges after July 2018 were made to this YR 27 continuation project. Test and materials charges for the full-scale test were still applied to this YR 27 project.

In a May 2017 memo, the FHWA declared that eligibility letters will now only be granted to systems that have completed the entire suite of tests within the MASH testing matrix. Since the small car test (MASH 3-20) was previously deemed non-critical by MwRSF and the Pooled Fund States, it will not be conducted as part of this project. Thus, the transition buttress will not meet FHWA's new criteria to qualify for a letter, and an application for a letter will not be submitted. Instead, MwRSF's opinion on the crashworthiness of the buttress will be explicitly written in the report and supported with details and references.

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): 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. #108	**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: MASH Testing of the Thrie Beam Bullnose System – Phase I		
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: 2611211136001	**Other Project ID (i.e., contract #):** RPFP-17-BULLNOSE-1	**Project Start Date:** 10/1/2016
Original Project End Date: 9/30/2019	**Current Project End Date:** 9/30/2019	**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
$275,477.00	$275,477.00	90%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$4,231	

Project Description:

The research objective is to conduct full-scale vehicle crash testing on the thrie-beam bullnose median barrier system according to Test Level 3 (TL-3) of the MASH 2016 impact safety standards. The research effort will focus on either the timber CRT post or the UBSP steel-post variation of the barrier system.

The research effort for this study will focus on the evaluation of the thrie-beam bullnose system to the MASH 2016 criteria through a series of full-scale crash tests. The thrie-beam bullnose system is classified as a non-gating crash cushion for the purposes of evaluation. In MASH 2016, as many as ten full-scale crash tests are potentially required to evaluate this type of hardware. Those tests are listed in Table 11.

Out of the ten required crash tests, two tests may potentially be deemed non-critical. Test no. 3-36 on the transition to the rigid structure may not be required as it is assumed that the bullnose will use MASH TL-3 approved thrie-beam approach guardrail transitions for attachment to any rigid structures. Test no. 3-38 is intended to evaluate the performance of mid-sized sedan vehicles with terminals and crash cushions. However, MASH uses an analytical estimation of 1500A vehicle decelerations based on the results of test no. 3-31 to determine whether or not this test is required. Thus, test no. 3-38 may potentially be deemed non-critical as well. MwRSF would need to consult with FHWA officials prior to omitting either test. All ten tests are included herein for completeness.

Due to the extensive number of crash tests required to evaluate the thrie-beam bullnose, MwRSF will phase the full-scale crash testing in order to more efficiently determine the potential for the system to meet the MASH TL-3 criteria. Phase I will consist of evaluation of the bullnose with three of the potentially most critical crash tests, while Phase II will be funded at a later date if the three initial full-scale crash tests are successful.

Phase I

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

MwRSF surveyed the sponsoring states to determine whether they preferred the steel post or timber post version of the bullnose system be evaluated. The responses indicated that steel post version of the system was preferred.

CAD details for the steel post bullnose system were developed and parts were ordered and fabricated. The base plate of the lower portion of the UBSP post was increased in thickness by 1/8" to prevent damage and allow it to be more reusable following an impact. Critical impact points for each of the three tests were also selected.

On March 3, 2017, MwRSF conducted test no. MSPBN-1 according to MASH test designation no. 3-35. For non-gating crash cushions, this test is designed to evaluate a CIP where the crash cushion behavior transitions from capture to redirection with the 2270P vehicle. The critical impact point (CIP) for test designation no. 3-35 was selected at post no. 3, which is halfway between the cable anchor at post no. 1 and the assumed beginning of LON/redirection point at post no. 5. In test no. MSPBN-1, a 5,001 lb. Dodge Ram Quad Cab pickup truck impacted the thrie beam bullnose at a speed of 62.9 mph and an angle of 26.7 degrees. Initial impact occurred, 4 in. downstream of the targeted impact point at post no. 3. After initial impact, the vehicle was captured and safety redirected by the bullnose system. As the vehicle redirected UBSP post nos. 5 through 8 were fractured and disengaged. This created some pocketing and snag at post nos. 9 and 10, which were the first two W6x8.5 posts in the system. However, this behavior did not compromise vehicle capture or stability and did not negatively affect the occupant risk values. Occupant risk values for the test were well below the MASH limits and occupant compartment deformations were minimal. Based on these values and the safe capture and redirection of the 2270P vehicle, this test was deemed acceptable under the MASH TL-3 criteria for test designation no. 3-35.

The second test of the system was conducted on March 22, 2017. Test no. MSPBN-2 was conducted according to MASH

Anticipated work next quarter:

In the upcoming quarter, MwRSF will work towards completion of the summary report of the three full-scale crash tests.

Significant Results:

CAD details of the bullnose system were developed and system fabrication and construction is underway.

Three successful full-scale crash tests were completed to MASH TL-3.

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

None.Note that because there are two ongoing an related bullnose projects through the Midwest Pooled Fund, MwRSF is depleting the funding from this Year 27 effort prior to charging the Year 28 project.

Some of the reporting effort for this project will be charged to the Year 28 project as portions of the Year 28 testing were charged to this portion of the research.

Potential Implementation:

The thrie-beam bullnose system provides a safe, cost effective, non-proprietary option for shielding of median piers and other median hazards. Evaluation of the barrier system to the MASH 2016 criteria will allow the state DOTs to continue to use this system on their roadways and ensure that its safety performance will remain adequate with respect to the current vehicle fleet.

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #110	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title: Pooled Fund Center for Highway Safety		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-9070	**E-Mail** kpolivka2@unl.edu
Lead Agency Project ID: 2611211131001	**Other Project ID (i.e., contract #):** RPFP-17-PFCHS	**Project Start Date:** 10/1/2016
Original Project End Date: 9/30/2019	**Current Project End Date:** 9/30/2019	**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
$12,668	$12,668	100%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,789	

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.

Updated research hub with new completed projects.

Anticipated work next quarter:

None.

The project funds were depleted this quarter and the project was closed. All further project progress will be reported the next years project.

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; 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; and Project No.: RPFP-15-PFCHS – TPF-5(193) Supplement #84, Project Title: Pooled Fund for Highway Safety; and Project No.: RPFP-16-PFCHS – TPF-5(193) Supplement #97, Project Title: Pooled Fund for Highway Safety. Funding from Project No.: RPFP-16-PFCHS – TPF-5 (193) Supplement #97, Project Title: Pooled Fund for Highway Safety was 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 Transportation

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #111	☐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:**
2611211137001	RPFP-17-TF13	10/1/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2019	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$3,686	$525	15

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$402	

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.):

Updating drawings based on comments.

Anticipated work next quarter:

Update drawings based on comments received from online review of drawings as they are obtained.

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-16-TF13 – TPF-5(193) Supplement #98, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans will be used prior to starting this project. As of the 2nd quarter of 2017, 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): 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. #113	☐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 & Evaluation of a Culvert-Mounted, Strong-Post MGS to TL-3 Guidelines		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Bielenberg, Faller, Reid, Rosenbaugh	(402) 472-9070	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130103001		10/01/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
3/31/2018	12/31/2018	2

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**
$233,945	$193,972	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**
	$16,682	

Project Description:

Based on previous NCHRP Report No. 350 and MASH testing of culvert mounted guardrail systems, the WisDOT desires to evaluate the MGS installed on a culvert with the MwRSF version of the strong-post attachment, half-post spacing, and a 12-in. offset from the back of the post to the culvert headwall. WisDOT also desires evaluation of the culvert mounted posts using an epoxy anchorage rather than the through-bolt system used in the original design. It is believed that if the epoxy anchorage performs adequately, then through-bolted option posts would work equally as well.

The research objective is to conduct full-scale vehicle crash testing on the MGS installed on a culvert with the MwRSF version of the strong-post attachment with epoxy anchorage, half-post spacing, and a 12-in. offset from the back of the post to the culvert headwall. All testing will be performed according to the Test Level 3 (TL-3) impact safety standards found in MASH 2016.

Objectives / Tasks
1. Simulated culvert CAD details
2. Simulated culvert construction
3. System CAD details - test no. 1
4. System construction - test no. 1
5. Full-scale crash testing & data analysis (MASH 3-11) - test no. 1
6. System CAD details - test no. 2
7. System construction - test no. 2
8. Full-scale crash testing & data analysis (MASH 3-10) - test no. 2
9. System removal
10. Transition analysis and guidance
11. Written report documenting design, testing, and conclusions

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

MwRSF conducted the first of the two full-scale crash tests on the MGS system installed on culvert. Test no. CMGS-1 on 12/1/2017. In this test, a 1100C small car vehicle impacted the barrier system at a speed of at 61.3 mph and an angle of 25.1 degrees. During the impact, the vehicle was captured and stably redirected. Occupant risk criteria were within the MASH limits. It should be noted that a partial tear of the rail splice downstream of impact was noted during the test. This type of rail tearing has been observed in other small car tests of increased stiffness MGS systems and is believed to be due to combined loading of the rail splice by the small car. However, the integrity of the rail was not compromised nor did the tear adversely affect the performance of the barrier in the test. This test was deemed successful under the MASH TL-3 impact conditions.

In this quarter, MwRSF conducted the second full-scale crash test on the strong post MGS mounted on culvert. In test CMGS-2, a 5,013 lbs. Ram 1500 Quad Cab pickup truck impacted the barrier at a speed of 62.8 mph and an angle of 25.7 degrees. During the test, the vehicle was captured and smoothly redirected by the culvert mounted guardrail. Some wheel snag was observed on the posts, but the vehicle stability and occupant risk evaluation were well within the MASH TL-3 criteria. No evidence of high rail loads or the potential for rail rupture were observed. The MASH TL-3 test evaluation criteria values were all found to be acceptable. Barrier damage was moderate and consisted of damaged W-beam and deformed posts. Two of the posts were disengaged from their base plates due to fracture at the base of the post. Static and dynamic barrier deflections are still being evaluated but will not affect the test outcome. Vehicle damage was moderate and occupant compartment deformations were well within limits. MwRSF believes that test no. CMGS-2 met the MASH TL-3 criteria.

The internal draft of the summary report for the research effort and testing was completed and is currently in review. An

Anticipated work next quarter:

In the next quarter, MwRSF plans to continue working towards completion of the summary report and the LS-DYNA transition analysis.

Significant Results:

None.

Task	% Completed
1. Simulated culvert CAD details	100%
2. Simulated culvert construction	100%
3. System CAD details - test no. 1	100%
4. System construction - test no. 1	100%
5. Full-scale crash testing & data analysis (MASH 3-11) - test no. 1	100%
6. System CAD details - test no. 2	100%
7. System construction - test no. 2	100%
8. Full-scale crash testing & data analysis (MASH 3-10) - test no. 2	100%
9. System removal	100%
10. Transition analysis and guidance	55%
11. Written report documenting design, testing, and conclusions	75%
12. Hardware Guide drawings	0%
13. FHWA eligibility application	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).

Due to the timing of the full-scale crash testing and the need to complete the transition analysis, MwRSF requested and received a no-cost extension for this research until 12/31/18.

Potential Implementation:

A strong-post attachment for mounting the MGS on low-fill culverts will provide a safe, cost effective, non-proprietary option for the placement of guardrail across culverts that are too wide for current long-span guardrail systems. Evaluation of the barrier system to the MASH 2016 criteria will allow state DOTs to continue to use this systems on roadways and ensure that its safety performance will remain adequate with respect to the current vehicle fleet. Full-scale crash testing will also identify the dynamic deflection and working width of the barrier system with respect to the current vehicle fleet.

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. #114	☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31)

Project Title: Evaluation of Anchored Temporary Concrete Barrier to MASH 2016 TL-3		
Name of Project Manager(s): Faller, Bielenberg, Reid	**Phone Number:** (402) 472-9064	**E-Mail** rbielenberg2@unl.edu
Lead Agency Project ID: 2611130104001	**Other Project ID (i.e., contract #):**	**Project Start Date:** 10/01/2016
Original Project End Date: 5/31/2018	**Current Project End Date:** 11/30/2018	**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
$190,745.00	$124,998	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
	$308	

Project Description:

The research objective is to conduct full-scale vehicle crash testing on both the bolt-through, tie-down anchorage system for concrete road surfaces with a reduced embedment epoxy anchorage as well as the steel pin tie-down anchorage system for asphalt surfaces. All testing will be performed on F-shape PCB according to the Test Level 3 (TL-3) impact safety standards found in MASH 2016.

The research effort for this study will test and evaluate the bolt-through, tie-down system for concrete road surfaces and the steel pin tie-down system for asphalt surfaces for use with F-shape PCBs to MASH 2016. MASH 2016 requires two full-scale crash tests to evaluate the length-of-need of longitudinal barriers.

Test no. 3-10 with the 1100C vehicle may be omitted as it is not deemed critical for evaluation of the barrier system. Previous full-scale crash tests of rigid safety-shape concrete barriers under both NCHRP Report No. 350 and MASH have found that safety-shape barriers can safely redirect small car vehicles. Additionally, small car testing of New Jersey shape PCB systems found that deflections during small car impacts are generally minor, and that the small car performance with respect to the PCB was similar to the rigid barrier testing. Based on these previous tests, it is believed that the small car testing would not be necessary to evaluate the tie-down anchorages for use with F-shape PCBs. Test no. 3-11 is more critical due to concerns for increased barrier loading during 2270P impacts, the need to evaluate the barrier restraint system, and determine dynamic deflection and working width. It should be noted that it may be worthy to consider evaluation of the system with the 1100C vehicle in order to build further confidence in the safety performance of these systems based on the recent switch to new vehicle types as part of the implementation of the MASH criteria and the lack of experience and knowledge regarding the performance of the new vehicle types with certain types of hardware. Additionally, it should be noted that any tests within the evaluation matrix deemed non-critical may eventually need to be evaluated based on additional knowledge gained over time or additional FHWA eligibility letter requirements.

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

Preliminary discussions with the sponsor were held this quarter concerning the potential to modify the anchors used in the bolt-through, tie-down system for concrete road surfaces. There has been some concern in the past regarding the use of plain steel anchor rods epoxied into bridge decks due to the potential for corrosion if left in place. In order to remove these rods, they must be cored out of the deck which is problematic. Thus, the potential to replace the A307 rods fro the original system with stainless steel rods of equivalent strength was discussed. This would allow the rods to remain in place after use.

MwRSF has began research of potential stainless steel rod materials for use in the bolt-through, tie-down system for concrete road surfaces. Once an appropriate material is identified, MwRSF will review the material with WisDOT to get t heir feed back prior to developing CAD details and fabrication of a test system.

In this quarter, MwRSF finalized the details for the full-scale test setups. For the concrete anchorage, review of the potential stainless steel anchors indicated that 300 series stainless steels should provide the best corrosion resistance and comes ins several grades with greater strength and ductility than A307 Grade A. If the test was conducted with a 316 stainless anchor with greater capacity than the original A307 anchor and the test passes MASH TL-3, the A307 anchor may no longer be considered crashworthy as it has lower capacity. Thus, there were two potential options for moving forward.

1. Test with the original A307 anchor and then use engineering analysis to justify the 316 stainless anchors as an alternative based on the material strength.
2. Test with the 316 stainless anchors. Then we may need to specify a stronger (a449 or A193 B7) plain steel threaded rod as an equivalent.

After discussion with WisDOT, it was decided to pursue option 1.

Anticipated work next quarter:

In the upcoming quarter, MwRSF will work on finalizing the summary report of the two full-scale crash tests.

Significant Results:

CAD details for both of the PCB anchorage tests were completed.

Test no. WITD-1 on the concrete anchored PCB was successful under MASH TL-3.

Test no. WITD-2 on the asphalt anchored PCB was unsuccessful under MASH TL-3.

A follow on proposal to revise the failed system in WITD-2 has been funded by WisDOT.

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 no-cost project extension was given that revised the completion date to 11/30/2018.

Potential Implementation:

The tie-down anchorages for use with F-shape PCBs provide a safe, cost effective, non-proprietary option for reducing the deflection of free-standing PCBs and retaining PCB segments installed adjacent to drop-offs and bridge deck edges. Evaluation of the barrier systems to the MASH 2016 criteria will allow state DOTs to continue to use these systems on roadways and ensure that their safety performance will remain adequate with respect to the current vehicle fleet. Full-scale crash testing will also identify the dynamic deflection and working width of the barrier systems with respect to the current vehicle fleet.

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl #115

Project Title: Minnesota DOT Evaluation of MnDOT's Noise Wall System Under MASH TL-3

Principal Investigator: Ronald K. Faller

Principal Contact Information Email: rfaller1@unl.edu **Phone:** (402) 472-6864

Project Start Date: 4/6/2017 **Project Completion Date:** 1/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☐ **On Schedule**
- ☒ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning and Correspondence	$14,635.00	2%	$300.00	100%	$0.00
2. Phase I Full-Scale Testing	$185,692.00	2%	$17,000.00	100%	$3,613.00
3. Phase II Full-Scale Testing	$79,788.00	13%	$1,834.00	90%	$56,250.00
4. Reporting and FHWA letter	$25,000.00	8%	$2,000.00	50%	$15,269.00
5.					
6.					
7.					
8.					
9. Total	$305,115.00		$19,134.00		$75,132.00

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

The draft report was prepared and submitted to MwRSF's internal review system. Internal review has continued on the report. The systems were removed and disposed of from the test site. Additionally, a journal paper was prepared and submitted on this project to the Transportation Research Board. The topic was selected to be presented at a lectern session at TRB on January 15, 2019.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

The projected timeline included in the proposal including the project starting in January 2017 and extending through March 31, 2018 (5 quarters total). The contract was not approved until April 6, 2017. Thus, the project started over a quarter behind. As of April 6, 2018, all three full-scale crash tests have been completed. However, not all of charges have been applied to the project and are not reflected in this progress report. An extension was requested and approved to extend the project to September 30, 2018 to allow sufficient time to process all of the test data as well as prepare and review the summary report. An additional extension was requested and approved until January 31, 2019 to allow more time for internal and sponsor review of the report. Additionally, the project has been under budget thus far and remaining funds will be returned to the sponsor upon project close.

Anticipated Work Next Quarter:

The report will be sent to the sponsor for review.

Total Percentage of Project Completion:

90%

Research Project Quarterly Progress Report

Date: 7/24/2018 **Project Number:** TPF-5(193) Suppl#116

Project Title: Illinois DOT and Ohio DOT MASH TL-4 Steel Tube Bridge Rail and Guardrail Transition

Principal Investigator: Ronald K. Faller

Principal Contact Information Email: rfaller1@unl.edu **Phone:** (402) 472-6864

Project Start Date: 5/4/2017 **Project Completion Date:** 9/30/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☐ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☒ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Bridge Rail Planning, Literature Review, Design	$53,131.00	0%	$0.00	100%	$0.00
2. Bridge Rail Full-Scale Testing	$344,162.00	3%	$10,000.00	7%	$308,674.00
3. Bridge Rail Reporting	$30,000.00	20%	$3,000.00	30%	$13,000.00
4. Bridge Deck Component Testing	$187,956.00	36%	$51,530.00	90%	$7,953.00
5. Transition Planning	$13,859.00	50%	$7,000.00	50%	$6,859.00
6. Transition Analysis and Design	$67,261.00	0	$0.00	0	$67,261.00
7. Transition Full-Scale Testing	$200,482.00	0	$0.00	0	$200,482.00
8. Transition Reporting	$30,000.00	0	$0.00	0	$30,000.00
9. Total	$926,851.00		$71,530.00		$634,229.00

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Five component tests were conducted on additional post-to-deck connections. In test no. ILOH4-3, a single 1" thick place was welded to the lower portion of the post flange and connected to the web with gussets, and 1/2" thick HSS tubes were used as spacers. Due to poor weld quality, premature weld failure occurred. After the fabricator fixed the poor welds, test no ILOH4-4 was conducted on the same setup at a 4.5" stirrup spacing in the prestressed box. The flange and web tore after reaching the capacity. The same post-to-deck connection was tested in test no. ILOH4-5, only with a 9" stirrup spacing in the prestressed box. The posts hinged above the gussets after reaching the capacity. The same post-to-deck connection was test in test no. ILOH4-6, only a 24" threaded embedment was evaluated in a solid end section (instead of a 32" embedment near the hollow interior). The post hinged above the gussets after reaching the capacity. Since the third test did not result in any usable results due to fabricator error, an additional bogie test was conducted. In test no. ILOH4-7, a 15" threaded embedment was evaluated in a solid end section, and 3/4" thick plate attachment was utilized. The post formed a plastic hinge above the gussets after reaching capacity. However, the 3/4" plate was bent at the top.

A meeting was held with the sponsors on August 31, 2018 to discuss the results of the bogie testing and finalize details for the upcoming full-scale crash tests. During this meeting, solutions were proposed to prevent concrete spalling during tightening of the threaded rods, and the sponsors agreed to implement lower coupler nuts. Additionally, the surrogate bridge deck was discussed. The capacity of the bridge rail was also re-calculated using the capacities determined during the bogie tests. The overall bridge rail capacity was lower, and both the research team and sponsors that it would still have a satisfactory performance as the calculations are conservative.

The drawings and details for the steel stube bridge rail test installation were drafted. The test pit for the bridge rail has been excavated and prepared for the construction of the system.

Initial planning, literature review, and concept development began on the approach guardrail transition.

Writing continued on the 2 summary reports - 1) bridge rail design and analysis and 2) post-to-deck attachemtn design and analysis.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

The original gantt chart in the proposal had the project starting in April 2017. Due to the time it took to get the contract in place (May 4, 2017), the project timeline will be shifted by approximately 1 month. Along with the initial delay, design and optimization of the connections and rails has taken longer than expected. Part of these delays are due to the mutliple rounds of design that were required to meet the sponsors' desires, especially with the rail sizes, post spacing, connections, and post-to-deck connection spacer. This level of design was not anticipated, and we have spent more funds than originally budgeted. The component and full-scale crash tests have not begun as early as anticipated and are delayed several months from the gantt chart. Every effort will be made to get the project completed by its original end date (September 30, 2019). The project is currently behind on its proposed budget, but the project team will work to make up for these additional funds.

Anticipated Work Next Quarter:

Materials will be orderd for the bridge rail system. Construction and installation will begin on the bridge deck and rail system.

The literature review on the AGT will be completed, and concepts will be further refined. Refined AGT concepts will be presented to the sponsors.

Writing will continue on the summary reports.

Total Percentage of Project Completion:

20%

Research Project Quarterly Progress Report

Date: 4/30/2018 **Project Number:** TPF-5(193) Suppl #117_OHIOSS-1

Project Title: MASH TL-3 Evaluation of the Ohio Single-Slope Concrete Barrier

Principal Investigator: Dr. Ronald K. Faller and Mr. Robert W. Bielenberg

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 7/1/2017 **Project Completion Date:** 12/31/2018

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☐ **On Schedule**
- ☒ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning and Correspondence	$5,000.00	25%	$850.00	70%	$2,650.00
2. Full-Scale Crash Testing	$116,259.00	0%	$4,728.00	95%	$51,905.00
3. Reporting and Project Deliverables	$14,155.00	50%	$3,244.00	95%	$6,411.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Test, no. OSSB-1 was conducted on 12/13/17. In test OSSB-1, a 5,001 lbs. Ram 1500 Quad Cab pickup truck impacted the barrier at a speed of 101.0 mph and an angle of 24.8 degrees. During the test, the vehicle was captured and smoothly redirected by the single slope barrier. Some wheel snag was observed at the vertical separation in the barriers that was included to represent through cracking of the unreinforced barrier, but the vehicle stability and occupant risk evaluation were well within the MASH TL-3 criteria.

Occupant risk criteria are shown below. Note that OIV must be less than 40 ft/s and ORA must be ≤ 20.49 g's. All of the values were acceptable.

PRIMARY UNIT: SLICE2

Longitudinal	MASH			
ORA	-9.3566148	g's	@	0.0841 sec
OIV	-19.179486	ft/s		
Time	0.0791 sec			

Lateral	MASH			
ORA	10.4034925	g's	@	0.2125 sec
OIV	26.9061463	ft/s		
Time	0.0791 sec			

Vehicle stability was also acceptable vehicle remained upright and stable during the impact and the maximum roll angle of the vehicle was 20.0 degrees and the maximum pitch angle was 6.6 degrees. Barrier damage was minimal and was limited to minor spalling and cracking of the barrier. Dynamic barrier deflections were less than 1" at the top of the first impacted barrier segment, and permanent set deflections were negligible.

Vehicle damage was moderate. Detailed occupant compartment deformations have not been measured, but visual inspection of the vehicle floorboard and interior suggested that they were well below the MASH limits as well. There was a small tear at the floor seam, about an inch long. We don't believe this is an issue based on MASH recommendations. MwRSF believes that the minimal floorboard seam in this test falls under the safe limits noted in MASH. Thus, test OSSB-1 was successful under MASH TL-3 impact conditions.

In this quarter, implemented sponsor comments on the final report and will close the project in the finla 3 months of 2018.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

Other project priorities and needs limited work on the completion of the summary report for this project. As the due date for completion was 7/31/2018. However, there is no issue with remaining projects funds. Thus, MwRSF will requested and received a no-cost time extension until 12/31/2018.

Anticipated Work Next Quarter:

Closing of the project.

Total Percentage of Project Completion:

95%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #118, RPFP-18-CABLE-1

Project Title: Redesign of the High-Tension Cable Median Barrier (Continuation)

Principal Investigator: Reid, Faller, Bielenberg, Lechtenberg, Rosenbaugh, Schmidt

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Correspondence & Reporting	$29,614.00	15%	$5,000.00	50%	$7,371.00
2. Design and Analysis	$20,386.00	25%	$5,520.00	85%	$12,746.00
3. Bogie Testing	$0.00	0%	$0.00	0%	$0.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Internal draft report on the nineteen dynamic component tests and one floorpan cutting dynamic component test on the closed post sections completed. Internal review was initiated.

Conducted 14 tensile tests on various sleeve nut designs for connecting the tabbed bracket to the new post design. Combinations of dome and cone head sleeve nuts as well as plain and corrosion resistance finishes were evaluated. All designs performed similarly with the bolt failure around 7 kips. The dome head was chose due to a rounder profile.

System drawings were completed with the new HSS3x2x1/8 post, existing cable bracket, and new cone shaped head sleeve nut.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

This project will not be started until the original project funds (Project No. TPF-5(193) Supplement #89 - RPFP-16-CABLE-4) have been exhausted. The funds in the aforementioned project were exhausted in Quarter 1 of 2018. All progress was noted under the previous project and further progress will be noted herein starting in Quarter 2 of 2018.

This is supplemental funding of the ongoing cable median barrier development project. Only $50,000 was funded of the total project costs. This effort will be conducted to the extent possible using these funds and existing funding from previous years noted.

Anticipated Work Next Quarter:

Complete internal review of the dynamic component test report on closed post sections. Potentially send draft report to the member states.

Continue to write the research report on the sleeve nut development and testing.

Acquire materials for the first system. Begin construction on the first system.

Total Percentage of Project Completion:

60%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #119 or RPFP-18-CONC-1

Project Title: PCB Steel Cover Plate for Large Open Joints - PHASE II

Principal Investigator: Rosenbaugh, S.K., Reid, J.D., Bielenberg, R.W., Faller, R.K., & Lechtenberg, K.A.

Principal Contact Information Email: srosenabugh2@unl.edu **Phone:** (402) 472-9324

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31) ---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30) ---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total Expenses to Date	Total % of Task Completed	Remaining Budget
1. Project Planning and CAD	$15,299.00	10%	$2,237.00	$12,799.00	85%	$2,500.00
2. Full-Scale Crash Testing	$132,517.00	60%	$50,000.00	$122,167.00	90%	$10,350.00
3. Reporting and Project Deliverables	$25,000.00	40%	$10,000.00	$10,000.00	10%	$15,000.00
4.						
5.						
6.						
7.						
8.						
9. Total Project	$172,816.00		$62,237.00	$144,966.00		$27,850.00

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

The second of 2 budgeted full-scale crash tests was conducted on the system. The test installation for this test incorporated a 3-ft gap between the the PCBs with a single stiffener located at the gap midspan and between the front and back-side thrie beam rails.This second test was conducted to evaluate potential vehicle stability issues when the vehicle impacts the thrie beam just downstream of short gap lengths as computer simulations on this configuration resulted in high vehicle roll displacements and occasional rollovers. As such, test GSH-2 was conducted according to MASH test 3-11 with the 2270P pickup truck impacting the test installation 12-in. downstream of the 3-ft gap. During the test, the vehicle was captured and redirected by the barrier system. The vehicle experienced significant roll toward the barrier as predicted by the simulation analysis. The vehicle reached a maximum roll of 40 degrees before returning to its upright position. The pickup truck came to rest downstream and in front of the system in a stable manner. All of the vehicle accelerations were within MASH limits, and all other evaluation criteria were satisfied.

Damage to the system consisted mostly of contacts marks to the rail and concrete damage to the impacted PCB on the downstream end of the gap. The front toe of the PBC was cracked and fractured at multiple locations along the toe-plate anchorage bolts. An additional section of the PCB toe broke away from the backside of the PCB adjacent to the downstream end of the toe plate, and concrete cracks were observed on the backside of the PCB just above this location. The maximum permanent set deflection of the system was 61 in. located at the first PCB joint downstream of impact.

With the completion of the this second test on the PCB gap spanning hardware system, the test portion of this project has been completed. Both full-scale crash tests were succesffuly conducted to MASH 3-11 conditions on the two previously identified critical system configurations. Note, small car tests (MASH 3-10) were not considered to be critical to the evaluation of the system, and tus, were not conducted.

Work also began on the project summary report documenting the full-scale testing. The Phase I report in undergoing internal edits before being sent out to the sponsoring agencies for comments and edits.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

This project was not started until the Phase I project (Pooled FUnd Year 26 project TPF-5(193) Suppl. #82) was completed, as Phase I contained the full design, analysis, and selection of the critical impact points required for full-scale testing. This Phase II was funded with this understanding as the project plan (Gantt chart) did not anticipate work to begin on this project until spring of 2018. The project is still anticipated to be completed on time.

Anticipated Work Next Quarter:

Work will continue on both the full-scale testing report (Phase II report) and the original Phase I report, which detailed the design and computer simulations of the system. Additionally, a project update presentation will be put together and shown to the sponsors at the Midwest Pooled Fund mid-year meeting in November.

Total Percentage of Project Completion:
80%

Research Project Quarterly Progress Report

Date: 4/30/2018 **Project Number:** TPF-5(193) Suppl. #123 RPFP-18-BULLNOSE-1

Project Title: MASH Testing of the Thrie Beam Bullnose System – Phase II

Principal Investigator: Jennifer Schmidt, J. Reid, R. Faller, R. Bielenberg, K. Lechtenberg, S. Rosenbaugh

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning and Correspondence	$19,019.00	25%	$1,717.00	25%	$17,302.00
2. Full-Scale Crash Testing	$364,028.00	50%	$83,348.00	90%	$208,278.00
3. Reporting and Project Deliverables	$27,719.00	0%	$2,845.00	10%	$24,874.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Test no. MSPBN-5 was conducted on the thrie beam bullnose system. Recall that this test is a repeat of test no. MSPBN-4, test designation no. 3-10, which failed due to poor vehicle capture and vehicle penetration through the system. In order to improve the system performance we added a third nose cable to the system behind the lowest thrie beam corrugation as shown below. Note that the addition of a third nose cable was not expected to affect the system relative to the three previous, successful MASH crash tests (test nos. 3-32, 2-34, and 3-35), and these tests would not need to be rerun if this modification is successful.

Test no. MSPBN-5 was conducted under the MASH TL-3 guidelines for test no. 3-30. Test no. 3-30 is an impact of the 1100C vehicle at 62 mph and 0 degrees on the nose of the system with a ¼ vehicle offset. In test no. MSPBN-5, a 2,409 lbs. Kia Rio sedan impacted the barrier at a speed of 62.7 mph and an angle of 0.31 degrees. During the test, the vehicle was captured by the thrie beam nose of the system. As the vehicle proceeded into the system, the thrie beam rail and nose cables remained wrapped around the front of the vehicle. The deformation of the thrie beam panels and the disengagement of several breakaway posts on both sides of the system decelerated the vehicle to a safe and controlled stop. The MASH TL-3 test evaluation criteria were met. Thus, the modified bullnose system was acceptable under the MASH TL-3 criteria.

Test no. MSPBN-6 was conducted under the MASH TL-3 guidelines for test no. 3-31. Test no. 3-31 is an impact of the 2270P vehicle at 62 mph and 0 degrees on the nose of the system. In test no. MSPBN-6, a 5,061 lbs. Kia Rio sedan impacted the barrier at a speed of 63.4 mph and an angle of 0.21 degrees. During the test, the vehicle was captured by the thrie beam nose of the system. As the vehicle proceeded into the system, the thrie beam rail and nose cables remained wrapped around the front of the vehicle. The deformation of the thrie beam panels and the disengagement of several breakaway posts on both sides of the system decelerated the vehicle to a safe and controlled stop. The pickup truck was brought to a controlled stop in approximately 54 ft. The MASH TL-3 test evaluation criteria were met. Thus, the modified bullnose system was acceptable under the MASH TL-3 criteria.

Test no. MSPBN-7 was conducted under the MASH TL-3 guidelines for test no. 3-33. Test no. 3-33 is an impact of the 2270P vehicle at 62 mph and 15 degrees on the nose of the system. In test no. MSPBN-7, a 5,043 lb. Ram Quad Cab pickup impacted the barrier at a speed of 63.1 mph and an angle of 15.1 degrees. During the test, the vehicle was captured by the thrie beam nose of the system. As the vehicle proceeded into the system, the thrie beam rail and nose cables remained wrapped around the front of the vehicle. The deformation of the thrie beam panels and the disengagement of breakaway posts on both sides of the system decelerated the vehicle to a safe and controlled stop. It was noted that late in the impact event, approximately 500 msec after impact, the vehicle engaged some of the buildup of breakaway post debris and the first non-breakaway post on the left side of the system which caused the vehicle to climb up the posts and roll to the right slightly as it was brought to a stop. This behavior did not cause issues with vehicle capture or the overall stability of the vehicle, nor did the override of the post debris cause any contact or tearing of the floor board. The pickup truck was brought to a controlled stop in approximately 54 ft. The MASH TL-3 test evaluation criteria were met. Thus, the modified bullnose system was acceptable under the MASH TL-3 criteria.

Test no. MSPBN-8 was conducted under the MASH TL-3 guidelines for test no. 3-37b. Test no. 3-37b is an impact of the 1100C vehicle at 62 mph and 25 degrees on the system in the reverse direction. The critical impact point for this test was selected to maximize the potential for vehicle interaction and snag on the cable anchorage near the upstream end of the bullnose system. In test no. MSPBN-8, a 2,394 lb. Kia Rio Sedan impacted the barrier at a speed of 63.2 mph and an angle of 25.0 degrees at the fourth post upstream of the cable anchorage. This impact point was the same impact point used previously in the evaluation of the trailing end anchorage for the MGS (test no. WIDA-2). During the test, the vehicle was captured and redirected by the thrie beam. During the redirection of the vehicle, deflection of the UBSP and BCT posts was noted, but none of the posts fractured. It was noted that the left-front wheel of the vehicle clipped the final BCT post and disengaged a small piece of the post near the base. However, vehicle interaction with the cable anchorage was not observed and the anchorage remained intact. Vehicle capture and stability of the vehicle were good and occupant risk measures were within the MASH limits. The MASH TL-3 test evaluation criteria are shown

on the attached pdf file, and all of the evaluation criteria were met. Note that after exiting the bullnose system, the small car impacted protective PCBs at the MwRSF test site and rolled onto its side. The stability and trajectory of the vehicle prior to the secondary impact were acceptable, the roll experienced during the secondary impact was not a concern with respect to the system evaluation. Thus, the modified bullnose system was acceptable under the MASH TL-3 criteria.

Test no. MSPBN-8 completes the MASH test matrix for the thrie beam bullnose system with steel posts. This system represents one of the only MASH compliant crash cushions available.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

Note that because there are two ongoing an related bullnose projects through the Midwest Pooled Fund, MwRSF is depleting the funding from the Year 27 effort prior to charging this Year 28 project.

Anticipated Work Next Quarter:

Summary reporting of the full-scale crash testing conducted to date will continue.

Total Percentage of Project Completion:

70%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #120, RPFP-18-MGS-1

Project Title: Steel Post Version of Downstream Anchorage System □ Phase II

Principal Investigator: Reid, Faller, Bielenberg, Lechtenberg, Rosenbaugh, Schmidt

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning & Correspondence	$21,027.00	47%	$10,000.00	47%	$11,027.00
2. Full-Scall Crash Testing	$128,945.00	23%	$30,111.00	23%	$98,834.00
3. Reporting & Project Deliverables	$25,000.00	0%	$0.00	0%	$25,000.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

None.

This is the Phase II of an ongoing project. See the Phase I project (Project no. TPF-5(193) Supplmeent #92 - RPFP-16-MGS-3, Project Title: Steel Post Version of Downstream Anchorage System) for the work completed this quarter.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

This project will not be started until the Phase I project (Project No. TPF-5(193) Supplement #92 - RPFP-16-MGS-3, Project Title: Steel Post Version of Downstream Anchorage System) is completed, as Phase I contains the full design and analysis required for full-scale testing. This Phase II was funded with this understanding as the project plan (Gantt chart) did not anticipate work to begin on this project until spring of 2018. The project is still anticipated to be completed on time.

Anticipated Work Next Quarter:

Internal review of the literature review, patent search, concept development, and component test documentation will continue.

Complete documentation and analysis of test SPTA-2.

Initiate research report of the two crash tests.

.

Total Percentage of Project Completion:

25%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #122; FPFP-18-SIGN-1

Project Title: MASH Testing of Single-Post, U-Channel Sign Supports

Principal Investigator: Jennifer Schmidt, J. Reid, R. Faller, R. Bielenberg, K. Lechtenberg, S. Rosenbaugh

Principal Contact Information Email: jennifer.schmidt@unl.edu **Phone:** (402) 472-870

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning & Reporting	$28,506.00	11%	$3,000.00	33%	$22,643.00
2. Analysis & Selection of Configurations	$24,396.00	32%	$7,909.00	40%	$22,824.00
3. Develop Bogie, Install and Remove Signs	$51,348.00	0%	$0.00	0%	$51,348.00
4. Dynamic Bogie Tests	$90,988.00	0%	$0.00	0%	$90,988.00
5.					
6.					
7.					
8.					
9. Total	$195,238.00		$10,909.00		$176,894.00

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Internal meetings discussing the project plan were held. The research team reviewed prior crash tests and estimated the sign support performance with MASH test designation nos. 3-60, 3-61, and 3-62. The survey results were compiled and further organized. The sign support performance with the MASH tests was estimated for the highest need systems identified from the survey.From the high need systems, a list of several systems for possible bogie testing was compiled. Additionally, MwRSF had an extra MASH small car vehicle from a prior project that was available for use with no additional charge to this project. Thus, one full-scale crash test was conducted according to MASH 3-61 on September 26, 2018 with 3 of the selected signs impacted in one test run. These tests technically counted as 3 separate bogie tests. However, since the crash test met MASH 3-61 requirements, they could also count toward a full-scale crash test. Two of three systems were successful according to MASH 3-61 and one was indeterminate as debris interfered with that impact. The test results were sent to the sponsors, and the research team asked if the states if they desired the successful tests to be written up as full-scale crash tests. Several states responded that they desired for the two tests to count as full-scale crash tests. Thus, these tests will be written as certified MASH tests.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

The full-scale crash test was conducted at the end of the reporting period. Thus, September labor charges and the test charges are not included in this progress report.

Many Pooled Fund members requested that the 2 successful bogie tests be reported as full-scale crash tests since they were conducted according to MASH 3-61 test criteria. This requires additional reporting which may slightly affect the number of bogie tests that can be conducted with this project. However, it is anticipated that much of the original scope of the project will remain the same.

Anticipated Work Next Quarter:

The report will begin to be drafted on the background review and full-scale crash tests. The research team will start development of the bogie vehicle and make plans for future bogie tests to be conducted.

Total Percentage of Project Completion:

12%

Research Project Quarterly Progress Report

Date: 7/31/2018 **Project Number:** TPF-5(193) Suppl. #124 RPFP-18-CONSULT

Project Title: Annual Consulting Services Support

Principal Investigator: Jennifer Schmidt, J. Reid, R. Faller, R. Bielenberg, K. Lechtenberg, S. Rosenbaugh

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. **Project Planning and Correspondence**	$56,310.00	25%	$6,891.00	50%	$34,267.00
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

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.

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.

The summary of the consulting effort for this quarter is given in the attached file - Midwest States Pooled Fund Program Consulting Quarterly Summary-3Q 2018.pdf

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

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/

Total Percentage of Project Completion:
50%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #125, RPFP-18-PFCHS

Project Title: Pooled Fund Center for Highway Safety

Principal Investigator: Reid, Faller, Bielenberg, Lechtenberg, Rosenbaugh, Schmidt

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Website Develop, Populate, and Host	$12,669.00	0%	$0.00	0%	$12,669.00
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

None.

This is continuation funding for the original project. Funds from Project Title: Pooled Fund for Highway Safety. Funding from Project No.: RPFP-17-PFCHS – TPF-5(193) Supplement #110, Project Title: Pooled Fund for Highway Safety will be used prior to starting this project.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

This is continuation funding untill the funds from Project No.: RPFP-17-PFCHS – TPF-5(193) Supplement #110, Project Title: Pooled Fund for Highway Safety have been exhaused.

Anticipated Work Next Quarter:

Maintenance, repair, and upkeep of the website continued.

Updated research hub with new completed projects.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #126, RPFP-18-TF13

Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans

Principal Investigator: Reid, Faller, Bielenberg, Lechtenberg, Rosenbaugh, Schmidt

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 9/15/2017 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Annual CAD Services Support	$3,999.00	0%	$0.00	0%	$3,999.00
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

None.

This is continuation funding for the original project. Funds from Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans. Funding from Project No.: RPFP-17-TF13 – TPF-5(193) Supplement #111, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans will be used prior to starting this project.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

This is continuation funding untill the funds from Project No.: RPFP-17-TF13 – TPF-5(193) Supplement #111, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans have been exhaused.

Anticipated Work Next Quarter:

None until funds from previous project have been exhausted.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #128

Project Title: Crash Testing of Transition between Box Beam and Corrugated Beam Guide Rail

Principal Investigator: Faller, Lechtenberg, Holloway, Asadollahipajouh, Ranjha

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 10/18/2017 **Project Completion Date:** 5/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☐ **On Schedule**
- ☒ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning & Correspondence	$10,985.00	0%	$300.00	70%	$2,878.00
2. Full-Scale Crash Testing	$200,641.00	25%	$50,272.00	60%	$81,321.00
3. Reporting & Project Deliverables	$25,000.00	0%	$0.00	0%	$0.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Acquired materials for second systems. Repaired the system to conduct the next test impacting in the W-beam portion.

On July 24, MwRSF conducted the test on NYSDOT's box beam to W-beam transition according to MASH 2016 test designation 3-21. We impacted the system 8 feet upstream from the leading edge of the box beam (in the W-beam portion of the system) at a speed of 62.5 mph and an angle of 25.7 deg. There was moderate roll of the vehicle, but the vehicle remained upright and the system safely redirected the vehicle. Essentially no occupant compartment deformation was found. All occupant risk values were found to be within the limits. Therefore, test no. NYBWT-3 was determined to be acceptable according to the MASH 2016 safety performance criteria for test designation no. 3-21.

Research report was initiated.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

Anticipated Work Next Quarter:

Continue to compile the results into a draft research report.

Total Percentage of Project Completion:

55%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #129

Project Title: Crash Testing MoDOT Devices

Principal Investigator: Lechtenberg, Faller, Holloway, Schmidt

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 3/1/2018 **Project Completion Date:** 2/28/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☐ **On Schedule**
- ☒ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. System #1 - X-Foot Signs with Trim-line Posts	$109,634.00	0%	$2,312.00	0%	$106259.00
2. System #2 - Crash System with 2 bolts instead of 4	$157,099.00	0%	$0.00	0%	$157,099.00
3. System #4 - Sign Modification with PSST Post	$109,634.00	0%	$0.00	0%	$109,634.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Continuing to wait for sponsor decisions.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

Note project dates were originally 12/27/17 through 12/26/18 but not approved until later.

Anticipated Work Next Quarter:

Awaiting feedback from sponsor on systems that will be tested. Potentially begin drafting test plan and obtain system material if decision is made on what systems will be crash tested.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 7/31/2018 **Project Number:** TPF-5(193) Suppl. #130

Project Title: Development and Evaluation of a MASH TL-3 Compliant Parapet Mounted Fence (Phase I)

Principal Investigator: Robert Bielenberg

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 6/29/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning & Correspondence	$42,874.00	30	$4,000.00	30	$38,736.00
2. Literature & State Standard Review	$47,885.00	20	$10,315.00	20	$37,570.00
3. Phase I Summary Report	$29,329.00	0	$0.00	0	$29,329.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Project was started. Correspondence with Iowa DOT was initiated. State standard plans were collected and archived. Preliminary concepts were investigated as variations of the state DOT designs.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

Anticipated Work Next Quarter:

Complete analysis of state DOT standard plans for debris fences. Complete investigation of full-scale crash testing of debris fence designs. Begin preliminary design for fence components based on existing state plans.

Total Percentage of Project Completion:

15

Research Project Quarterly Progress Report

Date: 7/31/2018 **Project Number:** TPF-5(193) Suppl. #131

Project Title: Crash Safety Evaluation of Concrete Barrier Sloped End Treatments

Principal Investigator: Cody Stolle

Principal Contact Information Email: cstolle2@unl.edu **Phone:** (402) 472-4233

Project Start Date: 6/29/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning & Reporting	$30,198.00	30	$10,300.00	30	$19,898.00
2. Crash Data Analysis	$44,802.00	10	$4,015.00	10	$40,787.00
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Project was started. Correspondence with Iowa DOT was initiated. Some initial cases were obtained at bridges from Iowa's database. Issues with collecting, displaying, and reviewing crash data were resolved. Crashes were mapped in ArcGIS and summarized in a Microsoft Access database.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

Anticipated Work Next Quarter:

Collect crash narratives and scene diagrams for selected bridge end crashes. Begin some summary writeup of work collected to date.

Total Percentage of Project Completion:

15

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #133 RPFP-17-CALTRANS-LSDYNA-1

Project Title: LS-DYNA Simulation Consulting Support

Principal Investigator: R. Bielenberg and J. Schmidt

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 6/27/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. LS-DYNA Model Review and Support	$31,391.00	0%	$0.00	0%	$31,391.00
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

This research effort was initated during this quarter. MwRSF will meet with CALTRANS regarding consultation efforts in the next quarter.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None.

Anticipated Work Next Quarter:

MwRSF will meet with CALTRANS regarding consultation efforts in the next quarter.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #132 NJDOT-THRIE-1

Project Title: Evaluation of Modified Thrie Beam Guardrail under MASH TL-3

Principal Investigator: R. Bielenberg and R. Faller,

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 6/27/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning and Correspondence	$7,042.00	5%	$352.00	5%	$7,042.00
2. Full-Scale Crash Testing	$150,175.00	5%	$12,867.00	8%	$150,175.00
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

This research effort was initated during this quarter. MwRSF has constructed the first of the two modified thrie beam systems for full-scale testing. Both tests are anticpated for completion in the 4Q of 2018.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None.

Anticipated Work Next Quarter:

Conduct to full-scale crash tests of the modifed thrie beam system.

Total Percentage of Project Completion:

10%

TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

INSTRUCTIONS:

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Suppl. #102	☐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 & Evaluation of a New York DOT Prototype Box Beam Guardrail End Terminal System Under AASHTO M

Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Faller, Lechtenberg, Reid, Schmidt	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
261113010001		8/15/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
10/30/2017	7/31/2019	2

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$265,250	$108,988	40%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$1,814	

Project Description:

The New York State Department of Transportation (NYSDOT) has designed a a prototype box beam guardrail end terminal system. They have a desire to preliminarily evaluate it with the more critical MASH tests.

The objective of this research effort is to investigate the performance of a prototype box beam guardrail end terminal system through MASH-compliant crash testing (three preliminary tests).

Objectives / Tasks
1. System CAD details - test no. 1
2. System construction - test no. 1
3. Full-scale crash testing (MASH 3-31) - test no. 1
4. System CAD details - test no. 2
5. System construction - test no. 2
6. Full-scale crash testing (MASH 3-30) - test no. 2
7. System CAD details - test no. 3
8. System construction - test no. 3
9. Full-scale crash testing (MASH 3-36) - test no. 3
10. Written report documenting design, testing, and conclusions

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

Internal review of the draft report was continued

Anticipated work next quarter:

Continue internal review of the draft report.

Significant Results:

None

Objectives / Tasks	% Complete
1. System CAD details - test no. 1	100%
2. System construction - test no. 1	100%
3. Full-scale crash testing (MASH 3-31) - test no. 1	100%
4. System CAD details - test no. 2	
5. System construction - test no. 2	
6. Full-scale crash testing (MASH 3-30) - test no. 2	
7. System CAD details - test no. 3	
8. System construction - test no. 3	
9. Full-scale crash testing (MASH 3-36) - test no. 3	
10. Written report documenting design, testing, and conclusions	
10a. Report - Test no. 1	75%

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:

Investigation and evaluation of the box beam end terminal would provide for MASH TL-3 acceptance of a box beam end terminal.

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #134 Part 1

Project Title: NYSDOT - MASH 2016 Safety Hardware Evaluation - Phase I - System B2a - Type I Flared

Principal Investigator: Faller, Lechtenberg, Holloway, Schmidt, Song, Steelman, Stolle

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 8/1/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning, Correspond, CAD, Material Certs	$43,369.00	2%	$1,091.00	2%	$42,278.00
2. Full-Scale Crash Testing	$517,258.00	0%	$0.00	0%	$517,258.00
3. Reporting & Project Deliverables	$29,838.00	0%	$0.00	0%	$29,838.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Model of the system was initiated in order to develop test plan drawings.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

Anticipated Work Next Quarter:

Complete test plan drawings.

Order and acquire system materials including material certificates/mill certificates/COC

Potentially construct the first system.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #134 Part 2

Project Title: NYSDOT - MASH 2016 Safety Hardware Evaluation - Phase I - System B2b - Type 0 Box

Principal Investigator: Faller, Lechtenberg, Holloway, Schmidt, Song, Steelman, Stolle

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 8/1/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning, Correspond, CAD, Material Certs	$37,326.00	0%	$0.00	0%	$37,326.00
2. Full-Scale Crash Testing	$303,007.00	0%	$0.00	0%	$303,007.00
3. Reporting & Project Deliverables	$25,153.00	0%	$0.00	0%	$25,153.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

None. At the request of the sponsor, work is not to start until after numerous tests in System B2a - Type I Box Beam Terminal have been conducted.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

Anticipated Work Next Quarter:

None, until the sponsor confirms enough tests have been conducted on the System B2a - Type I Box Beam Terminal project.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #135 Part 1

Project Title: NYSDOT - MASH 2016 Safety Hardware Evaluation - Phase I - System C1 - Cable Guide

Principal Investigator: Faller, Lechtenberg, Holloway, Schmidt, Song, Steelman, Stolle

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 8/1/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning, Correspond, CAD, Material Certs	$22,328.00	3%	$864.00	0%	$21,464.00
2. Full-Scale Crash Testing	$263,648.00	0%	$0.00	0%	$263,648.00
3. Reporting & Project Deliverables	$20,468.00	0%	$0.00	0%	$20,468.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

Model of the system was initiated in order to develop test plan drawings.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

Anticipated Work Next Quarter:

Complete test plan drawings.

Order and acquire system materials including material certificates/mill certificates/COC

Potentially construct the first system.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #135 Part 2

Project Title: NYSDOT - MASH 2016 Safety Hardware Evaluation - Phase I - System C3 - Cable Guide Rail Terminal

Principal Investigator: Faller, Lechtenberg, Holloway, Schmidt, Song, Steelman, Stolle

Principal Contact Information Email: kpolivka2@unl.edu **Phone:** (402) 472-9070

Project Start Date: 8/1/2018 **Project Completion Date:** 12/31/2019

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning, Correspond, CAD, Material Costs	$37,812.00	0%	$0.00	0%	$37,812.00
2. Full-Scale Crash Testing	$655,623.00	0%	$0.00	0%	$655,623.00
3. Reporting & Project Deliverables	$33,584.00	0%	$0.00	0%	$33,584.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

None. At the request of the sponsor, work is not to start until after numerous tests in System B2a - Type I Box Beam Terminal have been conducted.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None

Anticipated Work Next Quarter:

None, until the sponsor confirms enough tests have been conducted on the System B2a - Type I Box Beam Terminal project.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #136 FY19-WISC-1-PCB-TIE DOWN MOD

Project Title: Modification and MASH 2016 TL-3 Evaluation of the Asphalt Pin Tie-Down For F-shape PCB

Principal Investigator: R. Bielenberg and R. Faller,

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 8/7/2018 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning and Correspondence	$18,911.00	5%	$0.00	5%	$18,911.00
2. Design and Analysis	$27,234.00	5%	$0.00	5%	$27,234.00
3. Full-Scale Crash Testing	$105,967.00	0%	$0.00	0%	$105,967.00
4. Reporting and Project Deliverables	$8,872.00	0%	$0.00	0%	$8,872.00
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

This research effort was initated during this quarter. MwRSF has begun the process of brainstorming design modifcation options and will further review and develop those options in the upcoming quarter for presentation to WisDOT.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None.

Anticipated Work Next Quarter:

Review and analysis of potential design modifications. Presentation of options to WisDOT.

Total Percentage of Project Completion:

5%

Research Project Quarterly Progress Report

Date: 10/31/2018 **Project Number:** TPF-5(193) Suppl. #137 FY19-WISC-2-MASH-PORTABLE BARRIER

Project Title: Development of a New MASH 2016 TL-3 Portable Barrier System

Principal Investigator: R. Bielenberg and R. Faller,

Principal Contact Information Email: rbielenberg2@unl.edu **Phone:** (402) 472-9064

Project Start Date: 8/7/2018 **Project Completion Date:** 12/31/2020

Report Period: **Due Date:**

- ☒ Quarter 1 (July 1 – September 30) ---------- October 31
- ☐ Quarter 2 (October 1 – December 31)---------- January 31
- ☐ Quarter 3 (January 1 – March 31) ---------- April 30
- ☐ Quarter 4 (April 1 – June 30)---------- July 31

Project Schedule Status:

- ☒ **On Schedule**
- ☐ **On Approved Revised Schedule**
- ☐ **Ahead of Schedule**
- ☐ **Behind Schedule**

Progress:

Task	Total Budget	% work Completed This Quarter	Expenses This Quarter	Total % of Task Completed	Remaining Budget
1. Project Planning and Correspondence	$24,836.00	5%	$0.00	5%	$24,836.00
2. Design and Analysis	$50,630.00	5%	$0.00	5%	$50,630.00
3. Reporting and Project Deliverables	$13,551.00	0%	$0.00	0%	$13,551.00
4.					
5.					
6.					
7.					
8.					
9.					

Progress and Accomplishments this Quarter:

(Provide an informative summary of tasks/activities that occurred this quarter includes meetings, work plan status, significant progress, etc.)

This research effort was initated during this quarter. MwRSF has begun the process of brainstorming design concepts. Additional work is need on basic deisgn criteria and literature search and patent materials.

Circumstances Affecting Project, Scope, or Budget:

(Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints, along with recommended solution to those problems.)

None.

Anticipated Work Next Quarter:

Review of literature and patents. Development of design criteria.

Total Percentage of Project Completion:

5%

Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

6-30-2018 to 10-30-2018

Guardrail Downstream Anchorage - TRP-03-279-13

Question
State: FL
Date: 07-18-2018

I have a question on MwRSF report TRP-03-279-13 for downstream anchorages.

Basically, the crash-tested trailing-end terminal has a "strut anchorage" between the end posts, while many trailing-end terminals from various states shown throughout the report use the "buried anchorage" (soil plate) instead of the strut. These differing systems are shown in Table 3.

Florida currently uses the buried anchorage system, similar to that shown in Figure 2 for Wisconsin (Sheet 15 of the report). Basically, what are your thoughts on the buried anchorage soil plate system? Is the assumption that these anchorage types are reasonably equivalent, or is the crash-tested strut version the only terminal style considered MASH tested?

Thank you!

Response
Date: 07-19-2018

I'm happy to offer any assistance I can. I spoke about this with Ron and Bob here as they have excellent experience with end anchorages and terminals.

General Thoughts

The Wisconsin design denoted in the report is similar to the trailing end anchorage design which MwRSF utilizes standard in crash testing, but a determination of equivalency would be based on some considerations:

Soil foundation tube length and embedment

Soil plate size

Terminal post(s)

When the MGS was adopted and we formalized the trailing end anchorage shown in the report, we used a deeper soil embedment tube for the posts than the prior design adopted for G4(1S) and G4(1W) BCT terminals. When combined with the strut, no soil plate was needed for the end anchorage. We would recommend that the soil foundation tube be at least 6 ft deep.

Also, we use a modified BCT post (MGS BCT post) as described in the report. During the compliance test at TL-3, the trailing end anchorage produced longitudinal forces in the car which were high and approached, but did not exceed, the allowable thresholds. We would therefore strongly encourage that the MGS BCT posts be used for both of the final two posts in the system to ensure similarity with the MGS trailing end anchorage design, and that other untested post shapes not be substituted.

NOTE: We currently have a project ongoing at MwRSF to evaluate a steel post, breakaway option for the trailing end anchorage. This steel post version should be equivalent to the wood post version. That project is still ongoing, thus no formal recommendations or implementation guidance have yet been provided.

Specific Notes for Florida Design

I would be happy to review a standard drawing if you have one, and offer comments.

Please let me know if you have any further thoughts, comments, or questions. I hope all is well in Florida.

Response
Date: 07-20-2018

In looking at our FDOT drawings, it looks like we can lengthen our tube for the first post based upon your comment. The "BCT MGS" post shown in Figure 47 of the report looks very similar to our "Short Timber Breakaway Post", but we can modify if you recommend it. Also, we can then add the tube/BCT at the second post and enlarge the soil plate if required.

Thank you for offering to take a look at our drawings (attached). The full source document can be found
here… http://www.fdot.gov/design/standardplans/current/IDx/536-001.pdf

One last consideration is that we still support a double-faced guardrail option with a history of success. I'm not sure how a strut design would mix with it, but I'd prefer to keep and update the soil plate design if possible.

Thank you!

Response
Date: 07-21-2018

Upon review of Florida's drawings, we came to the following conclusions:

- I think that your "short timber breakaway post" is reasonably similar to the MGS BCT post we use –measurements are within ½ in. of what we use as standard here.
- I observed that you utilize the MGS design setup with 8-in. deep blockouts, which TTI demonstrated was successful at TL-3 impact conditions.
- The foundation tube with soil plate may provide similar soil resistance as the double foundation tube with channel strut. There is some unpublished research which suggests that a single foundation tube / driven pile with a soil plate can provide meaningful resistance, and we have used installations of single foundation tubes in applications such as the bullnose guardrail system and a temporary barrier anchoring system. However, we do not know what the capacity of your setup is, and as such, we cannot verify that it has an equivalent strength to the MGS. If you have any concerns about the strength of that foundation tube and soil plate compared to the double-foundation tube with channel strut, we could discuss a small testing effort to construct and measure forces and deflections sustained by both designs.
- We recommend deepening the steel tube foundation from 5 ft to 6 ft for similarity with the MGS foundation tubes. We are not aware of tested designs right now which use 5-ft deep foundation tubes without a groundline strut.

One item that Bob observed that warrants some consideration is your double-sided guardrail end termination, page 9 of http://www.fdot.gov/design/standardplans/current/IDx/536-001.pdf. In that design, only one side of the W-beam guardrail is attached to a cable anchorage. There are some concerns that only anchoring one side of the W-beam could reduce the capacity of the W-beam to resist impacts when struck on the other side of the system. It may be helpful to install two cable anchorage assemblies, with the second cable attached at the second post and to the opposite-side rail, as shown below. As a possible alternative, you could consider splicing a second cable onto the existing BCT cable and anchoring it to the other rail, which is similar to the originally-designed BCT system developed at SwRI. Although these double-sided, trailing end anchorage modifications have not been full-scale crash tested, they represent the best advice we have now.

I apologize for the delayed response as my schedule has been hectic recently. Still, feel free to ask any questions and I will try to get you an answer as quickly as I can, to the best of my ability.

Attachment: https://mwrsf-qa.unl.edu/attachments/a805b11ce3c30fb77d74eb2e53226687.jpg

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Response
Date: 07-22-2018

Based on your review, we will keep our short timber breakaway post, but we'll update the foundation design to include the strut anchorage, double tube foundation, and deeper tube foundations (from 5 to 6 feet). These changes will be made to both single and double-faced designs.

Regarding the double-faced trailing anchorage, it's assumed that the cable connection will be on the panel side that is within the clear zone. If both sides of the guardrail were within the clear zone for a typical median application, then we'd require the use of an approach crash cushion instead. That said, we will reorient our drawing to show the cable connection on the panel side likely to be in the trailing clear zone. For the rarer case of guardrail between merging lanes (traffic in same direction), we're okay with the assumption that redirective capability of the guardrail may be further upstream on the side lacking the cable connection.

This brings me to my final question. It appears that TL-3 design for the pickup truck requires 5 post spacings downstream of the impact point to successfully redirect the vehicle. This being the case, should design policy require guardrail to extend 5 post spacings downstream of the hazard being shielded (to ensure only redirective guardrail is adjacent to the hazard)? The other consideration would be departure angle and offset of the guardrail to the hazard, which may shorten the need to extend guardrail downstream of the hazard. What are your latest thoughts on extending the guardrail downstream of the hazard?

Thank you!

Response
Date: 07-23-2018

I am providing you with two references that may address your later questions. See the Transportation Research Record (attached pdf file) for a proposed hazard envelope near the downstream end of the system anchored by the noted hardware in combination with MGS. Similarly, this information is provided in MwRSF research report no. TRP-03-279-13, which can be accessed on our website. Unfortunately, our website is down for maintenance. You will find guidance pertaining to the clear areas and acceptable hazard areas for impacts near the downstream end. Guardrail may need to be extended if hazards are too close to back of rail at end. If hazards are even closer, then stiffened guardrail systems may be required. Please let us know if you have any other questions.

Thanks!

Response
Date: 07-25-2018

I did have access to TRP-03-279-13, and my apologies for not spotting that information in the 490 page report. I actually just got lucky and landed on page 238, so I believe that's what we're going for! This is perfect. It does seem that some national publications should update their trailing end design recommendations based upon this. The information here is great… Some might even say it's impactful.

Thank you again for all of your help. We'll get our trailing end anchorage up to the latest and greatest soon.

Guardrail Downstream Anchorage - TRP-03-279-13

Question
State: FL
Date: 07-18-2018

I have a question on MwRSF report TRP-03-279-13 for downstream anchorages.

Basically, the crash-tested trailing-end terminal has a "strut anchorage" between the end posts, while many trailing-end terminals from various states shown throughout the report use the "buried anchorage" (soil plate) instead of the strut. These differing systems are shown in Table 3.

Florida currently uses the buried anchorage system, similar to that shown in Figure 2 for Wisconsin (Sheet 15 of the report). Basically, what are your thoughts on the buried anchorage soil plate system? Is the assumption that these anchorage types are reasonably equivalent, or is the crash-tested strut version the only terminal style considered MASH tested?

Thank you!

Response
Date: 07-19-2018

I'm happy to offer any assistance I can. I spoke about this with Ron and Bob here as they have excellent experience with end anchorages and terminals.

General Thoughts

The Wisconsin design denoted in the report is similar to the trailing end anchorage design which MwRSF utilizes standard in crash testing, but a determination of equivalency would be based on some considerations:

Soil foundation tube length and embedment

Soil plate size

Terminal post(s)

When the MGS was adopted and we formalized the trailing end anchorage shown in the report, we used a deeper soil embedment tube for the posts than the prior design adopted for G4(1S) and G4(1W) BCT terminals. When combined with the strut, no soil plate was needed for the end anchorage. We would recommend that the soil foundation tube be at least 6 ft deep.

Also, we use a modified BCT post (MGS BCT post) as described in the report. During the compliance test at TL-3, the trailing end anchorage produced longitudinal forces in the car which were high and approached, but did not exceed, the allowable thresholds. We would therefore strongly encourage that the MGS BCT posts be used for both of the final two posts in the system to ensure similarity with the MGS trailing end anchorage design, and that other untested post shapes not be substituted.

NOTE: We currently have a project ongoing at MwRSF to evaluate a steel post, breakaway option for the trailing end anchorage. This steel post version should be equivalent to the wood post version. That project is still ongoing, thus no formal recommendations or implementation guidance have yet been provided.

Specific Notes for Florida Design

I would be happy to review a standard drawing if you have one, and offer comments.

Please let me know if you have any further thoughts, comments, or questions. I hope all is well in Florida.

Response
Date: 07-20-2018

thank you very much for the thorough and helpful response. In looking at our FDOT drawings, it looks like we can lengthen our tube for the first post based upon your comment. The "BCT MGS" post shown in Figure 47 of the report looks very similar to our "Short Timber Breakaway Post", but we can modify if you recommend it. Also, we can then add the tube/BCT at the second post and enlarge the soil plate if required.

Thank you for offering to take a look at our drawings (attached). The full source document can be found
here… http://www.fdot.gov/design/standardplans/current/IDx/536-001.pdf

One last consideration is that we still support a double-faced guardrail option with a history of success. I'm not sure how a strut design would mix with it, but I'd prefer to keep and update the soil plate design if possible.

Thank you!

Response
Date: 07-21-2018

Upon review of Florida's drawings, we came to the following conclusions:

- I think that your "short timber breakaway post" is reasonably similar to the MGS BCT post we use –measurements are within ½ in. of what we use as standard here.
- I observed that you utilize the MGS design setup with 8-in. deep blockouts, which TTI demonstrated was successful at TL-3 impact conditions.
- The foundation tube with soil plate may provide similar soil resistance as the double foundation tube with channel strut. There is some unpublished research

which suggests that a single foundation tube / driven pile with a soil plate can provide meaningful resistance, and we have used installations of single foundation tubes in applications such as the bullnose guardrail system and a temporary barrier anchoring system. However, we do not know what the capacity of your setup is, and as such, we cannot verify that it has an equivalent strength to the MGS. If you have any concerns about the strength of that foundation tube and soil plate compared to the double-foundation tube with channel strut, we could discuss a small testing effort to construct and measure forces and deflections sustained by both designs.

- We recommend deepening the steel tube foundation from 5 ft to 6 ft for similarity with the MGS foundation tubes. We are not aware of tested designs right now which use 5-ft deep foundation tubes without a groundline strut.

One item that Bob observed that warrants some consideration is your double-sided guardrail end termination, page 9 of http://www.fdot.gov/design/standardplans/current/IDx/536-001.pdf. In that design, only one side of the W-beam guardrail is attached to a cable anchorage. There are some concerns that only anchoring one side of the W-beam could reduce the capacity of the W-beam to resist impacts when struck on the other side of the system. It may be helpful to install two cable anchorage assemblies, with the second cable attached at the second post and to the opposite-side rail, as shown below. As a possible alternative, you could consider splicing a second cable onto the existing BCT cable and anchoring it to the other rail, which is similar to the originally-designed BCT system developed at SwRI. Although these double-sided, trailing end anchorage modifications have not been full-scale crash tested, they represent the best advice we have now.

I apologize for the delayed response as my schedule has been hectic recently. Still, feel free to ask any questions and I will try to get you an answer as quickly as I can, to the best of my ability. Take care,

Attachment: https://mwrsf-qa.unl.edu/attachments/74c2aa148517080c285fb423a7f9ef8d.jpg

Response
Date: 07-23-2018

Based on your review, we will keep our short timber breakaway post, but we'll update the foundation design to include the strut anchorage, double tube foundation, and deeper tube foundations (from 5 to 6 feet). These changes will be made to both single and double-faced designs.

Regarding the double-faced trailing anchorage, it's assumed that the cable connection will be on the panel side that is within the clear zone. If both sides of the guardrail were within the clear zone for a typical median application, then we'd require the use of an approach crash cushion instead. That said, we will reorient our drawing to show the cable connection on the panel side likely to be in the trailing clear zone. For the rarer case of guardrail between merging lanes (traffic in same direction), we're okay with the assumption that redirective capability of the guardrail may be further upstream on the side lacking the cable connection.

This brings me to my final question. It appears that TL-3 design for the pickup truck requires 5 post spacings downstream of the impact point to successfully redirect the vehicle. This being the case, should design policy require guardrail to extend 5 post spacings downstream of the hazard being shielded (to ensure only redirective guardrail is adjacent to the hazard)? The other consideration would be departure angle and offset of the guardrail to the hazard, which may shorten the need to extend guardrail downstream of the hazard. What are your latest thoughts on extending the guardrail downstream of the hazard?

Thank you!

Response
Date: 07-24-2018

I am providing you with two references that may address your later questions. See the Transportation Research Record (attached pdf file) for a proposed hazard envelope

near the downstream end of the system anchored by the noted hardware in combination with MGS. Similarly, this information is provided in MwRSF research report no. TRP-03-279-13, which can be accessed on our website. Unfortunately, our website is down for maintenance. You will find guidance pertaining to the clear areas and acceptable hazard areas for impacts near the downstream end. Guardrail may need to be extended if hazards are too close to back of rail at end. If hazards are even closer, then stiffened guardrail systems may be required. Please let us know if you have any other questions.

Thanks!

Attachment: https://mwrsf-qa.unl.edu/attachments/364a922d8804fb80db044b3b9287f5d2.pdf

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Response
Date: 07-26-2018

I did have access to TRP-03-279-13, and my apologies for not spotting that information in the 490 page report. I actually just got lucky and landed on page 238, so I believe that's what we're going for! This is perfect. It does seem that some national publications should update their trailing end design recommendations based upon this. The information here is great… Some might even say it's impactful.

Thank you again for all of your help. We'll get our trailing end anchorage up to the latest and greatest soon.

Request to use IaDOT Concrete Barriers

Question
State: NE
Date: 07-20-2018

I am interested in your opinion regarding the following request.

The NDOT is reviewing a request from Hawkins Construction Company.
They desires to build concrete protection barriers for regional use in NE and IA and they have requested permission to use concrete barriers constructed per the IDOT design on NDOT construction projects.

The two designs are attached. Please note the differences shown in red and orange.

As part of the review of this request, Mr. Jim Knott suggested that I get your opinion of the reduced surface area on the bottom of the IDOT-designed barrier (having the chamfer) vs the NDOR design without a chamfer. More specifically, do you think, the reduced are would result in unacceptable deflection of the barriers when struck at a location where they cannot be pinned (such as on a bridge deck).

From: Neemann, Matt
Sent: Thursday, July 19, 2018 3:19 PM
To: Dearmont, Andy
Subject: RE: Temporary Barriers

The only difference that I see is the "marker inset" that we have in our barriers. If this was not in there though, it can be accomplished in another way.

From: Dearmont, Andy
Sent: Thursday, July 12, 2018 1:24 PM
To: Neemann, Matt
Subject: FW: Temporary Barriers

Matt,
Hawkins is planning to make concrete barriers and are asking, if they make them in accordance with the attached Iowa standard, would they be acceptable for use on NDOT projects?

Phil indicates that they would need to comply with the loop-steel certificate submittal

requirement.

Any concerns from Traffic?

Andrew W. Dearmont
Nebraska Department of Transportation
OFFICE 402-479-4451
andy.dearmont@nebraska.gov
dot.nebraska.gov | Twitter

From: TenHulzen, Phil
Sent: Friday, June 29, 2018 7:15 AM
To: Dearmont, Andy
Cc: Sorben, Nathan
Subject: RE: Temporary Barriers

Traffic owned the concrete barriers do they allow/ disallow?

On our std plan M&R gets the Loop steel certificate showing they meet the correct steel – If they can produce this; allow them.

Phil
From: Dearmont, Andy
Sent: Thursday, June 28, 2018 4:57 PM
To: TenHulzen, Phil ; Sorben, Nathan
Subject: FW: Temporary Barriers

Are you the individuals that can review and accept/deny this request?

Andrew W. Dearmont
Nebraska Department of Transportation
OFFICE 402-479-4451
andy.dearmont@nebraska.gov
dot.nebraska.gov | Twitter

From: Mike Olson
Sent: Thursday, June 28, 2018 3:42 PM
To: Dearmont, Andy
Subject: Temporary Barriers

Andy,

As discussed on the phone, can you take a look at the Iowa temporary barrier design and determine if they would acceptable as Type C barriers in Nebraska?

Thanks for your help.

Mike Olson
Hawkins Construction Company

Attachment: https://mwrsf-qa.unl.edu/attachments/065a21b9c2bd4947814159e38d42cb6d.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/c01db551178878f9663b0995196c4f34.pdf

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Response
Date: 07-20-2018

With respect to the differences in the designs, I have the following comments.

1. The chamfers on the underside of the barrier in the Iowa design should not pose and issue for the barrier in terms of is performance in a free-standing configuration. We have tested this design of free-standing PCB in the past both with and without that base chamfer and did not observe as significant difference in barrier performance or dynamic deflection. Barrier mass and friction on the ground are not greatly affected by the small amount of area removed. As such, we have no concerns with this.
2. Iowa does not have the additional two drainage/lifting slots slots that NDOT uses on their PCB. NDOT discussed those additional slots for drainage prior to including them in the design and we concurred with their addition. We have some tests on the PCB design with two and four drainage/lifting slots, and have not observed any difference in the barrier performance.
    a. Previous review of NDOT design --- https://mwrsf-qa.unl.edu/view.php?id=278
3. Details in the link above also discuss the loop steel comments we had with NDOT previously.

Please let me know if you have further questions.

Thanks

Request for clarification to MwRSF regarding stick wleding of side-mounted weak-post guardrail

Question
Date: 07-23-2018

Greetings MwRSF folks.

Tonight's email is to ask for clarification regarding required welding processes for a side-mounted weak-post guardrail system. The report is:
https://mwrsf.unl.edu/reportresult.php?reportId=293&search-textbox=MGS%20weak%20post

We have attached the following to this email for reference:
MGS-2.4_2016-01-15.pdf
SGR53_R9.pdf
MGS-2.4_2016-01-15 (TRN Comments).pdf

Our shop is indicating that "EX70xx" shown in the tail of the weld symbols on the attached Ohio DOT drawings is specific to a stick welding process. Our shop(s) utilize a GMAW (commonly called MIG) welding process – which is wire fed vs a stick welding (typically also called SMAW)

The same "E70xx" shown on the ODOT drawings in the tail of the weld symbols are also shown on the attached MwRSF drawing and the drawings within Report No. TRP-03-277-14. Would MwRSF allow welding processes which are comparable as the call out symbols of the MwRSF drawings but which utilize a different process than stick welding?

Please advise your thoughts. Or – if I can provide additional information, please let me know.

Attachment: https://mwrsf-qa.unl.edu/attachments/5adaaf9a20f9de3b03b3beb3218933df.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/afb22454340398bdf2e6b62527a7fb61.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/00c9f77c8a3d00e7194601728043ffc8.pdf

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Response
Date: 08-14-2018

We used to specify our weld specifications with the "ex70xx" note, but have stopped doing that for our more recent system details. I believe it was there previously to match the process that a local fabrication shop was utilizing. We now leave the note off so that the welds can be made with any appropriate process. The welding process utilized to fabricate the socket assemblies for the system you are inquiring about should not matter. Sorry for the confusion.

MASH 2016 Cable Barrier Testing Matrices

Question
State: SC
Date: 07-23-2018

We are concerned that the 4 tables presented in MASH 2016 will result in products having different completed tests that get marketed as fully MASH 2016 compliant.

It does not appear that MASH 2016 requires cable barrier manufacturers to test every condition of all tables 2-2B through 2-2E. If this is the expectation, why are so many conditions repeated throughout the tables?

We recommend that tables 2-2B through 2-2E be consolidated into a single matrix of

tests to ensure that all cable barrier products are at least held to the same testing criteria.

Use of Table 2-2D would seem to be the most appropriate in that a single cable can be placed throughout the 6:1 cross section.

Table 2-2B results in the concern that the ditch bottom would violate Roadside Design Guide Figure 3-6.

Table 2-2D could be augmented to allow testing from the high side of a 4:1 slope with placement of the cable 4' beyond the shoulder break. This would allow installations of dual runs of cable on 4:1 slopes while not violating RDG Fig 3-6 since the ditch bottom would be shielded from either side.

We are concerned that the remaining tables 2-2C and 2-2E are too limiting in real world applications, and that products tested to these conditions may not perform as well in real world installations.

Has there been any discussion of consolidation of these tables within the MASH criteria? Are there any concerns that proprietary manufacturers may not test their products in every situation?

Thanks,

Response
Date: 07-24-2018

I can understand the concern from a state standpoint. Obviously, it can be a maze of tests for you to wade through to determine to what level any given cable system has been evaluated and if it did so adequately.

MASH does require all of the tests in each table to be conducted. The various tables are needed to deal with specific systems that were desired by manufacturers and states. Thus, there are separate matrices for both the 4:1 and 6:1 ditches as well as placement anywhere in the ditch versus at a 4' offset.

The basic parameters and purpose of the tests in each table are similar. However, the impact points and barrier placement may change to evaluate the critical scenario for that specific configuration. I don't believe that a single matrix would be sufficient to cover all of the variable configurations that were required when we complied the matrix with TTI.

I can also understand the concern that the 0-4' placement may not meet a state's needs. However, no one has met the criteria for the placement of the cable system anywhere in either a 6:1 of 4:1 v-ditch at this time and it was desired by AASHTO and the manufacturers that a matrix be provided for the 0-4' offset case.

We had discussions on the slope geometry of the ditch and the RDG guidance as well. However, some states use and wanted the option of 4:1 v-ditches. As such, it was included.

Let me know if that addresses your questions or if you want to discuss it further.

Response
Date: 07-25-2018

Thanks for the response, we greatly appreciate it.

We do have some follow-up comments/questions we are hoping you could address:

First of all we wanted to clarify that, for the generic high tension cable barrier MSWRF is developing, the plan is to ultimately run all eight of the tests in Table 2-2D (with tests 3-10/3-11 being performed first as voted on this year). Then the system may possibly need to be modified, and all of the tests in table 2-2C will be ran,

ultimately resulting in 2 potentially distinct systems. Is this still accurate? If so, I am guessing 3-10 and 3-11 may be reran in 2-2C based on whether the system is modified?

If a state is to infer that a product is appropriate to install based on real world geometry and select a version of the device based on the table it was tested to, then tests like 3-15, 3-16, and 3-18 in tables 2-2C and 2-2E become confusing since the cable in these tests is not located in the 0'-4' offset from shoulder break.

Tests 3-15, 3-16, and 3-18 will be required for a single barrier system offset 0'-4', correct? Yes When a barrier is restricted to the 0'-4' section, does this mean that it must remain in the 0'-4' offset for its entire run, or are these tests implying that it may cross over the ditch and into the 0'-4' offset of the other shoulder so long as a certain amount is present in the 0'-4'? If the former is accurate, then would tests 3-15/3-16/3-18 have any relevance to when using 2-2C and 2-2E matrices?

The only exception we see listed for all of these tests is if the system is a double median barrier system, but the tables allow for single or double barrier systems. The exception regarding ditch widths appears to only apply to test 3-15, and this test must still be ran if the system is to be approved used in anything other than V-ditches > 26'/24', correct?

Thanks again for taking the time to respond to our questions, and hope you are having a good start to the new week.

Response
Date: 07-27-2018

We are happy to help you all out. These matrices are confusing due to the large number of potential configurations and the complexity of cable barriers.

Responses below in red.

Let me know if you need anything else.

We do have some follow-up comments/questions we are hoping you could address:

First of all we wanted to clarify that, for the generic high tension cable barrier MSWRF is developing, the plan is to ultimately run all eight of the tests in Table 2-2D (with tests 3-10/3-11 being performed first as voted on this year). Then the system may possibly need to be modified, and all of the tests in table 2-2C will be ran, ultimately resulting in 2 potentially distinct systems. Is this still accurate? If so, I am guessing 3-10 and 3-11 may be reran in 2-2C based on whether the system is modified?

The generic cable median barrier being developed through the Midwest Pooled Fund is focused on a system for use anywhere in a 6:1 V-ditch. The test matrix for that type of system is defined in Table 2-2D. We plan to conduct both a small car and pickup truck test (3-10 and 3-11) on the system as part of the Pooled Fund program for the upcoming year. We have not moved towards placement of the barrier at a 4' offset in a 4:1 ditch at this time. Previously, there was desire in the Pooled Fund to develop a system for anywhere in a 4:1 v-ditch . However, that has been scaled back for now. To use the system designed for use anywhere in a 6:1 V-ditch at a 4' offset in a 4:1 v-ditch, we would have to re-examine the design of the system after completion of the test matrix in 2-2D and see if the cable heights and system design chosen would work in that application. However, it may be that little to no modification is required as there is potential that the cable heights selected for use anywhere in a 6:1 V-ditch would still work for placement in a 4:1 v-ditch with a 4' offset. Depending on the level of modification needed, we would determine what tests in 2-2C would need to be rerun.

If a state is to infer that a product is appropriate to install based on real world geometry and select a version of the device based on the table it was tested to, then tests like 3-15, 3-16, and 3-18 in tables 2-2C and 2-2E become confusing since the cable in these tests is not located in the 0'-4' offset from shoulder break.

Tables 2-2C and 2-2E are for evaluation of median cable systems place at 0 ft – 4 ft offsets from a median v-ditch.

Test 3-15 is used to evaluate the potential for small car underride and is not required for systems placed at 0-4 ft offsets if they are used in ditches over a specified width. If the system is intended for use in narrower v-ditches, then the test must be run, but at the location used for cable systems used anywhere in a v-ditch. This point is the critical underride location in the respective ditches. As such a vehicle that does not underride at this point would not be expected to underride at the system's typical 0-4 ft offset.

Test 3-16 evaluates the performance of the barrier for a small car traversing the v-ditch. As such, a critical offset from the backside SBP is specified that is critical in terms of vehicle capture and stability. For systems intended for use at a 0-4 ft offset from a 4:1 and 6:1 v-ditches, that critical point was determined to be 1 ft and 4 ft from the backside SBP, respectively. These points were based on computer simulation modeling done by MwRSF combined with data from other labs. Similar to test 3-15, evaluation at this critical offset would allow the use of the system at anywhere within the standard 0-4 ft offset for the barrier.

Test 3-18 evaluates the performance of the barrier for a pickup truck traversing the v-ditch. The logic behind this test is similar to that of test 3-15, but different placements were determined for the critical barrier placement based on computer modeling. Evaluation at this critical offset would allow the use of the system at anywhere within the standard 0-4 ft offset for the barrier.

Tests 3-15, 3-16, and 3-18 will be required for a single barrier system offset 0'-4', correct? Yes When a barrier is restricted to the 0'-4' section, does this mean that it must remain in the 0'-4' offset for its entire run, or are these tests implying that it may cross over the ditch and into the 0'-4' offset of the other shoulder so long as a certain amount is present in the 0'-4'? If the former is accurate, then would tests 3-15/3-16/3-18 have any relevance to when using 2-2C and 2-2E matrices?

Conducting the matrices for 2-2C or 2-2E would not ensure the crashworthiness of the system in an area where it traversed the width of the ditch outside of the 0-4 ft offset. Thus, it would be recommended to leave the system at its 0-4 ft offset for the entire run or use a system for use anywhere in the ditch.

The only exception we see listed for all of these tests is if the system is a double median barrier system, but the tables allow for single or double barrier systems. The exception regarding ditch widths appears to only apply to test 3-15, and this test must still be ran if the system is to be approved used in anything other than V-ditches > 26'/24', correct?

Yes

MGS in median

Question
State: OH
Date: 08-03-2018

Good Morning,

We currently have a strong-post median barrier with rub rail (SGM06a - ODOT Type 5MR) installed in the median of Interstate 71 (see attached cross section). The district is adding 3" of asphalt to the pavement up to the face of the barrier.

1) Is there a height tolerance for this barrier?
2) Can this system be raised by moving the blockouts and would the backside rub rail also be raised?
3) Would two sided MGS be an acceptable option with a 6:1 backside slope on a 30' median cross section?

We had a similar issue in 2006.
http://mwrsf-qa.unl.edu/view.php?id=459

Thanks!

Attachment: https://mwrsf-qa.unl.edu/attachments/bbc7f898ec0a7dea117f98cc472d5b03.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/c16eb04be6d011f6d0f51494cfca7170.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/267088eb370169875d7c7409977a0a33.JPG

Response
Date: 08-15-2018
I have several comments with regards to the median guardrail in question.

First, you noted that we had discussed this system previously in 2006 - http://mwrsf-qa.unl.edu/view.php?id=459

We had a follow on discussion in 2013. In it we noted some concerns regarding the use of rub rail and placement of the system adjacent to 6:1 slopes. You should review that and see if you have any questions regarding those previous comments related to this system.

https://mwrsf-qa.unl.edu/view.php?id=713

I have a few other comments as well.

1. We would not recommend using heights below 31" for the MGS median barrier or other doubled sided median W-beam systems at this time. TTI tested the G4(1S) median barrier system in NCHRP 157 to MASH TL-3. In those tests, the pickup truck vaulted the barrier when installed at the 27 in. mounting height. It has been successfully tested to MASH TL-3 at the 31in. height.
2. The system height could potentially be raised by moving the blockouts up. This has been shown to be acceptable for roadside installations, so we would expect similar performance for the median version.
3. I noted in the detail that the posts for the system were installed in 3-in. of asphalt. We would have concerns that installation of the post in asphalt could degrade performance due to limited post rotation if proper leave outs were not employed.

Let me know if that addresses you questions or if you have further items you wish to discuss.

Thanks

Guardrail attached to low fill culverts

Question
State: OH
Date: 08-14-2018

There are two MASH TL-3 crashworthy, top-mounted, strong-post, W-beam guardrail systems for use on low-fill culverts. The report you referenced herein evaluated variations of a system developed at MwRSF. This system incorporated a 1/2" thick base plate that is intended to yield and deform during loading. this plastic deformation in the plate absorbs energy and limits the resistance forces of the posts. The second guardrail on culvert system was developed at TTI and incorporated a 7/8" thick base plate, which remains rigid during impacts. Thus, the forces from the posts are higher. Both systems have been crash tested, so either can be used for treatments on low-fill culverts.

The drawings you attached appear to be utilizing the details from the TTI system. The upper right base plate in the attachment has the same thickness, hole dimensions, and offset from the headwall as the TTI base plate. Since the as-tested system used A36 steel and didn't experience deformations to the plate, the same result would be expected for a plate made from stronger, grade 50 steel. A copy of the TTI report on this system is attached.

The base plate detail shown in the upper left of your detail incorporates a wider design with lateral slots spaced 11" apart instead of 9". Also, this plate is thinner that the original plate (3/4" vs. 7/8"). The combination of a wider anchorage spacing and a thinner plate may alter the performance of this post-and-plate assembly. As such, further analysis may be required to evaluate this baseplate design to MASH criteria.

Attachment: https://mwrsf-qa.unl.edu/attachments/4611b97003feb36ecab8630b5019ef3f.JPG

Response
Date: 08-14-2018
In Research Report No. TRP-03-278-13 - *Post Weld and Epoxy Anchorage Variations for W-beam Guardrail Attached to Low-Fill Culverts,* the results conclude that both ASTM A36 and Grade 50 steel post and base plates are expected to perform similarly. The design Ohio uses is slightly different (see attached). Would you expect this design to also perform similarly regardless of which of these two steels are used?

Thanks!

Attachment: https://mwrsf-

qa.unl.edu/attachments/4611b97003feb36ecab8630b5019ef3f.JPG

Guardrail Blockout compressive Strength

Question
State: NE
Date: 08-15-2018

The importance of the 12" blockout in the MGS, from what I recall - is to keep the tire of the pickup away from the post.
Could a lightweight blockout weaker than what was tested improve the performance of the MGS?
Assuming the answer is no; Is there a minimum compressive strength of a guardrail blockout between the post & the back of guardrail?
Or What's the strength needed to redirect the pickup away from the post when impacted?

Response
Date: 08-15-2018

The blockout was used to reduce wheel contact with the posts for both vehicle types and to hold the rail up longer during lateral post movement & rotation. The standard MGS was tested with 12" blocks (MwRSF and others), 8" blocks (TTI), and no blocks (MwRSF and others). We found improve performance for larger blocks versus no blocks, although all options worked for base configuration. With weaker blocks, those that fracture or crush, we would expect acceptable performance in the base configuration. However, I could not say that it would be improved performance over that observed with 12" wood blocks. Even with blocks, we may still have wheel contact with posts for both vehicle types. Unfortunately, we do not know the minimum compressive strength to provide similar safety performance to that observed for standard MGS with 12" wood blocks.

Chamfer on Corners

Question
State: WI
Date: 08-21-2018

We have received a request to place a chamfer near the top of the MwRSF TL-5 barrier designed for head slap.

Is this acceptable?

Attachment: https://mwrsf-qa.unl.edu/attachments/c7f433cc0a5313d9d34689e71066ff9c.jpg

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Response
Date: 08-21-2018
Yes, the chamfers are acceptable. 3/4" chamfers like these are common on concrete structures and will not affect the strength of the barrier.

Standardized AGT Buttress

Question
State: VA
Date: 08-29-2018

We are trying to use the AGT that MWRSF crash tested in combination with a 32" Kansas Corral Railing (our NCHRP 350 version).

The AGT height is 36". Is it acceptable to use the AGT buttress at a constant 32" height (other details staying the same) and still consider it to conform to TL-3 MASH? See the Option 1 markup in the attached file

I understand that the reduction in height may make it difficult to tell if it meets MASH TL3 at the reduced height, so I have a second question. Do you think that it will perform as required at 32" with the MGS.
Virginia has implemented MGS for guardrail everywhere. As part of that we have been employing a height transition to our existing bridge terminal walls. In a few

locations this height transition is causing trouble because there is not a long run of guardrail leading up to the bridge. So we propose to replace the terminal wall with the new AGT, but our bridge railing is only 32" so we propose to make the AGT 32" rather than 36" and a 24" taper to get it back down to our bridge railing.

We want to confirm that this proposal makes sense and whether it will perform as intended after the change.

We have a second option, and that is to taper the far end of the wall down from 36" to 32" for the last 2ft. See attached markup listed as Option 2.

Any insight or guidance would be appreciated.

Attachment: https://mwrsf-qa.unl.edu/attachments/e054d56b016ab073b8820477204d3cb4.pdf

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Response
Date: 08-29-2018

Option 1 is preferred for attachment to a 32" tall bridge rail. Any time you are connecting to a 32" tall barrier, you may eliminate the vertical slope on the front end of the buttress. We had a drawing sketched up for the project report illustrating a version of the buttress when attached to a 32" F-shape bridge rail (see below for reference). For any geometric variation of the standardized buttress, including this height change, the size and quantity of the steel rebar should remain the same. However, the shape may be slightly altered to fit within the various shapes, just as you noted in your attached drawing. We believe that the shorter height will remain MASH TL-3 crashworthy.

Attachment: https://mwrsf-qa.unl.edu/attachments/ac74236a01fd7baeb97c775f5ddae194.jpg

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UBSP Bolt Hardware

Question
State: NE
Date: 08-30-2018

Gregory Industries was reviewing our Bullnose plan finding the hardware hard to find domestically.

Is there an alternate bolt we can substitute? which is not fully threaded.
He mentioned issues with the washer & nut also?

Response
Date: 08-30-2018

Due to the design of the post, the grade and the full thread are required. A325 structural bolts are not typically made in this diameter. Thus, there are a couple of options.

1. One can get A449 bolts that are custom made to the thread configuration and diameter. They will have equivalent grade to the ones used in the testing as A449 and A325 are equivalent grades.
2. A second options is to use SAE Grade 5 cap screws. These will come in the specified diameter and thread configuration.

Our current details list

Bolt – ASTM A449 or SAE J429

Gr. 5

Nut – ASTM A563DH or SAE J995

Gr. 5

Note that this hardware should all be galvanized. That may require ordering plain SAE Grade 5 cap screws and having them glavanized or special ordering the A449 bolts. I have contacted Bennett Bolt in NY and know they can fabricate them.

Thanks

Traffic Barrier Terminal (AGT) MASH Guidance

Question
State: IL
Date: 08-31-2018

IDOT is currently reviewing our Traffic Barrier Terminal (TBT/AGT) standards to

make sure they meet MASH requirements. We had a couple questions we wanted to run by you guys as guidance on a few items which will be described below.

I've attached the following documents for your review:
Our current TBT Type 6 (NCHRP 350)
Drafted changes to our TBT Type 6
Permanent Concrete Barrier Design that TBT Type 6 will be attached

Questions we have:
1. Is the curb required or can it be an option?
2. Is the wedge plate required? If so, is our design okay to use?
3. Is the vertical face taper under the connection of the AGT required when there is NOT curb present? (See page 2)
4. Is the vertical face taper under the connection of the AGT required when there is a curb present? (See page 2)
5. Can we use 3'- 1 ½" spacing for the first 10 post instead of the 1'-6 ¾" spacing?
6. Block out widths for post 1 – 11 can be either 12", 8" or either?
7. Block out material can be wood or composite for entire run?
8. Would the height have to be at 34" tall to match the proposed AGT design for the steel railing you guys are developing for us if we want to be consistent?

Please let me know if you have any questions or need any additional information from us. We look forward to discussion these changes and any recommendations you guys may have for us. Thank you!

Attachment: https://mwrsf-qa.unl.edu/attachments/ecdcf5a52958bb40fc357e6cc1e7f588.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/0707f410b03a6c4551c8872fb22f19ff.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/235a3c87c021ab6555fc8ef41b06fc35.pdf

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Response
Date: 08-31-2018

I have responses to your questions below in in the same order as numbered in your email. However, before we get too far into the AGT design, I want to remind you of the standardized transition buttress that was recently designed here at MwRSF. This

buttress has been evaluated to MASH and is compatible with a variety of transitions, curbs, and adjacent concrete barrier configurations. We highly recommend utilizing the standardized buttress in your approach transitions in the future. I have attached a TRR Journal paper to this email that explains the design and some implementation issues.

Questions (and answers):

1. The standardized buttress was tested without a curb (critical snag configuration), so it can be utilized within both curbed or non-curbed installations. This is one of the biggest benefits to the new buttress design. If you wish to stay with older transition parapet designs that were tested with a curb, you should keep the curb within the design to prevent snag.
2. Wedge plates are required for all transitions that incorporate sloped-faced buttresses. Testing of thrie beam transitions attached to safety shape and single slope barriers without a wedge plate has resulted in failures. As such, the thrie beam needs to remain vertical throughout the transition. Note, a wedge plate is not required for the standardized buttress since it utilizes a vertical face (another benefit of the new buttress)
3. Removing a taper, flare, or chamfer from the upstream end of a concrete buttress can easily result in increased snagging that can lead to vehicle instabilities, excessive crush, and/or excessive vehicle decelerations. As such, you should stick to the buttress as it was initially designed and crash tested. Speaking specifically about the new standardized buttress – both the upper and lower chamfers/tapers should be utilized regardless of the presence of a curb. A curb by itself is likely not enough to prevent snag on the buttress. Curbs may be placed directly adjacent to (or in contact with) the sloped face of the lower chamfer/taper, so they don't have to be offset back from the roadway.
4. See #3 above.
5. The thrie-beam transition you are showing incorporates W6x9 posts at 18.75" spacing. There are other transition designs that incorporate larger posts at 37.5" spacing. The new standardized buttress is compatible with either of these types of transition systems. However, the upstream stiffness transition from W-beam MGS to stiffened thrie beam was only designed to use standard W6x9/W6x8.5 guardrail posts at very specific spacings. As such, only the posts 1-6 would be able to go to a larger post spacing. The proper way to attach the upstream stiffness transition to various thrie beam transitions is described in Chapter 14 of the research report – linked below:

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

6. Blockouts on posts 1-6 may be either 12" or 8". Blockouts within the upstream MGS stiffness transition (posts 7-14 on your drawing) should be 12" deep to prevent vehicle snag.
7. Blockouts can be wood or composite (granted that the composite blockouts have been previously shown to be crashworthy). We have also designed tubular steel blockouts for use within transitions – if you are interested in steel blocks, I can get you the details.
8. The transition design to the TL-4 steel tube bridge rail we are currently developing has not been designed yet. One of the design goals will be to allow the thrie beam rail to be mounted at 34" so that the system can remain in place after 3" roadway overlays. However, until we are further along in the design process, it is difficult to know what this transition will look like and you will likely need a separate standard for this transition. If you are asking if all of your thrie-beam transitions need to be mounted at 34", the answer is no. You could have both 31" and 34" AGTs within your standards – Nebraska has done this. Alternatively, you could raise the heights of all your transitions to 34" in anticipation of overlays if so desired.

Please review these comments, attached paper, and the MGS stiffness transition report and let me know if you have further questions.

Attachment: https://mwrsf-qa.unl.edu/attachments/f192065e57773a6375207e53793ba63f.pdf

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MGS Adjacent to mixed fill

Question
State: OH
Date: 09-07-2018

We are installing MGS barrier adjacent to a fill section where part of the fill is dumped rock (see attachment). Can standard MGS barrier be used in this situation at 1' from the break point or are long posts or a reduced post spacing necessary?

Thanks!

Attachment: https://mwrsf-qa.unl.edu/attachments/33d7ab5dfb57841b78b196b5a308a278.pdf

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Response
Date: 09-11-2018

The MGS has not been evaluated adjacent to slopes as steep as the 1:1 slopes shown in your detail. Additionally, it is not known how much additional lateral support for the post will be provided by the dumped rock fill as it is not compacted.

Due to these concerns, it may not be advisable to use the standard 6' MGS post length in this type of installation. The MGS has been successfully tested at the slope break point of to 2:1 slopes with 6' posts, but barrier deflections increased significantly.

The MGS was also evaluated adjacent to 2:1 slopes with 8' and 9' long posts. These tests had lower deflections and would likely perform better in this installation with a 1' offset to a 1:1 slope. Thus, we would recommend using either 8' or 9' long posts in this type of installation.

If you desired to keep the 6' post length, we would recommend a minimum offset of 2' from the back of the post to the slope break point.

Note that none of these specific installations have been full-scale crash tested, adjacent to 1:1 but they represent our best engineering judgement based on the current data for the performance of the MGS adjacent to slopes.

MGS Trailing end Anchorage

Question
Date: 09-07-2018

We have a question from a contractor we would like to run by you. Our BA-204 (https://iowadot.gov/design/SRP/IndividualStandards/eba204.pdf) uses a foundation tube and soil plate as an anchorage. Our contactors sometimes run into issues with putting in the soil plate. The most common one is not having the room due to the adjacent concrete. We would like to know your thoughts on replacing this anchorage with anchorage from our BA-203 (https://iowadot.gov/design/SRP/IndividualStandards/eba203.pdf). Another question would be how to deal with the changing the location of the splices.

Thanks,

Response
Date: 10-30-2018

We have currently been using trailing end anchors for all of our testing that do not use soil plates. We use the 6' long foundation tubes with the ground line strut line. I have attached a detail from our testing of the MGS trailing end anchorage.

In terms of moving the splices, we have typically just hung the extra rail of the end of the trailing end anchorage. Some states have used special end rail sections with non-standard lengths.

Two other, more difficult options exist. One is to place an extra non-standard spacing post at half-post spacing in to allow the switch. Another is to omit a post (or rather use a 9.375' post spacing) to facilitate the splice switch. However, these options have to be done relatively far from the anchorage in order to not affect the performance of the trailing end anchor during impacts near the end.

Thanks

Attachment: https://mwrsf-

qa.unl.edu/attachments/b482589614ace3e20db24616ee9244af.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/99845ad73ecc5ed48460bf0cb606f882.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/ec853fa45efa71df59ec94cc8e616066.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/fb17f12d73e76210bcb4069c1a2bc1e1.pdf

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Guardrail over shallow culvert

Question
State: ME
Date: 09-07-2018

I was recently introduced to your joint report – Paper Reference NO. 0824-000067, A Synthesis of MASH Tested 31-in. Tall, Non-Proprietary, W-Beam Guardrail Systems, and found it to be extremely helpful. Thanks for your efforts to assemble everything in one place and clarify things.

A couple questions:

It was good to learn that the omission of a single post without any further action (no double nesting rails, etc.) actually passed MASH Test 3-11. My question relates to leave out multiple posts in an area with a shallow culvert. We have tried to avoid wood posts for long-term maintenance reasons, so we would prefer not to use the MGS long-span guardrail system, unless a steel post option is available (any thoughts on that?). Attaching guardrail to a culvert looks like a good alternative. The top mounted system (Figure 8b)requires a minimum of 9" of soil fill. Is there an upper limit to the amount of soil fill allowed? If there were 3 feet of fill, would it still be acceptable to use the top mounted system? In the past, we have embedded cut-off posts in concrete. Has anything like that ever been tested?

Thanks for any help you can give!

Response
Date: 09-07-2018

MwRSF tried to incorporate steel posts within an elongated version of the MGS long-span system a few years ago. In this configuration, the wooden CRT posts were replaced with Universal Steel Breakaway Posts, and the unsupported span length was increased from 25 ft to 31.25 ft. Unfortunately, the system did not pass MASH TL-3. This testing with an elongated span was the only attempt that I am aware of which tried to incorporate steel posts within the MGS long span. As such, we currently do not have a steel post long span system. I have provided a couple links to reports dealing with this project

https://mwrsf.unl.edu/researchhub/files/Report328/TRP-03-339-17.pdf

https://mwrsf.unl.edu/researchhub/files/Report341/TRP-03-362-17.pdf

With the top-mounted posts on low-fill culverts, thre currently is not a maximum embedded distance for the posts. The top mounted posts within shallow fill depths should be stiffer/stronger that standard posts embedded 40-in. in to the soil. However, as the embedment depth is increased, the post stiffness becomes closer and closer to the stiffness of the standard post in soil. We currently don't have the testing necessary to identify embedment depths less than the nominal 40 in. that would result in crashworthy system. Thus, our current recommendation has been to use top mounted posts until an embedment depth of 40 in. can be achieved.

Posts embedded directly into concrete have created problems in the past. The concrete does not allow the post to rotate back through the soil and results in a very stiff system. Crash tests into such guardrail configurations have resulted in failures due to rail tearing, loss of containment, and excessive vehicle decelerations. Thus, embedding posts directly into concrete is not recommended. To place posts within an concrete or asphalt pavement, leave-outs should be utilized around the post to allow post movement. The currently approve leave-outs measure 18-in. x 18-in. and are filled with a very low strength grout (200-300 psi) after the post is installed.

Let me know if you have any further questions.

Response
Date: 09-08-2018

Thanks for the clarifications. As a follow up I thought I would send a detail sheet showing a typical situation we run in to. In these situations we are not dealing with a headwall and a vertical drop, but rather a 2:1 slope down to the top surface of a much longer box culvert. Now that we are typically installing MGS rail at 31" height, we want to make sure we handle these situations correctly. Top mounted rail seems to be a good fit.

I've also attached a detail that we used before switching over to MGS. This system doesn't seem a lot different than the top mounted system. When the top mounted system is impacted, how do the posts react – do they break away or do they deform? Also, wondering if you observed any damage to the concrete structure when the rail was impacted during the testing?

In case you are interested, we typically install guardrail at the top of 2:1 slopes. Our preferred cross section would include 18" of level terrain behind the 7 foot posts. Alternatively we will often use 6" of level terrain behind 8 foot posts. The longer posts would account for variable soil types with less than 2 feet of level terrain behind the posts. This seems to fit with what you are recommending.

Thanks again for your help. I really appreciate you taking the time to respond!

Atlee

Attachment: https://mwrsf-qa.unl.edu/attachments/7a75c77fbdd262911ccf24ebe9e9b3ff.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/52a4afb92580b54e9e47b3b12fbb6ecb.pdf

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Response
Date: 09-10-2018

The top-mounted posts for MGS that we have been discussing will not breakaway. The posts will plastically deform near the baseplate as the post is deflected backward. Occasionally, a post flange or 2 will tear, but the post has remained attached to the baseplate.

We have not observed significant damage to the concrete slabs during our testing of guardrail with top-mounted posts. We have evaluated both through bolt and epoxy anchored bolts. Neither pulled out during testing. Note, the concrete slabs were all reinforced and at least 8" thick. Thinner slabs or unreinforced slabs may be subjected to concrete damage.

We have successfully tested a standard MGS at the slope breakpoint of a 2:1 slope to MASH TL-3 criteria. See the following link for the report: https://mwrsf.unl.edu/researchhub/files/Report325/TRP-03-320-16.pdf

That said, we have never evaluated top mounted W6x9 posts adjacent to a 2:1 slope. The top mounted posts should provide a little more stiffness than a standard 6-ft post (as discussed previously), so the deflections should be held to within the tested bounds of the MGS. Thus, I think this configuration should perform as intended. However, I have no support to prove that it would be crashworthy.

I hope this helps.

Length of guardrail damage during impact

Question
State: IA
Date: 09-07-2018

We're trying to put together some estimates on length of repair for w-beam guardrail and cable after impact. In all of your testing, is there a general longitudinal length of impact for a standard MASH TL-3 test where damage to the barrier exists?

In our hypothetical situation, a vehicle leaves the road and impacts w-beam protecting a culvert. Under ideal and unrealistic conditions, it engages the barrier at the beginning of a standard 12.5 ft section of w-beam and travels longitudinally for some length before being redirected by the barrier. From crash tests and/or your expert opinion, should we estimate that the length of damaged barrier is 25 ft, 37.5 ft, 50 ft, etc.? If both the truck and passenger vehicle damage lengths from a TL-3 test for MGS are available, that would be super, otherwise I'll take a value for whichever vehicle you're able to find.

Feel free to call if the above makes no sense.

Response
Date: 09-07-2018

I had a chance to dig up the numbers you requested.

I reviewed our standard post spacing MGS length of need tests under MASH TL-3 impacts with the 2270P vehicle. I looked at the contact lengths and deformed length of the barrier for those tests. Contact length is the general length that the vehicle was in contact with the barrier. I also determined a deformed length which included the length of deformed rail and posts in the testing based on our damage documentation and review of the overhead film.

I reviewed three MGS tests with standard post spacings. Two steel post systems and a wood post system (SYP-1). Results are below.

Test No.	Vehicle Contact Length (ft)	Length of Deformed Barrier (ft)
2214MG-2	33.7	50
SYP-1	23.1	43.75
ILT-1	39.92	50

As you can see, the contact length may vary somewhat, but the deformed length of the barrier system is pretty consistently around 50'. This would probably serve as a relatively good estimate for damaged system length for a TL-3 impact.

For MGS special applications like long-span guardrail or MGS adjacent to slopes, that distance may increase significantly. Other systems like MGS over curb or with reduced post spacing may have shorter deformed lengths.

Let me know if that answers your question.

Shorten MGS Post Length to Bridge Guardrail over Two Large Pipes

Question
State: IN
Date: 09-19-2018

INDOT has come across a location where we have twin 10ft span x 7ft rise pipe arches on a 45 degree skew. The cover over these pipes is 2.5 ft so a standard 6 ft MGS post cannot be driven over the pipes. We do know that there are some weak post socket designs that will be completed soon. However we would like to ask the following question in the anticipation that our maintenance staff may question why we want to introduce a new type of post to stock in our inventory. Our question is, would it be an option to reduce the post length to 5 ft and space the posts at 3'-1.5", assuming a working width of 5.0 ft (similar to the 6'-3" post spacing)? There would 2 ft (10:1 max.) of embankment behind the back of the posts. We do understand that reduced

post spacing has not been MASH tested but based on other tests would it be possible to give some guidance. Thank you
Attachment: https://mwrsf-qa.unl.edu/attachments/3aba6776b34cce18c2af19b22ab33460.pdf

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Response
Date: 09-20-2018

That's a tough problem that doesn't have a lot of well defined an tested solutions. The situation you have appears too large for a long span system, and you appear to have resistance to the weak post version of the MGS.

As you noted, one approach would be to use half post spacing with reduced (28") embedment. That is a reasonable approach. The concern is that we have very little data with respect to post with embedment less than 36". There is concern that a post with such a limited embedment may rotate too easily or pull out of the ground and greatly reduce the lateral resistance of the system. Thus it is hard to recommend that approach without further research to quantify the post response at the reduced embedment.

The only other solution I can envision is related to work we completed on the MGS attached to a culvert headwall 9" below grade. This system used strong posts bolted to the culvert slab at 1/2 post spacing. Thus, we could do something similar here by building a slab footing below grade and using this type of post and attachment. One would have to design the slab to resist the post moment, but it should be achievable.

I can send you the details on the post and connection if you would like.

Thanks

Response
Date: 09-21-2018

Thank you for the review and suggestions. Given we have a little time, we may try to persuade others to try the weak post system. We have looked at mostly using the weak post system with a concrete cylinder connected to the top of a culvert. I see there is also a slab option that may be available, see picture below. Would it be reasonable to place concert as deep the steel tube? Also, do I remember correctly there is an option to have just a concrete cylinder that is not attached to a culvert? I know this report is coming soon, so if I need to wait I will. Thanks again.

Attachment: https://mwrsf-qa.unl.edu/attachments/52c54441e4221a75e92ba34d16694bb8.jpg

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Response
Date: 09-24-2018

There are two weak post options available for attachment to culverts. We did not test them as standalone options. One we as concrete cylinder that was anchored to the culvert slab and the other was a steel socket. NDOT asked us to try an unreinforced concrete slab, but that did not perform acceptably.

In order to use a slab type system for weak posts, it would have to be larger and reinforced such that it could develop the post capacity.

This could be a 18" deep reinforced slab or an approximately 12"x24" reinforced vertical wall that has the sockets for the post built in it.

Does that make sense?

Thanks

Attachment: https://mwrsf-qa.unl.edu/attachments/0ae9d572519ea5e2664301f13eef2c11.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/c8f8bc3754e333c4d4026b857ffc8f20.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/2e1f314dcd3f1c2b98ca3e7439442b20.pdf

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Approach Guardrail Transition Attach to 8" Concrete Sidewalk

Question
State: NJ
Date: 09-27-2018

In many of our projects, the contractors discover electric line or other utility running under the approach guardrail transition (AGT) posts. The locations of these utility will not allow for the new posts to be installed in accordance to our design standards for the AGT. Right now, we have a construction detail CD-609-11 for the guardrail attachment to a 8" sidewalk. We usually use this detail when there are underground utilities that prevent the posts from meeting the required embedment length along the normal section of the MGS. Can this construction detail be used along the AGT where there are underground utilities? For this kind of attachment to the 8" sidewalk, the required post size is W6x20 (see attached file). Thank you for your help.

Attachment: https://mwrsf-qa.unl.edu/attachments/59a9839ac5125aa7c3a265a287255ec9.pdf

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Response
Date: 10-23-2018

In theory, this type of a post connection could work within an approach guardrail transition. However, to my knowledge, this type of system has never been evaluated and there are questions related to multiple features within this system, as detailed below.

1. What are the effects of adding an 8" tall curb below the guardrail transition? Curbed transitions are typically tested and implemented with a 4" tall triangular shaped curb, while the MGS with curb was tested and is implemented with a 6" tall Type B curb. Thus, the performance of guardrail (and the more sensitive transition regions) is unknown.
2. Will a top-mounted, W6x20 post provide similar stiffness to the original transition post? Transitions are sensitive regions that are carefully designed to gradually increase lateral stiffness and prevent snagging and pocketing. Changes to the stiffness of the posts can negatively affect the performance of the guardrail transition. Thus, the top-mounted posts need to be designed with similar strengths to the original transition posts.
3. How would you safely transition from these large top mounted posts to standard posts embedded in soil (with or without a curb? There will likely be a great difference in post strength at this location that must be treated properly to prevent pocketing, snag, and possible rail tearing.
4. I also question the use of wide-flange steel sections as blockouts in transition regions. Previous full-scale testing has demonstrated that I-shaped steel blockouts are susceptible to web buckling, which decreases stiffness, increases deflections, and increases the likelihood of snag and vehicle instabilities.

As noted above, changes to the post size, the post anchorage, blockout shapes, and adding a curb are significant changes to the guardrail transition that may have huge effects on its performance. Therefore, I would recommend that this type of a system be analyzed and evaluated prior to implementing it.

Mis-fabricated Stirrup for Barrier Rail, RFI 90, Project IM-NHS-074-1(199)5--03-82, 2274' Welded Girder Bridge-WBL

Question
State: IA
Date: 10-03-2018

We have an issue on one of our projects where the reinforcing supplier misfabricated one of the reinforcing bars. A tail was missed on bar 5c1, see the plan sheet excerpt last page. The picture on the last page of the first attachment shows what was actually fabricated.

The contractor has requested to use these bars for every other instance of 5c1 in the barrier rail. The spacing for this bar is every 6 inches in the rail. The bars that go into the deck are every 12 inches. We were thinking they could use the misfabricted bars between the bar that go into the deck.

A consultant designed this project and used rail designs from other states so we are

not very familiar with the design. It is intended to be a TL5 system. Do you see a concern with using the misfabricated bars as we described? As always the contractor is anxiously awaiting our decision. I know this question is out of left field with a short fuse so if you think it is too much for our question and answer let me know.

Brian

Brian,
This is to follow up on our conversation this morning by you, Stuart Nielsen, and myself regarding whether mis-fabricated barrier stirrups can be used as proposed by the contractor in a request for information (CnRFI 90.pdf). A pdf of CnRFI 90 is attached which describes the issue.

Also attached for reference are plan sheet excerpts from the project plans. See attachment "Plan_Sheet_Excerpts.pdf." Note that Section A-A on Design Sheet 199 of 258 shows a section thru the barrier rail, and reinforcement bar details are on Design Sheet 207 of 258.)

I will also mention for your information that the subject barrier rail is a combination of a Pennsylvania and a Texas rail and it was reviewed by the by the Midwest Roadside Safety Facility in 2010. Attached is a pdf of project Task_209 which has some background information regarding the 2010 review of the rail design.

Please let me know if you have any questions or would like to discuss this.
Thank you.

Attachment: https://mwrsf-qa.unl.edu/attachments/7ac58d2079908aeb5394108f6d24b00f.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/c374f09bc2ffd6ea41eda1968bf12e76.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/ef3a3636a6997b71a6c85bcc9f6da4d0.pdf

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Response
Date: 10-03-2018

I reviewed the information you sent.

While typical stirrup design would have hooked ends like those shown in your detail, the as-fabricated stirrup may function appropriately. Based on the function and loading of that stirrup in the bridge rail, the development of the vertical arms of the stirrup is most critical. This can be developed through a simple 90 degree bend. According to code, that would require a length of 12*db or 7.5" in this case. It appears that the as-fabricated stirrup has this length in the bend adjacent to the vertical arms.

The other load directions on the stirrup are less critical here during impact loading, and the additional stirrups that tie into the deck at 12" spacing will help reduce the potential for overloading of the 5c1 stirrup.

As such we don't see a major issue with using the as-fabricated stirrup as proposed below.

Thanks

Guardrai Post alignment and which post bolt hole to utilze

Question
Date: 10-04-2018

We have been approached on several occasions lately by various stakeholders as to which is the correct post bolt hole to utilize when bolting standard guardrail? I believe the issue is coming up more frequently due to standard DOT drawings showing all post bolts installed consistently using one post bolt hole or the other and newer DOT inspection forces not having the history of guardrail installations as some of their older (and perhaps now retired) predecessors and counterparts.

Typically most states show 2 post bolt holes – one in each flange – of the guardrail post. Typically the blocks utilized with guardrail panels and guardrail posts are designed to allow bolting to either flange of the guardrail post. Further, the slots in the guardrail are ¾"H x 2-1/2"W and of course a 5/8"D bolt goes through the entire assembly. The slots being as wide as they are would appear to suggest that either post

flange bolt hole could be utilized – the one that best aligns for instance.

I'd be interested in learning if MwRSF can provide any information as to which post bolt hole should be used (or must be used) to bolt standard W-beam guardrail to the guardrail post? Does it matter? Is there any testing conducted where the bolting of the panel to the post varied on the MGS to use as an example?

Since field conditions of MGS may not be as consistent as testing laboratory installations and the spacing from post-to-post might vary slightly (typical I have seen is a tolerance of +/- 1") would MwRSF suggest that the appropriate guardrail post hole to utilize would be the hole that best aligns with the slot in the guardrail?

Any information on this subject that you might be able to provide would be appreciated. Thanks - Greg

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Response
Date: 10-05-2018

This issue has been brought up in the past to us as well, and we also have encountered it in testing.

We generally conduct guardrail testing with the bolt on the upstream side of the post for consistency. That said, we have run tests with it on the downstream side as well. We don't believe that the effect is significant either way.

When you impact a guardrail system, there is lateral loading of the post and longitudinal loading of the post. The lateral loading of the post and compression of the blockout would not really be affected by the post bolt location. With the longitudinal loading, there is some torsion applied to the post through the blockout and post bolt due to tension in the rail. However, the torsion is applied to the post in different directions upstream and downstream of the impact. Thus, changing the post bolt location would not really change the loading of the posts.

Thus, we have generally recommended that states select a consistent bolt location for more uniform installations, but we don't believe it is required. Guardrail with different

connections or terminals may have other considerations, but for the MGS, we would believe this is true.

Thanks

Attachment: https://mwrsf-qa.unl.edu/attachments/b5e4e6ebb741ec639ec0cee1d1ec1e59.jpg

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Anchored PCB placed behind free standing crash cushion - Shielding Piers

Question
State: UT
Date: 10-09-2018

See photo below of a stand alone crash cushion with 2 sections of anchored PCBs installed around 2 sign poles.
I thought of 3 options as stated below.
1. Remove the PCBs and relocate the crash cushion up to the first pole. It would be highly unlikely for an errant to impact the second pole in this case. For a car to impact the pole, the vehicle would be impacting the pole at such a high angle that it would be similar to impacting a cast-in-place concrete barrier.
2. Install seven anchored barrier with three barrier upstream of the beginning of LON and three barrier downstream of the end of LON as suggested in the response to IA: https://mwrsf-qa.unl.edu/view.php?id=1227
3. Install 40 feet of CIP barrier on both sides with foundation design. As I understand it a study for minimum length CIP barrier is not available but TTI is currently working on something similar with Texdot.
Question:
Would you agree that these are viable options?
Would you agree that option 1 would be the better choice because placing additional barrier would be more of a hazard than just placing the crash cushion placed in-front of the poles?
Thank you for your time,

Attachment: https://mwrsf-

qa.unl.edu/attachments/6ea8a03a2a6dd0638fbdcd794e3d37ec.jpg

Response
Date: 10-09-2018

I have provided a few thoughts below. By appearance, the site seems to have same direction traffic on both sides of the poles.

One option would be to utilize a thrie-beam bullnose guardrail envelope with the downstream end left open The upstream end would incorporate the rounded, slotted head with containment cables. This system would not require a concrete pad.

A second option would utilize the FLEAT median version that allows both rails to gradually spread apart such that the poles were adequately shielded from impacting vehicles with tolerable working width. This system would be long and not require a concrete pad.

A wide crash cushion with backup structure might be used here if backup structure is nearly touching poles. It is holed that the wider CC would protect against oblique impact near the downstream end of CC. However, the wide CC would need to be placed in CAD to determine if this solution is effective.

I do not like placement of PCBs on soil foundations. If PCBs were to be used, the ends of the PCBs would need to be treated with CC or sand barrels. The PCBs would also need to have sufficient clear area between poles and PCBs. The PCBs would need to have sufficient overlap of barriers past the poles as well per guidance. The upstream anchorage system would be needed on each column of PCBs. Asphalt should be under the PCBs too.

Overall, I like option 1 of 4 above the best.

Bridge Pier and other nearby hazards

Question
State: SC
Date: 10-17-2018

Mr. Bielenberg,

SCDOT historically used a device we referred to as "critical offset guardrail" often for bridge pier protection and in some cases adjacent to drop-offs when very limited shoulder space was available between the edge of travel and the hazard. We are looking for products that could be used to upgrade some of these sites that would fit within the same footprint and not introduce drainage changes that rigid barriers will introduce.

Critical offset consisted of Nested Thrie-Beam rail with W6x8.5 posts (6.5' long) at 1'-6.75" post spacing with 8" deep composite offset blocks.

We will most likely be using rigid barriers for many of these conditions in future designs, but we hope to find a suitable tested product that can be used to retrofit existing sites.

Can you provide us with a list of semi-rigid or post and beam style devices that are MASH tested (or even available under NCHRP Report 350 testing) that meet Test Level 5 requirements? If you can provide links to reports or letters for these devices that would be very helpful.

If you are not aware of any products that meet test level 5 conditions, can you provide any recommendations for details appropriate to meet the requirements of Roadside Design Guide for Zone of Intrusion (page 5-34) and AASHTO LRFD Bridge Design Specification 3.6.5 and conditions outlined in SCDOT Bridge Design Memo DM0213.

https://www.scdot.org/business/pdf/structural-design/bridge-memos/DM201302.pdf

Additionally, do you have thoughts on what conditions are appropriate for these barriers?

If site has lower ADT, lower speed, or lower truck traffic, would other barriers suffice?)

Thanks,

Attachment: https://mwrsf-qa.unl.edu/attachments/4e7563b6c4df872cd81e84561015aa43.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/30daf2ac231585acd08fe5129681284d.PDF

Attachment: https://mwrsf-qa.unl.edu/attachments/90792f674930b7520f0d6d913f81e533.pdf

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Response
Date: 10-30-2018

I have some comments on your email.

First, with respect to thrie beam, no thrie beam system has met MASH TL-3 at this time. The original G9 thrie beam system was tested during NCHRP 22-14(3), but it resulted in rollover of the 2270P vehicle. We believe this was due to the blockout length and can be solved easily. This issue came up during the pooled fund meeting last year, but it did not move forward. SDDOT would like to evaluate thrie beam as well as thrie beam with curbs. Further reduction of deflection through reduced post spacing and nested could likely be achieved, but it would require additional analysis and testing.

We also plan to test modified thrie beam to MASH TL-3 for NJDOT and CALTRANS within the next week. This would be another thrie beam option.

Both the standard and modified thrie beam systems are NCHRP TL-3 system currently. Modified thrie beam was tested to NCHRP 350 TL-4 and may work under MASH TL-4, but it would need to be tested.

However, it appears that you are looking towards higher service level barrier to shield piers and abutments. The only beam and post type system I know of for this is the ArcelorMittal TL5 Steel Median Safety Barrier. For this system, passenger car deflections are low, but the TL-5 deflection are over 4' and the working width is almost 5.5'.

There are several concrete barriers that could be used in this type of application that would meet TL-5 and limit working width, but it sounds like you are looking for something less costly. We can help with these if you are interested.

In terms of the warrants for bridge pier shielding, NCHRP 12-90 was conducted to deal specifically with this issue. http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3170 The website states it is completed, but I have not seen and cannot locate the final report. You may want to contact Mac Ray at RoadSafe and see if he can get you the results of that study.

These issues may be something to consider for the upcoming Year 30 problem statements for the Midwest Pooled Fund. SCDOT can submit them if they would like to. I have SCDOT on the mailing list, but I am not sure if you get the problem statement submission information. I have forwarded it to you.

Let me know if that addresses your questions and if I can help you in any other way.

Attachment: https://mwrsf-qa.unl.edu/attachments/0f26c506c1ec70109b41f462bb79db34.pdf