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	$76,592	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
	$3,281	

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	100%
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	25%
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	$161,377	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
	$10,276	

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

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$702,369	642,180	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
	$4,729	

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.):

Received feedback from sponsor.

Reports for test nos. NJPCB-1, NJPCB-2, NJPCB-3, NJPCB-4, NJPCB-5, NJPCB-6, NJPCB-7, NJPCB-8, and NJPCB-9 finalized and published

Anticipated work next quarter:

Dissemination of the research reports to sponsor.

Brainstorming of potential design modifications to improve performance for systems placed on asphalt.

Creation of papers from the research.

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

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.

Note Q4 2018 progress report does not include November or December labor charges

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)* 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	$20,424	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
	$54	

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 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. #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	$79,019	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**
	$309	

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.):

Effort continued to focus on assembling the project summary report. Note, labor charges for November and December are not included in the budget numbers shown herein due to the charges not being posts prior to the writing of this progress 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): 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. #95	☐ Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☑ Quarter 4 (October 4 – December 31)

Project Title:		
Enhancements to MwRSF Hub Website		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9070	kpolivka2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211125001	RPFP-16-WEB-1	10/1/2015
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2018	9/30/2019	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
$30,102	$28,803	95%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$5,014	

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.):

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	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).

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	$19,584	49%

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	$53	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. Work continued on validating the AGT model, but funds from this project were not necessary.

Anticipated work next quarter:

Work will conducted as problems with LS-DYNA arise.

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.

Note, this quarterly progress report does not include labor charges from November or December

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):	**Phone Number:**	**E-Mail**
Faller, Bielenberg, Reid, Rosenbaugh	(402) 472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130099001		7/01/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
12/31/2018	5/31/2019	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
$254,445.00	$175,249	73

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$11,937	

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 1st quarter of 2019.

Summary report for the full-scale testing will be worked on during the 1st quarter of 2019.

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): 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	$111,921	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**
	$2,933	

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 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.

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	$158,735	92%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$2,550	

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 edits to the TRB journal paper and an LS-DYNA transition model. The journal paper was accepted for publication by the Transportation Research Board in its TRR journal. Edits and comments provided by the paper reviewers and the editorial board were addressed and the paper was revised.

Last quarter, an LS-DYNA model was created to replicate the 34" tall AGT full-scale tests and to analyze future variations to guardrail transitions. This quarter, the LS-DYNA model was further revised to correlate better with the full-scale crash tests. changes included improving the strength of the thrie-beam rail and adjusting the soil resistance against the guardrail posts.

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, which will be shown at the annual meeting of the TRB in Washington DC in January.

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. A second no-cost extension was granted so that a journal paper to TRB could be written and supported to better disseminate the findings of the 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	$247,654	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**
	$11,066	

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.):

The test article, including the bridge rail and simulated bridge deck, from the full-scale crash test conducted last quarter were removed from the test site and disposed of. A summary of test 4cbr-1 was sent out to the project sponsors, and a summary presentation was given as part of the Midwest Pooled Fund Mid-Year meeting in November. Additionally, work continued on the project summary report, which will document all design, testing, and conclusions for the new optimized TL-4 concrete bridge rail.

Note, the project funds were exhausted by the end of 2018. As such, MwRSF will be looking to utilize contingency funds from within the Midwest Pooled Fund Program to complete the summary report and finish the project.

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.

The project funds were exhausted by the end of 2018. As such, MwRSF will be looking to utilize contingency funds from within the Midwest Pooled Fund Program to complete the summary report and finish the project.

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:

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 #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	$107,281	95%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**
	$3,381	

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.):

A draft of the project summary report, which includes all testing and conclusions, was completed and is now in internal review. Note, labor charges for November and December are not included in the budget numbers shown herein due to the charges not being posts prior to the writing of this progress report.

Anticipated work next quarter:

The summary report will be sent out to the project sponsors for review. If the review is conducted in a timely manner, final reports will go out n the 1st quarter of 2019, and the project will be closed.

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 #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):	**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:**
2611211135001	RPFP-17-MGS-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**
$161,926	$83,105	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**
	$2,779	

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.):

Work was focused on writing the project summary report, which documents both of the MASH full-scale crash tests and all analysis and conclusions. Additionally, detailed drawings for inclusion in the Task Force 13 Barrier Hardware Guide were assembled.

Anticipated work next quarter:

The summary report will be completed.

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. Further, much of the test installation from the MGS with omitted post test installation was re-used as part of the test installation for this project. Thus, system installation costs were minimal and significant funds are expected to remain upon completion of the project.

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:

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	$43,222	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
	$391	

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.):

Minimal work was conducted on this project over the last quarter, as efforts were focused on higher priority projects within the Midwest Pooled Fund Program (either projects that were closing or those that required immediate physical testing). Only a few hours were charged to the project to update budgets and reports as part of standard project maintenance.

Anticipated work next quarter:

The project summary report will be written and sent to the project sponsors for review.

Significant Results:

Following the unsuccessful full-scale crash test associated with Phase I of this project (Year 25 project), 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 3"x4". this reduction in slope was intended to reduce snag on the vehicle bumper and quarter-panel.

The second full-scale crash test, test no. AGTB-2, was conducted on the revised version of the standardized buttress according to MASH 3-21 impact criteria. During the test, the 2270P pickup truck was smoothly redirected by the guardrail transition with limited snag on the standardized concrete buttress. Data analysis showed all accelerations fell within acceptable limits, so the test satisfied the MASH criteria.

A journal paper on the development of the standardized buttress was written and submitted to the Transportation Research Board. The paper submission was presented at the 2018 annual TRB meeting in Washington D.C. and was published in 2018.

Objectives / Tasks:	% Complete
1. Redesign of Standardized Parapet	100%
2. CAD Details	100%
3. Construction of Test Article	100%
4. Full-Scale Crash Testing – MASH 3-21	100%

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

A 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
	$0	

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)*	**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
	$0	

Project Description:

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

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

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

Tasks:

1. Prepare CAD details for Hardware Guide

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

None as no comments were received due to no reviews from TF-13.

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	12/31/2019	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
$233,945	$226,144	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
	$32,173	

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.

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	95%
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 12/31/19.

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):	**Phone Number:**	**E-Mail**
Faller, Bielenberg, Reid	(402) 472-9064	rbielenberg2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611130104001		10/01/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
5/31/2018	2/28/2018	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
$190,745.00	$130,621	95

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$5,625	

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.

MwRSF received a no-cost time extension until 2-28-2019 to complete the summary report.

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

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: 1/30/2019 **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, Schmidt, Holloway, Lechtenberg, Rosenbaugh

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	0%	$0.00	100%	$0.00
2. Phase I Full-Scale Testing	$185,692.00	0%	$0.00	100%	$3,613.00
3. Phase II Full-Scale Testing	$79,788.00	10%	$1,164.00	100%	$55,086.00
4. Reporting and FHWA letter	$25,000.00	20%	$4,000.00	70%	$11,269.00
5.					
6.					
7.					
8.					
9. Total	$305,115.00		$5,164.00		$69,968.00

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 review was completed on the draft report. The draft report was sent to the sponsor for review.

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,this progress report does not include labor charges from November or December. 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:

Sponsor comments will be implemented. The final report will be sent to the sponsor.

Total Percentage of Project Completion:

98%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	7%	$25,051.00	4%	$283,623.00
3. Bridge Rail Reporting	$30,000.00	17%	$5,000.00	50%	$8,000.00
4. Bridge Deck Component Testing	$187,956.00	10%	$7,953.00	100%	$0.00
5. Transition Planning	$13,859.00	36%	$5,000.00	88%	$1,859.00
6. Transition Analysis and Design	$67,261.00	5%	$3,000.00	5%	$64,261.00
7. Transition Full-Scale Testing	$200,482.00	0	$0.00	0	$200,482.00
8. Transition Reporting	$30,000.00	13%	$4,000.00	13%	$26,000.00
9. Total	$926,851.00		$50,004.00		$584,225.00

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 drawings and details for the steel stube bridge rail test installation were completed. The bridge deck slab was poured. All materials were ordered and received, and assembly of the steel tube bridge rail began.

Concept development continued on the approach guardrail transition. Several options were reviewed and a single steel piece with bolts was designed to attach the thrie beam end connector to the face of the steel tube bridge rails. The sponsor desired for the AGT to have a top height of 34 in. to accommodate a future 3-in. overlay. The top tube of the bridge rail was sloped down to rest of top of the middle tube. The connector piece was sized to accommodate loads across a 6-ft opening from the last AGT post to the 1st bridge rail post.

An LS-DYNA finite element analysis model began to be developed for the bridge rail post and post-to-deck connection. This model will be used as part of the simulations of AGT connection prior to full-scale crash testing.

Writing continued on the 3 summary reports - 1) bridge rail design, analysis, and testing, 2) post-to-deck attachement design, analysis, and component testing was submitted for MwRSF internal review, and 3) AGT development and testing.

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 multiple 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 orginal gantt chart. Every effort will be made to get the project completed by its original end date (September 30, 2019). Note, November and December labor charges are not included in this progress report.

Anticipated Work Next Quarter:

Three full-scale crash tests will be conducted on the bridge rail, and the data will be analyzed.

The AGT concepts will be presented to the sponsors in January 2019. Simulation of the AGT connector will begin.

Writing will continue on the summary reports.

Total Percentage of Project Completion:

45%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	75%	$850.00	100%	$2,650.00
2. Full-Scale Crash Testing	$116,259.00	5%	$6,495.00	100%	$45,410.00
3. Reporting and Project Deliverables	$14,155.00	5%	$3,347.00	100%	$3,064.00
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, the final report was completed and sent to the sponsor and the project was closed.

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.

Total Percentage of Project Completion:

95%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	25%	$7,840.00	100%	$0.00
2. Design and Analysis	$20,386.00	0%	$0.00	100%	$0.00
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.)

Draft report on the nineteen dynamic component tests and one floorpan cutting dynamic component test on the closed post sections continued to be reviewed internally.

Initiate draft report on the sleeve nut development and testing.

Acquired materails for the first system.

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:

None.

All funds were exhausted and this project is closed. Further work will be reported under project TPF-5(193) Supplement #138.

Total Percentage of Project Completion:

100%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	10%	$2,000.00	57%	$9,027.00
2. Full-Scall Crash Testing	$128,945.00	8%	$10,500.00	31%	$88,334.00
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.)

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

Completed documentation and analysis of test SPTA-2.

Initiated research report of the two crash 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.)

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:

Potentially complete internal review of the literature review, patent search, concept development, and component test documentation. Potentially send draft report to member states for review if internal review completed.

Continue writing research report of the two crash tests.

.

Total Percentage of Project Completion:

30%

Research Project Quarterly Progress Report

Date: 1/30/2019 **Project Number:** TPF-5(193) Suppl. #122; RPFP-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) 472-0870

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	23%	$6,526.00	56%	$16,117.00
2. Analysis & Selection of Configurations	$24,396.00	20%	$5,000.00	60%	$17,824.00
3. Develop Bogie, Install and Remove Signs	$51,348.00	10%	$5,000.00	10%	$46,348.00
4. Dynamic Bogie Tests	$90,988.00	15%	$15,000.00	15%	$75,988.00
5.					
6.					
7.					
8.					
9. Total	$195,238.00		$31,526.00		$145,368.00

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 data from the crash test was analyzed. The first draft of the 3 full-scale crash tests was completed. Drawings were completed of the next U-channel sign supports to be bogie tested.

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 crash test charges were posted to the project. Note, November and December labor charges are not included in this progress report.

Anticipated Work Next Quarter:

The draft testing report will be reviewed. 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:

25%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	5%	$3,250.00	95%	$205,028.00
3. Reporting and Project Deliverables	$27,719.00	20	$6,299.00	25%	$18,645.00
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:

75%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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%	$11,791.00	75%	$44,519
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-4Q 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:

75%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	7%	$963.00	7%	$11,706.00
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.)

Maintenance, repair, and upkeep of the website continued.

Updated research hub with new completed projects.

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 continue.

Update research hub with new completed projects.

Total Percentage of Project Completion:

7%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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: 1/31/2019 **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%	$0.00	70%	$2,878.00
2. **Full-Scale Crash Testing**	$200,641.00	2%	$3,919.00	85%	$130,617.00
3. **Reporting & Project Deliverables**	$25,000.00	0%	$0.00	15%	$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.)

Demolishion and test site clean up.

Completed analysis on NYWBT-3.

Compiling the results in a draft research report.

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: 1/31/2019 **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:** 2/28/2020

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. System #1 - X-Foot Signs with Trim-line Posts	$109,634.00	0%	$0.00	0%	$106,231.00
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 RSST Posts	$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.)

System components were delivered by sponsor on Novemer 13. Meeting to discuss the systems and project was also held on that same day.

Drafting of test plans for the X-stand systems and U-channel system.

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.

Note Q4 2018 progress report does not include November or December labor charges

Anticipated Work Next Quarter:

Continue drafting test plans.Send to sponsor for review.

Obtaining material certificates and/or certificates of conformance.

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	10	$4,523.00	40	$33,610.00
2. Literature & State Standard Review	$47,885.00	10	$4,000.00	30	$33,570.00
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.)

Literature review was drafted and summarized. Initial concepts for posts, fence shape and size, strength requirements, failure conditions, and anchoring were developed. Calculations for post shapes were completed for prismatic, circular poststs.

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 post analysis and concept generation for cap rail, end terminations, anchoring, and bracket designs for the back side of parapet. Meet with Iowa DOT to discuss progress and recommendations. Discuss full-scale testing recommendatinos and system design, as well as transitions, terminations, anchoring requirements, and debris generation.

Total Percentage of Project Completion:

25

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	20	$4,152.00	50	$15,746.00
2. Crash Data Analysis	$44,802.00	10	$3,000.00	20	$35,675.00
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.)

Crash narratives received from Iowa and reviewed in detail to assign likelihood of sloped end crash. Reports localized to areas near concrete barrier sloped ends and which included a fixed-object crash. Requests issued for scene diagrams to confirm accuracy of narrative assignments.

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 scene diagrams and begin injury, exposure, crash freuqency, and relative risk analysis. Work with Iowa Motor Vehicle Division to obtain sensitive data and records. Continue workign on summary research report.

Total Percentage of Project Completion:

25

Research Project Quarterly Progress Report

Date: 1/31/2019 **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%	$515.00	10%	$6,572.00
2. Full-Scale Crash Testing	$150,175.00	5%	$56,008.00	38%	$94,167.00
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.)

Two crash tests are planned on the system. The first test is test no. 3-11 on a single-sided roadside version of the system, while the second test is test no. 3-10 on a dual-sided median version of the barrier system.

Test no. MTB-1 was conducted under the MASH TL-3 guidelines for test no. 3-11. Test no. 3-1 is an impact of the 2270P vehicle at 62 mph and 25 degrees on the system. The critical impact point for this test was selected to maximize vehicle snag on the system posts and splice loading. In test no. MTB-1, a 5,003 lb. Ram 1500 quad cab pickup impacted the barrier at a speed of 62.9 mph and an angle of 25.5 degrees at 138 in. upstream of post no. 13 in the system. During the test, the vehicle was captured and redirected by the thrie beam. During the redirection of the vehicle, torsion collapse of some of the W-section blockouts was observed similar to that seen in the original NCHRP 350 testing of the system. The torsional collapse of the blockouts did not compromise the overall test result. However, it may have led to increased wheel snag on the posts and disengagement of the right-front wheel. Additionally, The collapse of the blockouts appeared to allow the thrie beam to contact the post flange at post nos. 12 and 13. The contact at post no. 13 was sufficient to cause a small tear just downstream of the thrie beam splice. However, this small tear did not adversely affect the barrier system performance. Vehicle capture and stability of the were good and occupant risk measures were within the MASH limits. The stability and trajectory of the vehicle were acceptable. The MASH TL-3 test evaluation criteria were met. Thus, the modified thrie beam system was acceptable under the MASH TL-3 criteria.

The second test on the dual-sided median barrier has been constructed and should be conducted during the upcoming 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:

Conduct the second full-scale crash test of the modifed thrie beam system.

Total Percentage of Project Completion:

33%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	10%	$699.00	10%	$30,692.00
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.)

In this quarter, MwRSF reviewed CALTRANS models of a breakaway lumnaire support. MwRSF developed a list of potential modeling improvements and had a meeting with CALTRANS to review those suggestions.

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 support CALTRANS LS-DYNA efforts as needed.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #134 Part 1

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

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, [illegible]	$43,369.00	57%	$25,000.00	60%	$17,278.00
2. Full-Scale Crash Testing	$517,258.00	4%	$21,349.00	4%	$495,909.00
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.)

Completed test plan drawings.

Ordered and acquired system materials including material certificates/mill certificates/COC

Constructed the first system.

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 the first test into the system. Document and analyze the test data.

Complete test plan drawings for subsequent tests.

Repair/rebuild system for the next test.

Conduct the second test into the system. Document and analyze the test data.

Potentially repair/rebuild system for the next test.

Total Percentage of Project Completion:

8%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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: 1/31/2019 **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	45%	$10,000.00	49%	$11,464.00
2. Full-Scale Crash Testing	$263,648.00	13%	$34,606.00	13%	$229,042.00
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.)

Completed test plan drawings.

Ordered and acquired system materials including material certificates/mill certificates/COC

Working on constructing the first system.

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 the first test into the system. Document and analyze the test data.

Complete test plan drawings for subsequent tests.

Repair/rebuild system for the next test.

Conduct the second test into the system. Document and analyze the test data.

Potentially repair/rebuild system for the next test.

Total Percentage of Project Completion:

15%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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 Certs	$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 C1 - Cable Guide Rail Tangent Run 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 C1 - Cable Guide Rail Tangent Run project.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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%	$453.00	10%	$18,458.00
2. Design and Analysis	$27,234.00	5%	$720.00	10%	$26,514.00
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.)

MwRSF has continued 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:

8%

Research Project Quarterly Progress Report

Date: 1/31/2019 **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	10%	$954.00	15%	$23,882.00
2. Design and Analysis	$50,630.00	5%	$162.00	5%	$50,468.00
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.)

MwRSF continued the process of brainstorming design concepts and complying the background literarure. Basic, initial design concepts were formulated.

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:

Completion of review of literature and patents. Development of design criteria.

Total Percentage of Project Completion:

8%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #138, RPFP-19-CABLE-1

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

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

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

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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 Carts	$13,264.00	38%	$5,000.00	35%	$8,264.00
2. Full-Scale Crash Testing	$214,157.00	13%	$28,046.00	13%	$186,111.00
3. Reporting & Project Deliverables	$13,579.00	0%	$0.00	0%	$13,579.00
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.)

Draft report on the nineteen dynamic component tests and one floorpan cutting dynamic component test on the closed post sections continued to be reviewed internally.

Initiate draft report on the sleeve nut development and testing.

Acquired materails for the first system.

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

Continue to write the research report on the sleeve nut development and testing. Potentially send draft report to member states.

Construction of the first system. Conduct first test.

Total Percentage of Project Completion:

13%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #139, RPFP-19-CONC-1

Project Title: Evaluation of Permanent Concrete Barriers to MASH 2016

Principal Investigator: Faller, R.K., Bielenberg, R.W., Lechtenberg, K.A., and Rosenbaugh, S.K.,

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

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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. Planning and Correspondence	$46,190.00	0%	$0.00	$0.00	0%	$46,190.00
2. Analysis and Design	$94,270.00	0%	$0.00	$0.00	0%	$94,270.00
3. Reporting and Project Deliverables	$23,161.00	0%	$0.00	$0.00	0%	$23,161.00
4.						
5.						
6.						
7.						
8.						
9. Total	$163,621.00		$0.00	$0.00	0%	$163,621.00

Progress and Accomplishments this Quarter:

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

No work was conducted on this project over the last quarter, the first quarter in which the project was open, as efforts were focused on higher priority projects within the Midwest Pooled Fund Program (either projects that were closing or those that required immediate physical testing).

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:

The literature review will begin, and a survey will be sent out to the Midwest Pooled Fund states requesting the submission of any permanent concrete barriers in which they deisre to be analyzed/evaluated as part of this project.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #140, RPFP-19-MGS-3

Project Title: Evaluation of MGS with Curb and Omitted Post (Continuation)

Principal Investigator: Faller, R.K., Bielenberg, R.W., Lechtenberg, K.A., and Rosenbaugh, S.K.,

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

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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. Planning and CAD	$11,576.00	0%	$0.00	$0.00	0%	$11,576.00
2. Physical Crash Testing	$91,703.00	0%	$0.00	$0.00	0%	$91,703.00
3. Reporting and Project Deliverables	$7,854.00	0%	$0.00	$0.00	0%	$7,854.00
4.						
5.						
6.						
7.						
8.						
9. Total	$111,133.00		$0.00	$0.00	0%	$111,133.00

Progress and Accomplishments this Quarter:

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

No work was conducted on this project over the last quarter, the first quarter in which the project was open, as efforts were focused on higher priority projects within the Midwest Pooled Fund Program (either projects that were closing or those that required immediate physical testing).

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.)

Anticipated Work Next Quarter:

A CIP will be identified for the full-scale crash test utilizing BARRIER VII simulation. Subsequently, a test plan including detailed drawings will be assembled and sent to the MwRSF test site.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/30/2019 **Project Number:** TPF-5(193) Suppl. #141; RPFP-19-AGT-1

Project Title: Guidelines for Flaring Thrie-Beam Approach Guardrail Transitions - Phase I

Principal Investigator: Jennifer Schmidt, Faller, Bielenberg, Lechtenberg, Rosenbaugh, Stolle

Principal Contact Information Email: jennifer.schmidt@unl.edu **Phone:** (402) 472-0870

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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	$12,994.00	0%	$0.00	0%	$12,994.00
2. Computer Simulation	$45,524.00	0%	$0.00	0%	$45,524.00
3. Report	$13,893.00	0%	$0.00	0%	$13,893.00
4.					
5.					
6.					
7.					
8.					
9. Total	$72,411.00		$0.00		$72,411.00

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 project began this quarter, so no significant progress has been made.

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.

Note, this quarterly progress report does not include labor charges from November or December.

Anticipated Work Next Quarter:

The research team will hold a kickoff meeting with the team engineers and graduate student to determine the best plan of action for the project. The team will conduct the literature review on prior MASH-tested transitions and flared guardrail systems. A critical transition will be selected. Development will begin on an LS-DYNA model.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/30/2019 **Project Number:** TPF-5(193) Suppl. #142; RPFP-19-TERM-1

Project Title: Generic End Terminal - Phase II

Principal Investigator: Jennifer Schmidt, Faller, Bielenberg, Lechtenberg, Rosenbaugh, Stolle

Principal Contact Information Email: jennifer.schmidt@unl.edu **Phone:** (402) 472-0870

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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	$40,364.00	0%	$0.00	0%	$40,364.00
2. Concept Refinement & Simulation	$95,701.00	0%	$0.00	0%	$95,701.00
3. Dynamic Bogie Tests	$153,861.00	0%	$0.00	0%	$153,861.00
4. Report	$35,467.00	0%	$0.00	0%	$35,467.00
5.					
6.					
7.					
8.					
9. Total	$325,393.00		$0.00		$325,393.00

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 project began this quarter, so no significant progress has been made. A brief meeting was held in December to get the project started.

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.

Note, this quarterly progress report does not include labor charges from November or December.

Anticipated Work Next Quarter:

The research team will hold a kickoff meeting with all of the Co-PIs and lead engineer to determine the best plan of action for the concept refinement, simulation, and bogie testing. Concept refinement will begin.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Supl. #143, RPFP-19-MASHIMP-1

Project Title: MASH 2016 Implementation Support

Principal Investigator: Faller, R.K., Bielenberg, R.W., Lechtenberg, K.A., and Rosenbaugh, S.K.,

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

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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. Analysis and Evaluation	$40,010.00	100%	$304.00	$304.00	1%	$40,010.00
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9. Total	$40,010.00		$304.00	$304.00	1%	$40,010.00

Progress and Accomplishments this Quarter:

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

Minimal work was conducted on this project over the last quarter, the first quarter in which the project was open. Only one request to evaluate a barrier system was received by MwRSF.

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:

An email will be sent out to the members of the Midwest Pooled Fund to remind them of this project and request that any system they desire for MwRSF to evaluate be submitted as part of this project.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #144, RPFP-19-MASHHC-1

Project Title: Midwest Pooled Fund MASH Hardware Clearinghouse - Phase 1

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

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

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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 Planing & Correspondence	$6,627.00	0%	$0.00	0%	$9,927.00
2. Survey, Website Development & [illegible]	$40,185.00	0%	$0.00	0%	$40,185.00
3. Research Deliverables	$4,394.00	0%	$0.00	0%	$4,394.00
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.

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:

Survey to member states to determine the desired information to be contained on the clearinghouse.

Initiate layout of clearinghouse

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #145, RPFP-19-MWQA-1

Project Title: Enhancements to the MGS Website Research Hub

Principal Investigator: Ron Faller, Bielenberg, Lechtenberg, Rosenbaugh, Schmidt, Stolle

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

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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 Hub Improvements**	$30,102.00	0%	$0.00	0%	$30,102.00
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9. **Total**	$30,102.00		$0.00		$30,102.00

Progress and Accomplishments this Quarter:

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

Project was started. MwRSF responsibilities were assigned. First group meeting to discuss content and project startup scheduled for January 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.)

None.

Note, this quarterly progress report does not include labor charges from November or December

Anticipated Work Next Quarter:

A survey will be developed and sent to Midwest Pooled Fund States to rank and prioritize improvements to the Q&A site, as well as to query for any new recommendations which may be provided. Responses to surveys will be summarized and priorities assigned. Meetings will be held with programmers to discuss the anticipated time and effort to implement the recommendations, and which improvements can be implemented concurrently. Estimated costs will be identified for the improvements.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #146 - RPFP-19-MWQA-2

Project Title: Revisions to Midwest Pooled Fund Q&A Website Technical Information

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: 10/9/2018 **Project Completion Date:** 12/31/2021

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	$4,785.00	0%	$0.00	0%	$4,785.00
2. Website Design and Improvement	$41,130.00	0%	$0.00	0%	$41,130.00
3. Reporting and Project Deliverables	$3,810.00	0%	$0.00	0%	$3,810.00
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.)

In this quarter, no progress was made on the Revisions to Midwest Pooled Fund Q&A Website Technical Information project due to other research project having higher priority.

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 attempt to initiate this effort in the upcoming quarter by starting the process of sorting the current Q&A responses into categories and subcategories.

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #147 RPFP-19-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: 10/10/2018 **Project Completion Date:** 12/31/2021

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**	$62,001.00	0%	$0.00	0%	$62,001.00
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.

To date no progress has been made on this effort as we are still using the funds from the Year 28 Midwest Pooled Fund Consulting 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.)

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:

0%

Research Project Quarterly Progress Report

Date: 1/31/2019 **Project Number:** TPF-5(193) Suppl. #148, RPFP-19-PFCHS

Project Title: Pooled Fund Center for Highway Safety

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

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

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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	$13,340.00	0%	$0.00	0%	$13,340.00
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-18-PFCHS – TPF-5(193) Supplement #125, 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-18-PFCHS – TPF-5(193) Supplement #125, Project Title: Pooled Fund for Highway Safety have been exhaused.

Anticipated Work Next Quarter:

None

Total Percentage of Project Completion:

0%

Research Project Quarterly Progress Report

Date: 1/30/2018 **Project Number:** TPF-5(193) Suppl. #149, RPFP-19-LSDYNA

Project Title: LS-DYNA Modeling Enhancement Support

Principal Investigator: Jennifer Schmidt, Faller, Bielenberg, Lechtenberg, Rosenbaugh, Stolle

Principal Contact Information Email: jennifer.schmidt@unl.edu **Phone:** (402) 472-0870

Project Start Date: 10/1/2018 **Project Completion Date:** 12/31/2021

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 Modeling EnhancementSupport	$42,366.00	0%	$0.00	0%	$42,366.00
2.					
3.					
4.					
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.)

None. Funds will not be expended from this project until the remaining Year 26 LS-DYNA funds have been spent.

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.

Note, this quarterly progress report does not include labor charges from November or December

Anticipated Work Next Quarter:

None. Funds will not be expended from this project until the remaining Year 26 LS-DYNA funds have been spent.

Total Percentage of Project Completion:

0%

Midwest States Pooled Fund Program Consulting Quarterly Summary

Midwest Roadside Safety Facility

10-01-2018 to 02-01-2019

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

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

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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

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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.

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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Question about thrie beam approach transition

Question
State: WI
Date: 10-31-2018

To all,

Is having a post in the location below a concern?

Attachment: https://mwrsf-qa.unl.edu/attachments/5be0fb3636f6c92a6edfd8b1c9077e09.jpg

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Response
Date: 10-31-2018

From the analysis done on the upstream MGS stiffness transition, the addition of a post at the location you have highlighted red should not negatively affect the performance of the guardrail. It likely isn't necessary, but I don't see how it would cause issues. One note, the recommended barrier lengths upstream of the transition would increase (distance to terminal or flared section). The recommendations provided within the MGS transition report for the length of MGS upstream of the transition would need to increase by 6.25-ft. But, if you have a long installation length, this wouldn't be a problem.

Temporary Barrier Rail and 6" curb

Question
State: IA
Date: 11-06-2018

As shown in the attached detail, there will be 6" sloped curve adjacent to a paved shoulder with a permanent concrete barrier on top of it. The MSE wall in the detail will be under construction this winter and the Finished Grade Shoulder Pavement and the Barrier will not be in place. The plan right now is to place temporary barrier rail in front of the 6" sloped curb. This will be in a workzone with a 45mph speed limit and be in place for 5-6 months. We are assuming the temporary must be anchored. Are there any other concerns with the barriers potential interaction with the 6" sloped curb?

Thanks,

Attachment: https://mwrsf-qa.unl.edu/attachments/7241037fce8804bbf6ee02178c51f2b1.pdf

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Response
Date: 11-06-2018

Typically we do not recommend installation of PCBs in front of curbs or other obstructions that limit translation of the back face of the barrier.

The concern is that restraining the back of the barrier will cause the barrier to rotation rather than translation when impacted. This will tend to induce increased vehicle climb and stability on the toe and the sloped face of the barrier.

Anchoring of the barrier will help reduce this significantly depending on the type of anchorage used.

It is also less of a concern at the 45 mph speed you are using which corresponds to TL-2 speeds as compared to TL-3.

We would generally recommend anchoring in this case to prevent the rotation.

If you had the room, you could provide 24" between the back of the PCB and the curb to allow for translation and redirection prior to interaction with the curb. However, I don't know what your space limitations are.

Thanks

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parapet termination at tunnel emergency egress

Question
State: VA
Date: 11-09-2018

We are about to build a new tunnel. The door shown is required for emergency exit. Any thoughts about how the door frame and parapets could be modified to mitigate crash severity.
The tunnel shown is one way, the new tunnel will have reversible traffic.

Attachment: https://mwrsf-qa.unl.edu/attachments/501a512cc273197ff58b8838f76bef35.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/6f9cefbbb72f7081421df67572f44b56.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/6481e14ec75e98f3040eecd2c220dddd.jpg

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Response
Date: 11-10-2018

Bob and I have discussed this situation. The main concerns are vehicle snag on the downstream edge of the door frame and exposed end of barrier downstream from the door frame for one way traffic. For cases of reverse-direction traffic, both exposed ends are a snag risk for errant vehicles.[Zickler(VDOT)] that matches what I was thinking.

To mitigate snag risk, we have been guiding states to use a lateral transition or flare of 1:10, or 1 ft laterally to 10 ft longitudinally. Now, it can be challenging to feather reinforced concrete to zero. Thus, one may need to grind the wall down near the end to allow for larger thickness but a smooth transition at surface. What materials currently make up the walls in the tunnels depicted in photographs? [Zickler(VDOT)] walls are reinforced concrete and are covered by a fire proofing material that screwed on (similar to a ceiling tile) Is your door crashworthy? [Zickler(VDOT)] Not sure, I know it is not crash tested. What happens to door under MASH impact loading?[Zickler(VDOT)] I am fairly sure it deforms and causes a sudden deceleration.

The recessed door would also need to use tapered upstream and downstream edges. One option is to move door forward to eliminate exposed recession. If one cannot do this. Then, one must consider 1:10 transition there too.***[Zickler(VDOT)]*** makes sense to me.

A different option would be to use a structural gate that shields the entire opening. The gate would likely need to activate with ease upward when door access is required. Can you accept the use of a vertically swinging gate to allow access to door?***[Zickler(VDOT)]*** a swinging would likely be very difficult to get past the fire code if it swings into the roadway. Do you mean something that would rotate in a plane parallel to the plane of the door about an axis perpendicular to the roadway? Counterweighted to move up and out of the way? The gate arm would provide continuity from parapet end to parapet end? Similar to the fill in concepts we have been discussing for median barrier openings or temporary barrier closures but able to rotate up and out of the way? That might work.

If handicap access is not needed, one could raise door access to above barrier and add small strategically-sized steps into barrier face. A door on a platform would be easier to shield.***[Zickler(VDOT)]*** Handicapped access is required. We are nailing down refuge behind the door for handicapped folks and an egress for the able bodied.

It may be helpful to verbally discuss options after knowing all of your tunnel constraints. Please let me know if a live discussions is desired to further brainstorm options and current ideas.***[Zickler(VDOT)]*** I am sure that would be helpful. After Thanksgiving?

Response
Date: 11-11-2018

Thank you very much for your feedback.

Please see below for additional information. I will send some sketches based on your feedback and then we can set up a time to talk.

I have another concept that I want to discuss but I will start a new chain.

Thank you very much for your help.

MGS Post Length Tolerance

Question
State: IN
Date: 11-09-2018

I apologize if this question is covered in a report. We have a specification that allows for a 2" length tolerance for wood posts. I know we have a 1 inch tolerance for the height of rail but do we have an embedment tolerance? Basically I am wondering if a length tolerance of plus or minus 2" is acceptable for wood posts to be used for MGS w-beam guardrail? If it is covered in a report, which one? Thank you

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Response
Date: 11-09-2018

This is not located in any report. I did answer this question for Wyoming back in March.

https://mwrsf-qa.unl.edu/view.php?id=1226

My response was as follows:

"We generally use a relationship to describe the changes in post-soil forces that varies with the square of the ratio of the embedment depths of the post.

$F_2 = F_1(d_2/d_1)^2$

So, if we increase embedment depth from 40" to 43", we expect the post-soil forces to increase by a factor of 1.156.

The concern with wood post with increased lengths would be that increased length could significantly increase the post-soil forces and lead to fracture of the wood post rather than rotation through the soil. Fracture of the post can lead to pocketing, increased rail loads and fracture, and vehicle instability similar to a system with an omitted post.

Based on these concerns, we would recommend that the post length tolerance for wood posts be around plus or minus 2". For a 40" post embedment, this limits the variation in post soil forces to around 10%. Variation more than this may start to adversely affect barrier performance."

Let me know if you need anything else.

Thanks

Standard MGS W-Beam with Weak Soil

Question
State: IN
Date: 11-27-2018

Would it be acceptable to place standard MGS w-beam guardrail (6 ft posts at 6'-3"

post spacing and 2 ft of 10:1 slope behind the post) in weak soil? We have projects where the soil is predominately peat. After reading Q&A #1132, the standard system should be acceptable but we should assume a working width of 60 inches. Do you have any additional thoughts. Thank you

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Response
Date: 12-04-2018

The MGS system has not been evaluated in weak soils at this time, so a definitive answer on its performance in weak soils cannot be given. However, there is evidence that it may perform satisfactory with reduced soil strength.

Previous testing of the standard MGS with 6' long posts installed at the slope break point of a 2:1 slope found that the MGS could safely redirect a vehicle adjacent to a steep slope with reduced soil forces under MASH TL-3. However, the dynamic deflection of this system increased to 72.9" as compared to 44" for the standard MGS in strong soil. Thus, there would seem to be potential for the MGS to work in weak soils.

Similar comparisons can be made to W-beam systems tested to MASH TL-3 with larger deflections such as the G3 weak post W-beam, which had a dynamic deflection of 103.2", and the MGS long span, which had a deflection of 92".

Based on these tests of previous systems, it is reasonable that the MGS has the potential to function with weaker soil. However, it is not known what the strength/resistance levels of the peat soil in your state are or what the dynamic deflection or working width of a system installed in that soil would be.

Thus, we would anticipate that the MGS would redirect errant vehicles under MASH TL-3 impact conditions, but that system deflections would increase significantly. Quantifying the increase in deflection would be difficult without further study. These comments are also limited to the LON of the MGS system. Anchorages and/or end terminals and approach guardrail transition performance may be affected as well. We would also not recommend the use of the weak soil for MGS special applications without further study.

W-beam on shallow box culverts

Question
Date: 12-04-2018

I would appreciate your thoughts and recollection about the design and testing of the base plated w-beam system on shallow (low fill) concrete box culverts. Both of the designs shown below from TTI (Report No. 405160-23-2 - MASH Test 3-11 of the W-Beam Guardrail on Low-Fill Box Culvert) and from MwRSF (TRP-03-114-02 - NCHRP 350 Development And Testing Of A Guardrail Connection To Low-Fill Culverts) were designed and tested with 9" of cover. Page 25 of MwRSF report (TRP-03-114-02) states that "since zero or minimal thickness of soil fill is generally not an option for most culvert designs, a 229-mm layer of soil fill was selected for the research study and was believed to still provide a critical safety performance evaluation on the new barrier system". The TTI design duplicated the 9" cover used for the MwRSF design.

I am trying to confirm whether these base plated designs would be acceptable for installation on an exposed culvert deck (or bridge deck) without the 9" of fill (cover) that both MwRSF and TTI evaluated and tested. I did not see any other details in either report suggesting the 9" of cover is actually required for the based plated systems to perform acceptably during an impact, but both show 9" cover as the minimum.

If the 9" of cover is required for these designs, are you aware of another MGS or thrie beam system that could be base plated to the top of an exposed concrete deck that meets MASH TL-2 or higher? I am also dealing

with an existing curb in front of the barrier system, which I could remove or partially remove, but would prefer to retain it. I was thinking about potentially doubling up on the 8" offset blocks to keep face of w-beam within 5" of face of curb (similar to MGS with 12" offset blocks with w-beam set 5" behind 6“ high barrier curb) if you did not have any concerns. Proposed installation is on a narrow low volume low speed road, so TL-2 would be acceptable.

MwRSF TRP-03-114-02 – Based plated W-beam, NCHRP 350 TL-3

TTI Report No. 405160-23-2: Base plated MGS, MASH TL-3

Attachment: https://mwrsf-qa.unl.edu/attachments/144c4e10a0e5547c1942fa7fc787fb4b.jpg

Attachment: https://mwrsf-qa.unl.edu/attachments/7fd8e2e3e4ba7b367dfa293f7b742ecd.jpg

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Response
Date: 12-05-2018

At this time, we would not recommend installing either of these guardrail systems without a minimum of 9" soil fill on top of the culvert. Over the past few years we have observed multiple instances of rail tearing (both partial tears and complete rupture) related to MASH testing of stiffened guardrail systems. In fact, both of these systems experienced partial rail tearing as part of their MASH testing and evaluation. Eliminating the soil fill results in a reduction to the post length and the corresponding moment arm (distance from base plate to center of rail), which will effectively stiffen the barrier system. This additional stiffening may lead to further tearing of the rail and even complete rupture. As such, we would recommend testing of these systems with reduced soil fill prior to installing them in the real world.

TTI has developed and crash tested a top-mounted, weak-post W-beam bridge rail. Both MASH TL-2 and MASH TL-3 variations have been tested and differ only by the spacing between posts. I have provided a few links to this system below. Links to the testing reports should be at the bottom of the respective web pages.

https://www.roadsidepooledfund.org/longitudinal-barrier/txdot-t631-bridge-rail/

https://www.roadsidepooledfund.org/longitudinal-barrier/txdot-t631-bridge-rail-2/

The TTI system was based off of the MGS bridge rail developed here at MwRSF (a socketed, side-mounted system). We have also developed socketed, side-mounted barrier options for culvert headwalls, and we have recently developed a new side-mounted socket attachment that better distributes deck loads, thereby preventing damage. If you are interested in utilizing any side-mounted options, let me know.

Response
Date: 12-07-2018

I was not aware of the two TTI deck mounted MGS systems, which are perfect for one side of project (and others), whereas we are considering the MwRSF side mounted MGS system for the other side (which is shown below from TRP-03-277-14 - Concept D2: Side-Mounted, Epoxy-Anchored). If you have another option we should consider, please advise.

Currently both sides of the triple cell culvert/dam has 10" high x 8" wide curbs (one side at edge of deck, other in front of dam control lifts for control gates. Would it be potentially acceptable to use 8" or 12" offset blocks with the top and side mount weak post systems to get face of rail in front of existing curbs for this low speed low volume single lane structure, or could we consider reduction in curb height to 4" or 6" with sloped face (similar to MGS with 12" blocks offset 5" behind 6" barrier curb)), or is complete removal of curb our best option.

Thanks again for your quick response and references.

Attachment: https://mwrsf-qa.unl.edu/attachments/45ed804f2829863e269968deba21cdd1.jpg

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AGT minimum length

Question
State: OH
Date: 12-05-2018

Good Morning,

We are looking for a clarification of the implementation guidelines as stated in report no. ***TRP-03-243-11 Development of Alternative Wood-Post MGS Approach Guardrail Transition.***

From page 90:

"1. A recommended minimum length of 12 ft - 6 in. for standard MGS is to be installed between the upstream end of the asymmetrical W-beam to thrie beam transition section and the interior end of an acceptable TL-3 guardrail end terminal...

2. A recommended minimum barrier length of 46 ft - 10.5 in. is to be installed beyond the upstream end of the asymmetrical W-beam to thrie beam transition section...."

ODOT includes 46 ft - 10.5" as the length of an MSKT end terminal. Can this unit be directly attached to AGT or is a 12.5 ft panel required between the AGT and the end terminal?

Thanks!

Attachment: https://mwrsf-qa.unl.edu/attachments/29f3b70d0a7f18c08630019cf24deff9.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/8400ff656a62712c4f12fbc39af356b6.pdf

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Response
Date: 12-06-2018
Based on the FHWA eligibility letter and the MASH 3-31 test (pickup truck at 0 degrees) conducted on the MSKT, the stroke length of the the MSKT was found to be 50.5 ft. If only 46'-10.5" of W-beam were installed upstream of the W-to-thrie transition segment, the impact head of the MSKT would be sliding over the transition segment. This transition segment is made from 10-ga. steel and has an increasing vertical height and bending strength. It is unlikely that any w-beam end terminal head would perform as intended if it had to interact with this larger and stronger transition piece. Thus, MwRSF would recommend that you add an additional W-beam (MGS) between the terminal and the W-to-thrie segment of the transition.

The intent of the first guideline listed in that report and copied in your question was intended to ensure a separation between the terminal and the transition hardware. 12.5' was picked to match standard rail lengths with the understanding that it was likely a conservative length. If this guideline is followed precisely, you would need a minimum of 50.5 + 12.5 = 63 ft of w-beam upstream of the transition. However, a single 12.5-ft long rail would provide enough length to keep the impact head out of the transition hardware - 46.5 + 12.5 = 59 ft, which is greater than the stroke length of 50.5 ft. MwRSF would not have a problem with this installation as it would satisfy the intent. It would just be less conservative than the original guideline.

Note, if you are utilizing nested W-beam guardrail upstream of the W-to-thrie transition segment, the critical rail strength location is moved 12.5-ft upstream to the end of the nested section and your required length upstream of the W-to-thrie transition would need to increase by another 12.5 ft.

Temporary Barrier with head to head traffic

Question
State: MO

Date: 12-06-2018

At one of our meetings with industry, a question came up about pinning/bolting/strapping temporary traffic barrier when opposing traffic is on both sides of the barrier. All barrier being used at this time is NCHRP 350 rated.

I have four scenarios (pinning is used as term for all three types pinning/bolting/strapping for these questions):
1) The roadways have two 12-ft lanes and at least 2-feet of shoulder between the lane line and barrier. Do you have to pin the barrier or can you leave the barrier free standing?
2) The roadways have two 12-ft lanes but the lane line is less than 6-inches from the barrier. Do you have to pin the barrier or can leave the barrier free standing? Would you pin only one side or both?
3) The roadways have three 10-ft lanes but the lane line is less than 6-inches from the barrier. Do you have to pin the barrier or can leave the barrier free standing? Would you pin only one side or both?
4) The roadways have two 12-ft lanes but at least 2-feet of shoulder on one side of the barrier. The other side of the barrier roadway has two 10-ft lanes but the lane line is about 6-inches from the barrier. Do you have to pin the barrier or can leave the barrier free standing? Would you pin only one side or both?

Please let me know if you have any questions or clarification. I believe, these questions would be through pooled fund allowance for questions. Thank you for your time.

Response
Date: 12-06-2018

Would you like responses based on MASH testing when available? Or, do you only want responses based on NCHRP Report 350 testing?

Response
Date: 12-10-2018

Both MASH and NCHRP will be important to us. For now especially, a response based on NCHRP 350. We have a contractor which will have to stage another section of a project in March, that would entail several of the below scenarios. Currently, we have NCHRP 350 barrier in place. I know March seems a long time, but the sub-contractor is wanting to provide a cost for the installation to us.

Side note: We are very interested in the MASH testing of our Iowa style barrier because we have so many contractors who have invested in that type of barrier. Thank you for all the help you provide us.

Response
Date: 12-11-2018

I do a lot of the research related to PCBs here at MwRSF, so I will try to respond to your question to Ron.

First, anchoring of PCBs depends on the barrier system being used because every PCB anchorage cannot necessarily be used with any PCB design. I noted in the email that you mentioned you were using the Iowa PCB design. The PCB design that we have developed anchorages for is a version of the original Iowa F-shape PCB that has been modified over time. The current iteration that has been used in our MASH testing is attached. We would recommend that your barrier be similar to this in order to employ the anchorages we are discussing. Note that this is details for NDOT's version of the barrier with slightly different draining/lifting slots. The MASH TL-3 free-standing barrier report can be found at this link
- https://mwrsf.unl.edu/researchhub/files/Report150/TRP-03-174-06.pdf

Second, we have developed several anchorage methods for this F-shape PCB.

1. A concrete anchorage that uses through bolts or epoxy threaded rod anchors. This system has been tested to both NCHRP 350 and MASH.
2. An asphalt pin anchorage. This system met NCHRP 350, but recently failed when tested to MASH TL-3. We are working on revising and retesting this system.
3. A steel strap anchorage. This system has only been tested to NCHRP 350.

Currently the only system we can recommend for median installations is the steel strap tie-down. The asphalt pin and concrete bolted options were designed and tested only for anchorage on the traffic side face. Application of these options to two-way traffic installations has not been recommended in the past due to the need to place anchors on both sides of the barrier system. There are concerns that anchors on the backside of the barrier can create a rotation point when impacted and that may cause increased vertical barrier rotation and potential vehicle instability.

Now to your 4 questions below.

1. The roadways have two 12-ft lanes and at least 2-feet of shoulder between the lane line and barrier. Do you have to pin the barrier or can you leave the barrier free standing?
    a. Under NCHPR 350 MwRSF did an analysis on the F-shape PCB to account for more typical and slightly less severe impact conditions than we test to under TL-3 conditions. For this study, we analyzed the deflection of the F-shape PCB under the 85 percentile speed and 85% angle impact conditions and determined the barrier deflection under those reduced impact conditions. Based on that study under NCHRP 350, we concluded that when the barrier is used in a free standing mode, immediately adjacent to the edge of a bridge deck, the design deflection limit should be the distance that the barrier was deflected during full-scale crash testing, 1.15 m (45.3 in.). For all other applications, the design deflection limit should be set at 600 mm (2 ft). This distance corresponds to the distance that the Iowa temporary barrier could be expected to deflect under the 85th percentile impact for passenger cars and light trucks. We also noted in that report, "When used to separate traffic, barrier deflections up to 600 mm (2 ft) would not cause a significant problem for opposing traffic. Even in narrow construction

zones, traffic lanes of less than 3-m (10-ft) wide are rare, and a 600-mm (2-ft) lateral barrier displacement would not intrude significantly into the paths of oncoming traffic. Although larger deflections could begin to intrude into the normal paths of 2 oncoming traffic, the risk of an accident involving opposing traffic is still relatively low. Even when a vehicle in the opposing lane strikes a deflected barrier, the impact angle associated with any resulting crash would be expected to be extremely low. For this situation, the consequences of exceeding the deflection limit are not catastrophic." Thus, this would suggest that for NCHRP 350, we would allow this configuration without anchoring.

b. https://mwrsf.unl.edu/researchhub/files/Report243/TRP-03-113-03%20(revised).pdf
c. It should be noted that this would not hold true under MASH as the expected deflections for that PCB effectively double. We did a similar analysis under MASH (https://mwrsf.unl.edu/researchhub/files/Report331/TRP-03-337-17.pdf), but the 85 percentile impact condition deflections were 68" rather than 24. At this level the intrusion into adjacent lanes may be too high to ignore.

2. The roadways have two 12-ft lanes but the lane line is less than 6-inches from the barrier. Do you have to pin the barrier or can leave the barrier free standing? Would you pin only one side or both?

   a. Due to the limited space, one would generally need to anchor the barrier in this situation to prevent excessive intrusion into adjacent lanes. However, we do not currently have a pinning solution for this situation as noted above. The asphalt pin and the concrete anchorage have not been evaluated in a median configuration to either NCHRP 350 or MASH and concerns exist as noted above.
   b. The steel strap anchorage deflection was approximately 33" under NCHRP 350 TL-3 which would suggest intrusion into adjacent lanes. We
   c. However, we have previously argued that limited intrusion into opposing lanes may not be a major issue under NCHRP 350 as noted in TRP-03-113-03 above. Thus, under NCHRP 350, one may consider not pinning or anchoring in this situation. Under MASH TL-3, this would not be recommended.

3. The roadways have three 10-ft lanes but the lane line is less than 6-inches from the barrier. Do you have to pin the barrier or can leave the barrier free standing? Would you pin only one side or both?

a. See no. 2.

4. The roadways have two 12-ft lanes but at least 2-feet of shoulder on one side of the barrier. The other side of the barrier roadway has two 10-ft lanes but the lane line is about 6-inches from the barrier. Do you have to pin the barrier or can leave the barrier free standing? Would you pin only one side or both?

    a. See no. 2.
    b. You may want to consider placement of the barrier midway between the opposing lanes.

Let me know if you have further questions or concerns.

Thanks

Attachment: https://mwrsf-qa.unl.edu/attachments/1d7f4da46938eff1d93a4a16021e4d79.pdf

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InDOT Anchored PCB Questions

Question
State: IN
Date: 12-10-2018

INDOT had Texas A&M
Transportation Institute (TTI) test our previous standard anchored temporary barrier on January 8, 2015 (Test 1) for MASH test 3-11 compliance. That test resulted in unacceptable structural adequacy due to anchor bolts shearing off and excessive barrier lateral deflection. INDOT then had TTI test a revised anchored temporary barrier with additional lower anchorages, larger diameter lower anchorages, and barrier top connections consisting of a recessed flat plate and two (2) (2) 1" dia. F42 cast-in ferrule loops on each end of the barrier segments (Test 2). That test showed acceptable performance for MASH test 3-11. Since the top connection used in Test 2 could not be retrofit into existing temporary barriers, INDOT had TTI test another revised anchored temporary barrier that used a surface mounted flat plate and one (1)

field drilled 1" dia. drop-in wedge anchor on each end of the barriers in lieu of the two ferrule loops (Test 3). That test also showed acceptable performance for MASH test 3-11.

1. Crash Test 2
(4/16/15) and Crash Test 3 (5/19/15) both used J-J Hooks to connect adjacent barriers rather than the pin and loop connection as shown on 801-TCCB-02. The current standard drawing for unanchored temporary barrier (801-TCCB-02) indicates that the J-J Hooks may be used in lieu of the pin and loop connection. We're wondering if the pin and loop can be used in lieu of the J-J Hooks for our anchored temporary barrier.
2. Crash Test 2
(4/16/15) and Crash Test 3 (5/19/15) both used 1" dia. wedge anchors to secure the lower anchor bracket plates to the unreinforced concrete test apron. Based on the descriptions and photos in the test reports, it doesn't appear that the anchors were placed near a free edge of the concrete apron. We're wondering if there is a minimum distance from the center of the anchor to the edge of the supporting concrete surface. Our internal discussions have lead us to proposing a minimum edge distance from the back of the barrier to a free edge of 12", but we'd like to get your opinion on this distance.
3. Crash Test 2 (4/16/15)
used two (2) 1" dia. F42 cast-in ferrule loops on each end of the barrier segments for the top connection detail. Crash Test 3 (5/19/15) used one (1) 1" dia. drop-in wedge anchor on each end of the barrier segments for the top connection detail. We're wondering if the 1" dia. F42 ferrule loops can be considered equivalent to the 1" dia. drop-in wedge anchors, such that one (1) 1" dia. F42 cast-in ferrule loop anchors can be used on each end of the barrier segments.
4. Crash Test 2
(4/16/15) and Crash Test 3 (5/19/15) both used 1" dia. wedge anchors to secure the lower anchor bracket plates to the unreinforced concrete test apron. It's our understanding that these large wedge anchors aren't able to be removed after use, so they'll need to be cut off and the exposed steel will be left flush with the bridge deck. We're wondering if 1" dia. drop-in wedge anchors (the anchors that were used in the top connections in Crash Test 3) can be considered equivalent to the 1" dia. wedge anchors, so that the 1" dia. drop-in wedge anchors can be used to secure the lower anchor bracket plates. This would allow us to fill the drop-in anchor with epoxy after removal of the bolt, thereby eliminating the exposed steel at the bridge deck surface."

Response
Date: 12-10-2018

I can attempt to address these items, but I will need additional details as we were not involved in this development and testing.

Can we get the following from you?

1. Test reports for all of the tests
2. CAD details of the tested systems and the noted changes below.
3. Test videos

Thanks

Response
Date: 12-11-2018

I just copied the test reports and videos to a OneDrive folder and sent you think link. Please let me know if you don't receive it or if you have any problems. I didn't find any CAD files in the first folder that I checked, but there are drawings included in the test reports. Please let me know if you still need CAD drawings and I can do some more searching.

Thanks,

Response
Date: 12-12-2018

I have some comments on your questions. Sorry for the delay in replying, I had NCHRP panel meetings this week and just got back.

Thanks

1. Crash Test 2
(4/16/15) and Crash Test 3 (5/19/15) both used J-J Hooks to connect adjacent barriers rather than the pin and loop connection as shown on 801-TCCB-02. The current standard drawing for unanchored temporary barrier (801-TCCB-02) indicates that the J-J Hooks may be used in lieu of the pin and loop connection. We're wondering if the pin and loop can be used in lieu of the J-J Hooks for our anchored temporary barrier.
    1. The system was evaluated with the JJ-Hooks connection and noted above. However, we believe that the testing may have been conducted with the JJ-Hook in a more favorable position that makes the connection stronger. From what I can see in the test reports, the hooks are bearing on each other when loaded, which is less critical than if they are impacted in the reverse orientation where the hooks would pull apart. It appears that the joint sustained a significant load and damage. Thus, we would recommend that InDOT use the barrier with the loops in the stronger orientation that was tested with the anchorages to ensure that the system performs adequately.

       We are unable to determine the exact effect of the conversion to a pin and loop system at this time. I am not sure what type of pin and loops system you wish to implement. The connection would have to have similar moment, shear, and tensile capacity at the joint. Thus, it is difficult to say if a pin an loop system would sustain similar loads without further information.

       Additionally, the implementation of a pin and loops design would like increased the gap between barrier segments. Doing so would increase the loading of the barrier toes and toe fracture as well as create more exposure of the vehicle to the ends of the barrier segments. We have seen in other anchored PCB tests that contact and snag with the barrier segment joints can cause increased decelerations, vehicle instability, and or occupant compartment deformation issues. Thus, we cannot recommend switching the joint type without further research.

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    1. This question may also be a little difficult to answer. I don't have any details on the exact wedge bolt anchor used. However, manufacturers of these anchors provide minimum edge distances or edge distance reduction factors when using these systems. I would follow their minimum guidance. You may also want to account for the anchor spacing when you look at these anchors. Typically, anchor spacing will affect their capacity as well. This may add to the edge distance issue if two anchors are spaced relatively close together. The issue is that the concrete area adjacent to the edge is loaded by both anchors rather than a single anchor which reduces its overall resistance. Thus, you may want to increase the edge distance accordingly based on the anchor spacing as well.

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    1. Not to sound like a broken record, but I would need more details to answer this effectively. Drop-in wedge anchors can have different capacities than ferrule loops. Thus, one would need to compare the capacities of both attachments to see which was more critical. I cannot tell from the reports what specific versions were used. I only know the bolt grade and diameter.

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(4/16/15) and Crash Test 3 (5/19/15) both used 1" dia. wedge anchors to secure the lower anchor bracket plates to the unreinforced concrete test apron. It's our understanding that these large wedge anchors aren't able to be removed after use, so they'll need to be cut off and the exposed steel will be left flush with the bridge deck. We're wondering if 1" dia. drop-in wedge anchors (the anchors that were used in the top connections in Crash Test 3) can be considered equivalent to the 1" dia. wedge anchors, so that the 1" dia. drop-in

wedge anchors can be used to secure the lower anchor bracket plates.
This would allow us to fill the drop-in anchor with epoxy after removal of the bolt, thereby eliminating the exposed steel at the bridge deck surface."

1. Potentially, but in order to do so, one has to compare the capacities of the anchors for the spacing and edge distances of your problem. The different anchors can have different capacities. Thus, you would need to check and see if they were equivalent for the given anchor spacing and edge distances. However, the report does not contain the details on the specific anchors used, so I cannot look them up.

Response
Date: 12-22-2018

Thanks for your responses. I've included some follow-up questions/responses below in green. I've also attached some information for you reference. Thanks again for all your help and I hope you have a great holiday!

Thanks,

Pete

From: Robert Bielenberg [mailto:rbielenberg2@unl.edu]
Sent: Friday, December 21, 2018 12:31 PM
To: White, Peter <PeWhite@indot.IN.gov>; Smutzer, Katherine <KSMUTZER@indot.IN.gov>
Subject: RE: InDOT Anchored PCB Questions

Hi Pete and Katherine,

I have some comments on your questions. Sorry for the delay in replying, I had NCHRP panel meetings this week and just got back.

Thanks

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Just FYI, I've attached the current INDOT Standard Drawing which shows the pin and loop system in question. Thanks for your thorough explanation on why you can't recommend switching the joint type at this time.

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I've attached information on the anchor bolts that were used. I completely understand where you're coming from with following the manufacturer's recommendations for minimum edge distance and spacing in order to get full capacity. Based on the manufacturer's design charts we already have a reduced capacity due to spacing. I'm hoping to develop a justification for using an edge distance that's slightly less than the 'full capacity' edge distance given in the

design charts, since this become critical in phased construction of bridges. Without knowing a design load to apply to the anchors I'm struggling to figure out a way to make this justification. Since my current focus is on bridge decks and these are always reinforced, I might be able to compare unreinforced capacity (basis for design tables) and capacity with typical deck reinforcing. In your opinion, could that be a reasonable approach?

3. Crash Test 2 (4/16/15) used two (2) 1" dia. F42 cast-in ferrule loops on each end of the barrier segments for the top connection detail. Crash Test 3 (5/19/15) used one (1) 1" dia. drop-in wedge anchor on each end of the barrier segments for the top connection detail. We're wondering if the 1" dia. F42 ferrule loops can be considered equivalent to the 1" dia. drop-in wedge anchors, such that one (1) 1" dia. F42 cast-in ferrule loop anchors can be used on each end of the barrier segments.
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    I've attached information on the ferrule loops and drop-in wedge anchors that were used in the tests. It appears that the ferrule anchors have less capacity than the drop-in wedge anchors, but the reductions in capacity due to edge distance muddy the water. My intuition leads me to think that a cast in anchor should have at least as much capacity as a post-installed anchor, but the documentation appear to contradict this assumption. Can you think of anything I might be overlooking? Could it be possible that the capacity of the ferrule loop could be controlled by the bolt pulling out of the threads in the loop?

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Attachment: https://mwrsf-qa.unl.edu/attachments/68c3e3f56ac4ae26d9ef4e57d15a1f65.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/c1c91758d33bf82b141b5c1c81e27022.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/506f096562efe22456f827ecc0089852.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/87ef71b3907fa0d38e5957e63168619a.pdf

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Response
Date: 12-22-2018

More comments below in purple

Bob Bielenberg, MSME

Research Engineer

Assistant Director Roadside Safety Division

Manager – Midwest States Pooled Fund Program

Midwest Roadside Safety Facility

Civil Engineering Department

Nebraska Transportation Center

University of Nebraska–Lincoln

Prem S. Paul Research Center

130 Whittier Building, P.O. Box 830853

2200 Vine St., Lincoln, NE 68583-0853

402-472-9064 | rbielenberg2@unl.edu | http://mwrsf.unl.edu/

From: White, Peter <PeWhite@indot.IN.gov>
Sent: Friday, December 21, 2018 2:37 PM
To: Robert Bielenberg <rbielenberg2@unl.edu>; Smutzer, Katherine <KSMUTZER@indot.IN.gov>
Subject: RE: InDOT Anchored PCB Questions

Bob,

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Thanks,

Pete

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Ok

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This may be difficult to achieve. I have attached a couple of images to shown how we (and ACI) think about the loading of these anchors adjacent to an edge. When the anchors are loaded in shear, they apply a load to a shear block of the concrete. For a single anchor with sufficient

distance from an edge, the concrete can develop load based on that shear block area. When you have closely space anchors and an edge, that shear block area is reduced in effectiveness due to the areas of adjacent anchors overlapping and loss of capacity due to concrete not being present past the edge of the deck.

There is likely an effect of having reinforcement present that increases the capacity, but it is not well defined. Current ACI procedures do not have methods for calculating this and we have tried to develop research in this area and have had limited luck generating funding. You amy want to see an attached report that began to look into this and a recent study I did for Iowa on bridge rail anchoring to a parapet where shear capacity was critical but difficult to calculate.

https://mwrsf.unl.edu/researchhub/files/Report14/TRP-03-264-12.pdf

https://mwrsf.unl.edu/researchhub/files/Report313/TRP-03-325-15.pdf

So I think the concept of your approach is reasonable, but it may be difficult to realize through calculations. We may be able to develop dynamic component tests that could evaluate this if you were interested. Full-scale testing would be able to evaluate this as well. In that case, even if the some anchors did disengage, we could determine if the system remained crashworthy.

3. Crash Test 2 (4/16/15)
used two (2) 1" dia. F42 cast-in ferrule loops on each end of the barrier segments for the top connection detail. Crash Test 3 (5/19/15) used one (1) 1" dia. drop-in wedge anchor on each end of the barrier segments for the top connection detail. We're wondering if the 1" dia. F42 ferrule loops can be considered equivalent to the 1" dia. drop-in wedge anchors, such that one (1) 1" dia. F42 cast-in ferrule loop anchors can be used on each end of the barrier segments.
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I've attached information on the ferrule loops and drop-in wedge anchors that were used in the tests. It appears that the ferrule anchors have less capacity than the drop-in wedge anchors, but the reductions in capacity due to edge distance muddy the water. My intuition leads me to think that a cast in anchor should have at least as much capacity as a post-installed anchor, but the documentation appear to contradict this assumption. Can you think of anything I might be overlooking? Could it be possible that the capacity of the ferrule loop could be controlled by the bolt pulling out of the threads in the loop?

Based on the information you sent, it would appear that the ultimate tensile capacities of the ferrule loops are slightly higher than the Power Stud while the ultimate shear capacities are lower. Thus, it would be difficult to recommend the ferrule loops over the tested system as the tested option has higher capacity.

I am not sure of the cause of the difference, but we have seen similar differences with other types of anchors. For example, drop-in anchors have higher shear capacity than mechanical screw-in type anchors. Generally, when we have seen an anchor with higher shear capacity it is based on higher grade steel, a larger diameter anchor, or increased embedment. In this case, I would guess that the cylindrical portion of the ferrule anchor is only 1 1/8" long. Thus, it does not develop shear loads in the concrete as well as the 1" Power stud which extends several inches farther into the concrete with a similar area. Similar to the question above, one would likely need some form of dynamic component testing or full-scale testing to verify the performance. We did similar testing for the steel strap tie-down anchors for KDOT and NDOT. See below.

https://mwrsf.unl.edu/researchhub/files/Report266/TRP-03-182-07.pdf

I would doubt that the cause is the threads pulling out of the loop as the shear loads don't tend to load the threads in pullout. Again tensile capacities seem similar when ignoring edge effects and spacing effects.

4. Crash Test 2
(4/16/15) and Crash Test 3 (5/19/15) both used 1" dia. wedge anchors to secure the lower anchor bracket plates to the unreinforced concrete test apron. It's our understanding that these large wedge anchors aren't able to be removed after use, so they'll need to be cut off and the exposed steel will be left flush with the bridge deck. We're wondering if 1" dia. drop-in wedge anchors (the anchors that were used in the top connections in Crash Test 3) can be considered equivalent to the 1" dia. wedge anchors, so that the 1" dia. drop-in wedge anchors can be used to secure the lower anchor bracket plates. This would allow us to fill the drop-in anchor with epoxy after removal of the bolt, thereby eliminating the exposed steel at the bridge deck surface."
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I've attached information for the two different anchor systems. Based on the capacities given in the design tables it appears that the drop-in anchors can be used in lieu of the wedge anchors that were used in the tests. Please let me know your thoughts.

I would concur with that. If they have similar shear and tensile capacities, then you should be ok.

You should consider the grade of the bolt you use with the drop-in. We have typically used Grade 5/A325/A449 capacity bolts with our drop-ins to ensure that the steel is not shearing off at lower loads than the concrete capacity.

Attachment: https://mwrsf-qa.unl.edu/attachments/b7aec3f5acc4e0a3bb2b180f72ae0f57.jpg

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Response
Date: 01-16-2019

I hope all is well with you. We've come across another challenge with our anchored temporary barrier and I'm hoping you might be able to share your opinion. This question is a follow-up on question #4 shown in the email chain below. It occurred to us that leaving the drop-in wedge anchors in the concrete could pose problems in the future during milling operations. A Contractor that we spoke to suggesting using threaded rod epoxied into the concrete, which they indicated can be removed after use.

Crash Test 2 (4/16/15) and Crash Test 3 (5/19/15) both used 1" dia. wedge anchors to secure the lower anchor bracket plates to the unreinforced concrete test apron. It's our understanding that these large wedge anchors aren't able to be removed after use, so they'll need to be cut off and the exposed steel will be left flush with the bridge deck. We're wondering if 1" dia. threaded rod epoxied into the concrete can be considered equivalent to the 1" dia. wedge anchors. I've attached some information on the tested wedge anchor and an epoxy anchoring system. Based on this information, it appears to me that since the epoxy system has as much ultimate capacity as the wedge anchor, this should be an equivalent method of anchoring the lower bracket.

Thanks again for all of your help. Please let me know if you have any questions.

Thanks,

Attachment: https://mwrsf-qa.unl.edu/attachments/08f22348b57eef72af16c9899a421517.pdf

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Response
Date: 01-17-2019

Your anchors can potentially be replaced with epoxy anchors. We have used similar arguments previously. You would need to show that the epoxied rods have equal or greater capacity in shear and tensile to the tested anchors. The determination on if it can be done would be based on several factors.

1. The embedment of the anchor will be critical to determining the load capacity of the anchor. I am not sure what embedment you are thinking, but you would need sufficient anchorage to develop the equivalent strength to the tested anchor.
2. The grade of the threaded rod would need to such that the threaded rod has greater strength than the tested anchor. This may require a higher grade steel as the shear section of the tested anchor appears to be a solid shank, while a threaded rod would have reduced section.
3. Similar to what we discussed previously, edge spacing and anchor spacing would need to be considered. Like we discussed previously, this may make the anchorages difficult to calculate. As such we have often done dynamic component tests to compare anchorages.

This is a fairly conservative approach, but it needs to be if no additional testing is conducted.

Thanks

Standardized Concrete Buttress AGT

Question
State: WY
Date: 12-10-2018

Hi Bob,
I have a question about the standardized buttress. The stirrups are only extending below the buttress by 6 inches for embedment into a concrete slab. That doesn't appear to be adequate to develop the full strength of the stirrups and to resist overturning. Do you have additional details on how this would connect to the concrete slab below?

Attachment: https://mwrsf-qa.unl.edu/attachments/d8c330a04e28563e4a752f37c908e384.pdf

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Response
Date: 12-11-2018

The details shown in our cad are only for anchorage to our tarmac and do not represent what would be used in a bridge deck.

I have copied Scott on this. He did the development work on the buttress and may be able to guide you on the tie into a bridge deck. It would likely depend on the deck in question, but is mostly a question of achieving appropriate development of the anchor bars.

Response
Date: 12-12-2018

You are correct. The 6" embedment by itself is not sufficient to fully develop the stirrups. The simplest thing to do would be to put a 90 degree bend in the front leg of the stirrup and tie it into the lower mat of steel in your concrete slab. Unfortunately, we don't have anything sketched up showing these bars fully anchored to a slab right now.

transition pieces for crash cushions

Question
State: IN
Date: 12-19-2018

A crash cushion distributor for Trinity posed a couple of questions to me regarding transitions for crash cushions. I've copied them below with my planned responses. I don't expect you to answer the question specific to the Quadguard M10, just trying to understand current requirements and past practice. My questions to you are

- Does the MASH suite of tests include a transition to account for exposure to bi-directional traffic?

- If not, how have transitions for crash cushions been evaluated previously?

- If there aren't standardized evaluation protocols, what should we be considering when a NCHRP350 transition is requested for a MASH compliant crash cushion?

Questions from the distributor

Is INDOT
going to require the MASH certification of transitions for crash cushions? *I will need to get back to you. Under NCHRP350 were the transitions tested and certified? Were the specifics included in the FHWA eligibility letters under 350?*

Can we
supply a NCHRP350 transition for a Quadguard M10? *I will need to get back to you. The answer may depend on the answer to the previous question. Is it the opinion of the testing facility that ran the M10 tests, that the NCHRP350 transition will perform acceptably under MASH criteria?*

Response
Date: 12-19-2018

I assume that you are referring to reverse direction impacts due to your reference to bi-directional traffic. Test no. 3-37 in MASH is designed to deal with bi-direction traffic and reverse direction impacts on the crash cushion.

Test 37 examines the behavior of crash cushions and terminals during reverse-direction impacts. This test is recommended for any safety feature that will be placed within the clear zone of opposing traffic. This test involves a 2270P or 1100C vehicle striking the critical impact point (ClP) for reverse-direction impacts. CIP locations for reverse direction impacts vary greatly from one system to another and a generalized system for identifying these locations has yet to be developed. Note that the configurations shown in Figure 2-3A for Test 37 are intended for illustration purposes only and do not necessarily reflect the actual test configuration.

For most crash cushions with fender panels lapped against opposing traffic, the ClP should be selected to maximize the risk of snagging on the end of the last fender panel lapped in this manner.

Many crash cushions attached to concrete barriers incorporate a tapered section between the wider cushion and the narrower barrier face . Tn this situation, Test 37 should normally be configured to first strike the barrier or the tapered section in order to maximize the potential for snagging. The 2270P will generally be the critical vehicle for this test when a crash cushion is being evaluated.

For post-and-beam terminals utilizing a breakaway cable system, the 1100C will generally be the critical vehicle for this test, and the impact point should be selected to maximize the risk of the vehicle snagging on the anchor cable.

That test is currently divided into two potential tests (test 3-37a and 3-37b) using the 2270P and 1100C vehicles respectively. For your question, test 3-37a with the 2270P vehicle is required. Under NCHRP 350, many labs ran those tests in the reverse direction along the mid length of the crash cushion. Additionally, the NCHRP 350 test was at a lower (20 degree) angle. This was test no. 3-39 in NCHRP 350.

However, MASH specifies it differently by indicating that the test should be conducted upstream of the transition between systems and at 25 degrees. Note that it also notes that the CIP is device dependent. It may be that multiple test no. 3-37 would need to be conducted depending on the design.

SCI ran this test. See attached letter.

In terms of NCHRP 350 transitions, I am not sure what this would refer to in terms of attachment hardware as this test was may not have been conducted under NCHRP 350 or may have been conducted at a different impact location and impact conditions. I would be wary of applying NCHRP 350 crash cushion transitions that may or may not have been previously crash tested to a MASH device.

Let me know if that answers your questions or if you would like to discuss it further.

Attachment: https://mwrsf-qa.unl.edu/attachments/d11a0adfb188e556b1d79a2f2f0db3b0.pdf

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Beam Guard Posts Embedment Tolerance

Question
State: WI
Date: 01-02-2019

Our material people have been looking into using sound waves to check post depth. I don't think it is going as well as they like. We have told them they need to be accurate with 3". I think your Q/A indicates that the difference should be 2"

Thanks for your input.

Response
Date: 01-02-2019

The guidance you are referring to for post depth was provided to Wyoming.

https://mwrsf-qa.unl.edu/view.php?id=1226

For wood posts, we would likely recommend keeping that post tolerance at the 2" limit. Doing so limits the variation in the post soil response to around 10%. Variation of soil depth more that this could cause increased wood post fracture and more drastic effects on the barrier performance. This may be even more of an issue for WisDOT when white pine posts are potentially used.

Thanks

Side-Mounted Str Tube Bridge Rail and Transition

Question
State: IN
Date: 01-09-2019

INDOT has been reviewing our current standard drawings for bridge rails. We currently detail out a side-mounted bridge rail identified as TS-1, with a NCHRP-350 TL-2. This railing is only used on local roadways (not state or NHS routes). This railing uses a structural-tubing post (TS 6"x3"x1/4"), see the attached PDF (TS-1 INDOT Details) that includes all three sheets of our standard drawings. This bridge rail is very similar to SBT01a, see the attached PDF (SBT01a) found in the Guide to Standardized Highway Barrier Hardware. INDOT, as you can see on sheet 3 of the attached details, lengthened the anchor bolt with a piece of structure tubing (spacer) on either side of the post. The test level of TL-2 was given based on the fact that it was indicated as an SL-1 railing in NCHRP-239 (Multiple Service Level Highway Bridge Railing Selection Procedures). According to a document, Bridge Railing Design and Testing, also attached (Document), in a FHWA memo date August 13, 1990 any bridge railing indicated as SL-1 in NCHRP-239 could also be considered equivalent to a PL-1 . Further in the same document it mentions the Railing Level Equivalency Table which allows all PL-1 tested rails to be considered as NCHRP-350 TL-2 with no further testing required. So with all this said, we have a few questions.

1. Does the addition of the structural tube spacers at the anchor bolts affect the design? See attached figure SBT01a and attached figure TS-1 INDOT Details.

2. Is SBT01a still in the Guide to Standardized Highway Barrier Hardware? We only have a hard copy of an older version. In a later version of the guide I could only find SBT01b which uses a steel beam rather than a structural tube.

3. In the crash test I believe a post spacing of 8'-4" was used, our standards allow for spacing to vary between 6'-3" and 8'-4" is this ok?

4. The transition, as you can see in the attachment TS-1 INDOT Details, page 3, INDOT uses a different length and post spacing for the transition than shown in the crash report, see attachment TS-1 Crash Test Detail. Are both transition ok? If not which should we use?

5. Do you think we could replace the symmetrical thrie-Wbeam transition with an asymmetrical thrie-Wbeam transition to accept MGS w-beam? If so, what would be the best way to transition the splice location to midspan?

Thank you for your time.

Attachment: https://mwrsf-qa.unl.edu/attachments/1a0806850e05efc45a1cd5c9819b529c.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/de9bd43438fdd1f1ee4b7e34b1ca5ee2.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/7e1c6aabb9b2adde62a1959004470b98.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/7f316ae53b2bf088f1153504b027a080.pdf

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Response

Date: 01-31-2019

I will start by addressing your questions in order of submitted:

1. The additions of the spacer tubes should not alter the performance of the post attachment to the side of the deck
2. The current version of the online Hardware Guide is a mess. It has many errors and omissions. In fact, most of the drawings attached at the bottom of the page for SBT01b are for the SBT01a system. I am not aware of issues resulting in the system being taken down, so I think you are ok to continue using it.

3. I don't see any issues with using a tighter spacing of 6'-3". Tighter spacing would only increase the stiffness and strength/capacity of the bridge railing. A 6'-3" spacing makes more sense in terms of rail-to-post attachments being at standard hole punch distances anyway.
4. I am not aware of any transition to this bridge rail being tested or evaluated. The one shown in NCHRP 239 was not tested as part of the bridge rail evaluation. I would recommend using the TL-2 guardrail transition developed and tested at TTI. It is short and connects 31" MGS to thrie beam utilizing the asymmetric transition segment. Currently, it is the only MASH TL-2 transition that I'm aware of, so it is probably the best system to utilize here. I have attached a PDF of the report on this system.
5. See notes above and the attached PDF for TL-2 transition design details.

From the details you have sent, it looks like INDOT has lowered the location of the anchor rods (base-plate-to-deck attachment) with respect to the post-to-base plate bolt. The original system had a vertical offset of 1.25" between the post bolt and the anchor rods, but your drawings show a 4" vertical offset. I'm not sure why this was done, but perhaps they were shifted downward to center them within the spacer tubes. This increased offset distance (increased moment arm in the plate) will likely result in the base plate bending away from the deck as the post is loaded laterally. This behavior could significantly alter the stiffness and performance of the bridge rail. Thus, if you desire to continue using this system, the anchor rods in the deck should be shifted upward to return to a vertical offset of 1.25" between the post bolt and the anchor rods.

Although the system you are proposing may work fine for TL-2 applications, I suggest utilizing a new railing. MwRSF recently developed and crash tested a side-mounted, MASH TL-2 bridge rail for Nebraska DOT. This railing utilizes S3x5.7 posts spaced at 6'-3" and standard W-beam rail. Thus, it would result in a significant reduction in materials/cost. Similar to the MGS bridge rail, it can be directly connected to standard MGS with a 6'-3" post spacing between bridge post and MGS post, so it does not require a guardrail transition at the ends of the bridge. I encourage you to consider using this bridge railing based on improved performance, simplified design, and reduced installation costs. The report is still being written, but I have attached a drawing set for the tested system. If you would like more information on the new bridge railing, let me know.

Attachment: https://mwrsf-qa.unl.edu/attachments/bcf2c91b51eeeecc3185e3b1ce0672c9.pdf

Attachment: https://mwrsf-qa.unl.edu/attachments/48b6e7774e74213a2b7e3a691506a277.pdf

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Modification to Texas Combination Rail Type C411

Question
State: IA
Date: 01-10-2019

We would like your opinion to a modification to TXDOT's Combination Rail (Type C411). We want to place a 6 inch thick sidewalk behind the rail (see page 2 of the attached) and we're curious to know how/if this would affect the performance of the rail. Any thoughts you can give would be much appreciated.

Thanks!

Attachment: https://mwrsf-qa.unl.edu/attachments/5ceee188f753c34e13b2a9f0d86c6408.pdf

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Response
Date: 01-10-2019

To the best of my knowledge the system shown has been evaluated to MASH TL-2.

We don't see any structural or safety issues with installation of a sidewalk behind the barrier as long as the railing design and anchorage remained similar to the tested system.

Let me know if that addresses your question.

Thanks

Potential Snagging Question - Combination Bridge Rail

Question
State: IA
Date: 01-16-2019

Attached are a few pictures of steel railing that was recently installed by a contractor for us. Do you believe any of the 3 situations pictured will have an issue with snagging due to the gap size or elevation difference of the steel sections? Are there current guidelines available for what would be the maximum depth or protrusion allowed in a situation like this for steel or concrete barriers?

Thanks ,

Attachment: https://mwrsf-qa.unl.edu/attachments/164399dc59b6f78d3d2a4b76d93e5b92.pdf

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Response
Date: 01-29-2019

I have some thoughts on the tubular rail splice shown.

We know from previous crash testing that exposed edges as small as 3/8" thick have snagged vehicle components and either disengaged sheet metal or caught vehicle rims and instigated vehicle instabilities. Thus we have recommended 11/4" or less. The NCHRP 554 study performed at TTI regarding aesthetic bridge rail features came to similar conclusions and found that vertical asperities should be less than 1/4" deep. Your best source for exposed edge information would be in NCHRP 554. We have also addressed similar issue in the Pooled Fund Q&A.

https://mwrsf-qa.unl.edu/view.php?id=1208

https://mwrsf-qa.unl.edu/view.php?id=1118

In your case, the tube rail shown may exceed those limits for exposed edges, however it is also in a location that is less likely to grab the vehicle wheel. I don't have the heights of the tube rail and parapet or the shape of the parapet, so that may affect things to some degree. However, I would assume that the majority of the wheel interaction would be with what appears to be a vertical parapet and not with the higher tube rail. Your rail is also a round tube so there is not a continuous vertical edge to grab the vehicle as well. This lessens the potential snag significantly.

There may be some snag on the fender of the vehicle due to the exposed edge. However, we have seen previous TL-3 tests that have had significant fender snag and not had a serious issue.

Thus, we can't say definitively that the splice shown is not an issue based on existing testing and data. However, we based on the round tube shape limiting the exposure and the location of the splice, we believe the effects would not be as severe as previous guidance would suggest.

One item to note is that there may be a concern with the vertical plates supporting the tube and termination of the tube posing a snag hazard as well. Again, I don't have dimensions for the parapet or the offset of these structures from the parapet face, but we have seen that fenders can get above the top of the parapet and snag on these types of surfaces as well.

Thanks

MGS median

Question
State: OH
Date: 01-16-2019

We have a location where a median barrier was installed many years ago. A resurfacing project is scheduled for this location and we would like to upgrade the median barrier. The speed limit is 50 mph, with a 36" wide raised concrete median and a 2' shoulder on each side. The existing barrier has a mixture of wooden and steel posts set into the concrete and attached to the median as the barrier crosses a structure. Attached are some pictures.

https://www.google.com/maps/@41.3834394,-82.1180342,3a,75y,226.94h,78.53t/data=!3m5!1e1!3m3!1szv6zsu7Dc__jUe-kL-ZBuQ!2e0!6s%2F%2Fgeo3.ggpht.com%2Fcbk%3Fpanoid%3Dzv6zsu7Dc__jUe-kL-ZBuQ%26output%3Dthumbnail%26cb_client%3Dmaps_sv.tactile.gps%26thumb%3D2%26w%3D203%26h%3D100%26yaw%3D253.62108%26pitch%3D0%26thumbfov%3D100

1) Can a MGS median barrier be installed at this location and attached to the concrete median?

2) If not attached to the concrete median, we can drill out holes to allow the posts to rotate. How do you recommend we cross the structure?

Thanks for your help!

Response
Date: 01-18-2019

There are a few issues at work here that make this a complicated installation. I will do my best to address all of them.

First, a median version of the MGS installed with curb has never been evaluated. Individually, both median MGS and MGS with curb (roadside) have been successfully crash tested to MASH TL-3. Thus, adding a curb to the median MGS may also be crashworthy. Note, the face of the W-beam needs to be within 6" of the face of the curb as recommended in the current MGS with curb study. However, during the testing of both of these MGS applications, partial rail tearing was observed. There is a concern that combining the median MGS with the curb could result in further tearing and possible rupture. We just can't tell without further evaluation.

Second, We know that MGS has failed crash tests when installed directly in rock, concrete, or other pavements. Thus, leave-outs are necessary for the posts to properly rotate through the soil. I believe the current recommendations are to have the leave-out extend 7" from the backside of each post. Since this would be a median application, the leave-outs would need extend 7" from both sides of the post for a total lateral length of 7 + 7 + 6 (post) = 20". Hopefully that will fit within your raised concrete median. I would not extend the leave-outs all the way through the curb (leaving gaps in the curb at each post location) as this could introduce vehicle stability issues.

Although we get the question all the time, a top mounted strong post has never been developed for the MGS. Consequently, we don't have any guidance for mounting the MGS on top of curbs, raised medians, wing walls, or any other structures. Development of a top-mounted guardrail post for use with the MGS would be a great research project, and I recommend submitting a problem statement to the Pooled Fund website for consideration in future research programs (next year).

Let me know if there is anything else we can help with.

12" OFFSET BLOCK VS 8"

Question
Date: 01-17-2019

Can
you quickly tell me if it has been put in writing from anyone that for the
following two special designs which MWRSF tested that either size block may be
used:

1.
Long span design (2 or 3 posts omitted)

2.
Curb and MGS combo (up to 6" behind a 6" curb)

As
to 1. above, I know you have responded to Shawn Dedenham of UDOT that using
12" blocks only on the CRT posts should be fine. But I'm seeing a
lot of standards in similar states using 8" blocks for their standard that
these two special designs are also shown with 8" blocks. Your 187
report makes no comment about allowing an 8" block. I thought
Q&A 1268 was going to get to it but only related to the steel vs CRT post
(don't know what ME has in their standards).

Would
appreciate your info.

Response
Date: 01-18-2019

The original MASH evaluation of the MGS long span occurred before testing the MGS with 8" blockouts was completed, and the MASH TL-3 testing of the MGS long span was conducted with 12" deep blockouts. With respect to the MGS long span system, we have noted that the shorter 8" blockout are likely acceptable in the MGS long span system. Although the system has not been evaluated to MASH with the shorter 8" blockouts, the general performance of MGS systems that have been tested and evaluated with both blockout depth options have been similar enough to suggest that the performance of the MGS long span system would be similar with either blockout as well. As always, this recommendation comes with the caveat that crash testing is the best option to truly determine the efficacy of the 8" blockout depth with the MGS long span and the recommendation is based on our best engineering judgement at this time. Thus, it may be refined as new information and research becomes available.

In terms of the MGS installed 6" behind a 6" tall Type B curb, all of our MASH TL-3 curb testing has been done using 12" blockouts as well. As with the MGS long span, we expect that the shorter 8" blockout are likely acceptable in the MGS with curb system. Although the system has not been evaluated to MASH with the shorter 8" blockouts, the general performance of MGS systems that have been tested and evaluated with both blockout depth options have been similar enough to suggest that the performance of the MGS long span system would be similar with either blockout as well. As always, this recommendation comes with the caveat that crash testing is

the best option to truly determine the efficacy of the 8" blockout depth for the MGS with curb and the recommendation is based on our best engineering judgement at this time. Thus, it may be refined as new information and research becomes available.

We have not recommended the use of non-blocked post in the immediate area around the unsupported span of the MGS long span or with curbs due to differences in the vehicle snag on the barrier post that has been observed in non-blocked MGS systems. Recommendations for the MGS long span and MGS with curbs and with non-blocked posts is located in MwRSF Report No. TRP-03-262-12. We do know that the performance of guardrail systems is affected by shorter blockout lengths, but it is not clear what the limits of the barrier performance is at this time without further study.

Thanks

Permanent Concrete Barrier next to 2:1 slope

Question
State: OH
Date: 01-23-2019

Do you have any guidance or research available for a permanent concrete barrier next to a 2:1 slope. The barrier is unanchored except for the end sections. At locations with pavement on only one side, we allow 3" of compacted soil but do not specify a minimum length before a slope drop off. Attached is the Ohio standard.

Thanks!

Attachment: https://mwrsf-qa.unl.edu/attachments/f679b118a9be42b0a872f9d7075f8599.jpg

Attachment: https://mwrsf-

qa.unl.edu/attachments/ec908768e684760a4938a55241ae532d.pdf

Response
Date: 01-29-2019

To start, there has been no research to date determining anchorage requirements for median and roadside permanent concrete barriers. We do have a proposal in the Year 30 Pooled Fund that we hope will move forward to address this. However, at this time, the data we have is only a function of what we can compare from similarly tested barriers and anchorages.

To the best of our knowledge, no testing of the permanent concrete barriers adjacent to slopes has been completed at this time. The concerns with such a system is that the lack of anchorage or a footing may allow the barrier to displace and translate and affect the barrier performance. The concern would be less for barriers with a foundation or footing below grade, a barrier with some form of anchorage, or a reinforced barrier as these factors would all tend to resist displacement and translation or provide lateral resistance.

Thus, we cannot determine for certain if the installation shown is sufficient to adequately restrain barrier motions, and there are limited options to recommend without further study. One could install dowel rods similar to what OhDOT uses in some instances for barrier anchorage in addition to the 3" fill and 1' offset shown. If the offset can be increased, a large offset to the slope would only reduce the concerns and perform better. A more conservative and more costly option would be to provide a dedicated footing below grade for barrier close to the steep slope to provide more resistance.

One other item to note with respect to the proposed configuration shown is that the weight of that barrier segment may lead to degradation of the slope over time. At some point, placement of that section close to a steep slope may creep and cause movement of the barrier and damage to the slope. It is not clear what point that is, but it may be something to consider.

W-Beam Guardrail Splice Section

Question
State: NC
Date: 01-23-2019

I have a question. What would be the smallest section or length of W-Beam guardrail allowable for a repair splice? 12'-6" or 6'-3"? This repair is for an over the post splice section of guardrail. Any guidance would be greatly appreciated.

Response
Date: 01-23-2019

I am not sure I am envisioning the repair splice you are considering.

Do you have a schematic/diagram/photo of the repair you are proposing?

Thanks

Response
Date: 01-24-2019

A small portion of an existing 25' w-beam section is damaged and they want to cut out a 6'-3" segment of that rail. They would then like to put back a new 6'-3" section. Is that advisable? I am thinking they should replace the entire section or at least 12'-6" of the damaged piece.

Response
Date: 01-26-2019

We would not recommend field splicing of the rail in general due to concerns with the structural integrity of the splice.

If a section of rail is damage, we would recommend that the entire section be replaced. You could use smaller sections to comprise the removed section length.

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

Thanks