# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

| **Project Title:** | | |
|---|---|---|
| Phase II - Guidelines for Post-Socketed Foundations for 4-Cable, High-Tension, Barrier System | | |
| **Name of Project Manager(s):** | **Phone Number:** | **E-Mail** |
| Reid, Sicking, Faller, Rosenbaugh | 402-472-9324 | srosenbaugh2@unl.edu |
| **Lead Agency Project ID:** | **Other Project ID (i.e., contract #):** | **Project Start Date:** |
| 2611211026001 | RPFP-10-CABLE-1 | 7/1/2009 |
| **Original Project End Date:** | **Current Project End Date:** | **Number of Extensions:** |
| 7/31/2012 | 4/30/2014 | 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** |
|---|---|---|
| $92,207 | $66,827 | 90% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $13,218 | |

**Project Description**:

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

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

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

Objectives/Tasks:

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

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

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

Work continued on reporting the foundation designs for S3x5.7 posts, and a first draft was completed. The draft is now in internal review.

**Anticipated work next quarter**:

The draft of the S3x5.7 post foundation report will be reviewed and edited internally before being sent out to the project sponsors for review.

**Significant Results:**

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

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

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

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

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

| Objectives/Tasks: | % Completed (Phase II) |
|---|---|
| 1. Design new socket foundations for barrier posts. | 100% |
| 2. Fabrication and dynamic testing of socketed foundations. | 100% |
| 3. Analysis of test data and evaluation of socketed foundation designs. | 100% |
| 4. Written report documenting all work and conclusions. | 90% |

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

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

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $159,193 | $132,117 | 35% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $12,437 | |

**Project Description:**

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

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

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

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

Task 4.
Further simulation continued on the end terminal model with a reverse 25-degree impact with an 1100C vehicle. An impact point was selected between post nos. 2 and 3, at a point where it is unknown whether the barrier will gate or redirect the car. At the current status, the top cable release from the cable anchor bracket. However the other cables, remain intact with the cable anchor bracket and interlock with the car's bumper. The model has an error at this time, and further investigation is needed to improve the cable contact with the vehicle.

**Anticipated work next quarter**:

Task 4.
Simulation of the reverse direction impact will continue to be evaluated. Other CIPs will need to be evaluated. The cable end terminal design will be finalized and evaluated using dynamic bogie tests. Writing will commence on the third report which will summarize the cable end terminal design, simulation, and evaluation. The MWPs and post spacing that are part of the cable end terminal will be updated as needed to reflect the changes made to the cable median barrier length of need system.

**Significant Results:**

Report TRP-03-268-12 documenting part 1 of this project was published July 17, 2012.
"Development and Recommendations for a Non-Proprietary, High-Tension Cable End Terminal System"

History of cable terminal design changes were documented in a Midwest Roadside Safety Facility internal document, June 2013.

Report TRP-03-294-14 documenting part 2 of this project was published March 21, 2014.

Simulations of a bogie vehicle impacting the end terminal system at 0 and 15 degrees released the cables quickly and easily with minimal damage to the cable anchor bracket and cable release lever.

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

Final design details and full-scale testing for this project cannot be conducted until the High Tension Cable Barrier System is completed. Because of timing in that project, this project is behind schedule.

$64,736 of the project funds have been re-allocated to PF-Yr 24 Cable Project. $64,736 of that re-allocation has been reflected on page 1 of this quarter report under "Total Amount of Funds Expended This Quarter".

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl.#22 | **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:** Maximum MGS Guardrail Height | | |
| **Name of Project Manager(s):** Reid, Sicking, Faller | **Phone Number:** 402-472-3084 | **E-Mail** jreid@unl.edu |
| **Lead Agency Project ID:** RPFP-10-MGS | **Other Project ID (i.e., contract #):** 2611211029001 | **Project Start Date:** July 1, 2009 |
| **Original Project End Date:** July 31, 2012 | **Current Project End Date:** April 30, 2015 | **Number of Extensions:** 3 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $166,953 | $146,435 | 100% |

***Quarterly*** Project Statistics:

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

**Project Description**:

Objective: Identify an upper bound on the acceptable height of the Midwest Guardrail System (MGS).

Tasks
1. Full-scale crash testing - completed
2. Report on full-scale crash testing - completed, Report TRP-03-255-12 published March 9, 2012
3. Analysis phase - completed

Note: The analysis phase of this project was supplemented by NDOR project SPR-1(12) M318,"Maximum Safe Guardrail Height."

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

The project was extended so that remaining funds in this project would be available for contingency spending.

**Anticipated work next quarter:**

The project is essentially completed. The project remains open while the funds are being spent on contingency projects..

**Significant Results:**

On June 29, 2010, MwRSF conducted one small car crash test (test no. MGSMRH-1) into a 34-in. tall Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 safety performance guidelines of MASH. The small car was successfully contained and redirected.

On September 9, 2010, a second small car test (test no. MGSMRH-2) was conducted into a 36-in. tall Midwest Guardrail System (MGS) using an 1100-kg Kia Rio according to the TL-3 MASH safety performance guidelines. Again, the small car was successfully contained and redirected.

Report TRP-03-255-12 documenting the above crash tests was published March 9, 2012.

A recent investigation showed that for newer vehicle models there is a consistent trend among the most important car manufacturers to increase the cowl height. The results from the simulations indicated that a higher cowl high will likely improve the safety performance of a guardrail system, thus potentially increasing the safety margin of the identified critical height for the MGS.

Report TRP-03-274-12 documenting the analysis phase was published December 5, 2012.

**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 supplemental project, NDOR project SPR-1(12) M318, was being worked on before completing this project. Results from that project were used to help direct and complete this project. The NDOR project has been completed and closed.

Remaining funds will be used as pooled fund contingency funds.

**Potential Implementation:**

Clearly defined limits on the upper height for MGS guardrail will allow states to accurately determine when a guardrail is too high, either as a result of improper installation or frost heave. Further, a clearly defined upper height will be very helpful when determining acceptable MGS placement guidelines on moderate slopes or behind curbs.

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* | **Transportation Pooled Fund Program - Report Period:** |
|---|---|
| TPF-5(193) Suppl. #32 | ☐Quarter 1 (January 1 – March 31)<br>☐Quarter 2 (April 1 – June 30)<br>☑Quarter 3 (July 1 – September 30)<br>☐Quarter 4 (October 4 – December 31) |

| **Project Title:** | | |
|---|---|---|
| MGS Guardrail Attached to Culverts | | |
| **Name of Project Manager(s):** | **Phone Number:** | **E-Mail** |
| Reid, Sicking, Faller, Rosenbaugh | 402-472-9324 | srosenbaugh2@unl.edu |
| **Lead Agency Project ID:** | **Other Project ID (i.e., contract #):** | **Project Start Date:** |
| 2611211046001 | RPFP-11-MGS-2 | 7/1/2010 |
| **Original Project End Date:** | **Current Project End Date:** | **Number of Extensions:** |
| 12/31/2013 | 9/30/2014 | 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** |
|---|---|---|
| $91,071 | $98,750 | 100% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $1,408 | |

**Project Description:**

Some cross-drainage culverts are wider than 24 ft and therefore cannot be treated with a long-span guardrail system. Although it is acceptable to utilize the deformable, top-mounted post attachment design developed for metric height guardrail under NCHRP Report No. 350, many existing culverts are too narrow to accommodate the loss of roadway width that comes with a top mounted system. Recently, the MGS Bridge Railing system was successfully developed and crash tested using the TL-3 MASH guidelines. The bridge railing system attaches to the exterior, vertical edge of reinforced concrete decks. It is believed that this bridge railing system could be adapted to mount to the backside face of an existing culvert headwall. The objective of this research effort is to develop an MGS guardrail system that attaches to the outside vertical face of the culvert headwall for box culverts greater than 24 ft wide.

Objectives / Tasks

1. Literature review of current culvert designs
2. Design of MGS attachment to face of headwall
3. Dynamic bogie testing
4. Data analysis and evaluation
5. Written report documenting all design work, testing, and conclusions

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

The project report was finalized and sent out to sponsors in April 2014.
Task Force 13 Hardware guide drawings were completed
A letter of eligibility was prepared and submitted to FHWA

**Anticipated work next quarter:**

NA

**Significant Results:**

A complete review of culvert designs used by Pooled Fund member states revealed a critical culvert design for testing and evaluation. A simulated culvert matching this critical design was constructed at MwRSF's test site. Four attachment concepts were developed, fabricated, attached to the simulated culvert and bogie tested. These concepts included a single-bolt top-mounted concept, a double-bolt top-mounted concept, a side-mounted concept, and a concept that wrapped around the top of the headwall and attached to the inside face of the headwall. Both the single anchor top mounted design and the side mounted design satisfied all resistance and damage requirements during lateral and longitudinal testing. Thus, these two designs were be recommended as attachment designs for the MGS Bridge Rail system attached to culvert headwalls.

| Objectives / Tasks | % Complete |
|---|---|
| 1. Literature review of current culvert designs | 100% |
| 2. Design of MGS attachment to culvert headwall | 100% |
| 3. Dynamic bogie testing | 100% |
| 4. Data analysis and evaluation | 100% |
| 5. Written report documenting all design work, testing, and conclusions | 100% |

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

The cost to construct the simulated culvert was underestimated in the original budget. As such, the project is currently over budget (currently by $7,679). The excess funds are being drawn from the Year 21 contingency fund.

Multiple members of the Pooled Fund program requested additional time to review the draft report. Thus, the project needed to be extended. Additionally, three other projects funded during Year 21 of the Pooled Fund program had remaining funds upon their completion. In order to reallocate those remaining funds to other projects and contingency funds, those projects also needed to be extended. Therefore, the entire Year 21 Pooled Fund program was extended to September 2014.

**Potential Implementation:**

Development of a new attachment for the MGS system to low-fill culverts will allow designers to install the MGS system on culverts wider than 24 ft without reducing the width of the overall roadway. In addition, it is anticipated that the new attachment design on the outside of the headwall will reduce construction and maintenance costs.

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl.#37 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Annual LS-DYNA Modeling Enhancement Support | | |
| **Name of Project Manager(s):** Reid, Sicking, Faller | **Phone Number:** 402-472-3084 | **E-Mail** jreid@unl.edu |
| **Lead Agency Project ID:** RPFP-11-LSDYNA | **Other Project ID (i.e., contract #):** 2611211050001 | **Project Start Date:** July 1, 2010 |
| **Original Project End Date:** December 31, 2013 | **Current Project End Date:** September 30, 2014 | **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 |
|---|---|---|
| $35,901 | $32,588 | 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 | $14,397 | 0 |

**Project Description**:

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

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

Research into improving simulation of rail release from posts on the MGS system was completed. A document detailing the progress made was written and will be included in the MGS Long Span project Phase II report.

In some events that experience significant tire impacts, the Silverado tires behave overly stiff causing what is believed to be exaggerated rebound. Research into replacing the Silverado tires with the detailed tire modeling technique developed for the C2500 pickup model was conducted. Previously, that technique was too cpu expensive to implement in general. But now with much faster computers available (starting in 2014), such a technique has become feasible computationally wise. During this quarter, the detailed tire model was placed on the reduced Silverado model and tested on a project investigating into curbs.

**Anticipated work next quarter**:

The research on implementation of the detailed tire model in the reduced Silverado model will be completed.

**Significant Results:**

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

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

**Potential Implementation:**

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* | **Transportation Pooled Fund Program - Report Period:** |
|---|---|
| TPF-5(193) Suppl. #40 | ☐Quarter 1 (January 1 – March 31)<br>☐Quarter 2 (April 1 – June 30)<br>☑Quarter 3 (July 1 – September 30)<br>☐Quarter 4 (October 4 – December 31) |

| **Project Title:** | | |
|---|---|---|
| Length of Need - B/C Analysis | | |
| **Name of Project Manager(s):** | **Phone Number:** | **E-Mail** |
| Albuquerque, Sicking, Faller, Stolle | 402-472-4233 | csstolle@huskers.unl.edu |
| **Lead Agency Project ID:** | **Other Project ID (i.e., contract #):** | **Project Start Date:** |
| 2611211060001 | | 7/1/2011 |
| **Original Project End Date:** | **Current Project End Date:** | **Number of Extensions:** |
| 6/30/2014 | 3/31/2015 | 1 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $113,499 | $151,924 | 100% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $5,602 | |

**Project Description**:

Guardrail is used to shield motorists from collisions with roadside hazards and must extend long distances in advance of any roadside obstacle to minimize the risk of a vehicle traveling behind the barrier and striking the hazard. When the length of guardrail is increased, the risk that a vehicle will travel behind the barrier and strike the hazard is reduced. However, guardrail is also a roadside hazard that produces approximately 1,200 fatal crashes across the nation every year. Increasing the length of a guardrail installation increases the frequency of impacts with the barrier and thereby increases the risk of a serious crash. Further, the increase in barrier crash frequency associated with each incremental increase in guardrail length does not diminish as the guardrail is extended. At some point, the increase in the risk of serious injuries and fatalities associated with extending the guardrail outweighs the reduction in the risk of a vehicle traveling behind guardrail and producing serious injury or fatal impacts with the shielded hazard. Extending the guardrail beyond this optimal length will increase the overall risk that motorists will be involved in a serious injury or fatal crash.

The objective of this research effort is to quantify the probability of a vehicle traveling behind guardrail and striking a shielded hazard and its relationship to guardrail length. This probability will then be used to develop a revised procedure for determining optimal guardrail upstream length.

Objective / Task
1. Literature review
2. Guardrail, hazard and crash data collection
3. Data analysis
4. RSAP analysis
5. Written report containing all analysis and conclusions

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

The final report was published and disseminated to the sponsor.

All work has been completed.

**Anticipated work next quarter**:
None as all work has been completed.

**Significant Results:**

An identification of the lowest-crash cost and highest-cost-effectiveness lengths-of-need (LONs) were pursued. It was determined that both the lowest-crash cost and highest-cost-effectiveness LONs were similar. Runout lengths corresponding to the optimum hazard and crash configurations were identified, and were observed to be approximately half as large as the runout lengths recommended in the 2006 Roadside Design Guide (RDG), and were significantly less than the recommended runout lengths presented in the 2011 RDG and Sicking and Wolford's recommendations.

| Objective / Task | % Complete |
|---|---|
| 1. Literature review | 100% |
| 2. Data collection | 100% |
| 3. Accident data analysis | 100% |
| 4. RSAP analysis | 100% |
| 5. Written report containing all analysis and conclusions | 100% |
| 6. Review and revise written report | 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).**

The project demanded significantly more work during both vehicle crash data collection and RSAPv3 analyses than was originally predicted and budgeted. Researchers originally had planned to only collect data from Kansas's highway I-70. As the study progressed, it became apparent that additional data was needed. Thus, additional guardrail, hazard, and traffic volume data from all guardrail sites located on all Interstate highways in the State of Kansas was collected. This effort consumed a significant amount of resources.

In addition, researchers used the most recent version of the Roadside Safety Analysis Program, RSAPv3, in this study. Completion of nearly 1,000 simulations using RSAPv3 required an extensive amount of time to analyze and process the results. Although these factors have not negatively affected the project schedule, they have significantly affected the project budget.

The fund in this project were exhausted prior to the completion of the project. Therefore, the overrun budget is being posted to Project No. TPF-5(193) Suppl. #16 and Project No. TPF-5(193) Suppl. #43. To date, $5,490 has been posted to Project No. TPF-5(193) Suppl. #16 and $32,945 to Project No. TPF-5(193) Suppl. #43.

**Potential Implementation:**

The proposed research study would develop guardrail length design procedures calibrated to provide optimal safety for occupants of vehicles involved in ran-off-road crashes. These new procedures should provide both a reduction in the cost of guardrail construction and a reduction in the overall risk of motorist injury and fatality.

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $234,629 | $133,819 | 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** |
|---|---|---|
| | $22,793 | |

**Project Description:**

Situations arise on the roadside where a barrier or rail is required to prevent pedestrians from crossing into a certain area which may be acceptable for an errant vehicle. Although these rails would not need to redirect or stop an errant vehicle, they must also not present additional hazards to the motoring public. These rails/fences should not cause excessive decelerations, vehicle snag points, vehicle instabilities, or produce fragments that may cause harm to other motorists when impacted. In addition, pedestrian rail systems must comply with the Americans with Disabilities Act (ADA). Therefore, a need may exist for a crashworthy pedestrian rail to protect pedestrians and prevent improper street crossings.

The objective of this research effort is development of a pedestrian rail to be ADA compliant and crashworthy. The objectives will be to identify the highest priority, crashworthy pedestrian rail need, to develop viable design concepts to meet that need, to finalize development of the crashworthy pedestrian rail system, and to perform the necessary MASH compliance tests for the system.

Objectives / Tasks

1. Literature review
2. Identification of rail needs and design criteria
3. Pedestrian rail design concepts
4. Component testing of design concepts
5. Summary report of design concepts
6. Finalize system details
7. Full-scale crash testing (MASH 2-91)
8. Full-scale crash testing (MASH 2-90)
9. Written report documenting design, testing, and conclusions

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

A summary of the six bogie tests and recommendations for system modifications was sent to the sponsor. Based on sponsor feedback and direction, detailed drawings of the modified system design and bogie matrix were completed. The modified design was fabricated. On July 28, 2014, test no. WIPR-4 was conducted on the modified welded concept where the post was welded directly to the base plate. The system was impacted in the end-on orientation. The test and system damage was analyzed and evaluated.

On August 13, 2014, a conference call was held with the sponsor and FHWA to garner feedback on the required test matrix as well as to determine the length of the system. During this meeting, it was agreed that conducting two tests with the small car (1100C) would be necessary, one impacting at 0 degrees and the other impacting at 25 degrees, similar to the tests conducted during the component testing. In addition, it was left up to MwRSF to determine a system length and to justify how and why it was determined.

The modified welded concept where the post was welded directly to the base plate and the vertical spindles spanned from the top horizontal rail to the bottom horizontal rail and passed through the middle horizontal rail was chosen for full-scale crash testing. Detailed drawings of the system layout were completed. Fabrication of the system for full-scale testing was initiated.

Documentation of the design effort including all rail, posts, and connections for the three welded aluminum concepts and the modular concept continued. Documentation of the bogie testing effort was initiated.

**Anticipated work next quarter:**

Documentation of the design effort including all rail, posts, and connections for the three welded aluminum concepts and the modular concept and the bogie tests will continue.

Once system fabrication is completed, full-scale crash testing of the selected system is anticipated toward the end of the next quarter.

**Significant Results:**

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

| Objectives / Tasks | % Complete |
|---|---|
| 1. Literature review | 100% |
| 2. Identification of rail needs and design criteria | 100% |
| 3. Pedestrian rail design concepts | 100% |
| 4. Component testing of design concepts | 100% |
| 5. Summary report of design concepts | 50% |
| 6. Finalize system details | 100% |
| 7. Full-scale crash testing (MASH 2-91) | 0% |
| 8. Full-scale crash testing (MASH 2-90) | 0% |
| 9. Written report documenting analysis, design, testing, and conclusions | 35% |

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

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

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**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. #43 | ☐Quarter 1 (January 1 – March 31)<br>☐Quarter 2 (April 1 – June 30)<br>☑Quarter 3 (July 1 – September 30)<br>☐Quarter 4 (October 4 – December 31) |

| **Project Title:** | | |
|---|---|---|
| Roadside Grading Guidance - Phase II | | |
| **Name of Project Manager(s):** | **Phone Number:** | **E-Mail** |
| Reid, Sicking, Faller, Bielenberg, Lechtenberg | 402-472-6864 | rfaller1@unl.edu |
| **Lead Agency Project ID:** | **Other Project ID (i.e., contract #):** | **Project Start Date:** |
| 2611211063001 | | 7/1/2011 |
| **Original Project End Date:** | **Current Project End Date:** | **Number of Extensions:** |
| 6/30/2014 | 3/31/2015 | 1 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $199,502 | $119,089 ($32,945 for Suppl. #40, $2 | 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** |
|---|---|---|
| | $16,389 ($5,608 for Suppl. #40) | |

**Project Description**:

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

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

Objectives / Tasks

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

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

A presentation, with adjustments to the Pooled Fund presentation, was made in a workshop at the summer meeting of TRB AFB20 in Maine.

A journal paper was submitted to TRB's AFB20 committee for review.

The report was edited according to the requests of the sponsoring agency. The revised report was sent to the sponsoring agency for final review.

**Anticipated work next quarter**:

The report will be made final and disseminated to the sponsoring agency.

**Significant Results:**

| Objectives / Tasks | % Completed |
|---|---|
| 1. Accident data collection | 100% |
| 2. Data analysis and determination of critical elements | 100% |
| 3. RSAP analysis | 100% |
| 4. Written report documenting all analysis and conclusions | 99% |

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

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

Due to the amount of work remaining, this project is projected to have extra funds remaining at the time the project is complete. The funds in Project Nos. TPF-5(193) Suppl. #40 and TPF-5(193) Suppl. #42 were exhaust prior to the completion of the project. Therefore, the overrun budgets for Project Nos. TPF-5(193) Suppl. #40 and TPF-5(193) Suppl. #42 are being posted to this project. To date, $32,945 has been posted for Project No. TPF-5(193) Suppl. #40 and $2,813 has been posted for Project No. TPF-5(193) Suppl. #42.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

Project schedule status:

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

Overall Project Statistics:

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

***Quarterly*** Project Statistics:

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

**Project Description**:

This is a continuation of TPF-5(193) Suppl.#37, "Annual LS-DYNA Modeling Enhancement Support" and thus, no progress to report until funds are exhausted in that project.

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

**Anticipated work next quarter:**

**Significant Results:**

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

**Potential Implementation:**

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): 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. #48 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Pooled Fund Center for Highway Safety | | |
| **Name of Project Manager(s):** Lechtenberg, Reid, Faller, Bielenberg | **Phone Number:** 402-472-9070 | **E-Mail** kpolivka2@unl.edu |
| **Lead Agency Project ID:** 2611211068001 | **Other Project ID (i.e., contract #):** RPFP-12-PFCHS-1 | **Project Start Date:** 7/1/2011 |
| **Original Project End Date:** 6/30/14 | **Current Project End Date:** 6/30/15 | **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** |
|---|---|---|
| $24,859 | $24,859 | 100% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $5,106 | |

**Project Description:**

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

A dedicated and well-maintained Pooled Fund Center for Highway Safety web site would provide for all of these needs. It would provide for a searchable database of previous MwRSF inquiries and solutions, a searchable online listing of downloadable research reports, and a searchable archive of CAD details for crash tested and/or approved systems and features. Through MwRSF's relationship with the Nebraska Transportation Center (NTC), experienced personnel can be hired to perform website design, programming, as well as provide reliable website hosting facilities. However, the development, maintenance, operation, and hosting of the web site will require funding. It is anticipated that the costs to develop, operate, maintain, and host a Pooled Fund Center for Highway Safety web site would be $24,859.00 in funding for FY 22.

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

MwRSF continued to update the archive with completed projects as they are completed.

The funds used in the Year 22 portion of this project were applied to the maintenance and upkeep of the web site by UNL and MATC.

All funds from this project have been exhausted, all remaining work and progress will be reported under Project No.: RPFP-14-PFCHS – TPF-5(193) Supplement #66, Project Title: Pooled Fund Center for Highway Safety

**Anticipated work next quarter**:

None as all funds have been exhausted, all remaining work and progress will be reported under Project No.: RPFP-14-PFCHS – TPF-5(193) Supplement #66, Project Title: Pooled Fund Center for Highway Safety

This project will be closed.

**Significant Results:**

Upload of the tested system CAD files and existing full-scale testing wmv files was completed.

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

None.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* | **Transportation Pooled Fund Program - Report Period:** |
|---|---|
| TPF-5(193) Suppl. #55 | ☐Quarter 1 (January 1 – March 31)<br>☐Quarter 2 (April 1 – June 30)<br>☑Quarter 3 (July 1 – September 30)<br>☐Quarter 4 (October 4 – December 31) |

| **Project Title:** Breakaway Steel Posts for Other Applications | | |
|---|---|---|
| **Name of Project Manager(s):**<br>Reid, Sicking, Faller, Bielenberg, Lechtenberg | **Phone Number:**<br>402-472-9324 | **E-Mail**<br>srosenbaugh2@unl.edu |
| **Lead Agency Project ID:**<br>2611211081001 | **Other Project ID (i.e., contract #):**<br>RPFP-13-UBSP | **Project Start Date:**<br>7/1/2012 |
| **Original Project End Date:**<br>6/30/2015 | **Current Project End Date:** | **Number of Extensions:** |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $65,224 | $39,180 | 100% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $76 | |

**Project Description**:

MwRSF has recently developed a Universal Breakaway Steel Post (UBSP) for use in the thrie beam bullnose system. The satisfactory performance of the UBSP in the bullnose median barrier system would suggest that there is potential for the UBSP to be used as a surrogate in other CRT applications, such as in the long-span guardrail system, guardrail end terminals, guardrail systems installed in subsurface rock foundations or rigid pavement mow strips, future short-radius guardrails, and new, reduced maintenance barrier systems. However, further analysis and testing would be required to verify its performance in these other guardrail applications. Thus, there exists a need to conduct further analysis and testing of the UBSP in order to investigate its feasibility for use in other barrier systems.

Objectives / Tasks
1. Dynamic bogie tests (8 total)
2. Data analysis and evaluation
3. Ulterior systems design recommendations
4. Written report documenting all testing, analysis, and conclusions

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

The project report was reviewed by the Pooled Fund sponsors and their comments/edits were incorporated into the report. The report was then finalized, printed, and sent out to the sponsors on April 11th.

**Anticipated work next quarter**:

The project will close at the end of this quarter. The remaining funds will be transferred to the contingency fund.

**Significant Results:**

All eight of the originally proposed dynamic bogie tests have been conducted and analyzed. The USBP and wooden CRT posts preformed similarly during the strong axis tests in terms of resistance force and displacement at time of fracture. During the weak axis tests, the USBPs demonstrated a quicker release/fracture than the CRT posts (recall CRT posts were designed to fracture during weak axis impacts so this could be considered an improvement to the CRT design). In general, the USBP shows promise for use in multiple systems in which CRT posts are currently utilized.

| Objectives / Tasks | % Complete |
|---|---|
| 1. Dynamic bogie tests (8 total) | 100% |
| 2. Data analysis and evaluation | 100% |
| 3. Ulterior systems design recommendations | 100% |
| 4. Written report documenting all testing, analysis, and conclusions | 100% |

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

The project was completed under budget. The remaining funds ($26,044) will be transferred to the contingency fund.

**Potential Implementation:**

Further analysis and development of the UBSP post would aid designers by providing a potential surrogate post design for current CRT applications. Because the UBSP design is fabricated from steel, its use offers several benefits over timber posts, including reduced variability, reduced concerns for deterioration over time, and alleviation of environmental concerns regarding disposal of wood posts with preservative treatment.

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $212,730 + suppl $36,605 | $67,336 | 30% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $26,388 | |

**Project Description**:

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

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

Objectives / Tasks

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

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

Tasks 2 and 3 were completed in the quarter. Efforts on these tasks were primarily in support of documenting the project to date (see Task 6)..

Task 4.

System drawings were finalized and a full-scale crash test was placed in the testing queue.

Task 6.

The draft report documenting the simulation effort and selection of the 31¼-ft span length for the MGS long-span system was completed and sent to the states for review.

**Anticipated work next quarter:**

Task 4.

Depending on weather and MwRSF testing priorities, it is anticipated that one of the two full-scale crash tests will be completed next quarter.

Task 6.

Reviews from the states on the draft report documenting the simulation effort and selection of the 31¼-ft span length for the MGS long-span system will be implemented in the report and the report will be published.

**Significant Results:**

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

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

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

| Objectives / Tasks | % Complete |
|---|---|
| 1. Literature review of previous long-span systems | 100% |
| 2. Simulation of both original and any new long-span system designs | 100% |
| 3. Design modifications to extend unsupported length | 100% |
| 4. Full scale crash testing of new design (two MASH 3-11 tests) | 15% |
| 5. Data analysis and evaluation | 0% |
| 6. Written report documenting all design work, simulation, testing, and conclusions | 25% |

The simulation and design phase was the basis for Nick Weiland's Master Thesis. Nick graduated in August 2014 and his Thesis "Increased Span Length of the MGS Long-Span Guardrail System" was published June 17, 2014.

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $162,896 | $18,225 | 35% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $110 | |

**Project Description:**

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

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

Objectives / Tasks

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

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

Previously, bogie testing on a 30" deep socket with a 10" wide shear plate showed minimal movement of the socket during impacts in both the lateral and longitudinal directions.

This quarter, component testing continued to optimize the depth of the socket. A 20" deep socket with shear plate was impacted through the strong axis and resulted in the asphalt breaking apart behind the socket. Testing on a 24" deep socket resulted in approximately 3/4" of movement at the top of the socket - about the maximum translation we would consider acceptable for reuse.

Another component test was conducted on dual 24" deep sockets spaced 37.5" appart. The bogie impacted both posts at the same time and resulted in the asphalt breaking apart behind the sockets.

The results of these component tests were sent tot he project sponsors with a request for feed back on selected socket and asphalt pad configuration for the full-scale crash test. Options provided to limit the damage to the mow strip were: 1) test 30" deep socket, 2) increase the width of the asphalt mow strip from 4' to 6', and 3) increase the thickness of the asphalt mow strip from 4" to 6".

Drawings for the full-scale system were produced (only final mow strip and socket depth details remain).
Work was also continued on the project report, specifically documenting the bogie testing that has been conducted so far.

**Anticipated work next quarter:**

Based on sponsor feedback, a socket depth and mow strip configuration will be selected for the full-scale crash test. The system drawngs will be finalized, the system constructed at MwRSF's test site, and the full-scale crash test will be conducted.

**Significant Results:**

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

When a 10" wide shear plate was welded to the back of a 30" deep socket, both lateral and longitudinal tests resulted in minimal damage to the 4" asphalt mow strip and minimal displacements to the socket. Similar results for a 24" deep socket with 3/4" of socket translation at ground line. A 20" deep socket rotated and cause the asphalt to break away behind the socket. Impacting dual 24" sockets spaced at 37.5" also resulted in asphalt fracture socket rotations.

| Objectives / Tasks | % Complete |
|---|---|
| 1. State survey of existing mow strip practices | 100% |
| 2. System design and analysis | 90% |
| 3. Dynamic bogie component testing | 85% |
| 4. Full scale crash testing (MASH 3-10 and 3-11 tests) | 0% |
| 5. Data analysis and evaluation | 30% |
| 6. Written report documenting all design work, simulation, testing, and conclusions | 15% |

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

Matching funding in the amount of $60,000 was obtained through the Mid-American Transportation Center. Thus, additional component testing can occur to explore various options for installing the S3x5.7 posts within both concrete and asphalt mow strips. Since the MATC project closes in December 2014 (before the Pooled Fund project), all design, evaluation, and component testing since September 2013 has been charged to the MATC project. This explains why minimal Pooled Fund project funds were spent this quarter.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): 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. #60 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Pooled Fund Center for Highway Safety | | |
| **Name of Project Manager(s):** Reid, Faller, Lechtenberg, Bielenberg | **Phone Number:** 402-472-9070 | **E-Mail** kpolivka2@unl.edu |
| **Lead Agency Project ID:** 2611211086001 | **Other Project ID (i.e., contract #):** RPFP-13-PFCHS | **Project Start Date:** 7/1/2012 |
| **Original Project End Date:** 6/30/2015 | **Current Project End Date:** 6/30/2015 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $10,958 | $6,157 | 55% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $2,732 | |

**Project Description:**

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

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

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

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

Maintenance, repair, and upkeep of the website continued.

All completed projects in the third quarter 2014 were added to the research archive site.

Development of a page dedicated to the Pooled Fund to include historical information, state contacts, active projects, and problem statement submission was initiated.

**Anticipated work next quarter**:

Continue maintenance, repair, and upkeep of the website.
Continue updating the archive with completed projects as they are completed.

Continue the development of the dedicated Pooled Fund page. It is anticipated that a prototype may be available for review by the end of the next quarter.

**Significant Results:**

Several newly completed projects were added to the research archive.

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

This is a continuation of funding for the original project started in Pooled Fund Year 22, Project No.: RPFP-12-PFCHS-1 – TPF-5(193) Supplement #48, Project Title: Pooled Fund for Highway Safety.

**Potential Implementation:**

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

**Project Description**:

AASHTO highway design policies discourage the use of curbs along high-speed roadways. This guidance is largely based on the fact that curbs may cause impacting vehicles to become airborne, thus resulting in loss of control by the driver. In the case of a laterally skidding vehicle, a rollover may also be induced upon striking the curb (i.e., tripping). However, safety appurtenances, such as guardrail end terminals and crash cushions, are often placed in combination with curbs. Nonetheless, curbs are often installed along high-speed roadways for several reasons, including restricted right-of-way, drainage considerations, access control and other curb function requirements. In these situations, eliminating existing curbs or laterally offsetting curbs away from the traveled way may represent an expensive or unattainable alternative.

Historically, the safety performance of energy-absorbing guardrail end terminals has been based on the results of full-scale crash tests performed on level terrain. However, very limited research has been performed to investigate the safety performance of these features when installed in combination with curbs. Thus, there is a need to investigate whether curb placement in advance of guardrail end terminals significantly degrades barrier performance as a result of the changes in vehicle trajectory prior to impact. In addition, design recommendations are necessary for determining the safe placement of curb and gutter installed adjacent to energy-absorbing guardrail end terminals.

The objective of this research effort is to develop guidance for the safe placement of curbs adjacent to energy-absorbing guardrail end terminals. A combination of computer simulation and full-scale crash tests will be used to identify potential safety hazards, define critical curb and terminal impact scenarios, and select optimal curb placement. The effort will focus on a single, representative energy-absorbing, guardrail end terminal configuration that is selected during the study effort. In addition, the impact conditions for the simulation and crash testing programs will correspond with those published for Test Level 3 (TL-3) in the MASH impact safety standards.

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

The geometry of the generic end terminal system was determined by averaging dimensions from similar end terminal systems, including ET-Plus/ET-2000, SKT, FLEAT, and BEST. The configuration of the end terminal system was finalized.

A meeting was held in July with representatives from WisDOT, MwRSF, FHWA, TTI, Trinity Highway Products, and Road Systems to discuss our plan to model a generic end terminal system. CAD drawings and a brief summary of the modeling techniques were provided. The anticipated simulation matrix was presented, although the final configurations to be simulated are not final. Everyone in attendance agreed that the plan was reasonable.

Simulation efforts began to evaluate the modeling techniques, which showed promise. A 31" tall end terminal model was developed. Connections and contacts between all the parts is in the process of being evaluated with an impact by the 820C vehicle.

**Anticipated work next quarter**:

The end terminal system will be changed to 27 3/4 in. tall guardrail and impacted end-on with the 820C and 2000P vehicles. The simulations will be compared to available full-scale crash tests.

**Significant Results:**

Met with end terminal manufacturers to obtain consensus on the anticipated project plan. An end terminal model was developed, and connections and contacts are being evaluated.

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

None.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

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

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

| **Name of Project Manager(s):** | **Phone Number:** | **E-Mail** |
|---|---|---|
| Reid, Faller, Bielenberg, Lechtenberg | 402-472-6864 | rfaller1@unl.edu |
| **Lead Agency Project ID:** | **Other Project ID (i.e., contract #):** | **Project Start Date:** |
| 2611211095001 | RPFP-14-AGT-1 | 7/1/2013 |
| **Original Project End Date:** | **Current Project End Date:** | **Number of Extensions:** |
| 6/30/2016 | 6/30/2016 | 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $59,946 | $11,216 | 20% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $3,086 | |

**Project Description**:

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

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

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

Objectives & Tasks

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

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

The report was finalized and disseminated to the Pooled Fund member states.

**Anticipated work next quarter**:

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

**Significant Results:**

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

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

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

| Objectives/Tasks | % Complete |
|---|---|
| 1. Full-scale crash testing (MASH test designation nos. 3-20 and 3-21). | 100% |
| 1a. Full-scale crash test of modified transition (MASH test no. 3-20) | 100% |
| 2. Data analysis and evaluation. | 100% |
| 3. Report documenting R&D effort, including redesign, crash testing, and conclusions | 100% |
| 4. TF-13 Hardware Guide Drawings | 45% |

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

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

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

| **Project Title:** Continued Development of the Midwest Four-Cable, High-Tension, Median Barrier (Continuation Funding) | | |
|---|---|---|
| **Name of Project Manager(s):** Reid, Faller, Lechtenberg, Bielenberg | **Phone Number:** 402-472-9070 | **E-Mail** kpolivka2@unl.edu |
| **Lead Agency Project ID:** 2611211096001 | **Other Project ID (i.e., contract #):** RPFP-14-CABLE1 | **Project Start Date:** 7/1/13 |
| **Original Project End Date:** 6/30/16 | **Current Project End Date:** 6/30/16 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $375,513 (+$264,372 from Yrs 20 & 22) | $220,314 ($40,916 R&D/Reporting C | 0 |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $82,483 ($14,228 R&D/Reporting Cc | |

**Project Description**:

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

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

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

The reports containing the folded C-channel posts and Midwest Weak Posts and the component testing of the shear plate brackets continued to be written. The report containing the full-scale crash tests (test nos. MWP-1 through MWP-3) was initiated.

Construction of the Midwest high-tension cable median barrier system on level terrain 8' post spacing and reducing the number of keyways and holes in the post was completed. On July 11, 2014, MwRSF conducted one pickup crash test (test no. MWP-3) into the Midwest high-tension cable median barrier with the Midwest Weak Post using a 2270-kg Dodge QuadCab according to the TL-3 safety performance guidelines of MASH, specifically test designation no. 3-11. The pickup overrode the cables and eventually rolled over.

Following the completion of this full-scale crash test of the Midwest high-tension cable median barrier with 8' post spacing, a conference call was held on July 29, 2014 to discuss observations regarding the results of test no. MWP-3 and determine the project direction. Minor deviations in the test conditions of test nos. MWP-2 and MWP-3, specifically the vehicle front-end heights and the actual impact points, altered the barrier's capture characteristics. In order to make the capture more consistent, 4 major changes were discussed and include reducing the top cable height, increasing the bottom cable height, moving toward 5 cables instead of 4 cables, and adjusting the post spacing. The majority of state attendees agreed with reducing the top cable height to 38", increasing the bottom cable height to about 15", and staying with 4 cables unless it is shown that 5 cables is absolutely necessary. After soliciting the opinions of the absent states, the majority vote resulted in a 10' post spacing. Drawings of the modified Midwest high-tension cable median barrier system with 10' post spacing, 38" top cable height, 15.5" bottom cable height, and 7.5" cable spacing in between was completed. Fabrication of the new posts was initiated.

**Anticipated work next quarter**:

The report containing the folded C-channel posts and Midwest Weak Posts will continue to be written and reviewed. There is a potential the draft report may be sent to the member states for review toward the end of the next quarter.

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

The report containing the full-scale crash tests (test nos. MWP-1 through MWP-3) will continue to be written.

Fabrication of the new posts will be completed. Construction of the modified cable system placed on level terrain will be completed. The repeat test designation no. 3-11 with the 2270P will be completed. Following the completion of test designation no. 3-11 with reduced post spacing, the results of the test will be reviewed and presented to the states to determine if further design changes are desired.

Testing of the non-bolted connection concepts will be completed. The results will be analyzed and will be presented to the states to determine if any of the options seem promising and further work is desired. Documentation of the test results in a formal report will be initiated.

**Significant Results:**

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

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

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

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

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

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

To date, total funds spent are from the following project funds:
$64,736 from Project No.: RPFP-10-CABLE-3 – TPF-5(193) Supplement #21
$155,288 from Project No.: RPFP-12-CABLE1&2 – TPF-5(193) Supplement #46
$291 from this project, Project No.: RPFP-14-CABLE-1 - TPF-5(193) Supplement #64

In addition, Contingency Funds from several prior years have been designated for Cable R&D and Cable Reporting. To date, $40,916 has been posted to the contingency funds for Cable R&D and Cable Reporting.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #65 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Annual Consulting Services Support | | |
| **Name of Project Manager(s):** Ron Faller, John Reid, Bob Bielenberg | **Phone Number:** 402-472-9064 | **E-Mail** rbielenberg2@unl.edu |
| **Lead Agency Project ID:** 2611211097001 | **Other Project ID (i.e., contract #):** RPFP-14-CONSULT | **Project Start Date:** 7/1/2013 |
| **Original Project End Date:** 6/30/16 | **Current Project End Date:** 6/30/16 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $48,803.00 | $40,055.00 | 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** |
|---|---|---|
| | $8,386.00 | |

**Project Description**:

This project allows MwRSF to be a valuable resource for answering questions with regard to roadside safety issues. MwRSF researchers and engineers are able to respond to issues and questions posed by the sponsors during the year. Major issues discussed with the States have been documented in our Quarterly Progress Reports and all questions and support are accessible on a MwRSF Pooled Fund Consulting web site.

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

In the past quarter MwRSF has responded to a series of state inquiries. The Quarterly Progress Report summarizing these responses has been attached to this document. The summary will also be available for download at the recently completed MwRSF Pooled Fund Consulting web site - http://mwrsf-qa.unl.edu/

We are continuing to work with and improve the MwRSF Pooled Fund Consulting web site as our experience with it grows. We would ask that all Pooled Fund member states use the new site from this point forward for their inquiries and to contact us with any issues they experience with the web site.

**Anticipated work next quarter**:

MwRSF will continue to answer questions and provide support to the sponsors during the upcoming quarter.

We would ask that all questions be submitted through the web site so that they can be answered and archived therein.

http://mwrsf-qa.unl.edu/

**Significant Results:**

A quarterly summary of the consulting effort was provided and users can use the web site to search and find responses as well.

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

None.

**Potential Implementation:**

None.

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $11,519 | $0 | 0% |

***Quarterly*** Project Statistics:

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

**Project Description:**

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

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

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

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

None.

This project will not be started until the completion of Project No.: RPFP-13-PFCHS – TPF-5(193) Supplement #60, Project Title: Pooled Fund for Highway Safety.

**Anticipated work next quarter**:

None

**Significant Results:**

None.

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

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

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $3,695 | $1,433 | 40 |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $1,172 | |

**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.):**

The last drawings in the original lists were reviewed and approved with changes in September 2013 and April 2014. Began updating the remaining 10 component and 5 system drawings that were reviewed online by the barrier and component review group during the AASHTO TF-13 fall meeting and spring meeting held in September 2013 and April 2014, respectively.

**Anticipated work next quarter**:

Continue to update drawings based on comments received from online review of drawings.

**Significant Results:**

This project is used to supplement the preparation of the TF-13 format CAD details. Previously, it was determined that there are 14 systems and 11 components that need to be prepared in the TF-13 format. During discussions with the AASHTO TF-13 subcommittee in July 2011, new components had to be generated from the existing system drawings. Thus, the original 11 components became 32. Two of the systems and one component had limited work that need to be completed on the drawings as they were to be included in the Bridge Rail Guide and Luminaire Guide, respectively.

In evaluating the separation of the components, it was determined that some could be combined into one drawing based on the same type of component, but just one varying parameter.

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

| Task | % Complete |
|---|---|
| 1. Prepare CAD details for Hardware Guide | 35% |

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

Funding from Project No.: RPFP-13-TF13 – TPF-5(193) Supplement #53, Project Title: Annual Fee to Finish TF-13 and FHWA Standard Plans will be used prior to starting this project. All funding from previously mentioned project has been exhausted.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #68 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Minimum Offset for Standard MGS Adjacent to 2H:1V Slope | | |
| **Name of Project Manager(s):** Ron Faller, John Reid, Bob Bielenberg | **Phone Number:** 402-472-9064 | **E-Mail** rbielenberg2@unl.edu |
| **Lead Agency Project ID:** 2611211100001 | **Other Project ID (i.e., contract #):** RPFP-14-MGS-8 | **Project Start Date:** 7/1/2013 |
| **Original Project End Date:** 6/30/16 | **Current Project End Date:** 6/30/16 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $89,991.00 | $38,585.00 | 60% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $19,631.00 | |

**Project Description**:

W-beam guardrail is often used to protect motorists from steep roadside slopes adjacent to high-speed roadways. A roadside slope placed immediately behind a guardrail system greatly reduces the soil resistance associated with lateral deflection of the barrier. This reduction in the post-soil forces greatly reduces a system's energy-absorption capability, significantly increases dynamic rail deflections, and can potentially produce issues with vehicle capture or vehicle override. Further, when the guardrail extends over the embankment, the gap between the bottom of the rail and the ground will be greatly magnified and thereby increase the risk of severe wheel snag.

The MGS guardrail system has greatly improved the safety performance and stability of guardrail installed at the slope breakpoint of slopes as steep as 2H:1V. However, current MGS installations adjacent to 2H:1V slopes utilize increased length posts in order to provide sufficient embedment to generate the proper soil resistive forces. This requirement creates issues with state DOT hardware inventories and maintenance due to the need to stock and maintain non-standard length posts. In order to reduce hardware inventories, states have chosen in some cases to install the standard MGS system at an offset from the slope. Current guidance requires a minimum offset of 1 ft to 2 ft from the back of the post to the the slope breakpoint for the standard MGS system with 6-ft long posts depending on the slope grade. This large offset maintains the safety performance of the system but creates a great deal of additional expense in terms of earthwork. Thus, a need exists to evaluate a minimum offset for the standard MGS guardrail system adjacent to a 2H:1V fill slope in order to reduce current issues with state hardware inventories and earthwork costs.

The objective of this research effort is to evaluate the minimum offset for installation of the standard MGS guardrail system with 6-ft long W6x9 posts spaced at 75 in. on centers adjacent to a 2H:1V fill slope. The evaluation will focus on a system with the posts installed at the slope break point of a 2H:1V slope. The minimum offset will be evaluated through one full-scale crash test according to the TL-3 impact criteria in MASH for test designation 3-11.

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

In this quarter, MwRSF completed the full-scale crash test of the MGS guardrail system with 6-ft long W6x8.5 posts spaced at 75 in. on centers adjacent to a 2H:1V fill slope. On August 14th, the standard MGS (6-ft W6x8.5 posts and 12" blockouts) installed with the centerline of the posts at the slope break point of a 2:1 slope was subjected to AASHTO MASH TL-3 test conditions using a 2270P pickup truck vehicle (test designation 3-11). In test no. MGSS-1, the pickup truck impacted the system at a speed and angle of 61.6 mph and 26.2 degrees, respectively, resulting in an impact severity of 123.7 kip-ft. The system adequately contained and safely redirected the pickup truck. The occupant impact velocities and occupant ridedown accelerations were within the suggested limits provided in MASH. The maximum lateral deflection of the system and working width of the system were approximately 73 in. and 77.5 in., respectively. The occupant crush measurements have not been completed yet, but we do not anticipate any exceeding the limits provided in MASH. Therefore, we can tentatively say that the test was acceptable according to the safety performance criteria of AASHTO MASH for test designation no. 3-11.

The final documentation of that crash test is being completed and the effort to write the research report has been started.

**Anticipated work next quarter**:

In the upcoming quarter, MwRSF will continue work on the research report documenting the tested system.

**Significant Results:**

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

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

None.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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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. #69<br>MwRSF Project No. RPFP-14-MGS-11 | ☐Quarter 1 (January 1 – March 31)<br>☐Quarter 2 (April 1 – June 30)<br>☑Quarter 3 (July 1 – September 30)<br>☐Quarter 4 (October 4 – December 31) |

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $49,044 | $4,773 | 25% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $2,700 | |

**Project Description:**

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

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

Objectives / Tasks:

Phase I - Evaluation of Standard MGS

1. LS-DYNA computer simulation
2. Summary Report

Phase II - Evaluation of MGS installed with a 6" curb

1. LS-DYNA computer simulation
2. Summary Report

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

Work on this project was focused on the LS-DYNA simulation of the standard MGS (Phase I). The MGS model was validated and the calibrated. Simulations for lower speed impacts have begun. Also, the project report was started to document the study efforts to date.

**Anticipated work next quarter**:

Phase I simulation of the project will continue, and the study will be documented in the project report.

**Significant Results:**

The MGS model has been validated and calibrated against TL-3 impacts. Simulations of lower speed impacts have begun, but definitive results have not yet been recorded.

| Objectives / Tasks: | % Complete |
|---|---|
| Phase I - Evaluation of Standard MGS | |
| 1. LS-DYNA computer simulation | 75% |
| 2. Summary Report | 25% |
| Phase II - Evaluation of MGS installed with a 6" curb | |
| 1. LS-DYNA computer simulation | 0% |
| 2. Summary Report | 0% |

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

None

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Iowa DOT

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

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

| **Project Title:** | | |
|---|---|---|
| Attachemnt of Combination Rails to Concrete Parapets Utilizing Epoxy Adhesive Anchors - Phase I | | |
| **Name of Project Manager(s):** | **Phone Number:** | **E-Mail** |
| Bielenberg, Faller, Reid, Rosenbaugh | (402) 472-9064 | rbielenberg2@unl.edu |
| **Lead Agency Project ID:** | **Other Project ID (i.e., contract #):** | **Project Start Date:** |
| 2611130087001 | | 2/1/2014 |
| **Original Project End Date:** | **Current Project End Date:** | **Number of Extensions:** |
| 7/31/2015 | 7/31/2015 | 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $50,891.00 | $16,142.00 | 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** |
|---|---|---|
| | $8,801.00 | |

**Project Description**:

The research objective is to design and evaluate alternative epoxy adhesive anchorages for use in the IaDOT BR27C combination bridge rail system. The alternative epoxy adhesive anchorages would be developed to have equal or greater capacity than the current cast-in-place anchorage, so that they can be used in new construction or as a retrofit to modify existing bridge railings. The proposed epoxy attachment designs will be evaluated through dynamic component testing.

The research effort will consist of redesign, testing, and evaluation of alternative epoxy adhesive anchorage systems for attaching the beam and post system to the concrete parapet according to the details for the BR27C combination bridge railing. This first task in this effort would be for MwRSF to review the current cast-in-place anchorage design and develop alternative epoxy adhesive anchorage configurations. This effort could include an inline anchor system and/or a four anchor system similar to the cast in place configuration but with spacing more compatible with the clearances required for a drill in system. The alternative epoxy adhesive anchorage systems would be submitted to IaDOT for review and selection of the one or two preferred systems to be tested and evaluated.

Dynamic component testing will be used to evaluate the proposed epoxy adhesive anchorages and to demonstrate that the capacity of the proposed epoxy anchorages was equal to or greater than the existing cast-in-place anchorage system. The capacity of the current cast-in-place anchorage has not been fully quantified with testing. Thus, one dynamic component test would be performed on the post using the current cast-in-place anchorage configuration. Additional dynamic component tests would also be performed on the proposed alternative epoxy adhesive anchorage systems. The target impact conditions for all tests would be identical. The tests would be configured so that the applied impact load would occur at a height on the post/rail in order to produce a bending moment in the post and combined loading on the anchorage system similar to that provided during vehicle crash events. The force versus deflection, energy dissipated versus deflection, and failure modes would be documented for each test and compared to one another. These comparisons would be used to verify that the proposed anchorages provided equal or greater capacity than the current

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

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

Work continued on the research effort during the 3rd Quarter of 2014. In this quarter, all four of the proposed configurations were constructed on a simulated concrete parapet at the MwRSF Outdoor Test Facility and bogie tested. During these tests, various failure modes were observed, including epoxy pullout, concrete fracture, and steel anchor fracture. The damage to the anchorage system for each test was documented for the report and comparison purposes. The accelerometer data from the testing is current being analyzed to compare the force vs. deflection data for the four anchorage configurations. These comparisons will be used to determine the feasibility of the alternative anchorages as compared to the current cast-in-place design.

**Anticipated work next quarter**:

In the upcoming quarter, MwRSF will finish the analysis and comparison of the component testing of the alternative epoxy anchorages. In addition, work will be done on creating a summary letter report to document the results.

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

**Significant Results:**

All four of the proposed component tests on the original cast-in-place BR27C anchorage and the alternative epoxy anchorages were completed. The tests were documented and analysis of the acceleration data is currently underway.

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $124,345 | $0 | 1% |

***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:**

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.):**

Work this quarter has begun on the literature review of previous cable barrier tests on or adjacent to slopes.

**Anticipated work next quarter**:

The literature review of previous cable systems will be completed, and the development of design concepts will begin.

**Significant Results:**

none to date.

| Major Task List | % Complete |
|---|---|
| 1. Literature review of cable barrier on/adjacent to slopes | 30% |
| 2. Concept Design | 0% |
| 3. Component Testing of Post Configurations | 0% |
| 4. LS-DYNA model development, validation, and calibration | 0% |
| 5. LS-DYNA simulation of various cable barrier modifications | 0% |
| 6. CAD details of proposed cable system designs | 0% |
| 7. Preparation of research report and recommendations for future research | 0% |
| 8. Preparation of Technical Brief for NDOR. | 0% |

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

none

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #75 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Length of Need for Free-Standing, F-Shape, Portable 12.5' Concrete Protection Barrier | | |
| **Name of Project Manager(s):** Ron Faller, Bob Bielenberg, John Reid | **Phone Number:** 402-472-9064 | **E-Mail** rbielenberg2@unl.edu |
| **Lead Agency Project ID:** 2611211107001 | **Other Project ID (i.e., contract #):** RHE-08 | **Project Start Date:** 7/1/2014 |
| **Original Project End Date:** 12/31/15 | **Current Project End Date:** 12/31/15 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $189,820.00 | $1,675.00 | 5% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $1,675.00 | |

**Project Description:**

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

Phase I

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

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

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

During this quarter, MwRSF had a TAC meeting to kick off the project. At that it was noted that in addition to the taks in the proposal, the TAC would also like to evaluate the friction coefficient between the PCB segments and asphalt paving to see if it is similar to concrete and would like to investigate the deflection of the barriers under the 85th percentile IS values.

The researchers also began validation of the baseline PCB model for use in the study. Preliminary models of the PCB system at the standard 200 ft length were simulated and are being compared to full-scale crash tests to build confidence in the simulation model.

**Anticipated work next quarter**:

In the next quarter, MwRSF will continue the simulation effort for determining minimum system length and the number of barriers required for the beginning and end of the length of need. Once the baseline PCB model is validated, the researcher will begin simulation of impacts at various points near the beginning and end of the PCB system. These models will provide a preliminary determination of the number of barrier segments needed on the upstream and downstream ends of the system to safely redirect errant vehicles along the length of need of the system.

Static pull testing of a PCB segment on asphalt will be conducted to evaluate friction coefficients between the asphalt and PCB.

**Significant Results:**

TAC meeting and creation of baseline simulation model.

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

None.

**Potential Implementation:**

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

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

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

**Project Title:**

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $213,677.00 | $0.00 | 5% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $0.00 | |

**Project Description**:
The objective of this research is to evaluate the safety performance of the transition between guardrail and free-standing F-shape TCB developed in Phase I of the research effort. The safety performance evaluation is to be conducted according to the TL-3 impact safety standards published in MASH.

The research effort for Phase II would consist of final design, fabrication, and testing of the TL-3 transition between temporary concrete barrier and guardrail selected by the sponsor from Phase I. Design details of the proposed transition would be fully developed in three-dimensional CAD software. Next, fabrication and installation of the transition system would be completed at the MwRSF's full-scale crash test facility. It is anticipated that three full-scale crash tests would be required to fully evaluate the transition system. These tests would include MASH test designation nos. 3-20 and 3-21 which are tests to evaluate the design of the barrier transition with 1100C small car and 2270P pickup truck vehicles. In addition, it is anticipated that a reverse direction impact of test designation no. 3-21 with the 2270P vehicle would be required for evaluation of the transition for installations that require two-way traffic adjacent to the barrier. Following the completion of the full-scale crash testing, a summary report will be completed detailing the evaluation effort as well as providing guidance for implementation of the new transition design. MwRSF will also prepare a technical brief and a PowerPoint presentation of the research results to NDOR at the completion of the project.

Major Task List:

1. Project planning and correspondence
2. Development of design details in 3D CAD and review by TAC
3. Fabrication of hardware and installation at MwRSF test site.
4. Three full-scale crash tests according to TL-3 of MASH.
a. MASH test no. 3-20 with the 1100C small car

**Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):**
During this quarter, MwRSF developed proposed details for the attachment of the W-beam guardrail to the TCB segments, including connection of the end of the rail to the TCB and mounting of blockouts on the TCB segments.

After the first phase of the research, the overall layout of the transition system was developed, but attachment details remained to be designed between the guardrail and the PCB segments and the blockouts that were attached to the PCB. Based on this research, a nested-MGS configuration was recommended for evaluation using a full-scale crash testing program. In addition, the nested MGS should use an attachment location where the W-beam end-shoe should be attached to the upstream end of the fourth PCB segment with three PCB segments extending behind the nested MGS. A minimum of five 12-ft 6-in. (3,810 mm) long, W-beam sections should be nested upstream from the end-shoe. For testing purposes, the transition should consist of at least a twenty-five post MGS system and an eleven segment PCB system at a 15H:1V flare.

Thus, work remained to determine the exact attachment between the guardrail and PCB segment and the attachment of the blockouts directly to the PCB. MwRSF developed preliminary details of these connections and submitted them to NDOR for comment and review.

1. Guardrail to PCB attachment
a. The guardrail to PCB attachment was designed suing a steel mounting bracket that bolts to the PCB and allows for direct attachment of the W-beam end shoe. The basic design is similar to attachments that have been previously developed for attachment of thrie beam approach transitions to sloped concrete parapets. However, the attachment developed for this design was slightly more complex as the mounting bracket needed to accommodate both the vertical taper of the barrier and the 15:1 flare of the PCB segments. In addition, the additional steel bars for the loop connections

**Anticipated work next quarter**:

In the upcoming quarter, CAD details for full-scale crash testing will be developed and put into the testing que for scheduling. The actual date for the full-scale crash testing will be determined once the test facility personnel have reviewed the details and ordered materials.

**Significant Results:**

Attachments between the TCB segments and the MGS guardrail were developed and approved buy the sponsor.

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

None.

**Potential Implementation:**

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

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

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* | **Transportation Pooled Fund Program - Report Period:** |
|---|---|
| TPF-5(193) Suppl # 77 | ☐Quarter 1 (January 1 – March 31)<br>☐Quarter 2 (April 1 – June 30)<br>☑Quarter 3 (July 1 – September 30)<br>☐Quarter 4 (October 4 – December 31) |

| **Project Title:** | | |
|---|---|---|
| Phase IIA Vehicle Dynamics Testing, Validation of Vehicle Models & Computer Simulation of Rock Ditch Liners | | |
| **Name of Project Manager(s):**<br>Reid, Bielenberg, Faller, and Lechtenberg | **Phone Number:**<br>(402) 472-3084 | **E-Mail**<br>jreid@unl.edu |
| **Lead Agency Project ID:**<br>2611130089001 | **Other Project ID (i.e., contract #):** | **Project Start Date:**<br>6/30/2014 |
| **Original Project End Date:**<br>6/30/2017 | **Current Project End Date:**<br>6/30/2017 | **Number of Extensions:**<br>0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $110,000 | $0 | 0% |

***Quarterly*** Project Statistics:

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

**Project Description**:

The primary research objective for this study includes the continued development of safety guidelines for use in the design and placement of ditch liners and check dams along highways and roadways. During the Phase I effort and as part of the initial research funding, preliminary safety guidelines were proposed along with a preparation of a research plan for use in their future evaluation. At this time, the Wisconsin Department of Transportation has deemed the preliminary guidelines viable and has requested that continued research be performed to further evaluate and modify the guidelines using computer simulation and full-scale vehicle crash testing.

Due to the significant scope of this ongoing research program, the study has been split into multiple phases. The objective for each specific phase is listed below:

Phase I - Develop preliminary guidelines for the safe construction of rock ditch liners and rock check dams – (Completed 2011)

Phase II - Conduct LS-DYNA computer simulation to develop critical crash testing matrix for evaluating vehicular impacts into rock ditch liners and rock ditch checks.

This current project is a subset of Phase II. This subset is limited to simulation of a 1100c vehicle over a 1:1 slope ground rock ditch liner and one full-scale crash test of such.

Phase III - Perform a series of full-scale crash tests on rock ditch liners and check dams placed in a traversable ditch.

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

Work on this project has not begun.

**Anticipated work next quarter**:

An initial investigation on how to model a 1:1 sloped ground rock ditch liner will be performed. This will include simulation with the Toyota Yaris 1100c model.

**Significant Results:**

None to date.

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

None

**Potential Implementation:**

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): Wisconsin DOT

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl # 78 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Transition from Free-Standing TCB to Reduced Deflection TCB | | |
| **Name of Project Manager(s):** Bielenberg, Faller, and Reid | **Phone Number:** (402) 472-9064 | **E-Mail** rbielenberg2@unl.edu |
| **Lead Agency Project ID:** 2611130090001 | **Other Project ID (i.e., contract #):** | **Project Start Date:** 6/30/2014 |
| **Original Project End Date:** 6/30/2017 | **Current Project End Date:** 6/30/2017 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| Total Project Budget | Total Cost to Date for Project | Percentage of Work Completed to Date |
|---|---|---|
| $95,852 | $0 | 0% |

***Quarterly*** Project Statistics:

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

**Project Description**:

Recently, the Wisconsin Department of Transportation sponsored a research project to develop a retrofit design for reducing deflections for temporary concrete barriers (TCB) without anchoring the barriers to the bridge deck or roadway. This research was successful in reducing the deflection of the TCB system, as the addition of steel tubes to both the front and back sides of the barrier reduced the deflection of the TCB system by roughly 50 percent. However, the effort was focused on developing the length-of-need of the system and did not include design of a transition between the reduced deflection TCB system and standard F-shape TCB segments. Thus, a need exists to develop a transition between the new reduced deflection system and free-standing TCB segments.

The objective of this research effort is to develop a MASH TL-3 transition between the recently developed reduced deflection TCB system and free-standing, F-shape TCB segments. The research effort will focus on development of a design that safely transitions between the stiffness and deflection of the two barrier systems while maintaining vehicle stability. The design will also focus on minimizing the length of the transition and additional hardware components. Phase I of this project will involve initial development and computer simulation of the transition design (work described herein). Phase II of the project (currently unfunded) will include full-scale crash testing to evaluate the transition.

Main Objectives/Tasks

1. Literature Review
2. Concept Development
3. Selection of Transition Design
4. LS-DYNA Analysis and Evaluation
5. Project Report

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

Work on this project has not begun.

**Anticipated work next quarter:**

The literature review on previous TCB transition will begin

**Significant Results:**

None to date.

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

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

None

**Potential Implementation:**

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

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

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

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $125,906 | $0 | 2% |

***Quarterly*** Project Statistics:

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

**Project Description:**

Although most approach guardrail transitions (AGTs) look similar, each AGT has a unique combination of features including rail thickness, post size and spacing, use of a hydraulic curb, and downstream parapet or bridge rail in which it attaches to. However, due to the sensitivity of transition regions, these variables are not interchangeable between AGTs. Thus, each AGT is specific to its own features as well as the bridge railing or parapet to which it is anchored.

Crash testing has illustrated the sensitive nature of these AGT designs with recent failures occurring due to an alteration of an AGT feature (e.g., addition/removal of a curb or changes to the rigid parapet geometry and attachment hardware). The majority of these failures have been the result of excessive vehicle contact on the lower, upstream corner of the rigid parapet. This result indicates that the parapet toe and end geometry may be even more critical than previously believed. Thus, there exists a need to develop a standard concrete parapet end geometry for use with all thrie beam AGTs.

The objective of this research effort is to develop a standardized concrete parapet end section for attachment of various thrie beam AGTs.

Objectives / Tasks:

1. Literature Review
2. Parapet Design and Analysis
3. System CAD Details
4. System Construction
5. Full-scale Crash Test
6. System Removal
7. Data Analysis
8. Design Recommendations

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

Work has not yet begun on this project.

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $80,815 | $0 | 0% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| $0 (0%) | $0 | 0% |

**Project Description**:

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

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

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

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

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

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

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

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

None

**Anticipated work next quarter**:

Initial contact will be made with potential marketing companies to develop a project plan. The literature review will commence.

**Significant Results:**

None

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

None

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #83 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) |
|---|---|

| **Project Title:** Annual Consulting Services Support | | |
|---|---|---|
| **Name of Project Manager(s):** Ron Faller, John Reid, Bob Bielenberg | **Phone Number:** 402-472-9064 | **E-Mail** rbielenberg2@unl.edu |
| **Lead Agency Project ID:** 2611211115001 | **Other Project ID (i.e., contract #):** RPFP-15-CONSULT | **Project Start Date:** 8/1/2014 |
| **Original Project End Date:** 7/31/17 | **Current Project End Date:** 7/31/17 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $50,001.00 | $0.00 | 0% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $0.00 | |

**Project Description**:

This project allows MwRSF to be a valuable resource for answering questions with regard to roadside safety issues. MwRSF researchers and engineers are able to respond to issues and questions posed by the sponsors during the year. Major issues discussed with the States have been documented in our Quarterly Progress Reports and all questions and support are accessible on a MwRSF Pooled Fund Consulting web site.

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

This project just became active in the past quarter. Consulting inquiries over the last quarter were addressed using funds from project RPFP-14-CONSULT. Once the funds in RPFP-14-CONSULT are depleted, MwRSF will charge time and costs to this project.

**Anticipated work next quarter**:

MwRSF will continue to answer questions and provide support to the sponsors during the upcoming quarter.

We would ask that all questions be submitted through the web site so that they can be answered and archived therein.

http://mwrsf-qa.unl.edu/

**Significant Results:**

A quarterly summary of the consulting effort was provided and users can use the web site to search and find responses as well.

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

None.

**Potential Implementation:**

None.

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #80 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** MGS Guardrail with an Omitted Post | | |
| **Name of Project Manager(s):** Ron Faller, John Reid, Bob Bielenberg | **Phone Number:** 402-472-9064 | **E-Mail** rbielenberg2@unl.edu |
| **Lead Agency Project ID:** 2611211112001 | **Other Project ID (i.e., contract #):** RPFP-15-MGS-5 | **Project Start Date:** 8/1/2014 |
| **Original Project End Date:** 7/31/2017 | **Current Project End Date:** 7/31/2017 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $99,973.00 | $0.00 | 5% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| | $0.00 | |

**Project Description**:

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

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

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

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

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

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

CAD details for the tested system were completed and the details were sent to the MwRSF Outdoor Test Facility for placement in the test que.

**Anticipated work next quarter**:

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

**Significant Results:**

Selection of the CIP for the testing of the MGS with a single omitted post was completed and CAD details were completed and sent to test site.

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

None.

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

| **Transportation Pooled Fund Program Project #** *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* TPF-5(193) Suppl. #84 | **Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☑Quarter 3 (July 1 – September 30) ☐Quarter 4 (October 4 – December 31) | |
|---|---|---|
| **Project Title:** Pooled Fund Center for Highway Safety | | |
| **Name of Project Manager(s):** Reid, Faller, Lechtenberg, Bielenberg, Rosenb | **Phone Number:** 402-472-9070 | **E-Mail** kpolivka2@unl.edu |
| **Lead Agency Project ID:** 2611211116001 | **Other Project ID (i.e., contract #):** RPFP-15-PFCHS | **Project Start Date:** 8/1/2014 |
| **Original Project End Date:** 7/31/2017 | **Current Project End Date:** 7/31/2017 | **Number of Extensions:** 0 |

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $11,468 | $0 | 0% |

***Quarterly*** Project Statistics:

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

**Project Description**:

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

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

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

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

None.

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

**Anticipated work next quarter**:

None

**Significant Results:**

None.

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

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

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

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

Project schedule status:

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

Overall Project Statistics:

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

***Quarterly*** Project Statistics:

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

**Project Description**:

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

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

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

Tasks:

1. Prepare CAD details for Hardware Guide

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

None

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

**Anticipated work next quarter:**

None

**Significant Results:**

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

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

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

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

**Potential Implementation:**

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

# TRANSPORTATION POOLED FUND PROGRAM
# QUARTERLY PROGRESS REPORT

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

**INSTRUCTIONS:**

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

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

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

Project schedule status:

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

Overall Project Statistics:

| **Total Project Budget** | **Total Cost to Date for Project** | **Percentage of Work Completed to Date** |
|---|---|---|
| $990,000.00 | $570,388 | 58% |

***Quarterly*** Project Statistics:

| **Total Project Expenses and Percentage This Quarter** | **Total Amount of Funds Expended This Quarter** | **Total Percentage of Time Used to Date** |
|---|---|---|
| $106,433 (10.8%) | $106,433 | 58% |

**Project Description:**

Concrete barriers have gained widespread application along our nation's highways and roadways, primarily as median barriers and bridge railings. Most of these barriers are largely maintenance free and can provide the capacity to contain high-energy truck impacts at much lower construction costs than metal barriers. However, accident data has shown that impacts with these barriers cause more fatalities than observed with flexible guardrails. Vehicular impacts into rigid concrete barriers often impart high decelerations to vehicles and their occupants. Thus, there is a need for an energy-absorbing roadside/median barrier that lowers vehicle decelerations but still has the capacity to contain high-energy truck impacts without significant increases in cost. The objectives of the research are to identify the most promising highway application for SAFER Barrier technology and adapt the barrier system to this highway application. The adapted barrier design must provide optimized energy management for highway vehicles, consider construction costs in comparison to existing barrier technologies, be more damage resistant, and require no to limited routine maintenance and repair. The research will be accomplished through the following tasks.

1. Identify target applications.
2. Analyze energy management and deformation of current SAFER barrier during high-speed impacts to guide selection of new highway barrier.
3. Brainstorm and develop concepts for the design of the new barrier and energy absorbers.
4. Evaluate the best concepts and energy absorbers with finite element analysis and static, dynamic, and durability tests.
5. Develop and simulate a preferred final design concept.
6. Construct barrier prototypes for full-scale crash tests and refine finite element simulations & designs as needed:
a. MASH TL-3 with 2270P vehicle; b. MASH TL-3 with 1100C vehicle; c. MASH TL-3 with either 2270P or 1100C vehicle if re-design is necessary; d. MASH TL-4 with 10000S vehicle; & e. retests as needed.
7. Prepare final report to document the research, development, testing, and evaluation effort.

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

The barrier was assembled, and two full-scale crash tests were conducted. In the first crash test, test no. SFH-1, the 2270P pickup truck impacted the barrier at a speed of 63.4 mph and an angle of 24.8 degrees on July 2, 2014. The pickup truck was contained and redirected, and all MASH TL-3 safety performance criteria were adequate. Peak lateral accelerations were reduced up to 43%, lateral OIV was reduced up to 29%, and lateral ORD was reduced up to 28% as compared to similar impacts into rigid concrete parapets. The barrier restored almost completely. Gouging occurred to the front face of the concrete rail from wheel rim contact, and some minor concrete spalling occurred to the ends of two concrete beams near the impacted joint. However, the spalling damage was not believed to be structural in nature as the continuity across the joint appeared to remain intact.

The same system was impacted again in test no. SFH-2. An 1100C small car impacted the barrier at a speed of 64.3 mph and at an angle of 24.8 degrees on August 11, 2014. The small car was contained and redirected, and all MASH TL-3 safety performance criteria were adequate. Peak lateral accelerations were reduced up to 16%, lateral OIV was reduced up to 31%, and lateral ORD was reduced up to 9% as compared to similar impacts into rigid concrete parapets. The barrier restored almost completely. Gouging occurred to the front face of the concrete rail from wheel rim contact, and two of the rubber posts had small cuts from wheel rim contact. No structural damage occurred to the barrier.

Simulations of test nos. SFH-1 and SFH-2 had good correlation with the first two crash tests.

Overall, the first two crash tests showed enhanced performance of the new barrier as compared to rigid barriers, which were close to our reduced lateral acceleration goals. Based on the results of the first two crash tests, several minor improvements were suggested to improve the constructability of the barrier and to mitigate damage that occurred. However, the design team met and decided to proceed with the TL-4 SUT impact on the same barrier before considering

**Anticipated work next quarter**:

A full-scale crash test with the 10000S single-unit truck will be conducted according to TL-4 of MASH in late September. The results from all three crash tests will then be evaluated to determine if the barrier system provides: satisfactory safety performance according to the MASH TL-3/4 evaluation criteria; a desired reduction in lateral acceleration; and a permissible level of barrier damage. The results will be analyzed to determine what modifications and refinements are necessary, followed by any additional analysis, design, and LS-DYNA computer simulation if warranted. Crash tests with the 1100C, 2270P, or 10000S vehicles will be conducted as necessary to evaluate the barrier modifications/refinements. The first draft will be completed on the third and fourth reports. Design criteria for stiffness transition will be established and preliminary concepts will be developed.

**Significant Results:**

Report TRP-03-281-13 documenting phase 1 of this project was published July 16, 2013.
Report TRP-03-280-13 documenting phase 2 of this project was published February 6, 2014.
Test no. SFH-1 was conducted on July 2, 2014.
Test no. SFH-2 was conducted on August 11, 2014.

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

Throughout the project, several concerns regarding the use of rubber posts have arose and have been addressed. The barrier was redesigned multiple times in advance of the first crash test in order to obtain a more successful performance in a variety of environmental conditions, to optimize the concrete and steel rail, and to have greater confidence for a successful crash test result. Installation concerns were also addressed, which will allow the barrier to be installed in a larger range of conditions in the real world. Therefore, the start of the full-scale crash testing program was delayed. Now that the first two crash tests have been completed successfully, it is anticipated that the remaining crash test, re-design, and further evaluation can be completed by the current project end date.

**Potential Implementation:**

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

# Midwest States Pooled Fund Program Consulting Quarterly Summary

## Midwest Roadside Safety Facility

**06-16-2014 to 09-15-2014**

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## Nebraska Tubular Thrie Beam Bridge rail

### Question

State: NE
Date: 06-18-2014

NDOR previously received guidance regarding the Nebraska Tubular Thrie beam bridge rail. Can you resubmit that inofrmation.

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### Response

Date: 06-18-2014

I found the original report from 1987. I have attached 2 pages for design details from the report. In addition, I have attached a sampling of prior correspondence on this matter. Ralph Hansen of Speece-Lewis has updated this railing over the last 5 years or so. I do not have a copy of their final version.

Attachment: http://mwrsf-qa.unl.edu/attachments/82195c3027d14bdfb956cfff4e4ee8bd.zip

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## Wire strand reinforcement

### Question

Date: 06-26-2014

color:#002060">I request your opinion on the attached Colorado DOT standard detail.

color:#002060"> Question: Have you folks crash tested R.C. barrier using wire strand

color:#002060"> (see note 8 sheet 1of4).

Attachment: http://mwrsf-qa.unl.edu/attachments/c5c946e3551d96b6cf6026beef166b4f.pdf

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**Response**
Date: 06-27-2014

We have never tested barriers using wire strand as the reinforcing steel but we believe it may be feasible. The closest thing we have seen to this is pre-stressing strands used in reinforced concrete design. in this case they are only used as reinforcement.

The strength of the specified strand appears to be equal or greater than the Grade 60 rebar, so that should not be an issue. We cannot see any direct reasons why it would not work, but we can note some potential differences between rebar and the wire strand.

1. Development length may differ for the wire strand as compared to rebar and thus may change the interaction or bond to the concrete somewhat. It is difficult to say how different that would be, but it may affect the performance of the reinforcement to some level. You would need to consider this when splicing the strands or other areas where development of the reinforcement was critical.

2. The modulus or elastic stiffness of the wire strand will be considerably less than that of the rebar due to the construction of the strand. Thus, while the strength of the rebar and strand are similar, the stiffness of the wire strand would be less. As the reinforcement severs mainly as a tension member, this may not affect ultimate capacity, but may change the flexural and longitudinal stiffness for the reinforced concrete section.

3. The difference in the modulus of the rebar and the strand may lead to increased cracking under flexural loading and temperature shifts.

Let me know if we can help you further.

# Questions about the MGS Trailing End Terminal

## Question

State: WY
Date: 07-03-2014

We have a couple of questions regarding the MGS Trailing End Terminal as reported in TRP-03-279-13:

1. On pages 155 and 167, a single span rail (6'-3"), part a3 is incorporated into the design. Why? Is this necessary for the terminal to work properly?

2. On sheet 165, the cable anchor is shown to have an overall length of 80 inches. The old metric standard barrier guide calls out 2000 mm (78 ¾"). The old, old guide calls out 78 inches. Obviously some rounding was applied when it was made metric. This cable is not shown in the current on-line guide. Should this figure on page 165 really show 78 inches since it references a part number from the standard barrier guide, or does it require a special cable?

Attachment: http://mwrsf-qa.unl.edu/attachments/acfd0277a8b5f1aabf775d543f735c01.docx

## Response

Date: 07-10-2014
The single 6'-3" rail segment was used for testing purposes to set the overall system length at 175'. For real world installations, this system length is not required and would not necessitate the extra rail segment. It is important to maintain the splice locations at the mid-span between the posts to maintain the benefits of the MGS system.

With respect to the anchor cable length, we believe that either length is acceptable. The hardware guide specifies the 78.75" long anchor cable. We have used that length in these types of end anchorage for many tests. In more recent years, our guardrail part supplier has begun supplying the 80" long version, so we have been testing with that.

One related item to note deals with the location of the cable bracket on the guardrail. According to the hardware guide, the cable bracket should be located such that the first bolt for the bracket is 1250 mm or 49.25" from the center of post no. 1. The downstream anchor report you mentioned above shows this distance as 47.625". Going back through our records, it appears that this anchor bracket has varied slightly in location over time. However, we would recommend that the 49.25" location be used in order to be consistent with the hardware guide and to minimize the angle of the cable as it approaches post no. 1.

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## What Degree of Slope of a Concrete Barrier Would Require Head Ejection Considerations

### Question

State: WY
Date: 07-03-2014

Our Bridge Program designed a 42 inch high single slope concrete barrier
to protect some bridge columns underneath the interstate. The design speed of this roadway is only 30
mph. The slope of the barrier face is 5.8 degrees. The barrier the pooled fund tested with head ejection criteria is about 3 degrees. Do
we need to consider head ejection for a barrier with a slope of 5.8 degrees
(and also considering the speeds are relatively low). As a follow-up question, do you have an idea
of what barrier slope face would dictate head ejection criteria for a high
speed roadway?

Attachment: http://mwrsf-qa.unl.edu/attachments/429a701a42dffc8abeba0af7a21d840d.docx

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### Response

Date: 07-07-2014

Although we have not studied head ejection for impact speeds below TL-3 conditions, I don't believe that an occupants head would extend very far out the side window on a 30 mph roadway. Thus, the risk of head slap is greatly reduced, and I do not think you need to incorporate head ejection into your design for such a low speed roadway.

The head ejection envelope was developed for vertical (or near vertical) barrier geometries. Although single slope barriers show increased vehicle stability during impacts over safety shaped barriers, existing single slope barriers (9.1 and 10.8 degrees from vertical) do cause some vehicle climb. However, head ejection is still present with single slope barriers. In fact, a few impacts with single slope barriers were utilized in the initial development of the ejection envelope. We do not have a set slope angle in which the envelope should be applied as this has never been studied. Though, the answer would probably be more of a sliding scale reduction factor that increased with an increase in slope. Unfortunately, we just don't know this answer at this time. So, on the side of safety and being conservative, you could apply the head ejection envelope as it currently stands to any single slope barrier (MwRSF recommended method). Or, you can choose to use engineering judgment and take a more aggressive approach.

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# Ballasting Questions for the FHWA/DOT Midwest Work Zone Roundtable

## Question

State: MO
Date: 07-16-2014

**From:** Nick.Artimovich@dot.gov
[mailto:Nick.Artimovich@dot.gov]

**Sent:** Monday, July 21, 2014 12:25 PM

**To:** Daniel.Smith@modot.mo.gov

**Cc:** Ken.Wood@dot.gov; marc.thornsberry@dot.gov; Julie.Stotlemeyer@modot.mo.gov; Rob.Frese@modot.mo.gov; James.Connell@modot.mo.gov

**Subject:** RE: Ballasting Questions for the FHWA/DOT Midwest Work Zone Roundtable

Mr. Smith,

Thank you for your inquiry. I will defer to the researchers at Midwest Roadside Safety Facility on this question. They have conducted numerous tests on portable sign stands and would be a better source for information. If their extensive crash testing experience leads them to the opinion that your requested options would not seriously compromise the crash-worthiness of these devices under NCHRP Report 350 then I would concur with their assessment.

While I have reviewed numerous crash test reports of portable sign stands I have not kept a record of which used ballast, nor the performance of the ballast upon impact.

You may find contact information for the MWRSF on our website listing all accredited laboratories: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/laboratories/

Regards,

Nicholas A. Artimovich, II

Highway Engineer, Safety Design Team

Office of Safety Technologies, Rm E71-322

Federal Highway Administration

U.S. Department of Transportation

1200 New Jersey Avenue, SE

Washington, DC 20590

Phone 202-366-1331

Email nick.artimovich@dot.gov

WebSite http://safety.fhwa.dot.gov

**From:** Dan Smith [mailto:Daniel.Smith@modot.mo.gov]

**Sent:** Wednesday, July 16, 2014 1:39 PM

**To:** Artimovich, Nick (FHWA)

**Cc:** Wood, Ken (FHWA); Thornsberry, Marc; Julie Stotlemeyer; Rob Frese; JAMES D CONNELL

**Subject:** Ballasting Questions for the FHWA/DOT Midwest Work Zone Roundtable

Mr. Artimovich: MoDOT has been working on several ballasting ideas as possible alternatives to sandbags. In May, I presented the ballasting ideas to the FHWA/DOT Midwest Work Zone Roundtable and they were interested in the different ballasts and field applications. As a consensus, the roundtable would like your our opinion if they would be acceptable alternatives or would need crash testing. The description and examples are located in the attached word document.

If you have any questions please let me know. Thank you for your time.

Daniel J. Smith, P.E.

Traffic Management and Operations Engineer

MoDOT – Traffic Division

830 MoDOT Drive P.O. Box 270

Jefferson City, MO 65102

Office: (573) 526-4329

Daniel.Smith@modot.mo.gov

Attachment: http://mwrsf-qa.unl.edu/attachments/9a5f56ae9008b3a02bf46dce864c6891.docx

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**Response**
Date: 07-31-2014

We have briefly reviewed the material contained in the recent inquiry. In general, if the ballast is not positioned higher than the originally configured sandbags/ballast and does not provide a potentially hazardous condition (based on size, material selection, attachment to base/legs, etc.), then alternative ballast options would likely allow the work-zone device to perform similarly and in a safe manner. If sand ballast bags or sacks are fabricated using a stronger material and protrude farther above the base and legs than original tested and evaluated, then I could envision a condition where small car vehicles encountered increased instabilities after traversing across the system.

http://mwrsf-qa.unl.edu/view.php?id=641

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# MGS Omitted Post Questions

## Question

Date: 07-18-2014

I have several questions regarding the MGS when posts are skipped or omitted.

1. When using the MGS and a post is needed to be skipped due to an underground feature that is in conflict, what happens if just one or two post need to be skipped? Can you place less than the 3 CRT post? If we skip one post can we place just 1 CRT post? If we skip 2 post can we place just 2 CRT post? If we skip 3 post then we need to place all 3 CRT post?

2. If you are on a one way roadway or a wide roadway so that you are not concerned about apposing traffic, do we need to place CRT post on the near side of the missing post or just on the far side (downstream)? Is the number of nearside CRT post the same as the downstream need?

3. Does the steepness of the slope behind the guardrail matter? (Max 3:1 or 2:1 or 1.5:1 or ? or vertical culvert headwall???)

4. If you are skipping a post due to an underground conflict, but there is another fixed object behind the guardrail just downstream, say 12' downstream, but just 5' behind the face of the rail. Should we increase our CRZ behind the rail for some distance downstream and further from the guardrail from where the post needs to be skipped?

5. If you are missing 3 post I understand that the guardrail should remain inline before any flaring of terminals or redirection of the guardrail for an additional 62' but if you are just skipping 1 or 2 post can this be reduced to 50' or 38' or 25' or ???

6. If you have to skip a post or two and then 50' latter need to do this again is there concern or limitation to how often this can repeat?

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## Response

Date: 07-21-2014

I have some feedback for you regarding the MGS with omitted post questions you gave me at the meeting.

1. When using the MGS and a post is needed to be skipped due to an underground feature that is in conflict, what happens if just one or two post need to be skipped? Can you place less than the 3 CRT post? If we skip one post can we place just 1 CRT post? If we skip 2 post can we place just 2 CRT post? If we skip 3 post then we need to place all 3 CRT post?

The MGS Long-Span system was developed for use to span transverse culverts measuring 24 ft wide or less. In this circumstance, three posts would be removed from the system. This system also utilizes three CRT posts on each side of the culvert structure. For culverts measuring less than 24 ft wide and where one or two posts are omitted, it still would be necessary to utilize the CRTs on each side of the unsupported segment of rail.

Although it may be possible for the MGS to work with one post removed and without CRTs adjacent to the long span, it should be noted that crash testing has not been performed on this MGS system nor to verify that acceptable performance would result. As such and in the absence of test data, we recommend that the CRTs be installed in systems where one, two, or three posts are removed.

2. If you are on a one way roadway or a wide roadway so that you are not concerned about apposing traffic, do we need to place CRT post on the near side of the missing post or just on the far side (downstream)? Is the number of nearside CRT post the same as the downstream need?

Similar to the comment above, we believe that the CRT's are needed on both the upstream and downstream end without further analysis. The CRT's on the downstream side are more critical in terms of rail pocketing and snag, but review of the barrier performance in testing found that the CRT's on the upstream end often fracture as well, which may make the barrier system more forgiving and reduce rail loads and pocketing angles. Thus, we cannot recommend removing the upstream CRT's without further analysis and/or testing.

3. Does the steepness of the slope behind the guardrail matter? (Max 3:1 or 2:1 or 1.5:1 or ? or vertical culvert headwall???)

We recommend providing 2 ft of level, or mostly level, soil grading behind the wood CRT posts. However, we understand that this can be difficult. As such, there is potential that the wood CRT posts could be lengthened to account for the reduction in soil resistance resulting from an increased soil grade behind these six posts, especially when placed at the slope break point of a 2:1 fill slope.

Recently, MwRSF performed limited research to determine an acceptable MGS post length for a 6-in. x 8-in. solid wood post installed at the slope break point of a 2:1 fill slope. MwRSF

determined that 7.5-ft long wood posts are an acceptable alternative when considering the 31-in. tall MGS placed at the slope break point of a 2:1 fill slope using 6-ft 3-in. post spacing.

The MGS Long Span system utilizes six CRT wood posts. A CRT post's moment capacity about its strong axis of bending is approximately 81 percent of that provided by the standard wood post. In the absence of dynamic component test results, it is believed that the six CRT wood posts could also be fabricated with the 7.5-ft length when used in the MGS Long Span system. If the steep fill slopes continue beyond the location of the CRT posts, then the guardrail would transition to the MGS for 2:1 Fill Slopes using either 6-in. x 8-in. by 7.5-ft long wood posts or W6x9 by 9-ft long steel posts.

For general installations at slope breakpoints or offsets less than 2' from the slope breakpoint of 2:1 to 6:1 slopes, we would recommend using the 7.5' long CRT posts. For slopes steeper than 2:1, we have little test data or analysis to guide us. Thus, we would recommend maintaining the 2' minimum offset in those locations.

4. If you are skipping a post due to an underground conflict, but there is another fixed object behind the guardrail just downstream, say 12' downstream, but just 5' behind the face of the rail. Should we increase our CRZ behind the rail for some distance downstream and further from the guardrail from where the post needs to be skipped?

In locations where posts are left out, dynamic barrier deflections and working widths would be expected to increase. Test results are available for the case with three posts removed from the MGS. However, data is not available for cases with one or two posts removed. BARRIER VII computer simulations could be performed to estimate barrier deflections and working widths. A small modeling study would be necessary to validate the model for the MGS long-span system and then predict barrier performance with fewer posts removed.

That said, attempting to account for the expected increase in deflection would be a step in the right direction. Full-scale crash testing of the MGS Long Span had dynamic deflections of 92.25". Based on this level of increased deflection over the 60" you note above, the a reasonable approach may be to assume a 12" increase in dynamic deflection for every omitted post. For example, one omitted post = 72" and two omitted posts = 84". However, this guidance is only based on rough approximations on a limited number of tests and it would be better to derive more accurate values through modeling as noted above.

We currently have a project to investigate the omission of a single post from the MGS without the use of the CRT's through full-scale crash testing that may provide further information.

5. If you are missing 3 post I understand that the guardrail should remain inline before any flaring of terminals or redirection of the guardrail for an additional 62' but if you are just skipping 1 or 2 post can this be reduced to 50' or 38' or 25' or ???

The MGS Long-Span Guardrail System was successfully crash tested and evaluated according to the Test Level 3 (TL-3) safety performance criteria found in MASH. For this testing program, the overall system length was 175 ft, including 75 ft of tangent rail upstream from the long span, a 25-ft long unsupported length, and 75 ft of tangent rail downstream from the long span. As part of the final recommendations, MwRSF had noted to provide a minimum "tangent" guardrail length adjacent to the unsupported length of 62.5 ft.

In lieu of a recent MASH crash testing program on a 75-ft long version of the MGS (unpublished at this time), there may reason to consider potentially reducing the 75-ft total guardrail length on the upstream and downstream ends of MGS Long-Span Guardrail System. For example and based on the MASH 2270P test into the MGS Minimum Length System, we believe that the MGS Long-Span Guardrail System would likely have performed in an acceptable manner with 62.5 ft of rail on the upstream and downstream ends, thus resulting in an overall system length of 150 ft. A 62.5-ft long tangent length adjacent to the unsupported length would still provide adequate space to incorporate a 37.5 ft or 50 ft long energy-absorbing guardrail end terminal.

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

likely obtain approval from the manufacturers as to whether they would allow three CRTs to be used within the last 12.5 ft of a 50-ft long guardrail terminal.

If one were to follow the logic used above and consider the situation of no missing posts (i.e., 6.25 ft post spacing throughout), the upstream and downstream ends would be reduced by 6.25 ft each and include the interior 6.25 ft long span in the middle of the system. As a result, the overall system length would be 43.25 ft + 6.25 ft + 43.25 ft for a total of 92.75 ft. As noted above, MwRSF recently crash tested a 75-ft long version of the MGS with satisfactory results, effectively configured with two 37.5-ft long guardrail segments with tensile anchorage devices and placed end-to-end.

Of course, it should be noted that the design modifications for the 25 ft, 18.75 ft, and 12.5 ft long unsupported lengths were based on engineering judgment combined with the unpublished results from the MGS Minimum Length System crash testing program. In addition, the opinions noted above are based on the assumption that the currently-available proprietary guardrail end terminals would provide comparable tensile anchorage for the MGS as provided by the common tensile anchorage system using in the MwRSF crash testing program (i.e., two steel foundation tubes, one channel strut, one cable anchor with bearing plate, and BCT posts at positions 1 and 2 on each end). Although we are confident that the modifications noted above would provide acceptable performance, the only sure means to fully determine the safety performance of a barrier system is through the use of full-scale vehicle crash testing. We are hopeful that these design modifications can be evaluated in the near future and as part of a continued R&D Pooled Fund program involving the MGS Long-Span Guardrail System.

6. If you have to skip a post or two and then 50' latter need to do this again is there concern or limitation to how often this can repeat?

This question has not been answered to date. There are concerns about how close these post omissions can occur. We currently have a project to investigate the omission of a single post from the MGS without the use of the CRT's that may shed some light on this issue. We plan to test the MGS with the omitted post with the 2270P vehicle. Based on the outcome of that test we plan to give guidance on what the minimum allowable offset between omitted posts should be.

# South Dakota Road Closure Gate

## Question

State: KS
Date: 07-25-2014

We would like your comments on the use of a double-sided road closure gate based on the single arm gate that was tested for South Dakota.

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## Response

Date: 07-25-2014

The South Dakota Road Closure Gate does not pose any significant hazard for vehicles impacting the gate in a stowed position. The crash tests were conducted on the road closure gate oriented in a stowed position as opposed to a closed position, since it was believed that it would result in the most severe impact. In addition, SDDOT reasoned that vehicle impacts into road closure gates in the closed position rather than the stowed position would not be as likely to occur due to the significant increase in delineation and subsequent lower driving speeds. Head-on tests were conducted since the vehicle would be required to break both the gate support post and the hold back post. The impact location, consisting of the centerline of the hinged connection, was selected because the post and gate weights were approximately equal.

We have some basic comments on the use of the double-sided gate.

1. Switching to a double-sided gate would not affect the performance of the gate in the open position. This would basically be the same as the single-sided gate that was tested.

2. When the double-sided gate was in the closed position, there are some concerns. If the closed gate has too strong of a connection, there is concerns that impacts on the gate in the closed position may not cause the support posts and hinges to breakaway easily enough and may post a risk to vehicle occupants. The concerns would include occupant impact velocity and ridedown acceleration increases and the potential to cause vehicle instability. Thus, any closure of a double-sided gate would have to release under very low loads. With a breakaway or weak connection at the connection between the gate arms, the potential for impact safety issues may exist, but the potential is much less.

3. Gate closure capacity would need to be very small to reduce concerns for impact with the double-sided gate. Ultimate capacities of the closure between 1-2 kips or less would be recommended. This is roughly equal to the capacity of two 1/8" dia. A307 bolts or a single ¼" dia. A307 bolt.

Let me know if you need further information.

# Vehicle Impact Protection

## Question

State: OH
Date: 07-28-2014

Putting this as simply as possible, do we think a 32" Jersey Barrier can accomplish the intended goal below?

**Maria E. Ruppe, P.E.**

Roadway Standards Engineer

Ohio Department of
Transportation

Mail Stop 1230

1980 W. Broad St.

Columbus, OH 43223

614.466.2847

**From:** French, Lynn

**Sent:** Monday, July 28, 2014 10:38 AM

**To:** Stargell, Reynaldo

**Subject:** FW: Vehicle Impact Protection

Hi Reynaldo…

I was referred to you by David
Powers to assist with this question.

Thanks,

Lynn

The Ohio Fire Code (OFC) requires all aboveground flammable and combustible liquid tanks to be protected from vehicles using barriers meeting the following code requirement:

**Section**
**312 Vehicle impact protection**

(1)
**312.1 General.** Vehicle impact protection required by this code shall be provided by posts that comply with *paragraph* (L)(2)(312.2) *of this rule* or by other approved physical barriers that comply with *paragraph* (L)(3)(312.3) *of this rule*.

(2) **312.2**
**Posts.** Guard posts shall comply with all of the following requirements:

(a) Constructed of steel not less than 4 inches (102 mm) in diameter and concrete filled.

(b) Spaced not more than 4 feet (1219 mm) between posts on center.

(c)
Set not less than 3 feet (914 mm) deep in a concrete footing of not less than a 15-inch (381 mm) diameter.

(d) Set with the top of the posts not less than 3 feet (914 mm) above ground.

(e) Located not less than 3 feet (914 mm) from the protected object.

(3)
**312.3 Other barriers.** Physical barriers shall be a minimum of 36 inches (914 mm) in height and shall resist a force of 12,000 pounds (53 375 N) applied 36 inches (914 mm) above the adjacent ground surface.

I have quickly looked thru your Roadside Safety Field Guide
and would appreciate if you could help with a variance request we received.

The request is to allow the barriers (jersey barriers
proposed) to be 32" in height in lieu of the required OFC height of 36".

Any input to these proposed type barriers being equivalent
to the required 36" (3 feet) posts or other barriers would be greatly
appreciated.

Thanks for your input

**Response**
Date: 07-28-2014

The spec below is specific in terms of height, but not very specific in any other way when regarding the specification for other barrier types. The height is limited to a minimum of 36". Without further knowledge of the intent of the specification, I don't believe that we could justify going any lower.

In terms of the forces, the spec lists a set load at a height of 36" that the barrier must resist. However it is unclear if the barrier is allowed to deflect or not. Free-standing 32" tall barriers would deflect significantly under that type of load at the top of the barrier and would not be a good fit for this application. Permanent parapets would not deflect appreciably depending on the design, as most of the TL-3 or TL-4 parapet design have withstood crash test impact loads of over 60 kips.

Thus, in short, a permanent 36" tall or taller NJ shape, single-slope, or vertical barrier that we use for roadside safety with appropriate anchorage and footing would likely withstand that loading. Vertical barriers would likely be more appropriate for the application as they would produce less vehicle climb and extension and are more typically used in this type of protection scheme.

I am not sure if that answers you question. Let me know if you need more information.

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## Epoxy Anchorages for F-shape Barrier Tie-Down

**Question**
State: MN
Date: 07-30-2014

During our teleconference this
morning, we had a discussion regarding appropriate epoxy anchorage depths for the F-shape PCB tie-down system and related research on epoxy adhesive anchorages in Wisconsin. Can you review the information we discussed.

---

**Response**
Date: 07-30-2014

During our teleconference this morning, we had a discussion regarding appropriate epoxy anchorage depths for the F-shape PCB tie-down system and related research on epoxy adhesive anchorages in Wisconsin.

First, the barrier system we are discussing was a redesigned F-shape PCB that incorporated a three-loop connection that provided double shear at two locations on each pin. The bolt-through, tie-down system consisted of three 1⅛-in. diameter, ASTM A307 anchor bolts with heavy hex nuts and 3-in. x 3-in. x ½-in. thick washers spaced evenly across the traffic side of each PCB segment. Each anchor bolt was epoxied into the concrete with an embedment depth of 12 in. The test installation consisted of sixteen 12-ft 6-in.) long, redesigned F-shape PCB segments placed adjacent to a simulated bridge deck edge with a total system length of 204 ft. During test no. KTB-1, a 4,448-lb (2,018-kg) pickup trück impacted the system 5 ft – 5 in. upstream from the joint between barrier nos. 8 and 9 at a speed of 62.0 mph (99.8 km/h), and at an angle of 25.3 degrees. The system contained and redirected the vehicle with maximum lateral dynamic and permanent set deflections of 11.3 in. and 3½ in., respectively, and was considered successful according to TL-3 of NCHRP Report No. 350.

In the past, we have often been asked what embedment depth was required for the epoxy anchorage of the A307 rods used in that system. Adhesive anchorage capacity depends on many factors, including anchor size, anchor embedment, concrete strength, adhesive bond strength, spacing effects, edge effects, and other factors. Thus, we have typically recommended that the embedment for the anchor rods should be selected to develop the ultimate shear and tensile capacities of the anchorage. For the 1 1/8" dia. A307 rod, the ultimate shear and tensile capacities are 26.4 kips and 45.8 kips, respectively.

MwRSF has also done some recent work to investigate epoxy adhesive anchors for permanent concrete barriers. As part of that research, MwRSF conducted static and dynamic testing of threaded rod and rebar with shallow embedment and attempted to determine design procedures for the epoxy adhesive anchors. The full report can be downloaded at the following link.
http://mwrsf.unl.edu/researchhub/files/Report14/TRP-03-264-12.pdf

In that report, we tested the 1 1/8" dia. A307 rod used in the tie-down system in concrete with an f'c = 6,454 psi, an epoxy with a nominal bond strength of 1,800 psi (1,904 psi based on threaded anchor diameter effects in manufacturer literature). In this test, the rod developed 45.3 kips in

tension loading and over 40 kips in shear loading prior to anchor fracture. Based on these results, we made the following comments.

"The ultimate tension and shear capacities were calculated to be 45.9 kips (203.6 kN) and 26.4 kips (117.6 kN), respectively. The average ultimate tension and shear loads observed from the dynamic testing program of the 1 1/8 in. (29 mm) diameter A307 rods were 45.3 kips (201.5 kN) and 40.6 kips (180.8 kN), respectively. The failure mode in tension consisted of a pullout of the adhesive core accompanied by a 2 ¾ in. (70 mm) deep concrete cone breakout. The ultimate shear value obtained during the component test is an estimated minimum value because the anchor did not fail in the test and the load was governed by the equipment. Nonetheless, the ultimate shear capacity was determined to be far greater that the nominal shear capacity of the anchor and the ultimate tension capacity was within one percent of the nominal tension capacity for the concrete strength in the component tests. Therefore, the anchorage design with 5 ¼ in. (133 mm) embedment depth utilizing the Hilti HIT-RE 500-SD epoxy adhesive was considered an adequate alternative anchorage design for the 1 1/8 in. (29 mm) diameter A307 rods used in the tie-down temporary concrete barrier developed by MwRSF because the tested capacities met the nominal capacities of the anchorages used in the full-scale crash test. However, the failure in the tension test created significant concrete damage. This concrete damage would be expected to occur to the bridge decks of real-world installations during severe, high-energy impacts. In addition, the compressive strength of the concrete used in these component tests may be higher than the typical strength of concrete bridge decks. Thus, some decrease in the capacity of the anchors would be expected for lower strength concrete. This decrease in strength would likely be offset to some extent by the presence of reinforcing steel in the bridge deck. Thus, it is believed that using the A307 rod with Hilti HIT-RE 500 or Hilti HIT-RE 500 SD epoxy adhesive with a 5 ¼-in. embedment depth should provide similar anchorage to the tested system, but some increased deflection and increased deck damage may result. It should also be noted that epoxy adhesive manufacturer recommendations for torque requirements on threaded anchors should be closely followed for these types of anchors to prevent concerns for anchor creep and associated reductions in anchor capacity."

So while component level testing did indicate that the shallow embedment had the potential to meet the desired loads, it was noted that reduced concrete strengths would reduce the loads and that damage and release of the anchors could occur in high-energy impacts.

MnDOT has different embedment depths listed in their standards. The bridge standard suggests an embedment of 5.5" due to deck thickness concerns, while the roadside standards suggest 9" of embedment. In order to shed more light on the issue, I reviewed the anchor design procedures suggested in TRP-03-264-12. In this report, we calculated anchor capacities based on two methods:

1. A factored, as-tested procedure based on the ACI-11 code that applied dynamic increase factors for the steel and concrete, used as-tested values for the material strengths, and without strength reduction factors. This was used to compare the analytical procedure to tested values as closely as possible.

2. A design procedure based on the ACI-11 code that applied dynamic increase factors for the steel and concrete, used published values for the material strengths, and included standard strength reduction factors. These were more conservative and recommended for design values.

If the factored, as-tested procedure is used to estimate the anchor tensile capacity in the component test, the procedure returns a value of 43.6 kips. This corresponds very well to the test value of 45.3 kips and predicts the failure mode (concrete failure). Using the factored, as-tested procedure for concrete with strengths of 4,000 psi and 3,000 psi yields tensile loads of 34.3 kips and 29.7 kips respectively. Thus, reduction in concrete strength would be expected to reduce tensile capacity significantly. Shear capacities for all concrete strengths were acceptable.

If the design procedure is used to estimate the anchor tensile capacity in the component test, the procedure returns a value of 27.3 kips and predicts the concrete failure mode. Using the design procedure for concrete with strengths of 4,000 psi and 3,000 psi yields tensile loads of 22.3 kips and 19.3 kips respectively. Shear capacities for all concrete strengths were acceptable. Thus, the design procedure provides more conservative estimates on anchor capacity.

We typically design our hardware and anchor systems near the edge of the ultimate capacities without reduction factors or factors of safety. However, we generally test those systems to verify their capacity. Thus, the method of estimating anchor loads may be dependent on what level of conservativeness the DOT wants to have in their spec.

It should be noted that higher bond strengths won't improve performance as the failure are concrete controlled. In addition, cracked concrete may be very difficult to design a reasonable anchorage for. Published values for bond strength tend to decrease over 50% for cracked concrete. That does not include reductions in strength for the concrete. Thus, it is difficult to recommend anchoring in cracked concrete. The numbers above also consider only individual shear and tensile loads and not combined loading. Estimation of the effect of combined loads on anchor performance is difficult. Thus, the best avenue for addressing this issue may be full-scale testing of the tie-down system with shallow anchor embedment to evaluate its performance.

I also analyzed the 9" embedment listed in the roadside spec. For 3,000 psi to 6,000 psi concrete, 9" embedment is sufficient to generate the ultimate steel rod capacities using both the factored, as-tested procedure and the design procedure.

Please review this information and contact me the any questions and or comments.

Thanks

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# PL-1/TL-2 Bridge Railings w/ Sidewalk

## Question

State: MN
Date: 07-31-2014

We are looking for details for a 32" tall bridge railing that is installed on an 8" tall sidewalk. Do you know of any?

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## Response

Date: 07-31-2014

I have not yet found a 32" tall bridge railing that is installed on an 8" tall sidewalk. I have found a couple that utilized a 42" height.

TL-2 BR27C Bridge Railing w/ sidewalk – 42" above sidewalk

TL-2 BR27D Bridge Railing w/ sidewalk – 42" above sidewalk

The file 'FHWA-RD-93-058.pdf' (20.3 MB) is available for download at

< http://dropbox.unl.edu/uploads/20140814/258b3211a4258bec/FHWA-RD-93-058.pdf>

for the next 14 days.

It will be removed after Thursday, August 14, 2014.

The file 'FHWA-RD-93-065-1.pdf' (19.6 MB) is available for download at

< http://dropbox.unl.edu/uploads/20140814/a142a3dd65c8a61d/FHWA-RD-93-065-1.pdf>

for the next 14 days.

It will be removed after Thursday, August 14, 2014.

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**Response**
Date: 08-12-2014

Any luck in finding a 32" tall vertical face parapet mounted on an 8" sidewalk that meets TL-2? We've verified that our parapet meets the structural requirements to resist TL-2 loads, but still need confirmation that the geometry meets crash test requirements (32" vertical face parapet mounted on an 8" sidewalk). We've been using this standard for a number years and need to decide if we should discontinue its use, and if retrofitting of past installations is necessary.

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**Response**
Date: 08-13-2014

I had only found the 42" tall railing systems with advance sidewalk. I have emailed Dean Alberson at TTI to inquire whether they have tested shorter variations at 32" with sidewalk.

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## STH 78; additional guardrail over culvert question 5590-03-30

**Question**
State: WI
Date: 08-12-2014

Please review the text and
drawing and let me know if the proposed installation is acceptable.

Here is additional information
with a section view.

Notice due to the elevation of the roadway with respect to the elevation
of the existing headwall a reinforced concrete section will be added to the
existing headwall in order to meet the 10:1 requirement for grading at the
guardrail. We did a structural analysis to know that what we have shown
will work structurally to retain the earth that needs to be against it for
grading. This will also allow us to extend the wings vertically to
better grade behind the posts and in which case the posts could be moved closer
to the edges of the box, if that will address some of the beam guard deflection
concerns. If we meet the 15' horizontal roadway clearance requirement,
we still are not meeting typical criteria for placement of the headwall
behind the guardrail post installation. For the installation to meet
current long span system guardrail installation requirements using the CRT
posts the horizontal clearance would only be 14'3" instead of 15'.
Horizontal clearance is a controlling criteria. We are asking
for an exception to the typical beam guard installation criteria to allow the
back of the post to be placed in the same plane as the headwall.
Attachment: http://mwrsf-qa.unl.edu/attachments/b7e55a5cc24348efaf42903a5bc0b6fd.pdf

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**Response**
Date: 08-13-2014

We have concerns that changing the offset of the posts relative to the headwall from the tested system may increase vehicle extent over the culvert and potential wheel snag on the culvert. In the detail shown, the culvert wingwalls appear to be perpendicular to the headwall, which would further increase the snag concerns.

Thus, we would not recommend the offset shown.

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# CALTRANS Bridge Rail

## Question

State: MN
Date: 08-13-2014

**From:** Ronald K. Faller [mailto:rfaller1@unl.edu]

**Sent:** Wednesday, August 13, 2014 1:10 PM

**To:** Jewell, John R@DOT; Whitesel, David A@DOT

**Cc:** rfaller1@unl.edu

**Subject:** Bridge Rail

John and David:

I received an inquiry from one of our Pooled Fund Member States (MnDOT) regarding a CALTRANS bridge railing, specifically B11-54. This concrete parapet utilizes an 8-in. curb/sidewalk in advance of the 27-in. tall vertical RC parapet. A tubular hand-railing is attached to the top of the parapet. What is the height to top of hand-railing? Does the hand-railing contribute to vehicle redirection in the PL-1 or TL-2 tests? Can I get a copy of the test report as well. Thanks!

---

## Response

Date: 08-26-2014

Ron,

Here is the detail for the handrail. The bridge rail you are referring to is the Type 26 and it was never crash tested. I believe it was grandfathered in as a TL-2 bridge rail a long time ago but I can't say exactly how that happened. John Jewell may have more information. That said, we have an ongoing project to test a (hopefully) TL-2 MASH-compliant version of that bridge rail, called the 732SW. All the crash testing is complete on that project and I am currently finishing up the final report. To qualify this bridge rail at TL-2, we conducted the pickup test at MASH TL-3. In that test, it appears the handrail may contribute slightly to vehicle direction and rollover

stability as the dynamic deflection of the handrail was approximately an inch. As a side note, we also conducted a TL-3 small car test but had it fail due to high ridedown acceleration when the impact point was the sidewalk edge. Essentially the sidewalk impact caused just enough flail space to be taken up such that the occupant impact occurred near the beginning of the impact with the barrier face, thus resulting in higher than expected ridedown accelerations. It was an interesting phenomenon. Because of this, FHWA concurred that we could use a TL-2 small car test to qualify the bridge rail at TL-2 so we also performed that test. If you would like, I can send you a copy of the report when it is complete, which should be in the next month or two depending on how much time I can devote to it. Please let me know if you would like any more information.

David Whitesel, P.E.

Roadside Safety Research Group

Office of Safety Innovation and Cooperative Research

Division of Research, Innovation and System Information

California Department of Transportation

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# Cable Median Barrier Statistics

## Question

State: KS
Date: 08-26-2014

Kansas was interested in
some information on cable median barrier statistics for crashes (i.e. % pass thrus, number of fatalitites, etc.). I seem to recall an update for ongoing research from this year or last year where some Missouri information crash data was used. The only report I'm aware of that's been completed is TRP-03-275-12 "Cable Median Barrier Failure Analysis and Prevention". We've got a copy of that report. Is there any other data you're aware of for research performed by MwRSF?

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## Response

Date: 09-04-2014

MwRSF has been involved in a limited number of in-service studies for cable or other barrier types. This type of analysis generally tends to be sensitive and not within the scope of funding of

most state DOTs, proprietary companies, or the federal government. Thus, I can't point to any other MwRSF research regarding cable barrier in-service; the closest I can get is TRP-03-265-12, "Test Matrices for Evaluating Cable Median Barriers Placed in V-Ditches", which has simulated trajectories of various vehicles and may help to guide cable barrier placement in V-ditches.

Recently, however, there have been a number of studies regarding the performance evaluation of cable median barrier in various states:

- Florida DOT submitted a paper to TRB regarding CMB performance, indicating penetration rates as high as 18-20% (http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_RD/FDOT-BDK80-977-19-sum.pdf, http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_RD/FDOT-BDK80-977-19-rpt2.pdf, also TRB paper attached –should not be disclosed) that led to a moratorium on cable barrier construction (attached)

- TTI provided a cost-effectiveness and performance evaluation in 2009 (http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/0-5609-1.pdf)

- One of the more quoted research reports in Washington in 2003, which really set the ball rolling for cable barriers (http://www.wsdot.wa.gov/publications/fulltext/design/roadsidesafety/cablemedian.pdf)

- Malcom Ray conducted a limited survey in 2003 (attached)

- Auburn University prepared a rudimentary performance evaluation in Alabama (http://www.eng.auburn.edu/files/centers/hrc/IR-05-01.pdf)

- University of Tennessee conducted an in-service performance evaluation (http://www.tandfonline.com/doi/full/10.1080/19439962.2013.812168#.VAhuEWNNiNI; if you would like additional resources, I can point you to additional papers)

None of the state DOT or independent researcher reviews was as extensive as the MwRSF research, but each does present a snapshot of the state of cable barrier performance in each state. I hope this helps with the consideration of cable barrier in-service performance evaluation studies.

Attachment: http://mwrsf-qa.unl.edu/attachments/6bbd7540eef55be01df86ff5d78bed81.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/b94fa5181c2b0181cd03a7e1fc46a144.pdf

Attachment: http://mwrsf-qa.unl.edu/attachments/bae983a9dc37aa049e60182dd1479e23.pdf

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# Wood vs steel posts

**Question**
State: MN
Date: 08-26-2014

I am doing some research for a
story about our use of wood vs steel guardrail posts. DeWayne Jones has been very helpful in answering my questions.

I have one other question that
perhaps someone else should answer. And if that's not you, will you forward this to that person? Or if it is DeWayne, let me know and I will ask him.

DeWayne provided me with
information that indicates steel posts initially cost higher, but they can be recycled and they last longer. The labor to install steel posts is less and crews are safer for that time savings by not being near traffic as long. With the steel posts, One Call is not needed either, resulting in faster response time.

With that said, I am wondering if
guardrails with steel posts are stronger and safer than guardrails with wood? Are there any studies that show that?

Thank you!

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**Response**
Date: 08-26-2014

We have done many studies that relate on some level to this topic over the years and did a TRB paper on it specifically last year.

I have attached several reports and papers related to this topic for your review. The TRR paper from last year on wood vs steel posts in the MGS probably has the most direct answers for you, but the others may be useful as well.

The file 'Wood vs Steel Posts.zip' (73.5 MB) is available for download at

http://dropbox.unl.edu/uploads/20140909/18aa46e220d62216/Wood%20vs%20Steel%20Posts.zip

for the next 14 days.

It will be removed after Tuesday, September 9, 2014.

Take a look at this information and contact me if you have any questions.

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## Long Span Guardrail -- Minimum Lengths with Common Terminals

**Question**
State: IL
Date: 08-29-2014

Illinois has developed Highway Standard 630106-1 (attached) to implement the MGS Long Span design for crossing culverts. In this design we have shown 62.5 feet of Type A guardrail (MGS with 6'-3" post spacing) beyond the three CRT posts before any other pay item may begin. This means that attachment of a crashworthy end terminal is generally going to add another 37.5 feet of length of need guardrail (according to IDOT pay item definition for these items), plus the gating portion , if any.

We note that a previous question on the consulting website (6/18/2007) inquired specifically about the FLEAT terminal and how it could be used with the long span design. As we read the result, the 37.5 feet of the proprietary FLEAT design plus 25 feet of guardrail item would satisfy the needed 62.5 feet minimum installation beyond the three CRT posts. This was allowed specially for the FLEAT because crash testing in the flared section showed that the FLEAT works for impacts in that region.

We would like to adopt this practice to help make the long span installations more economical and practical, and also wish to explore similar applications for other guardrail terminals to allow for competitive bidding for these terminal applications.

The SRT terminal by Trinity is a flared terminal that includes a version accepted for use with the MGS system. Is it acceptable to use this terminal in a similar layout to that described for the FLEAT system? It does not appear that the length of need point impact was tested in the acceptance for MGS use, but that was considered and agreed to be waived by FHWA.

With respect to "tangent" guardrail terminals, the ET-Plus by Trinity and the SKT by Road Systems are commonly used in Illinois. Neither of these terminals were tested at the length of need point for the MGS version. Could the length of these systems be counted against the required 63.5 feet beyond the three CRT posts? Would the same answer also apply if these terminals were flared at a rate of 1:50 as is the practice to avoid having extruder heads overlap the shoulder area?

Lastly, Connecticut submitted a question on July 5, 2012 regarding the long span installation and you responded soon thereafter July 16th, in which you pointed out MASH testing done on 75' long version of the MGS - we ask, would this also apply to the use of the same flared terminals just discussed above?

Attachment: http://mwrsf-qa.unl.edu/attachments/a09e6b4dc997285a436512aee4db3fe8.pdf

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**Response**
Date: 09-13-2014

As you note in the email, the MGS long span system was tested to MASH and the implementation of the system was accompanied by recommendations regarding the system length and the amount of guardrail tangent to the long span. Special systems such as the MGS long-span could actually further increase the loading of the barrier system and create higher anchor loads and affect the length of the system and the anchorage. Although it was likely that guardrail lengths shorter than 175 ft could redirect 2270P vehicles impacting at the TL-3 conditions, there was no crash test data to support or recommend the use of shorter lengths at that time. Based on these noted concerns, it was recommended that the minimum installation length of the MGS long-span be set at 175 ft for a long span length of 25 ft. However, if a shorter long span length was used, it was still recommended that the upstream and downstream lengths of the installation including the end anchorage be no less than 62.5 ft beginning at the third CRT post. This length is based on the 175 ft system length that was tested. At that time, there may be a potential to reduce the downstream distance, but this would require further analysis and verification with full-scale crash testing.

Following those recommendations, we were contacted by IaDOT for clarification on the system lengths as well as questions regarding the use of the FLEAT terminal with the MGS long span. At that time we reviewed this question, the FLEAT had been tested near the beginning of length of need with the MGS under the NCHRP Report 350 impact criteria. See attached. Because the FLEAT had been tested under NCHRP 350 in the flared section of the barrier, it was believed that the FLEAT possessed sufficient anchor capacity for the MGS long span even if the flaring of the terminal occurred within the 50 ft of tangent guardrail recommended originally. The overall length of the installation remained 175 ft. Of course, this recommendation was only relevant for NCHRP 350 impact conditions, but it gave IaDOT some additional flexibility in their installations. MASH impacts (with their higher angle and vehicle mass) have not been conducted on the FLEAT or the majority of the other terminal system at the beginning of length of need.

You have requested our thoughts regarding the use of the SRT terminal and its parabolic flare in a similar fashion. There is potential that this configuration would be acceptable. FHWA acceptance letter HSSD/CC-100, dated August 30, 2007 specific to "NCHRP Report 350 Test 3-35 of the SRT-31" contains details of successful Test 3-35 of the SRT-31. Based on this test, the argument for using the SRT 31 would be very similar to the FLEAT. Thus, it would be acceptable to use the SRT 31 and its associated flare with the MGS long span as long as the minimum system length is still met.

With respect to tangent terminals, the length of the terminal is included in the 62.5 feet required adjacent to the CRT posts in the MGS long span. The SKT system uses a similar anchorage to the FLEAT system that was tested to NCHRP 350 with the MGS. No terminal system has repeated their beginning of LON tests under the MASH criteria. Thus, we have confidence in their ability to anchor systems under NCHRP 350 loading and they potentially can develop the loads for MASH impacts. However, we cannot definitively determine their anchor capacities with respect to MASH loading at this time.

For a tangent terminal with a 50:1 flare, we do not expect to see a large difference in the loading of the terminal anchor. This flare is approximately a 1.15 degree angle and would not have a large effect on anchorage of the MGS long span system.

FHWA has also had discussion regarding the flaring of tangent terminals in a general sense based on NCHRP 350 testing of terminals. They, along with industry and researchers at MwRSF and TTI, determined that 15:1 flares were appropriate for general tangent terminal applications (see attached). However, the use of these more aggressive flares with shorter system lengths or special applications like the long span would likely require further analysis and study.

Finally, with respect to your last question, we have given guidance previously based on reduced system lengths for the MGS long span system with shorter unsupported span lengths. This guidance was based on recent research we had done on the minimum system length of the MGS system, collection of data regarding the capacity of the generic end anchorage we use in our evaluation testing, and the assumption of tangent guardrail. The addition of a flared terminal such as the FLEAT could create potential issues when applied with reduced system lengths. Specifically, there are some concerns that shorter systems would place the CRT's and unsupported span significantly closer to the end terminal. Placement of two critical regions of the barrier in such close proximity could have additional consequences and affect the performance of the barrier system. Thus, we believe more study would be required to evaluate the flared terminals with the reduced system lengths that we developed for Connecticut.

Attachment: http://mwrsf-qa.unl.edu/attachments/3cdc352ae738398fcbb064165893faae.pdf

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# Welded Vs Continuous Stamped Asymmetric Section

**Question**
State: WY
Date: 09-11-2014

One of our major suppliers of guardrail components, Universal Industrial Supply out of Utah provide the asymmetric transition pieces as shown in the attached drawings. As you can see, they have cut a thrie beam element and welded a rear flange to the bottom of the asymmetric section. During development of the "transition to the transition," I know Midwest was using a welding section and then found a manufacturer who could make stamped sections. Is this welded section acceptable? Are other states having problems getting the continuous stamped asymmetric section?

Attachment: http://mwrsf-qa.unl.edu/attachments/7196b09c000d1f60179b699cba8b8e50.docx

Attachment: http://mwrsf-qa.unl.edu/attachments/bfedaa857e8e7789e58f0bc4e717ef22.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/39423e454e86e78b6162635667b36465.jpg

Attachment: http://mwrsf-qa.unl.edu/attachments/a35e065d4425882f95494368b87909d5.jpg

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## Response

Date: 09-13-2014

The asymmetric W-to-thrie beam transition piece shown in the attached photos corresponds to a design variation that was evaluated during the development of the MGS upstream stiffness transition for approach guardrail. In test no. MWT-4, a 2000P vehicle impacted upstream of this W-to-thrie beam transition piece at a speed of 98 .1 km/h (61.0 mph) and at an angle of 25.3 degrees. As the truck progressed into the guardrail during test no. MWT-4, vehicle redirection continued until the front bumper contacted the point of the flat plate extension on the bottom of the transition element. The start of the weldment proved to be a stress concentrator that produced a tear in the W -beam to thrie beam transition section. The tear quickly propagated through the entire segment and ruptured the rail system. Thereafter, all redirection stopped, and the test vehicle moved forward into the end of the stiff transition section where it was brought to an abrupt stop. Thus, this test showed that the current design was unsafe and should not be used on high-speed roadways.

http://mwrsf.unl.edu/researchhub/files/Report188/TRP-03-94-00.pdf

Following test no. MWT-4, MwRSF designed a revised W-to-thrie beam transition piece that is recommended for use when creating approach guardrail transitions with the MGS. This design is attached and has been successfully crash tested to the MASH criteria.

Attachment: http://mwrsf-qa.unl.edu/attachments/99cd4312bfc7ee4adb43f22bb12318c9.pdf

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