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:** 6/30/2017	**Number of Extensions:** 6

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	$973,390	97%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
$3,766 (0.4%)	$3,766	97%

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 fifth report was published on September 26, 2016.

Writing continued on the sixth report, which documents the four component tests that were conducted to evaluate the damage that occurs at various concrete beam splices. The setups ranked with the least amount of damage (concrete spalling and cracking) to the most damage are as follows:
1) Embedding steel plates into the ends of the barriers had almost no damage, and would also incur the highest increase in cost.
2) Adding rubber pads underneath the joint angles significantly reduced damage at a minimal cost.
3) Normal weight concrete slightly reduced damage and had a reduced cost compared lightweight concrete.
4) Lightweight concrete, which was utilized in the full-scale crash tests, incurred the most cracking and spalling.

At this time, additional simulation and crash tests to evaluate potential barrier modifications/refinements and further transition modifications are recommended in the future with additional project funding.

Anticipated work next quarter:

Writing will continue on the sixth report.

Significant Results:

With the results of all three crash tests, the barrier satisfactory safety performance according to the MASH TL-4 evaluation criteria for longitudinal barriers. The reductions in lateral acceleration for the passenger vehicles met the desired levels. During both of the passenger vehicle impacts, more damage occurred to the barrier than desired, which included concrete spalling at the beam joints, gouging on the front faces of the beams, and two rubber posts were cut by the small car. Damage also occurred to the concrete beams and top metal rail during the impact with the single-unit truck, although some damage was permissible during the larger truck impacts.

Report TRP-03-336-16 documenting phase 5 of this project was published on September 26, 2016.
Report TRP-03-318-15 documenting phase 4 of this project was published on November 3, 2015.
Report TRP-03-317-15 documenting phase 3 of this project was published on July 29, 2015.
Report TRP-03-280-13 documenting phase 2 of this project was published February 6, 2014.
Report TRP-03-281-13 documenting phase 1 of this project was published July 16, 2013.

Test no. SFH-3 was conducted on March 13, 2015 and was successful.
Test no. SFH-2 was conducted on August 11, 2014 and was successful.
Test no. SFH-1 was conducted on July 2, 2014 and was successful.

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

Throughout the project, several concerns regarding the use of rubber posts have arose and have been addressed. The barrier was redesigned multiple times in advance of the first crash test in order to obtain a more successful performance in a variety of environmental conditions, to optimize the concrete and steel rail, and to have greater confidence for a successful crash test result. Installation concerns were also addressed, which will allow the barrier to be installed in a larger range of conditions in the real world. Therefore, the start of the full-scale crash testing program was delayed. All required full-scale crash tests have been successfully completed on the length-of-need longitudinal barrier system. Additional design refinements were recommended to reduce damage to the barrier and maintenance costs and a transition from the length-of-need longitudinal barrier to a rigid concrete barrier was desired before the system could be installed on roadways. Therefore, the project has received multiple extensions. The budget of the project was not been affected. At this time, additional simulation and crash tests to evaluate potential barrier modifications/refinements and further transition modifications are recommended in the future with additional project funding.

Potential Implementation:

Study findings on rubber material models under high-velocity impacts are available to future researchers to use in other investigative efforts. The rubber post, open concrete median barrier concept has demonstrated a significant reduction in lateral vehicle accelerations and occupant risk values for passenger vehicles, and the barrier also has demonstrated the ability to contain TL-4 single-unit truck impacts under MASH test conditions. The barrier demonstrated restorability during full-scale crash testing. However, some damage occurred in the impacts with passenger vehicles and the single-unit truck. Note that the damage should not affect the structural integrity of the barrier as the barrier should be reusable after impact events. With further design refinements, the barrier could have very low maintenance requirements for TL-4 impact events. It is anticipated that severe injuries and fatalities could be reduced with the RESTORE barrier installed in lieu of current rigid concrete median barriers along urban, high-speed roadways.