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. #90	**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: Portable Concrete Barrier–Steel Cover Plate for Large Open Joints		
Name of Project Manager(s): Reid, Faller, Bielenberg, Lechtenberg, Rosenb	**Phone Number:** 402-472-9064	**E-Mail** srosenbaugh2@unl.edu
Lead Agency Project ID: 2611211120001	**Other Project ID (i.e., contract #):** RPFP-16-CONC-4	**Project Start Date:** 10/1/2015
Original Project End Date: 9/30/18	**Current Project End Date:** 9/30/18	**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
$118,925	$118,925 + $45,418 (contingency)	80%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$68,607	

Project Description:

Temporary concrete barriers (TCB) are commonly used to protect work zones and to shield motorists from hazards in construction areas. During setup or contractor operations in work zone areas, it is not uncommon to layout, construct, and connect free-standing TCB installations from different ends or to install barriers with a longitudinal gap between adjacent barrier segments. Longitudinal gaps can also be created due to tensioning issues following an impact event. These gaps can range from 6 in. to as long as a full barrier segment length, or 12.5 ft. Gaps in the barrier system pose a serious safety concern, but limited guidance is available for this situation. Overlapping two runs of barriers has been recommended in the past. However, the length of barrier overlap is relatively large and also requires significant lateral offset between the overlapped segments, which reduces available space in constricted work zones. Thus, a need exists to develop crashworthy and efficient methods for treating longitudinal gaps in adjacent runs of free-standing TCBs.

Previous research efforts to investigate gaps between adjacent TCB installations have focused on gate designs for providing emergency or maintenance access through temporary barriers. These devices include the ArmorGuard Gate, the BarrierGuard Gate, and the Vulcan barrier system. All of these gate systems are proprietary with fixed lengths that can be attached to permanent and temporary concrete barrier systems. While these systems have been crash-tested and demonstrated to function adequately, they are fixed-length solutions that would not be effective at spanning variable length gaps. In addition, these gates can be relatively costly to install.

For a more general solution to variable length gaps, the current guidance is to longitudinally overlap two adjacent barrier runs with a minimum of eight TCB segments and provide a minimum lateral offset of 2 ft between adjacent barrier runs. While this solution is adequate in terms of crashworthiness, it is not always manageable in terms of available space in the work zone. A more efficient solution would involve some form of gap-spanning hardware that could be adjusted for a variable gap length, would be easy to install and remove, and would be crashworthy. Crashworthiness of any design solution would require development of continuity (shear, tensile, and flexural loads) across the variable gap length and

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

Previously, LS-DYNA analysis was utilized to develop preliminary designs for both of the sponsor selected design concepts, the 2-piece steel cover plate concept (Concept #7) and the thrie beam with toe plate concept (Concept #4), were created.

This quarter, a presentation was given in October to the project sponsors detailing the LS-DYNA simulation and design efforts on both design concepts. The sponsors voted unanimously to proceed with the thrie beam and toe plate concept. As such, further simulations were conducted on the thrie beam concept to select critical impact points for full-scale crash testing. Impacts were simulated over a range spanning 3 barrier segments upstream of the PCB gap to the barrier segment downstream of the gap. Further, simulations were conducted with both 12.5-ft and 3-ft gap widths to investigate the effect of gap length on system performance.

During the CIP study, it became evident that the tow plate was not strong enough to prevent wheel snag on the toe of the downstream PCB. Thus the toe plate was increased in size to a 5/8-in. thick x 8.5-in tall plate. Additionally, it was determined that snagging was held to a minimum when a stiffener was present at the center of the gap for the 3-ft gap. Thus, it was determined that stiffeners would be utilized whenever possible (based on gap length) to strengthen the attachment hardware and prevent snagging.

Simulated impacts on the the PCB downstream of the gap were resulting in significant vehicle roll, and occasionally rollover. Further analysis revealed that the downstream portion of the thrie beam, which was overlapping 6 ft of the downstream PCB, was restricting the impacting tire from climbing the toe of the barrier. This then resulted in accentuated roll toward the barrier. Previous full-scale crash testing on a similar thrie beam connection system showed some vehicle roll toward the barrier, but not to the degree observed in the simulations. It is anticipated that this region of the system

Anticipated work next quarter:

The CIP study on the selected design concept will be completed, and the CIPs for full-scale crash testing of the PCB gap hardware will be selected. Additionally, work will continue on writing the project summary report.

Significant Results:

A literature review was completed on State DOT standards, private manufacturer hardware, and a patent search. Next, 7 different conceptual designs were shown to the project sponsors for consideration. The sponsors voted to proceed with designing 2 concepts, a 2-piece end plate concept and a thrie beam with toe plate concept, through structural analysis and LS-DYNA simulations.

Simulations on the 2-piece cover plate design illustrated that the cover plate had to be 3/8" - 1/2" thick to prevent the cover plate from hinging and creating a snag point at the upstream end of the PCB. Adding 1/4" thick stiffening plates spaced at about 2 ft intervals allowed the cover plate thickness to be reduced to 1/4". these stiffeners would have to be bolted in place or removed depending on the actual gap width between PCBs. Finally, the end plate would need to be 5/8" thick in order to prevent failure at the connection between loops and the end plate of the cover plates.

Simulations with the thrie beam and toe plate concept illustrated that single ply thrie beams would not be sufficient to prevent vehicle snag on the PCBs. Thus, nested 12-gauge thrie beam was selected for the design. 10-gauge terminal end connectors are used to connect the beams to the PCBs. Spacer blocks were placed at 37.5" intervals to connect the beams on the front and back sides of the system and to provide added strength. the spacers had to be extended all the way to the ground and connected to the toe plate in order to prevent excessive deformations of the toe plate and the associated risk of vehicle snag on the toe of the PCB. The spacers will be fabricated from 1/4" thick steel and resemble the cross section of an F-shape barrier.

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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 funds were depleted early in the 4th quarter of 2017. In order to complete the CIP study and assemble the project summary report, multiple contingency funds (or remaining funds from completed Midwest Pooled Fund projects) were designated for use on the PCB gap connection hardware project:

- project code 2611211112003, money moved to contingency from a Year 25 project - "MGS with Omitted Post"
- project code 2611130126001, contingency funds from Year 28 of the pooled fund

Note, Phase II of this project was selected for funding as part of the Year 28 pooled fund research program, so testing of the system will begin in 2018.

Potential Implementation:

Development of a crashworthy system for spanning variable gaps in adjacent runs of TCBs would provide states with increased safety through removal of the hazard posed by interruption of the barrier continuity and would improve the flexibility of work zone operations by making it easier to move or coordinate TCB installations.