TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

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

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

Transportation Pooled Fund Program Project # *(i.e, SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)*	**Transportation Pooled Fund Program - Report Period:**
TPF-5(193) Supplement #104	☐ Quarter 1 (January 1 – March 31) ☐ Quarter 2 (April 1 – June 30) ☐ Quarter 3 (July 1 – September 30) ☑ Quarter 4 (October 4 – December 31)

Project Title:		
Optimized TL-4 Concrete Bridge Rail		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Reid, Faller, Bielenberg, Lechtenberg, Rosenb	402-472-9324	srosenbaugh2@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211133001	RPFP-17-CONC-2	10/1/2016
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
9/30/2019	9/30/2019	0

Project schedule status:

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

Overall Project Statistics:

Total Project Budget	Total Cost to Date for Project	Percentage of Work Completed to Date
$247,654	$62,165	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
	$23,372	

Project Description:

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

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

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

Objectives / Tasks:

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

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

Previously, a barrier optimization analysis was completed to identify configurations with a minimum strength capacity of 80 kips and their corresponding material and labor costs associated with concrete and steel reinforcement.

An update meeting was held in October with the project sponsors. at this meeting, a table of the lowest cost configurations to satisfy the 80 kip capacity was presented and the various options were discussed. The states were then asked to vote for their most desired barrier configurations. The selected configuration incorporated a single slope front face angled 3 degrees from vertical, an 8" top width, and an installation height of 39". The barrier was reinforced with (8) #5 longitudinal rebar and #4 stirrups spaced at 12" intervals.

A bridge deck was also configured for the full-scale test based on existing deck designs from the sponsor DOTs. The deck is 8" thick with a 5-ft cantilever to the deck edge. The lateral reinforcement in the deck was designed to support the barrier and MASH TL-4 impact loads. The top steel mat incorporated #6 bars at 12" spacings, while the bottom steel mat incorporated #4 bars at 12" spacings.

Details for the full-scale crash test of the selected bridge rail and deck designs have began to be drawn in CAD.

Anticipated work next quarter:

CAD details for the selected barrier and deck designs will be completed. The test plan will be sent to the test site for construction and full-scale testing.

Significant Results:

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

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

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

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

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

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

Potential Implementation:

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