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 # 62	☐ 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:		
Safety Investigation & Design Guidance for Curb & Gutter Near Energy-Absorbing Terminals		
Name of Project Manager(s):	**Phone Number:**	**E-Mail**
Schmidt, Bielenberg, Faller, Reid	(402) 472-0870	jennifer.schmidt@unl.edu
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
2611211094001		7/1/2013
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**
6/30/2016	6/30/2017	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
$173,716	$141,340	85%

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	Total Amount of Funds Expended This Quarter	Total Percentage of Time Used to Date
	$4,630	

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.):

Writing continued on the report. All simulations have been ran with the flared, tangent end terminal system. The feed lengths through the impact head decreased slightly when the system was flared vs. tangent. 2-in., 4-in., and 6-in. tall curbs adjacent to the flared system did not significantly affect the performance of the end terminal.

With all of the simulations with curbs, the vehicle models, especially the Yaris, did not have the appropriate steering and suspension response after impacting the curbs. Most of the simulations had small curbs offsets, so this behavior did not significantly affect the vehicle trajectory or impact with the end terminal. However, in some of the impacts with the flared end terminal and the 6-ft wide sidewalk (MASH 3-32 and MASH 3-33 with 5-degree impact angles), the centerline of the vehicle did not impact the centerline of impact head as desired. In some of the simulations with the sidewalk, the small car did not impact the impact head at all. A CarSim of a previously calibrated small car vehicle model was used to impact a curb. The steering angle and trajectory of vehicle changed very minimally, so the steering and suspension response of the LS-DYNA vehicle models was not believed to be accurate and further improvements need to be made, which is outside the scope of this study.

Anticipated work next quarter:

Compile all of the simulation results into the report. Complete first draft of report.

Significant Results:

Baseline simulations were completed.

End terminal models with the G4(1S) and MGS were developed. Twelve impact conditions were simulated for both the G4 (1S) and MGS models, and the results were reasonable when compared to full-scale crash testing. A flared end terminal model was developed and compared to the tangent end terminal. Simulations with all curb configurations were completed, which include 2-in., 4-in., and 6-in. tall sloped and vertical curbs at 0-in. and 6-in. offsets from a tangent end terminal; 2-in., 4-in., and 6-in. tall sloped curbs at a 0-in. offset with a flared end terminal; 2-in., 4-in., and 6-in. tall sloped curbs with a tangenet end terminal at a 6-ft offset.

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

None.

Note, this quarterly report only includes labor charges from July and August.

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.