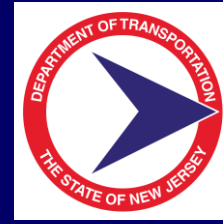


New Jersey Department of Transportation  
Bureau of Research

## Technical Brief



### Route 139 Rehabilitation: Pulaski Skyway Contract 2

*This study addressed the need for an aesthetically pleasing historic concrete balustrade design alternative for the Pulaski Skyway in Jersey City, Hudson County. In this study, a crashworthy design was developed according to AASHTO Section 13 specifications and was modeled using the nonlinear transient dynamic finite element analysis software, LS-DYNA, and the AASHTO Manual for Assessing Safety Hardware (MASH) TL-4 collisions were simulated. Crash tests were performed successfully at the Texas A&M University Transportation Institute (TTI). The computer simulations were updated to match field testing conditions, and were then validated according to the procedures set forth in NCHRP W179: Procedures for Verification and Validation of Computer Simulations Used for Roadside Safety Applications. The state of New Jersey now owns a historic looking barrier that can be used on any corridor in the U.S. which requires the containment of a single unit truck. The validated models can be used to evaluate retrofits or small changes without the need for additional crash tests.*

### Background

Many historic concrete balustrades on bridges in New Jersey are reaching the end of their design service lives, and must be replaced with new ones during the bridge rehabilitation programs. As typical solid and crash tested barriers may ruin the aesthetic appearance of the bridge, the Historical Preservation Office (HPO) requires a new open-face balustrade similar to current aesthetic barrier. The new barrier should comply with AASHTO Section 13 to ensure capacity, and with AASHTO MASH to ensure safety.

### Research Objectives and Approach

The main objective of this study is to develop a historic-looking balustrade that meets the requirements of the HPO as well as AASHTO MASH TL-4 requirements which involves three vehicles – single unit truck, pick-up truck and passenger car. The research work to achieve this objective includes the following tasks:

1. Review designs of open-face balustrades that other states have tested;
2. Develop an initial balustrade design similar to current design;
3. Develop a detailed finite element (FE) model and validate the model using crash testing data for similar design barriers;
4. Conduct a parametric study for various barrier height, post width and window opening width configurations using FE simulation;
5. Select the final design and have the design approved by NJDOT and aesthetics approved by HPO;
6. Perform full scale crash tests under MASH TL-4 conditions; and
7. Obtain the FHWA approval for the new balustrade design.

## Findings

- As the single unit truck has the highest impact severity and incurs the most damage on the barrier, this test governs the overall performance. Post and window opening widths control how the vehicle interacts with the barrier and how much damage will be incurred to the barrier and vehicle. It was found that as the window opening increases, the capacity of the barrier per linear foot decreases and the potential for vehicle components to get caught in between the posts and damage vehicles increases. A post width of 8-in. and a window opening width of 6-in. are selected to meet the HPO and MASH TL-4 requirements.



Figure 1. Aesthetic barrier tested at TTI

- The total barrier height is the most important factor in determining the behavior of a single unit truck during a collision. It was found that a height of 44-in performs very well in containing the truck on the traffic-side of the barrier and preventing overturning.



Figure 2. Crash test and simulation comparison at collision for single unit truck

- The barrier was constructed and tested at Texas A&M Transportation Institute (TTI) for three vehicles (single unit truck, pick-up truck and passenger car). All three vehicles were successfully contained and redirected on the correct side of the barrier, remained upright, also stayed very close to the barrier for the duration of the collision, and was very stable throughout the whole event. The crash tests proved that the new aesthetic balustrade is suitable for use on any corridors where containment of the single unit truck is necessary.
- Future study is needed to evaluate the barrier at MASH TL-5 which requires the containment of the tractor-trailer, and to design a transition terminal guardrail.

## For More Information Contact:

NJDOT Project Manager:	Giri Venkateela, PhD (609) 530-8038 Giri.Venkateela@dot.nj.gov
Principal Investigator:	Hani Nassif, PE, PhD Rutgers University, Rutgers Infrastructure Monitoring and Evaluation (RIME) Group (848) 445-4414 nassif@soe.rutgers.edu

A final report is available online at: <http://www.state.nj.us/transportation/refdata/research/>  
If you would like a copy of the full report, send an e-mail to: [Research.Bureau@dot.nj.gov](mailto:Research.Bureau@dot.nj.gov).

**Route 139 Rehabilitation: Pulaski Skyway Contract 2**  
**NJDOT Research Report No: FHWA-NJ-2017-012**