



RESEARCH SERVICES SECTION

TECHNICAL SUMMARY

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PROJECT COST:

\$160,000



Investigators measured the response of a bridge test section to stresses.

Improving the Strength and Stability of Prestressed Concrete Through-Girder Pedestrian Bridges

What Was the Need?

Each year, concrete pedestrian bridges are struck by overheight vehicles, resulting in structural damage to the bridge and injuries to pedestrians and motorists. Because pedestrian bridges are of lighter construction than highway bridges, with only two girders supporting the whole system, and because of the number and type of connections used to join the girders, these bridges are more vulnerable than others to collapse when a collision occurs.

Prestressed concrete through-girder pedestrian bridge systems have a simple design: Two girders support floor beams at their bottom flange and a bridge deck covers the floor beams. These bridges are used in Minnesota over several interstate highways and span approximately 130 feet. The American Association of State Highway and Transportation Officials and transportation professionals around the country have expressed several safety concerns regarding these bridges:

- The reinforcement used in the girders of these bridges makes them less ductile (less deformable), and so less able to absorb the impact of a crash without collapsing.
- As the force from a vehicle impact is transferred along the bridge, the connections between parts of the bridge are subjected to large forces and can fail, possibly resulting in bridge collapse.

An earlier phase of this research performed by the University of Minnesota Center for Transportation Studies determined that these pedestrian bridge girders do not meet the ductility standards in AASHTO's Load and Resistance Factor Design specifications. That study was initiated with the expectation that additional research would be required, and Mn/DOT's ongoing partnership with the university offered an excellent vehicle for pursuing this.

What Was Our Goal?

This project was undertaken to validate the preliminary analyses of the above-mentioned study: Investigators aimed to determine why this type of pedestrian bridge is vulnerable to collapse. Laboratory experiments and numerical simulations were designed to:

- Test and analyze the ductility, strength and stability of these bridges when subjected to impact by overheight vehicles, to see if they are overreinforced according to AASHTO Standard Specifications and AASHTO LRFD Specifications.
- Recommend design modifications for these bridge systems that improve stability and minimize structural damage upon vehicular impact.

What Did We Do?

Investigators brought sections of the standard prestressed concrete girders used for these pedestrian bridges into the laboratory and assembled typical girder-to-floor-beam connections. They subjected these specimens to stresses to evaluate the distribution of strain across the section, and hence the overall ductility of the bridge. They compared the responses of the section to those predicted by the AASHTO specifications.

To perform additional tests on the strength and stability of various bridge elements, investigators used the bridge characteristics from the above analyses to create computer

“This was a very valuable study on a topic that has seen very little research. The design changes will improve the strength and flexibility of prestressed concrete through-girder pedestrian bridges built in Minnesota.”

–**Jihshya Lin**,
Mn/DOT Bridge Design
Unit Leader

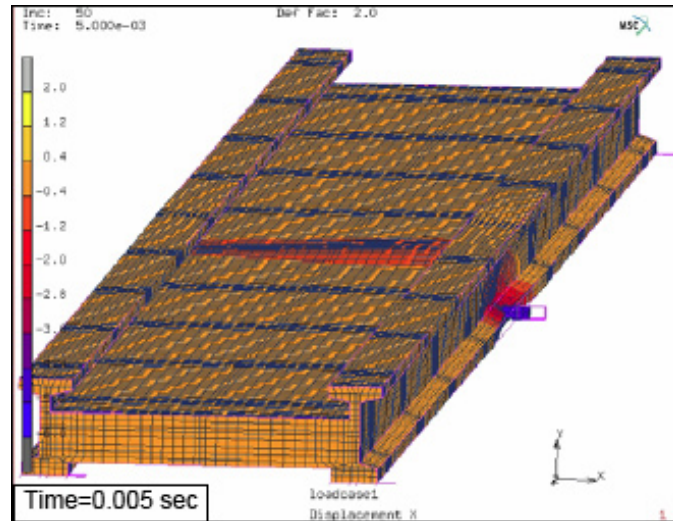
“The lateral load capacity of the bridge system was improved by providing additional steel connectors between the girders and the deck. Eighteen-inch-spaced connectors increased the lateral load capacity about 50 percent.”

–**Arturo Schultz**,
Professor, University of
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of Civil Engineering

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Investigators simulated impacts on computerized models to gauge probable amounts of deformation in real pedestrian bridges.

models, which were subjected to a series of simulated loads and impacts. The models analyzed both material responses, such as cracking and crushing of concrete, and structural responses, such as the friction between the surfaces of different bridge members.

What Did We Learn?

Results from strain analyses showed inconsistencies in the AASHTO specifications for predicting the response of prestressed concrete bridge girders: These specifications can overestimate the ductility of these high-strength girders. Limiting the maximum amount of reinforcing steel in the girders should provide enough ductility that the girders will deform upon impact rather than collapsing from sudden brittle concrete failure.

When the flexibility of the girder supports was factored into the modeling, the overall deformation of the bridge system was controlled more by the sliding of girders at the supports. The behavior of the bridge system also changed significantly depending on whether the force of impact was applied at the exterior face of one girder or the interior face of the other girder. Providing additional steel connectors between the girders and the deck improved the bridge's ability to laterally deflect the force of the collision. The stability of the bridge was also improved through the use of steel tie-rods between the exterior faces of the two girders.

What's Next?

The recommendations in this study to modify AASHTO bridge design specifications to address the inconsistencies in girder ductility predictions have been accepted by AASHTO. Because of this study, departments of transportation, both in the United States and around the world, can now build stronger, more flexible pedestrian bridges that are safer and more resistant to collapse.

This Technical Summary pertains to Report 2007-08, “Strength and Stability of Prestressed Concrete Through-Girder Pedestrian Bridges Subjected to Vehicular Impact,” published January 2007. This report covers both the Mn/DOT study and Phase I, which was funded by the University of Minnesota’s Center for Transportation Research. It can be accessed in full at www.lrrb.org/PDF/200708.pdf.