



## RESEARCH SERVICES SECTION

# TECHNICAL SUMMARY

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### PROJECT COST:

\$149,000



Researchers exposed and affixed strain gages to the prestressing strands that reinforce the girder.

# Shear Capacity of Prestressed Concrete Bridge Girders

## What Was the Need?

Prestressed concrete girders have been used in U.S. bridges for more than 50 years. During manufacture, tension applied to the steel reinforcement rods that run the length of the girder is transferred into compression of the concrete as it cures, resulting in a much stiffer beam. However, traffic loads and the weight of the bridge itself cause strains within the girders that can lead to failure of the beam. These shear forces can be very large, especially in regions close to the beam support, requiring reinforcement.

Experience has led to significant changes in the American Association of State Highway and Transportation Officials bridge design code in recent years with respect to the amount of shear reinforcement required in prestressed concrete girders. Current design provisions in the 2002 AASHTO Standard (initially adopted in 1983) and the 2004 AASHTO Load and Resistance Factor Design Specifications (initially adopted in 1994) require more shear reinforcement than was dictated by the 1979 Interim and prior provisions. Girders designed to these earlier specifications may not meet the shear capacity requirements of current codes.

Mn/DOT oversees more than 1,200 prestressed concrete bridges, about 900 of which could have been designed according to guidance from the 1979 Interim codes or earlier. Research was needed to help evaluate the shear capacity of girders in these older bridges and determine whether action was warranted to increase this capacity.

## What Was Our Goal?

The objective of this project was to experimentally determine the shear capacity of an existing girder from a bridge built before 1980 and evaluate whether it had been sufficient during its lifetime.

If researchers determined that the older codes overpredicted the shear capacity provided by a given amount of shear reinforcement—resulting in a bridge built with less capacity than expected—then they would develop a method for evaluating the shear capacity of existing bridges and possible ways to retrofit them to increase shear capacity.

## What Did We Do?

Researchers performed a laboratory analysis of two ends of an 88-foot girder removed from a bridge, instrumenting these girder sections with strain gages and load-testing them to the point of failure. These test results were compared with the predicted shear capacity of a prestressed concrete girder built according to each of the three design specifications (1979 Interim, 2002 AASHTO Standard and 2004 AASHTO LRFD). Researchers then performed a parametric study into the quantities that determine the shear capacity of the beam, extrapolating the insights gained from the load testing to a wider set of girders.

## What Did We Learn?

The tested girder had enough shear capacity to meet all three standards, and it is likely that bridges with similar characteristics would meet these standards as well. Researchers recommended that the computer programs for the 2002 AASHTO Standard be used to evaluate the shear capacity of the girders because the 2004 LRFD program was cumbersome to use, and both standards provided similar results for shear capacity.

*“The design requirements have changed to include much more shear reinforcement. We want to make good decisions about the safe operating load of these older bridges.”*

–Yihong Gao,  
Bridge Designer,  
Mn/DOT Office of Bridges

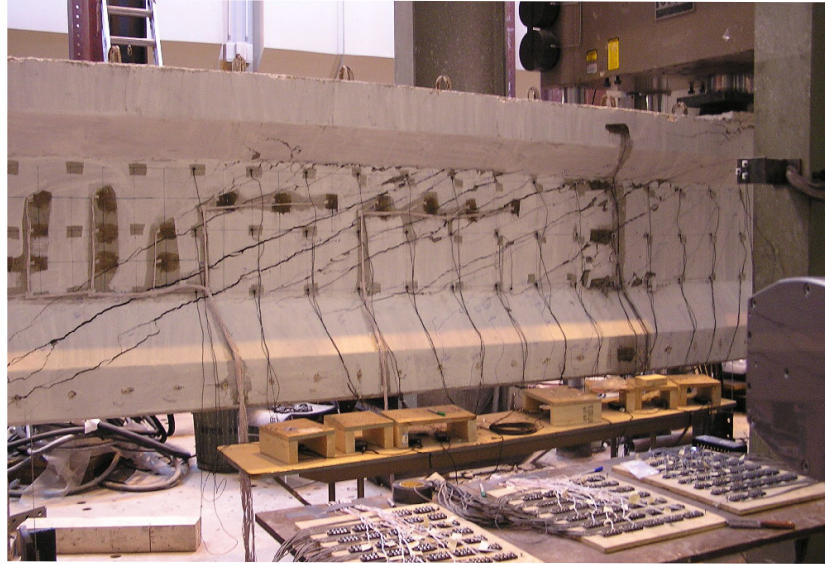
*“The 1979 Interim revision was abandoned because it had too much variation with respect to experiment and could assign a large shear capacity to some designs that were known from experiment to have low shear capacities.”*

–Carol Shield,  
Professor, University of  
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Investigators load-tested two 30.5-foot end sections of an 88-foot girder from Mn/DOT bridge 73023, both with and without a bridge deck, measuring strain, compression, displacement and cracking.

The parametric study found that girders are most likely to be underdesigned in the region between the girder support and a distance of one-tenth of the length of the girder from the support (the region of the beam in which the newer codes call for increased steel reinforcement). The ratio of the span length to girder spacing (8.8 for the lab-tested girder) correlates well with quantities measuring the shear capacity of the girders. Bridges with a ratio of 8.5 or less were judged to be at risk of being understrength for shear. Nearly three-quarters of the bridges designed to the 1979 Interim specifications fall into this category.

### What's Next?

This large fraction indicates that this ratio is a rough tool for judging shear capacity; further understanding of the shear capacity of these beams is required. Additionally, a significant number of the bridges that Mn/DOT oversees do not conform to the 1979 Interim specifications. These fall outside of the study altogether; additional research is required to judge their shear capacity. In all, more work is needed to understand the relationship between a bridge's design specifications and its actual shear capacity to determine if any retrofitting is required.

A new \$114,000 Mn/DOT project expanding the current study is under way to meet this need. Its purpose is to investigate the effects of different specifications for girder construction on the shear capacity of existing bridge girders and to determine their reserve shear capacity, paying particular attention to the differences between design provisions and load-rating provisions. If retrofits are required, this study will also explore methods for increasing shear capacity.

*This Technical Summary pertains to Report 2007-47, “Shear Capacity of Prestressed Concrete Beams,” published March 2008. The full report can be accessed at <http://www.lrrb.org/PDF/200747.pdf>.*