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RESEARCH SERVICES

OFFICE OF POLICY ANALYSIS, RESEARCH & INNOVATION

TECHNICAL SUMMARY

Technical Liaison:
Lowell Johnson, Mn/DOT
Lowell.Johnson@state.mn.us

Administrative Liaison:
Shirlee Sherkow, Mn/DOT
Shirlee.Sherkow@state.mn.us

Co-Principal Investigators:
Carol Shield, University of Minnesota
Cathy French, University of Minnesota

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$114,390

Mn/DOT cares for more than 1,200 prestressed concrete bridges built between 1929 and 2005.

Discrepancies in the Shear Strength of Prestressed Beams with Different Specifications

Previous studies have revealed discrepancies between load rating calculations and the expected carrying capacity based upon visual inspections of bridges. In this study, researchers investigated possible sources of these discrepancies and suggested some remedies.

What Was the Need?

The codes and standards for bridge design and load rating have changed significantly over the years. Nearly two-thirds of the 1,200 prestressed concrete bridges under Mn/DOT's care were designed using pre-1983 AASHTO Standard Specifications, which are now known to contain potential shear design flaws.

When older bridges are rated using current standards, it is not unusual for the shear capacity to reduce the overall rating, meaning that the exact same bridge design would not be permitted for new construction today. While this low rating correlates with reduced capacity, some bridges receiving such a rating show no signs of distress upon visual inspection. Consequently, this method of computing load ratings makes it difficult to discern which bridges actually need attention, maintenance and repair. This uncertainty leads to a backlog in scheduling detailed inspections as well as wasted time and money. In addition, a significant number of bridges in the Mn/DOT inventory have untapped capacity and load limits that are overly conservative, unnecessarily restricting them from carrying permit loads and making the regulation of truck weights on Minnesota's roads and bridges more difficult.

What Was Our Goal?

The primary goal of this research was to resolve the discrepancies among the various methods used to determine shear capacities of prestressed concrete girders. This would facilitate recommendations that would make bridge load ratings more precise and the selection process more robust for bridges in need of closer inspection.

What Did We Do?

Researchers conducted an analytical research program, exploring a variety of factors that regulate the calculation of the shear component of a bridge's inventory rating and operating rating levels, including the effect of girder end-blocks and increased concrete strength on the overall shear strength of the girders. The inventory rating level corresponds to a live load level that can be safely supported by a bridge an indefinite number of times, while the operating rating level corresponds to the maximum live load level that can be safely supported by the bridge. Both ratings are used in guiding judgments regarding the loads allowed on the bridges. The operating rating level is used to restrict legal and permit overloads on bridges.

Fifty-four bridges with a low inventory rating level (less than unity) for shear were selected and evaluated according to the 2002 AASHTO Standard Specifications. (Note that no Mn/DOT bridges have operating rating levels for shear that are less than unity.) Researchers used the *Virtis*-BRASS software rating tool for the study. They also evaluated the rating tool by comparing the results to detailed calculations done by hand.

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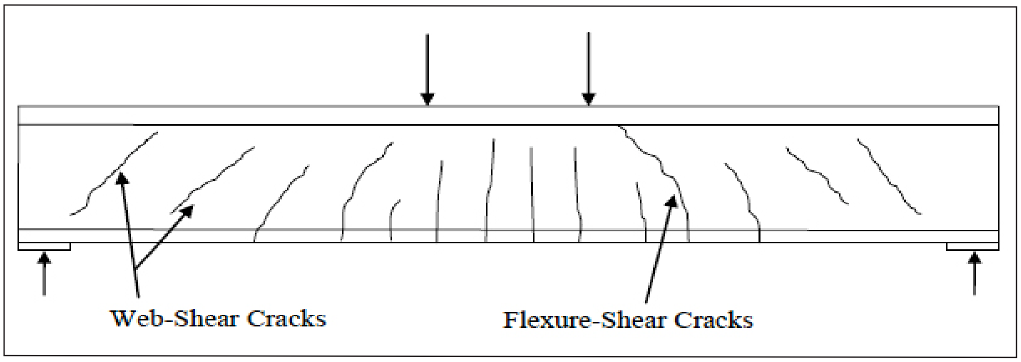

Excessive shear—the net force on a girder perpendicular to its length resulting from the pilings holding up the ends and the supported weight pushing down across the span—can crack the concrete of a girder, possibly compromising its strength.

What Did We Learn?

Researchers:

- Identified several errors in the *Virtis*-BRASS software. They notified the vendor about these errors, which have since been corrected. These corrections moved about 25 percent of the bridges that rated below unity for shear to above unity. With these corrections, bridge owners should continue to use the software to rate Mn/DOT bridges.
- Found that detailed calculations of end-block contributions to shear strength are unnecessary as they do not significantly change the shear ratings.
- Determined that compressive strengths of girders that are at least 20 years old can be assumed to increase by 20 percent from the nominal 28-day concrete compressive design strengths, producing a 2 percent to 5 percent increase in shear capacity and raising the load ratings by approximately 6 percent.
- Discovered that a number of girders in the inventory do not meet the requirements of the specification in effect at the time of design, making a simple specification-based selection impossible. Bridges with small span-to-spacing ratios (that is, $L/S_g < 10$) should receive further inspection.
- Found that shear rating in the critical section of $h/2$ from the face of the girder support is a good indicator of the overall shear rating throughout the girder and may be used as an indicator for whether further inspection is required.
- Determined that selection for further inspection should include consideration of heavy commercial average daily traffic counts.
- Found that heavy sand trucks should be used to load the bridge during inspection to reveal potential diagonal cracking due to shear. Such cracks may exist but be closed without the application of external load.

What's Next?

Though this research resolved a number of issues, questions remain about the relation between rating and performance of some Mn/DOT bridges. These questions will be resolved by more detailed on-site inspection. Researchers have also proposed a study to examine the effects of weight distribution on overall shear capacity, looking for further sources of reserve load capacity.

"Mn/DOT has a large number of prestressed concrete bridges built over 50 years. According to current rating methods, some of them rate low in shear, but these bridges are still performing well, and inspections have not detected problems."

–Lowell Johnson,
Load Rating Engineer, Mn/DOT Bridge Office Rating Section

"With the corrections, the software gives a good hierarchical ranking of the bridges."

–Carol Shield,
Professor, University of Minnesota Department of Civil Engineering

Produced by CTC & Associates for:
Minnesota Department of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us

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