Minneapolis disaster spawning new concepts in bridge research, testing and safety

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A research initiative at Oregon State University did tests with this type of connector as part of a project that will improve bridge testing and safety around the world. Credit: Photo courtesy of Oregon State University

Civil engineers at Oregon State University have developed a new system to better analyze the connections that hold major bridge members together, which may improve public safety, help address a trillion-dollar concern about aging infrastructure around the world, and save lives.

When testing is complete and the technology implemented, the system might allow a technician working for a day to produce a better analysis of a bridge's structural condition than a more expensive and highly-trained engineer could do in weeks.

Developed at OSU, the technology is being tested this fall by a simulated laboratory failure of the exact type of truss connecting plate that caused a bridge to collapse on Interstate 35W in Minneapolis in 2007, killing 13 people and injuring 145.

The work also brings focus to a little-understood aspect of bridge safety - that most failures are caused by connections, not the girders and beams they connect, as many people had assumed. The issues involved are a concern with thousands of bridges worth trillions of dollars in many nations.

"The tragic collapse of the interstate bridge across the Mississippi River in 2007 brought a lot of attention to this issue," said Chris Higgins, a professor in the School of Civil and Construction Engineering at OSU. "For decades in bridge rating and inspections, we've been concentrating mostly on the members, but in fact it's the connectors where most failures occur. And the failure of a single critical connection can bring down an entire bridge, just like it did in Minneapolis."

This is a growing concern, Higgins said, because thousands of bridges were built around the world in the 1950s and later that may be nearing the end of their anticipated lifespan, including many of those on the interstate highway system in the United States. Maintenance, repair and replacement of this infrastructure could cost trillions of dollars, he said, at local, state and federal levels.

But prioritizing which bridges are still safe and which most urgently need repair or replacement is not easy and has never been obvious, Higgins said.

"The failure of the bridge in Minneapolis was caused by a single connecting plate that inspectors saw repeatedly," Higgins said. "They took pictures of it, actually had to touch it, because an access ladder was right next to it when they were doing inspections.

"But it still wasn't readily apparent that it had a deficient design and was distorted before the accident happened," he said. "Then one day, as part of a repaving project, they had stockpiled material right above this weak spot, and the bridge collapsed."

To address this issue, Higgins has created a computerized plate analysis system that incorporates digital imaging and machine vision, and can be used by any trained technician. It can provide sophisticated data that are much more precise than a human eye could detect, analyzing connections to make sure they meet specifications and are still sound. It should allow for more widespread, low-cost and accurate inspections that will better identify trouble spots before another disaster occurs, he said.

The system works, researchers say, but now they are putting it to the ultimate test, using a state-of-the-art structural testing laboratory and other technology at OSU that will provide real data unlike any other available in the world. Using a copy of the failed connector from the Minneapolis bridge, they are going to test it this fall by applying enormous forces until it collapses. The data provided should prove the efficacy and accuracy of the system.

Similar technology, Higgins said, might also be used to inspect construction processes for new buildings or bridges to make sure they meet design standards, or even help create customized replacement parts more easily and at lower cost for existing structures.

"The bridges built 40 and 50 years ago used the design standards available at the time, which were based on the forces it was believed the bridges would be exposed to," Higgins said. "Now we have better quality materials, different construction procedures, more precise analysis methods, and we ask tougher questions, like what forces will it take to actually collapse a bridge."

In other words, modern bridges are built better. But most of the world is still driving on older bridges that have to be maintained, used, and kept safe for some time, Higgins said. The new OSU technology may allow that to be done more cost effectively while increasing the accuracy of inspections.

The findings will be published soon, Higgins said, and the system may be used more broadly in the near future. Consultants and transportation agencies have already begun to deploy the system on bridges around the country.

Provided by Oregon State University