Bridge destruction to reveal clues about 'fracture-critical' spans

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A Purdue civil engineer is taking advantage of the demolition of a bridge spanning the Ohio River to learn more about how bridges collapse in an attempt to reduce the annual cost of inspecting large spans. He will purposely damage this approach span leading to the Milton-Madison Bridge in southern Indiana, which is being demolished in stages. (Purdue School of Civil Engineering photo/Ryan Sherman)

A civil engineer at Purdue University is taking advantage of the demolition of a bridge spanning the Ohio River to learn more about how bridges collapse in efforts to reduce the annual cost of inspecting large spans.

"There is a whole family of bridges called fracture-critical," said Robert J. Connor, an associate professor of civil engineering. "This means that if an important tension member breaks, it's thought the bridge will fall down."

However, modern analysis techniques could be used to learn whether such bridges really are fracture-critical, or whether other structural elements would share the load if a major piece failed.

"We are looking at 'after-fracture redundancy,' or whether a bridge does remain standing after a key element fails," Connor said. "There is a lot of interest now in this issue because bridges classified as fracture-critical are very expensive to inspect and are subjected to more rigorous inspection requirements that are somewhat arbitrary. However, as is well known, bridge owners have limited resources. But if we could show they have redundancy, that a bridge won't collapse, more rational inspection strategies could be developed, allowing resources to be placed on the bridges that really should be inspected."

To test his hypothesis, Connor will purposely damage an approach span leading to the Milton-Madison Bridge in southern Indiana. The 82-year-old bridge, on U.S. Route 421 connecting Milton, Ky., and Madison, Ind., is being demolished in stages. A replacement bridge is scheduled for completion in 2012.

Federal law requires that the fracture-critical bridges be inspected every two years. Workers must perform a detailed "hands-on" inspection of such spans.

"A bridge over the Ohio River is almost a mile long, and the inspectors have to be arm's length away from any of these members identified as fracture-critical, looking for cracks and whatnot," Connor said. "That's really expensive, and if there is no point in doing it because that member isn't going to fail that way, why are you doing it?"

Connor saw an opportunity in the span's demise.

"At any major river crossing you always have little bridges, called approach spans, leading to the big bridge," he said. "I said to myself, 'These are really good test specimens that they are just going to demolish when they put the new bridge in.'"

Connor suggested piling a load of sand onto one of the approach spans to simulate the weight of trucks and then cutting a critical member of the bridge with an explosive charge. He took his idea to an engineering consultant, Michael Baker Corp., and general contractor Walsh Construction, as well as officials from the Federal Highway Administration and Indiana and Kentucky state transportation departments.

The proposal was approved and federal funding provided.

Connor and his team of research engineers and a student have fitted the 100-foot approach span with 50 sensors and will damage a portion of the span and record the findings. The researchers will take high-speed video in addition to recording sensor data. The test is tentatively set for mid-August.

"We expect to be able to show whether, if one piece fails, the whole bridge won't fail because there are secondary load paths that kick in," said Connor, who has been involved in numerous steel bridge failure investigations, the most recent being the 2007 I-35W Mississippi River

bridge collapse in Minneapolis.

Connor believes it is the first study of its kind on a truss bridge that is in place.

Provided by Purdue University