Modern tests demonstrate soundness of old iron bridge

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This photo shows the condition of the bridge in 1977 with the flooring system removed, before it was moved from Bedford County to the Ironto Wayside and restored by the Virginia Transportation Research Council. Credit: Photo by Wallace T. McKeel Jr., VTRC senior research scientist

An unusual bowstring truss iron bridge that carried traffic across Roaring Run in Bedford County, Va. for almost 100 years is now a picturesque footbridge at the I-81 Ironto, Va. rest stop. Built in 1878, it is the oldest standing metal bridge in Virginia. In early December, a Virginia Tech undergraduate conducted a load-bearing analysis of the structure.

It may have been the first such test on the bridge. "There was no documentation of a structural analysis from when the bridge was designed," said Elaine Huffman of Bowie, Md., a student in civil

engineering. As part of her research project, she did a historical survey of the bridge through a literature review, developed a computer-based structural analysis, and recently verified the computer model with an actual load test.

The bowstring truss design was patented by Z. King in 1859 under the name "Tubular Arch Bridge," Huffman learned. When the bridge was bypassed by a pipe culvert in the 1970s, it began to fall into disrepair. "The Virginia Transportation Research Council recognized the importance of the bridge as a historical landmark and worked to preserve it by restoring it and putting it into use elsewhere," said Huffman. "Much work was put into determining the original paint scheme and recreating it once the bridge was relocated. The new site was selected to maintain the function of the bridge."

Huffman noted a number of unique features of the wrought iron bridge. For example, "there is a unique bracing system perpendicular to the truss that restrains lateral movement of the arch," she said. "Cross braces prevent longitudinal motion of the bridge deck as it hangs from the vertical cables."

In her computer model stress analysis, Huffman applied three different loads, two of them from the era of iron bridges. One test came from the 1893 Practical Treatise on the Construction of Iron Highway Bridges, which suggested that a uniform distributed load of 75 pounds per square foot (psf) be applied to ordinary country bridges 60 feet and shorter to represent a typical load. For a vehicular point load, the 1898 work, De Prontibus, suggested using a six-foot by eight-foot wagon load of five tons distributed equally between all four wheels. The third load was representative of the three-ton truck that would be used in the load test.

The deflected shape of the truss with the 3.5-ton wagon load was the same as the five-ton wagon load, Huffman determined. The uniform

load created the highest stresses and highest deflections. "Generally, stresses are limited in a modern bridge design to 60 percent of the yield stress in service," Huffman said. "But in its current location, the bridge will most likely never see such high stresses because pedestrian traffic over it is neither constant nor high enough."

On a clear, late fall day, Virginia Tech researchers conducted load tests on the restored 1878 iron bridge at the Ironto Wayside -- the only such bridge in Virginia. Credit: Jim Stroup, Virginia Tech Photo

On December 3, Huffman carried out a load test to verify the accuracy of the computer model. Dial gages, which turn small linear movements into readable increments on a dial, were set up below the center of each truss. Then, a truck weighing three tons was driven across the bridge, pausing every five feet to record the deflection.

"The bridge behaved as expected for the most part. The maximum deflection recorded for one truss was 0.14 inches, 70 percent of the result predicted by the model. However, the second truss deflected a smaller amount," Huffman said. "Preliminary analysis suggests that the diagonal cable members have loosened over time and are supporting the bridge loads unevenly, allowing one truss to deflect more than the other,"

The results from this test will be contributed to the Adaptive Bridge Use Project based at the University of Massachusetts Amherst and supported by the National Science Foundation. The program aims to restore and study historic bridges to enhance structural engineering curriculum and preserve examples of bridge designs from the past, said Huffman's advisor, Cris Moen, assistant professor of civil and environmental engineering.

The Ironto Wayside footbridge, the last remaining bowstring arch-truss in the state, is a significant landmark in Virginia. "It is useful to study historic landmarks, as they can guide us in the design of future structures," said Huffman.

Her computer model can be used as an example for creating structural models to test other bridges, said Moen.

"Perhaps the analysis will aid in the future assessment of the bridge's condition as it continues to be preserved as a historic landmark," said Huffman.

More information: www.ecs.umass.edu/adaptive_bridge_use/

Provided by Virginia Tech