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NEW BRIDGE UNFOLDS IN JAPAN

By Kevin Wilcox

Engineers test a lightweight, folding bridge that can speed access to victims following a natural disaster.

August 18, 2015—A research team at Hiroshima University's Institute of Engineering, inspired by traditional Japanese origami, has developed and successfully tested a folding bridge that can be deployed quickly, in some cases without foundations, to aid rescue efforts in the immediate aftermath of a natural disaster.

The team is led by Ichiro Ario, Ph.D., an assistant professor in the Department of Social and Environmental Engineering within the university's Division of Civil and Structural Engineering. Ario sought to address the chaotic situation following major earthquakes, floods, tsunamis, or landslides when critical infrastructure has been destroyed and the lives of victims depend on the swift action of emergency responders.

At a recent test, the largest folding bridge developed to date was deployed across a small stream and tested with passenger vehicles. Hiroshima University

Japan has a long history of devastating earthquakes, tsunamis, typhoons, and mudslides that have killed thousands and destroyed infrastructure. In 1923, the Great Kantō earthquake killed as many as 142,800 people and created $14 billion in damages in current valuation. Portions of the country are still recovering from the Tōhoku earthquake and tsunami in 2011.

The Mobile Bridge, as it is called, resembles a scissor lift turned on its side with aluminum beams telescoping from one side of a stream or ravine to the other. In the largest of the test bridges, the beams have large circular voids to reduce weight.

"This type of bridge has the advantages of compact volume and speedy expansion, [requiring] no large yard, and only a few engineers," said Ario, who provided written answers to questions posed by *Civil Engineering* online.

Ario said that a typical replacement bridge put into place following a natural disaster in Japan is heavy and complex, designed to accommodate large trucks as well as first responders. This type of span requires multiple deliveries to a disaster site at a time when that can be difficult. It also requires a large staging area. Ario wanted to create a lighter bridge that could be delivered in a single shipment on one trailer and deployed rapidly.

The Mobile Bridge was inspired by origami, in which paper is folded into patterns that often optimize structural integrity. By optimizing this folding process with computer models, Ario was first able to develop and test a pedestrian bridge in 2009. This pedestrian folding bridge can be deployed by three people in a matter of minutes using manual power. The bridge can support one person at a time and span as far as 26.9 ft.

Ario said that once his dream of completing the small prototype had been realized, he knew "I would have to carry [on] to assemble the real-sized Mobile Bridge, which a vehicle can pass [through]."

A type of folding bridge with a single joint in the middle has been commonplace in military applications for decades, but those bridges require heavy, specialized tanks to deploy. The goal of the team at Hiroshima University was to develop a bridge that can be transported by a more commonly available trailer and put into place more easily; the design that the team devised can be deployed by three people in approximately 10n minutes. It can span 56 ft and has a capacity of 5 tons, enough to hold most light vehicles. The folded bridge weighs approximately 13 tons, is 13 ft tall and 9.5 ft wide. The larger bridge is equipped with hydraulics to extend the scissor members and integral deck plates.

Earlier this summer, the team tested the latest version of the large bridge, deploying it over a small stream known as the Hongo River in Fukuyama City, near Hiroshima. Once it was deployed, a series of passenger cars was driven across it.

Ario notes that foundations for a deployment are determined on a case-by-case basis. "Ordinarily, we have many block protections made of concrete materials along both sides of a river," he said. "It is very simple. If there is not any deformation when a heavy truck preloads on the foundations, it will be possible" to use the bridge in that location, he explained.

The team would like to develop an even larger version of the bridge, capable of handling heavier loads and remaining in place for a longer period time. It is seeking the funding to continue the research.

"We hope that we don't have to use this [bridge] after a natural disaster, such as earthquake, landslide, or flooding, in your country or our country," Ario said. "However, we should be equipped if it happens."