Results Show Seismic Potential Of Prefabricated Segmental Bridges

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By Jim Parsons

Prefabricated segmental bridge designs that have helped speed construction and save money in many parts of the country may also have a place in seismically active regions, according to recent tests conducted by the University of Buffalo's Department of Civil, Structural and Environmental Engineering, and its Multidisciplinary Center for Earthquake Engineering Research (MCEER).

As part of a Federal Highway Administration-funded project exploring seismic response of Accelerated Bridge Construction (ABC) systems, the research team erected a half-scale 60-ft-long, eight-segment post-tensioned superstructure supported by 10 ft, 5 in. tall hollow piers on 10 x 10 ft concrete foundation blocks. The blocks were mounted on the twin shake tables at the university's Structural Engineering and Earthquake Simulation Laboratory (SEESL).

Unbonded post-tensioned tendons were used to provide the test bridge with maximum freedom of movement, according to Amjad Aref, a University of Buffalo civil engineering professor and the project's co-principal investigator

“We wanted to allow the segments to rock or slide relative to each other, which is a very good way to dissipate seismic energy,” Aref says. “Locking segments together with shear keys would focus the load on different components and potentially cause failures.”

Over a three-week period, the 70-ton test structure was subjected to more than 150 simulated earthquakes, each lasting about a minute. The tests gradually increased in intensity, with varying levels of horizontal, transverse, and vertical motion. Some simulations were performed with the shake tables moving in unison, while others simulated seismic waves.

Between each test, white noise acoustical measurements were performed to spot any signs of structural fatigue resulting from the repetitive shaking.

The final two tests replicated a 7.0 magnitude earthquake, the maximum capacity of the shake tables.

“Aside from some minor spalling on the segments, there was no damage to the superstructure from start to finish,” says Aref. “Even when we subjected the test structure to the MCE [maximum credible earthquake] for vertical motion, the segments returned to place with no more than a 1/16-inch sliding offset.”

Aref adds that the earthquake simulations answered some questions, but raised others.

“There's no doubt that that this design would perform well in a severe seismic environment,” he says. “That's a credit to the post tensioning, which held up extremely well under three weeks of near-continuous shaking. The segments always came back plum and confirmed our original idea of the system's re-centering capability.”