Engineers simulate large quake on curved bridge (w/ video)

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Laboratory technician Chad Lyttle makes adjustments to sensor cables in final preparations for earthquake engineering tests at the University of Nevada, Reno's Large-Scale Structures Lab. The first-ever tests on a bridge with truck traffic will help improve design regulations and standards and assure safer bridges during large earthquakes. Credit: Photo by Mike Wolterbeek, University of Nevada, Reno.

Six full-size pickup trucks took a wild ride on a 16-foot-high steel bridge when it shook violently in a series of never-before-conducted experiments to investigate the seismic behavior of a curved bridge with vehicles in place. The 145-foot-long, 162-ton steel and concrete bridge was built atop four large, 14-foot by 14-foot, hydraulic shake tables in the University of Nevada, Reno's world-renowned Large-Scale Structures Earthquake Engineering Laboratory.

"We took the bridge to its extreme, almost double what we planned at the outset," Ian Buckle, professor of civil engineering and director of the large-scale structures lab, said. "Preliminarily we see that in low amplitude earthquakes the weight of the vehicles actually helps the seismic effects on the structure, while at higher amplitudes the trucks hinder considerably the bridges ability to withstand an earthquake."

The trucks bounced and swayed as the four-span bridge's concrete columns deflected more than 14 inches in each direction, the steel girders twisted and the floor of the lab shook from the energy applied to the bridge. The bridge, with 80 feet of curvature, filled the cavernous high-bay lab on the University of Nevada, Reno campus from end-to-end.

"Whether you saw the experiment in person or watch the video, remember that this is a 2/5 scale model, and the movement you see would be two and a half times greater on a full-scale bridge," Buckle, principal investigator of the research project, said. "It would be scary to be driving under those conditions."

"Currently, bridges are not designed for the occurrence of heavy traffic and a large earthquake at the same time," he said. "With increasing truck traffic and frequent congestion on city freeways, the likelihood of an earthquake occurring while a bridge is fully laden is now a possibility that should be considered in design. But there has been no agreement as to whether the presence of trucks helps or hurts the behavior of a bridge during an earthquake, and this experiment is intended to answer this question."

The complete answer will come after months of examining the many gigabytes of information gleaned from the 400 sensors placed on the bridge and trucks. The results of this work, titled "Seismic Effects on Multi-span Bridges with High Degrees of Horizontal Curvature," will be

used to frame changes to current codes and lead to safer bridges during strong earthquakes.

The four, 50-ton capacity shake tables simulated more than twice the strength of the 1994 Northridge, Calif. earthquake, which resulted in 33 deaths, 8700 injured and $2 billion damage in southern California. The ground acceleration of that quake was one of the highest ever instrumentally recorded in an urban area in North America, measuring 1.7 g (acceleration) with strong ground motion felt as far away as Las Vegas, Nev., more than 270 miles away. Through computer programs, the recordings of the quake control the hydraulically driven shake tables to simulate the seismic event in the University's lab.

Six different configurations of the curved bridge will be tested in the experiment that will continue for several more months, without the trucks, to examine different components, including column design, abutment design, seismic isolation systems. The bridge was designed by a team of eight graduate students under the supervision of Buckle and two other professors, Ahmad Itani and David Sanders, in the civil and environmental engineering department. The team includes Project Manager Kelly Lyttle, and graduate research assistants Moustafa Al-Ani, Michael Levi, Eric Monzon, Ahmad Saad, Danielle Smith, Chunli Wei, Joe Weiser, and Hartanto Wibowo.

The California Department of Transportation is one of the agencies sponsoring the live load portion of the experiment. The testing of this model is part of a larger project, investigating seismic resilience of highway systems, funded by the Federal Highway Administration.

The University of Nevada, Reno earthquake simulation facility is managed as a national shared-use Network for Earthquake Engineering Simulation equipment site created and funded by the National Science Foundation to provide new earthquake engineering research testing

capabilities for large structural systems.

Provided by University of Nevada, Reno