Quake Research to Provide Rare Glimpse of How Structures Collapse

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Structural engineers at the University at Buffalo are conducting some of the most comprehensive experiments ever attempted to develop methods of evaluating and designing steel buildings so that they will be less vulnerable to collapse during strong earthquakes.

The experiments are part of a project aimed at both designing new structures that can withstand large deformations without collapsing and at evaluating existing buildings to determine where retrofits may be necessary.

The gap in information about how structures collapse became painfully clear last month after the 7.9 earthquake in Sichuan, China, when the tragic collapse of numerous schools throughout the province caused the deaths of thousands of schoolchildren, the UB researchers noted.

"The whole idea of this project is to find out how much damage a particular building can take before it collapses," said Gilberto Mosqueda, Ph.D., assistant professor in the UB Department of Civil, Structural and Environmental Engineering and principal investigator on the research.

He explained that the philosophy behind building codes is that while buildings may sustain damage in a strong earthquake, they should do so in such a way that the damage can be absorbed by the structure without collapsing so that people can safely evacuate.

"But many different factors besides design come into play, such as the quality of construction, the known seismicity of an area and the magnitude of an event," he continued.

"The problem from the structural side is that there is very little experimental data available to verify our models or assumptions on the nature of how structures collapse because these experiments are very difficult to do in a laboratory," he said.

Mosqueda said that the shake table facility in Miki City, Japan -- the world's largest -- is the only one in the world capable of subjecting full-scale structures to simulated ground motions that can trigger a collapse. Those experiments tend to be expensive in terms of cost, time and labor.

For that reason, Mosqueda has geared his research toward developing more realistic, reliable and economical ways of testing large-scale structures. To do this, his project will combine laboratory experiments of partial structures that can capture the initiation of a collapse either in slow-motion or in real-time with numerical simulations of the remaining full-scale building. This hybrid numerical and experimental model will then be subjected to earthquake loading.

In order to simulate the earthquake loads, the experimental portion of the research will employ high-performance hydraulic actuators that will push and pull elements of the partial structure plus or minus 20 inches at forces of up to 220,000 pounds. Experiments will be performed in UB's Structural Engineering and Earthquake Simulation Laboratory (SEESL) in the School of Engineering and Applied Sciences.

"Through these experiments, we will be able to capture the interaction between a building's elements, such as columns, beams and floor slabs during strong ground motions," Mosqueda said.

Some of those experiments will be conducted over the Internet, with pieces of the same structure simultaneously being tested at UB and Kyoto University, Japan, while numerical simulations will produce data on how the entire structure would perform under the same conditions. These "distributed hybrid tests," as they are called, are made possible by international collaborators and the National Science Foundation's George E. Brown Jr. Network for Earthquake Engineering Simulation (NEES) Facility, a nationwide earthquake-engineering "collaboratory" of which UB is a key node.

Mosqueda's project is the result of a prestigious $400,000 Faculty Early Career Development Award he received from the NSF to develop a "Hybrid Simulation Platform for Seismic Performance Evaluation of Structures Through Collapse." According to the NSF, the CAREER program recognizes and supports the early career-development activities of teacher-scholars "who are most likely to become the academic leaders of the 21st century."

Source: University at Buffalo