'Smart' shock absorbers for quake-prone structures

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Rice University structural engineering researchers are leading a new $1.6 million research program funded by the National Science Foundation to help design a new generation of adaptive, "smart" shock absorbers for buildings and bridges in earthquake-prone areas.

"What we are trying to do is to come up with new and intelligent ways to develop smart buildings and bridges that sense what's happening when a quake hits and react in real-time," said principal investigator Satish Nagarajaiah, professor in civil and environmental engineering and professor in mechanical engineering and materials science.

To imagine what a building undergoes in an earthquake, Nagarajaiah suggests imaging yourself standing in a moving bus or train.

"Riders make their bodies and muscles tense when the bus moves, and they relax as soon as the sudden motion stops," Nagarajaiah said. "The typical steel-framed building or bridge can't do that, but we want to find technologies like adaptive stiffness and damping systems that can give structures that ability."

Nagarajaiah said about 100 U.S. buildings and bridges -- including the famed Golden Gate Bridge -- have been built or are being retrofitted with large, passive dampers, which work just like the shock absorbers in a car, using pistons and hydraulic fluid to absorb the impact of sudden shocks. But passive dampers do not have the ability to adjust their properties—such as stiffness and damping—in real time. By design, they perform the same way in every earthquake, but Nagarajaiah said quake researchers have discovered in recent years that all quakes are not created equal.

The 1994 Northridge earthquake in California, the 1995 Kobe earthquake in Japan, the 1999 Chi Chi earthquake in Taiwan and the most recent 2008 Sichuan earthquake in China are each examples of quakes that delivered a massive, initial shockwave that was particularly damaging for structures near the epicenter.

"Our aim is to create smart structures that have the intelligence to sense what kind of shock is arriving and react with the best possible strategy to minimize damage," Nagarajaiah said.

Nagarajaiah's earlier research on smart structures and structural control for seismic protection has led to quake-protection systems that have been implemented in China and Japan.

In the newly funded project, his lab is partnering with researchers at the University at Buffalo; Rensselaer Polytechnic Institute; the University of California, Los Angeles; and California State University, Fresno.

The grant was awarded through the NSF's George E. Brown Jr. Network for Earthquake Engineering Simulation, or NEES. The 15 NEES sites provide a shared network of experimental facilities, earthquake simulation software and online collaborative tools that allow earthquake researchers across the country to perform large-scale experiments remotely. The advantages are that universities without large-scale facilities can perform experiments remotely at a NEES site, and costs of testing are borne by the NEES site that is separately funded by NSF, thus allowing the researchers to use the entire grant for theoretical research and validation.

Nagarajaiah said he and his colleagues will coordinate and run experiments at the University of Buffalo's NEES site, the Structural Engineering and Earthquake Simulation Laboratory. The lab has state-of-the-art shake tables and large-scale building and bridge models that Nagarajaiah's team can access via the Internet.

Source: Rice University