Designing a (Wooden) Earthquake-Proof Home

Last week, a 6.0-magnitude earthquake hit China, destroying an estimated 18,000 homes and damaging 75,000 buildings, according to the Xinhua News Agency. The affected area, Yao'an county, is a relatively poor agricultural region, and many of its homes were not designed to withstand an earthquake. The disaster highlights the need for more affordable earthquake-proof structures, and new research could help. New building designs may help make cheap, accessible materials like wood as earthquake-proof as expensive ones. But first, researchers have to test the designs–in the world's largest shake lab.

By Lisa Merolla
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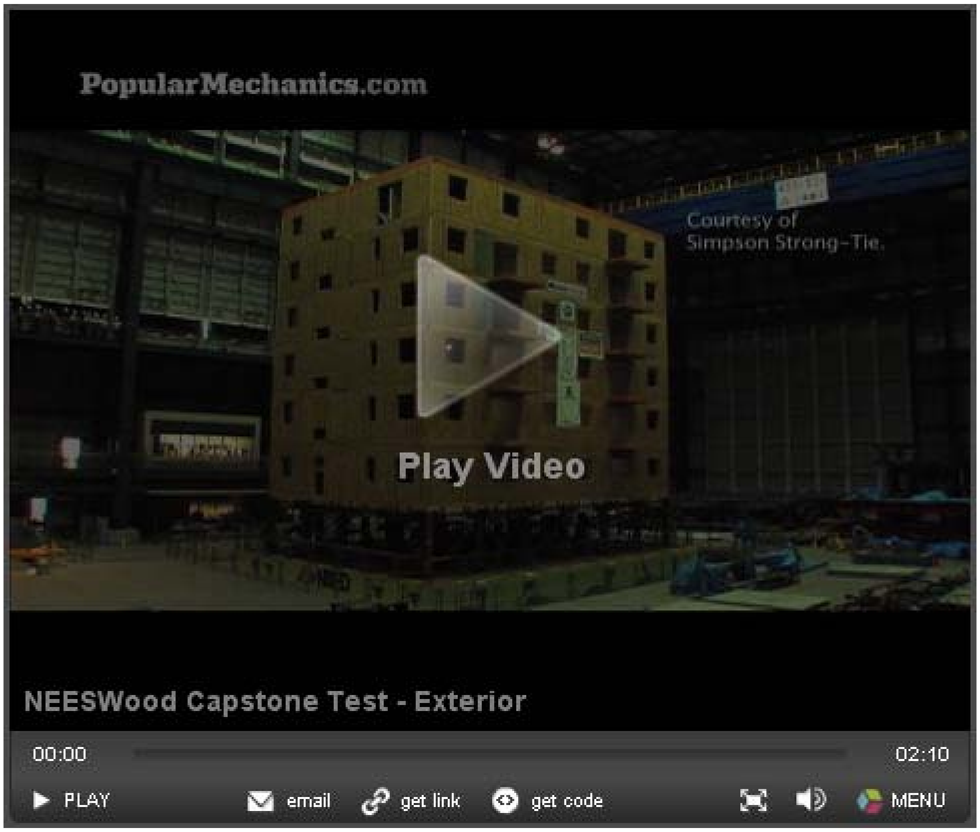
On July 14, all eyes in Japan's Hyogo Earthquake Engineering Research Center turned to the seven-story wood condominium in the center of an enormous room. Deep rumblings and the sound of massive pistons pumping filled the room as the condo began to shake. It moved up and down, left and right, back and forth. Less than a minute later, the violent movement stopped and the surrounding engineers erupted in cheers. The condo remained standing, with only minor signs of damage–the building had just survived a simulated quake that reached approximately 7.5 on the Richter scale.

This shake test is part of a larger experiment in which engineers are trying to make wood, a cheap, abundant material, earthquake-proof. Typically, earthquake research focuses on testing high-tech materials such as flexible concrete or metal alloys. But because wood is more prevalent in the construction business, a group of researchers from five universities is trying to earthquake-proof wood midrise buildings.

The idea is to look for new, innovative ways to construct wood buildings, says lead researcher John van de Lindt, an engineer at Colorado State University. "New designs will give a new option [for builders] that is less expensive and more sustainable," he says.



The first design, being tested in Miki City, Japan, changes the pattern of nails in a building to better distribute stiffness among different floors. Tall wood buildings in an earthquake are vulnerable to what van de Lindt calls soft story, a phenomenon in which one story does not remain as stiff as the floors above it. "It just collapses, almost pancakes," van de Lindt says. Engineers previously took into consideration only a building's initial stiffness, but this new model is based on measurements of how stiffness changes in a building during an earthquake. After looking at the pressure points around the building, engineers changed the nail patterns to make points of strength that coincided with the structural pressures experienced during a quake.

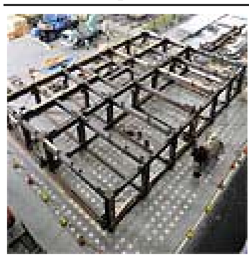
The researchers also used 63 anchor tiedown systems from Simpson Strong-Tie to add stability. These steel-rod systems run from the building's steel-frame foundation to the roof–working to prevent the building from rocking. Steel straps and plates attached adjacent levels to resist shearing, the tendency for different levels to slide sideways relative to each other and come apart.

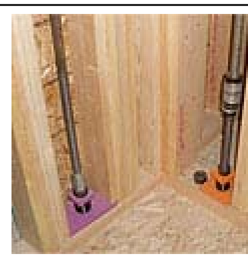
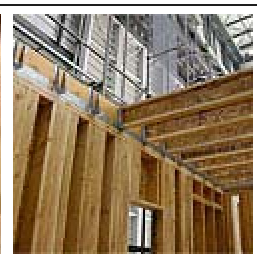
This condo was tested on the world's largest shake table, called E-Defense, which can recreate the conditions of large earthquakes. The quake is simulated by forcing large amounts of fluid in and out of hydraulic pistons. Those pistons under the table move it up and down, while others cause left and right as well as front and back motions.

E-Defense is the only shake table in the world able to accommodate the researcher's model building, a seven-story condominium weighing almost 1 million pounds. The table can support models up to 2.5 million pounds. During the test on July 14, researchers carefully examined the building for signs of damage, including cracks and ruined stairs. Steve Pryor, an engineer with Simpson Strong-Tie, said they were very pleased with the building's performance and the damage appeared to be "largely cosmetic."

But the world's largest shake table is not likely to keep that title for long. Another earthquake project at the University of Buffalo will test two 72-foot bridges under earthquake-like vibrations. These bridges use seismic isolation technology, which isolates a structure from its foundation to prevent it from feeling ground vibrations. Tests on these bridges are scheduled to begin in July 2010.

Earthquake House Photo Gallery



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