Researchers Announce New Way to Assess How Buildings Would Stand Up in Big Quakes

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How much damage will certain steel-frame, earthquake-resistant buildings located in Southern California sustain when a large temblor strikes? It's a complicated, multifaceted question, and researchers from the California Institute of Technology, the University of California, Santa Barbara, and the University of Pau, France, have answered it with unprecedented specificity using a new modeling protocol.

The results, which involve supercomputer simulations of what could happen to specific areas of greater Los Angeles in specific earthquake scenarios, were published in the latest issue of the *Bulletin of the Seismological Society of America*, the premier scientific journal dedicated to earthquake research.

"This study has brought together state-of-the-art 3-D-simulation tools used in the fields of earthquake engineering and seismology to address important questions that people living in seismically active regions around the world worry about," says Swaminathan Krishnan, a postdoctoral scholar in geophysics at Caltech and lead author of the study.

"What if a large earthquake occurred on a nearby fault? Would a particular building withstand the shaking? This prototype study illustrates how, with the help of high-performance computing, 3-D simulations of earthquakes can be combined with 3-D nonlinear analyses of buildings to provide realistic answers to these questions in a quantitative manner."

The publication of the paper is an ambitious attempt by the researchers to enhance and improve the methodology used to assess building integrity, says Jeroen Tromp, the McMillan Professor of Geophysics and director of the Seismological Laboratory at Caltech. "We are trying to change the way in which seismologists and engineers approach this difficult interdisciplinary problem," Tromp says.

The research simulates the effects that two different 7.9-magnitude San Andreas earthquakes would have on two hypothetical 18-story steel frame buildings located at 636 sites on a grid that covers the Los Angeles and San Fernando basins. An earthquake of this magnitude occurred on the San Andreas on January 9, 1857, and seismologists generally agree that the fault has the potential for such an event every 200 to 300 years. To put this in context, the much smaller January 17, 1994, Northridge earthquake of 6.7 magnitude caused 57 deaths and economic losses of more than $40 billion.

The simulated earthquakes "rupture" a 290-kilometer section of the San Andreas fault between Parkfield in the Central Valley and Southern California, one earthquake with rupture propagating southward and the other with rupture propagating northward. The first building is a model of an actual 18-story, steel moment-frame building located in the San Fernando Valley. It was designed according to the 1982 Uniform Building Code (UBC) standards yet suffered significant damage in the 1994 Northridge earthquake due to fracture of the welds connecting the beams to the columns. The second building is a model of the same San Fernando Valley structure redesigned to the stricter 1997 UBC standards.

Using a high-performance PC cluster, the researchers simulated both earthquakes and the damage each would cause to the two buildings at each of the 636 grid sites. They assessed the damage to each building based on "peak interstory drift."

Interstory drift is the difference between the roof and floor displacements of any given story as the building sways during the earthquake, normalized by the story height. For example, for a 10-foot high story, an interstory drift of 0.10 indicates that the roof is displaced one foot in relation to the floor below.

The greater the drift, the greater the likelihood of damage. Peak interstory drift values larger than 0.06 indicate severe damage, while values larger than 0.025 indicate that the damage could be serious enough to pose a serious threat to human safety. Values in excess of 0.10 indicate probable building collapse.

The study's conclusions include the following:

o A 7.9-magnitude San Andreas rupture from Parkfield to Los Angeles results in greater damage to both buildings than a rupture from Los Angeles to Parkfield. This difference is due to the effects of directivity and slip distribution controlling the ground-motion intensity. In the north-to-south rupture scenario, peak ground displacement is two meters in the San Fernando Valley and one meter in the Los Angeles basin; for the south-to-north rupture scenario, ground displacements are 0.6 meters and 0.4 meters respectively.

o In the north-to-south rupture scenario, peak drifts in the model of the existing building far exceed 0.10 in the San Fernando Valley, Santa Monica, and West Los Angeles, Baldwin Park and its neighboring cities, Compton and its neighboring cities, and Seal Beach and its neighboring cities. Peak drifts are in the 0.06-0.08 range in Huntington Beach, Santa Ana, Anaheim, and their neighboring cities, whereas the values are in the

0.04-0.06 range for the remaining areas, including downtown Los Angeles.

o The results for the redesigned building are better than for the existing building. Although the peak drifts in some areas in the San Fernando Valley still exceed 0.10, they are in the range of 0.04-0.06 for most cities in the Los Angeles basin.

o In the south-to-north rupture, the peak drifts in both the existing and redesigned building models are in the range of 0.02-0.04, suggesting that there is no significant danger of collapse. However, this is indicative of damage significant enough to warrant building closures and compromise human safety in some instances.

Such hazard analyses have numerous applications, Krishnan says. They could be performed on specific existing and proposed buildings in particular areas for a range of types of earthquakes, providing information that developers, building owners, city planners, and emergency managers could use to make better, more informed decisions.

"We have shown that these questions can be answered, and they can be answered in a very quantitative way," Krishnan says.

Source: Caltech

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