How Quakes Affect Buildings

by Kathy B. Sedgwick

During a quake, horizontal forces are estimated to reach 100 percent of the building’s weight. The whiplash effect of the horizontal movements causes foundations to shift, rotating in all directions at once.

Buildings that are too close together suffer from “pounding” damage. As buildings remaining on their foundations flex from side to side, they actually knock into each other.

Falling parapets and cornices create a risk to people outside the building.

Tall buildings have special problems. In a strong gust of wind, a skyscraper flexes and bends. The period of time it takes a building to oscillate back and forth is called its “natural period.” If the period of a seismic wave matches the natural period of a building, the seismic energy is simply added to the oscillation of the building, wave after wave. As a result, the swaying of this particular building increases dramatically. Nearby buildings of a different height are not similarly affected because their natural period is different.

Past construction techniques exacerbate the problem. Many older unreinforced masonry and wood-frame structures simply rest on a concrete or brick foundation. A quake only has to knock a building a few inches off center for the walls to drop and the load of the upper floors collapses the lower floors.

Seismic Isolation Technology

There have been numerous theories of how buildings can best “ride out” an earthquake. One such theory suggests that if a building is isolated from the ground, it will be protected from the ground’s motion. Based on this theory, called seismic isolation, engineers place buildings on rollers, springs, sheets or, most commonly, bearings. Isolators are put in place at the top of basement columns, middle supports or the sub-basement. They act like shock absorbers to give building occupants a more comfortable ride during a quake.

Although the theory of base isolation has existed for at least 100 years, only about 150 structures in the world use this technology, most of them in Japan.

U.S. engineers also have put the base isolation theory to test in a number of prominent structures. For example, the new Law and Justice Center in Rancho Cucamonga, Calif., employed base isolation technology. The center is supported by 98 giant rubber pads to absorb shock waves. During a quake, the pads will allow the building to move as much as 15 inches from side to side without damaging the structure.

While most often applied in new construction, retrofit applications of base isolation technology, though considered expensive, are not unknown. When the Salt Lake Buildings — Cont’d on page 43
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City Civic Center was retrofitted in 1984, seismic isolation technology was put into use. The center is located just two miles from a fault line. During retrofit, the building was jacked up, parts of columns were cut away, and rubber bearings were added.

What We’ve Learned from Past Quakes

On Oct. 17, 1989, the Pacific Plate slipped more than six feet closer to the North Pole relative to the North American Plate. The resulting Loma Prieta earthquake measured 7.1 on the Richter Scale.

The Loma Prieta revealed a number of important facts about earthquake-resistant construction:

■ Although high-rise structures designed and built in recent years pitched and swayed, they didn’t sustain significant damage.

■ Deep, soft soils are dangerous.

■ Unreinforced masonry buildings are potential killers. They are not especially strong, and buckle under the lateral forces of a quake.

Earlier quakes also did much to improve our understanding of how seismic activity affects structures.

From a 1971 quake engineers learned that buildings need to be ductile as well as strong. They must be flexible, able to bend and stretch without breaking. Tall buildings must be especially flexible and should behave as one unit with all the elements tied together, much like a tree bending in the wind. All floors should be the same height and strength. And, the taller the building, the stronger the structural skeleton should be. Medium buildings can be flexible or rigid. Windows should be symmetrical and not too large.

Are We Prepared?

Experts say the United States is prepared for moderate activity earthquakes but not for “the Big One,” the 8.0 quake that is predicted will occur before 2013. (A one point increase on the Richter Scale equals a ten times increase in activity; thus the Big One will be more than 10 times stronger than the Northridge quake.)

By 1989, when the Loma Prieta struck, only 1,000 of 7,000 old masonry buildings in Los Angeles had been reinforced under a 1981 ordinance requiring that all be strengthened or demolished by 1992. Since then remedial strengthening of buildings in Los Angeles has progressed, but such efforts are slow or absent elsewhere in the region. It is to be hoped that normal attrition of susceptible structures and code-mandated retrofit will have made headway before the big one strikes.

About the Author

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