Functional Recovery from Earthquakes?

Some consider the typical "Collapse Prevention Objective" an inadequate target for the seismic design of tall buildings, advocating instead that buildings "functionally recover," e.g., be inhabitable after an earthquake. Debating Tall asks two experts, "Can we design tall buildings for 'functional recovery'?"

YES

Rene Lagos

CEO, Rene Lagos Engineers

Seismic performance of buildings historically has been evaluated against a "Collapse Prevention Objective." Today, the profession is already capable of providing safe buildings in seismic regions when the proper technologies are incorporated. The greater concern is related to a different design objective: resilience of tall buildings – preserving or recovering functionality – while collapse prevention is purely a life-preservation objective during the event.

In buildings with conventional lateral load systems, collapse prevention assumes and accepts large lateral displacements and non-reparable damage in order to dissipate energy in a ductile and predictable process in the nonlinear range for the Maximum Considered Earthquake (MCE) event. In other words, it provides "life insurance." Resilience requires stiffness to limit lateral displacements and to avoid significant damage, keeping the structure essentially elastic. This is "health insurance" that will keep the building functional after common-to-rare seismic events. These two design objectives are related to different problems and require conceptually different solutions.

To assure satisfactory seismic performance, select a structural lateral load system that takes care of both objectives simultaneously, because they correspond to two different limit states for two different ground motion magnitudes. The divergent perceptions of "safety" by structural engineers and the common citizen can be traced to this issue.

Today, the knowledge and the technology to solve these challenges already exists and it has been developed and used by mechanical engineers for almost a century. It has only been used by structural engineers, in the form of seismic protection devices such as isolators and energy dissipation devices, on a few buildings in seismically active countries in the last two decades – importantly, with excellent results under strong earthquakes.

In the future, the tall building community must envision the structural systems of buildings as systems of passive and active mechanical devices, rather than the conventional lateral-load systems commonly used today. The approach has demonstrated its efficacy in all the big earthquakes of the past decade.

NO

Dr. Thomas Heaton

Director, Earthquake Engineering Research Laboratory, California Institute of Technology

The current practice of designing tall buildings to survive the strongest expected shaking in 2,500 years, (the MCE standard) is flawed. Developers use this design criteria to give the public the notion that their building is "safe." While this helps to sell buildings, it also tells people that the problem of earthquakes is "solved." That is, we understand everything well enough about both buildings and earthquakes to make this statement.

I study the physics of earthquakes, and I also study the physics of tall buildings. I can say with confidence that we do not understand earthquakes or buildings well enough to make the statement that we can design for the 2,500-year shaking. Furthermore, we have examples of recorded shaking that would cause collapse of even the best tall buildings (it's simple physics). I don't debate the merits of any particular structural design; I simply argue that the problem has been poorly presented to the general public.

It's not that difficult to design a six-story building that could survive all known ground shaking, but it is almost impossible to develop a design for tall buildings that can survive the ground shaking due to earthquakes with large slip (displacement). Unfortunately, the physics of the rupture process that produces large slip is highly debated in the physics community. We are far from solving this problem, and I feel certain that the eventual solution will be very different from what is currently used in probabilistic seismic hazard analysis.

If someone wants the simple reassurance that a building is safe, then this can be achieved with a short, high-strength building. If, on the other hand, someone finds true value in living high above the street level, then by all means live in a high-rise. Just don't fool yourself into thinking that the same level of seismic safety can be achieved in the high-rise.