

Earthquake-safe Buildings

Article 23. Advanced Earthquake-Resilient Approaches for Buildings

Civil engineers around the globe believe an important building design principle against earthquakes is to create strong foundations to support the superstructure. However, an irony is that while strong foundations prevent buildings from sinking or toppling during an earthquake, they simultaneously transmit ground shaking into the superstructure. This results in stronger shaking within the stories above ground.

The breakthrough was seismic isolation, an approach initially applied in the 1960s. In this technique, the superstructure of a building is largely isolated from the effects of ground shaking. This is usually achieved by placing bearings, flexible against horizontal movement, between the foundations, at the base of a building, and the superstructure above (Figures 1 and 2). Hence it is commonly known as base-isolation. When the ground shakes, only a fraction of potential earthquake forces is transferred through the flexible bearings to the structure above. It's rather like placing the superstructure on ball-bearings!

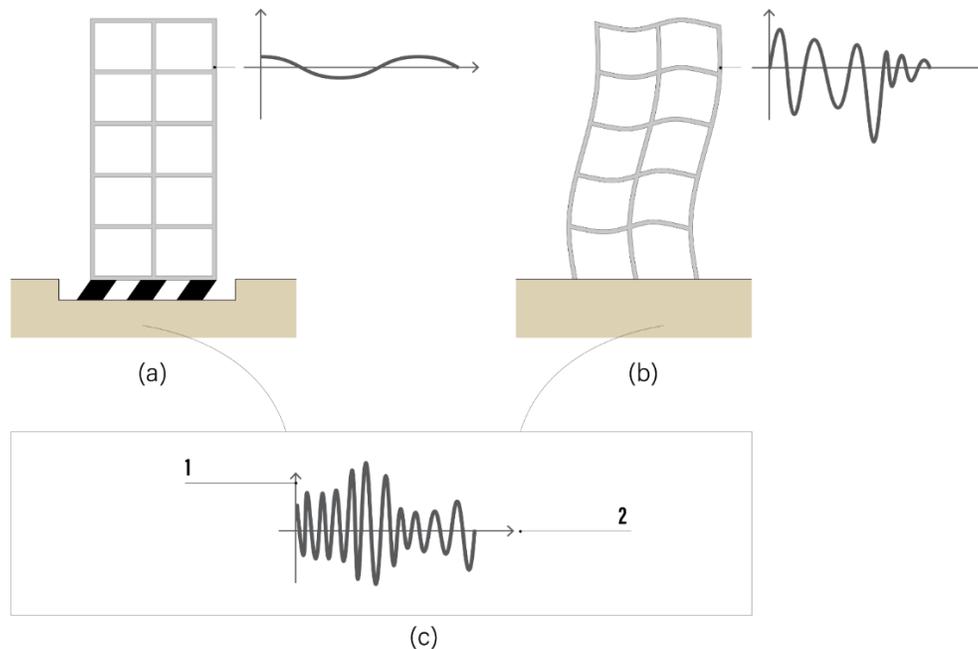


Figure 1. (a) A base-isolated building moves as a whole above its bearings while (b) shows how a conventional building bends up its height. Both buildings experience an earthquake record (c) where (1) is acceleration and (2) is time. Notice how the shaking in (a) is less and gentler than that of (b).



Figure 2. Two black and cylindrical isolation bearings under a building. Each bearing is bolted to a concrete base attached to the foundation and the base of a column that rises up the building.

The first bearings were large blocks of rubber and steel plate sandwich construction. Later, a lead plug was inserted to absorb some of the earthquake energy. Since then, other types of bearings have been produced, such as the friction pendulum system. It works by allowing sliding between two curved smooth surfaces. They can be viewed by searching online for “seismic isolation devices”.

Seismic isolation is the gold standard for earthquake resistance. It offers the best protection for the structure, non-structural elements like partitions and cladding, and building contents. Most new hospitals in seismic regions like Japan, California and New Zealand incorporate seismic isolation.

However, other approaches are also being introduced to make buildings safer in earthquakes. For example, devices called dampers are installed up the height of a building to reduce the intensity of earthquake shaking. Dampers act like, and sometimes look like, car shock absorbers (Figure 3). Very effective in damping down vibrations they are often placed at the top or bottom of diagonal braces (Figure 4). An alternative approach, where the whole brace functions as both a brace and a damper is known as a “buckling restrained brace” (Figure 5).



Figure 3. A damper to reduce earthquake movements.

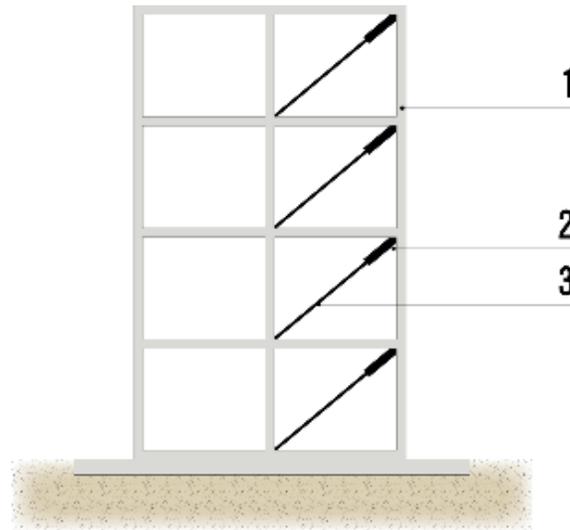


Figure 4. A frame building of columns and beams (1) with dampers (2) at the tops of diagonal braces (3).



Figure 5. Two buckling-restrained braces resist and dampen down movement in an earthquake.

Another new approach known as damage-avoidance design is becoming popular. Conventional structures like walls and frames that are capable of resisting earthquake are specially designed so that during an earthquake their primary members are not damaged. Rather, structural damage is confined to replaceable energy absorbers (Figures 6 and 7).

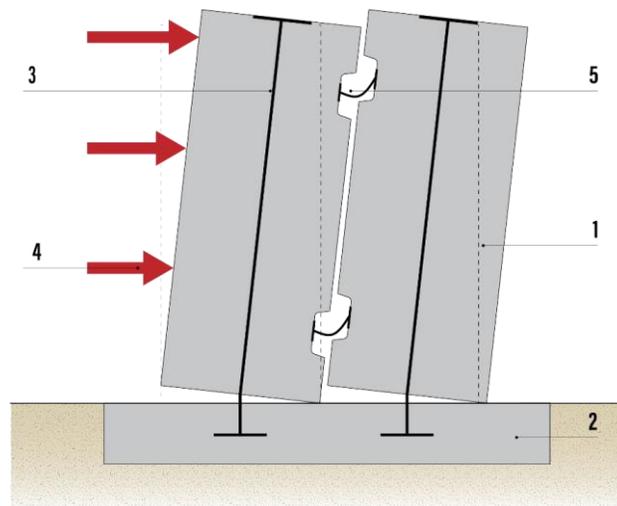


Figure 6. Two concrete walls side by side (1) connected to the foundations (2) by steel tendons (3) which stretch during earthquake loads (4). Steel plates (5) are distorted, absorbing energy and reducing resonance.



Figure 7. An earthquake energy absorber located between two rocking walls.

All the techniques mentioned above are far more sophisticated than conventional design and construction approaches. Therefore, only the most experienced and competent civil engineers should implement them.

About this article series:

This is a series of articles about earthquakes, their effects on buildings, and how to ensure that buildings are safe against earthquakes. They are intended for potential owners of new houses and larger buildings and others involved in the building industry. The articles are written by Andrew Charleson and colleagues from the World Housing Encyclopedia (<http://www.world-housing.net/>) which is sponsored by the Earthquake Engineering Research Institute (<https://www.eeri.org/>) and the International Association of Earthquake Engineering (<http://www.iaee.or.jp/>).

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Equipped with base isolation and/or energy dissipation devices. Glossary for GEM Taxonomy. Global Earthquake Model. <https://taxonomy.openquake.org/terms/equipped-with-base-isolation-and-or-energy-dissipation-devices-dbd>.