

Earthquake-safe Buildings

Article 21. Preventing Damage to Non-structural Components

Most of these articles focus on ensuring that structures of buildings protect inhabitants during earthquakes. The aim is to avoid serious structural damage. If this goal is achieved, then lives are saved. It may also be technically and economically feasible to repair the structure post-earthquake. But what about damage to the rest of the building?

In terms of cost, main structure represents a modest percentage of the overall cost of a building. Typically, approximately 70% of a building's cost arises from parts other than structure. These are usually referred to as "non-structural components", such as chimneys, roof coverings (e.g., tiles), cladding, glazing, partitions, ceilings, mechanical and electrical systems, and so on. And we shouldn't forget the building contents, which may be very expensive. Not only do all these non-structural elements represent a huge financial investment, but during an earthquake, many are hazardous.

There are two causes of damage to non-structural components. The first is due to the sideways horizontal movement of the structure. Secondly, these components or elements are damaged by the accelerations from the earthquake shaking. See images by searching "nonstructural earthquake damage" online.

Sideways movements that occur during earthquakes are likely to damage elements like masonry cladding and partition walls. When an upper floor of a building moves horizontally further than the floor beneath, we expect damage to these elements (Figure 1). After all, stiff and brittle walls are incompatible with relatively flexible structural frameworks. Damage to elements such as walls can be reduced by either making them flexible (dry framing), or separating them from the columns and floor above. Careful architectural detailing is required.

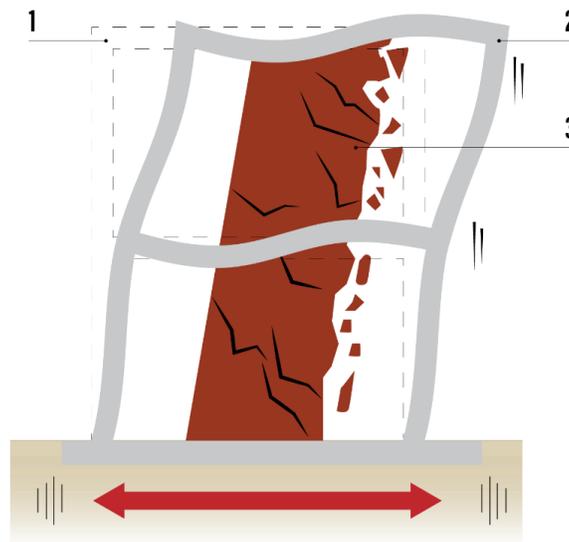


Figure 1. A structural frame before (1) and during an earthquake (2). Partitions (3) attached to floors above and below are damaged by horizontal movement due to the frame swaying.

Most other non-structural elements are damaged by earthquake accelerations. Intense shaking can break elements, shake them loose from their fixings so they fall over (Figures 2-4). Unrestrained building contents are flung around, causing injury and breakage. The lesson learned from previous earthquakes is that non-structural elements should be restrained. All items, including water tanks and mechanical and electrical equipment must be restrained (Figure 5). Otherwise, during shaking they will slide or overturn, often causing far more damage than they themselves sustain.

Refer to the document FEMA E-74 for examples of typical restraint methods. Many methods of restraining equipment are relatively cheap and are a wise investment by preventing damage during an earthquake.



Figure 2. Walls damaged by earthquake shaking pose risk to life.



Figure 3. A brick chimney has broken off at roof level and fallen. Most of the remaining chimney is damaged (N. Allaf).



Figure 4. An earthquake has destroyed most of the brick cladding and glazing of this building.

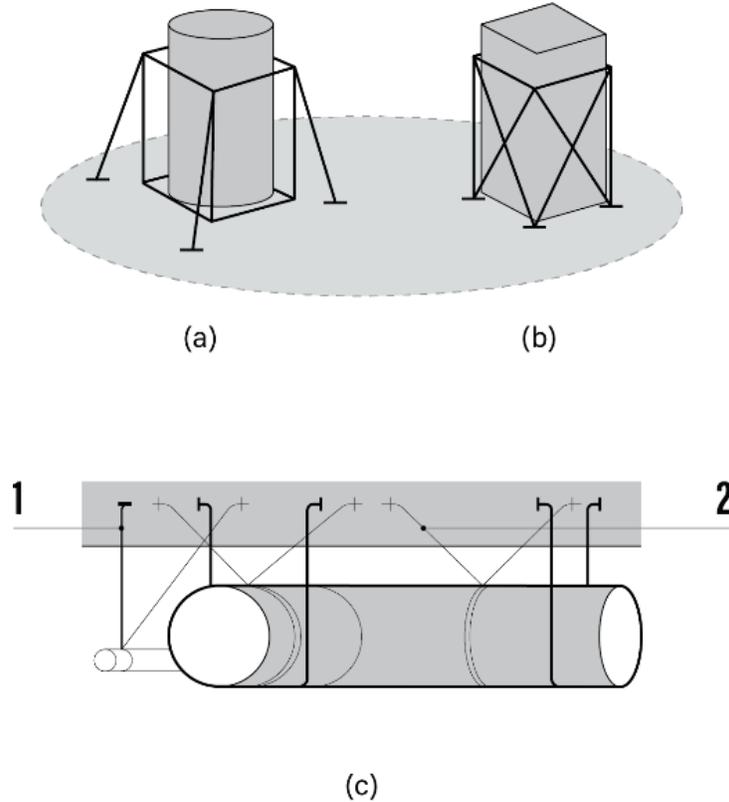


Figure 5. Tanks (a) and mechanical equipment (b) should be braced against earthquake. Also, in (c) pipework hangers (1) and ducting are braced (2).

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/>).

References:

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