Earthquake-safe Buildings

Article 8. Tying Parts of Buildings Together to Resist Earthquakes

Buildings consist of many different parts. Some parts, like floors, roof, columns, beams and walls are parts of the main structure. Others, like partition walls, cladding walls, and stairs are not load-bearing. They are necessary to make the building livable, but the building wouldn't fall down without them.

During an earthquake, a building including all its parts, gets severely shaken. The most damaging shaking are to-and-fro horizontal motions in random directions. Earthquake shaking has the potential to shake a building to pieces. If not properly designed and constructed a building can be torn apart into many pieces and collapse. This horrifying scenario has been observed after earthquakes in many countries.

It is possible to prevent such severe damage. What is required is to tie parts of the main structure together at each floor level and at roof level. Vertical elements like walls, also need to be tied at each level by ring or tie beams, which are usually made of reinforced concrete. This technique is similar to wrapping strong belts or ties around each level of a building to prevent its parts bulging and falling apart during earthquake shaking (Figure 1).

Figure 1. A damaged building during an earthquake can be held together at floor and roof level by tie or ring beams which function like strong belts.

Fortunately, where the floors of a building are of reinforced concrete, they are usually sufficient to tie the building together at those levels. Of course, the main purpose of a floor is to create a surface to walk and store things on. But when horizontal shaking occurs, a floor ties a building together at that level (Figure. 2). A floor forces everything to move together - as a whole, and stops parts being shaken loose and falling off the building. It may not even be necessary to add extra reinforcing steel to a concrete slab in order to achieve this tying action.

Figure 2. The reinforced concrete floors of this building tie the beams and columns together and force all these parts to move together horizontally during an earthquake.

It's more difficult to tie a level of a building together where there's no floor or roof slab, or where masonry walls are used in conjunction with wooden floors. In these cases, ring or tie beams do the job (Figure 3). They create a horizontal framework within and around the perimeter of a building to tie everything together. They stop walls and columns being shaken loose towards or away from each other. They prevent parts of the roof sliding off their supports and falling down. A framework of ring beams is more flexible than a concrete slab but has proved to function like that imaginary perimeter belt.

Figure 3. Walls of a simple building are not prevented from falling by columns alone. Roof-level ring or tie beams can tie the building together. (From Guide book for building earthquake resistant houses in confined masonry (World Housing Encyclopedia, 2018).

In summary, each level of a building, from the foundation until roof level needs to be strongly tied together. Floor slabs, roof slab or ring beams are required.

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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