Earthquake-safe Buildings

Article 14. Preventing a Building from Twisting during Earthquake

To some extent all buildings twist during an earthquake. Twisting means that as you look down on a building from above it rotates slightly. Not only will earthquake shaking itself cause buildings to twist, but twisting becomes more severe if the structure of a building is not symmetrical compared to the overall building area (Figure 1a).

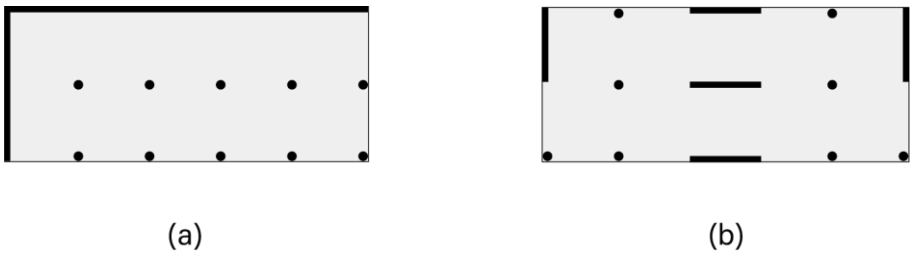

Figure 1. Two ground floor plans of buildings. In (a) earthquake force in each direction is resisted by a wall on the side of the building that is not symmetrical compared to the area of the building. This building will twist badly during an earthquake. In (b) the walls in each direction are located symmetrically. Twisting will be minimal.

To understand the problem, try this experiment. Use your body to appreciate what a building experiences. So, first, stand upright and hold your arms out horizontally. Then, rotate your head and shoulders, first in one direction and then in the other (Figure 2). You can feel your body twisting, experiencing torsion.

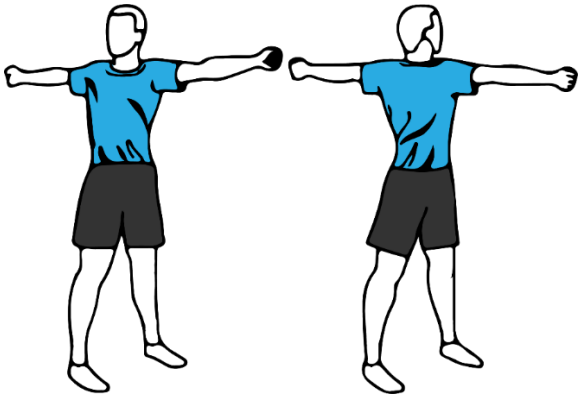

Figure 2. Twisting your body to experience torsion.

When you twist your body, you notice how much further your hands move compared to, say, your ears. Next, imagine your body is a structural core or tower supporting a much larger building (Figure 3) whose length extends to the ends of your fingers. Imagine several columns along the length of each arm supporting the floors of your 'building'. Now when you and your building twist, the columns furthest away from the core move sideways a great deal. And when they have to move sideways excessively, they are seriously damaged in the process and perhaps no longer capable of supporting the weight of the building.

Figure 3. An example of a reinforced concrete core in a building under construction.

Designers, civil engineers and architects have two ways to control torsion and reduce column damage. First, they locate the load-bearing walls or other vertical structure like column and beam frames reasonably symmetrically over the floor plan (Figure 1b). Secondly, in both horizontal directions, along and across a building, they provide at least two strong vertical structural elements well separated from each other. If these two elements are located on the perimeter of the building, at both ends and both sides, they become most effective in controlling torsion. They prevent too much sideways movement of the columns and subsequent serious damage (Figure 4).

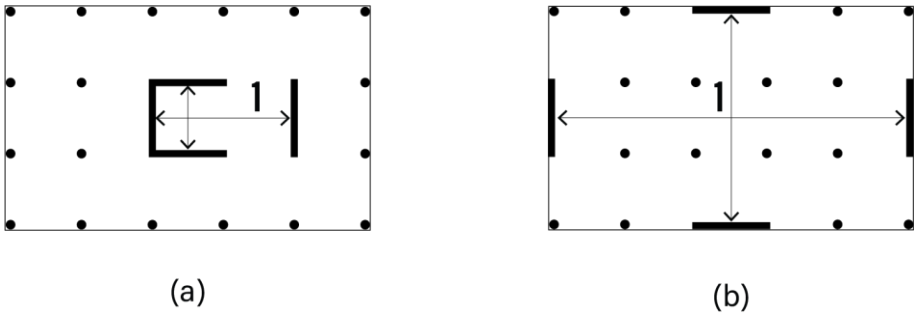

Figure 1. Two ground floor plans of buildings. In (a) earthquake forces in each direction, across and along the building, are resisted by two walls placed reasonably symmetrically. The walls are separated (1) but not by much. However, in (b) the walls acting in each direction have maximum separation (1) and so provide the best control of torsion.

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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Murty, C. V. R., 2005. How Buildings Twist During Earthquakes?: Earthquake Tip 7. IITK-BMTPC “Learning earthquake design and construction”, NICEE, India. http://www.iitk.ac.in/nicee/EQTips/EQTip07.pdf (accessed 5 May 2020).

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