IITK - BMTPC Earthquake Tip 24

Learning Earthquake Design and Construction

How to Reduce Earthquake Effects on Buildings?

Why Earthquake Effects are to be Reduced

Conventional seismic design attempts to make buildings that do not collapse under strong earthquake shaking, but may sustain damage to non-structural elements (like glass facades) and to some structural members in the building. This may render the building non-functional after the earthquake, which may be problematic in some structures, like hospitals, which need to remain functional in the aftermath of the earthquake. Special techniques are required to design buildings such that they remain practically undamaged even in a severe earthquake. Buildings with such improved seismic performance usually cost more than normal buildings do. However, this cost is justified through improved earthquake performance.

Two basic technologies are used to protect buildings from damaging earthquake effects. These are *Base Isolation Devices* and *Seismic Dampers*. The idea behind *base isolation* is to detach (*isolate*) the building from the ground in such a way that earthquake motions are not transmitted up through the building, or at least greatly reduced. *Seismic dampers* are special devices introduced in the building to absorb the energy provided by the ground motion to the building (much like the way shock absorbers in motor vehicles absorb the impacts due to undulations of the road).

Base Isolation

The concept of base isolation is explained through an example building resting on frictionless *rollers* (Figure 1a). When the ground shakes, the rollers freely roll, but the building above does not move. Thus, no force is transferred to the building due to shaking of the ground; simply, *the building does not experience the earthquake*. Now, if the same building is rested on flexible pads that offer resistance against lateral movements (Figure 1b), then *some* effect of the ground shaking will be transferred to the building above. If the flexible pads are properly chosen, the forces induced by ground shaking can be a few times smaller than that experienced by the building built directly on ground, namely a *fixed base building* (Figure 1c).

The flexible pads are called *base-isolators*, whereas the structures protected by means of these devices are called *base-isolated buildings*. The main feature of the base isolation technology is that it introduces flexibility in the structure. As a result, a robust medium-rise masonry or reinforced concrete building becomes extremely flexible. The isolators are often designed to absorb energy and thus add damping to the system. This helps in further reducing the seismic response of the building. Several commercial brands of base isolators are available in the market, and many of them look like large rubber pads, although there are other types that are based on sliding of one part of the building relative to the other. A careful study is required to identify the most suitable type of device for a particular building. Also, base isolation is not suitable for all buildings. Most suitable candidates for base-isolation are low to medium-rise buildings rested on hard soil underneath; high-rise buildings or buildings rested on soft soil are not suitable for base isolation.

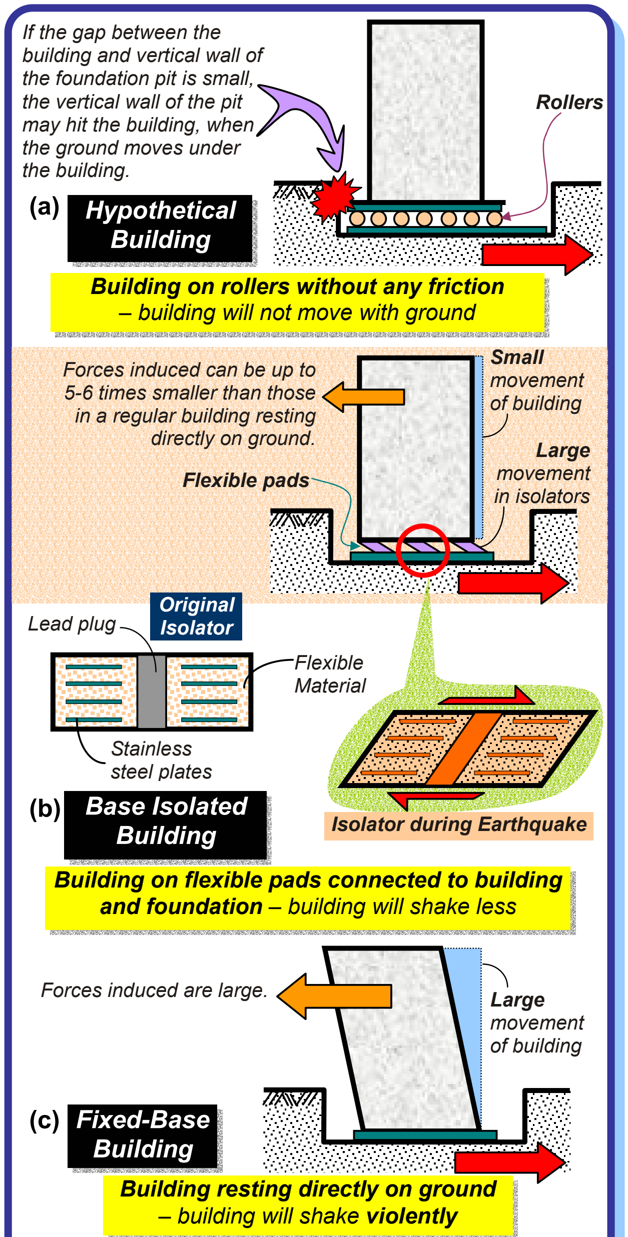

Figure 1: Building on flexible supports shakes lesser – *this technique is called* ***Base Isolation***.

Base Isolation in Real Buildings

Seismic isolation is a relatively recent and evolving technology. It has been in increased use since the 1980s, and has been well evaluated and reviewed internationally. Base isolation has now been used in numerous buildings in countries like Italy, Japan, New Zealand, and USA. Base isolation is also useful for retrofitting important buildings (like *hospitals* and *historic buildings*). By now, over 1000 buildings across the world have been equipped with seismic base isolation. In India, base isolation technique was first demonstrated after the 1993 Killari (Maharashtra) Earthquake [EERI, 1999]. Two single storey buildings (one school building and another shopping complex building) in newly relocated Killari town were built with rubber *base isolators* resting on hard ground. Both were *brick masonry buildings* with *concrete roof*. After the 2001 Bhuj (Gujarat) earthquake, the four-storey Bhuj Hospital building was built with base isolation technique (Figure 2).

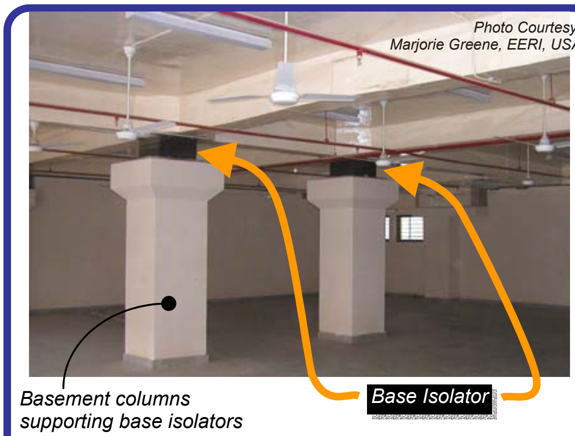

Figure 2: View of Basement in Bhuj Hospital building – *built with base isolators after the original District Hospital building at Bhuj collapsed during the 2001 Bhuj earthquake.*

Seismic Dampers

Another approach for controlling seismic damage in buildings and improving their seismic performance is by installing *seismic dampers* in place of structural elements, such as diagonal braces. These dampers act like the hydraulic shock absorbers in cars – much of the sudden jerks are absorbed in the hydraulic fluids and only little is transmitted above to the chassis of the car. When seismic energy is transmitted through them, dampers absorb part of it, and thus *damp* the motion of the building. Dampers were used since 1960s to protect tall buildings *against wind effects*. However, it was only since 1990s, that they were used to protect buildings *against earthquake effects*. Commonly used types of seismic dampers include *viscous dampers* (energy is absorbed by silicone-based fluid passing between piston-cylinder arrangement), *friction dampers* (energy is absorbed by surfaces with friction between them rubbing against each other), and *yielding dampers* (energy is absorbed by metallic components that yield) (Figure 3). In India, friction dampers have been provided in a 18-storey RC frame structure in Gurgaon (See *http://www.palldynamics.com/main.htm*).

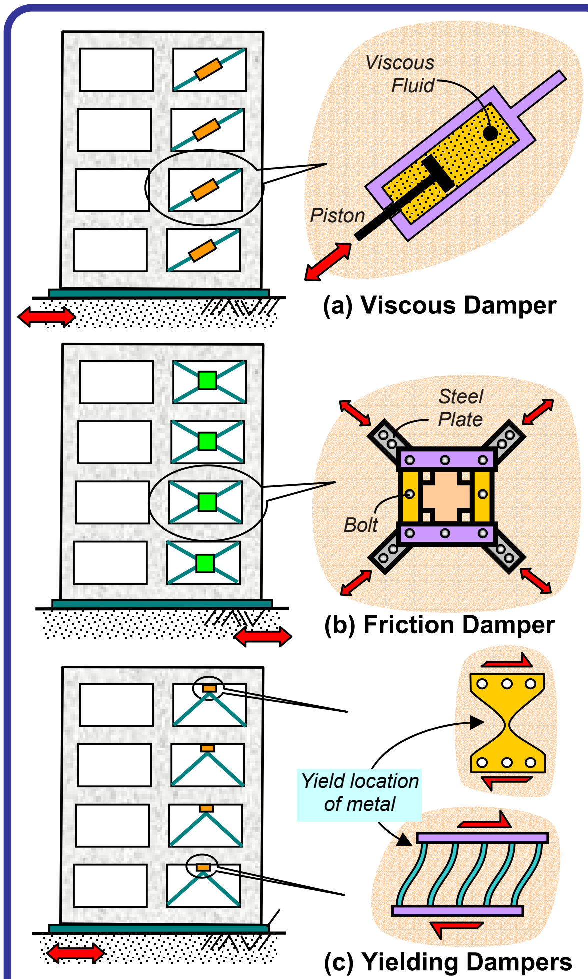

Figure 3: Seismic Energy Dissipation Devices – *each device is suitable for a certain building.*

Related IITK - BMTPC Earthquake Tip

Tip 5: What are the Seismic Effects on Structures?
Tip 8: What is the Seismic Design Philosophy for Buildings?

Resource Material

EERI, (1999), *Lessons Learnt Over Time – Learning from Earthquakes Series: Volume II Innovative Recovery in India,* Earthquake Engineering Research Institute, Oakland (CA), USA; also available at *http://www.nicee.org/readings/EERI_Report.htm*.

Hanson,R.D., and Soong,T.T., (2001), *Seismic Design with Supplemental Energy Dissipation Devices*, Earthquake Engineering Research Institute, Oakland (CA), USA.

Skinner,R.I., Robinson,W.H., and McVerry,G.H., (1999), *An Introduction to Seismic Isolation,* John Wiley & Sons, New York.

Authored by:
C.V.R.Murty
Indian Institute of Technology Kanpur
Kanpur, India
Sponsored by:
Building Materials and Technology Promotion Council, New Delhi, India