

# How to protect buildings against the disastrous effects of earthquakes?

By Philippe Gambette

Earthquakes are very dangerous. Apart from damaging property, they also cause the deaths of many people. It is thus crucial that we reduce that damage. Apart from earthquake prediction, **seismic hazard reduction** is very effective for that purpose. This approach recognizes **the inevitability of earthquakes** and tries to reduce their effect in populated regions. Designing buildings that can withstand strong vibrations in the ground and using non-flammable construction materials would reduce significantly the number of victims and monetary damage due to earthquakes. This is why the **MCEER** (Multidisciplinary Center for Earthquake Engineering Research), based in Buffalo, is specialized in testing **new techniques of construction** and apparatus which aim at reducing the damaging effects of seisms on buildings.

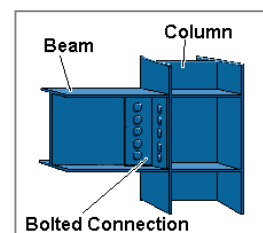
For the construction of a building, engineers have to think about which materials they are going to use, to protect it against seisms. But they can also protect existing buildings, even if they are quite old. For that purpose, they often use two kinds of devices : base isolation, or energy dissipation devices.

## I/ Materials

The choice of material is very important for the construction of a building. “We have to worry about materials, whether they are ductile, flexible, if they can take pressure without breaking or whether they are brittle and will crack easily “, (Mrs Andrea S. Dargush, Assistant Director for Research and Education - MCEER)

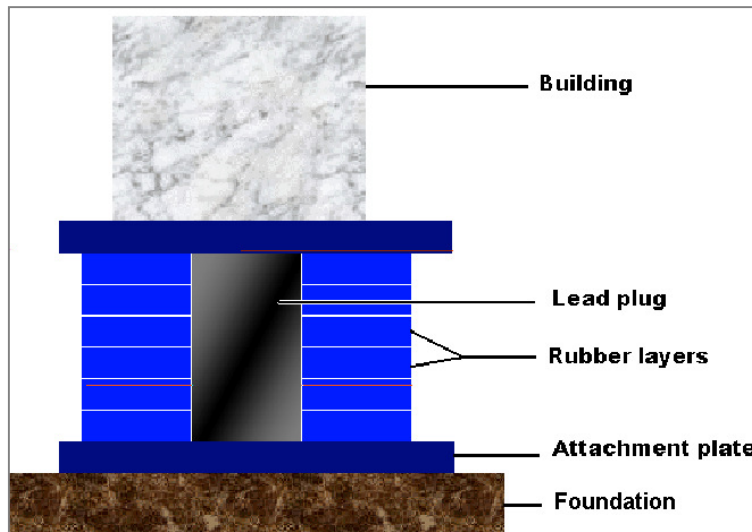
Brittle materials, like bricks, do not perform very well during a seism. But the flexible ones, like wood, reinforced concrete are very useful for construction in seismic activity areas. Steel is considered to be the best material to build a seismic-protected building.

But the architecture is also important. First, the general architecture of the building : symmetric buildings are more stable. Then, some structures like bolted connections between steel beams and columns make the buildings stronger. Some websites also recommend special devices to protect his own house from seisms.



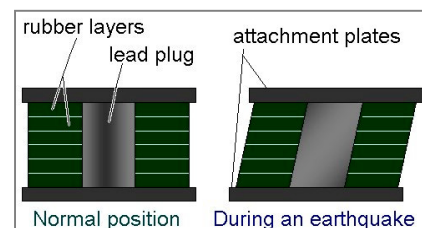
## II/ Base Isolation

### 1) Lead-rubber bearings

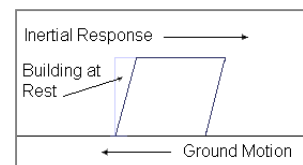


A **base isolated structure** is supported by a series of **bearing pads**, which are placed between the building and the building's foundation. There are different sorts of bearing pads, for example **lead-rubber bearings**.

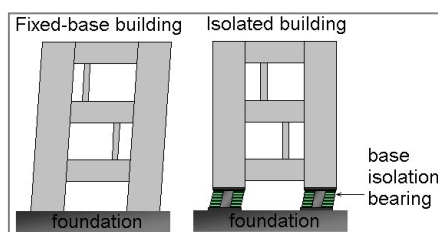
A lead-rubber bearing is a “sandwich” of many layers of rubber and steel. In the middle of this system is a solid lead “plug”. At the top and bottom, two steel plates attach the bearing to the building and foundation. The bearing is very stiff and strong in the vertical direction, but flexible in the horizontal direction.



What happens when a seism occurs? For example, when the ground moves to the left, the **fixed-base** building (the one which is not isolated) begins to move to the right. This movement is due to inertia: the inertial forces are proportional to the acceleration of the building.



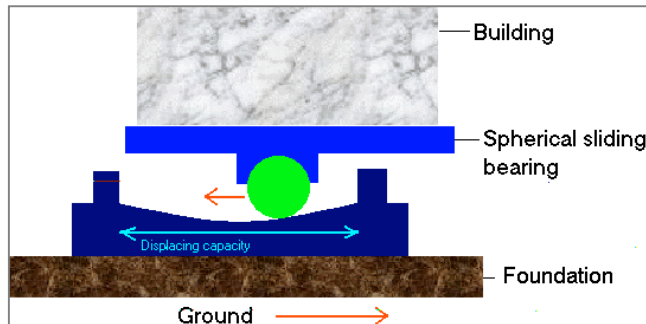
Because of this movement, the fixed-base building changes its shape from a rectangle to a parallelogram: the building becomes deformed and that deformation can cause fissures and damage to the building.



On the contrary, even if it is also displaced, the base-isolated building maintains its original, rectangular shape. Only the lead-rubber bearings supporting the building are deformed. But since they are elastic, they aren't damaged. Experiments and observations of base-isolated buildings in earthquakes have been shown to reduce building

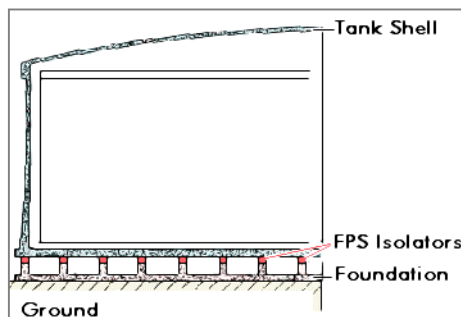
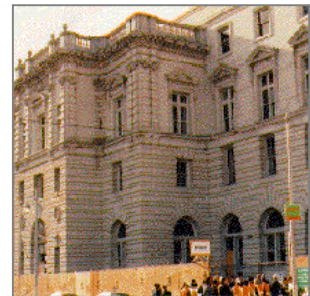
accelerations to as little as 1/4 of the acceleration of comparable fixed-base buildings. So, as the acceleration decreases, the inertia forces will also decrease, proportionally (thanks to Newton's Second Law of Dynamics). Acceleration is decreased because the base isolation system lengthens the building's **period of vibration**, the time it takes for the building to rock back and forth and then back again.

## 2) Spherical Sliding Isolation Systems (or Friction Pendulum Sliding Bearing)



**FPS bearing** is another type of base isolation. It is placed between the foundations and the structure of the building, and it is composed of two parts: the first one, fixed to the foundation, has got a low friction curved surface, so that the second part can slide on it.

This device has been used to reinforce the seismic resistance of the US Court of appeals Building in San Francisco. The MCEER has been studying the problem for 5 years. The fabrication of the FPS started in 1994. The engineers used 256 FPS bearings, having a displacement capacity of 350 mm. The installation was completed in 1996.



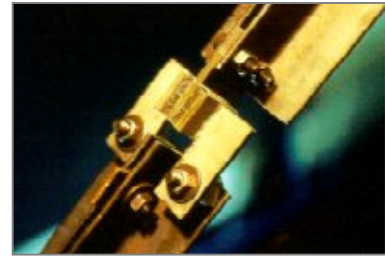
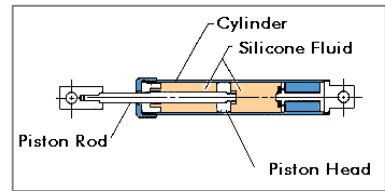
FPS Bearing Systems have also been used to protect a building the purpose of which is to stock gas, in Greece, on the Revithoussa Island. To ensure that protection, 212 bearings have been used.

FPS Bearings have also been chosen to isolate the new terminal of the International Airport in San Francisco. It is not the first time that it is used in an airport. Indeed, C. Constantinou, (Ph. D. , professor and chair of the Department of Civil, Structural and Environmental Engineering) who designed the seismic modernization of the Istanbul Airport, used FPS tested at the University of Buffalo and at MCEER, and manufactured by Earthquake Protection Systems of Richmond (California).

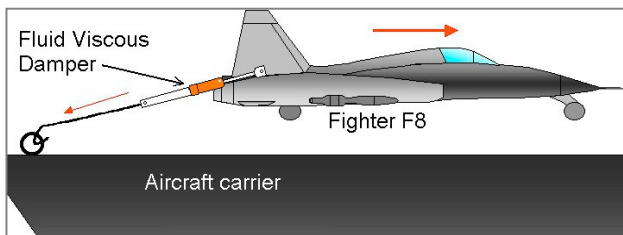
### III/ Energy Dissipation Devices (or Damping Devices)

The principle of these devices is to transform the energy given to a building during a seism into another type of energy, or to dissipate the energy, and thus decrease damage.

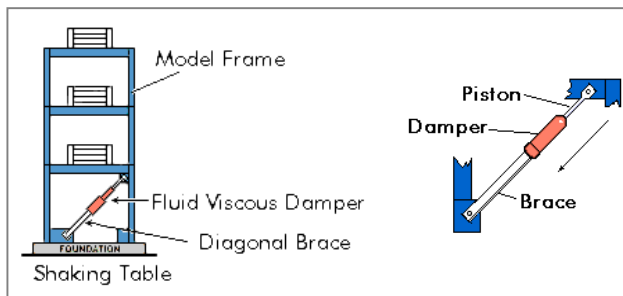
- **Viscous Dampers:** use the forced movement of fluids within the damper.
- **Friction Dampers:** use frictional forces to dissipate energy.
- **Metallic Dampers:** use the deformation of metal elements within the damper.
- **Viscoelastic Dampers:** use the action of viscoelastic materials bonded to solid parts.



#### 1) Fluid viscous dampers and friction dampers

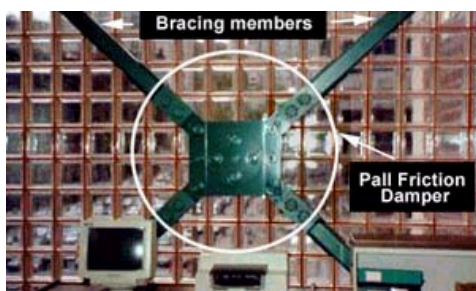


The first Viscous Dampers were used to reduce the backfire of canons. In 1955, Taylor Devices, Inc., North Tonawanda, NY, started the production of FVD for the army, especially for fighter planes: one part of the FVD was stuck to the plane and the other one to a rope which was fixed to the bridge of an aircraft carrier.



Since 1994, Taylor Devices have been involved in many projects using FVD for seismic resistant buildings, after having tested their Fluid Viscous Dampers thanks to computers and shaking tables.

For example, they isolated the five buildings of the Medical Center in San Bernardino, California. 233 Fluid Viscous Dampers were used for the project and it costed 680 millions dollars.



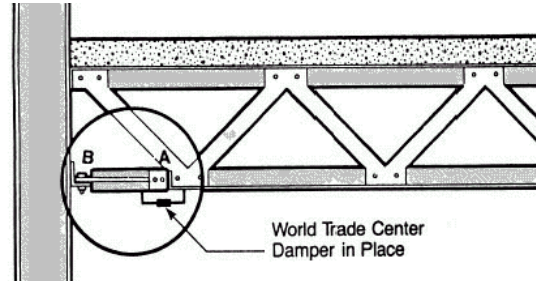
In friction dampers, the energy is dissipated when the parts of the device slide on each other.

## 2) Metallic dampers

They are usually made of steel, and deform so much that they do not go back to their original shape after a seism.

## 3) Viscoelastic dampers

They consist in viscoelastic materials bonded to steel plates (or recently wood plates), and are used in metallic or reinforced concrete structures, to protect them against seisms, but also to resist against wind forces. Those devices add stiffness to the walls by dissipating a constant amount of energy, at constant amplitude cycling.



## Conclusion

Many solutions exist to protect existing buildings against earthquakes, or to build resistant houses. However, it has a cost : a seismic protected building is approximately 10% more expensive. So, it is important to use also other preventive techniques : study the nature of the ground on which a house is going to be build, and train people so that they know what to do while a seism occurs, and after. This is why countries like Japan or the USA often organize simulations of earthquakes, and train rescuers.

## Bibliography, websites

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## Special thanks to:



## **Vocabulary:**

You can download this file here :

<http://freecorp.free.fr/ENS/scolaire/Vocanglais/Anglais306SeismPrevention.fic>

seismic hazard reduction	la réduction des risques sismiques
to withstand	supporter [résister à]
non-flammable	non inflammable
earthquakes	les tremblements de terre
brittle	friable
reinforced concrete	le béton armé
steel	l'acier
to bear	supporter
a pad	un bloc
lead	le plomb
a layer	une couche
stiff	rigide
to rock back and forth	se balancer d'avant en arrière
completed	terminé
to bond	coller [adhérer]
a damper	un amortisseur
to damp	étouffer [déprimer, humidifier]
a fighter plane	un avion de combat
an aircraft carrier	un porte-avions
rescuers	des secouristes