УДК 699.841

SEISMIC ISOLATION AND ENGINEERED DAMPING

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Problems of construction maintenance integrity and minimization of damages on the basis of constructive decisions and specific properties of buildings are very significant. The solution to the problems is necessary in the conditions of active seismic regions. The topicality of these problems is reflected in the program of the Russian Federation of the federal target program called "Seismosafety in Russia" dated September 25,2001, № 690. The issues of seismic stability both for existing buildings and the buildings being built are designated in the document.

The technologies of construction in seismic areas constantly develop. However the collapse from earthquakes does take place. A destructive earthquake of the 9,0-Richter-magnitude which occurred in the north-east of Japan in March 11, 2011 became one of the latest events. It caused a tsunami of ten meters height. About 18,800 structures were completely destroyed, about 1,200 houses were carried away in the sea.

It is impossible to raise seismic stability only has increasing the size of cross sections, durability, weight in modern constructive decisions. A structure can be stronger, but not necessarily economically effective because both the weight and inertial seismic loading can increase even more. New effective methods of seismoprotection are required.

Traditional methods were widely adopted in various countries which expose to seismic danger. These methods are conventional. However special methods of seismoprotection allow to lower expenses for reinforcement and to raise reliability of erected constructions in many cases. Various technical solutions of special seismoprotection of buildings and engineering constructions were offered in Japan, the USA, New Zealand, the CIS countries during last decades.

There are some ways of making structures safer than the methods. Researchers and the engineering community have mobilized their effects to achieve that goal, working on removing shortcomings in the design of structures that have not performed well in seismic events and coming up with improved versions capable of standing up to a certain level of earthquakes. (Look Figure 1)

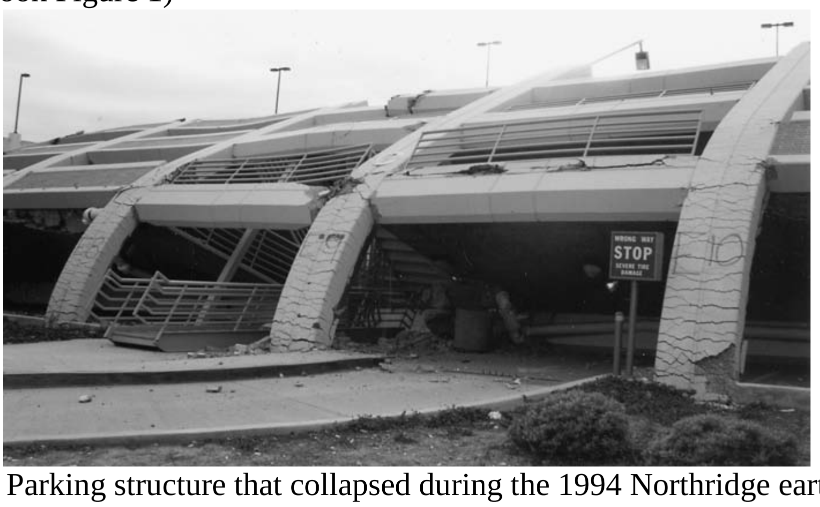

Figure 1. Parking structure that collapsed during the 1994 Northridge earthquake, California State University, Northridge Campus.

Structural failures may be categorized as overall failure and component failure. Overall failure involves collapse or overturning of the entire structure. The choice of the type of structure is instrumental and often a predetermining factor for failure.

One option is to build or retrofit on seismic isolators or structural dampers. An example is the Los Angeles City Hall, retrofitted with a viscous-device type of supplemental damping to improve seismic response. However, placing such a massive stone building and historic landmark on an earthquake damage control system comes at a cost that not all areas can afford.

A seismic isolation system may be defined as a flexible or sliding interface positioned between a structure and its foundation, for the purpose of decoupling the horizontal motions of the ground from the horizontal motions of the structure, thereby reducing earthquake damage to the structure and its contents.

Researchers on the subject of seismic isolated buildings state that proper application of this technology leads to better performing structures that will remain essentially elastic during large earthquakes. There are about 1000 seismically isolated structures around the world. The number includes not only buildings but also bridges and tanks.

The first seismically isolated building with a rubber isolation system emerged in 1969 in Skopje, in former Yugoslavia. It is a three-story school building that rests on solid blocks of rubber without the inner horizontal steel reinforcing plates as is done today. The first bridge structure that utilized an isolation system, with added damping, was the Te Teko viaduct in New Zealand, built in 1988. The isolation system contains a sandwich of laminated steel and rubber bearing layers with a central lead core for energy dissipation. This type of isolation system, referred to as lead–rubber bearing, is now widely used.

Common isolation systems are the elastomeric and sliding types. A third group, called hybrid, are elastomeric isolators combined with flat sliding type of isolators.

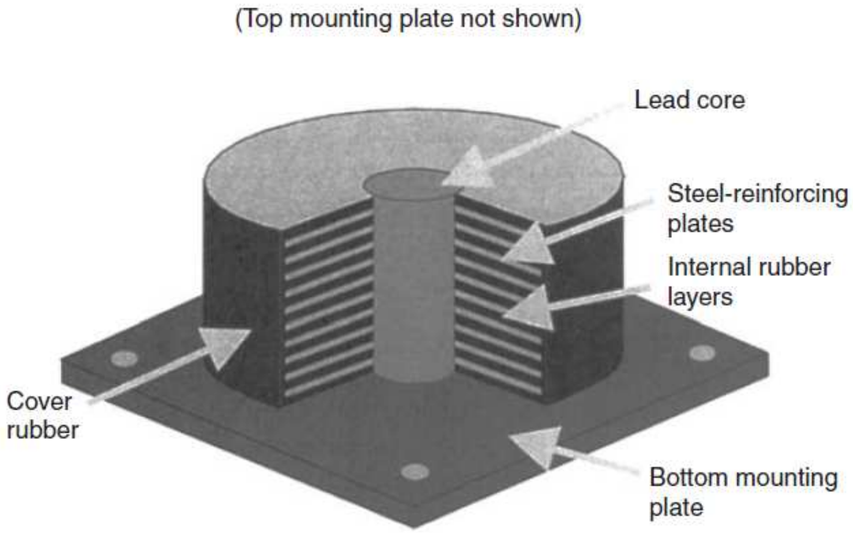

Figure 2. Cross section of a DIS Seismic Isolator TM. Vulcanized rubber layers can move in any horizontal direction and are laminated between steel sheets to form a movable, flexible base.

The Dynamic Isolation Systems (DIS) seismic (base) isolator consists of alternate layers of rubber and steel bonded together, with a cylinder of pure lead tightly inserted through a hole in the middle (Figure 2). The rubber layers allow the isolator to displace sideways, thus reducing the earthquake loads experienced by the building and its occupants. They are designed to also act as a spring to ensure that the structure returns to its original position once the shaking has stopped. Thick steel plates are bonded to the top and bottom surfaces to allow the isolator to be solidly bolted to the structure above and the foundation below. During earthquake events, the lead is pushed sideways by the rubber and steel layers absorbing a portion of the earthquake energy. This dampening effect helps to further reduce the earthquake forces and contributes to control the lateral displacement of the structure.

In general, the seismic isolation schemes described here are horizontal systems that act chiefly against lateral forces. California earthquakes have demonstrated that, contrary to common belief, there was a significant vertical component that occasionally exceeded 100% g. Stated otherwise, under the vertical-component force generated by an average California quake, the building is thrown up and down and becomes virtually weightless. Since it is not tied down to a vertical isolation system, the building can virtually fly off its base or overturn. Unless this problem is resolved, we do not have an optimum isolation system.

While seismic isolation could be costly, especially for tall buildings of excessive mass and dimensions, engineered damping may be a practical and economical solution that can even be applied to existing structures to boost a deficient inherent damping. Engineered damping, whether applied to a new building or a retrofitted structure, basically consists of bracing that incorporates calibrated hydraulic piston dampers (Figure 3). The system reduces the damage caused by excessive sway in the moment frames and provides improved shock-absorbing capabilities to brace-framed buildings.

An example of the use of both isolators and dampers is the Arrowhead Regional Medical Center in Colton, California.

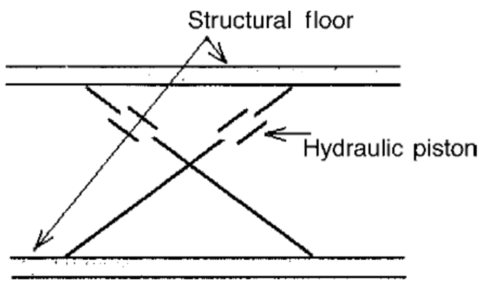

Figure 3. Bracing with calibrated hydraulic piston dampers.

In the future, the number of conventional structures built in seismic zones will be gradually reduced and replaced by either seismic isolators or another engineered systems.

Therefore, application of seismic isolators and engineered damping being properly designed can considerably increase such characteristics as:

- reliability of buildings;
- safety of equipment;
- absence of necessity of recovery work after strong earthquakes;
- safety to health and life of people.