International Congress on Earthquake & Lightweight Construction (ICELC)
28-29 September 2005
Technical & Engineering Faculty
Qom University

The effective Placement of shock isolation system in structures subjected to earthquake

Soghra Rezazadeh

Center of Engineering Researches of Jahad, Tabriz, Iran

sghrezazadeh@yahoo.com

Abstract

One of the most effective ways to reduce the earthquake damage is to use of shock isolating devices in the structure. These devices consume the earthquake energy and lead to safer situation.

Regardless of the type of shock isolating elements, there are some main approaches to place these devices. Shock isolating devices are placed on the base, wall or frame of the structure. They are also used in columns on intermediate floors. The elements, which are installed in the structural frame and wall, form an energy dissipation system while the elements that are placed under/over the base form a seismic (base) isolation system. Energy dissipation system reduces inter story drift caused by earthquake and Seismic (base) isolation system reduces ground motion transmitted into structure. In this paper, the feature of each method is explained and practical samples are discussed.

Key words: earthquake, shock isolation, fault zone, seismic isolator, dissipation energy, structure, installation

1-Introduction

The images of damage coming out of earthquake zones (for example Japan) have been a shock to both the public and the engineering community. Thousands of structures of all types have either collapsed or have been badly damaged.

Until recently, soaring skyscrapers and earthquake zones were considered mutually exclusive, but the use of revolutionary shock-absorbing dampers are now safely raising skylines in cities that are situated in fault zones.

To have the best insurance against loss of life, structural damage, content damage and business disruption, shock-absorbing system is improved.

The Torre Mayor is a world-class corporate complex and a premier Mexico City landmark, standing 738 feet tall. This structure is included seismic isolation and dissipation energy systems. On January 21, 2003, the coastal region of the State of Colima, Mexico experienced a 7.6 magnitude earthquake. When the quake reached Mexico City it was amplified by the soft soils in the area. This resulted in a relatively strong response with some 30 seconds of shaking. Occupants reported that from inside the building the quake felt far less severe. This may well be due to the extensive use of fluid dampers as a primary element of the building's seismic protection and earthquake resistance capability.So, there is a need for installation shock absorber in structure.

2- Shock isolating in structure

One of the most effective ways do reduce the earthquake damage is to use of shock isolating devices in the structure. These technologies fall into two effective categories: seismic (base) isolation and energy dissipation.

Seismic (base) isolation reduces ground motions transmitted into structures. these effects are illustrated in figure (1). By isolating can reduce the effects of seismic forces up to eight times.

For flexible structures, energy dissipation products are installed in the structural frame and wall and will reduce inter story drift cause by earthquakes. it has been shown in figure(2).Inter story drift is reduced by a factor of approximately two.

The magnitude and distribution of these forces are generally determined as a function of the structure's mass, its vibration properties (periods of response), the regional seismicity, the local soil conditions, the type of seismic system, and the importance of the structure.

In the structures that are equipped with seismic resistive system, such as a seismic bracing system, predominant periods of response and the damping capabilities are determined by its mass and the configuration and material properties of the elements that comprise the seismic bracing system.

The period of response of the structure and its damping capabilities affect the internal forces, accelerations, and displacements of the structure in response to a given earthquake.

3-Placement of shock isolation system in structures

Regardless of the type of shock isolating elements, there are some main approaches to place shock isolation system. Shock isolating devices are placed on the base, wall or frame of the structure. They are also used in columns for intermediate floors.

3-1- Base isolation

Base isolation involves using base isolation system installed underneath building to hinder the transfer of seismic force from the ground to the building.

There are three types of base isolation systems, depending on the location where rubber bearings are incorporated:

a) Pile head isolation
b) Foundation isolation
c) Mid-level isolation

When the gap between the underground exterior walls and the site boundary is narrow, making installation of base isolation systems is difficult, so mid-level isolation is adopted. A practical sample of this method is the head office of Himeji Shinkin Bank (Himeji Credit Bank). This approach involves flexible columns that incorporate rubber bearings (base isolation systems) and rigid columns which have been wrapped in steel plates to add to their toughness. A combination of these two types of columns is then used to improve the earthquake-resistant performance of the building as a whole.

By cutting horizontally all columns and walls on a specific intermediate floor (the first floor on this occasion) and installing rubber bearings in the columns that have been cut, that floor becomes extremely flexible.

In this structure, columns with rubber bearings incorporated in them to allow them to move flexibly and rigid columns which were made tougher by wrapping steel plate were placed effectively, thereby suppressing horizontal deformation and improving the earthquake resistance of the building as a whole.

The process of this method is illustrated in figure (3), (4).

Isolators can be placed directly on foundation footings, at the top of basement columns. This method is shown in figure (5). Figure (6) shows the detail of isolator placement at the bottom of first story columns and in two locations above grade.

Also, isolator can be used in combination with sliders to achieve the right combination of load support and isolation system stiffness. It is shown in figure(7)that seismic isolator placed within 1 and 2 story buildings.

Vibration Isolation is used for Rail and Transit Systems. Figure (8) shows the installation procedure for shock isolation element in a tunnel.

3-2-.Energy dissipation in wall and frames

Adding Energy Dissipating Units (EDU) within the bracing elements of a conventional seismic bracing system may provide supplemental damping. The added damping improves the seismic performance of the structure by reducing deflections, accelerations, and structural and non-structural damage.

A typical arrangement of supplemental damping within a moment frame structure is illustrated in fig.(9A). All or part of the system's lateral static stiffness is a result of the flexural stiffness of the beams 1 and columns 2 that are connected with a rigid or semi-rigid joint also known as a moment joint 3. The braces 4 are added to the frame between each level in order to couple the levels with an Energy Dissipation Unit (EDU) 5. The energy dissipation devices may work by using several mechanisms such as friction, yielding metals, energy absorbing plastics, rubbers, etc, and fluids forced through orifices. These devices (EDUs) may be activated by the relative displacement between each level, by the relative velocity between each level, or by active control methods. The EDUs may also provide additional static stiffness to the frame via the braces. In a second common arrangement, illustrated in fig.(9B), a brace 4 extends diagonally between portions of a frame with an EDU 5 in the middle.

Another prior art system, illustrated in fig.(9C) has an isolation layer under the entire building and is commonly referred to as a base isolation system.

4-Conclusion:

1-The application of seismic (base) isolation system and energy dissipation unite (EDU) in structure was studied.

2-Types of base isolation systems were introduced in structures and tunnels.

3- Suitable procedures for placement of shock isolation system in structures were presented.

4- Some practical samples were presented and discussed.

5-References:

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Figure 1: Seismice isolation vs. without seismic isolation

Figure 2: Energy dissipation vs. without energy dissipation

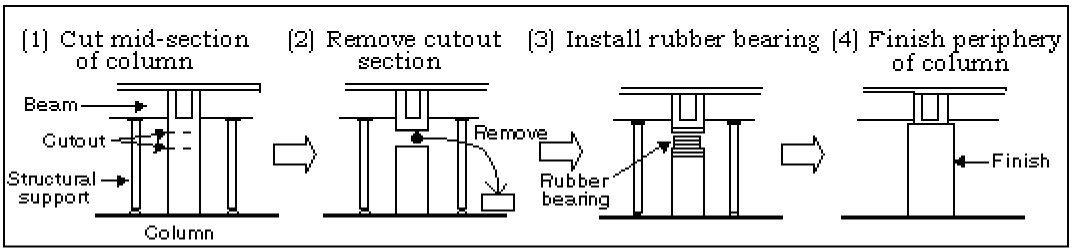


Figure 3: Base isolation improvement procedure for 1st floor columns [1 to 4]

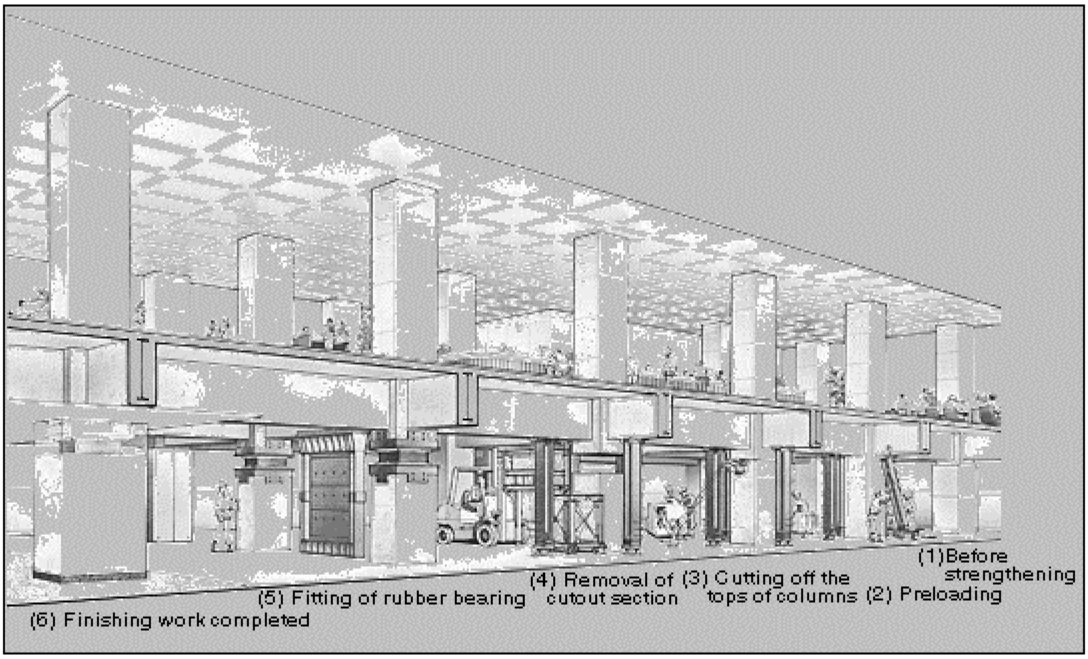


Figure 4: Improvement work on the first floor, Second floor and above area business as usual

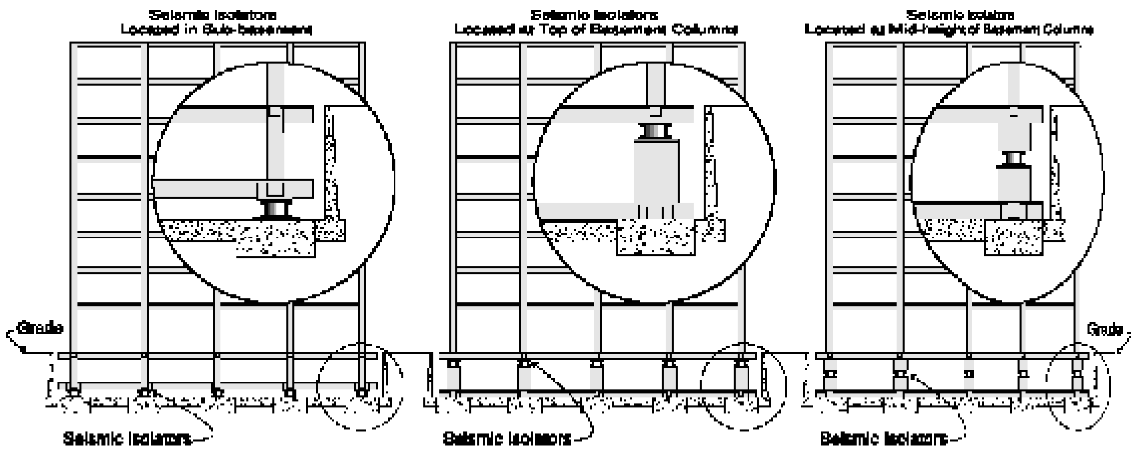


Figure 5: Isolator placement on foundation footing, basement columns and column mid-height.

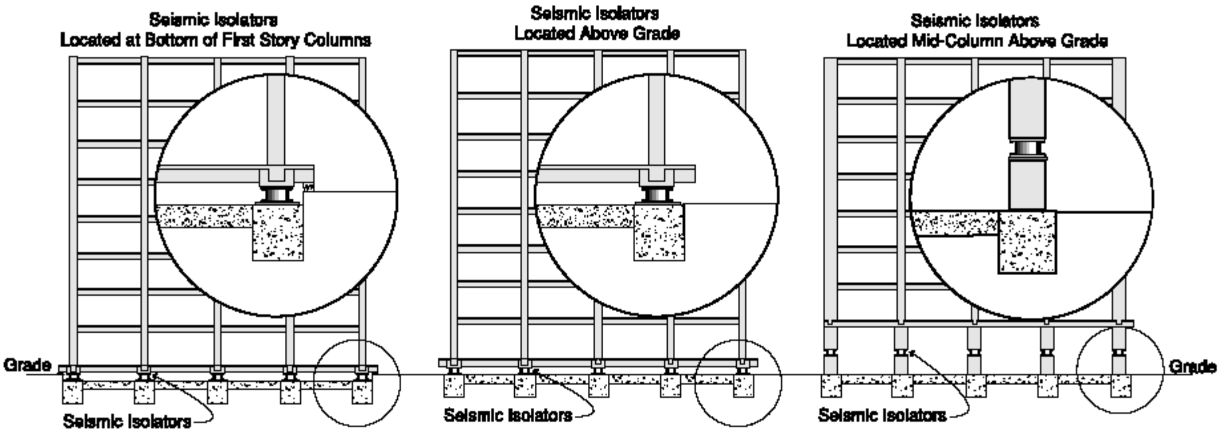


Figure 6: Isolator placement at the bottomof columns and above grade.

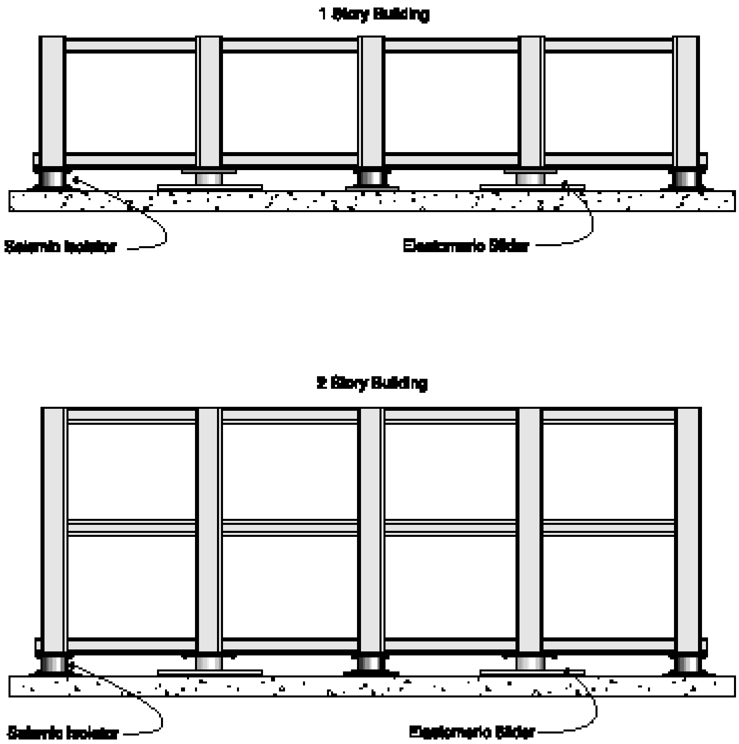


Figure 7: Isolator placement within 1 and 2 story buildings

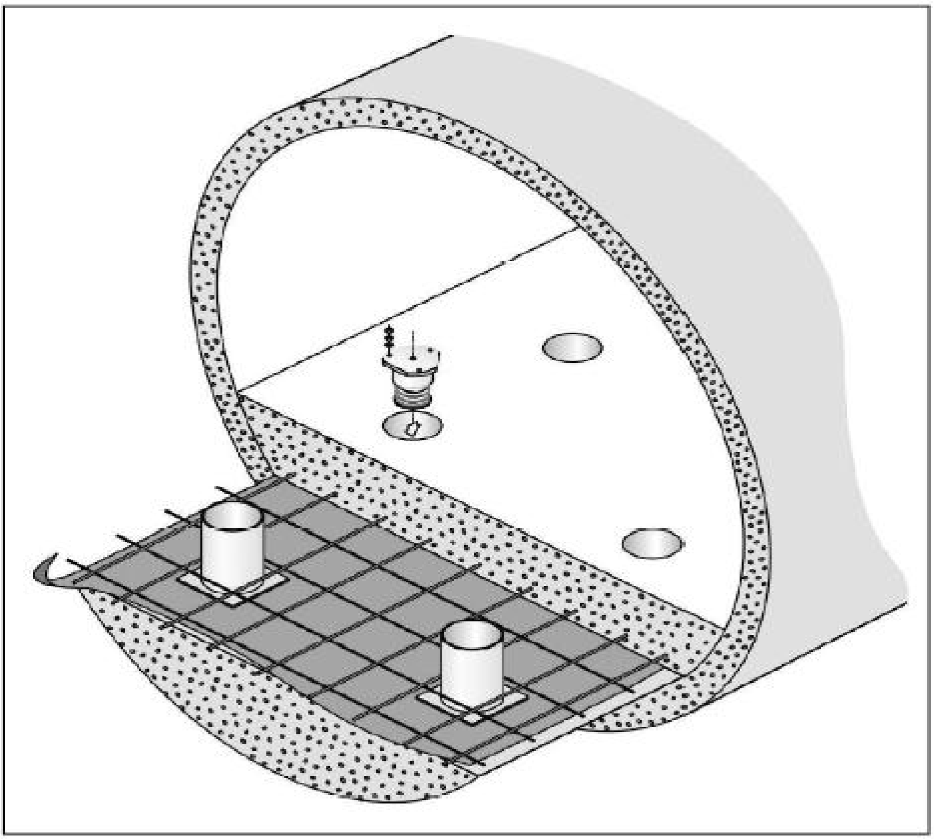
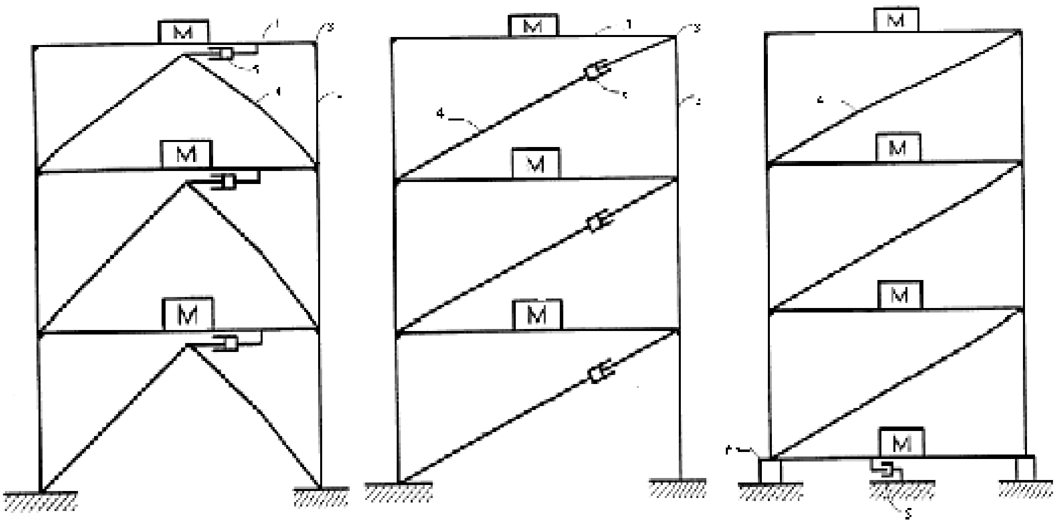


Figure 8 : Installation procedure for absorber element in tunnel



(A) (B) (C)

Figure 9: Arrangements of supplemental EDUs within a frame