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A Review on Comparative Study of Earthquake Resistance Techniques

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ABSTRACT: At present, demand for a building with amazing appearance and design is increasing day by day. Along with these qualities, people also demand for safety against weathering agencies & lots of other disaster, from which, one of the major is Earthquake. Different studies confirmed that static and dynamic forces, earthquake, causes huge damage to building with huge loss. It can be controlled if the building has enough resistance against these effects by being stiff and by having other mass properties. These mainly depend upon internal design force of building and also how the design are accompanied and applied. Moreover, different old techniques for providing resistance against earthquake proved to be useful. Different modern techniques have been also taken in consideration such as Base isolation, energy dissipation method etc.

KEYWORDS: About Earthquake, Base Isolation, Energy dissipation technique, Comparison

I. INTRODUCTION

An earthquake is one of the most terrifying natural phenomena. Earthquake occurs when energy stored in elastically strained rocks is suddenly released. This release of energy causes intense ground shaking in the area near the source of the earthquake and send waves of elastic energy. They cause sudden impact in our life due to destruction caused by the vibration produced from the movement of seismic waves. Many people lose their money and property. It affects the mental health and emotional health of people.

In conventional method of earthquake resistant design, the energy dissipation is achieved by the ductility of material. This method ensures safety of life but does not ensure required damage control and hence the functionality of the structure after the earthquake becomes questionable. The required structural performance can be achieved by introducing non conventional methods of earthquake hazard mitigation techniques like base isolation, passive energy dissipation devices, active, hybrid and semi active control systems. But in this study, we will discuss only Base isolation and Energy dissipating techniques.

1. BASE ISOLATION

Base Isolation (BI) is the system or technique that is provided to resist or prevent the vibration produced by earthquake from damaging a structure or building. Base isolation simply defined as the disassociation or separation the structure from the foundation. The concept of base isolation can be replaced with seismic isolation i.e., the structure above the ground level which is mostly affected by the earthquake is being avoided by the effect of earthquake by a mechanism that will help the structure to drift. It is meant to enable a building or non-building structure to survive a potentially devastating seismic impact through a proper initial design. The concept of base isolation is quite easy to hold. The isolation can be obtained by the use of various techniques like rubber bearings, friction bearings, ball bearings, spring systems etc. Base isolation is also used on a smaller scale like sometimes down to a single room in a building. Isolated raised-floor systems are used to safeguard essential equipment against earthquakes.



(A)



(B)

FIG.1 (A) AND (B) REPRESENT THE ELASTOMERIC RUBBER BEARING

1.1 PRINCIPLE OF BASE ISOLATION

The basic principal behind base isolation is to separate the building or the structure from the ground so as to prevent the vibration or forces produced due to earthquake from entering the building and prevent damage. In reality it is not possible to make building completely separated from the ground as vertical supports are needed to transfer the load to ground but to some extent, damage can be reduced to at its maximum point. By using this technique building is partially separated and the maximum damage to structure is prevented.

1.2 TYPES OF BASE ISOLATION TECHNIQUES

There is the few particle isolation techniques mechanisms which is mostly used in the earthquake:-

1. Elastomeric Rubber Bearing
2. Roller and Ball Bearing
3. Sliding Bearing
4. Springs

1.2.1 ELASTOMERIC RUBBER BEARING

This type of technique is mostly used base isolator. It consists of a horizontal layer of synthetic or natural rubber in thin layers filled between steel plates. These bearing have capability of bearing high vertical loads with very small deformations which beneficial during earthquake. These bearing are flexible under lateral loads. Steel plates prevent the rubber layers from bulging. They are usually soft in horizontal direction and hard in vertical direction.



(a)



(b)

1.2.2 ROLLER AND BALL BEARING

This type of isolation technique is mainly implemented to resist service movement and damping. It consists of cylindrical rollers and balls in their system. In this, balls or rollers move in either direction below the structure without allowing the vibration and stresses to reach the entire structure and hence, make the structure more stable in drastic earthquake condition. Rollers or balls are placed between two plates below the structure and are made moveable in any direction.

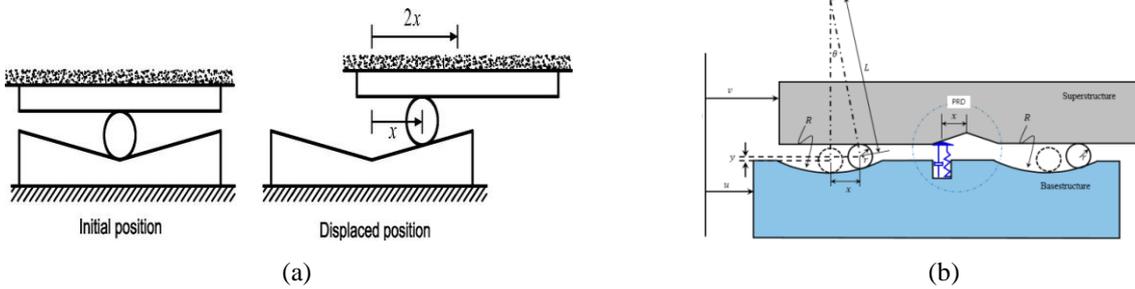
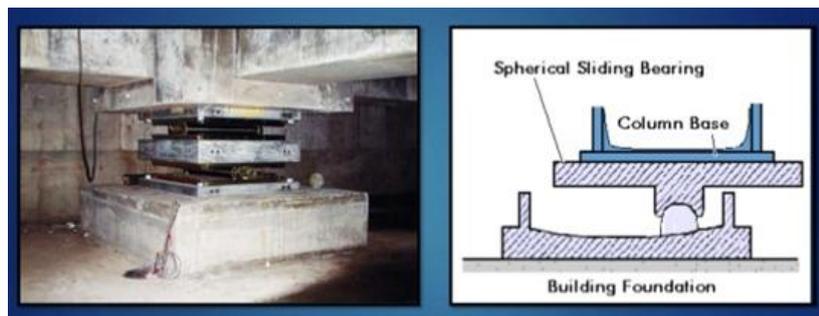


Fig.1.2.2 - Roller and Ball Bearing.(a) and (b) represent the mechanism of roller and ball bearing system.

This type is more preferably used as compared to sliding as it needs less installation cost and is easy to install but costly as compared to elastomeric rubber as need much material stronger for resisting the drastic vibration or force of earthquake.

1.2.3 SLIDING BEARING

In this type of isolation system, there is a shaft which is supported by the sliding surface with oil and air between them to make flexible sliding movement. They resist the vibration produced by the earthquake. They are able to restore forces. Sliding bearing are light weight and they have long life working durability.

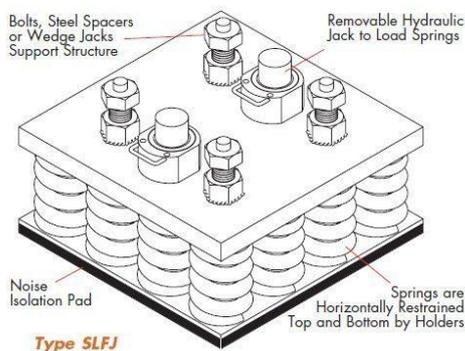


(A)

Fig. 1.2.3- Sliding Bearing.(A) represent the Mechanism of sliding bearing system.

1.2.4 SPRING ISOLATION

This type of isolation system is most likely used in structural engineering. This isolation system is not used because it is flexible from both direction (vertical and horizontal) due to this it can increase the chances of failure. They can be made using single or multiple spring.



(a)



(b)

Fig. 1.2.4- Spring Isolation.(a) and (b) represent the system and design of the base isolation.

II. ENERGY DISSIPATION TECHNIQUE

In this type of technique, several devices are used which enhances damping, stiffness and strength, and can be used for both rehabilitation of structures and new construction. These devices and system are differentiated or characterized by

their energy dissipating capacity in the structural systems in which they are installed. These type of devices works with different style with some advantage and different feature from one another. The different types of passive energy dissipating devices or dampers along with their working principles are described below.

2.1 Various Types of Dampers

- (a) Friction damper
- (b) Tuned Mass Damper
- (c) Viscous Fluid Damper

2.1.1 Friction Damper

There are number of energy-dissipating devices, utilizing friction for energy dissipation, have been developed and tested by researchers. These devices increase the capacity of the structure to dissipate energy. They do not change the natural vibration time periods significantly by about 10 to 20%. One of these devices is the slotted bolted connection. (S.B.C). They are designed to have moving parts that will slide over each other during a strong earthquake. When the parts slide over each other, they create friction, which uses some of the energy from the earthquake goes into the building.

The damper is made up from a set of steel plates, having slotted holes in them, and they are bolted together. When there is high enough forces, the plate can slide over each other creating friction. These plates are specially designed and treated to increase the friction between them.

Examples of this technique used in world are as follows:

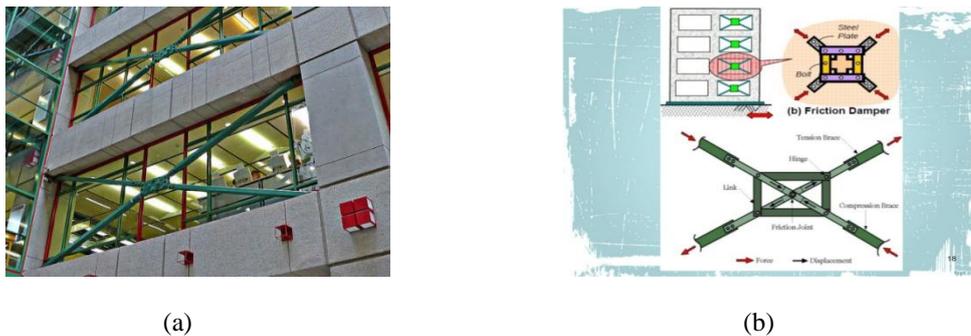


Fig. 2.1.1- Friction Damper.(a) Webster Library of Concordia University in Montreal, Canada.(b) represent the system design of this system.

2.1.2 Tuned Mass Damper

The tuned mass damper is a mechanical device used to decrease or eliminate vibration which occurs due to earthquake in buildings. It is often used in modern installation. It makes the structure stable against violent vibration caused by simple harmonic vibration. A tuned damper reduces the vibration of a system or structure so that the worst case vibration is less intense.

It consists of huge ball suspending in centre of the two buildings or two large high structure. The ball is connected with large wire type rope which moves in opposite direction to the force coming through the vibration coming due to earthquake.

When the force coming due to earthquake produces vibration the structure tries to move in some horizontal direction which is neutralized by the force of weight of this ball. This ball moves in direction like pendulum and makes the structure stable under violent vibrations. Examples of this technique used in world are as follows:

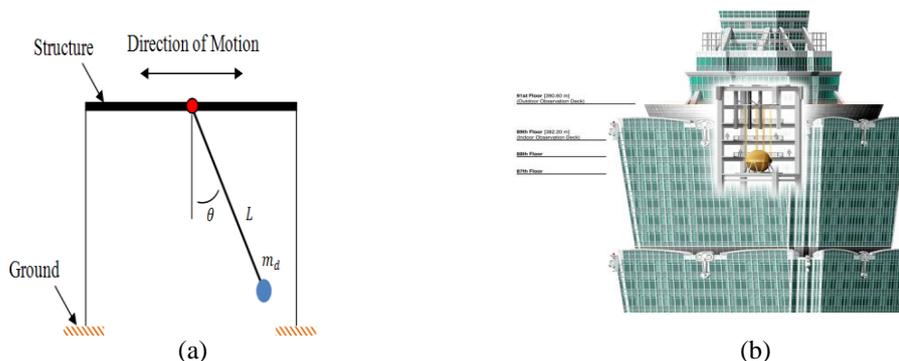


Fig. 2.1.2-Tuned Mass Damper.(b) Taipei 101's largest tuned mass damper, China. (b) represents the mechanism of this system.

2.1.3 Viscous fluid damper

Viscous fluid damper are similar to shock absorber in a car. This act as similar to the hydraulic movement in vehicles. When vehicle move over some small holes on the road, the vibration are reduced due to hydraulic shock absorber system due to which the person doesn't feel any kind of vibration. Similarly, these consist of a closed cylinder contain viscous fluid like oil. A piston rod is connected to a piston head with small hole in it. The piston can move out of the cylinder.

As it does this, the oil is forced to flow through holes in the piston head causing friction when the damper is installed in the building, the friction converts some of the earthquake energy going into the moving building into heat energy. These dampers are installed diagonally in the building's, floors As the building sways to and fro, the piston is forced in and out of the cylinder.

Examples of this technique used in world are as follows:

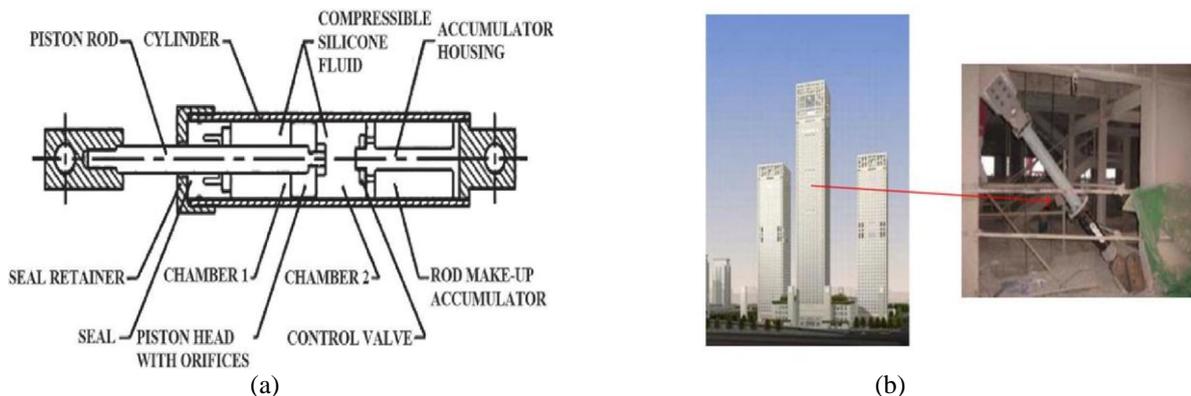


Fig. 2.1.3- Viscous fluid damper. (a) represent the system design of viscous fluid damper. (b) Viscous fluid dampers installed in Beijing Yintai Center, China

III. LITERATURE REVIEW

S.M. Dhawade concluded in his paper that base isolation is very technology to protect different structure like building, bridges and airport etc. from earthquake. It reduces the vibration or effect caused by earthquake. This isolation affects the superstructure to have a rigid movement and help the structure to have minimum displacement. Overturning of structure and its shear movement are reduced in this isolation results the superstructure above the isolation plane to become rigid and stiffer. Hence the performance of isolated structure is efficient in the earthquake prone areas.

Y. Rajesh Kumar concluded in his paper that fundamental time period in a base isolated structure is more due to its flexibility when compared to other bare frame structure. Also the fundamental time period in a structure with dampers is less since the structure with damper offer great stiffness. Base shear decreased largely to an extent of 96% by using base isolators since the forces transferred to the structure in base isolation will be less. The decrement in base shear in a structure with the damper are less when compared to base isolated structure and percentage reduction in base shear was found to be 38% with dampers.

Y. Li and J. Li, studied about base isolator with variable stiffness and damping, modeling design and experimental testing of the new isolator. Sometimes the effect of the earthquake is severe that the passive nature of rubber is not able to sustain the energy arises due to seismic activity. Hence smart base isolation with adoptive and controllable properties was developed with varied stiffness and damping properties of the isolator. The paper shows design and experimental testing, dynamic modeling of smart rubber.

S.D.Darshale et.al., investigated about the response of the base isolated structure. There is so Base isolation is one of the types of energy dissipation system. It is a passive system of energy control. Isolator basically isolates the superstructure and foundation and it partially reflects and partially absorb the part of the energy. Due to the introduction of lead rubber isolator, the horizontal movement of the building increases i.e. fundamental natural time period increase and horizontal stiffness of building decreases. The inner story drift after introduction of isolator is reduced up to certain level. G+14 regular RCC building is taken into the study for comparison of rigid base and base isolated structure. The fundamental natural time period of the structure is approximately 1.7 where in for isolated structure is 4.3sec. As the natural time period increases the energy dissipation also increases and response reduces. Due to isolation inner story drift, base shear acceleration is reduced.

Aperna Verma et al concluded that the performance of fixed base and isolated base structure depends on the type of underlying soil on which the structure rests. For hard strata, the response is relatively satisfactory but the soil of soft soil increases the acceleration, so the energy dissipation of the structure decreases and the frequency increases. For low to medium height buildings, the efficiency of isolators is good. The response of the structure is different because of the different types of changes due to the changes in physical properties of an isolator.

Naveena K et al concluded that the use of base isolation considerably reduces the response of the structure due to earthquake loading. Base isolation is very promising technology to protect different structures like buildings, bridges, airport terminals and nuclear power plants etc. from seismic excitation. The significant characteristic of base isolation a system affect the superstructure to have a rigid movement and as a result shows the relative story displacement & story drift of structural element will decrease and consequently the internal forces of beams and columns will be reduced. Due to decrease in lateral loads to stories, the accelerations of the stories are reduced. This results in the reduction of inertia forces. Story overturning moment and story shear are also reduced in base isolated building. From the above points, it is concluded that the performance of isolated structure is efficient in the Earthquake prone areas.

Donato Concellara et al (2013) describe the difference between lead rubber isolator and friction slider. Isolator was composed of lead rubber bearing in combination with friction slider (FS) and was named as high damping hybrid seismic isolator. The seismic response of high damping hybrid seismic isolator was the difference with lead rubber isolator response. Under different seismic activity in the form of frequency and intensity, the same structure was examined. The Paper is basically a composite centered on HDSI, compared to lead rubber isolator. Various seismic activities were taken into account and results were compared as in the form of base shear, shear force, displacement at the base of the super structure. The comparative result shows HDHSI gives superior safety for severe seismic activity than other.

IV. CONCLUSION

By above discussion, we may conclude that, earthquake resistant techniques are very important for the structures in earthquake prone areas for increasing the stability and strength of structure or building. Both isolation and dampers can be used according to their need among in the building.

Base isolation method is a kind of technique which ensures isolation of building from the ground so as to resist the vibration coming due to earthquake from providing damage to the structure where as energy dissipating technique absorb or dissipate the energy or vibration and prevent the structure from getting damaged.

Principle of base isolation is to just separate the building or structure from ground so as to prevent the energy or vibration coming from the ground and energy dissipation technique absorb the energy or vibration that enters the building or structure and prevent the structure from getting modified.

As compared to energy dissipation, base isolation is more used due to cost of installation and maintenance. Moreover, base isolation is more often used as it offers minimum to minimum damage to building as it does not allow the force and vibration to enter the structure whereas energy dissipation offers resistance but not as much as base isolation technique.

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