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Base Isolation of Structure and Behavior of Structure.

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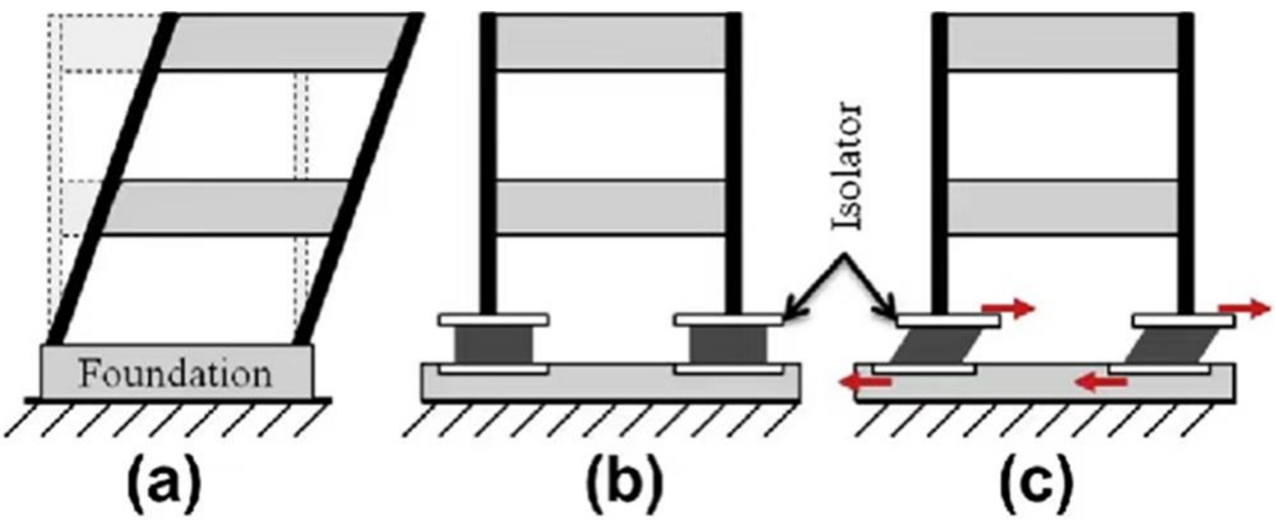

I - INTRODUCTION

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Vol 10 No 11 (2021)

To minimize the transmission of potentially damaging earthquake ground motions into a structure is achieved by the introduction of flexibility at the base of the structure in the horizontal direction while at the same time introducing damping elements to restrict the amplitude or extent of the motion caused by the earthquake somewhat akin to shock absorbers. In recent years this relatively new technology has emerged as a practical and economic alternative to conventional seismic strengthening. This concept has received increasing academic and professional attention and is being applied to a wide range of civil engineering structures. To date there are several hundred buildings in China, Europe, Japan, New Zealand, United States, India which use seismic isolation principles and technology for their seismic design. It may come as a surprise that the rubber foundation

elements can actually help to minimize earthquake damage to buildings, considering the tremendous forces these buildings must endure in a major quake. Contrasting the conventional design approach based on an increased resistance (strengthening) of the structures, the seismic isolation concept is aimed at a significant reduction of dynamic loads induced by the earthquake at the base of the structures themselves. Seismic isolation separates the structure from the harmful motions of the ground by providing flexibility and energy dissipation capability through the insertion of the isolated device so called isolators between the foundation and the building structure.

Invention of lead rubber bearing (LRB, 1970's) and high damping rubber bearing (HDRB,1980's) gives a new dimension to the seismic base isolation design of BI structure . ICBO (1997) included design specification for isolated structures as in Uniform Building Code . A significant amount of both past and recent research in the area of base isolation has focused on the use of elastomeric bearings, such as HDRB and LRB . Providakis (2008) investigated seismic responses of multi- storied buildings for near fault motion isolated by LRB. Dall'Asta and Ragni (2006, 2008), Bhuiyan et al. (2009) covered experimental tests, analytical model and nonlinear dynamic behavior of HDRB.

Although it is a relatively recent technology, seismic isolation for multi storied buildings has been well evaluated and reviewed (Barata and Corbi, 2004; Hong and Kim, 2004; Matsagar and Jangid, 2004; Komodromos, 2008; Lu and Lin, 2008; Spyrakos et al., 2009; Polycarpou and komodromos, 2010). Base isolator with hardening behavior under increasing loading has been developed for medium-rise buildings (up to four storeys) and sites with moderate earthquake risk (Pocanschi and Phocas, 2007). Nonlinear seismic response evaluation was performed by Balkaya and Kalkan (2003).

Resonant behaviour of base-isolated high-rise buildings under long-period ground motions was dealt by Ariga et al. (2006) and long period building responses by Olsen et al. (2008). Deb (2004), Dicleli and Buddaram (2007), Casciati and Hamdaoui (2008), Di Egidio and Contento (2010) have also given effort in progresses of isolated system. Komodromos et al. (2007), Kilar and Koren (2009) focused the seismic behavior and responses through dynamic analyses of isolated buildings. Wibowo et al. (2010) have done the failure and collapse modeling analysis of weak storey building. The low to medium earthquake risk region is prone to seismic hazard in the United States too. Many places at the Midwestern areas in US and China experience low to moderate seismicity. However, for building construction in these zones, seismic base isolation can be a suitable alternative as it ensures flexibility of building and reduces the lateral forces in a drastic manner. Apart from this as the additional cost of using the system is favorable; these sites can also benefit from implementation of this base-isolation system, especially in such buildings as museums, data centers etc. Though the application of isolator is going to be very familiar all over the world, there is a lack of proper research to implement the device practically in low to medium risk seismic zone especially for local buildings in Dhaka, Bangladesh region as per the local requirements. So, this concern is a very burning matter for this study. Site specific earthquake data are also very important in seismic design. This study focused on the detail revise on isolation system, characteristics of various device categories,

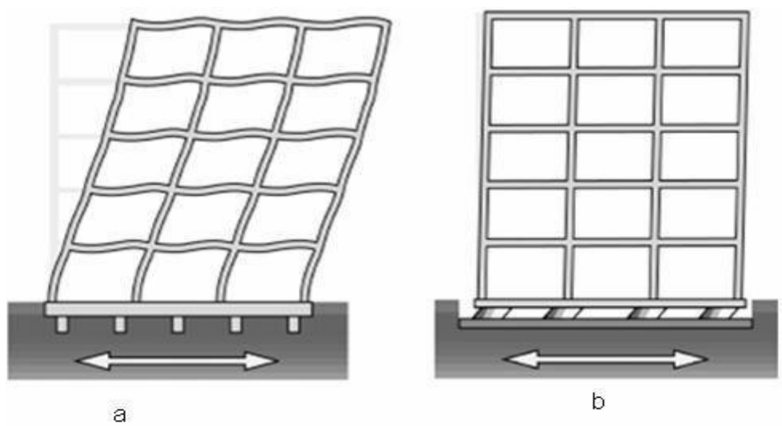
ISSN no. 2277-3037
Vol 10 No 11 (2021)

recognition along with its effect on building structures. Thorough schoolwork has also been accomplished about installation technique for various site stipulations.

2- BASE ISOLATION

2-1 THE PRINCIPLE

Fundamental concepts of base isolation



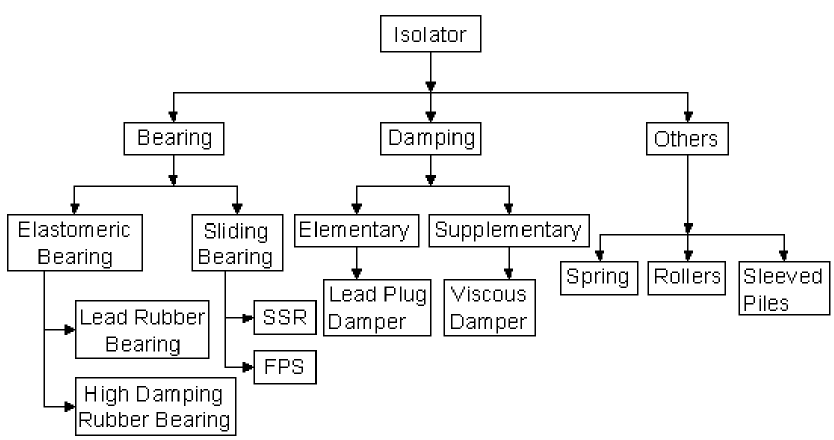


Figure 1. Behavior change while using isolator. (a) Conventional structure (b) base -isolated structur

The term base isolation uses the word a) isolation in its meaning of the state of being separated and b) base as a part that supports from beneath or serves as a foundation for an object or structure. As suggested in the literal sense, the structure (a building, bridge or piece of equipment) is separated from its foundation. The original terminology of base isolation is more commonly replaced with seismic isolation nowadays, reflecting that in some cases the separation is somewhere above the base – for example, in a building the

ISSN no. 2277-3037
Vol 10 No 11 (2021)

superstructure may be separated from substructure columns. In another sense, the term seismic isolation is more accurate anyway in that the structure is separated from the effects of the seism, or earthquake (Kelly, 2001).

The only way a structure can be supported under gravity is to rest on the ground. Isolation conflicts with this fundamental structural engineering requirement.

How can the structure be separated from the ground for earthquake loads but still resist gravity? It is practical isolation systems that provide a compromise between attachment to the ground to resist gravity and separation from the ground to resist earthquakes (Figure 7). Seismic isolation is a means of reducing the seismic demand on the structure:

The fundamental principle of base isolation is to modify the response of the building so that the ground can move below the building without transmitting these motions into the building. In an ideal system this separation would be total. In the real world, there needs to be some contact between the structure and the ground.

A building that is perfectly rigid will have a zero period. When the ground moves the acceleration induced in the structure will be equal to the ground acceleration and there will be zero relative displacement between the structure and the ground. The structure and ground move the same amount.

A building that is perfectly flexible will have an infinite period. For this type of structure, when the ground beneath the structure moves there will be zero acceleration induced in the structure and the relative displacement between the structure and ground will be equal to the ground displacement. The structure will not move, the ground will.

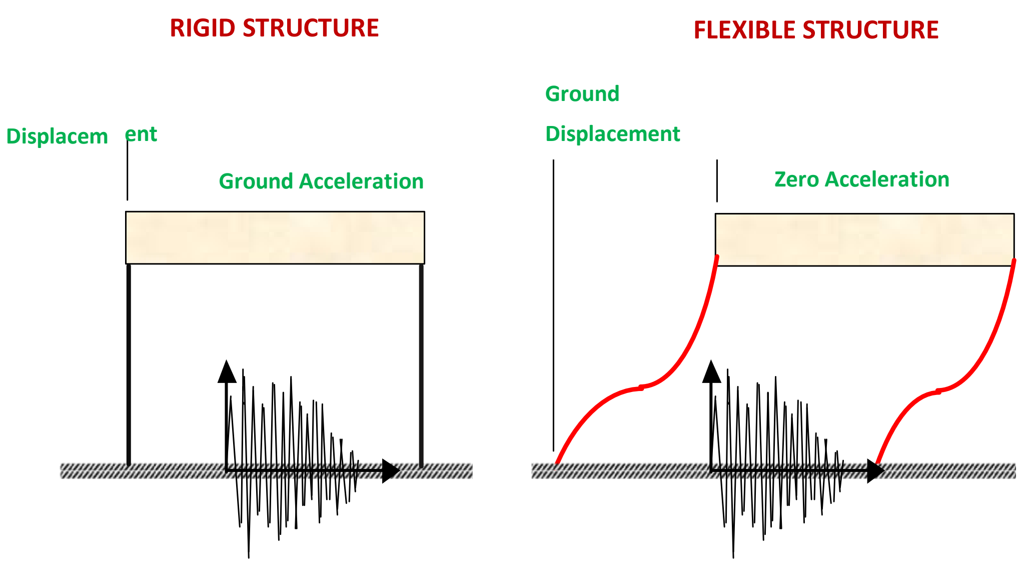


FIGURE 2: TRANSMISSION OF GROUND MOTIONS

ISSN no. 2277-3037
Vol 10 No 11 (2021)

All real structures are neither perfectly rigid nor perfectly flexible and so the response to ground motions is between these two extremes, as shown in Figure 2-2. For periods between zero and infinity, the maximum accelerations and displacements relative to the ground are a function of the earthquake, as shown conceptually.

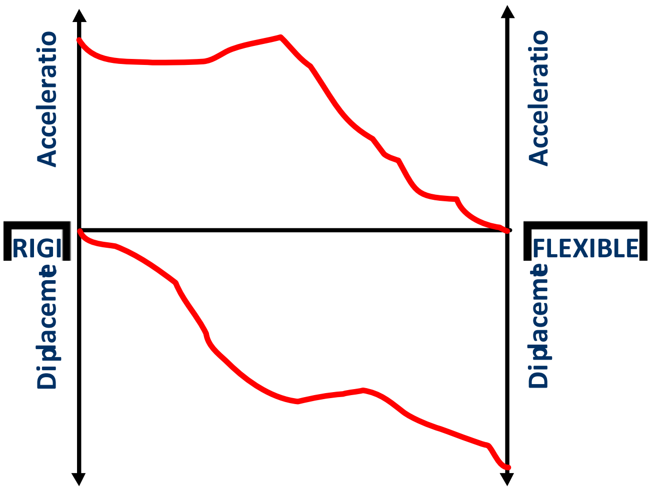


FIGURE 3: STRUCTURE ACCELERATION AND DISPLACEMENT

3-Action of base isolation

Hence, "base isolation" or, seismic isolation separates upper structure from base or, from down structure by changing of fix joint with flexible one (Figure 10).
Increasing of flexibility is done by the insertion of additional elements in structure, known as isolators. Usually, these isolators are inserted between upper structure and foundation (Figure 12). Seismic isolation system absorbs larger part of seismic energy. Therefore, vibration effects of soil to upper structure are drastically reduced. Figure 8 shows the failure pattern of a "fixed based" structure due to seismic loading.

But in case of isolated buildings as the ground moves, inertia tends to keep structures in place resulting in the imposition of structure with large displacements in different stories (Figure 9: left figure: dashed portion indicating displacements due to seismic loading).
For base isolated structure the situation is quite different. In such cases, the whole upper structure gets a displacement (which naturally remains in limits) and the relative displacement of different stories is so small that the structure can withstand a comparatively high seismic tremor with a low seismic loading in a safe, efficient and economic manner.

4-Goal of base isolation

A high proportion of the world is subjected to earthquakes and society expects that structural engineers will design our buildings so that they can survive the effects of these earthquakes. As for all the load cases encountered in the design process, such as gravity and wind, should work to meet a single basic equation: CAPACITY > DEMAND. Earthquakes happen and are uncontrollable. So, in that sense, we have to accept the demand and make sure that the capacity exceeds it. The earthquake causes inertia forces proportional to the product of the building mass and the earthquake ground accelerations. As the ground accelerations

ISSN no. 2277-3037
Vol 10 No 11 (2021)

increases, the strength of the building, the capacity, must be increased to avoid structural damage. But it is not practical to continue to increase the strength of the building indefinitely.

In high seismic zones the accelerations causing forces in the building may exceed one or even two times the acceleration due to gravity, g. It is easy to visualize the strength needed for this level of load – strength to resist 1 g means than the building could resist gravity applied sideways, which means that the building could be tipped on its side and held horizontal without damage.

Designing for this level of strength is not easy, nor cheap. So, most codes allow engineers to use ductility to achieve the capacity. Ductility is a concept of allowing the structural elements to deform beyond their elastic limit in a controlled manner (Figure 10). Beyond this limit, the structural elements soften and the displacements increase with only a small increase in force.

The elastic limit is the load point up to which the effects of loads are non- permanent; that is, when the load is removed the material returns to its initial condition. Once this elastic limit is exceeded changes occur. These changes are permanent and non-reversible when the load is removed.

A design philosophy focused on capacity leads to a choice of two evils:

1. Continue to increase the elastic strength. This is expensive and for buildings leads to higher floor accelerations. Mitigation of structural damage by further strengthening may cause more damage to the contents than would occur in a building with less strength.
2. Limit the elastic strength and detail for ductility. This approach accepts damage to structural components, which may not be repairable.

Base isolation takes the opposite approach; it attempts to reduce the demand rather than increase the capacity. We cannot control the earthquake itself but we can modify the demand it makes on the structure by preventing the motions being transmitted from the foundation into the structure above.

So, the primary reason to use isolation is to mitigate earthquake effects. Naturally, there is a cost associated with isolation and so it only makes sense to use it when the benefits exceed this cost. And, of course, the cost benefit ratio must be more attractive than that available from alternative measures of providing earthquake resistance.

Nowadays Base Isolation is the most powerful tool of the earthquake engineering pertaining to the passive structural vibration control technologies. It is meant to enable a building or non-building structure to survive a potentially devastating seismic impact through a proper initial design or subsequent modifications. In some cases, application of Base Isolation can raise both a structure's seismic performance and its seismic sustainability

5 .0TYPES OF ISOLATORS

Many types of isolation system have been proposed and have been developed to varying stages, with some remaining no more than concepts and others having a long list of installed projects. The following sections provide a discussion of generic types of system. Later chapters discuss devices that are commercially available.

The development of isolators ensured the properties required for the achievement of perfect base isolation. The chart (Figure 11) details the various types of Isolators used through out the world. A brief description along with their basic functions and

ISSN no. 2277-3037
Vol 10 No 11 (2021)

advantages is also included just after the chart. As the present research is mainly highlighting the use of LRB and HDRB type of isolator, so special attention is given to their characteristics.

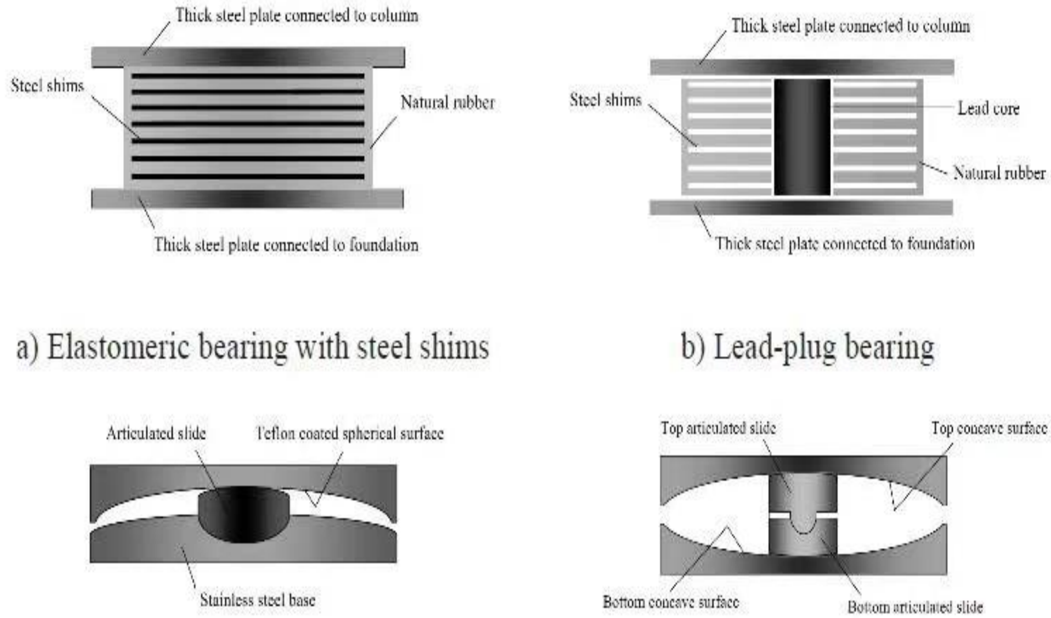
5.1 Design life of isolators

Most isolation systems are based on natural rubber bearings which have a long record of excellent in-service performance. As part of prototype testing, rubber tests including ozone testing and high temperature tests to simulate accelerated aging are performed to ensure the environmental resistance and longevity of the system. All steel components of the elastomeric based bearings are encased in a protective cover rubber except for the load plates. These plates are usually coated with a protective paint. The protective coating system adopted for the Museum of New Zealand, which had a specified 0150-year design life, was a deposited metal paint system.

5.2 Availability of isolator

There are continual changes in the list of isolation system suppliers as new entrants commence supply and existing suppliers extend their product range. A large number of manufacturers of elastomeric bearings worldwide are also providing the requirements as these bearings are widely used. These manufacturers may offer to supply isolation systems such as lead-rubber and high damping rubber bearings, sliding bearings. However, standard bearings are designed to operate at relatively low strain levels of about 25%. Isolation bearings in high seismic zones may be required to operate at strain levels ten times this level, up to 250%. The manufacturing processes required to achieve the level of performance are much more stringent than for the lower strain levels. In particular, the bonding techniques are critical and the facilities must be of clean-room standard to ensure no contamination of components during assembly.

ISSN no. 2277-3037
Vol 10 No 11 (2021)



a) Elastomeric bearing with steel shims

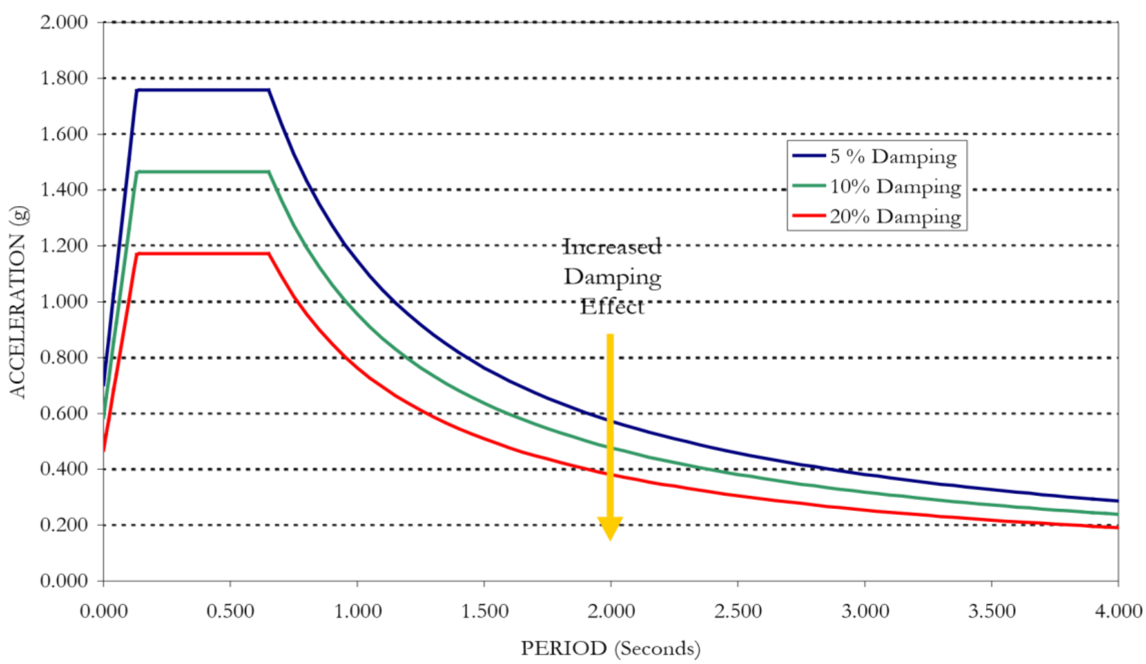
b) Lead-plug bearing

c) Friction pendulum bearing

d) Friction pendulum bearing with double concave surface.

6-ENERGY DISSIPATION –ADDING DAMPING

Damping is the characteristic of a structural system that opposes motion and tends to return the system to rest when it is disturbed. Damping arises from a multitude of sources. For isolation systems, damping is generally categorized as viscous (velocity dependent) or hysteretic (displacement dependent). For equivalent linear analysis, hysteretic damping is converted to equivalent viscous damping.



ISSN no. 2277-3037
Vol 10 No 11 (2021)

FIGURE 4: EFFECT OF DAMPING ON ACCELERATIONS

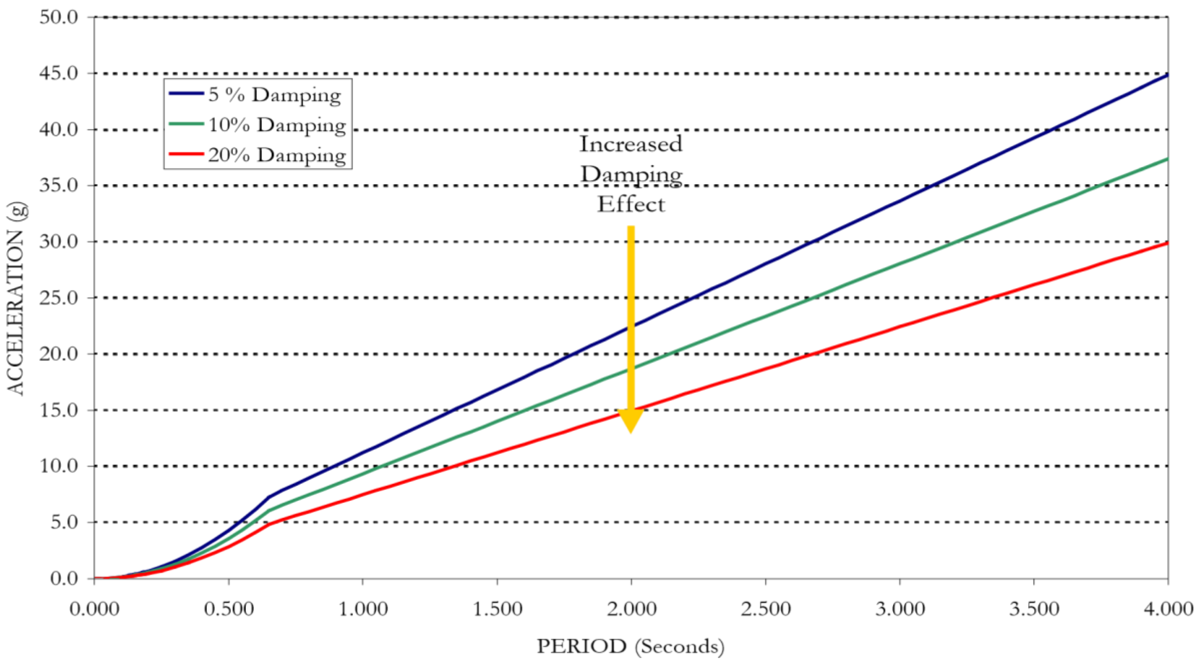


FIGURE 5: EFFECT OF DAMPING ON DISPLACEMENTS

ABSTRACT:

Although a great deal of research has been carried out regarding seismic isolation, there is a lack of proper research on its behavior and implementing technique in low to medium seismic region. The basic intention of seismic protection systems is to decouple the building structure from the damaging components of the earthquake input motion, that is, to prevent the superstructure of the building from absorbing the earthquake energy. This paper reviews a number of articles on base isolation incorporation in building structure. Lead rubber bearing (LRB), high damping rubber bearing (HDRB), friction pendulum system (FPS) have been critically explored. This study also addressed the detail cram on isolation system, properties, characteristics of various device categories, recognition along with its effect on building structures. Meticulous schoolwork has also been accomplished about installation technique for various site stipulations. The entire superstructure is supported on discrete isolators whose dynamic characteristics are chosen to uncouple the ground motion. Displacement and yielding are concentrated at the level of the isolation devices, and the superstructure behaves very much like a rigid body. Rigorous reckoning illustrated the isolation system as very innovative and suitable in buildings to withstand the seismic lateral forces and also contributed to safety ensuring flexibility of structures.

Key words: Earthquaque protection, base isolation, idealized behavior, hysteresis loop, ductility, installation technic

ISSN no. 2277-3037
Vol 10 No 11 (2021)

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Vol 10 No 11 (2021)

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