A Survey on Base Isolation Techniques For Earthquake Resistance

Shahid S. Qureshi[1], Swapnil V. Rajput[2], Sonu S. Thosar[3], Swapnil R. Shinde[4], Prof. R.R. Sarode[5]
[1, 2, 3, 4, 5] Dept of Civil Engineering
[1, 2, 3 4, 5] Padm. Dr. V.B.Kolte College of Engineering, Malkapur

Abstract- *Base isolation has become one of the reliable tools for earthquake resistant design of the structure. Researchers have done various important researches on the base isolation system, which has been fully accepted in the engineering field. Nowadays, a full-scale test is being done on the shake table to test the different features of different isolators. The present review essence literature and theoretical aspect available on base isolation system. Some of the research papers also deal with the effectiveness of variously available isolator and their applicability.*

The purpose of this project is to provide a safe and a proper design of an earthquake resistant building. As earthquake has been and become one of the major disasters in human world, which has caused many deaths and chaos to human lives, due to which the economy of a particular country also goes down. And it also affects the natural balance of the world. So, it is essential that proper measures of prevention must be taken to cope up with such situations. So, adoption of base isolation using bearing at foundation is done in our project for the protection of buildings and lives from the fatal earthquake vibration. It also preserves the economic and social state of a country.

Keywords- Isolation, base, HDRB, seismic etc.

I. INTRODUCTION

Base isolation is one of the most popular means of protecting a structure against earthquake forces. It is one of most powerful tools of earthquake engineering pertaining to the passive structural vibration control technologies. It is easiest to see the principle at work by referring directly to the most widely used of these advanced techniques, known as base isolation. A base isolated structure is supported by a series of bearing pads, which are placed between the buildings and building foundation. The concept of base isolation is explained through an example of building resting on frictionless rollers. When the ground shakes, the rollers freely roll, but the building above does not move. Thus, no force is transferred to the building due to the shaking of the ground; simply, the building does not experience the earthquake.

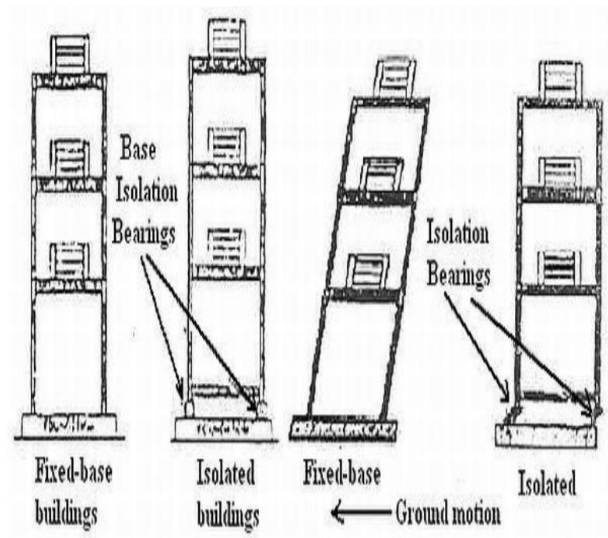

Figure 1.1:- Isolation base structure

Now, if the same building is rested on the flexible pads that offer resistance against lateral movements, then some effect of the ground shaking will be transferred to the building. If the flexible pads are properly chosen, the forces induced by ground shaking can be a few times smaller than that experienced by the building built directly on ground, namely a fixed base building. The flexible pads are called base-isolators, whereas the structures protected by means of these devices are called base-isolated buildings. The main feature of the base isolation technology is that it introduces flexibility in the structure. As a result, a robust medium-rise masonry or reinforced concrete building becomes extremely flexible. The isolators are often designed, to absorb energy and thus add damping to the system. This helps in further reducing the seismic response of the building. Many of the base isolators look like large rubber pads, although there are other types that are based on sliding of one part of the building relative to other. Base isolation is not suitable for all buildings. Mostly low to medium rise buildings rested on hard soil underneath; high-rise buildings or buildings rested on soft soil are not suitable for base isolation.

II. LITERATURE SURVEY

P. Komodromos in his book explains the basics of earthquakes and the detailed description on the seismic isolation. He has described the need of this technique, its main objective, principle on which it works, what exactly seismic isolation is?, the mathematical calculations required to be done during the design of the seismically isolated structures, the various factors affecting the building, etc.

Henry J. Lagorio has mainly written this book for the civil engineers and members of the architectural profession as a means of transferring to them some of the latest developments in earthquake hazards reduction. His interest in earthquake engineering began in 1947 when he joined the faculty of architecture at the University of California at Berkeley. He states that being the engineer, the main aim should be the safety of the people. Now earthquake proof structures could not be built but at least earthquake resistant structures could be built by using various techniques. One of those techniques is the Base isolation technique.

David Dowrick has written this book to help professionals of a wide range of disciplines in their attempts to reduce the social and economic risks of earthquakes. Earthquake risk reduction involves so many issues in planning, design, regulation, quality control and finance that are difficult for any individual to gain a full perspective on the issue, or for any society to move forward in the quest at their desired speed. The general principles of this book apply to the whole built environment. This book was written from the standpoint of a designer trying to keep a broad perspective on the total process starting from the nature of the loading through the details of the construction.

George G. Penelis and Andreas J. Kappos have started the book with the physics of earthquake generation and finished it with the social aspects of mitigating the effect of earthquakes. He has described about the various methods so that the structures which are earthquake resistant.

III. PROPOSED METHODOLOGY AND FINDINGS

An earthquake has been a major threat to human kind and the world, in the unrecorded and recorded human history. It causes an active shaking due to volcanic eruption, which causes the failure of weak and badly designed structures, leading to the innumerous fatalities. Base isolation technique is commonly adopted as safety precaution in earthquake prone areas all over the world. It is implemented in the foundation section of the structure to reduce the effects and damages caused by an earthquake. This system is designed to take the weight of the building and let the foundations move sideways during the earthquake. It provides flexibility at the supports of a structure in the horizontal plane. Seismic isolation can increase the performance expectation of structure in life and also minimizes damage

Response of Base Isolated Buildings: The base-isolated building retains its original, rectangular shape. The base isolated building itself escapes the deformation and damage-which implies that the inertial forces acting on the base isolated building have been reduced. Experiments and observations of base-isolated buildings in earthquakes to as little as ¼ of the acceleration of comparable fixed-base buildings. Acceleration is decreased because the base isolation system lengthens a buildings period of vibration, the time it takes for a building to rock back and forth and then back again. And in general, structures with longer periods of vibration tend to reduce acceleration, while those with shorter periods tend to increase or amplify acceleration.

Types of bearings:

Lead-rubber bearings

These are the frequently-used types of base isolation bearings. A lead rubber bearing is made from layers of rubber sandwiched together with layers of steel. In the middle of the solid lead “plug”. On top and bottom, the bearing is fitted with steel plates which are used to 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. Lead is a crystalline material which changes its structure temporarily, under deformations beyond its yield point, and regains its original structure and elastic properties as soon as the deformation is removed by the restoring force in the rubber. Note that lead has good fatigue properties for subsequent cycles of loading beyond its yield point

Elastomeric isolation system

The most popular seismic isolation systems use elastomeric bearings which consist of thin rubber sheets bonded onto thin steel plates and combine with an energy dissipation mechanism. The rubber sheets are vulcanized and bonded to the thin steel plates under pressure and heat.

The inner thin steel plates provide the vertical load capacity and Stiffness, and prevent lateral bulging of the rubber. In particular the steel plates laterally constrain the rubber sheets as vertical load is applied to the elastomeric bearing, providing the vertical stiffness. Horizontal flexibility is provided by the shearing deformability of the Base Isolation

– A Technique Earthquake Engineering 12 rubber sheets which are not restrained from deform in that direction by the steel plates. Thick mounting steel plates are bonded to the bottom and top surfaces allowing the isolator to be firmly connected to the foundation below and the superstructure above. The energy dissipation mechanism is based either on the plastic deformation of a metal or on the inherent damping properties of the rubber. In the first case either lead plugs are inserted in the elastomeric bearings or auxiliary dampers based on deformations of lead or steel are used. Lead rubber bearings (LRBs) and high-damping rubber bearings (HDRBs) are most useful in seismic isolation since they provide the following in a single unit: Vertical support due to the high vertical stiffness, which is usually several hundred times the horizontal stiffness .Sufficient vertical stiffness is necessary to avoid rocking of the structure. Horizontal flexibility which shifts the fundamental frequency of the structure out of the dangerous for resonance frequency range. An energy dissipation mechanism, either via the plastic deformation of the lead plug or through the inherent damping properties of high damping rubber. Finally, there are also some systems that use natural rubber bearings (NRBs) with additional steel or lead damper; in this case energy dissipation results from the plastic deformations of the damper.

High-damping rubber bearings (HDRBs)

This type of bearing consists of thin layers of high damping rubber sandwiched between steel plates. The same manufacturing methods for vulcanization and bonding that are used for LRBs are also used to construct HDRBs. The only difference is the composition of the rubber compound, which provides increased damping. High-damping rubber is actually a filled rubber compound with inherent damping properties due to the addition of special fillers, such as carbon and resins. The addition of fillers increases the inherent damping properties of rubber without affecting its mechanical properties. When shear stresses are applied to high-damping rubber, a sliding of molecules generates frictional heat which is a mechanism of energy dissipation. In unfilled natural rubber, used for LRBs, frictional heat is negligible because the molecular attraction in physical cross links is very weak. The energy dissipation mechanism of an HDRB is available for both small and large strains, is constant and is characterized by smooth elliptical hysteresis loops. Experimental studies of high damping rubber bearings verified the anticipated energy dissipation capacity, which is, typically, equivalent to about 15% damping ratio of equivalent linear elastic models. However, HDRBs may not provide the necessary initial rigidity under service loads and minor lateral loads, although some initial rigidity is provided by high-damping rubber compounds which exhibit higher stiffness under small strains. A structure isolated with HDRBs essentially has a constant, large fundamental period due to the flexibility of the isolation system, which makes the structure vulnerable to wind action with dominant frequencies close to the fundamental frequency. In addition, the damping and mechanical properties of the HDRB appear to be temperature dependent while the hysteretic energy dissipation mechanism of the LRB is not. HDRBs are not as widely used in seismic isolation as LRBs.

IV. WORKING OF BASE ISOLATION TECHNIQUES

Base isolation is the most commonly adopted method for earthquake resistant building. It is the method of providing a support to the foundation for the buildings in seismic zones as it enables the reduction in earthquake induced forces by increasing the period of vibration of the structure. It effectively protects the structure against extreme earthquake without sacrificing performance during the move frequent, moderate seismic events. With the conventional method of building earthquake structure, the structure may survive of the earthquake but then it may not remain operational after any major seismic event. This technique of base isolation not only prevents the earthquake from any serious damages but also maintains functionality i.e. building remains operational after earthquake.

Advantages:

- Maintenance cost is low.
- Provide sense of security to the people.
- It is durable and strong.
- Longer life span as compared to the normal structure.

Disadvantages

- Superstructure characteristics A seismic isolation is generally suitable for low- to medium-rise buildings which have their fundamental frequency in the range of the usual dominant frequencies of earthquakes. Super structure characteristics such as height, width, aspect ratio and stiffness are related to the applicability and effectiveness of seismic isolation.
- Site characteristics The seismicity of the particular region must be considered in order to determine the necessity of seismically isolated structure in that region. Base isolation is not suitable for all buildings. Mostly low to medium rise buildings rested on hard soil underneath; high-rise buildings or buildings rested on soft soil are not suitable for base isolation.
- Surrounding structures All adjacent structures or facilities which may impose restriction on the seismic

isolation system must be taken into account, especially in order to estimate the maximum allowable displacement..

Applications

Researchers on the subject of seismically isolated buildings state that proper application of this technology leads to better performing structures that will remain essentially elastic during large earthquakes. There are more than 3000 seismically isolated structures around the world. The number includes not only buildings but also bridges and tanks. Of these approximately 150 are in United States. Literature on seismic isolation repeatedly quotes the University of Southern California Hospital in Los Angeles as a significant example of a seismically isolated, seven-story-plus-basement structure that survived the Northridge earthquake and remained operational. The technology of seismic isolation has recently made remarkable advancements since the concept was first put into practice with two buildings constructed on rollers: one in Mexico, the other in Sevastopol, Ukraine.

The first seismically isolated building 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 seismically isolated building in the United States was the Foothill Communities Law and Justice Center in Rancho Cucamonga, California, completed in 1985. It took some time until another isolated building was built in the United States. The reason for the reluctance was quite simple: Seismic isolated structures did not find their way into the building codes. Design professionals, on the other hand, were not able to show any appreciable savings to their clients by using this system. Theoretically, in a perfectly functioning seismic isolation there will be no lateral seismic force acting on the isolated superstructure. Yet if the building codes and building officials persist in designing such superstructures to the same lateral forces pertaining to a fixed-base structure, there will be no savings. This is because the superstructure will end up with equally heavy steel sections or massive reinforced-concrete sizes to counter relatively light lateral seismic design forces.

The first seismically isolated bridge The first bridge structure that utilized an isolation system, with added damping, was the TeTeko 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.

V. CONCLUSION

We can use base isolation technique to construct the earthquake resistant building. Proper materials and design should be selected to get the best result. The safety of people should be the main aim.

VI. FUTURE SCOPE

Seismic isolation is an effective design scheme which successfully addresses earthquake loadings, and not only provides safety but also prevents damage. Seismic isolation is particularly useful for low-to medium rise buildings which happen to have their fundamental frequencies within the dangerous-for-resonance range of dominant earthquake frequencies. Critical facilities, such as emergency response centers, hospitals, fire-stations, utilizes and communication centers, should remain operational of such essential, for the public interest, facilities may be prevented by using seismic isolation to enhance their earthquake capacity by reducing the seismic loads that they may experience during a powerful earthquake. It is very useful, and is probably the only currently available technology that can be used, to seismically upgrade historic structures or to protect very sensitive equipment and the valuable contents of a building.

REFERENCES

[1] P. Komodromos Seismic isolation for earthquake resistance structure.
[2] Henry J. Lagorio Earthquake – An architect’s guide to nonstructural seismic hazards.
[3] Charles K. Erdey Earthquake Engineering. YousefBozorgnia&Vitelmo V.
[4] Bertero Earthquake Engineering. Wai – Fan Chen & Charles Scawthorn Earthquake Engineering Hand Book George
[5] G. Penelis& Andreas J. Kappas Earthquake resistant concrete structure David Dowrick Earthquake risk reduction
[6] Jessica Irene wiles, Dr. Sutton F. Stephens, S.E. An overview of the technology and design of base isolated buildings in high seismic regions in the United States.
[7] Skinner, R.I., Beck, J.L. and Bycroft, G.N., A Practical System for Isolating Structures from Earthquake Attack, Int. J. Earthq. EngngStruct. Dyn. Vol 3, No. 3, 1975 IS: 456 (2000), Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standards, New Delhi.
[8] Egyptian Code (1995): Egyptian Code for Soil Mechanics and Fundation-design. Part 5, Foundation on the problematic soil, Third Edition, 109p

[9] B. M. Saiful Islam*, Mohammed Jameel and MohdZaminJumaat ,Seismic isolation in buildings to be a practical reality: Behavior of structure and installation technique, Department of Civil Engineering, University of Malaya, Kuala Lumpur, Malaysia. Accepted 17 February, 2011