

Elastomeric Base Isolated Structure

Vismay Vartak¹, Rahul Shipkule², Prathamesh Vichare³, Mayuresh Padaskar⁴.

Department of Civil Engineering, Viva Institute of Technology, Mumbai University, INDIA

Abstract-*The main objective of this project has been to analyze the elastomeric base isolated structure that may have to fight against earthquakes.*

In view of huge financial losses and social suffering in the earthquakes, the engineers should carefully view seismic response of the building in terms of damage control and life safety of public.

In this project we have studied what is an earthquake, to know what are you facing, which has different ways of presentation and its possible consequences.

Many ingenious devices have been proposed to achieve this result, but very few have been tried and the concept now generally referred to as base isolation or seismic isolation has yet to become acceptable to the engineering profession as a whole. Although most of the proposed systems are unacceptably complicated, in recent years few practical systems have emerged and have been implemented. While some of these systems have been tested on large-scale shaking tables, none has to date been tested as built by a strong earth tremor. Overall the elastomeric base isolation system showed a significant improvement in dynamic response of the model structure by reducing the lateral acceleration and increasing the damping of the system.

Keywords- *Elastomeric, Earthquake, Damping, Isolated, Devices*

I. INTRODUCTION

1.1 Background: -

An earthquake is the vibration, sometimes violent to the earth's surface that follows a release of energy in the earth's crust. This energy is generated by a sudden dislocation of segments of the crust, by a manmade explosion or by a volcanic eruption. The dislocation of the crust causes most destructive earthquakes. The crust may first bend and then the stresses exceed the strength of rocks, they break. In the process of breaking, vibrations called seismic waves are generated. These waves travel outward from the source of the earthquake along the surface and through the earth at varying speeds depending on the material through which they move. These waves can cause disasters on the earth's surface.

In this project we concentrated architectural configuration of R.C.C structures, provisions ductile detailing as per IS 13920:1983 and elastomeric base isolation systems.

1.2 Base isolation: -

Base isolation is one of the most powerful tool in earthquake engineering for passive structural vibration control technologies. It is used to enable a building or non-building structure to survive a potentially devastating seismic impact through a proper initial design or subsequent modifications. Base isolation is a technique used to prevent or minimize damage to buildings during an earthquake. When a building is built away (isolated) from the ground, resting on flexible bearings or pads known as base isolators, it will only move a little or not at all during an earthquake.

Elastomeric base isolation pad bearings are structural joints that are installed between a structure and its foundation support columns. The purpose is to minimize damage caused by large lateral displacements observed during earthquakes.

1.3 Objectives: -

To analyze and design of earthquake resisting structure having a elastomeric base isolation system.

To increase the life and durability of a structure such that the structure are able to resist the seismic forces of the earthquake.

To decrease the life and property during the earthquake.

1.4 Effects of the earthquake:-

1.4.1 Movement and ground rupture-

They are the main effects of an earthquake on the Earth's surface due to friction of tectonic plates, causing damage to buildings or structures that are rigid in the area affected by the earthquake. Damage to buildings depends on the intensity of the movements, the distance between the structure and the epicentre and the geological and geomorphological conditions that enable better wave propagation.

1.4.2 Landslides and mudslides-

Earthquakes, storms, volcanic eruptions, tidal waves and fires can lead to instability at the edges of hills and other terrain elevations, causing shifts in the earth.

1.4.3 Fire-

Fire can be caused by power failure subsequently damage the gas in large cities. The fire can cause more victims than the earthquake alone

1.4.4 Liquefaction of the soil-

Liquefaction occurs when, because of the movement, water saturated material such as sand, temporarily loses its cohesion and changes from solid to liquid. This phenomenon can lead to collapse of rigid structures such as buildings and bridges

II. LITERATURE REVIEW

2.1 Ms. Sushma G. Sawadkar et al (2017)

[1] carried out a review on Base Isolation Technique. The Possible risk of loss of life adds a very serious dimension to seismic design, putting a moral responsibility on the structural engineers. In recent times many new systems have been developed either to reduce the earthquake or to absorb a part of seismic energy. One of the mostly implemented and accepted seismic protection systems is base isolation. Base isolation is one of the most widely accepted seismic protection system in earthquake prone areas. It mitigates the effect of an earthquake by essentially isolating the structure from potentially dangerous ground motions. The term isolation refers to reduced interaction between structure and ground.

2.2 Fabio Mazza et al (2004)

[2] compared different base-isolation techniques, in order to evaluate their effects on the structural response and applicability limits under near-fault earthquakes. In particular, high-damping-laminated-rubber bearings are considered, in case acting in parallel with supplemental viscous dampers, or acting either in parallel or in series with steel-PTFE sliding bearings. A numerical investigation is carried out assuming as reference test structure a base-isolated five-storey reinforced concrete framed building designed according to Eurocode 8 (EC8) provisions. A bilinear model idealizes the behavior of the reinforced concrete frame members, while the response of the elastomeric bearings is simulated by using a viscoelastic linear model; a viscous-linear law and a rigid-plastic one are assumed to simulate the seismic behavior of a supplemental damper and a sliding bearing, respectively.

2.3 TIAN Xue Min et al (2008)

[3] carried out the task of designing the base isolated structure with rubber bearing. During the time-history analysis of Seismic Response, the peak of natural seismic wave was regulated by the Site-related horizontal peak acceleration A_{max} , the artificial seismic wave is generated by the corresponding acceleration response spectra. In the computation process, El Centro wave, Taft wave, two artificial seismic wave are selected.

2.4 T. Subramani et al (2014)

[4] carried out simple case study on natural base isolation using naturally available soils. The effects of base isolation on structures located on soft soils and near active faults are given in brief. On the other hand, earthquakes provide architects and engineers with a number of important design criteria foreign to the normal design process. From well established procedures reviewed by many researchers, seismic isolation may be used to provide an effective solution for a wide range of seismic design problems. The application of the base isolation techniques to protect structures against damage from earthquake attacks has been considered as one of the most effective approaches and has gained increasing acceptance during the last two decades.

III. BASE ISOLATION SYSTEM

3.1 Base Isolation

3.1.1 What is base isolation: -

It is based on the idea of isolating a soil structure with structural elements that reduce the effect of earthquakes on the structures. These structural elements are called seismic isolators and they are devices that absorb energy by the high deformation that an earthquake transmitted to a structure.

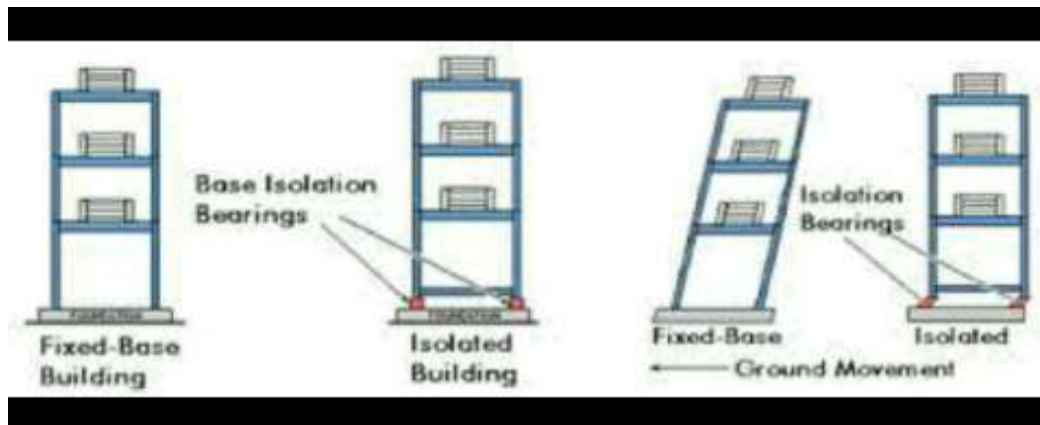


Fig. No. 3.1: Moment of the building

3.1.2 Type of Base Isolation Devices:-

There are six major types of base isolation devices which are widely adopted for seismic base isolation.

Elastomeric Bearings High Damping Bearings

Lead Rubber Bearings Flat Slider Bearings

Curved Slider Bearings or Pendulum Bearings Ball & Roller Bearings

3.1.3 Advantages of Base isolation:-

Reduced the seismic demand of structure, thereby reducing the cost of structure.

Lesser displacements during an earthquake thus reduces the damages caused during an earthquake.

Helps in improving the safety of an Structures.

Reduced the damages caused during an earthquake. This helps in maintaining the performance of structure after event.

Enhances the performance of structure under seismic loads and helps in preservation of property.

3.1.4 Materials used for base isolation:-

Lead rubber: - Lead rubber bearings were developed as base isolators in the 1970s. They consist of three basic components – a lead plug, rubber and steel, which are generally placed in layers.

Rubber: - The rubber provides flexibility through its ability to move but return to its original position. At the end of an earthquake, if a building hasn't returned to its original position, the rubber bearings will slowly bring it back. This might take months, but it will return to its original position.

Lead: - Lead was chosen because of its plastic property – while it may deform with the movement of the earthquake, it will revert to its original shape, and it is capable of deforming many times without losing strength. During an earthquake, the kinetic energy of the earthquake is absorbed into heat energy as the lead is deformed.

Steel: - Using layers of steel with the rubber means the bearing can move in a horizontal direction but is stiff in a vertical direction.

3.1.5 Elastomeric Base Isolation System: -

The developments in rubber technology made the base isolation a practical reality. In the implemented projects of base isolation worldwide, it is observed that elastomeric based systems are the most common. Typically, these systems consist of big rubber block, which can be natural or synthetic that are generally characterized by high vertical stiffness compared to the horizontal stiffness and damping capacity. The vertical stiffness is kept close to rigid, as the structural members are designed to take care of the vertical force component of the seismic excitation. Providing high vertical stiffness also prevents undesirable bouncing motion that is induced if vertical flexibility is provided. Discussions on few popular base isolation systems are provided. Bearings formed of horizontal layers of synthetic or natural rubber in thin layers bound between steel plates. These bearings are capable of supporting high vertical loads with very small deformations. These bearings are flexible under lateral loads. Steel plates prevent the rubber layers from bulging. Lead cores are provided to increase damping capacity as plain elastomeric bearings does not provide significant damping. They are usually soft in horizontal direction and hard in vertical direction.

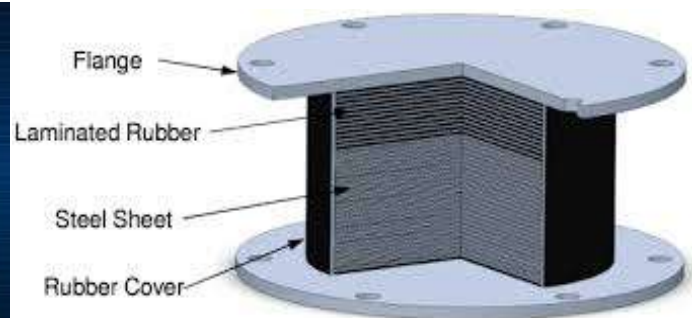
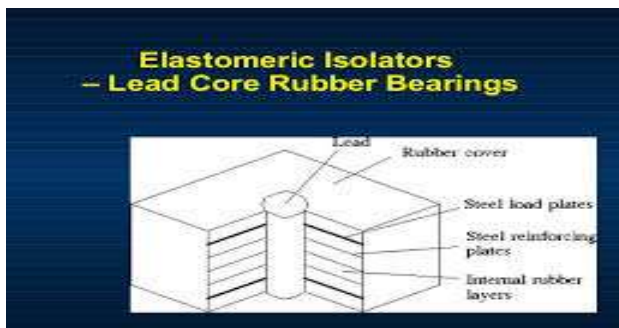


Fig. No. 3.2: Elastomeric Base Isolation Pad Bearing

3.2 Mechanism of Base Isolation:-

3.2.1 Three mechanisms employed by known seismic isolation devices to absorb energy are:

Friction dampening of a stack of abutting metal or metal alloy plates as disclosed.

Shear energy absorption through the cyclic deformation, crystallization, recovery and grain growth of lead, combined with utilizing the dampening characteristics of stacked thin layers of cured rubber separated by layers of a stiffener material.

Minimal shear and viscous dampening by way of a simple, thick, solid cured rubber support. When used as the vibrational energy absorbing means of a seismic isolation device, lead absorbs energy while undergoing a phase change caused by cyclical deformation of the lead, whereas cured rubber absorbs energy through shear and viscous dampening without changing phase.

3.2.2 Working Principle:-

Owing to an earthquake, the ground below each building begins to move. Each building responds with movement which slopes in the direction of the right. The buildings swing in the reverse direction to the ground movement is due to inactivity. The effects of the inertia acting on the building is the most critical of all those forces which takes place at the time of an earthquake. The un-isolated building also alters its form from a quadrangle to a quadrilateral causing deformation to the building. The most crucial harm that an earthquake brings to buildings is the swirl which the building undergoes due to the inertial forces acting on the building.

A fixed-base building (built directly on the ground) will move with an earthquake's motion and can sustain extensive damage as a result. When a building is built away (isolated) from the ground, resting on flexible bearings or pads known as base isolators, it will only move a little or not at all during an earthquake. The isolators work in a similar way to car suspension, which allows a car to travel over rough ground without the occupants of the car getting thrown around.

3.2.3 Assumptions made while constructing a Base Isolation Building:-

- The superstructure is considered to remain within the elastic state during the period of seismic excitation. This assumption is considered appropriate because the base isolation attempts to reduce the earthquake response keeping it within the elastic state.
- The floors are assumed to be rigid in its plane, and the mass is assumed to be lumped at each floor level.
- The columns are inextensible and weightless, providing lateral stiffness, which governs superstructure time period of the structure.

IV. CONCLUSION

Seismic isolation and energy dissipating systems present an effective way to common seismic design for improving the seismic performance of structures. These techniques reduce the seismic forces by changing the stiffness and/or damping in the structures, whereas conventional seismic design is required for an additional strength and ductility to resist seismic forces. The research and development works of passive, active and hybrid devices are ongoing intensively. The guidelines for designing Elastomeric Base Pad Bearing isolators are developed. Different isolator parameters were compared with respect to fundamental period and damping of the fixed base structure, axial load on the column, seismic zone, type of soil and shore hardness of rubber. Acceleration on building and displacement are altered by the installation of isolator. Acceleration on the building decreases and displacement of the building increases, whereas inter storey drift decreases. The increase in displacement can be reduced if the isolator is designed as nonlinear. Additional damping is also introduced by the non-linear isolator.

V. ACKNOWLEDGEMENT

I would like to thank my project guide Prof. Prerana Patil for her guidance throughout the project. Also would like to express my gratitude for the Civil Engineering Department Faculty and my U.G. classmates.

REFERENCE

- [1] Ms. Sushma G. Sawadkar, Mr. Mandar M. Joshi (2017) "A Review Paper on Base Isolation Technique" International Journal for Research in Applied Science & Technology - October 2017
- [2] Fabio Mazza, Alfanso Vulcano (2004) "Base Isolation Techniques for RC Framed Structure Subjected to Near-Fault Ground Motions" 13th World Conference on Earthquake Engineering, Canada – August 2004
- [3] TIAN Xue Min, LU Ming (2008) "Design of Base-Isolated Structure with Rubber-Bearing" 14th World Conference on Earthquake Engineering, China – October 2008
- [4] T. Subramani, J. Joyhi, M. Kavitha (2014) "Earthquake Analysis of Structure by Base Isolation Technique in SAP" Journal Research and Applications – June 2014

- [5] 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.
Refer by J.M. Ferritto
- [6] B. M. Saiful Islam*, Mohammed Jameel and Mohd Zamin Jumaat ,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
- [7] Aung Chan Win, Analysis and Design of Base Isolation for Multi-Storied Building, GMSARN International Conference on Sustainable Development: Issues and Prospects for the GMS 12- 14 Nov.2008.
- [8] T. K. Datta Indian Institute of Technology Delhi, India, Seismic analysis of structure.
- [9] IS: 456 (2000), Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standards, New Delhi.
- [10] Newmark, N.M. and Rosenblueth, E.: Fundamentals of Earthquake Engineering, Prentice-Hall 1971, pp. 225-228, and 343- 345.
- [11] Skinner, R.I., Kelly, J.M., and Heine, A.J., Hysteretic Dampers for Earthquake- Resistant Structures, Int. J. Earth. Engg Struct. Dyn, Vol. 3, No.3, 1975.
- [12] Skinner, R.I., Kelly, J.M., and Heine, A.J., Energy Absorption Devices for Earthquake Resistant Structures, Proc. 5th Wld. Conf. Earthq. Engng, Session 8C, Rome, Italy (1973).