Review on Comparative Study of RCC Building by Using Base Isolator of Various Thickness

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Abstract - *Earthquakes have been one of the most devastating natural disasters in human history, taking many lives and causing chaos on human life. In addition to gravity stresses, the building's structural elements must withstand lateral seismic loads. A lateral load causes high stresses and sway, which results in vibration and drift. If structures are not constructed to withstand lateral stresses, they may collapse, resulting in the death of people and destruction of property. One of the most common and successful techniques of protecting structures from severe dynamic excitations is seismic isolation. The steel bracing system with base isolation is efficient in high seismic areas. Numerous studies have been carried out for determining storey drift, base shear, etc. for conventional structure and base isolated structure by varying area or shape of base isolator; however, variation in storey drift, base shear, etc. by changing thickness of base isolator have not been adequately studied. This paper aims in exploring scope for studying effect of earthquake on structure by varying thickness of base isolator.*

Key Words: Earthquake, base isolation, bracing, Rubber bearing, storey drift, base shear

1.INTRODUCTION

From the ancient time and now also, earthquake is one of the major natural disasters in mankind. Earthquake has taken life of many people and make disorder in their life. An earthquake is a wave-like motion generated by forces that pass through the crust from under the earth's surface layer. Earthquakes cause ground vibrations which are transformed into dynamic loads, forcing the earth and everything connected to it to move in a complex way, causing structural damage [1].

Buildings with a fixed base behave like a tuning fork during an earthquake. Vibrations progressively increase from the base to the top of the building. As a result, the structure may experience major damage. It is difficult to construct a structure entirely earthquake resistant. As a result, the goal is to create a building that is highly earthquake resistant. Flexibility must be included into the structure to meet this as well as in-service functional requirements. This is achieved by installing isolators between the structure and the foundation. [2].
In number of countries, base isolation system is commonly used to protect the building from earthquake waves. Base isolators are installed at the foundation level of the building to reduce vibrations obtain in building during earthquake. Base isolation system has to takes total load of building and help the foundation to move sideways during earthquake. This unique design technique focuses on isolating a building from its supporting ground, which reduces transmission of vibrations occur due to earthquake [1,3].

The energy from an earthquake is absorbed by isolators before passing through the structure from base to roof in base-isolated buildings. As a result, the lateral force caused by an earthquake that is applied to structural elements, including non-structural components, is lower in the base isolation system as compared to the traditional construction system. [4].

After one another, many types of base isolation techniques are created, each suited to unique seismic conditions and buildings. Elastomeric bearings and friction pendulum bearings are two significant base isolation technologies utilized in structures [5].

1.1 Elastomeric Bearing:

The most common base isolator is an elastomeric bearing. A layer of natural or synthetic rubber is placed between the mild steel plates in this isolation device. As a whole, this functions as a single unit. During an earthquake, the steel plates assist the rubber layer in preventing bulging. It is the component that gives the unit its vertical load capacity and rigidity. The bearings provide vertical deformation as horizontal movements when the unit is subjected to motions that result in vertical deformation. Rubber sheets with shearing deformability give horizontal flexibility. The steel plates have no effect on this movement. Thick mounting steel plates are provided on the top and bottom units of the system for a secure connection to the superstructure above and the foundation below. Buildings and large-span bridges use elastomeric bearings widely.

There are 3 different categories for elastomeric bearings.

i) Natural Rubber Bearing
ii) Lead Rubber Bearing
iii) Synthetic Rubber Bearing [5].

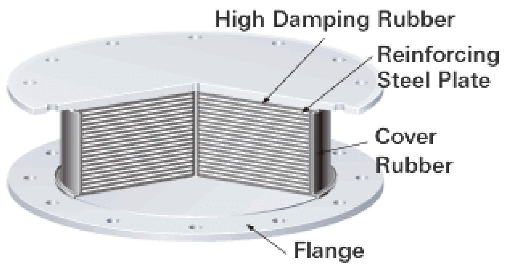

Fig -1: Natural Rubber Bearing

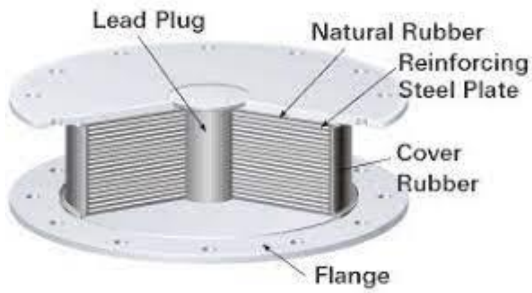

Fig -2: Lead Rubber Bearing [6]

1.2 Friction Pendulum Bearings:

The most often used kinematic mechanism in base isolation is a friction pendulum bearing. A globe is suspended between two steel concave curved surfaces in the pendulum system. A cylinder member with a global contact surface can be used instead of a globe. Special metals are used in this sort of isolation device. This isolation system combines the benefits of a rubber bearing with the ability to slide over a concave global surface. This technology raises the building during seismic lateral motion by taking a position. As a result, the impact of an earthquake on the structure is greatly reduced. In structures, the friction pendulum system is commonly applied in heavy roof systems with huge spans. Because these systems use specific metals, they may be used in building construction in cold climates where there is a greater risk of freezing.

There are two types of sliding bearings based on the sliding surface geometry:

i) Flat Slider Bearing
ii) Curved Slider Bearing [5].

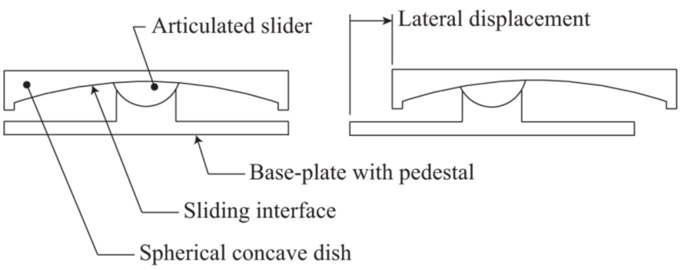

Fig -3: Friction pendulum Bearing [3]

2. LITERATURE REVIEW

Many researchers have studied the behavior and performance of base isolation system under various buildings, especially in the high seismic regions. The present theories published by various researchers related to the behavior of various structures using base isolator of different shape and area is presented in the following section.

Chougule and Jadhav (2019), investigated the behavior of an X type steel braced symmetrical building without and with rubber base isolators at different sections using response spectrum analysis. For analysis, ETABS software is used. The maximum displacement is decreased by the I-section of the rubber isolator, and the displacement is reduced by the usage of base isolators. As a result, the seismic effect on the building is reduced. The usage of base isolators increases the base shear, with the maximum base shear obtained by the I-section of a rubber isolator, making the structure more stable during earthquakes. The use of base isolators reduces story drift, making the superstructure more flexible and thus better for building resistance. As a result, it is beneficial that the risk of earthquake damage to buildings is greatly decreased by the application of bracing and base isolators to the structures. Structure become economical as it reduces the need of structural reinforcement [7].

Ambasta and Sahu (2018), focused on the design, modelling, and analysis of G+6 rigid jointed plane symmetric RCC structures. The purpose of author in this research is to see how successful base isolation with lead rubber bearings (LRB) is compared to traditional construction in the most seismically active region in India. One is building with fix base and other is building with base isolation system. For both cases, the displacement and acceleration of the building are compared. For analysis, ETABS software is utilized. After the lead rubber bearing (LRB) was installed as a base isolation system, the seismic effect on the structure was minimized. After installing LRB, base shear is decreased, resulting in a more robust building during an earthquake. Higher story has less story drift, making the structure more earthquake resistant. After installing LRB, modal displacements rise in every story, which is important for making a structure flexible during an earthquake. Natural periods are delayed, which minimizes the impact of earthquake forces on the ground [8].

Hassan and Pal (2017), designed and analyzed five-story RCC building according to IS Code for seismic analysis in ETABS-2015 software using time history analysis. Two models were used in the investigation. One model is a traditional structure with fixed base, while the other is a base isolation structure. The results show that the base isolation model reduces the moment and shear produced for the same mode, requiring less reinforcement than the fixed-base model. The results also show that the modal period increases in the base isolation model, resulting in higher displacement in this model than the fixed-base model due to the flexibility of the base isolation building. They concluded that after providing lead rubber base isolator the fundamental period mode of structure is increased due to the flexible property of the isolator and the base shear is decreased. As a result, building response is better in base separated buildings than in fixed base structures. The storey displacement is higher in the case of base isolation. Thus, building with base isolation is more flexible than building with fixed base [4].

Adin et al. (2016), provided a simple but innovative and effective Lateral load Resisting structural system or structural technology and methodology for seismic control that can be used to both new and existing industrial steel structures. Because of the huge member size, industrial steel structures have a high dead load, making them more susceptible to seismic damage. So, it is suggested that the response of steel buildings/frames with various steel bracing configurations and dampers be studied. The parametric study of response of Non-linear time history analysis of 3D industrial steel structure braced with varied bracing configurations and dampers with different mass ratios using SAP-2000 software is the focus of this research. This research was mainly conducted to determine how different bracings, dampers with varying mass ratios and height by breadth ratios affect various dynamic parameters. It is concluded that modals with bracings are more efficient than dampers for reducing structural characteristics and modals with dampers are more efficient than bracings for lowering systematic parameters. Time period, Base shear and Lateral displacement decreases with the increase in stiffness of building [9].

Tamang et al. (2016), analyzed the building with shear wall and base isolation experimentally. Lead rubber bearing is the form of base isolation used in this research to create earthquake-resistant structures. To offer lateral flexibility, an isolated rubber bearing consists of alternating rubber layers connected between thin steel plates. IS 875 -1987, IS 456- 2000 & IS 13920- 1993 [10,11,12] are used to design building. They found that the earthquake will undoubtedly be resisted by the basic isolation system in building. The building designed in their study can withstand earthquakes with a magnitude of up to 9. It concludes that, base isolation method is a reliable method of earthquake resistance design than the building without base isolation. Only business structures, such as hospitals, malls, and office buildings, use the base isolation approach; residential buildings are usually ignored. However, if this approach is used in the construction of residential structures as well, it will ensure that people's lives are protected and the planet will be less destroyed [1].

Ghodke and Admane (2015), used SAP2000 software to investigate base isolation in structural analysis for a five-story moment resistant frame with lead rubber seismic isolation. In a recent research, several factors such as base shear, acceleration, torsion, and storey drift were considered in relation to alternative base isolation techniques. The performance of a moment resisting frame in dynamic analysis is investigated with base isolation and the results are compared to those obtained for a moment resisting frame without base isolation. As a test model, a symmetrical frame is constructed. The displacement of a base-isolated building decreases as the height of the building rises also as the height of the structure rises, so does the displacement of the stationary foundation building. When compared to a building with fixed base, the displacement obtained with a building with base isolation is lower [13].

Mkrtychev and Dzhinchvelashvili (2014), studied the efficiency of seismic isolation system in the form of lead rubber bearings with varied height buildings under multicomponent seismic impact. For example, seismically isolated monolithic ferro-concrete 5 storey, 9 storey and 16 storey buildings are studied. A direct integration of the motion equations for an explicit scheme in the software gives the solution to the issue. The estimate is made with the nonlinear nature of lead rubber bearings in mind. The results demonstrate that seismic isolation in the form of lead rubber bearings is effective for structures of this kind and height [14].

Soleimanloo (2012), presented information on the design procedure of seismic base isolation systems. He uses some codes for the design examples of elastomeric bearings. He also analyzes the seismic responses of isolated structures. The seismic isolation is the technique which decouple the structure from the ground. This decoupling is done by improving the system's horizontal flexibility while also providing enough dampening. If response spectrum analysis is done, first model offers more crucial values for the design as compared to second model. If time history analysis is done, second model offers more crucial values for the design than first model. The cause for this is due to difference between the accepted scaling limits of both models [2].

Warn and Ryan (2012), summarizes existing methods, describes widely used seismic isolation hardware, chronicles the history and development of modern seismic isolation through shake table testing of isolated buildings and reviews past efforts to achieve three-dimensional seismic isolation. The assessment of current method and previous research is combined with recent results from shake table testing to indicate areas where more study is needed to ensure that structures are fully protected from seismic damage. The results from testing have several implications. First, a better knowledge of the reaction of nonstructural components and sensitive equipment is required for base-isolated building analysis and design. Second, vertical ground acceleration must clearly be considered in the construction of structure that aim to offer post-event functionality following a large earthquake. Vertical ground acceleration is sometimes taken into account in response history analysis methodologies that are often utilized in critical facility design [3].

Jangid (2007), investigated the analytical seismic response of multi-storey buildings isolated by lead–rubber bearings (LRB) under near-fault motions and found out optimum properties of LRB. Under various system parameters such as superstructure flexibility, isolation time, and bearing yield strength, the change of top floor absolute acceleration and bearing displacement of the isolated building is plotted. Increases in bearing yield strength can considerably reduce peak bearing displacement in near-fault motions while having very little effect on superstructure accelerations. Under near-fault movements, the LRB with a greater yield displacement outperforms the bearing with a lower yield displacement. Under near-fault motions, the optimum yield strength of the LRB is in the range of 10%–15% of the total weight of the structure. The stiffness of both the LRB and the superstructure is found to enhance the optimal yield strength of LRB under near-fault movements. Furthermore, the reaction of a bridge seismically isolated by the LRB is examined, and it is discovered that there is a certain value of bearing yield strength for which the pier base shear and deck acceleration are at their lowest under near-fault movements [15].

Yoo and Kim (2002), investigated the effects of damping in various laminated rubber bearings on the seismic response of a 1/8-scale isolated test structure by shaking table tests and seismic response analyses. For a fixed base design and a base isolation design, a series of shaking table tests were done. Natural rubber bearings and lead rubber bearings are considered. The LLRB was tested with three different designs, each with a different diameter of lead plug and hence varied damping values. The acceleration responses of the seismically isolated test structure were significantly decreased in both shaking table tests and analysis and the shear displacement at the isolators was increased. The diameter of the lead plug in the LLRB has to be increased to enhance isolator damping in order to decrease shear displacement in the isolators. As a result, the stiffness of the isolator increases. With a gradual reduction in isolator shear displacement, the isolator stiffness increases. It amplifies the floor acceleration response spectra of the isolated test structure in the higher frequency ranges [16].

3. CONCLUSIONS

From the literature review, following conclusions can be drawn:

i. The earthquake will undoubtedly be resisted by the basic isolation system in building.
ii. After providing rubber base isolator the fundamental period mode of structure is increased due to the flexible property of the isolator. As a result, building response is better in base separated buildings than in fixed base structures.
iii. After installing rubber base isolator, base shear is decreased, resulting in a more robust building during an earthquake. Higher story has less story drift, making the structure more earthquake resistant.
iv. In building with rubber bearing, modal displacements rise in every story, which is important for making a structure flexible during an earthquake.

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