International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 12 | Dec 2025 www.irjet.net p-ISSN: 2395-0072

Review Paper on Analysis of Isolated Lead Rubber Bearing

Mr. Kaushik Waghmare[1], Dr. A. P. Patil[2]

[1]*Post Graduate Student, Dept. of Civil Engineering, Datta Meghe College of Engineering, Airoli, Navi-Mumbai 400708, Maharashtra, India.*
[2] *Assistant Professor, Dept. of Civil Engineering, Datta Meghe College of Engineering, Airoli, Navi-Mumbai 400708, Maharashtra, India.*

Abstract –*Earthquakes are among the most destructive natural hazards, primarily triggered by the movement of tectonic plates within the Earth's crust. Such seismic events can cause severe structural damage and significant loss of life. Base isolation is an advanced seismic protection technique designed to decouple a structure from ground motion, thereby absorbing and dissipating earthquake forces. This system effectively reduces floor accelerations and inter-storey drifts, enhancing structural safety and improving post-earthquake operability.*

The present review synthesizes relevant literature and theoretical developments on seismic isolation technologies. The main objective of this paper is to evaluate and present the effectiveness of various isolator systems used to mitigate earthquake-induced impacts.

Key Words: Seismic isolation, Base isolation system, Earthquake engineering, Tectonic plates, Structural safety, Seismic mitigation, Inter-storey drift, Floor acceleration, Isolator effectiveness, Structural dynamics etc.

1. INTRODUCTION

In recent years, the rise of tall and slender high-rise buildings has made them increasingly vulnerable to lateral forces such as wind and earthquakes, requiring modern structural designs to focus on both strength and stability under these loads. Seismic design now emphasizes understanding inelastic structural behavior to ensure life safety and controlled energy dissipation during earthquakes. Among various seismic protection methods, base isolation has proven highly effective in minimizing earthquake damage. Originating in the early 20th century and widely adopted since the 1980s in countries like Japan, the USA, and New Zealand, base isolation has also been implemented in India—first after the 1993 Killari earthquake and notably in the Bhuj Civil Hospital following the 2001 Bhuj earthquake. Seismic base isolation is the most popular response-control structure technique, a device having some damping properties and sufficient bearing strength is used in the structure.

1.1 General Description of Base Isolation Systems

This study aims to evaluate how base isolators improve structural performance during earthquakes and to identify the types of structures for which lead rubber bearings (LRBs) are most effective. To achieve this, an 8-storey steel and RCC building with a fixed base is compared to an identical structure equipped with base isolation. Their seismic responses are analyzed to understand the improvements offered by isolation systems.

The research highlights how buildings of varying heights and flexibility behave under different seismic zones when base isolation is applied. The findings can help building owners and industry professionals better understand the advantages of adopting base isolation in a broader range of projects, promoting wider use of this technology.

2. LITERATURE REVIEW

To distinguish between the responses of the fixed base and the isolated base structure and to know the effectiveness of isolators, review of some papers is given:

Stefno Sorace, Gloria Terenzi (2014) In this paper, Stefano and Gloria discuss the design and analysis of a base-isolated building located in Italy. The building consists of 26 residential flats. Both the RCC structure and the base isolation system were designed by practicing engineers. Double Friction Pendulum (DFP) sliders were used as the isolation devices. Based on the structural analysis and construction details, the study concludes that the building achieves very high performance levels. It was also observed that the overall construction cost is significantly lower compared to a conventional fixed-base design. In addition, the reinforcement detailing was simplified, making the structure more efficient and economical.

Tejas Jitendra Chordiya and Vaishnavi Yogesh Totla (2018)

The primary purpose of base isolation is to minimize structural damage during strong ground motions by increasing the fundamental time period of the structure and providing adequate damping. In this project, a low-rise building is analyzed using ETABS software. The study also includes an overview of earthquake engineering principles and base isolation techniques, which helps in improving understanding in this field. Both fixed-base and base-isolated models were analyzed using the response spectrum method, with lead rubber bearings (LRB) provided as the isolation system. The results show that the use of LRB significantly

improves the structural stability and performance of the building during earthquakes.

Dhaval V Shankhpal, Ankit Pal (2013) Dhaval V. Shankhpal and Ankit Pal carried out the design and analysis of an elevated water tank using SAP2000 software. In their study, they reviewed various research works related to base isolation systems for buildings as well as elevated water tanks. Based on the response spectrum analysis, they concluded that the use of a base isolation system is an effective method for improving earthquake resistance. The results showed that base isolation significantly reduces base shear and earthquake-induced displacements in the structure.

Shameena Khannavar and M H Kolhar (2016) In this research paper, a 10-storey RC building was modeled and analyzed using ETABS software. Two types of models were developed: one with a fixed base and the other with base isolation. The study considered two vertically irregular models and two plan-irregular models. Structural analysis was carried out using both the equivalent static method and the response spectrum method. Lead rubber bearings (LRB) were designed according to the UBC 97 code and used as the base isolation system. Key response parameters such as storey displacement, storey shear, storey acceleration, and inter-storey drift were obtained from the analysis. The results indicate that base isolation is highly effective in reducing seismic responses in both plan-irregular and vertically irregular buildings when compared to fixed-base structures.

Michael D symans Symans investigated the effectiveness of an adaptive seismic isolation system in protecting structures subjected to different earthquake ground motions. The proposed system combines sliding isolation bearings with an adaptive hydraulic damper. The damping capacity of the hydraulic damper can be adjusted in real time to respond to the characteristics of the earthquake motion. The results show that, for earthquakes of varying intensities, the sliding base isolation system effectively controls the response of both the isolation system and the structure.

Sarvesh K Jain and Sashi K Thakkar (2004) This study focuses on the application of base isolation in flexible buildings. For the analytical investigation, three building models were considered: a ten-storey, a fourteen-storey, and a twenty-storey structure. The performance of base-isolated buildings was evaluated by comparing them with corresponding fixed-base buildings. The study clearly states that the effectiveness of base isolation is assessed using the Effectiveness Ratio (ER), defined as the ratio of the response of a fixed-base building to that of a base-isolated building.

N Murali Krishna et al (2016) The study focused on the nonlinear time history analysis of buildings equipped with seismic control systems. Asymmetric buildings were considered to evaluate how seismic responses can be effectively controlled. The analysis examined the influence of shear walls and base isolation systems using nonlinear time history analysis (NLTHA) on RCC moment-resisting frame structures. Key response parameters such as storey drift, base shear, torsional moment, and storey displacement were evaluated. The results showed that base isolation has a significant impact in reducing storey drift, storey shear, storey displacement, and torsional effects in low-rise asymmetric buildings. In contrast, shear walls were found to be more effective in improving the same responses in high-rise asymmetric buildings.

Minal Ashok Somwanshi (2015) et al. conducted a study on the seismic analysis of fixed-base and base-isolated building structures. The study involved modeling and analyzing a 13-storey rigid jointed plane frame under two conditions: a fixed-base system and a base-isolated system. The modeling and analysis were carried out using ETABS software, considering the Bhuj earthquake ground motion records. The maximum vertical reactions were obtained from the ETABS analysis, and based on these reactions and the total mass of the structure, lead rubber bearings were manually designed. Time-history analysis was then performed to evaluate floor responses, accelerations, and displacements during earthquake loading. The objective of the study was to demonstrate the effectiveness of the isolation system by examining reductions in key structural responses such as maximum shear force, maximum bending moment, base shear, storey drift, and storey displacement. The analytical results showed that base isolation significantly reduces seismic responses in both symmetric and asymmetric buildings when compared to fixed-base structures, thereby helping to control structural damage during strong ground shaking.

Yang et al (2006), In this paper, two hybrid aseismic control systems are proposed to protect building structures from strong earthquakes. Each hybrid system combines a base isolation system with either a passive or an active mass damper. The base isolation system, such as elastomeric bearings, helps reduce the transfer of horizontal ground motion to the building, while the mass damper—whether passive or active—enhances the safety and reliability of the base isolation system. The performance of these hybrid control systems was studied and compared with that of a conventional active control system. The theoretical and numerical results show that the proposed hybrid systems are highly effective in reducing the seismic response of tall buildings during strong earthquakes. In addition, these hybrid systems are easier to implement in practice compared to using an active control system alone.

Juan C. Ramallo, et al (2008). In this paper, the authors investigated the use of controllable semi-active dampers, such as magneto-rheological (MR) fluid dampers, in base-isolated building systems. A simplified two-degree-of-freedom (2DOF) model of a base-isolated building was used for the study. The main idea behind base isolation is to decouple the structure from ground motion, particularly in

the frequency range where the building is most vulnerable. The primary objective of the study was to reduce inter-storey drifts and floor accelerations in a cost-effective manner, thereby limiting damage to both the structure and its contents. The research examined the potential benefits of replacing conventional linear viscous dampers used in base isolation with semi-active dampers. A linear lumped-mass 2DOF model was adopted, where the superstructure was represented by a single-degree-of-freedom system characterized by its mass, natural frequency, and damping ratio. The performance of passive linear viscous dampers, active dampers, and semi-active dampers was evaluated. Both generalized semi-active dampers and magneto-rheological fluid dampers were considered for seismic protection. The results showed that semi-active dampers achieved performance levels close to those of fully active dampers. Compared to passive linear dampers, semi-active dampers significantly reduced peak base drifts. The study concludes that semi-active dampers, particularly MR fluid dampers, offer a promising and energy-efficient alternative for base isolation systems, requiring much less power than fully active control systems.

3. CONCLUSIONS

After reviewing numerous studies, it becomes evident that protecting structures from unpredictable seismic events is challenging when using conventional methods such as structural strengthening. Although these traditional approaches can enhance building safety, they often lead to increased floor accelerations and larger inter-storey drifts, which negatively impact structural performance. In contrast, the implementation of damping devices capable of absorbing earthquake-induced vibrations has proven more effective. This concept forms the basis of seismic base isolation.

Advantages of Base-Isolated Structures Compared to Fixed-Base Structures: Reduction in seismic energy transfer: Base isolation decouples the structure from ground motion, significantly limiting the amount of earthquake energy entering the building. This results in lower ductility demands and reduced inter-storey drift.

Lower natural frequency and minimized resonance: A structure's natural frequency depends on parameters such as mass, stiffness, and height. When the natural frequency aligns with predominant earthquake frequencies, the building may experience large oscillations. By decreasing the structure's stiffness, base isolators reduce the natural frequency, thereby limiting resonance and minimizing seismic vibrations. Reduced need for additional structural strengthening: Since base isolation decreases the seismic forces transmitted to the superstructure, extensive strengthening elements such as shear walls, braced frames, or additional reinforcement become less necessary.

REFERENCES

[1] R.S. Jangid ''Stochastic response of building with Lead rubber bearings.

[2] A Literature Study to Seismic Isolation in Building and Water Tank by Dhaval V. Shankhpal and Ankit Pal (International Journal of Current Engineering and Technology)

[3] A Review Paper on Base Isolation Technique by Miss.Sushma.G. Sawadatkar and Mr. Mandar.M. Joshi (IJRASET)

[4] Analysis, Design, and Construction of a Base-Isolated Multiple Building Structure by Stefano Sorace1 and Gloria Terenzi (Hindawi)

[5] Application of Base Isolation for Flexible Buildings by Sarvesh K. Jain1 And Shashi K. Thakkar (13th World Conference on Earthquake Engineering Vancouver, B.C., Canada)

[6] Tanwer M.T., Kazi T.A. and Desai M., 2019, A study on different types of base isolation system over fixed based, Information and Communication Technology

[7] Moniri H., 2017, Evaluation of seismic performance of reinforced concrete (RC) buildings under near-field earthquakes, International Journal of Advanced Structural Engineering, 9(1), pp.13-25

[8] Islam A.S., Ahmad S.I., Jameel M. and Zamin M.J., 2012, Seismic Base Isolation for buildings in regions of low to moderate seismicity: practical alternative design, Practice Periodical on Structural Design and Construction, 17(1), pp.13-20.

[9] Carlos Miguel Cabeçadas Calado (2014), Seismic response of base-isolated structures during impact with adjacent structures International Journal of Sciences and Engineering, October 2014, Volume 04, PP. 716-719

[10] Dr Manjunath N Hegde et al (2016), Comparison of Seismic Behavior of Building with Fixed Base, Base Isolator and Shear Wall, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 - 0056 Volume: 03 Issue: 10 | Oct -2016