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Review On Design Of Building with Base Isolation Techniques

Prof.Sayali Dharane[1],Shila Kamble[2],Vinayak Patil[3], Rahul Phad[4] ,Akanksha Mohite[5]

[1]HOD Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology ,Lonavala

[2]Student Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology ,Lonavala

[3]Student Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology ,Lonavala

[4]Student Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology ,Lonavala

[5]Student Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology ,Lonavala

ABSTRACT

In seismic regions, the design and construction of earthquake-resistant buildings are paramount to mitigating structural damage and safeguarding human lives. This case study investigates various techniques employed in the construction of earthquake-resistant buildings, focusing on their effectiveness in minimizing seismic risks. The study evaluates structural dynamics, material properties, and architectural considerations that contribute to enhancing seismic performance.

Key methodologies include a comparative analysis of different structural systems such as base isolation, damping systems, and reinforced concrete frames. Through a series of case examples from earthquake-prone regions globally, the study examines real-world applications of these techniques and their outcomes during seismic events.

The findings underscore the importance of integrating advanced engineering principles with regional seismicity data to optimize building resilience. Furthermore, the study highlights the role of interdisciplinary collaboration between architects, engineers, and material scientists in developing holistic earthquake-resistant building solutions.

Ultimately, this case study aims to provide insights into best practices and innovations in earthquake-resistant design, offering valuable lessons for architects, engineers, and policymakers involved in constructing resilient infrastructure in earthquake-prone areas

Keywords: **Earthquake, Resistance, Building, Area, Base Isolation, Seismic Protection, Structural Engineering, Earthquake Resilience, Damping Systems, Flexible Foundations, Isolation Bearings, Energy Dissipation, Stability, Vibration Control, Seismic Design, Retrofitting, Performance-Based Design, Rubber Bearings, Dynamic Response, Lateral Movement.**

1.INTRODUCTION

Many researches and studies have been done in order to mitigate excitations and improve the performance of tall building against wind loads & earthquake loads. An extremely important and effective design approach among these methods is aerodynamic modifications, including, modifications of buildings corner geometry and its cross-sectional shape. Tall buildings are gigantic projects demanding incredible logistics and management, and requires enormous financial investment. A careful coordination of the structural elements and the shape of a building which minimize the lateral displacement, may offer considerable savings. Nowadays, the challenge of designing an efficient tall building has considerable changed. The conventional approach to tall building design in the past was to limit the forms of the building to a rectangular shape mostly, but today, much more complicated building geometries could be utilized

A building should possess four main attributes, mainly having simple and regular configuration, adequate lateral strength, stiffness and ductility. Buildings having simple regular geometry in plan as well as in elevation, suffer much less damage than the irregular configuration. A building shall be considered as irregular as per is 1893-2002, if it lacks symmetry and has discontinuity in geometry, mass or load resisting elements. These irregularities may cause problem in continuity of force flow and stress concentrations Structural analysis is mainly concerned with finding out the behavior of a structure when subjected to some action. The dynamic loads include wind, waves, traffic, earthquakes, and blasts. Any structure can be subjected to dynamic loading. Structural symmetry can be a major reason for buildings poor performance under severe seismic loading, asymmetry contributes significantly to increased lateral deflections, increased member forces and ultimately the buildings collapse. To perform well in an earthquake a building should possess four main attributes namely simple and regular configuration and adequate lateral Strength, stiffness and ductility. Current earthquake codes define structural configuration as either regular or irregular in terms of size and shape of the building, arrangement of the structural and non-structural elements within the structure, distribution of mass in the building etc.

2 Background:

Recent years have seen a number of occurrences of catastrophic structures failure due to severe seismic events i.e. earthquakes. The huge earthquakes in Chile and Haiti that lead to a large number of deaths tolls and massive loss of properties are the examples. Nepal is too vulnerable to the disasters. So, it has been a great concern of all to make seismically strong structures. One of the widely implemented and accepted seismic protection systems is base isolation. Base isolation is an emerging approach that that is supposed to avoid the forces imposed on structures during earthquake the fundamental concept is to isolate a structure. The fundamental concept is to isolate a structure from ground motion, especially in the frequency range where the building is most affected. The goal is to reduce interstory drifts and floor accelerations to limit damage to the structure and its contents in a cost-effective manner.

For simple buildings, base- friction isolation maybe achieved by reducing the coefficient of friction between the structure and its foundation, or by placing a flexible connection between the structure and its foundation. For reduction of the coefficient of friction between the structure and its foundation, one suggested technique is to place two layers of good quality plastic between the structure and its foundation, so that the plastic layers may slide over each other. However still lots of concerns are there regarding its efficacy. It has been observed that base-isolated buildings are vulnerable to strong impulsive ground motions generated at near-fault locations. Also, flexible connections between the structure and its foundation are also difficult to achieve on a permanent basis.

Base Isolation

Base isolation of structures is one of the most desired means to protect it against earthquake

forces. It is the fundamental concepts for earthquake engineering which can be defined as separating or decoupling the structure from its foundation. This effects in reduction of inter storey drift and effective displacement in the floors of base isolated structural system, that ensures the least damage to facilities and also provides safety to life and property.The concept of base isolation had been suggested in last few decades, the technologies are made available, the knowledge of base isolation system are getting used, developed and hence well established. Seismic isolation systems are more effective when applied to high stiffness, low-rise buildings, owing to their abilities to alter the characteristic of the building from rigid to flexible. And the gradual increase in number of structures to be isolated enhances the fact that base isolation system is gradually becoming accepted as a proven technology in earthquake hazard mitigation Interestingly, base isolation is a passive control system; it does not require any external force or energy for its activation.

Generally, two basic types of isolation systems. In the first approach the isolation system

introduces a layer of low lateral stiffness between the structure and the foundation. With this isolation layer the structure has natural period that is much longer than its fixed base natural period. This lengthening of period can reduce the pseudo-acceleration and hence the earthquake-induced forces in structure. This system is being adopted most widely. The second basic type of isolation system is typified by the sliding system. This works by limiting the transfer of shear across the isolation interface.

Importance of base Isolation:

Base isolation is a critical technique in earthquake-resistant design that helps protect lives and property during seismic events. It works by isolating a building from ground motion, reducing the forces transmitted through its structure. Here's why it is important:

1.Protection of Lives:

- Reduces Building Shaking: Base isolators, typically made from flexible materials like rubber and steel, absorb and dissipate seismic energy. This significantly reduces the shaking experienced by the building, keeping it stable during an earthquake.
- Prevents Structural Collapse: By reducing the forces exerted on the building's frame, base isolation lowers the risk of structural failure or collapse, which is one of the main causes of fatalities during earthquakes.
- Minimizes Injuries: The reduced shaking helps prevent non-structural elements (like ceilings, windows, and fixtures) from falling or shattering, which can cause injuries.

2.Protection of Property:

- Preserves Structural Integrity: Base isolation minimizes damage to the building's core structure, allowing it to remain functional and safe after an earthquake. This is especially important for critical facilities like hospitals, emergency response centers, and data centers.
- Prevents Damage to Contents: The reduced vibrations protect valuable equipment, furnishings, and other contents from being damaged or destroyed. This is particularly important for businesses, cultural landmarks, and residential buildings.
- Reduces Repair Costs: Since the building sustains less damage during an earthquake, the repair costs are typically lower, reducing the financial burden on owners and insurers.
- Maintains Building Functionality: For essential services, such as hospitals and emergency centers, keeping the building operational during and after an earthquake is crucial. Base isolation helps ensure these buildings can continue to function without significant downtime.

3.Economic Benefits:

- Lower Insurance Premiums: Buildings equipped with base isolation may qualify for lower insurance premiums due to the reduced risk of damage.
- Increased Property Value: Structures with advanced earthquake-resistance technologies like base isolation are often considered more valuable, especially in seismic-prone areas.

Types of Base Isolation:

Well, what kind of mechanism can achieve this, resisting the gravitational pull of earth? A lubricated sliding surface? Or a strong magnetic levitation? These might sound right but are not the right engineering solution. It should be a system which is capable of restraining the structure under strong gust of winds and gravitational pull. Though an ideal solution is yet to be discovered or invented, there are a few practical isolation mechanisms which are widely used in the field of earthquake engineering. Which means that these systems are capable of reducing the seismic demand of the structure.

1. Elastomeric Rubber Bearings
2. Sliding Base Isolation Systems
3. Spherical Sliding Base Isolators.

. Elastomeric Rubber Bearing:

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. Elastomeric bearings are flexible support devices used in bridge engineering designed to accommodate movements and rotations while providing load support. These bearings are made from layers of elastomeric materials, typically rubber, which allow for vertical and horizontal movements due to thermal expansion, vibrations, and other forces acting on the bridge structure. Their ability to reduce stress concentrations and dampen vibrations makes them essential components in bridge design.

Fig 1 Elastomeric rubber bearing bridges

Sliding Base Isolation Systems:

The second most common type of isolation system uses sliding elements between the foundation and base of the structure. By high tension springs or laminated rubber bearing by making sliding curved surface. These mechanisms provide a restoring force to return the

Fig 2 Sliding Base Isolation

structure to its equilibrium position. Sliding isolators work on a principle of friction, limiting the transfer of shear across the isolation interface. Imagine two plates that can slide over each other: the sliding starts only when the exciting force of the earthquake is greater than the frictional force between the plates. As a result, the displacement motion of the isolator is of a stick-slip nature. Sliding isolators can be implemented in different ways.

Spherical Sliding Base Isolators:

Spherical Sliding Base Isolators (SSBIs) are a type of seismic isolation device used in earthquake-resistant structures to reduce the impact of ground motion on buildings or bridges. The primary function of these isolators is to decouple the structure from the ground, allowing it to move more freely during an earthquake and reducing the amount of force transferred to the building. SSBI's are commonly used in critical structures such as hospitals, bridges, high-rise buildings, and cultural heritage sites in earthquake-prone regions. Their ability to reduce structural stress and prevent damage makes them an important part of modern earthquake engineering

These isolators are part of the broader approach of base isolation, which is becoming increasingly popular in earthquake-prone areas, including India, due to their effectiveness in protecting structures from seismic forces. SSBI works on the principle of a pendulum. The isolator allows the building to move back and forth in a smooth, controlled manner, similar to a pendulum. This motion effectively lengthens the building's natural period of vibration, reducing the impact of the earthquake's high-frequency ground motions.

Fig 3 Spherical Sliding Base Isolation

3.LITERATURE REVIEW

1. Sarvesh K JAIN And Shashi K THAKKAR (2000).

In this analytical study, effect of earthquake characteristics on response reduction and effect of post-to-pre yield stiffness ratio & yield displacement of isolation system on equivalent viscous damping are studied for a six storey reinforced concrete building base isolated by filled rubber bearings. Five earthquakes recorded at different sites in India, are considered in this study.It is observed that filled rubber bearings are effective isolation system against ground motions with high dominant frequencies. Besides other bearing parameters, the damping available from these bearings depends upon input ground motion also. The desired amping in filled rubber bearings for a given input motion can be achieved by controlling the value of yield force/displacement.

2. Tai-Chieh Wu (2001).

To accomplish the predicted behaviours of the base-isolated buildings, the design for base isolation system is regarded as the dominant factor of the success of isolated buildings. Although the base isolation design can be fulfilled using Uniform Building Code 1997, conceptual design is yet necessarily analyzing to achieve the optimal and effective values of design. finally, the performance of base isolated buildings subjected to extreme loads and service loads are investigated. Specifically, the implementations of active control system and semi-active control systems are studied. The results show that the new devices can highly reduce the response of the building under service loads.

3. TIAN Xue Min and LU Ming (2008).

In this paper, the theories and steps of base-isolated structure with rubber-bearing designare introduced, then a practical example with isolating rubber-bearings and the corresponding design process are introduced and the simulation results are analyzed. The flexible connecting device of isolation layer design and a connection method of isolation bearing without top fixing plate are introduced. At last, the proposed isolated structure and the non-isolated structure are compared, the result shows the base isolation method can reduce the seismic response of structure evidently. The estimated isolation layer factors have already approached or met the design and aseismic fortification objects targets with the Iterative Computation of Response Spectrum Method of SDOF. With the effect of severe earthquake, the max displacement of isolation layer meets the requirement of code and standards.The connection of isolation bearing without top fixing plate is safe, while the cost of isolation bearing is largely decreased.

4. Dhiraj Narayan Sahoo, Dr. Prof. Pravat Kumar Parhi (2018).

The aim of present study was to analyse building at seismic zone i.e. in zone-II without and with base isolator and to assess the seismic behaviour of structure. The main purpose of this study is to investigate the effectiveness of base isolator which acts as energy dissipater. Moreover, this study provides an overall comparative result analysis of structure with increase of number of storeys. Following conclusions can be drawn after analyzing the results of 3-D analysis of G+ 10, G+ 15 storeys building in seismic zone II using ETABS software. The time period of structure increases approximately 2 times after providing the base isolator to fixed base structure. Due to this increase in time period, structure experiences less amount of seismic forces. The lateral earthquake Load, storey shear, column forces and moment are reduced to significant amount due to use of base isolator to the structure. From the above data, the damage to the base isolated structure will be less as compared to fixed base structure.

5. Mohit Arya, Aditya Sharma, OPS Bhadoriya (2020):

The study of base isolation along with seismic analysis is aimed to be carried out by using response spectrum analysis in SAP 2000. An overall comparison of G+10 with isolator and without isolator will be studied. The G+ 10 storey building has been simulated in SAP 2000 with isolated base. The rubber isolator is used to work as a damping device which is expected to improve seismic response. The expected results will be more stable structure with base isolation technique. The results shows that the base isolator is reducing the overall effect of earthquake forces on given RCC building. By introducing lead rubber bearing as base isolation system it increases the structures stability against earthquake and reduces reinforcement hence make structure economical. As the damage to the base isolated structure will be less as compared to fixed base structure, structure can be immediately occupied after the actual earthquake. Further for any important machinery installed in structure, due to the presence of the isolators, it is safer and suffers less damage than fixed base building.

4.Problem Statement:

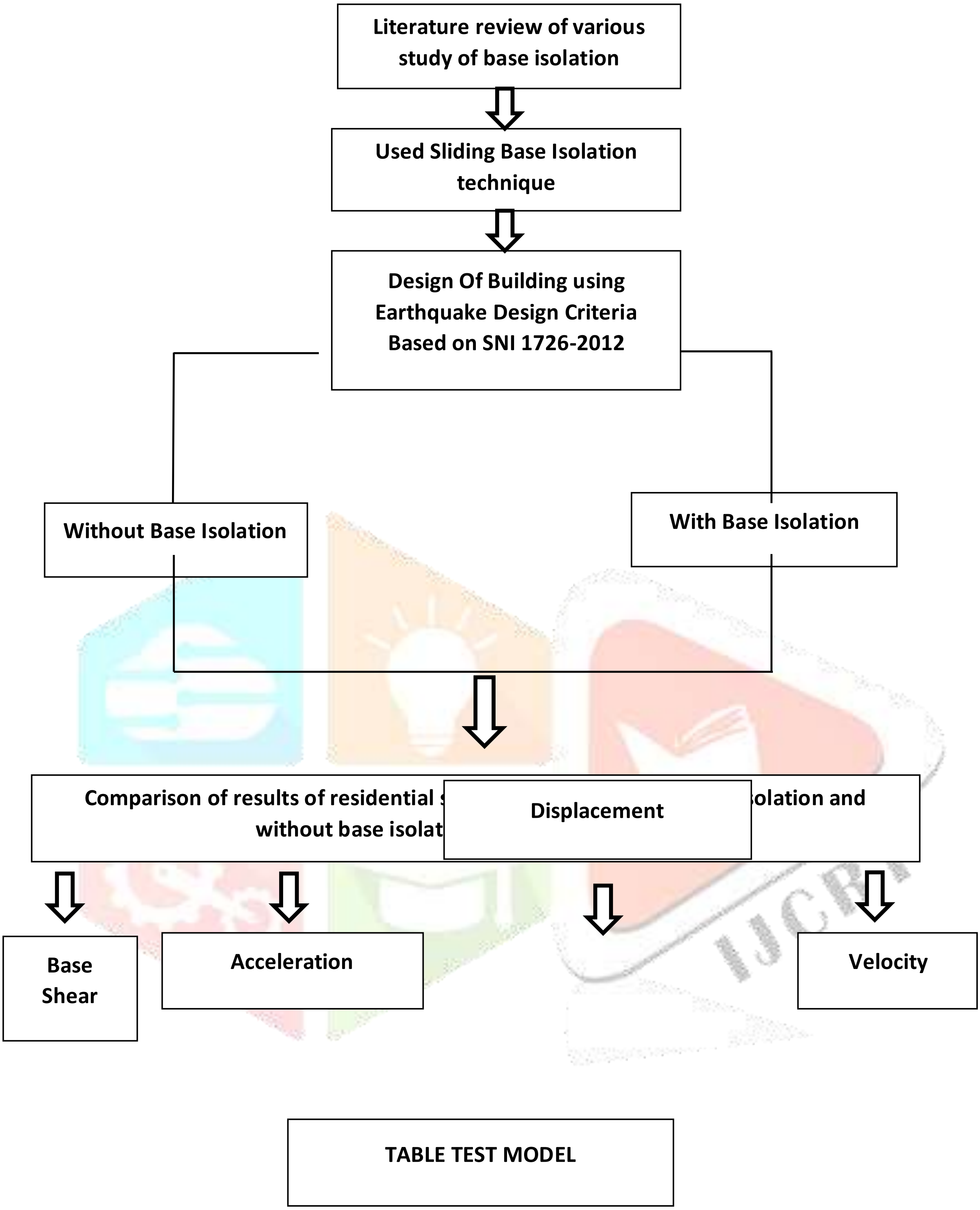
In regions prone to seismic activity, buildings are often vulnerable to catastrophic damage during earthquakes, posing significant risks to human life and infrastructure. Despite the availability of modern earthquake-resistant techniques and materials, many structures continue to be designed without adequate consideration of seismic forces. This is particularly critical in developing countries like India, where rapid urbanization and limited resources often result in compromised building safety.

5.Objectives:

i. To study the Base Isolation Techniques for the Earthquake Resistance Buildings.
ii. Ensure structural reliability without structural damage due to ground shaking of moderate intensities.
iii. To carry out the analysis of a multi-storey RCC building with and without laminated rubber bearing base isolator using Etab software.
iv. To compare parameters like Base shear, Acceleration, displacements, Velocity.
v. To understand how seismic forces affect different building structures and their components during an earthquake.
vi. To develop strategies and designs that enhance the overall safety of buildings, reducing the risk of collapse and ensuring structural integrity during an earthquake.
vii. To explore ways to reduce damage to buildings, thereby minimizing economic losses and ensuring faster recovery after an earthquake.
viii. To compare Model of Building with & without Base Isolation Techniques using Etab software.

6.Methodology:

We have constructed two models of building, one with base isolation and the other general model both fixed on base plywood. Cutting, drilling and welding were the major process gone through to develop the required models.



CONCLUSION:

i. Resilience is the major factor for buildings destruction.

ii. Earthquake resistant building can be obtained by isolating base and its structure.

iii. Base isolation is applicable to low to medium rise building.

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