

Comparative Seismic Analysis of a G+7-Storey Hostel Building with Fixed Base, X-Bracing and Base Isolation

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Abstract—This study investigated the seismic behaviour of a G+7-storey hostel building located on soft soil in Seismic Zone V using CSI ETABS 2022. To evaluate the effectiveness of different seismic protection techniques, three structural models were developed and analysed: Model M-I, representing a conventional fixed-base structure; Model M-II, incorporating an X-bracing system; and Model M-III, combining a base-isolation system with cross bracing. The seismic performance of the three models was evaluated in terms of story displacement, story drift, overturning moment, and shear force in both the X- and Y-directions. In conclusion, the study establishes that appropriate seismic protection measures are essential for improving the performance and safety of multi-storey buildings constructed on soft soil in high seismic regions. The combined application of base isolation and cross bracing provides an effective structural approach for controlling earthquake-induced responses and enhancing the overall seismic performance of the building.

Index Terms—*Seismic Seismic Analysis, Soft Soil, Seismic Zone V, ETABS 2022, Fixed-Base Structure, X-Bracing, Base Isolation, Cross Bracing, Story Displacement.*

I. INTRODUCTION

Earthquake resistance is influenced by a number of structural characteristics. A symmetrical and regular building layout reduces torsional effects and aids in the uniform distribution of seismic forces. The building can safely absorb seismic energy because ductile structural elements, including structural steel and reinforced concrete, can withstand significant deformations without abrupt failure. In order to withstand horizontal seismic stresses, shear walls, braced frames, and moment-resisting frames offer extra lateral strength and stiffness. In addition to preventing excessive settlement or instability, well-designed foundations guarantee the safe transfer of seismic loads to the earth. Advanced seismic

protection technologies including base isolation systems and energy dissipation devices (dampers) are also used in contemporary earthquake-resistant buildings. Base isolation uses flexible bearings to lessen the transfer of ground motion to the superstructure.

1.1. Base Isolation

The seismic protection techniques for earthquake-resistant building are base isolation. It works by sandwiching flexible isolation devices between the superstructure and the building foundation, protecting the structure from ground motion caused by earthquakes.

A base-isolated building permits controlled movement at the foundation level, greatly minimizing the transmission of earthquake energy, in contrast to traditional fixed-base buildings, where seismic forces are immediately transferred to the structure. This method increases structural safety, reduces damage, and guarantees that buildings will continue to function during an earthquake. Below is a discussion of the main purposes of base isolation.

1.2. Types of Base Isolators

1. Rubber (Elastomeric) Bearings:

These bearings are made from alternating layers of rubber and steel plates. The steel plates ensure strength and stability, while the rubber provides flexibility. A lead core might be added for extra energy absorption, creating a Lead Rubber Bearing (LRB).

Benefits:

- Durability and ease of construction.
- Offers damping and flexibility.

2. Sliding Bearings:

This type allows for horizontal movement with low-friction sliding surfaces. For example, the Friction

Pendulum System (FPS) uses a spherical surface that lets a building slide until gravity returns it to its original position.

Benefits:

- Effectively accommodates significant displacements.
- Capable of supporting heavy structures.

1.3. Hybrid Structure

A hybrid structure is defined as a system in which the beneficial aspects of two or more distinct materials or structural systems are combined, with the objective of ensuring that their individual strengths are utilized while their relative shortcomings are minimized or offset.

In other words, a hybrid structure is formed when materials such as steel, concrete, timber, or composite elements are integrated to achieve optimal, economical, and effective structural performance.

1.3.1. Purpose of Using Hybrid Structures

The main purposes for which hybrid structures are employed can be summarized as follows:

- Strength and stiffness are increased when materials with complementary properties are combined.
- The overall load is reduced without compromising structural integrity.
- Energy efficiency and durability are enhanced.
- Material usage and cost efficiency are optimized.

1. Steel–Concrete Hybrid Structures

This type of hybrid system is most commonly used in modern construction.

In such systems, strength in tension and ductility are provided by steel, whereas compressive strength and fire resistance are provided by concrete. Typical examples include a steel frame with concrete floors or a reinforced concrete core with steel bracing, through which both strength and stability are achieved.

2. Timber–Concrete Hybrid Structures

In this system, the sustainability of timber is combined with the strength and mass of concrete.

Such structures are generally used in mid-rise buildings and bridges. For instance, timber beams are combined with concrete slabs so that lightweight yet strong floor systems are produced.

3. Steel–Timber Hybrid Structures

Here, the lightness of timber is combined with the strength and elasticity of steel.

These types of structures are employed in roof systems and long-span designs, where lightness and durability are required.

4. Composite Hybrid Systems

In composite systems, fiber-reinforced polymers (FRP) are used in combination with either steel or concrete. Through this combination, strength, corrosion resistance, and durability are improved, particularly under extreme environmental conditions.

II. LITERATURE REVIEW

Amol Chirde (2022) The analysis of this project has suggested "Base Isolation," a significant kind of seismic protection system or device with mechanical properties that are flexible in a horizontal orientation. In essence, these devices are sliding base isolation and elastomeric base isolation. In order to safeguard the base isolation system from the vibrating effects of earthquakes, the proposed study introduces a sort of support that separates it from the shaking ground. One of the most often used techniques for shielding a building from the impact of an earthquake is base isolation, commonly referred to as seismic base isolation or base isolation system. Applying base isolation can sometimes significantly improve a structure's seismic performance and sustainability.[1]

Saruar Manarbek (2013) Outlining the pertinent concerns about the conceptual design of base isolated structures is the main goal of this inquiry. The response of both fixed base and base isolated methods to strong earthquake excitations is compared using a 90-foot-tall, six-story moment steel frame structure with tension cross bracing. Additionally provided are methods for simulating the isolation system and the superstructure. The comprehensive finite element structural analysis software program SAP200 was used to perform elastic time-history analyses. The comprehensive finite element structural analysis software program SAP200 was used to perform elastic time-history analyses. For the 1940 El Centro earthquake, a time history study was carried out. The effects of seismic loads on the structure were examined using response spectrum analysis.

Tariq H.R. Bermany et. al. (2025) The purpose of base isolation systems is to improve a structure's performance and seismic resilience. However, these technologies have drawbacks and difficulties when it comes to successfully safeguarding structures in a variety of seismic scenarios. The results indicate that creating a multi-directional base isolation system that combines EEWS for pre-activation with hybrid bearings and controllable fluid viscous dampers or piezoelectric actuators as supplement damping devices could provide a viable way to overcome the drawbacks of conventional isolation systems. These developments may open the door to more reliable, economical, and flexible base isolation techniques, particularly for high-risk seismic regions and vital infrastructure.

III. METHODOLOGY

In this chapter, the approach adopted for the structural analysis of a multi-storey building under various loading conditions is presented. A G+7-storey building located on soft soil has been considered for the study. The building is intended to be used as a hostel and is situated in Seismic Zone V.

For the evaluation of seismic performance, three structural models have been considered. The effect of base isolation and cross bracing on the structural performance of the building has also been investigated. The following models have been considered for the analysis and design; Model M-I: A multi-storey building with fixed supports representing the conventional foundation system. Model M-II; A multi-storey building provided with a X-Bracing system. Model M-III; A multi-storey building provided with a base-isolation system along with cross bracing.

The structural behavior of all three models has been evaluated under the specified loading conditions, and their seismic performance has been compared to determine the effectiveness of the proposed seismic protection systems in CSI Etabs 2022.

IV. RESULT AND DISCUSION

This study examines the seismic behaviour of a G+7-storey hostel building located on soft soil in Seismic Zone V. The analysis and design of the building are carried out using CSI ETABS 2022. To understand the

effect of different seismic protection methods, three structural models are considered. Model M-I represents the conventional fixed-base building, Model M-II is provided with an X-bracing system, and Model M-III combines a base-isolation system with cross bracing.

The three models are compared based on important structural responses such as story displacement, story drift, overturning moment, and shear force in both X- and Y-directions. The results show that the fixed-base model, M-I, experiences considerably higher lateral displacement and structural response. The maximum X-axis displacement of M-I reaches 66.476 at Story 7, whereas M-II and M-III show much lower values of 18.372 and 16.930, respectively. M-III generally provides better control of displacement and story drift, particularly at the upper stories.

A significant reduction in overturning moment is also observed for the braced and isolated models. The maximum X-axis overturning moment at the Base is 1,491,866.0 for M-I, compared with 125,800.7 for M-II and 75,909.0 for M-III. Similarly, the maximum Y-axis overturning moment for M-I is 940,448.1 at the Base. The maximum shear forces occur at the lower levels, with the X-axis shear reaching 5,070.535 and the Y-axis shear reaching 1,702.5 at Story 1.

V. CONCLUSION

Overall, M-1 shows the highest structural response in terms of displacement, story drift, overturning moment, and shear force.

M-2 and M-3 provide improved structural performance by reducing lateral deformation and force demands. Among the three models, M-3 generally shows the most favorable seismic response, particularly in controlling displacement, story drift, and overturning moment.

VI. FUTURE SCOPE

The present study can be extended in the following areas:

Different Building Heights: Future studies can consider buildings with different numbers of stories to evaluate the effectiveness of the structural system for low-, medium-, and high-rise buildings.

Different Soil Conditions: The analysis can be extended to medium and hard soil conditions to study the influence of soil properties on structural response.

Different Seismic Zones: Further research can be carried out for different seismic zones to compare the structural behaviour under varying earthquake intensities.

Advanced Isolation Systems: Different types of base isolation systems and isolator properties can be investigated to identify the most effective system for reducing seismic response.

Nonlinear Analysis: Future work can include nonlinear static and dynamic analysis to obtain a more realistic understanding of structural behaviour during severe earthquakes.

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