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Research Article

Dynamic Analysis of RCC Framed Structure Considering Effect of Base Isolation

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ABSTRACT

Introduction: Base isolation is a system that protects a building from the damaging effects of a seismic movement. If the structure separates from the ground during an earthquake, the ground is moving but the structure is still dormant. However, this scenario is not realistic. The current technology that is active and expanding is the introduction of a low lateral stiffness support that isolates the structure from the ground movement. The objective of base isolation system is to decouple the structure from the ground. It lowers the effect of ground motion transmitted to the structure. Behaviour of multi-storey buildings during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and vertical planes of building. A complete literature review is undertaken in this study to better understand seismic evaluation of building structures, the use of time-history analysis, and free vibration analysis. Design the footing for the G+14 building and assess its spring stiffness, as well as analyses the G+14 storey building and compare the findings of the fixed base structure with the isolated building structure using ETABS. A time-history analysis of fixed foundation structure and base isolation at building footing levels is performed to determine whether or not failure reduction occurs.

Keywords: Base Isolation, Spring Stiffness, ETABS, G+14 Building.

INTRODUCTION

Base isolation is a system that protects a building from the damaging effects of a seismic movement. If the structure separates from the ground during an earthquake, the ground is moving but the structure is still dormant. However, this scenario is not realistic. The current technology that is active and expanding is the introduction of a low lateral stiffness support that isolates the structure from the ground movement. This technology was introduced as early as the 1900's; however, not until the 1970's did it evolve into the practical strategy for seismic-resistant design.

Response of the Building under Earthquake

- **Building frequency and period**

The magnitude of Building response mainly accelerations depends primarily upon the frequencies of input ground motions and Buildings natural frequency. When these are equal or nearly equal to one another, the buildings response reaches a peak level

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- **Building stiffness**

Taller the building, longer the natural period and therefore building is more flexible then shorter building

- **Ductility**

Ductility is the ability to undergo distortion or deformation without complete breakage or failure. In order to be earthquake resistant the building will possess enough ductility to withstand the size and type of earthquake it is likely to experience during its lifetime

- **Damping**

All buildings possess some intrinsic damping. Damping is due to internal friction and adsorption of energy by buildings structural and non- structural components

Principles And Concepts Of Base Isolation

The objective of base isolation system is to decouple the structure from the ground. It lowers the effect of ground motion transmitted to the structure. Behaviour of multi-storey buildings during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and vertical planes of building. Structures that are midrise in height are the best candidate for the base isolation technology. Base isolation design provides a good substitute for fixed base design in locations where very strong seismic activities are likely. The initial cost of base isolation might be higher compared with a fixed based.

REVIEW OF LITERATURE

The free vibration analysis of framed structure is of great technical importance for understanding the behaviour of the framed structure under applied dynamic loading. The study of response analysis methodology of a base isolated framed structure with a fixed base structure is essential to conclude the effectiveness of base isolation using rubber bearing. “Earthquake proof structures” generally mean the structures which resist the earthquake and save and maintain their functions. The key points for their design includes select good ground for the site, make them light, make them strong, make them ductile, shift the natural period of the structures from the predominant period of earthquake motion, heighten the damping capacity.

Numerous studies have investigated the performance of base isolation systems and their interactions with structural and geotechnical parameters under seismic and wind loads. **Lin and Ahmadi (1989)** conducted a comparative study using the El Centro and Mexico City earthquake records and found that all base isolators significantly reduced acceleration transmitted to the superstructure, with frictional systems offering enhanced damping. **B.C. Lin et al. (1990)** evaluated laminated rubber bearings, New Zealand systems, and resilient-friction base isolators under earthquakes of magnitudes 6.0 to 7.3, concluding that friction plays a dominant role in energy dissipation. **Ferritto (1991)** noted significant differences in displacement and drift when modeling isolators as nonlinear hysteretic elements, while **Shenton and Lin (1993)** demonstrated that base-isolated concrete frames could achieve similar performance to fixed-base frames with lower design base shear. **Kulkarni et al. (2003)** emphasized that modeling the superstructure as rigid may underestimate acceleration, especially in flexible systems, under stochastic earthquake input. In parallel, wind load studies by **Kumar and Swami (2010) and Ahmed et al. (2015)** showed that terrain categories and building height significantly affect wind-induced deflections, with smoother terrains producing greater wind forces. **Raju et al. (2013)** reinforced the necessity of integrating wind and seismic analysis in the design of tall RC buildings, using IS codes to evaluate base shear, drift, and displacements. Soil-structure interaction (SSI) effects were highlighted by **Elwi et al. (2018) and Bajaj et al. (2013)**, who found that soil type (hard, medium, soft) alters seismic responses significantly, especially in isolated systems. **Hassan et al. (2018)** concluded that base shear and spectral acceleration increase with soil flexibility, recommending hard and medium soils for optimal isolator performance. **Roopa et al. (2015)** used ETABS and SAP2000 to show that neglecting SSI in clayey soils leads to conservative design assumptions, as real behavior deviates from fixed-base models. Despite substantial progress, the literature reveals a lack of integrated studies combining base isolation, SSI, and wind-seismic interaction in tall buildings under diverse soil and terrain conditions.

Summary and Gap Identification

Existing studies largely focus on low-rise buildings, with limited application of time-history and free vibration analysis to tall structures like G+14. The behavior of different isolators, especially hybrids, is not well explored under varying soil and structural conditions. Footing design and spring stiffness evaluation are often simplified, and comparative ETABS analyses of fixed vs. isolated tall buildings are rare. Few studies assess failure reduction at the footing level using detailed time-history analysis, highlighting the need for integrated research on isolator performance, foundation behavior, and seismic response in tall buildings.

Objectives

1. A study of different types of isolators to understand the behaviour.
2. Analysis G + 14 storey building and compare results of fix base and isolated building structure.

METHODOLOGY

The finite element method (FEM) is a widely used method for numerically solving differential equations arising in engineering and mathematical modelling. Typical problem areas of interest include the traditional fields of structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The FEM is a general numerical method for solving partial differential equations in two or three space variables.

Problem Statement

In this project, a G+14 storey structure of a rectangular building with 3 m floor to floor height has been analysed Non-Linear Dynamic Analysis of Multi-storey R.C.C Buildings using ETABS software in zones III. The plan selected is Rectangular in shape. The structure has been analysed for both static and dynamic forces. Soft soil condition has been selected for the structure. Gust factor method is method of calculating load along wind or drag load. Gust factor method is given in the code since IS 2015, these methods for calculating load across-wind or other components are not fully matured for all types of structures.

RESULTS AND DISCUSSION

Modelling In ETABS.

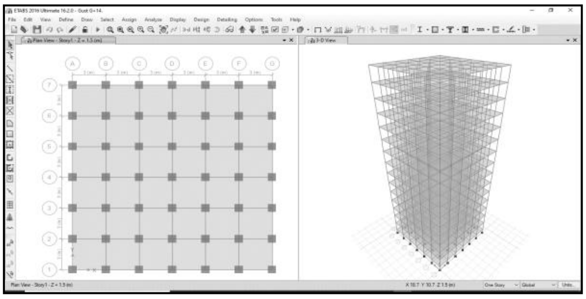

Fig 1 Prepare modeling in ETABS

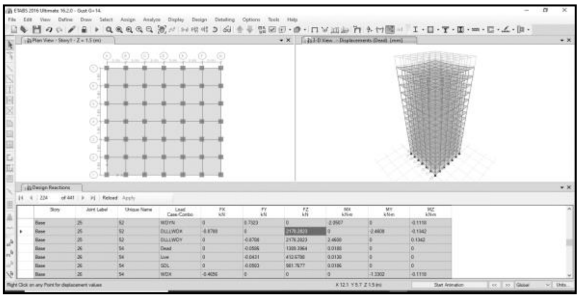

Fig 2 Design Reaction

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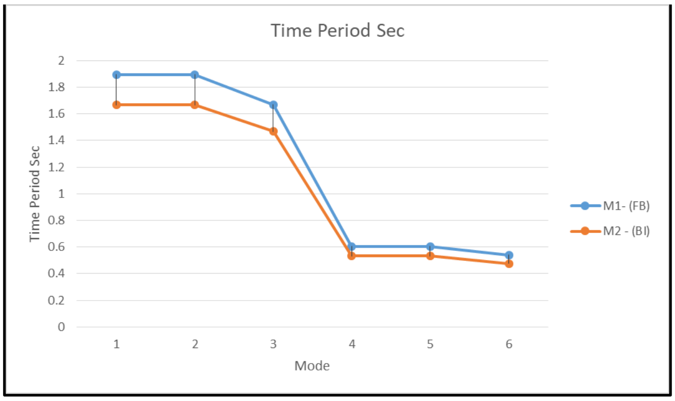
Table 1 Design Details Isolated

Data	Soft
P_u (Design Reaction)	2178 KN
Adopted Size Of Footing	4000 mm x 4000 mm x 550mm
Adopt depth of Footing	550 mm
No. Of Bar Req.	16T - 20

Table 2 Spring Stiffness

Spring Stiffness			
Sr No	**Degree of Freedom**	**Spring Stiffness**	**Spring Stiffness Per Footing** **(Total Footings =49)**
1	**Vertical Ky**	553926.7414	11304.63
2	**Horizontal (Lateral Direction)Kx**	366030.8864	7470.02
3	**Horizontal (Longitudinal Direction) Kz**	366030.8864	7470.02
4	**Rocking (about the Longitudinal) krx**	164713.8989	3361.51
5	**Rocking (about the Lateral) krz**	164713.8989	3361.51
6	**Torzion Kry**	151902.8178	3100.06

Result for Time Period



Graph 1 Time Period Sec

From the above table&graph, we can observe that percentage variation for Time Period for Time History Analysis for model 2 is less than model 1. The variation is found to be 10-15% less for model having Base Isolation than model have fix base only.

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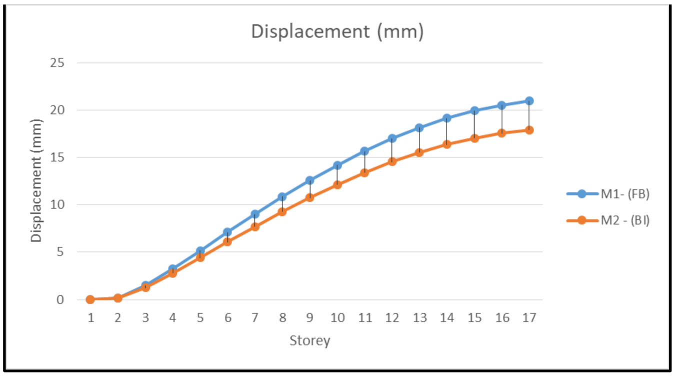
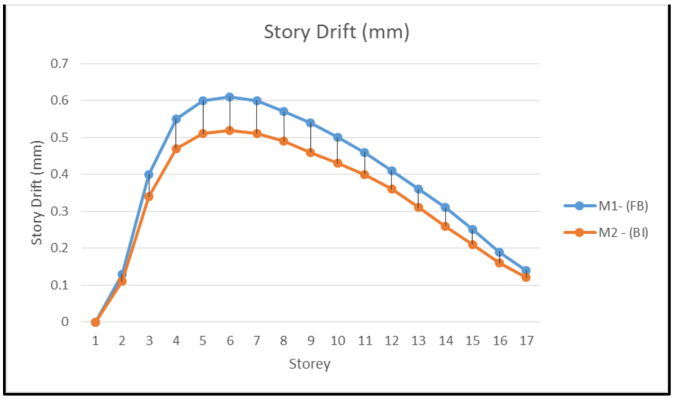
Result for Time History - Displacement (mm)



Graph 2 Time History - Displacement (mm)

From the above table&graph, we can observe that percentage variation for Displacement for Time History Analysis for model 2 is less than model 1. The variation is found to be 15-20% less for model having Base Isolation than model have fix base only.

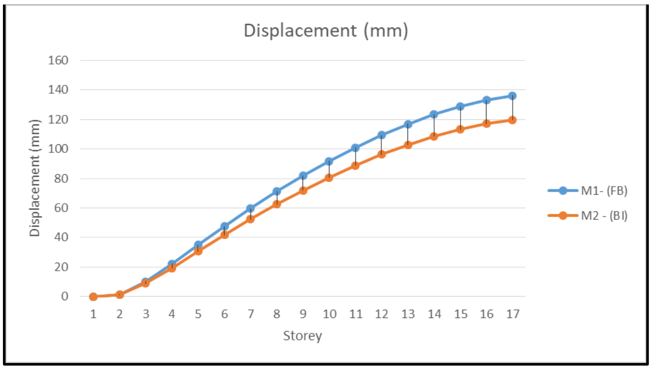
Result for Time History - Story Drift (mm)



Graph 3 Time History - Story Drift (mm)

From the above table&graph, we can observe that percentage variation for Story Drift for Time History Analysis for model 2 is less than model 1. The variation is found to be 20% less for model having Base Isolation than model have fix base only.

Result for Response Spectrum- Displacement (mm)



Graph 4 Response Spectrum- Displacement (mm)

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From the above table&graph, we can observe that percentage variation for Displacement for Response Spectrum Analysis for model 2 is less than model 1. The variation is found to be 25-30% less for model having Base Isolation than model have fix base only.

Result for Response Spectrum- Spectral Acceleration

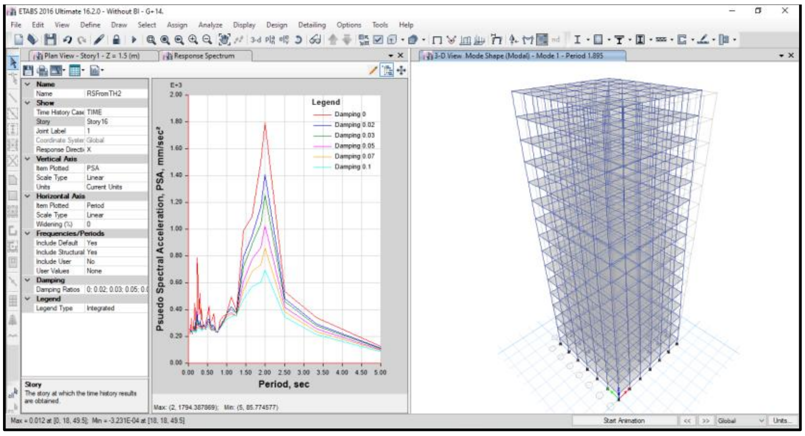

Fig 3 Spectral Acceleration M1- (FB)

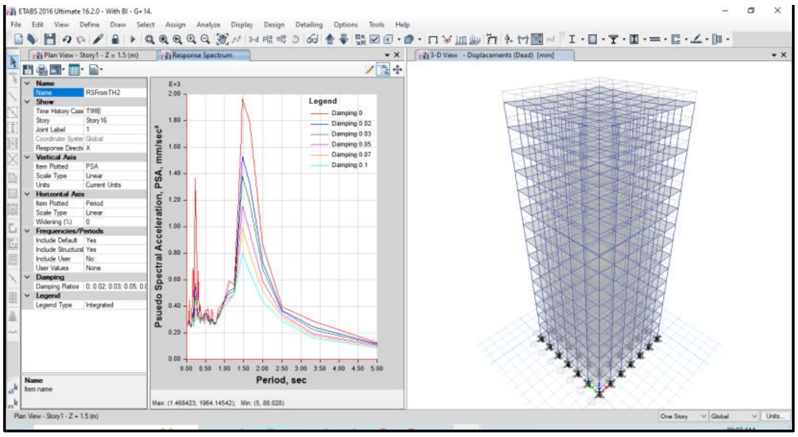

Fig 4 Spectral Acceleration M2 - (BI)

Above fig 3 and 4 indicates the results for Spectral Acceleration of model 1 - M1- (FB) and fig 6.21 indicates the results for Spectral Acceleration of model 2 - M2 - (BI) , for Spectral Acceleration of model 2 gives the less period for the acceleration than model 1

CONCLUSION

Based on the finite element analysis (FEA) results, it is concluded that base-isolated structures (Model 2) demonstrate significantly improved seismic performance compared to fixed-base structures (Model 1). The storey shear was found to be maximum at the base and reduced towards the top, while displacement and drift increased with height in both models. Time history and response spectrum analyses revealed that Model 2 consistently exhibited lower values for time period, displacement, and storey drift. Specifically, Model 2 showed a reduction of 10–15% in time period, 15–20% in displacement, and up to 25% in storey drift under time history analysis, compared to Model 1. In response spectrum analysis, displacement and drift reductions ranged from 25–30% and 20–25%, respectively. Furthermore, spectral acceleration results confirmed that Model 2 experienced a shorter period for peak acceleration, indicating improved energy dissipation and stability. Overall, base isolation proves to be a more efficient and economical design strategy for enhancing the seismic performance of high-rise buildings

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