

# Effect of Floor Height Variation on Seismic Performance of RCC Buildings Using ETABS

**Sagar D. Dule<sup>1</sup>, Mahesh Raut<sup>2</sup>**

M.Tech Scholar, Department of Civil Engineering, G H Rasoni College of Engineering and Management, Nagpur, India<sup>1</sup>

Assistant Professor, Department of Civil Engineering, G H Rasoni College of Engineering and Management, Nagpur, India<sup>2</sup>

**Abstract:** This paper studies how floor height variation affects the seismic behavior of a G+10 RCC building using ETABS. In modern cities, reinforced concrete buildings are often built with different floor heights for parking, commercial space, or architectural needs. While this is useful in practice, it can change how the building behaves during an earthquake. This study examines the effect of floor height variation on the seismic performance of a G+10 RCC building using ETABS. Three cases are studied: a uniform-height building, a soft-storey building with a taller ground floor, and a building with alternate floor height variation. The results show that floor height variation increases the fundamental time period and lateral displacement, while reducing base shear. It also increases drift at the irregular storey, especially in the soft-storey model. These findings show that vertical irregularity should be carefully considered in seismic design, because even if strength demand seems lower, serviceability and safety may become critical.

**Keywords:** Floor height variation, seismic performance, G+10 RCC building, soft storey, ETABS, response spectrum analysis, inter-storey drift, vertical irregularity.

## I. INTRODUCTION

Rapid urban growth has increased the demand for multi-storey RCC buildings in Indian cities. In many buildings, floor heights are not uniform because the ground floor is used for parking, shops, or a lobby, while upper floors are used for residential purposes. This creates vertical irregularity in the structure, which can significantly affect its seismic response.

A building with a taller storey becomes more flexible at that level. This reduces lateral stiffness and may cause drift to concentrate at the irregular floor. During an earthquake, such concentration of deformation can be dangerous, especially in soft-storey buildings. For this reason, floor height variation is an important issue in seismic design and should not be ignored.

This study focuses on a G+10 RCC moment-resisting frame because such buildings are common in practice and represent a useful case between mid-rise and taller structures. ETABS is used to compare the structural response of different height configurations under the same loading and material conditions.

## II. LITERATURE REVIEW

Previous studies have shown that floor height variation can significantly influence the seismic performance of RCC buildings in an important way. Researchers have observed that when a storey height increases, the lateral stiffness of the building reduces, which leads to larger natural periods, higher displacement, and greater drift concentration at the irregular level. Some studies on soft-storey and podium configurations reported that the base shear may decrease in taller or more flexible storeys, but the reduction in force is accompanied by an increase in deformation demand. Other researchers found that alternate-height buildings also show non-uniform seismic response, with drift developing at multiple irregular floors rather than at one single level. These studies indicate that floor height variation should not be ignored only because the building is of moderate height or appears structurally regular. Even in G+10 RCC buildings, vertical irregularity can change the response of the structure in terms of displacement, drift, stiffness, and overall seismic behaviour. Therefore, considering floor height variation gives a more realistic understanding of how the building will perform during earthquake loading.

### III. METHODOLOGY

The present study examines the effect of floor height variation on the seismic performance of a G+10 RCC building using ETABS software. The main purpose of the work is to understand how vertical irregularity changes the structural response of the building under earthquake loading. In real practice, many RCC buildings are not perfectly regular because the ground floor is often kept taller for parking, commercial use, or lobby space. This difference in floor height changes the stiffness of the structure and may create a soft-storey condition, which can become critical during seismic action.

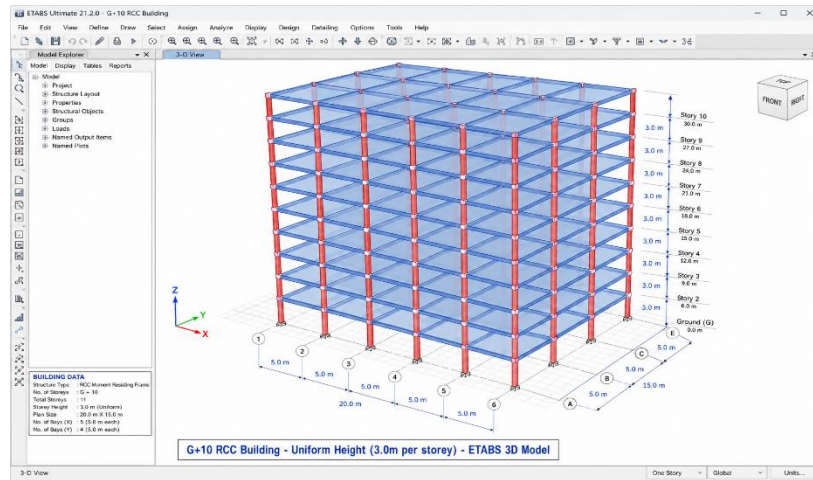


Fig 1.1 ETABS 3D model of the G+10 RCC building.

To study this effect properly, three building models were prepared. The first model was taken as the reference case with uniform storey height throughout the building. The second model had an increased ground floor height to represent a soft-storey condition. The third model had alternate storey heights so that the response of another type of vertical irregularity could also be studied. All other parameters such as plan dimensions, material properties, member sizes, and loading conditions were kept the same in all cases so that only the floor height variation influenced the results.

The building was modeled as a three-dimensional RCC moment-resisting frame in ETABS. The structure was analyzed using response spectrum analysis as per IS 1893:2016 for Seismic Zone III. Dead load, live load, and seismic load combinations were assigned as per Indian code provisions. The analysis was carried out to obtain key response parameters such as fundamental time period, base shear, storey displacement, storey drift, storey stiffness, and plastic hinge formation.

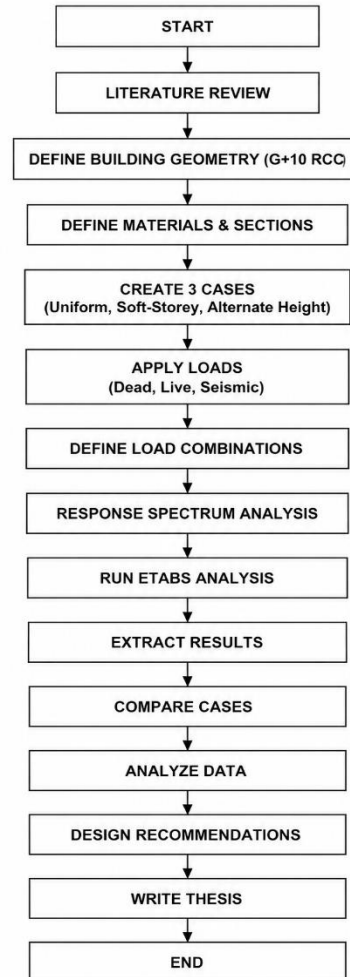


Figure 3.2: Flowchart showing the project process

After the analysis, results from all three models were compared to observe the effect of floor height variation. Special attention was given to drift concentration at the irregular storey, since this is the main indicator of soft-storey behavior. The study also compared the overall change in structural response to understand whether the irregular models remain within safe limits or not. This method provides a realistic and code-based way to assess the seismic behavior of RCC buildings with varying floor heights.

#### **IV. BUILDING AND INPUT DATA**

The building considered in this study is a **G+10 RCC moment-resisting frame** designed to examine the effect of floor height variation on seismic performance. The structure is modeled in ETABS and analyzed under seismic loading as per IS 1893:2016. Three different height configurations are considered so that the response of a regular building and irregular buildings can be compared clearly.

The first model has uniform storey height throughout the building and is used as the reference case. The second model has an increased ground floor height to represent a soft-storey or podium condition. The third model has alternate floor heights so that the effect of repeated vertical irregularity can also be studied. All models have the same plan dimensions, member sizes, loading conditions, and material properties; only the storey height is changed.

Table I. Building Parameters

Parameter	Value
Building type	RCC moment-resisting frame
Building height	G+10
Total storeys	11
Seismic zone	Zone III
Analysis software	ETABS
Analysis type	Response spectrum analysis

## V. RESULTS AND DISCUSSION

The analysis results show a clear difference between the regular and irregular building models. The uniform-height model behaves in a more balanced way, while the soft-storey and alternate-height models show higher flexibility and larger drift demand at the irregular storeys. This confirms that floor height variation has a direct effect on the seismic response of the RCC building.

In the uniform model, the lateral stiffness is distributed more evenly, so displacement and drift remain comparatively lower throughout the height of the building. In the soft-storey model, the increased ground floor height reduces stiffness at that level, causing greater deformation and concentration of drift near the base. The alternate-height model also shows irregular response, but the drift is spread across more than one floor level instead of being concentrated at only one storey.

The fundamental time period increases in the irregular models because the overall flexibility of the structure increases. At the same time, the design base shear becomes lower in the taller or more flexible models. However, this reduction in base shear does not mean the building is safer, because the displacement demand and drift concentration become more critical. From a seismic performance point of view, drift is often more important than force alone, especially in irregular buildings.

The storey drift results show that the soft-storey configuration is the most critical case. The drift value at the taller ground floor is much higher than in the uniform model, and this can approach the permissible limit given in the seismic code. The alternate-height model also shows increased drift, but the response is less severe than the soft-storey case. This indicates that irregularity at a single level is more dangerous when it creates a clear weak storey.

The storey displacement trend follows the same pattern. The uniform model gives smoother displacement variation, while the irregular models show larger top displacement and more abrupt changes in deformation profile. This can affect both structural safety and non-structural elements such as partitions, cladding, and masonry infill walls. In real earthquake conditions, such differences can lead to early damage at the irregular storey.

## Storey Displacement Comparison of G+10 RCC Building

(ETABS Results – Response Spectrum Analysis in X-Direction)

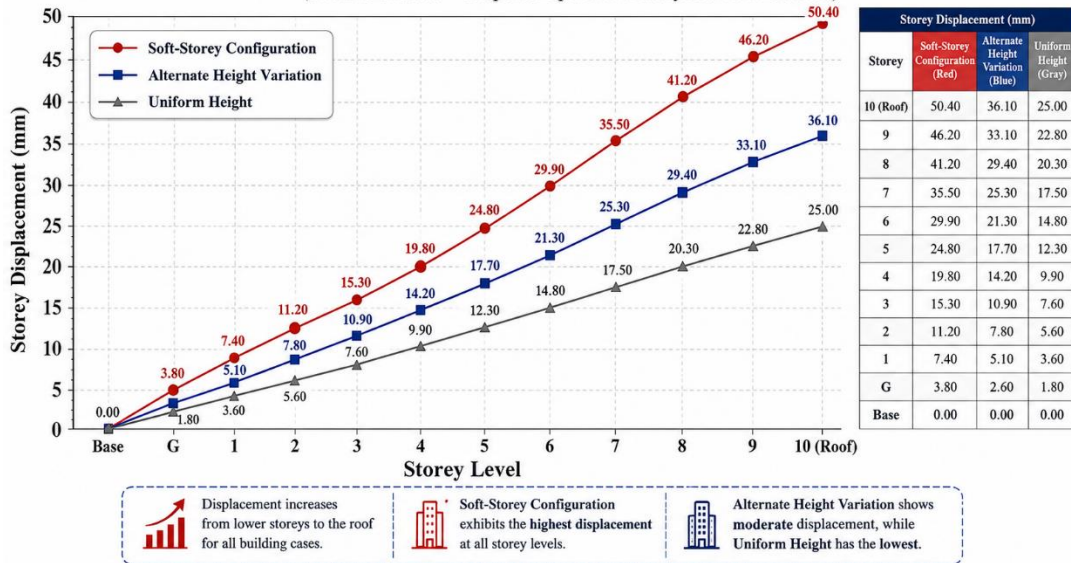


Fig. 4.1: Storey Displacement Graph

## Storey Drift Comparison of G+10 RCC Building

(ETABS Results – Response Spectrum Analysis in X-Direction)

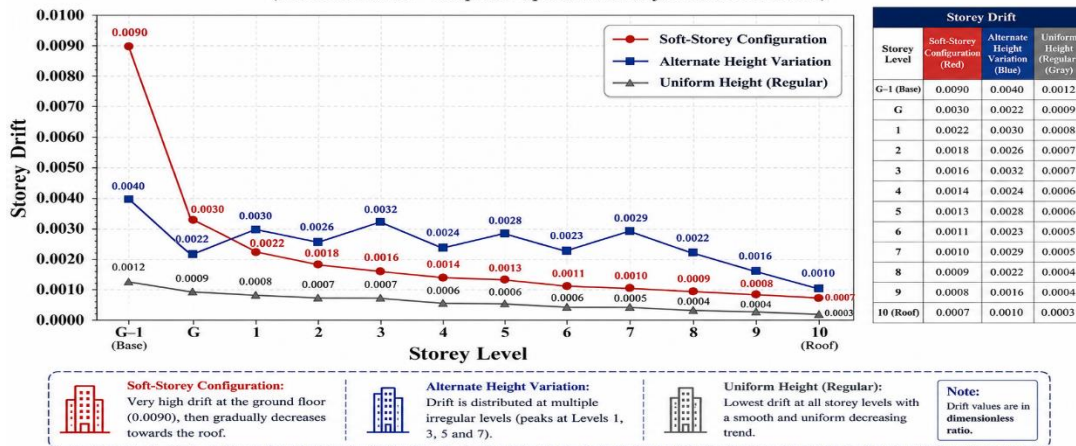


Fig. 4.2: Storey Drift Graph

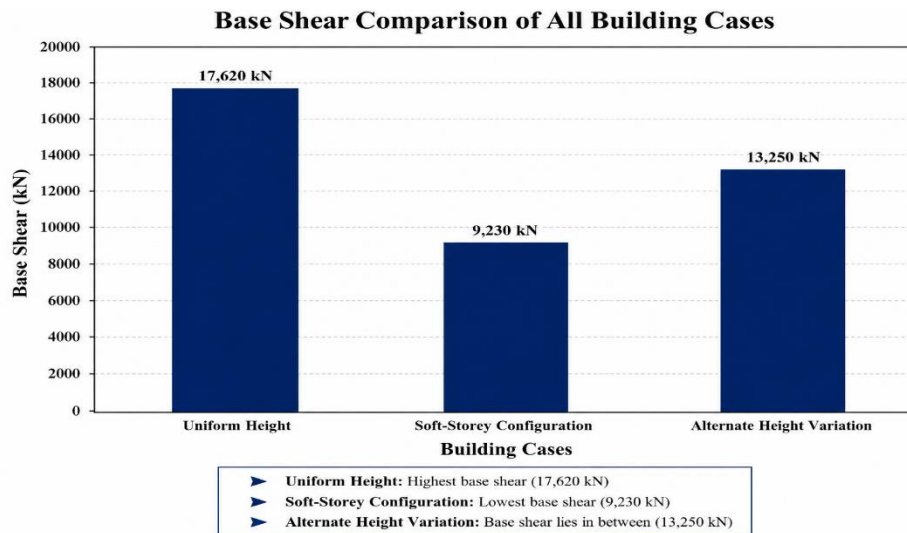


Figure 4.3: Base Shear Result

Overall, the results confirm that floor height variation significantly affects seismic behaviour. Even though the structure may satisfy strength requirements, serviceability and deformation limits may still become critical. Therefore, while designing RCC buildings, special attention should be given to taller ground floors and other vertical irregularities so that excessive drift and soft-storey formation can be avoided.

## VI. CONCLUSION

The study shows that floor height variation has a clear effect on the seismic performance of G+10 RCC buildings. When the ground floor is taller than the upper floors, the building becomes more flexible, and this leads to larger displacement and drift demand at the irregular storey.

Among the three models studied, the soft-storey configuration is the most critical. It shows the highest drift concentration at the ground floor, lower stiffness, and greater overall vulnerability during earthquake loading. The alternate-height model also changes the structural response, but its effect is less severe because the irregularity is distributed across more than one floor.

The results also show that a reduction in base shear does not necessarily mean a safer structure. Although the irregular models attract lower seismic force, they experience higher deformation demand, which is more important for serviceability and damage control. For this reason, drift and displacement should be given as much attention as strength in seismic design.

The study confirms that floor height variation should not be ignored in RCC building analysis. If a building requires a taller ground floor for parking, commercial use, or architectural reasons, the design should include stronger columns, shear walls, bracing, or other stiffness-enhancing measures. Proper consideration of vertical irregularity can help reduce soft-storey risk and improve the overall seismic safety of the structure.

## REFERENCES

- [1]. Gairola, A. and Dhyani, R., "Seismic performance of G+10 RCC buildings with soft storey using ETABS," 2025.
- [2]. Kumar, P., et al., "Seismic analysis and design of G+10 RCC buildings in different seismic zones using ETABS," 2025
- [3]. Tiwari, S. and Sharma, R., "Seismic behavior of vertically irregular RC buildings with varying storey heights," 2024.
- [4]. Patel, N. and Mehta, K., "Comparative seismic analysis of regular and vertically irregular RCC buildings using ETABS," 2024.
- [5]. Reddy, V. and Kumar, S., "Effect of podium floor height on seismic response of mid-rise RC buildings," 2023.Sagar.doc
- [6]. Sharma, P., et al., "Design and analysis of soft storey G+17 rectangular shaped buildings using STAAD.Pro," 2023.



- [7]. Singh, A. and Patel, M., “Seismic performance of RC buildings with vertical geometric irregularity using response spectrum analysis,” 2022.
- [8]. Ahmed, S. and Rahman, T., “Seismic performance of mixed-use RC buildings with vertical stiffness irregularity,” 2022.
- [9]. Gupta, R. and Verma, D., “High-rise RC building with vertical irregularity using response spectrum method,” 2022.
- [10]. Joshi, S. and Pandey, A., “Seismic response of RC frame buildings with soft-storey using ETABS and SAP2000,” 2021.
- [11]. Rao, S., Kulshreshtha, A. and Jain, V., “Seismic performance of mid-to-high-rise RC buildings with podium floors using response spectrum analysis,” 2020.
- [12]. Kumar, N. and Singh, R., “Effect of vertical irregularity due to alternate storey height on RC frame buildings,” 2020.
- [13]. Sharma, A. and Das, P., “Performance of soft-storey RC buildings observed in recent earthquakes,” 2020
- [14]. Mishra, P. and Agrawal, N., “Seismic performance of RC buildings with combined irregularities,” 2019.
- [15]. Mehta, P. and Jadhav, S., “Seismic response of RC buildings with transfer and podium floors using ETABS,” 2019.