

OBSERVING THE BEHAVIOR OF MULTI-STOREY BUILDINGS WITH FLOATING COLUMNS

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ABSTRACT

This study investigates the influence of floating columns on the structural performance of multi-story buildings. Floating columns, also known as hanging columns, are structural elements supported on beams or slabs of intermediate floors, not directly connected to footings or pedestals. The analysis focuses on key parameters such as story shear, displacement, and story drift, using ETABS software. Both static and dynamic analyses, including the response spectrum method, are conducted for buildings with and without floating columns. This study highlights the importance of integrating structural and architectural design considerations, ensuring that the aesthetic and functional benefits of floating columns do not compromise building safety and performance.

Key words: Story shear, displacement, story drift, floating columns, safety and performance, ETABS software

1. INTRODUCTION

A "floating column" (or "floating beam") is a structural element in a building that rests on a beam or slab rather than directly on a foundation. These columns do not carry the loads down to the foundation but rather transfer the load to a horizontal member (like a beam) which then transfers the load to the vertical columns below.

Characteristics and Uses of Floating Columns:

Design Flexibility: Floating columns provide flexibility in architectural design, allowing for open spaces or specific floor layouts that wouldn't be possible with conventional columns extending through all floors.

Load Distribution: The load from the floating column is transferred horizontally to beams, which in turn transfer the load to other columns or structural elements below.

Appearance: They are often used to achieve aesthetic objectives, creating more open spaces on the lower floors of a building.

Complex Analysis: The presence of floating columns necessitates more complex structural analysis and design to ensure safety and stability. Engineers must account for the additional stresses and load distribution carefully.

Seismic Performance: Floating columns can pose significant risks in seismic zones. During an earthquake, the dynamic loads can cause severe stresses in the beams supporting the floating columns, potentially leading to failure.

Structural Integrity: The transfer of loads through horizontal members can lead to increased bending moments and shear forces in these beams, requiring them to be designed robustly to handle the additional loads.

Regulations and Codes: Many building codes and regulations impose restrictions on the use of floating columns, especially in high-seismic regions, due to the potential risks involved.

Mitigation Strategies

Reinforcement: Adequate reinforcement of the beams and slabs that support floating columns can help mitigate the risks associated with their use.

Redundant Load Paths: Providing alternative load paths can enhance the building's ability to withstand unexpected loads or seismic activity.

Advanced Analysis: Utilizing advanced structural analysis and design techniques, such as finite element analysis (FEA), to ensure that all potential stresses and failure modes are accounted for.

2. LITERATURE REVIEW

Conducting a literature survey on the earthquake response of multi-story building frames with usual columns, particularly focusing on the strengthening of existing buildings in seismic-prone regions, is essential for understanding current methodologies and advancements in this field. The performance of usual columns, including their strength and ductility, is a critical factor. Columns designed with adequate confinement and reinforcement show better performance under seismic loads.

Harsha P V et al (2020) In recent years, the construction of multi-storey and commercial buildings with architectural complexities has become common. One such complexity is the inclusion of floating columns, which pose significant risks in seismically active areas. This study analyzes the behavior of a G+10 storey normal building and a G+10 storey building with floating columns subjected to external lateral forces. The objectives are to assess the safety of these structures in Seismic Zone III, identify the most critical and optimal positions for floating columns, and evaluate the impact of shear walls in floating column buildings. This study will provide valuable insights into the seismic performance of multi-storey buildings with floating columns, aiding in the development of safer structural designs in seismically active regions. By identifying critical positions and evaluating shear wall effectiveness, the research aims to enhance building resilience against earthquakes. Practical guidelines for architects and engineers on the design and placement of floating columns and shear walls in multi-storey buildings. Detailed understanding of how floating columns influence building behavior under seismic loads.

Venkat rao mane b.g et al (2021) Floating columns, also known as hanging or suspended columns, are vertical members that rest on beams rather than extending down to the foundation. These columns act as point loads on the supporting beams. While this architectural feature can be essential for meeting certain design and client requirements, it can compromise the structural integrity of multi-storey buildings, particularly in earthquake-prone areas.

The seismic performance of buildings with floating columns is typically less robust compared to those with conventional column layouts. However, by carefully selecting the optimal locations for floating columns, it is possible to mitigate some of the adverse effects and enhance the earthquake resistance of such structures. This study investigates the optimal placement of floating columns in multi-storey buildings through the analysis of three distinct scenarios using ETABS 2017 software. The study demonstrates that while floating columns can pose challenges to the seismic performance of multi-storey buildings, their impact can be mitigated through strategic placement. By optimizing the locations of floating columns, it is possible to enhance the earthquake resistance of buildings, ensuring safety and structural integrity while meeting architectural and client requirements.

Krishna Chaitanya Lingampally et al (2022) In recent years, the development of multi-storey and commercial buildings has seen an increase in architectural complexity, including the use of floating columns. While these designs can offer aesthetic and functional benefits, they present significant risks in seismically active areas due to disrupted load transfer paths. This study aims to analyze the lateral force response of a G+10 building with floating columns, determine its safety in seismic zone II, and identify the optimal position for floating columns within such a structure using response spectrum analysis via CSI ETABS 2018. Floating columns, which rest on beams instead of directly transferring loads to the foundation, are often used for architectural purposes. However, their presence can significantly alter the behavior of a building under seismic loads by creating points of discontinuity in the load transfer path. This study focuses on understanding the implications of using floating columns in a high-rise structure located in a seismically active zone. This paper aims to contribute to safer building practices in seismically active regions by providing detailed analysis and recommendations for the use of floating columns in high-rise structures.

3. METHODOLOGY

Case Studies

This study investigates the seismic performance of a G+7 storied building located in seismic Zone III of India, as per the guidelines of IS 1893 (Part 1): 2002. The analysis is conducted using ETABS software, focusing on two structural configurations.

- ❖ **Building with Floating Columns**
- ❖ **Building without Floating Columns**

Additionally, the study examines different positions of the floating columns in the first storey and the role of shear walls in enhancing the seismic performance of buildings with floating columns.

Geometric Modeling: Create 3D models of the G+10 building in ETABS with and without floating columns.

Material Properties: Define material properties for concrete and reinforcement steel.

Load Assignments: Apply dead loads, live loads, and seismic loads as per IS 1893 (Part 1): 2002.

Seismic Analysis:

Response Spectrum Method: Conduct the seismic analysis using the response spectrum method to determine key seismic response parameters such as storey drift, displacement, and shear forces.

- ❖ **Storey Drift:** Measure the relative lateral displacement between consecutive floors.
- ❖ **Storey Displacement:** Determine the total lateral displacement at each floor level.

- ❖ **Storey Shear:** Calculate the lateral forces experienced at each storey level.

Comparative Analysis:

Compare the seismic performance indicators (storey drift, displacement, and shear) for buildings with and without floating columns.

- ❖ Assess the impact of different positions of floating columns on the seismic response.
- ❖ Evaluate the effectiveness of shear walls in buildings with floating columns by comparing seismic response parameters with and without shear walls.
- ❖ Identifying whether the presence of floating columns significantly increases storey drift, displacement, and shear forces.
- ❖ Determining the most critical positions of floating columns that lead to adverse seismic responses.

4. RESULT AND DISCUSSION

Storey drift, also known as inter-storey drift, is a critical parameter in structural engineering, particularly in the design and assessment of buildings subjected to lateral forces such as wind, earthquakes, or other dynamic loads.

Table 1 story drift in Millimeter

Story height in m	Case I	Case II	Case III	Case IV
0	0	0	0	0
3	0.00350	0.00418	0.00621	0.00779
6	0.00540	0.00545	0.00541	0.00659
9	0.00550	0.00565	0.00559	0.00580
12	0.00520	0.00545	0.00535	0.00558
15	0.00479	0.00509	0.00489	0.00548
18	0.00428	0.00457	0.00439	0.00526
21	0.00368	0.00401	0.00378	0.00389

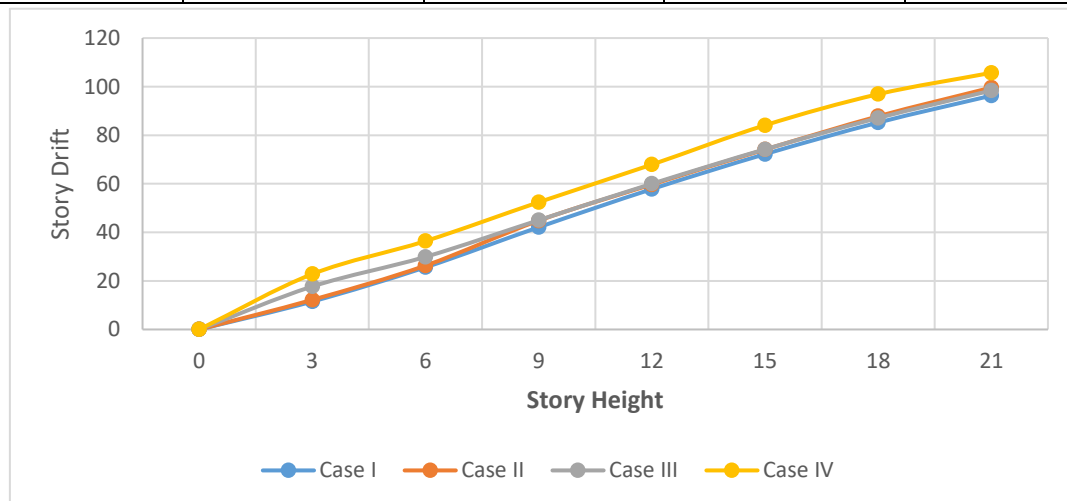


Figure 1 Story Drift

Story displacement,

Story displacement, also known as inter-story drift, is a critical concept in structural engineering, particularly in the design and analysis of buildings subjected to lateral loads such as wind, seismic activity, or other dynamic forces. It refers to the relative horizontal displacement between two adjacent floors of a building.

Table 2 Story displacement

Story height in m	Case I	Case II	Case III	Case IV
0	0	0	0	0
3	11.5	12.2	17.7	22.8
6	25.6	26.3	29.9	36.4

9	42.1	44.8	45	52.4
12	57.8	59.7	60	67.9
15	72.2	74.1	74.2	84.1
18	85.2	87.8	87.1	96.9
21	96.3	99.6	98.4	105.7

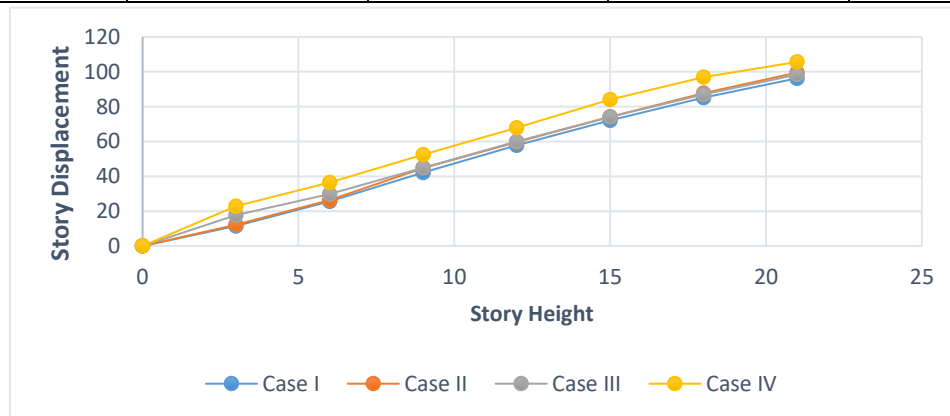


Figure 2 Story Displacement

5. CONCLUSION

The response spectrum approach is a common and effective method used to determine the seismic response of structures, particularly in terms of storey drift and displacement.

- ❖ Displacement in multi-story buildings increases progressively from the lower to the higher story.
- ❖ Buildings with floating columns, specifically those in Case II and Case III, exhibit higher displacements compared to normal buildings without floating columns.
- ❖ An increase in column discontinuity results in an increase in storey drift. Among the models studied, Model 7 shows the highest storey drift values.

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