An Advance Approach to Compare the Effects of Floating Column and Shear Walls under Seismic Loading in High Rise Structure

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Abstract: **High-rise buildings often incorporate floating columns to meet architectural and operational requirements. These columns can enhance the structural responses, particularly in buildings with irregular plan forms. Advanced comparative techniques are used to evaluate the performance of floating columns in both regular and irregular high-rise structures. Structural performance is analyzed using a combination of finite element analysis and response spectrum analysis to study lateral displacement, inter-story drift, base shear, and overall stability under seismic and static loading conditions.**

Research explores high-rise buildings with varying levels of irregularity, focusing on the placement of floating columns within these structures. Findings reveal that irregular buildings with floating columns experience increased stress concentrations and greater lateral movements compared to regular designs. Additionally, buildings with asymmetrically placed floating columns are prone to significant torsional effects, reducing structural integrity during seismic events. The results highlight the importance of proper structural planning and the use of shear walls and bracing systems to mitigate negative effects and improve overall performance.

This research provides valuable insights for engineers and architects, offering strategies to enhance the safety and design of high-rise buildings featuring floating columns and shear walls. Incorporating advanced modeling techniques alongside regulatory guidelines enables accurate predictions of structural behavior through comparative analysis. Future studies should include experimental testing to develop new materials and reinforcement strategies that enhance the durability and reliability of these structural systems.

Keywords: **Floating column, Shear wall, high-rise structure, structural irregularity, seismic response, lateral displacement, response spectrum analysis and structural stability.**

I. INTRODUCTION

High-rise buildings often incorporate floating columns, a structural element that has sparked considerable debate. These vertical supports are disconnected from the foundation and do not extend continuously from the foundation to the roof. Instead, they are supported by beams at higher levels, creating a configuration where the columns lose direct contact with the foundation. While floating columns offer several design advantages, they pose significant challenges, particularly under seismic forces.

Floating columns enhance architectural design flexibility by enabling open, column-free spaces in specific areas of buildings, particularly high-rises. They are vital for optimizing floor plans in mixed-use developments, allowing for wide, unobstructed layouts ideal for commercial, retail, parking, or atrium spaces while maintaining structural integrity. By transferring loads to beams or other structural supports, floating columns provide functionality and aesthetic appeal, maximizing space utilization and supporting creative designs. However, their implementation requires careful engineering to ensure safety, especially in seismic zones.

Floating columns provide significant benefits by creating extensive unobstructed spaces, ideal for retail areas, atriums, lobbies, and parking structures, enhancing versatility and functionality. This architectural technique eliminates lower-level columns, enabling clear floor plans and maximizing space availability, which increases the commercial and residential value of buildings. Additionally, floating columns improve aesthetics by offering clean sightlines that align with modern architectural designs, making them essential for impactful open spaces in commercial buildings.

High-rise buildings depend heavily on shear walls as basic structural elements which deliver vital resistance against forces that perimeter from seismic events and wind conditions and natural environmental load types. The designed vertical elements work against shear stress because they prevent lateral forces that act parallel to the wall surface from causing extreme building movement. High-rise buildings rely on shear walls to maintain stability including seismic events because they help ensure safe performance results.

Objectives:

• To Compare the Seismic Performance of High-Rise Structures with Floating Columns and Shear Walls.
• Assess the effects that shear walls achieve on lateral stiffness against the flexible properties of structures with floating columns.
• The study examines structural building integrity changes that occur because of seismic events when researchers use floating columns alongside shear walls in construction.
• To Analyze the Dynamic Response of High-Rise Buildings under Earthquake Loading A comparison shows how these systems affect earthquake-induced rotation and lateral movement of the building structure

II. LITERATURE REVIEW

Chad Felix, 2025: Chad's study used ETABS software to analyze how soft stories in high-rise buildings in Bangladesh impacted seismic performance. Soft stories caused structural irregularities, increasing drift, torsion, and lateral displacement by 25%, while shear resistance decreased by 18%. Chen, Huating, et al., 2025: Researchers developed a hybrid system combining shear walls and isolation devices to reduce seismic impacts. Their system lowered base shear by 30%, lateral displacement by 25%, and improved seismic resistance by 40%, enhancing both safety and functionality. Zhang Shuna et al., 2025: Zhang examined advanced steel plate shear walls, showing a 15-20% improvement in shear strength and a 30% reduction in lateral displacement. Enhanced energy dissipation reduced seismic forces by 25%, proving beneficial for floating column applications. Hosseini Mahsa, 2025: Hosseini analyzed seismic modification factors in Canadian concrete shear walls. Performance-based designs reduced base shear by 15-30%, improved critical spacing by 10-15%, and highlighted floating columns' vulnerabilities in seismic conditions.

Sheshadri G et al., 2024: The study explored shear wall placement in buildings on sloping grounds. Central wall positioning improved base shear resistance by 20-25% and stability by 30%, reducing risks posed by floating columns in irregular terrain. Hakim Seyed Jamalaldin Seyed et al., 2024: Hakim's research highlighted the seismic strength of shear wall framing systems, reducing lateral displacement by 25% and structural damage by 20%. These systems outperformed floating columns in resisting seismic forces. Singh Aashish Nimbe Raghvendra, 2024: Singh's study on curtailed shear walls showed they reduced base shear by 10-15% but increased torsional motion by 30%, creating weaknesses similar to floating columns in unsymmetrical buildings. Jagan Palani and Joseph Antony Visuvasam, 2024: This research found nonlinear soil behavior amplified seismic impacts on floating columns, increasing lateral displacement by 30% and seismic forces by 20-25%, highlighting critical soil-structure interactions. Sundari Mandapati Venkata Rama et al., 2024: Sundari analyzed seismic impacts on buildings with and without floating columns, finding a 25% increase in lateral displacement and 15% reduction in base shear in floating column structures, making them less stable. Prakash Akula et al., 2024: Prakash's study on asymmetrical buildings found floating columns caused higher lateral displacement, reduced stiffness, and increased torsion, worsening seismic stability and structural failure risks. Laissy Mohamed et al., 2024: Laissy found thermal expansion worsened seismic vulnerabilities in floating-column buildings, as AI-based simulations revealed increased stresses during temperature variations. Rana Md Sohel et al., 2024: Rana's study highlighted that central shear wall placement reduced torsion and lateral displacement, improving seismic performance. Buildings with floating columns showed inferior resistance. Kabir Syed Fardin Bin et al., 2024: Kabir found shear wall systems resisted seismic forces 25-30% better than masonry systems, providing stronger performance and cost-efficiency over floating-column constructions.

Al Samouly Aly, 2023: Al Samouly developed a steel-timber rocking shear wall system that reduced lateral displacement by 40%, proving superior for seismic regions compared to floating column structures. Thakur A.P. Singh and Vijay Baradia, 2023: Their STAAD Pro analysis showed buildings with floating columns had 20% more lateral displacement and greater torsion, reducing seismic stability compared to structures without them.

Alarcón Claudio et al., 2023: Alarcón demonstrated reinforced concrete shear walls increased base shear resistance by 35%, improving torsional and lateral stability. Floating columns performed poorly in comparison. Patange Ms. Shivani et al., 2023: Patange found floating column placement affected seismic performance, with perimeter placements causing higher displacement and torsion. Core placements slightly improved performance but reduced base shear.

III. METHODOLOGY

The research examines the seismic behavior of 15-story regular and irregular buildings using ETABS software for modeling and analysis. The structural evaluation includes three scenarios: an RCC bare frame, a structure with floating columns, and one incorporating both shear walls and floating columns for load distribution. The study investigates how shear walls enhance lateral stiffness to counteract the increased flexibility introduced by floating columns in high-rise buildings.

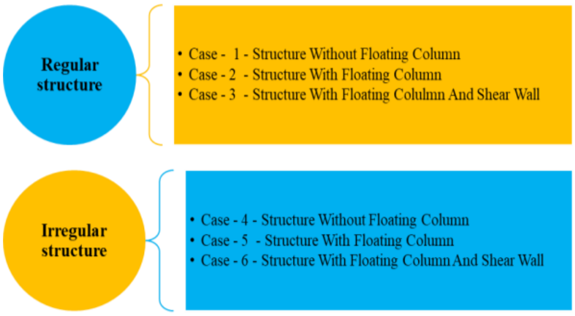
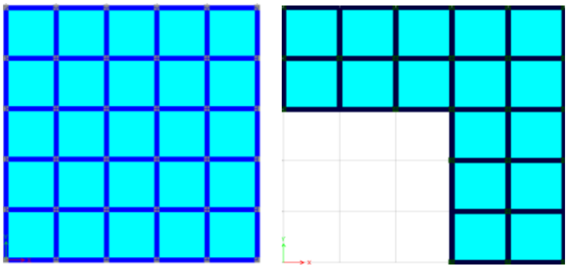


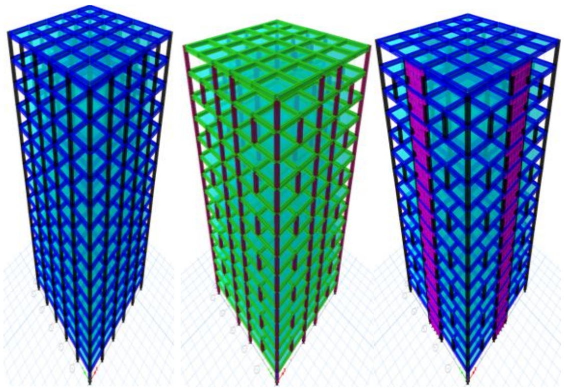
Fig. 1 Model Details

Table 1 Building Parameters

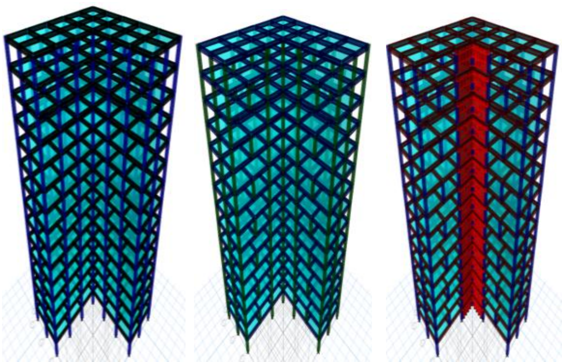
Parameter	Details
Rebar	HYSD 500
Grade of concrete	M 30
No. of bay along X-direction	5
No. of bay along Y-direction	5
Span along X-direction	5 m
Span along Y-direction	5 m
Column height	3 m
Column size	550*550 mm
Beam	500*400 mm
SHEAR WALL	200mm
Live load	3 Kn/m2
Software	CSI ETABS
seismic load	IS 1893-2016
Seismic zone	4
Site type	2
Importance factor	1
Response Reduction	5
Seismic Analysis Method	Time history
Number of Floors	15



a) Regular Plan Structure b) Irregular Plan Structure
Fig 2 Top View of Structures



a) Case-1 b) Case-2 c) Case-3



d) Case-4 e) Case-5 f) Case-6
Fig. 3 3D View of Structure in Different Cases

Table 2 Load Definition

Load Definition			
Load Patterns			
Load	Type	Self-weight multiplier	Auto lateral Load
Dead	Dead	1	-
Live	Live	0	-
EQL-X	Seismic	0	IS-1893-2002
EQL-Y	Seismic	0	IS-1893-2002

P-delta Options		Load Cases	
Pattern	Iterative Base on load Automation	Load	Types
Dead	1.2	Dead	Linear Static
Live	0.5	Live	Linear Static
EQL-X, Y	1.5	EQL-X	Linear Static
EQL-X, Y (1/3)	1.5	EQL-Y	Linear Static
EQL-X, Y (2/3)	1.5	TH-RS-X	Non-Linear Model History (FNA)
EQL-X, Y (3/3)	1.5	TH-RS-Y	Non-Linear Model History (FNA)
Load Combinations			
1.5 (DL+LL+EQL-X)			
1.5 (DL+LL+TH-RS-X)			

IV. RESULTS AND DISCUSSION

The effects of base shear, torsion, shear force, bending moment, storey drift, and displacement differ significantly between floating column and shear wall buildings.

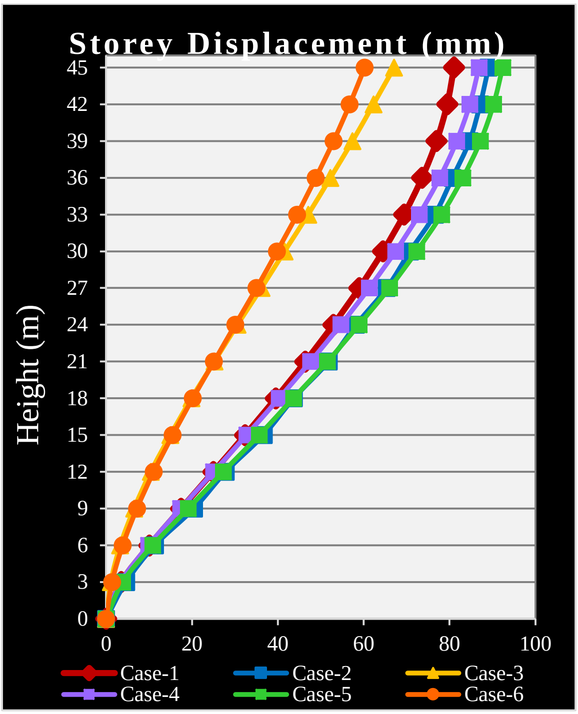


Fig. 4 Combined Storey Displacement of All Cases

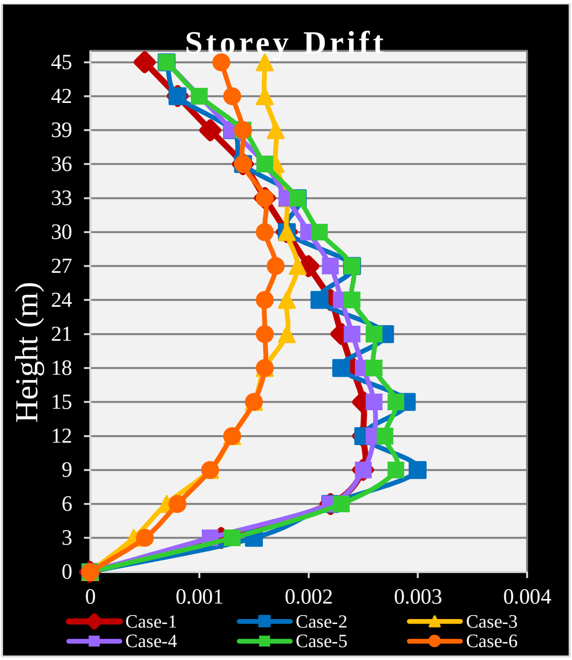


Fig. 5 Combined Storey Drift of All Cases

Storey drift is excessive in floating column structures, leading to potential damage during seismic events, but shear walls significantly reduce drift, ensuring better lateral performance. Lastly, displacement is higher in floating column buildings due to weak lateral resistance, whereas shear walls effectively control displacement, maintaining alignment and stability under lateral loads.

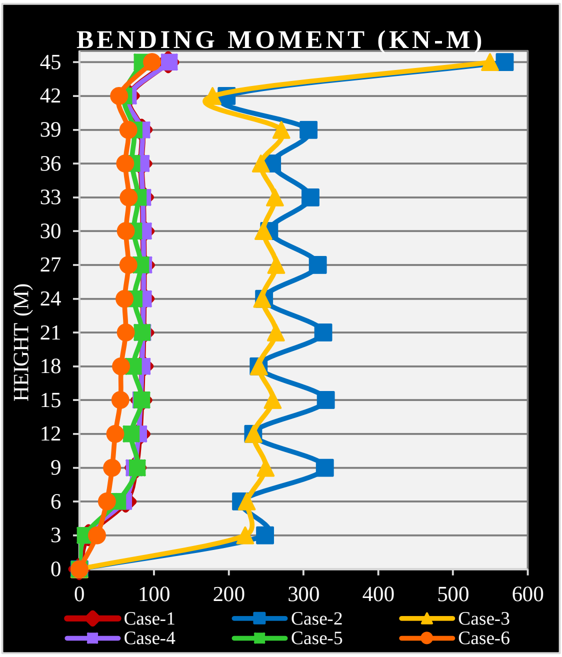


Fig. 6 Combined Bending Moment of All Cases

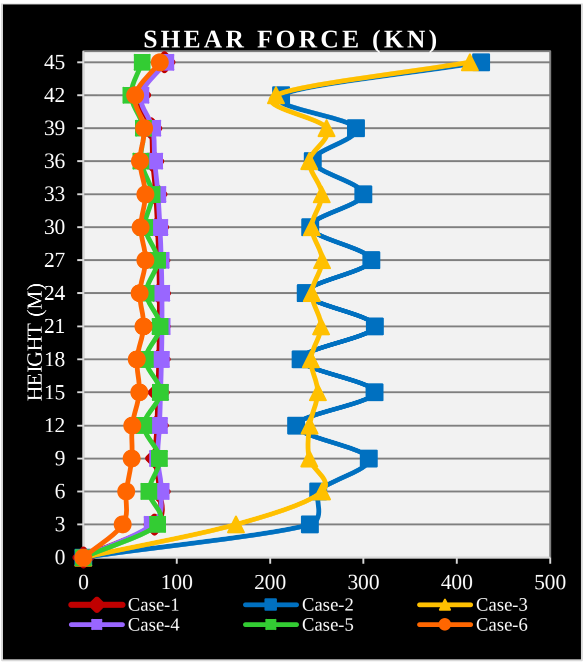


Fig. 7 Combined Shear Force of All Cases

In floating column buildings, base shear increases due to the lack of a direct load transfer path, making the structure more susceptible to seismic forces, while shear walls effectively resist base shear by providing a robust lateral load-resisting system. Torsion in floating column buildings is exacerbated due to uneven stiffness distribution, causing instability, whereas shear walls minimize torsional effects by improving structural symmetry and stiffness. Shear forces in floating columns concentrate at column-beam junctions, increasing failure risks, while shear walls uniformly distribute these forces, reducing stress concentrations. Similarly, bending moments are larger in floating column buildings due to discontinuous load paths, compromising stability, whereas shear walls manage bending moments efficiently, enhancing structural integrity.

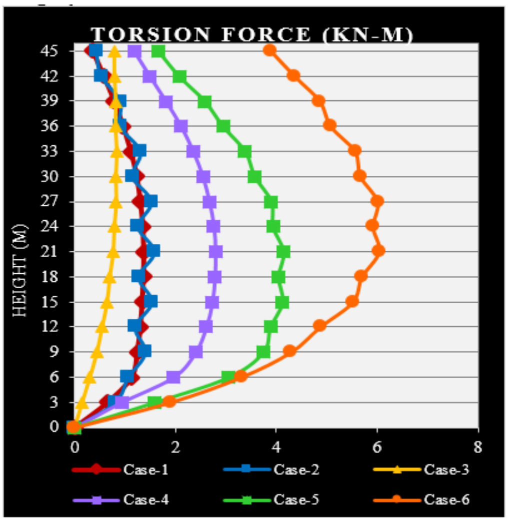


Fig. 8 Combined Torsion Force of All Cases

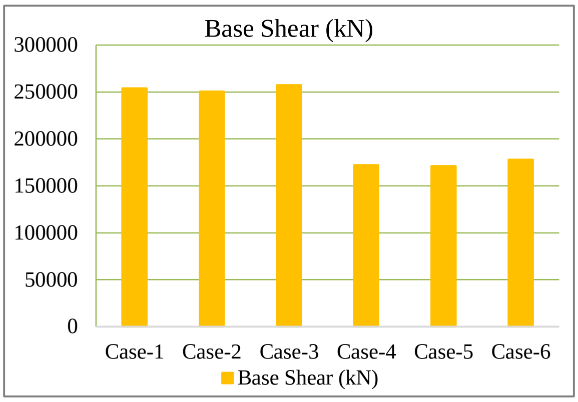


Fig. 9 Combined Base Shear of All Cases with and without dampers

V. CONCLUSIONS

The effects of base shear, torsion, shear force, bending moment, storey drift, and displacement differ significantly between floating column and shear wall buildings Regular and irregular structures were evaluated for performance in terms of story displacement, drift, bending moment, shear force, torsion, axial force, stiffness, and base reactions, revealing notable differences in structural behaviour and provided following conclusions.

- Displacement was higher in irregular structures compared to regular ones in the absence of floating columns. However, the addition of floating columns and shear walls altered displacement patterns, with regular structures showing increased displacements after incorporating shear walls.
- Drift values were greater in irregular buildings without floating columns. Floating columns caused an increase in drift for regular structures, but shear walls effectively reduced drift in both regular and irregular configurations.
- Bending moment values increased significantly in regular structures after the inclusion of floating columns. When both floating columns and shear walls were added, bending moments rose in regular structures but decreased in irregular ones.
- Regular structures experienced higher shear forces, especially with floating columns. However, the implementation of floating columns and shear walls in irregular structures mitigated shear force levels.
- Torsion was more pronounced in irregular structures under bare frame conditions. The addition

of floating columns increased torsion in regular structures but led to overall torsion reductions in both structural types when combined with shear walls.

- Axial forces were higher in regular structures compared to irregular ones, particularly when floating columns and shear walls were used together.
- Stiffness levels were greater in regular structures than in irregular ones in the absence of floating columns. Both structural types initially exhibited reduced stiffness with floating columns, but stiffness improved significantly with the addition of shear walls.
- Base reaction values were higher in regular structures than irregular ones, both with and without floating columns, and these values further increased with the incorporation of shear walls.

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