Seismic Behavior of Multistorey Rc Buildings with Floating Columns

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***Abstract*—The growing demand for open and flexible architectural spaces in high-rise buildings has led to the widespread adoption of floating columns, particularly at lower storey levels for parking areas, lobbies, and commercial spaces. This study evaluates the seismic response of a 30-storey (G+30) building positioned on sloping terrain with inclinations of 5°, 10°, 15°, and 20°, focusing on the influence of floating column termination height (3rd, 6th, and 12th levels) and the effectiveness of flag shear wall placement. Nonlinear dynamic analysis and modal evaluation were performed to quantify top-storey displacement, inter-storey drift, lateral stiffness, and fundamental time period in both principal directions.**

***Index Terms*—Floating columns; nonlinear time history analysis, Flag shear walls**

I. INTRODUCTION

Modern high-rise buildings often demand large column-free spaces at lower levels for commercial, parking, and functional requirements. This architectural need has significantly increased the use of floating columns, which interrupt the traditional vertical load-transfer mechanism. Although floating columns provide planning flexibility, they also introduce discontinuities in stiffness and strength, making the structure more vulnerable under seismic loading. In a tall G+30 reinforced concrete moment-resisting frame, even small irregularities can lead to amplified dynamic responses such as higher lateral displacement, excessive storey drift, and soft-storey formation. Additionally, flag shear walls have gained popularity as an alternative to full shear walls due to their architectural compatibility, but their contribution to lateral stiffness and overall seismic performance depends heavily on their location—whether positioned at the center, corner, or perimeter of the building. While past research has focused on conventional shear walls, there is limited detailed understanding of how flag-type shear walls interact with floating column irregularities.

To develop a detailed analytical model of a G+30 reinforced concrete moment-resisting frame in ETABS 2023, considering gravity and seismic loading as per the provisions of IS 1893:2016.

To assess the effect of increasing floating column termination height on the seismic behavior of a 30-storey building on sloping terrain in terms of lateral stiffness degradation, top-storey displacement, inter-storey drift, and overall seismic flexibility.

To identify the most efficient location of flag shear wall placement based on its influence on inter-storey drift control, storey stiffness improvement at 3rd, 6th, and 12th levels, and reduction in fundamental natural period in compliance with IS 1893:2016.

II. LITERATURE REVIEW

Sher A. (2025) investigated a G+20 irregular octagonal reinforced concrete building incorporating floating columns and an open central core. The study showed that floating columns cause critical load path discontinuities, leading to increased storey displacement and poor seismic performance. The introduction of a central shear wall significantly enhanced structural strength and reduced storey displacement by nearly 50%, demonstrating the effectiveness of shear walls in mitigating adverse effects caused by floating columns. Astha Maratha et al. (2025) examined the combined influence of setbacks and floating columns on the seismic behaviour of a G+7 building using nonlinear pushover analysis. The results revealed that setback configurations and the vertical placement of floating columns considerably affect seismic response. Buildings

with floating columns at higher levels exhibited increased storey displacement and drift, while configurations with lower-level floating columns showed higher target displacement and performance points.
Ritika Dongre et al. (2025) conducted a time history analysis on an irregular G+8 RCC building to evaluate the effects of shear walls, bracings, and floating columns. The study concluded that the inclusion of shear walls and bracing systems effectively reduced lateral displacements and inter-storey drifts, improving force distribution and overall seismic resilience, even in the presence of structural irregularities.
P. Keerthana et al. (2025) focused on the experimental and analytical assessment of hollow tubular steel floating columns with knee-type moment-resisting bracings. The findings indicated that floating columns with 50 mm moment-resisting bracing and 80° inclination exhibited optimal performance, achieving higher load-carrying capacity with minimum displacement. This configuration was identified as the most efficient in terms of strength, stability, and material utilization.
Nabin Khanal et al. (2025) compared equivalent static and response spectrum methods for the seismic analysis of G+4 buildings located in seismic zone IV. The study demonstrated that response spectrum analysis provides more economical and reliable seismic performance evaluation for multistorey buildings, particularly in capturing realistic dynamic behaviour.
Kamlesh Bamniya et al. (2024) presented a comprehensive review of dynamic analysis methods applied to buildings with and without floating columns. The review highlighted that structures incorporating floating columns experience higher inter-storey drifts, increased base shear, and stress concentrations under seismic loading, whereas conventional buildings exhibit more uniform load transfer and superior dynamic performance.

III. MODEL INFORMATION

Regular Model (G+30) For Slope Angle 5 Degree with Floating Column At 3rd,6th And 12th Level
- Floating Column Without Flag Shear wall
- Floating Column with Flag Shear wall at Corner
- Floating Column with Flag Shear wall at Center
- Floating Column with Flag Shear wall at Perimeter

Regular Model (G+30) For Slope Angle 10 Degree with Floating Column At 3rd,6th And 12th Level
- Floating Column Without Flag Shear wall
- Floating Column with Flag Shear wall at Corner
- Floating Column with Flag Shear wall at Center
- Floating Column with Flag Shear wall at Perimeter

Regular Model (G+30) For Slope Angle 15 Degree with Floating Column At 3rd,6th And 12th Level
- Floating Column Without Flag Shear wall
- Floating Column with Flag Shear wall at Corner
- Floating Column with Flag Shear wall at Center
- Floating Column with Flag Shear wall at Perimeter
-

Regular Model (G+30) For Slope Angle 20 Degree with Floating Column At 3rd,6th And 12th Level
- Floating Column Without Flag Shear wall
- Floating Column with Flag Shear wall at Corner
- Floating Column with Flag Shear wall at Center
- Floating Column with Flag Shear wall at Perimeter

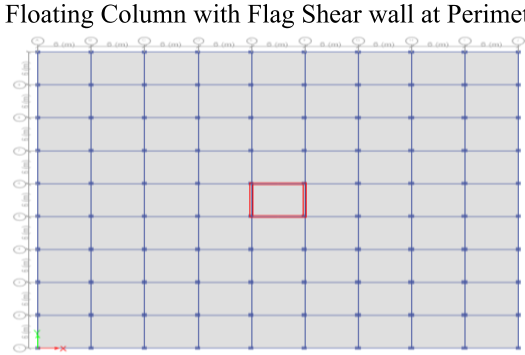


Figure 1 presents the plan view of the normal (conventional) building model used as the baseline reference for comparison in this study

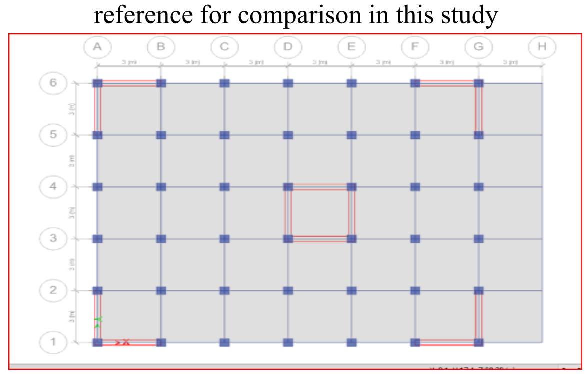


Figure 2 Model-plan view of normal building with corner flag walls

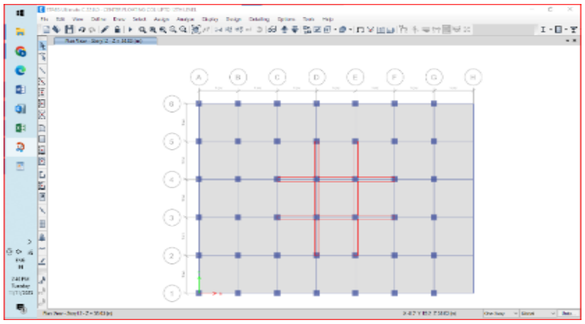


Figure 3 presents the plan view of the building model incorporating flag walls positioned at the central region of the structure

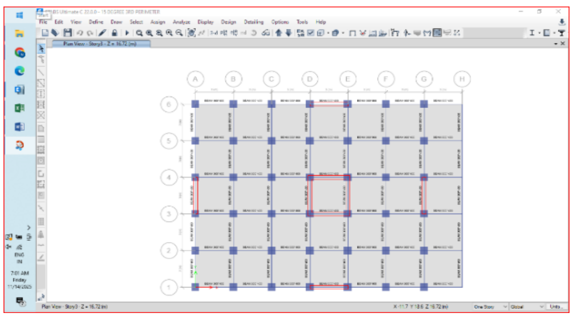
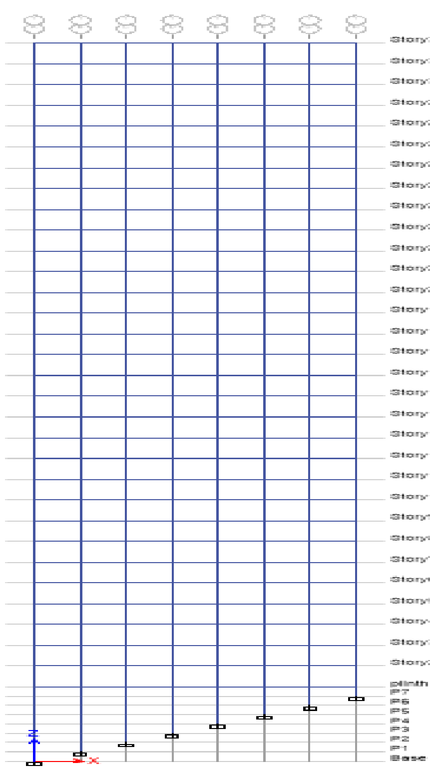
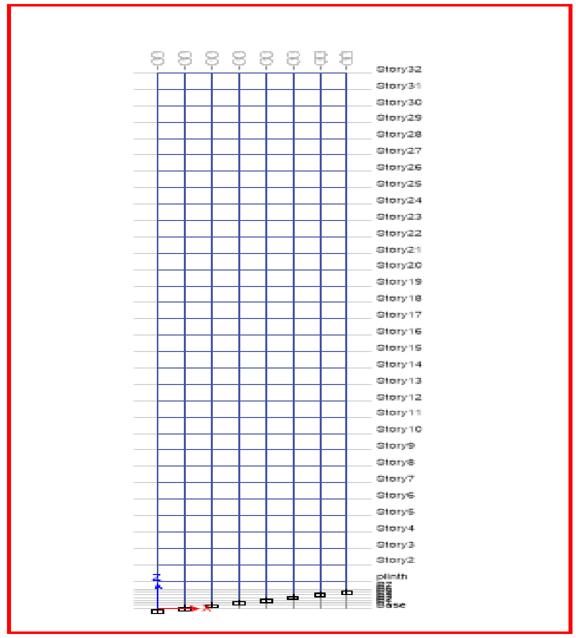


Figure 4 shows the plan view of the building model where flag walls are provided along the perimeter of the structure





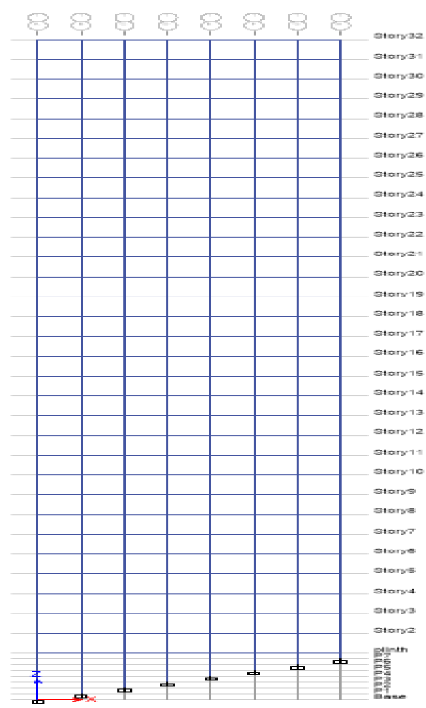


Figure 5 Elevation view of G+30 with 5- & 10-degree slope in Etabs

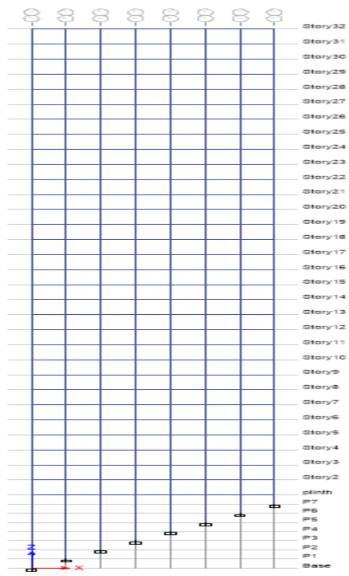


Figure 6: Elevation of G+30 reinforced concrete frame showing ground slope scenarios (left: 15° slope; right: 20° slope). Building axis runs into the page; elevation shows typical bay lines and all 31 floor levels (Ground + 30 floors

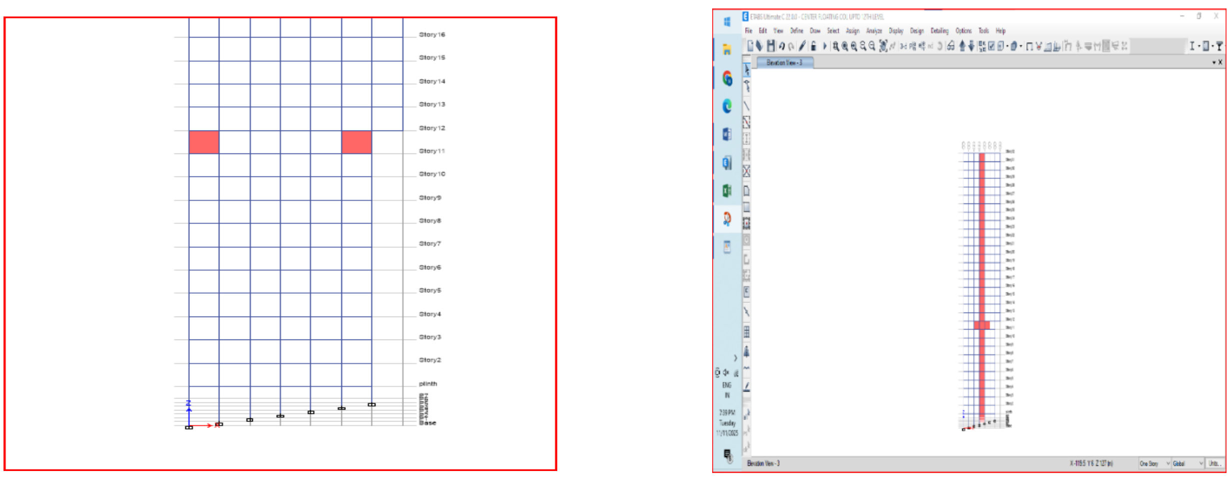
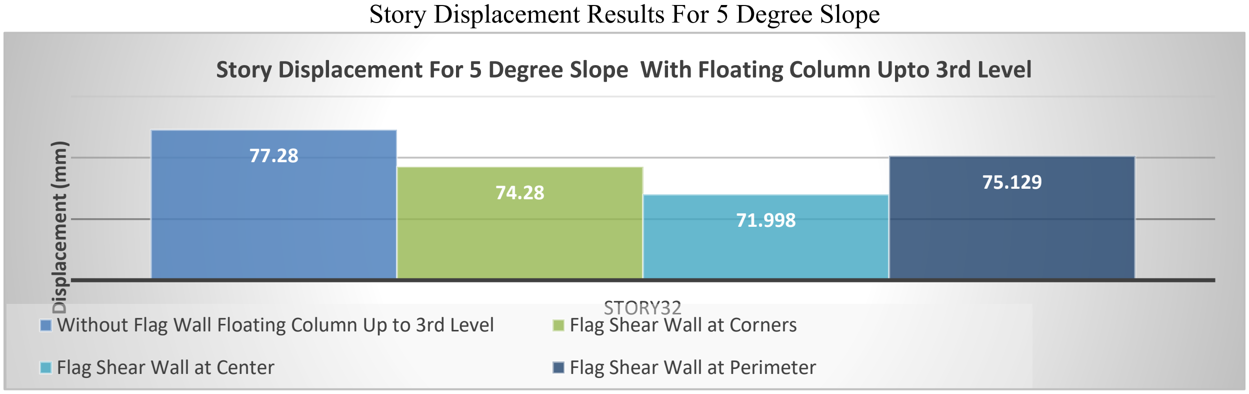
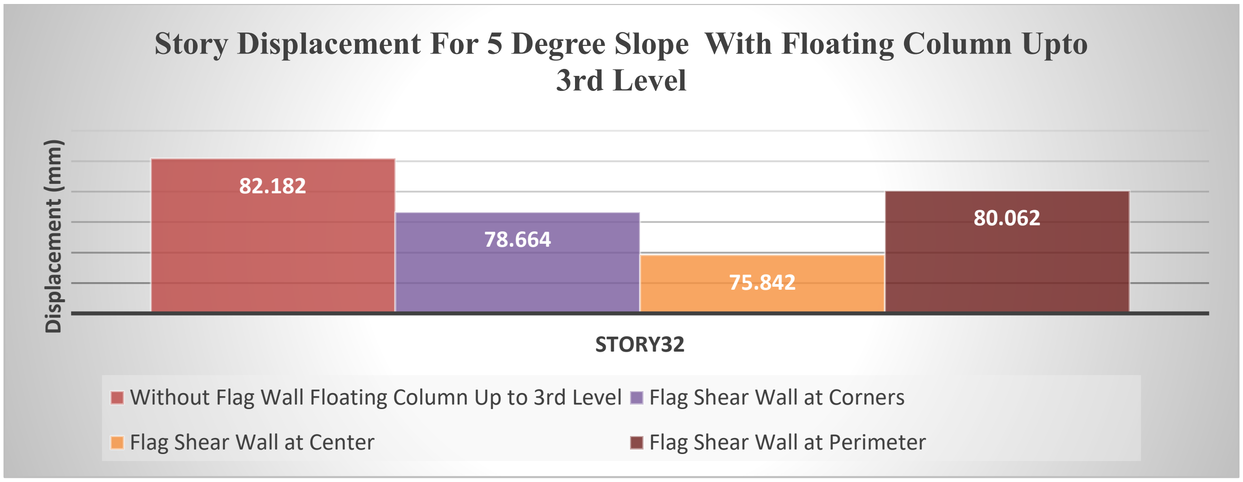


Figure 7: Isometric &Elevation Views of Normal Building with Flag Walls

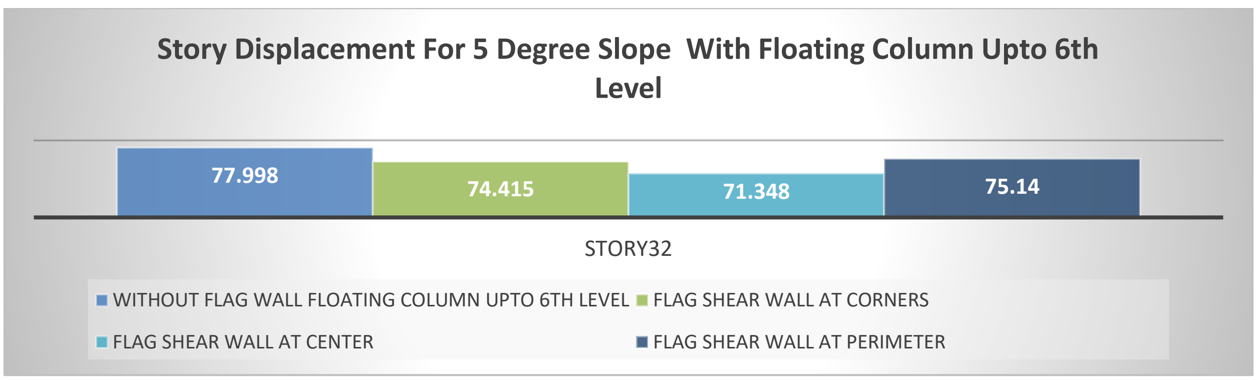
IV. RESULTS AND DISCUSSION

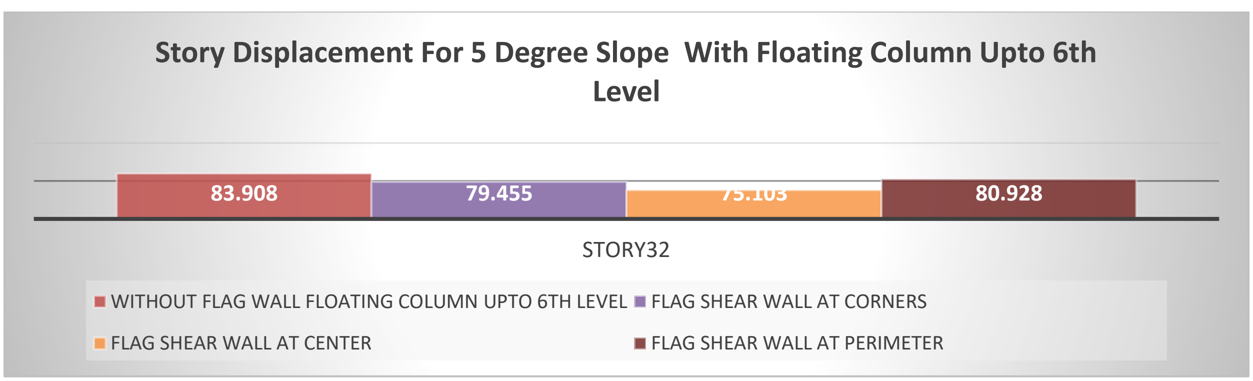
Story Displacement Results For 5 Degree Slope



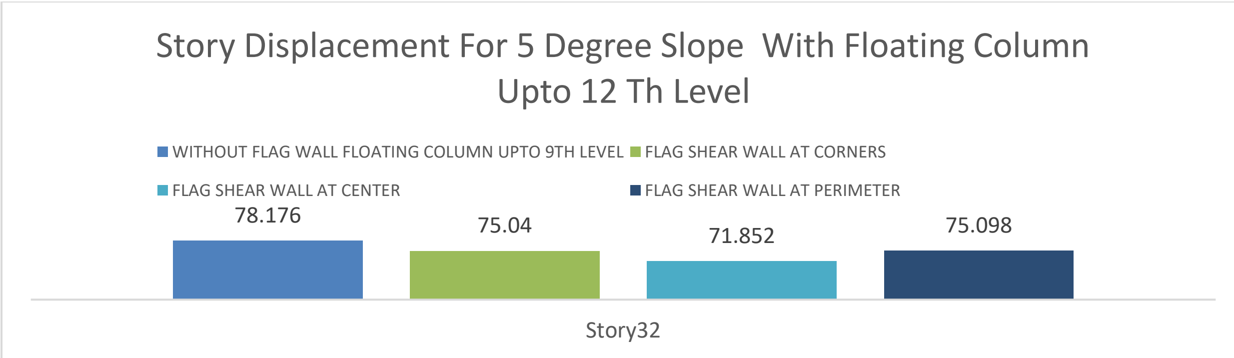


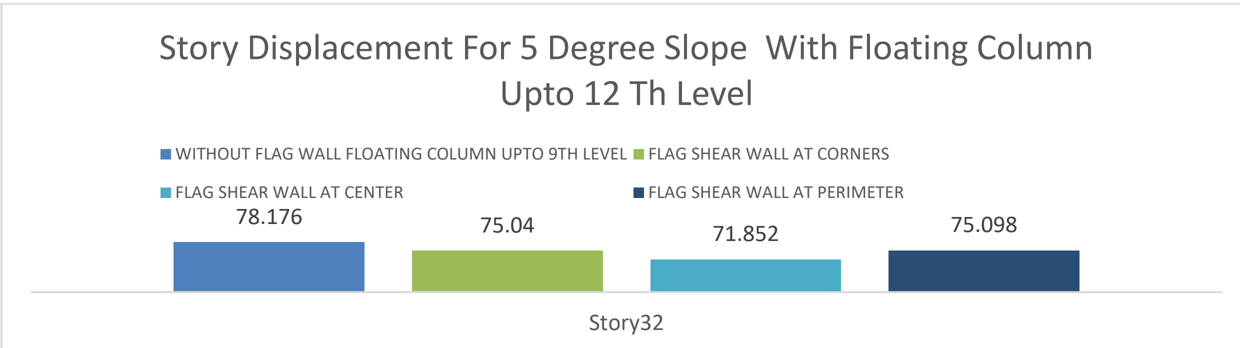
For above figure for the 5° slope model with floating columns up to the 3rd level, the inclusion of flag shear walls effectively reduces the top-story displacement in both X and Y directions. In the X–direction, the displacement reduction ranges from 2.78% to 6.84%, while in the Y–direction, it varies between 2.58% and 7.71% compared to the model without any flag shear wall.





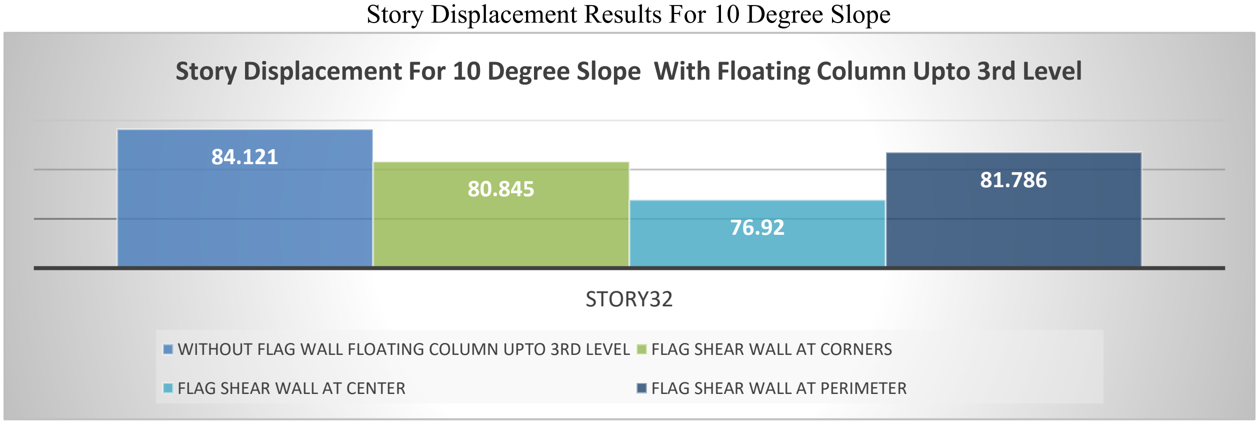
As per IS 1893:2016, the permissible inter-storey drift limit for RC buildings is 0.004 h (Clause 7.11.1), and all configurations remain within the allowable range, but the centrally located flag shear wall arrangement provides the highest improvement in seismic resistance by reducing lateral displacement at this level.

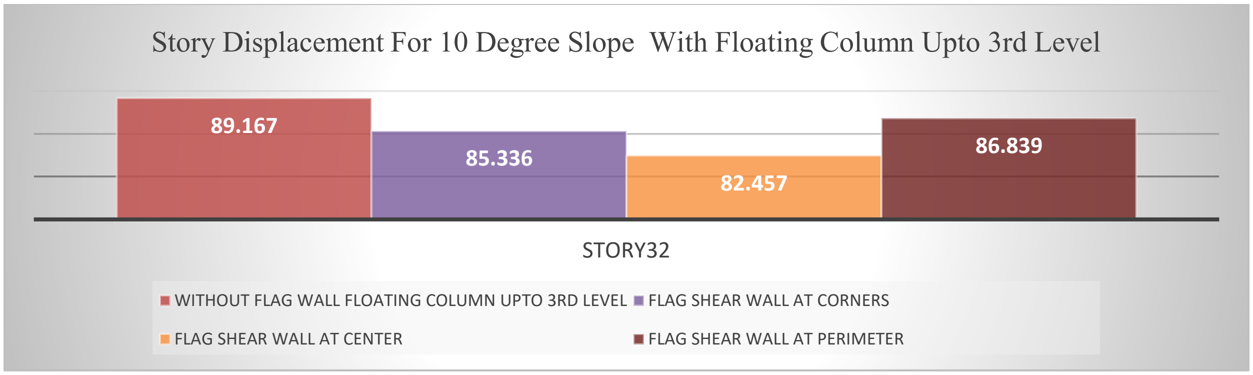


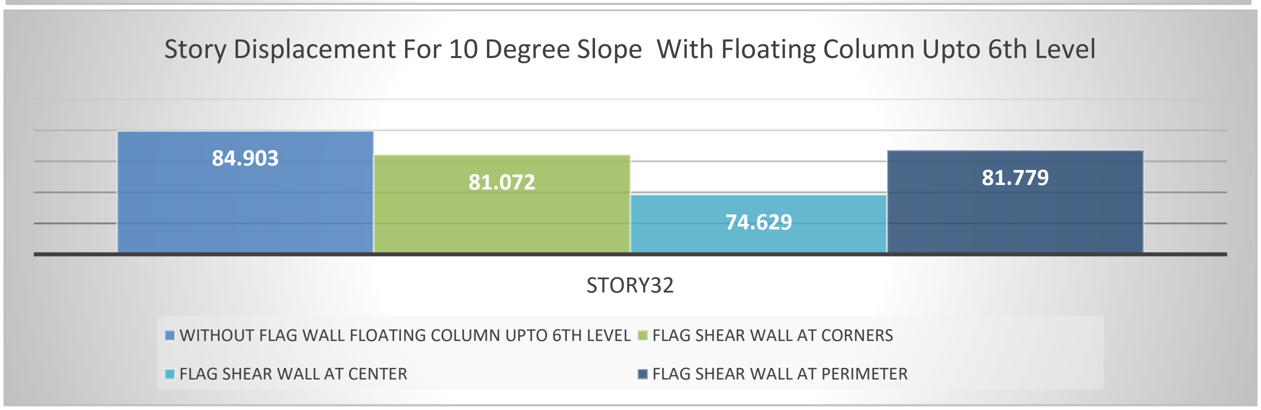


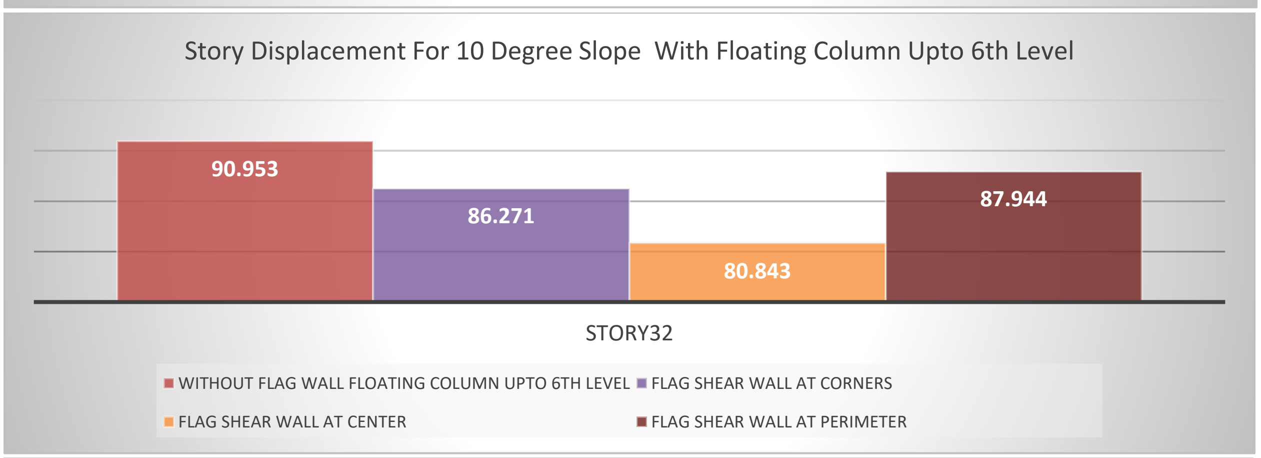
When the flag wall is introduced, the displacement values decrease from the baseline values of 78.176 mm (Dir-1) and 86.506 mm (Dir-2). In the first case, the displacements reduce to 75.04 mm and 82.43 mm, resulting in decreases of approximately 4.01% and 4.71%, respectively. In the second case, a more significant reduction is observed, where the displacements drop to 71.852 mm and 77.624 mm, corresponding to 8.09% reduction in Dir-1 and 10.27% in Dir-2. In the third case, the displacements reduce to 75.098 mm and 83.353 mm, indicating reductions of 3.94% and 3.64%.

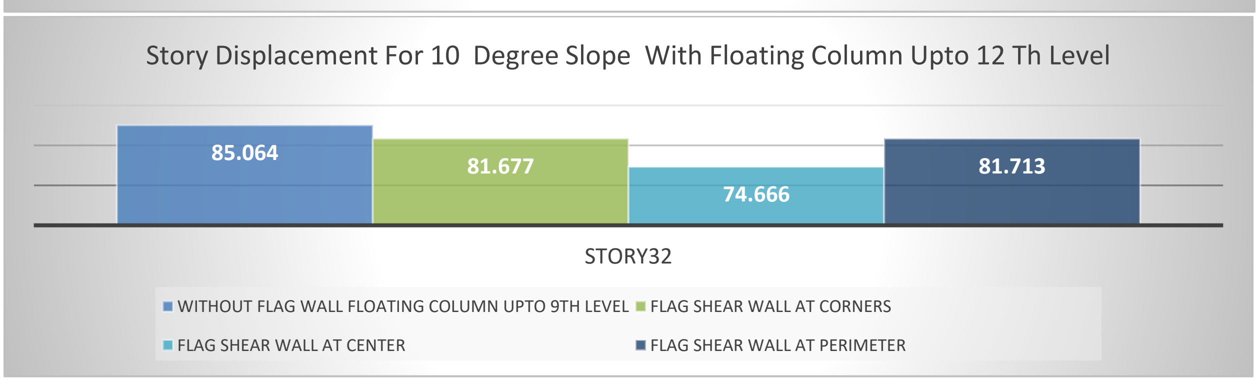
Story Displacement Results For 10 Degree Slope



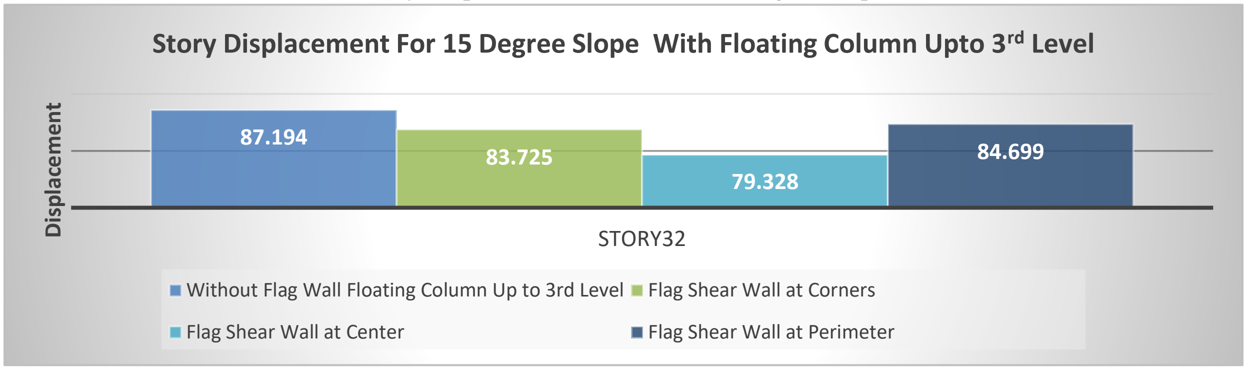

Story Displacement For 10 Degree Slope With Floating Column Upto 3rd Level
89.167
85.336
82.457
86.839
STORY32
WITHOUT FLAG WALL FLOATING COLUMN UPTO 3RD LEVEL
FLAG SHEAR WALL AT CORNERS
FLAG SHEAR WALL AT CENTER
FLAG SHEAR WALL AT PERIMETER

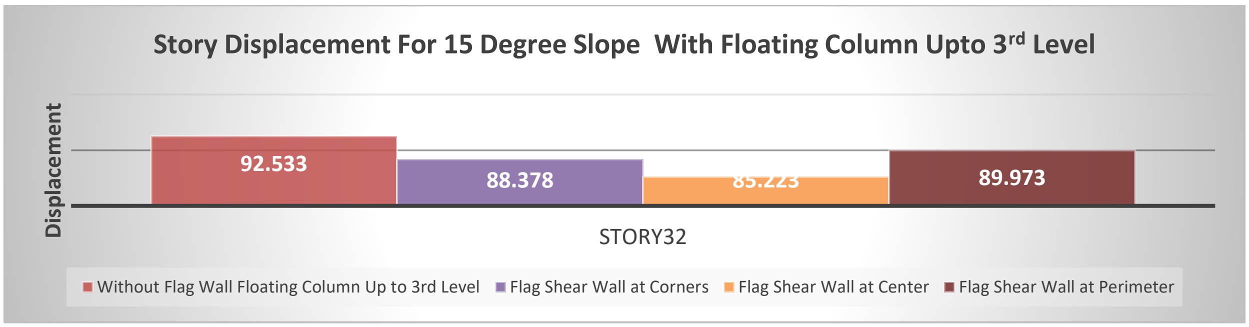

Story Displacement For 10 Degree Slope With Floating Column Upto 6th Level
84.903
81.072
74.629
81.779
STORY32
WITHOUT FLAG WALL FLOATING COLUMN UPTO 6TH LEVEL
FLAG SHEAR WALL AT CORNERS
FLAG SHEAR WALL AT CENTER
FLAG SHEAR WALL AT PERIMETER

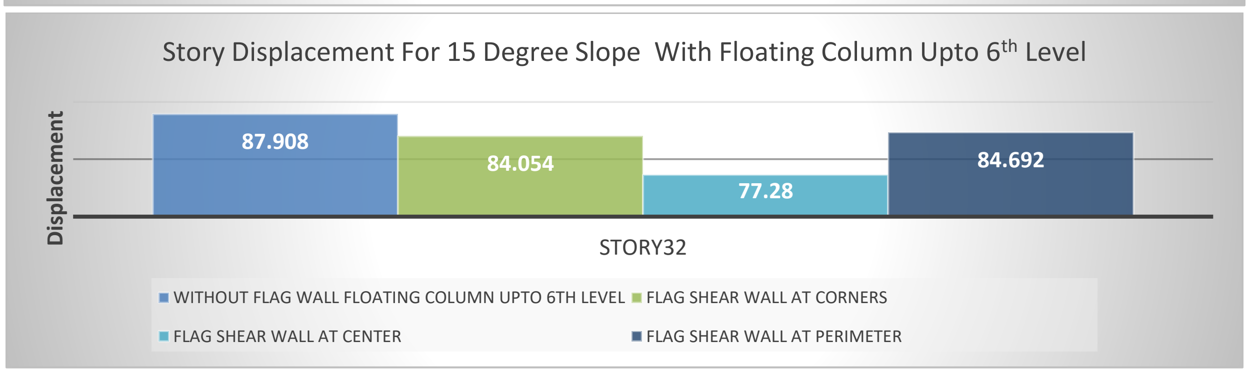

Story Displacement For 10 Degree Slope With Floating Column Upto 6th Level
90.953
86.271
80.843
87.944
STORY32
WITHOUT FLAG WALL FLOATING COLUMN UPTO 6TH LEVEL
FLAG SHEAR WALL AT CORNERS
FLAG SHEAR WALL AT CENTER
FLAG SHEAR WALL AT PERIMETER

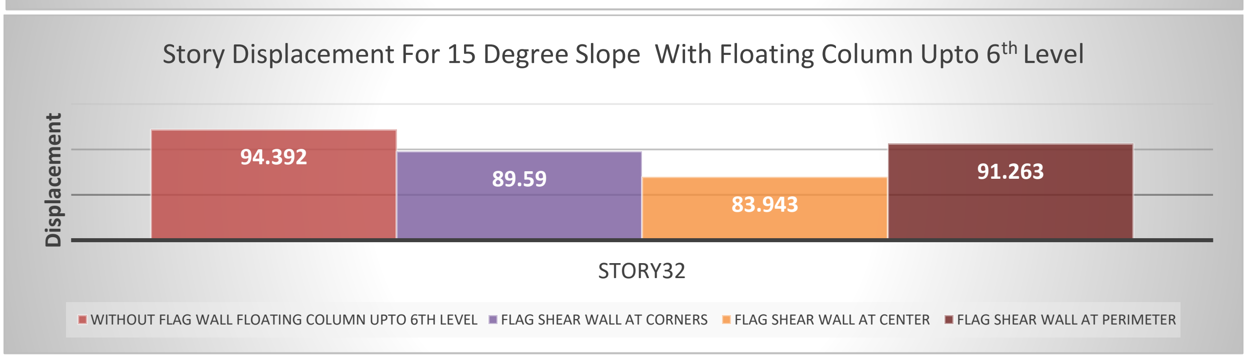

Story Displacement For 10 Degree Slope With Floating Column Upto 12 Th Level
85.064
81.677
74.666
81.713
STORY32
WITHOUT FLAG WALL FLOATING COLUMN UPTO 9TH LEVEL
FLAG SHEAR WALL AT CORNERS
FLAG SHEAR WALL AT CENTER
FLAG SHEAR WALL AT PERIMETER

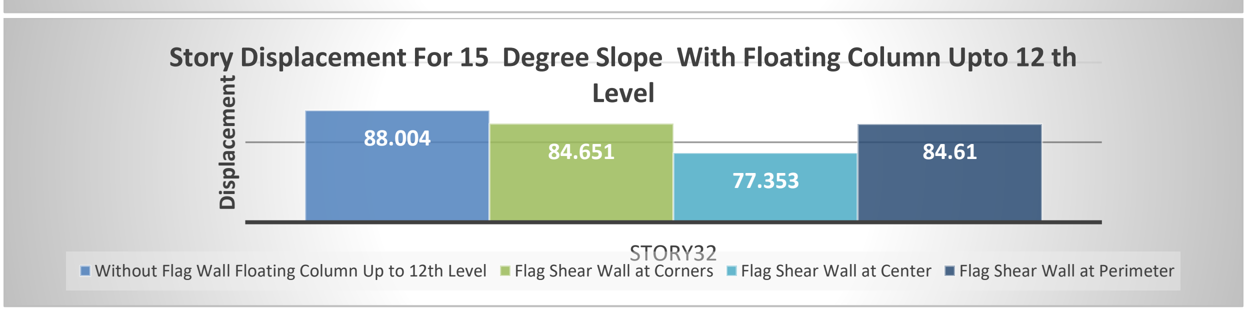
Story Displacement Results For 15 Degree Slope

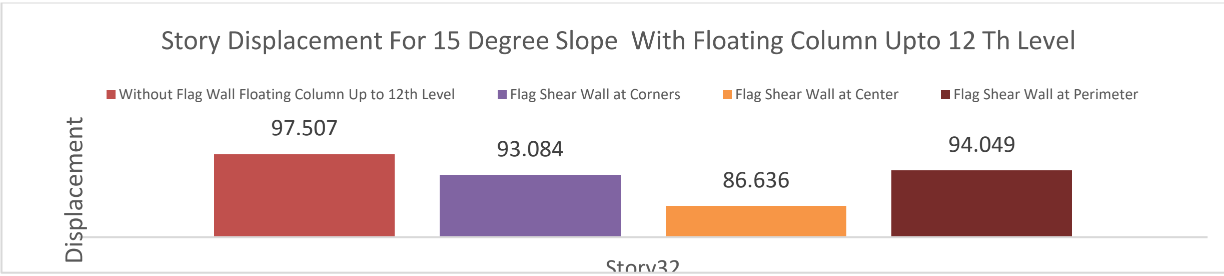




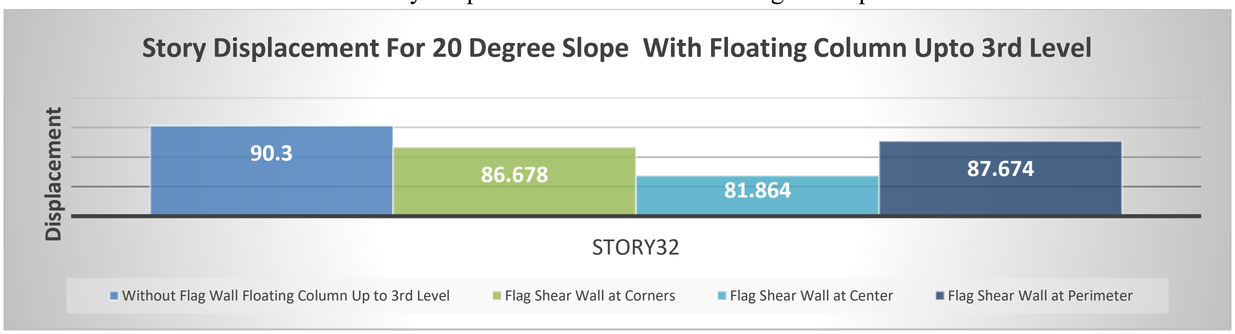


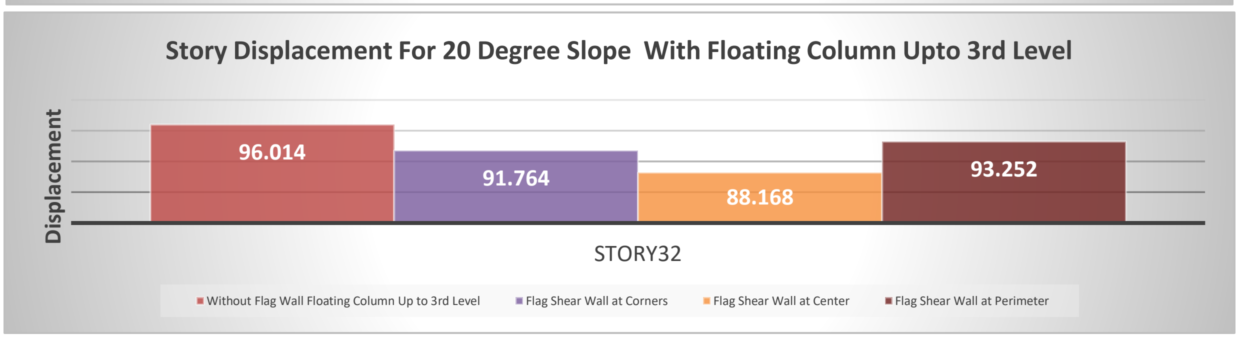


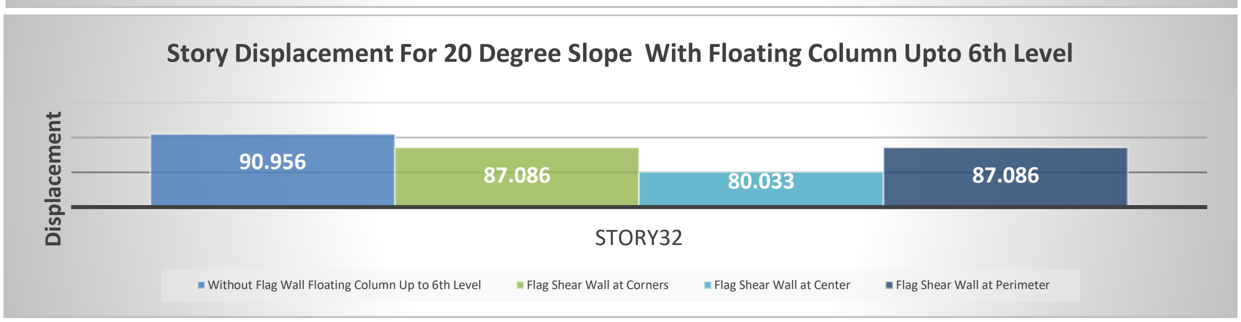


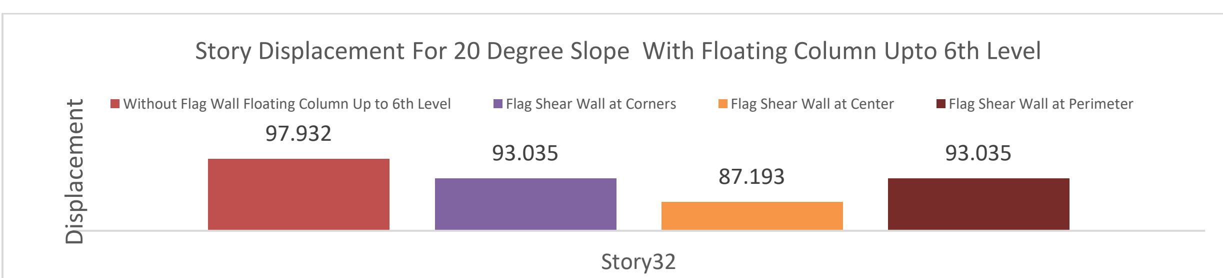


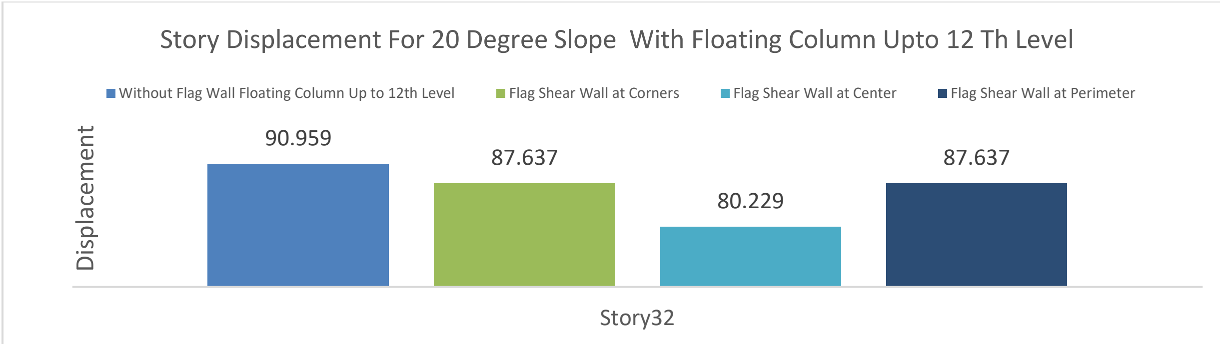
Story Displacement Results for 20 Degree Slope

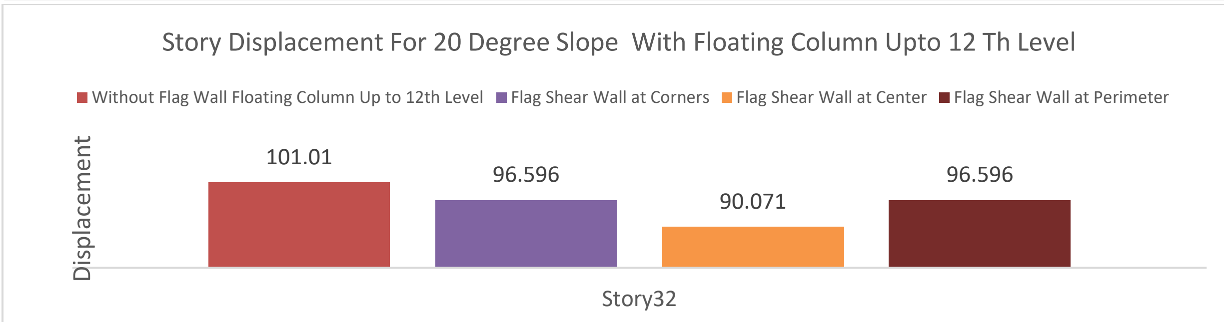












V. COMPARATIVE TABLE FOR TIME PERIOD

Comparative Table for Time Period						
			Without Flag Wall Floating Column	Flag Shear Wall at Corners	Flag Shear Wall at Center	Flag Shear Wall at Perimeter
Floating Column Up to 3rd Level	Time Period		Sec	Sec	Sec	Sec
		5-degree	4.199	4.118	4.04	4.146
		10 Degree	4.385	4.302	4.22	4.329
		15-degree	4.469	4.381	4.29	4.408
		20 Degree	4.553	4.462	4.364	4.489
Floating Column Up to 6th Level	Time Period					
		5-degree	4.221	4.111	3.962	4.14
		10 Degree	4.407	4.295	4.14	4.325
		15-degree	4.491	4.379	4.218	4.407
		20 Degree	4.577	4.465	4.298	4.465
Floating Column Up to 12th Level	Time Period					
		5-degree	4.262	4.147	3.949	4.165
		10 Degree	4.452	4.334	4.128	4.351

		15-degree	4.537	4.421	4.215	4.436
		20 Degree	4.622	4.509	4.304	4.509

VI. CONCLUSION

1. The analytical study of a G+30 reinforced concrete moment-resisting frame modeled in ETABS 2023 and analyzed under gravity and seismic loading as per IS 1893 (Part 1):2016 establishes a clear hierarchy in seismic performance among the investigated configurations. The reference model incorporating a centrally located (core) shear wall demonstrates the most favorable overall seismic response, making it a reliable benchmark for comparative evaluation.
2. The results indicate that an increase in floating column termination height combined with steeper ground slopes significantly amplifies seismic flexibility. From a slope of 5° to 20°, lateral displacement increases by approximately 17%, while global lateral stiffness reduces by nearly 89%, clearly evidencing progressive stiffness degradation and heightened vulnerability on sloping terrain.
3. The introduction of flag shear walls effectively mitigates these adverse effects across all slope conditions. Among the configurations studied, the center/core shear wall provides the highest displacement control, with reductions of about 6.8% in the X-direction and 7.7% in the Y-direction at a 5° slope. This improvement confirms enhanced lateral stiffness and improved plan-wise symmetry of the structural system.
4. Inter-storey drift is found to be minimum at a 5° slope and increases by approximately 10–13% as the slope increases to 20°. Nevertheless, the center/core shear wall configuration consistently yields the lowest drift values at all slopes, ensuring superior compliance with the drift limits prescribed by IS 1893:2016.
5. Storey stiffness enhancement is most pronounced in models with centrally placed shear walls. At a 5° slope, stiffness increases by approximately 45% in the X-direction and 43% in the Y-direction, demonstrating the effectiveness of core walls in compensating for stiffness loss induced by floating columns and sloping ground conditions.
6. The fundamental natural time period increases with slope angle, rising from about 4.199 s at 5° to 4.553 s at 20%, corresponding to an increase of approximately 8.4%. In contrast, the center/core wall configuration consistently exhibits the lowest time period (approximately 4.04–4.36 s), confirming its superior lateral rigidity and maximum reduction in dynamic flexibility.
7. Nonlinear Time History Analysis captures realistic behaviour and confirms that central shear core is the most efficient system, while 20° slope and 12th-level floating show worst nonlinear drift/displacement performance.

6.2 Future Scope

- Including flexible foundation and soil behavior will provide a better understanding of slope-induced amplification effects.
- Future studies can evaluate performance under Immediate Occupancy, Life Safety, and Collapse Prevention levels.
- Studies can explore optimized wall thickness, length, and placement for improved cost–performance balance.
- Research may extend to composite columns, steel–concrete hybrid walls, and outrigger–belt systems to enhance stability on sloping ground.
- Variation in floating column locations and transfer system types can be analyzed for more robust conclusions.
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REFERENCES

[1] Sher, A. (2025). Optimizing G+20 multistorey octagonal building with shear wall and floating column. Preprint retrieved from ResearchGate. ResearchGate

[2] Maratha, A., Garg, V., & Saraogi, A. (2025). Seismic performance of G+7 RCC buildings with setbacks and floating columns using non-linear pushover analysis. Preprint. https://doi.org/10.21203/rs.3.rs-6774786/v1

[3] Dongre, R., & Hora, M. S. (2025). Time history analysis of an irregular (G+8) RCC building frame: Effects of shear walls, bracings, and floating columns.

[4] Keerthana, P., & Parthasarathi, N. (2025). Experimental and analytical study of hollow tubular steel floating columns with knee-type moment-resisting bracings.

[5] Bamniya, K., & Koushal, M. (2024). Dynamic analysis of buildings with and without floating columns: A review.

[6] Khan, P. S. (2024). Stability and seismic behaviour of single-column structures with floating beams and ring beams.

[7] Raju, H. T., & Sundari, M. V. R. (2024). Seismic performance assessment of buildings with floating columns using dynamic analysis based on IS 1893.

[8] Rao, M. V. S., Bommisetty, J., & Vaibhavi, C. (2024). Effect of floating columns in multistorey buildings: Construction sequence analysis across seismic zones.

[9] Prakash, A., Kamala Raju, Y., & Munipally, S. K. (2024). Seismic analysis of buildings with floating columns using ETABS 2022.

[10] Baig, M., & Pahwa, S. (2024). Influence of floating columns on the seismic performance of vertically irregular G+10 RCC buildings.

[11] Bosh, P., Awall, M. R., & Hasan, M. (2023). Seismic performance of buildings with floating columns under BNBC 2020 using static and dynamic analysis.

[12] Ganesh, A., & Vivek Kumar, C. (2023). Seismic analysis of RC buildings with and without floating columns using ESA and RSA in ETABS 2017.

[13] Eldar, B., & Singh, G. (2022). Seismic behaviour of irregular G+10 buildings with and without floating columns using ETABS V19.

[14] Kakatkar, V., & Jambhale, N. (2022). Dynamic analysis of G+14 RC building with floating columns at various levels using ETABS

[15] Vivek Kumar, C., & Ganesh, A. (2022). Study on seismic response of G+10 RC building with floating columns under Zone V conditions.

[16] Mohammed Gazanfer & Rajashree Chinta. Analysis of Multistoried Irregular Building with and Without Floating Column Using ETABS. Journal of Scientific Research and Technology, 1(6), 100–118. 2023. DOI:10.5281/zenodo.8317104.

[17] Abdelrahim Abdalla Bashir, Kamal Satti Mohammed, & Mahgoub Elhaj Mahgoub Kambal. Study Performance of Floating Columns Subjected to Vertical Loads. Journal of Karary University for Engineering and Science, 2(2), 2024. https://doi.org/10.54388/jkues.v2i2.191.

[18] Ayush U. Atkari, Neha J. Wani, Khushi P. Chavan, Lokesh S. Chavan, Hritik V. Deshmukh & V. P. Jadhao. Seismic Performance of RC Building with Floating Column. International Education and Research Journal (IERJ), 11(05), 2025. https://doi.org/10.5281/zenodo.17120502.