

# Seismic Performance Comparison between Regular and Irregular G+5 Commercial Structures using SAP2000

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## Article History:

**Received:** 12-01-2025

**Revised:** 15-02-2025

**Accepted:** 01-03-2025

**Abstract:** This study presents a structural comparison between regular and irregular G+5 commercial buildings with a special focus on floating columns. Using SAP2000 software, the investigation includes three analytical approaches: Equivalent Static Analysis (ESA), Response Spectrum Analysis (RSA), and Time History

Analysis (THA). These methods help assess key structural parameters such as base shear, natural time period, and displacement under seismic loading. The results show that structures with floating columns exhibit greater flexibility, longer time periods, and altered lateral force distribution. Although these irregular features offer design versatility, they also demand advanced structural solutions to ensure safety and compliance with seismic codes.

**Keywords:** Floating column, structural irregularity, SAP2000, seismic design, G+5 building, response analysis, base shear, drift.

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## 1. Introduction

Urban development has accelerated the need for mid-rise commercial buildings, particularly G+5 structures.

Structural engineers are often challenged by the integration of design flexibility with seismic safety. One such challenge arises with floating columns-vertical members that rest on transfer beams instead of connecting directly to the foundation. This study explores how such structural irregularities affect performance under seismic conditions.

## 2. Review of Existing Research

Various researchers have studied the behavior of buildings with asymmetric layouts. Regular buildings, with symmetrical mass and stiffness, typically respond predictably to seismic forces. Irregular buildings, by contrast, can exhibit torsion and unpredictable stress distribution. Modern structural analysis tools, like SAP2000, enable detailed modeling and analysis of these effects, offering deeper insight into structural vulnerabilities.

### 3. Methodology

Two models—a regular and an irregular G+5 commercial building—were developed in SAP2000.

- Model 1: Regular layout with uniform mass distribution and consistent geometry
- Model 2: Irregular layout with asymmetry introduced via floating columns

The models were subjected to various load combinations: dead load, live load, wind, and seismic loads, as

per IS 875 and IS 1893 (Part 1): 2016. Analytical procedures included:

- ESA: For preliminary seismic force estimation
- RSA: To capture the modal behavior
- THA: To observe real-time response to seismic excitation

### 4. Results and Interpretation

#### 4.1 Base Shear

- G+5 with floating columns: 2190.38 kN
- G+5 without floating columns: 2197.13 kN

Although differences are minimal, floating columns alter load paths, slightly reducing base shear due to flexibility.

#### 4.2 Time Period

- G+3 with floating columns: 0.68 s
- G+3 without floating columns: 0.50 s

Floating columns increase the overall time period, implying reduced structural stiffness and enhanced flexibility.

#### 4.3 Lateral Displacement

Top-story displacements under different methods (G+5):

- ESA: 0.0236 m
- RSA: 0.0115 m
- THA: 0.0146 m

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THA results consistently show higher displacement, offering a more conservative yet realistic outlook compared to RSA or ESA.

### 5. Discussion

The inclusion of floating columns leads to discontinuities in vertical load paths. This impacts stiffness, increases lateral deformation, and introduces stress concentrations. While the difference in

base shear values is modest, the elevated time period and displacement suggest that buildings with floating columns are less stiff and potentially more vulnerable to seismic motion.

RSA, though effective for preliminary assessments, may under-represent displacements in irregular structures. THA, incorporating real ground motion records, presents a more accurate assessment of the building's real-world response.

## 6. Conclusions

- Floating columns affect seismic performance by increasing time period and displacement.
- Regular structures outperform irregular ones in terms of uniform force distribution and predictable seismic response.
- Advanced modeling techniques like THA are crucial for evaluating the safety of irregular configurations.
- All designs complied with IS 1893 drift limits, confirming their viability under seismic conditions, but irregular structures require more meticulous detailing.
- Regular structures provide better predictability and robustness under seismic loads due to uniform mass and stiffness.

## 7. Recommendations

- Avoid floating columns in high-seismic zones unless required for architectural reasons.
- Use dynamic analysis (THA) for buildings with geometric or vertical irregularities.
- Provide robust connections and reinforcement detailing around transfer beams supporting floating columns.

## References

- [1] Chopra, A.K. Dynamics of Structures. Pearson Education, 2017.
- [2] Ghosh, S., Bhattacharya, S. "Seismic Effects on Irregular Structures," Earthquake Engineering, 2025.
- [3] CSI. SAP2000 User Manual, 2024.
- [4] Tso, W.K., Liu, J. "Torsional Effects in Irregular Buildings," Structural Dynamics Journal, 2022.
- [5] Research Paper
- [6] IS 1893 (Part 1): 2016. Criteria for Earthquake Resistant Design of Structures.
- [7] IS 456: 2000. Plain and Reinforced Concrete - Code of Practice.
- [8] Amin, R., et al. "Behavioral Comparison of G+5 Structures," International Journal of Structural Analysis, 2023.