Analysis of Seismic Response in G+7 Structures: With and Without Hanging Columns

DASAKA VSS SUBRAHMANYAM[1], Dr. P. BALAKRISHNA, Ph.D[2],

[1]Master of Technology in structural engineering & MVR College of Engineering & Technology (Autonomous)

[2]*Associtae professor in the civil engineering department & MVR College of Engineering & Technology (Autonomous)*

---***---

Abstract - This document shows the required format and appearance of a manuscript prepared for IJSREM e-journals. The abstract should consist of a single paragraph containing no more than 200 words. It should be a summary of the paper and not an introduction. Because the abstract may be used in abstracting and indexing databases, it should be self-contained (i.e., no numerical references) and substantive in nature, presenting concisely the objectives, methodology used, results obtained, and their significance. A list of up to six keywords should immediately follow, with the keywords separated by commas and ending with a period.

Key Words: optics, photonics, light, lasers, templates, journals

1. INTRODUCTION

In modern urban architecture, especially in India, the provision of hanging columns is increasingly common to maximize open space at the ground level for parking or lobbies. Hanging columns rest on transfer beams rather than transferring loads directly to the foundation, leading to structural discontinuities. While structurally viable under gravity loads, these columns pose significant risks under seismic loads due to disrupted load paths. During earthquakes, such discontinuities can amplify vulnerability, as seen in the 2001 Bhuj earthquake. Hence, hanging columns in seismic zones require careful design and detailing, with reinforced transfer girders to ensure stability and safety under lateral forces.

1.1 Objective and Scope of Present Work

The target of the current research is

- ➢ Researching the behavior, in earthquake encouragement, of multi-story buildings with Hanging columns.
- ➢ The seismic analysis of the building with a Hanging column is used for analyzing the impact of Staad Pro.
- ➢ Investigate the displacement of base shear between Hanging columns in a G+7 Residential multi-story building at different locations.

1.2 Research Significance

In urban areas, multi-story buildings are designed for the various purposes mentioned above by having Hanging pillars in the ground floor. Such Hanging column buildings are built for gravity loads and safely subject to gravity loads, but not for earthquake loads. Therefore, in seismically prone areas these buildings are dangerous. Throughout the earthquake-resistant architecture of multi storage buildings, the project aims to raise understanding of these problems.

1.3 Previous Studies

Several researchers have studied the seismic performance of RC buildings with hanging columns. Rohilla et al. (2015) found that hanging columns increase storey displacement and drift, making buildings more vulnerable in Zone V. Kavya et al. (2015) observed higher lateral displacements and base shear in buildings with hanging columns, advising against their use in seismic zones. Singla et al. (2015) reported increased deflections and fundamental periods due to column discontinuities. Mundada et al. (2014) and Keerthigowda et al. (2014) emphasized structural vulnerability but noted improvements with lateral bracing. Overall, hanging columns weaken seismic response and require careful design or reinforcement.

2. METHODOLOGY

The methodology involves the systematic analysis and theoretical evaluation of structural loads acting on a building, particularly in seismic zones. Dead loads include the self- weight of structural elements such as slabs, beams, columns, and walls, determined using material unit weights (e.g., RCC = 25 kN/m³, steel = 78.5 kN/m³). Imposed loads for residential buildings are considered as 4.0 kN/m² as per IS 875 (Part 2)- 1987. Wind loads are evaluated using IS 875 (Part 3)-1987, based on design wind speed and topographic factors. Seismic loads are determined using IS 1893 (Part 1): 2002 through Equivalent Static Analysis. The design base shear is calculated using the formula V=A·WV = A \cdot W, where A is the horizontal seismic coefficient, and W is the seismic weight. The seismic coefficient depends on factors like zone (Z), importance (I), response reduction (R), and spectral acceleration (Sa/g). The base shear is then distributed along the height using floor-wise mass and height ratios. Load combinations considered include

1.5(DL+IL), 1.2(DL+IL+EL), and 0.9DL+1.5EL. Earthquake-resistant design also considers ductile detailing and dynamic parameters like natural period (T), damping ratio (5%), and soil conditions (hard soil). All calculations follow IS codes to ensure structural safety and reliability.

3. ANALYSIS OF THE STRUCTURE

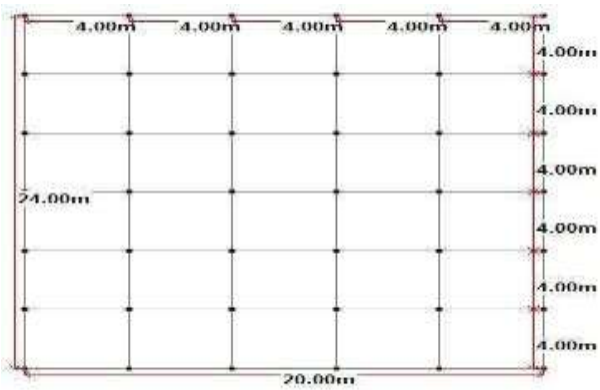
In the present study, a comparative seismic analysis of four multi-storey steel structures with and without hanging columns was conducted using STAAD Pro software. The models include: a regular rectangular building (Structure 1), and buildings with hanging columns at the 1st, 3rd, and 5th floors respectively (Structures 2, 3, and 4). All structures were designed per IS 800:2007 and IS 1893 (Part 1):2002 to comply with seismic safety requirements.

The base shear for the regular structure (Structure 1) was recorded at 2206.30 kN, marginally higher than that of structures with hanging columns: 2205.80 kN (Structure 2), 2201.93 kN (Structure 3), and 2198.26 kN (Structure 4). This slight decrease in base shear with the addition of hanging columns indicates a redistribution of seismic loads and reduced structural stiffness, especially at higher levels.

Displacement values increased progressively with the elevation of the hanging column. At the roof level (24 m), the regular structure showed a displacement of 14.59 mm, while Structures 2, 3, and 4 exhibited 14.54 mm, 16.55 mm, and 19.65 mm respectively. This trend indicates that placing hanging columns at higher floors increases lateral displacements significantly, thus impacting seismic performance adversely.

Similarly, inter-storey drift and deflection patterns revealed that buildings with hanging columns at higher levels are more flexible and vulnerable during seismic events. Structure 4, with a hanging column at the 5th floor, demonstrated the maximum displacement and drift values among all configurations.

In summary, the analysis confirms that introducing hanging columns disrupts load continuity, reducing overall stiffness and increasing lateral displacements and drift. These effects become more severe as the elevation of the hanging column increases. Hence, buildings with hanging columns, particularly at higher levels, require enhanced design considerations for seismic resilience.



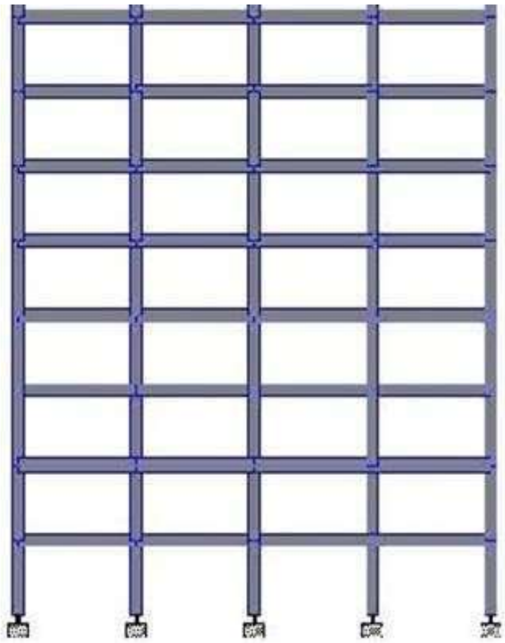


Fig.1An (G+7) story steel frame is used for this analysis. The average height of the floor is 3 m and the building is 24 m. As shown in Figure 1, the laterals cover 24 meters by 20 meters and are divided into 4 square meter bays

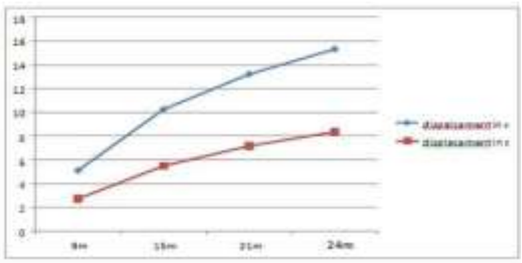


Fig.2X-axis and Z-axis directions Displacements

4. RESULTS AND DISCUSSIONS

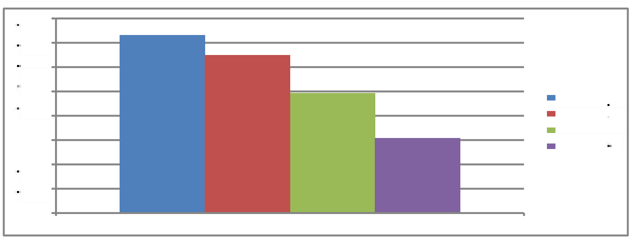


Figure3.Base shear

The comparative analysis of four structural models—one regular building and three buildings with hanging columns at the 1st, 3rd, and 5th floors—was performed using STAAD Pro as per IS 800:2007 and IS 1893:2002 guidelines. The base shear for the regular structure was slightly higher (2206.30 kN) than those with hanging columns, which showed a marginal reduction due to stiffness discontinuity. Structures 2, 3, and 4 exhibited base shear values of 2205.80 kN, 2201.93 kN, and 2198.26 kN respectively, indicating a reduction trend with the elevation of the hanging column.

Displacement analysis revealed significant lateral movement as the hanging column was positioned at higher floors. At the top floor (24 m), the regular building displaced 14.59 mm, whereas Structures 2, 3, and 4 displaced 14.54 mm, 16.55 mm, and 19.65 mm respectively. This increase highlights the adverse impact of vertical discontinuity on seismic behavior.

Overall, the study demonstrated that buildings with hanging columns are more prone to increased lateral displacement and storey drift. The effects become more pronounced when the hanging column is located at higher elevations. Therefore, special design attention is required for such buildings, particularly in seismic zones, to ensure structural safety and performance.

4.1 Base shear:

S.No	Seismic Weight	Base Shear	Time Period
STRUCTURE 1	52959.43	2206.30	0.94
STRUCTURE 2	52590.00	2205.80	0.94
STRUCTURE 3	52844.92	2201.93	0.94
STRUCTURE 4	52755.85	2198.26	0.94

TABLE 1 BASE SHEAR

3. CONCLUSIONS

The present study investigated the seismic behavior of multi-storey buildings with and without hanging columns using STAAD Pro, following IS 800:2007 and IS 1893:2002 standards. The comparison between four structural models revealed important trends related to base shear, displacement, and storey drift.

It was observed that buildings with hanging columns experienced slightly lower base shear than those without. This reduction in base shear values became more evident as the hanging column position shifted from lower to higher floors. However, this apparent benefit was offset by increased lateral displacements and storey drifts. The displacement values progressively increased with the elevation of the hanging column, indicating a loss of lateral stiffness and structural continuity.

Furthermore, storey drift values were found to be significantly higher in buildings with hanging columns, especially when placed at upper levels. This increase in both displacement anddrift highlights the detrimental effects of vertical irregularity in seismic performance. The results underline that hanging columns disrupt the efficient load transfer path, making the structure more flexible and vulnerable during earthquakes.

Therefore, hanging columns should be avoided in high-seismic zones, or, if necessary, designed with proper reinforcement, bracing, or deep transfer beams to minimize adverse seismic effects and ensure structural safety.

REFERENCES

1. **Agarwal Pankaj, Shrikhande Manish (2009**), "Earthquake resistant design of structures", PHI learning private limited, New Delhi..
2. **Arlekar Jaswant N, Jain Sudhir K. and Murty C.V.R, (1997**), "Seismic Response of RC Frame Buildings with Soft First Storeys". Proceedings of the CBRI Golden Jubilee Conference on Natural Hazards in Urban Habitat, 1997, New Delhi.
3. **Awkar J. C. and Lui E.M**, "Seismic analysis and response of multistory semirigid frames", Journal of Engineering Structures, Volume 21, Issue 5, Page no: 425-442, 1997.
4. **Balsamoa A, Colombo A, Manfredi G, Negro P & Prota P (2005),** "Seismic behavior of a full-scale RC frame repaired using CFRP laminates". Engineering Structures 27 (2005) 769– 780.
5. **Bardakis V.G., Dritsos S.E. (2007),** "Evaluating assumptions for seismic assessment of existing buildings ".Soil Dynamics and Earthquake Engineering 27 (2007) 223–233.
6. **Brodericka B.M., Elghazouli A.Y. and Goggins J**, "Earthquake testing and response analysis of concentrically-braced sub-frames", Journal of Constructional Steel Research ,Volume 64, Issue 9, Page no: 997-1007,2008.
7. **Chopra, Anil k. (1995),** "Dynamics of structures", Prentice Hall.
8. **Daryl L. Logan (2007),** "A First Course in the Finite Element Method", Thomson, USA
9. **Fall H.G (2006),** "Direct Stiffness Method For 2D Frames- Theory of structure".
10. **Garcia Reyes, Hajirasouliha Iman, Pilakoutas Kypros, (2010),**"Seismic behaviour of deficient RC frames strengthened with CFRP composites". Engineering Structures 32 (2010) 3075-3085.
11. **Hartley Gilbert and Abdel-Akher Ahmed,** "Analysis of building frames" Journal of Structural Engineering, Vol. 119, No. 2, Page no:468-483, 1993.

12. **Kattan P I (2003),** "MATLAB guide to Finite Element", Springer, Berlin & New York.

13. **K. N. V. Prasada Rao, K. Seetharamulu, and S. Krishnamoorthy,** "Frames with staggered panels: experimental study", Journal of Structural Engineering, VOL 110, No. 5, Page no: 1134-1148, 1984.

14. **Krishnamoorthy CS,** Finite element analysis, TMH Publications, 1987

15. **Maison Bruce F. and Neuss Carl F.,** "Dynamic analysis of a forty four story building", Journal of Structural Engineering, Vol. 111, No. 7, Page No:1559- 572,July, 1985.

16. **Maison Bruce F. and Ventura Carlos E.,** "DYNAMIC ANALYSIS OF THIRTEEN- STORY BUILDING",
Journal of Structural Engineering, Vol. 117, No. 12, Page no:3783- 3803,1991.

17. **Mortezaei A., Ronagh H.R., Kheyroddin A.,** (2009), "Seismic evaluation of FRP strengthened RC buildings subjected to near-fault ground motions having fling step". Composite Structures 92 (2010) 1200–1211.

18. **Niroomandia A., Maherib A, Maheric Mahmoud R., Mahini S.S.** (2010) "Seismic performance of ordinary RC frames retrofitted at joints by FRP sheets". Engineering Structures 32 (2010) 2326- 2336.

19. **Ozyigit H. Alper,** "Linear vibrations of frames carrying a concentrated mass", Mathematical and Computational Applications, Vol. 14, No. 3, pp. 197-206, 2009.

20. **Paz Mario** (2010), "Structural dynamics", CBS publishers.