

A Comparative Study on the Seismic Performance of Multistory Buildings Incorporating Floating Columns

ADDEPALLI KONDA SIVVA PAVAN¹ PRANEETH,

PG Scholar, Dept of Civil Engineering, RK College of Engineering (Autonomous),
Vijayawada, AP, India. praneethaddepalli@gmail.com

Abstract - The increasing demand for open spaces in modern multistorey buildings has led to the widespread adoption of floating columns in contemporary construction practices. Although floating columns provide architectural flexibility and functional advantages, they introduce structural irregularities that can significantly influence the seismic performance of buildings. This study investigates the seismic behaviour of a multistorey reinforced concrete (RC) building with and without floating columns. Special emphasis is placed on evaluating the effects of floating columns on load transfer mechanisms, storey stiffness, lateral displacement, and force distribution under seismic loading.

To mitigate the irregularities induced by floating columns, alternative measures involving the stiffness balancing of adjacent storeys are also examined. A three-dimensional analytical model of the building is developed and analyzed using STAAD.Pro V8i software. Equivalent Static Analysis is performed in accordance with relevant seismic design provisions, and the structural responses of the two building configurations are compared. The results provide valuable insights into the influence of floating columns on seismic performance and contribute to the development of safer, more efficient, and economical structural designs for multistorey buildings.

Keywords: Floating Columns, Seismic Analysis, STAAD.Pro, Reinforced Concrete Frame, Lateral Displacement, Storey Drift, Column Shear, Structural Irregularity.

1. INTRODUCTION

In modern urban developments across India, multi-storey buildings frequently incorporate an open ground storey to accommodate parking facilities, reception areas, and commercial spaces. While this architectural requirement enhances functionality, it also introduces vertical irregularities that can significantly affect the seismic performance of the structure. Although the total seismic base shear experienced by a building during an earthquake primarily depends on its natural period, the distribution of seismic forces along the height is governed by the stiffness and mass distribution of the structure.

The seismic response of a building is strongly influenced by its overall configuration, geometry, and structural layout.

*

During an earthquake, lateral forces generated at various floor levels must be transferred efficiently to the foundation through a continuous and direct load path. Any interruption or discontinuity in this load transfer mechanism can lead to stress concentrations and undesirable structural behavior. Buildings with vertical irregularities, such as setbacks, floating columns, open ground storeys, or sudden changes in stiffness and strength, are particularly vulnerable to earthquake-induced damage. Structures with a reduced number of columns, insufficient lateral load-resisting elements, or unusually tall storeys tend to experience excessive deformation, concentration of forces, and, in severe cases, partial or complete collapse during strong seismic events.

2001 Bhuj earthquake. Buildings with columns that hang or float on beams at an intermediate storey and do not go all the way to the foundation, have discontinuities in the load transfer path. A column is supposed to be a vertical member starting from foundation level and transferring the load to the ground. The term floating column is also a vertical element which (due to architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it.

There are many projects in which floating columns are adopted, especially above the ground floor, where transfer girders are employed, so that more open space is available in the ground floor. These open spaces may be required for assembly hall or parking purpose. The transfer girders have to be designed and detailed properly, especially in earth quake zones. The column is a concentrated load on the beam which supports it. As far as analysis is concerned, the column is often assumed pinned at the base and is therefore taken as a point load on the transfer beam. STAAD Pro, ETABS and SAP2000 can be used to do the analysis of this type of structure. Floating columns are competent enough to carry gravity loading but transfer girder must be of adequate dimensions (Stiffness) with very minimal deflection.

1.1 Objective and scope of present work

The objective of the present work is to study the behavior of multistory buildings with floating columns under earthquake excitations.

Finite element method is used to solve the dynamic governing equation. Linear time history analysis is carried out for the multistory buildings under different earthquake loading of varying frequency content. The base of the building frame is assumed to be fixed. Newmark's direct integration scheme is used to advance the solution in time.

Previous studies have extensively investigated the seismic behavior, analysis, and retrofitting of multi-storey buildings. Maison et al. (1984, 1991) demonstrated the effectiveness of

analytical models in predicting the dynamic properties and seismic responses of high-rise buildings. Arlekar et al. (1997) highlighted the adverse effects of open ground-storey irregularities, while Awkar et al. (1997) examined the influence of connection flexibility on frame responses. Studies by Balsamo et al. (2005), Mortezaei et al. (2009), Garcia et al. (2010), and Niroomandi et al. (2010) confirmed the effectiveness of CFRP and FRP systems in enhancing seismic performance, ductility, and damage resistance of reinforced concrete structures.

3.RESULT AND DISCUSSION

The following are the input data of the test specimen:

Size of beam – 0.1 X 0.15 m

Size of column – 0.1 X 0.125 m

Span of each bay – 3.0 m

Storey height – 3.0 m

Modulus of Elasticity, $E = 206.84 \times 10^6 \text{ kN/m}^2$

Support condition – Fixed

Loading type – Live (3.0 kN at 3rd floor and 2 kN at 4th floor)



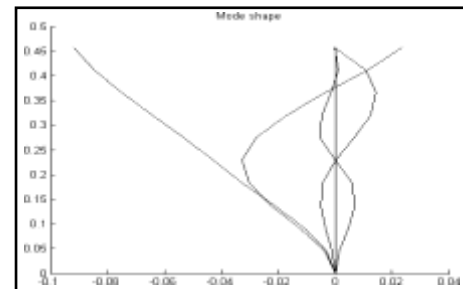
Fig. 1 2D Frame with usual columns

Table 1.Global deflection at each node
deflection at each node for general

Node	Horizontal	Vertical	Rotational
	X mm	Y mm	rZ rad
1	0	0	0
2	0	0	0
3	0	0	0
4	1.6	0	0
5	1.6	0	0
6	1.6	0	0
7	3.8	0	0
8	3.8	0	0
9	3.8	0	0
10	5.8	0	0
11	5.8	0	0
12	5.8	0	0

13	6.7	0	0
14	6.7	0	0
15	6.7	0	0

Table2: Global deflection at each node for a frame with a floating column



Node	Horizontal	Vertical	Rotational
	X mm	Y mm	rZ rad
1	0	0	0
2	0	0	0
3	2.6	0	0
4	2.6	0	0
5	2.6	0	0
6	4.8	0	0
7	4.8	0	0
8	4.8	0	0
9	6.8	0	0
10	6.8	0	0
11	6.8	0	0
12	7.7	0	0
13	7.7	0	0
14	7.7	0	0

Conclusion:

The behavior of multistory building with and without floating column is studied under different earthquake excitation. The compatible time history and Elcentro earthquake data has been considered. The PGA of both the earthquake has been scaled to 0.2g and duration of excitation are kept same. A finite element model has been developed to study the dynamic behavior of multi story frame. The static and free vibration results obtained using present finite element code are validated. The dynamic analysis of frame is studied by varying the column dimension. It is concluded that with increase in ground floor column the maximum displacement, inter storey drift values are reducing. The base shear and

overturning moment vary with the change in column dimension.

REFERENCES

1. Agarwal, P., and Shrikhande, M. (2009). *Earthquake Resistant Design of Structures*. PHI Learning Private Limited, New Delhi.
2. Arlekar, J. N., Jain, S. 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*, New Delhi, India.
3. Awkar, J. C., and Lui, E. M. (1997). "Seismic Analysis and Response of Multistory Semirigid Frames." *Engineering Structures*, 21(5), 425–442.
4. Balsamo, A., Colombo, A., Manfredi, G., Negro, P., and Prota, A. (2005). "Seismic Behavior of a Full-Scale RC Frame Repaired Using CFRP Laminates." *Engineering Structures*, 27, 769–780.
5. Bardakis, V. G., and Dritsos, S. E. (2007). "Evaluating Assumptions for Seismic Assessment of Existing Buildings." *Soil Dynamics and Earthquake Engineering*, 27, 223–233.
6. Broderick, B. M., Elghazouli, A. Y., and Goggins, J. (2008). "Earthquake Testing and Response Analysis of Concentrically Braced Sub-Frames." *Journal of Constructional Steel Research*, 64(9), 997–1007.
7. Chopra, A. K. (1995). *Dynamics of Structures*. Prentice Hall.
8. Logan, D. L. (2007). *A First Course in the Finite Element Method*. Thomson Learning, USA.
9. Fall, H. G. (2006). *Direct Stiffness Method for 2D Frames – Theory of Structures*.
10. Garcia, R., Hajirasouliha, I., and Pilakoutas, K. (2010). "Seismic Behaviour of Deficient RC Frames Strengthened with CFRP Composites." *Engineering Structures*, 32, 3075–3085.
11. Hartley, G., and Abdel-Akher, A. (1993). "Analysis of Building Frames." *Journal of Structural Engineering*, 119(2), 468–483.
12. Kattan, P. I. (2003). *MATLAB Guide to Finite Element Analysis*. Springer, Berlin and New York.
13. Prasada Rao, K. N. V., Seetharamulu, K., and Krishnamoorthy, S. (1984). "Frames with Staggered Panels: Experimental Study." *Journal of Structural Engineering*, 110(5), 1134–1148.
14. Krishnamoorthy, C. S. (1987). *Finite Element Analysis*. Tata McGraw-Hill Publications.
15. Maison, B. F., and Neuss, C. F. (1985). "Dynamic Analysis of a Forty-Four-Storey Building." *Journal of Structural Engineering*, 111(7), 1559–1572.
16. Maison, B. F., and Ventura, C. E. (1991). "Dynamic Analysis of a Thirteen-Storey Building." *Journal of Structural Engineering*, 117(12), 3783–3803.
17. Mortezaei, A., Ronagh, H. R., and Kheyroddin, A. (2010). "Seismic Evaluation of FRP-Strengthened RC Buildings Subjected to Near-Fault Ground Motions Having Fling-Step." *Composite Structures*, 92, 1200–1211.
18. Niroomandi, A., Maheri, A., Maheri, M. R., and Mahini, S. S. (2010). "Seismic Performance of Ordinary RC Frames Retrofitted at Joints by FRP Sheets." *Engineering Structures*, 32, 2326–2336.
19. Ozyigit, H. A. (2009). "Linear Vibrations of Frames Carrying a Concentrated Mass." *Mathematical and Computational Applications*, 14(3), 197–206.
20. Paz, M. (2010). *Structural Dynamics*. CBS Publishers.
21. Petyt, M. (2010). *Introduction to Finite Element Vibration Analysis*. Cambridge University Press, New York.
22. Sekulovic, M., Salatic, R., and Nefovska, M. (2002). "Dynamic Analysis of Steel Frames with Flexible Connections." *Computers and Structures*, 80(11), 935–955.
23. Vasilopoulos, A. A., and Beskos, D. E. (2006). "Seismic Design of Plane Steel Frames Using Advanced Methods of Analysis." *Soil Dynamics and Earthquake Engineering*, 26(12), 1077–1100.
24. Williams, R. J., Gardoni, P., and Bracci, J. M. (2009). "Decision Analysis for Seismic Retrofit of Structures." *Structural Safety*, 31, 188–196.
25. Wilson, E. L. (2002). *Three-Dimensional Static and Dynamic Analysis of Structures: A Physical Approach with Emphasis on Earthquake Engineering* (3rd Edition). Computers and Structures, Inc.