International Journal of Engineering Research and Science & Technology

www.ijerst.org

ISSN : 2319-5991

Vol. 21 No. 4 (2025)



ijerst.editor@gmail.com

editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 21, No. 4, 2025
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Research Paper

A COMPARATIVE STUDY OF INTERNAL AND EXTERNAL FLOATING COLUMNS UNDER SEISMIC LOADS

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Abstract

Currently, structures with floating columns are a common characteristic of contemporary multistory construction in metropolitan India. Such characteristics are very undesirable in structures located in seismically active regions. This research emphasises the need of clearly acknowledging the existence of the floating column in construction analysis. Proposed alternative approaches include achieving a stiffness equilibrium between the first story and the storey above to mitigate the irregularity caused by the floating columns. Earthquakes in various regions of the world clearly demonstrate the perilous repercussions and susceptibility of insufficiently constructed edifices. In contemporary urban India, structures with floating columns may be a characteristic element of popular multi-storey constructions. The floating column may be a vertical element that rests on a beam at its lower level. The unstable inertia forces produced at the floor levels of a structure must be transmitted from the top to the base, and any deviation or disruption in this load transfer pathway results in suboptimal performance. Consequently, solutions such as floating columns are very undesirable in structures constructed in seismically active regions. The gift research investigates the detrimental effects of floating columns in the structure. Models of the frame system are constructed for multi-storey reinforced concrete structures, both with and without floating columns, to conduct a comparative analysis of structural characteristics such as natural frequency, base shear, and horizontal displacement under seismic excitation.

The current research conducted a seismic analysis and design of a multi-story structure with floating elements using ETABS 2018. This research considers two forms of floating: outward floating and interior floating. The outcomes, including story drift, shear force, bending moment, and building torsion, are analysed for a G+10 structure with and without floating columns.

Key words: *floating columns, Earthquakes, story drift, Shear force, Bending moment, Building torsion.*

Received: 05-11-2025 Accepted: 15-12-2025 Published: 22-12-2025

1. Introduction

Many urban multi storey buildings in India today have open first storey as an unavoidable feature. This is primarily being adopted to accommodate parking or reception lobbies in the first storey. Whereas the total seismic base shear as experienced by a building during an earthquake is dependent on its natural period, the seismic force distribution is dependent on the distribution of stiffness and mass along the height.

The behavior of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with vertical setbacks (like the hotel buildings with a few storey wider than

the rest) cause a sudden jump in earthquake forces at the level of discontinuity. Buildings that have fewer columns or walls in a particular storey or with unusually tall storey tend to damage or collapse which is initiated in that storey. Many buildings with an open ground storey intended for parking collapsed or were severely damaged in Gujarat during the 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.

1.1 Floating column structure

A segment is an upward component that stretches out from the establishment level to the ground and moves the weight. A drifting segment is an upward component that lays on a shaft that is an even part at its lower level (end Level) attributable to structural design/site conditions. The heap is then moved to extra sections underneath the pillars.



Figure 1 Hanging or floating columns

Numerous urban multi-story edifices in India now exhibit an open first floor as an important characteristic. This is largely being used to facilitate parking or reception lobbies on the ground floor. The overall seismic base shear experienced by a structure during an earthquake is contingent upon its natural period, whereas the distribution of seismic forces relies on the vertical distribution of stiffness and mass.

The performance of a structure during seismic events is fundamentally influenced by its general shape, dimensions, and geometry, as well as the transmission of seismic pressures to the foundation. The earthquake forces generated at various floor levels in a structure must be transmitted to the ground via the most direct route; any deviation or discontinuity in this load transfer pathway leads to suboptimal building performance. Structures with vertical setbacks, such as hotel edifices with several stories broader than the remainder, induce a dramatic increase in seismic pressures at the point of discontinuity. Structures having a reduced number of columns or walls on a certain floor, or those with very high ceilings, are prone to damage or collapse originating from that floor. Numerous structures with an open ground floor designated for parking either collapsed or sustained significant damage in Gujarat after the 2001 Bhuj earthquake. Structures including columns that suspend or float on beams at an intermediate level, without extending to the foundation, exhibit discontinuities in the load transmission pathway.

1.2Objectives of the study

This study illustrates the sequential examination and structural response assessment of a building. This is a summary of the objective:

1) To compute the design lateral forces for a floating column structure using ETABS.
2) To analyse the story drift, shear force, bending moment, and building torsion in a floating column structure.
3) To juxtapose the analytical outcomes of the floating column structure with those of a conventional column.
4) To examine the behaviour of floating column constructions by response spectrum analysis.

2. Literature Review

Hardik Bhensdadia ,Siddarth shah, et al.,(2015) In this study an attempt is made to reveal the effects of floating column & soft story in different earthquake zones by seismic

analysis. For this purpose Push over analysis is adopted because this analysis will yield performance level of building for design capacity (displacement) carried out up to failure, it helps determination of collapse load and ductility capacity of the structure. To achieve this objective, three RC bare frame structures with G+4, G+9, G+15 stories respectively will be analysed and compared the base force and displacement of RC bare frame structure with G+4, G+9, G+15 stories in different earthquake zones like Rajkot, Jamnagar and Bhuj using SAP 2000 14 analysis package.

Susanta Banerjee ,Sanjay kumar patra, et al.,(2012) This paper presents the effect of stiffness of infill wall to the damage occurred in floating column building when ground shakes. Modelling and analysis are carried out by non linear analysis programme IDARC- 2D. Damage occurred in beams, columns, storey are studied by formulating modified Park & Ang model to evaluate damage indices. Overall structural damage indices in buildings due to shaking of ground are also obtained. Dynamic response parameters i.e. lateral floor displacement, storey drift, time period, base shear of buildings are obtained and results are compared with the ordinary moment resisting frame buildings. Formation of cracks, yield, plastic hinge, are also observed during analysis. From this it is concluded that lateral floor displacement ,storey drift of floating column building with infill wall are reduced than floating column building without infill wall. Also it is concluded that fundamental time period, lateral floor displacement of floating column building are higher than ordinary moment resisting frame.

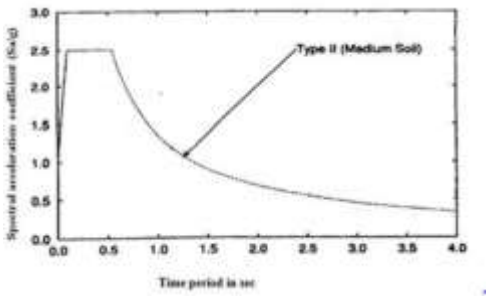
Sreekanth Gandla Nanabala1 , Pradeep kumar, et al.,(2014) In this paper find whether structure is safe or unsafe with floating column when built in seismically active areas and also find floating column building is economical or uneconomical. For that purpose analysis of G+5 storey normal building and floating column building are done for external lateral forces. this analysis done by using sap2000.external lateral load are calculated manually.

Prerna Nautiyal ,Saleem Aktar and Geeta Batham, et al.,(2014) In this paper investigate the effect of a floating column under earthquake excitation for various soil conditions and as there is no provision or magnification factor specified in I.S. Code, hence the determination of such factors for safe and economical design of a building having floating column. Linear Dynamic Analysis is done for 2D multi storey frame with and without floating column. For that purpose created the model G+4 and G+6 building having changing the position of floating column. After that response spectrum analysis is done for both building. Dynamic response parameters such as base shear and moment for hard and medium soil condition are obtained for both building models.

3. Methodology Used and Types of loads acting on structure

3.1 Response Spectrum analysis

The depiction of the maximum response of an idealised single degree of freedom system with specific period and damping during seismic ground movements. This analysis is conducted in accordance with IS 1893-2002 (Part 1). The soil type and seismic zone factor must be obtained from IS 1893-2002 (Part 1). The standard response spectrum for the specified soil type is used for building analysis in ETABS 2013 program. The figure illustrates the usual response spectrum for medium soil type, shown as a relationship between time period and spectral acceleration coefficient (Sa/g).



Response spectrum for medium soil type for 5% damping

This method allows for the consideration of a building's many response modes in the frequency domain. This is mandated in several construction regulations for all buildings, even those that are very basic or exceedingly complicated. The response of a structure may be characterised as a synthesis of many distinct forms (modes), which, in the context of a vibrating string, correspond to "harmonics." Computational analysis can be used to ascertain these modes for a structure. For each mode, a response is derived from the design spectrum, using the modal frequency and modal mass, which are then aggregated to determine the overall reaction of the structure. We must determine the amount of forces in all directions, namely X, Y, and Z, and thereafter assess their impact on the structure. The techniques of combination include the following:

- absolute - peak values are added together
- square root of the sum of the squares (SRSS)
- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The outcome of a response spectrum analysis utilising the response spectrum derived from ground motion generally differs from that obtained through a direct linear dynamic analysis of the same ground motion, as phase information is forfeited during the generation of the response spectrum.

When structures are excessively irregular, excessively tall, or have substantial value for a community during disaster response, the reaction spectrum technique becomes inadequate, necessitating more intricate analyses, such as non-linear static analysis or dynamic analysis.

3.2Building modeling and design considerations

Problem statement:

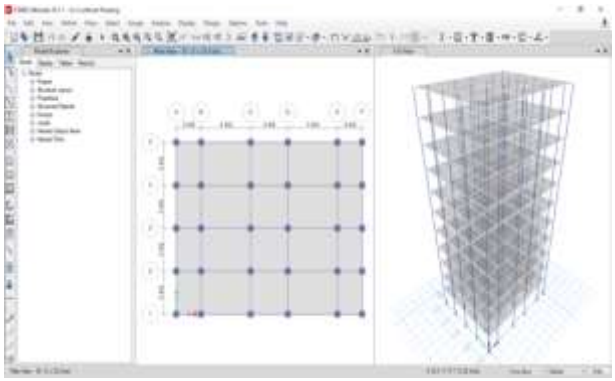
In the present study, analysis of G+10 multi-story building in Zone V seismic zones is carried out.

Basic parameters considered for the analysis are

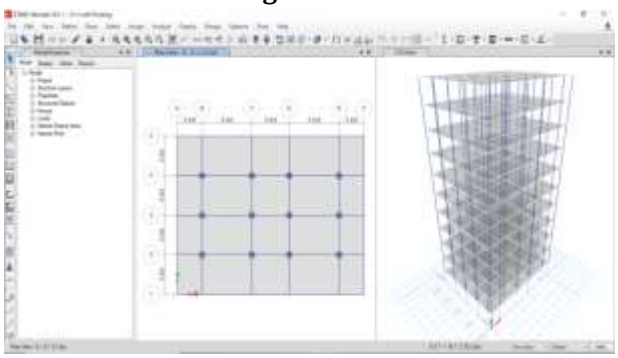
1. Utility of building : Residential building
2. Number of stories : G+5
3. Shape of building : Rectangular
4. Geometric details
   a. Ground floor : 3m
   b. floor to floor height : 3m
5. Material details
   a. Concrete Grade : M30 (COLUMNS AND BEAMS)
   b. All Steel Grades : HYSD reinforcement of Grade Fe550
   c. Bearing Capacity of Soil : 200 KN/m^2
6. Type Of Construction : R.C.C FRAMED structure
7. Column : 0.46m X 0.46m
8. Beams : 0.35m X 0.46m
9. Slab : 0.15m
10. Seismic Zone : V

Building 3D model in ETABS Software

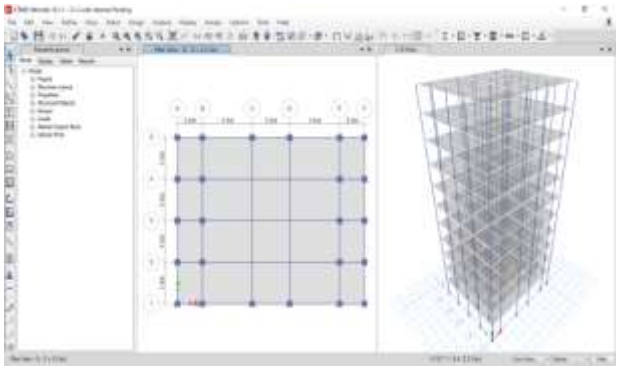
Without floating column building



With external floating

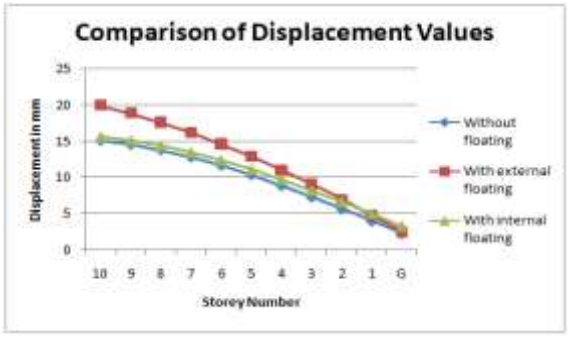


With internal floating



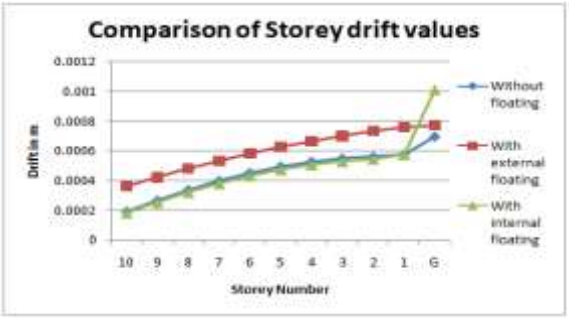
RESULTS AND ANALYSIS

4.1 Comparison of Displacement Values



Comparison of displacement Values

4.2 Comparison of Storey drift values



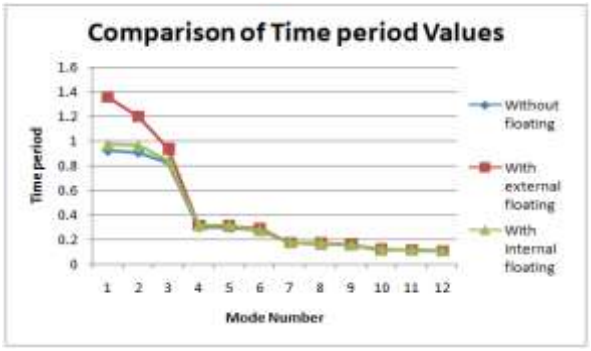
Comparison of Storey drift values

4.3 Comparison of storey acceleration



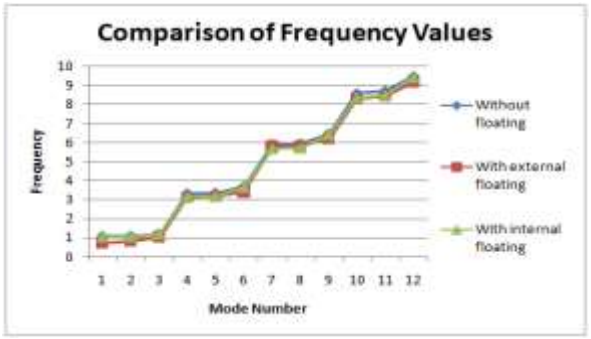
Comparison of storey acceleration

4.4 Comparison of Time period Values



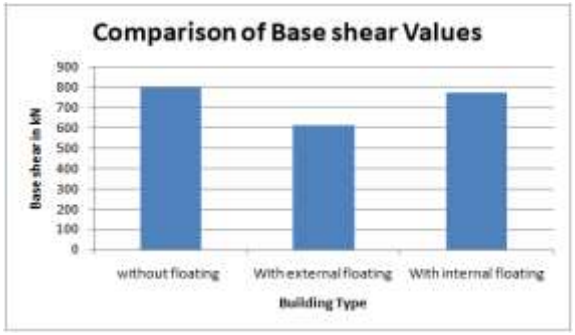
Comparison of Time period Values

4.5 Comparison of Time period Values



Comparison of Frequency Values

4.6 Comparison of Base shear



Comparison of Base shear

4.7 Comparison of Shear V Values



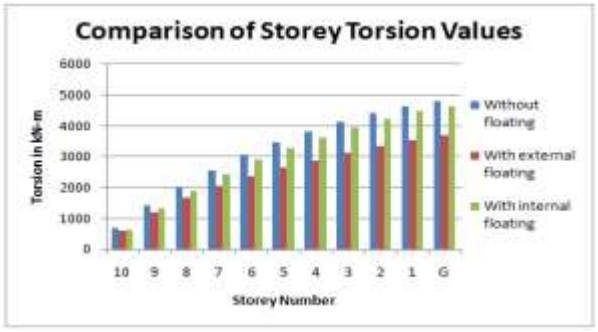
Comparison of Shear V values

4.8 Comparison of Bending M Values



Comparison of Bending M values

4.9 Comparison of Torsion T Values



Comparison of Torsion T values

5. Conclusion

The following findings were drawn from the aforementioned research.

1. The phrase "floating column" refers to a vertical element that, owing to architectural design or site conditions, rests on a beam at its lower termination level, which is a horizontal part.
2. The beams then convey the load to the columns underneath them.
3. The displacement values diminish from the top storey to the lowest floor, with elevated values seen in external floating column sections compared to internal floating and conventional structures.
4. The storey drift values increase from the top storey to the lowest storey, with larger values seen in external floating column sections compared to internal floating and conventional structures.
5. The storey acceleration rises by implementing floating at the bottom level.
6. The base shear values are lower for exterior floating column buildings compared to regular columns and interior floating columns.
7. The shear, bending, and torsional values are reduced by implementing floating for the building structures.
8. The time period values diminish from node 1 to node 12, while the frequency values escalate from node 1 to node 12.

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