Comparative Study of RC Frame with and Without Floating Column

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Abstract
The structural response of Reinforced Concrete (RC) frames determines the stability and safety of buildings. This research seeks to perform a comparative study of RC frames with and without floating columns based on primary parameters such as load distribution, deflection, bending moment, shear forces, and stability under different loads. Floating columns, although commonly adopted for architectural and spatial advantages, pose special problems regarding structural performance, particularly under dynamic loading conditions like earthquake loads. Employing theoretical examination and software simulation (ETAB) the research assesses the influence of floating columns on RC frame performance, focusing in particular on their influence on building stability and safety. The results show the remarkable difference in performance between the two types of frames and provide valuable suggestions on best design practices for structures with floating columns. The outcomes are anticipated to improve RC frame design methods, especially for high-rise buildings and multi-story structures.

Keywords: Reinforced Concrete (RC) Frames,Floating Columns, Structural Analysis, Load Distribution, Deflection, Bending Moments, Shear Forces, Seismic Load ETABS, Structural Stability, Building Design

I. Introduction

In modern architectural and civil engineering practices, Reinforced Concrete (RC) frames have been made a common choice for structural systems because of their flexibility, strength, and affordability. These frames are usually altered to accommodate architectural requirements, e.g., open spaces on the ground floor for parking, commercial purposes, or for aesthetic purposes. One such element of architecture is the floating column, a vertical supporting member which does not directly rest on the foundation but is supported by a horizontal structural member such as a beam or slab at an intermediate floor level.

Although floating columns provide unambiguous spatial benefits, they provide significant structural difficulties, especially in the context of seismic resistance. Discontinuity of the vertical load path presents significant stiffness and mass distribution irregularities in the structure, thus making the building more prone to earthquake-induced lateral forces. The changed load transfer mechanism may lead to amplified story displacement, drift, shear forces, and bending moments, especially at the lower floors of the structure.

In areas like Pune, which fall in Seismic Zone III under IS 1893:2016, the significance of these design decisions becomes absolutely crucial. Seismic safety cannot be sacrificed for architectural exigencies, particularly in G+2 buildings which are widely employed for residential or mixed-used applications.

This research intends to conduct a comparative seismic analysis of RC frames with and without floating columns based on ETABS software. The main concern is to analyze how floating columns affect some important structural parameters like base shear, displacement, drift, overturning moment, and stability under seismic loading. Cost analysis is also incorporated to compare the economic effects of using floating columns.

The results of this research will provide the practicing engineers and architects with practical insights on architectural design versus structural safety trade-offs, and ensuring improved building practices in seismically active areas.

II. PROBLEM DEFINITION

The use of floating columns in reinforced concrete (RC) structures has increased over the years because they can create open floor areas, especially at ground level, for parking, commercial space, or increased architectural freedom. This approach, however, brings about great structural discontinuities that have a very negative effect on the load transfer mechanism, particularly under dynamic load conditions such as earthquakes.

In traditional RC structures, the vertical loads are transmitted uniformly in a continuous path from the superstructure to the foundation. By contrast, those in floating columns interrupt this direct load path, compelling lateral and vertical loads to redistribute via beams and slabs, which are not specifically designed to support such concentrated loads. This leads to greater stress concentrations, shear forces, and story drift, particularly around the areas of the floating columns.

The issue becomes increasingly serious in the seismically active areas like the Pune district (India's seismic zone III), where the structures need to be designed to withstand high lateral forces. The structural irregularities imparted by floating columns can cause torsional effects, soft-story mechanisms, and premature failure during earthquakes, affecting stability as well as safety.

Though the risks are known, the practice of floating columns persists in the field, many times without sufficient structural compensation. This evokes a critical research question:

"How do floating columns impact the seismic behavior of G+2 RC buildings, and are they structurally acceptable in seismic zones like Pune without sacrificing safety and economic effectiveness?"

This work answers this question through a thorough comparative study of two models of RC frames—one with and one without floating columns—on their seismic behavior using ETABS software. The objective is to delineate key weaknesses, evaluate implications on design, and offer guidelines for safe structure practice.

III. OBJECTIVES

The main objective of the current study is to analyze and compare the structural response of reinforced concrete (RC) frames with and without floating columns in G+2 building arrangement under seismic load conditions characteristic of the Pune location (Seismic Zone III). The research tries to fill the gap between structural stiffness and architectural flexibility by satisfying the following specific objectives:

1. To compare and examine the seismic response of RC multi-storied buildings with floating columns and those without floating columns with the aid of structural analysis software (ETABS).
2. To assess the influence of floating columns on important structural parameters, such as base shear, story drift, lateral displacement, bending moment, and torsion.
3. To determine the structural stability and integrity of floating column buildings during seismic loading conditions as per IS 1893:2016.
4. To investigate the load distribution and deformation patterns caused by floating columns and their influence on the surrounding structural elements.

5. To determine possible risks and modes of failure related to floating column arrangements under seismic loads.

6. To carry out a cost analysis of buildings with and without floating columns in order to establish economic feasibility in actual construction projects.

7. To establish design recommendations and guidelines for the secure and efficient application of floating columns in RC frame buildings, especially in seismic areas.

IV. MOTIVATION

Recent building design trends prefer open floor spaces and functional flexibility, particularly in residential and commercial constructions. In order to meet these space demands, building designs introduce floating columns as a common feature. Such columns enable great column-free spans on lower floors, enhancing beauty and functionality. The architectural benefit of floating columns comes with a high cost in terms of structure, especially when the building is subjected to dynamic forces like earthquake-induced forces.

In areas such as Pune, which falls within Seismic Zone III according to IS 1893:2016, seismic resilience is a significant concern of building design. Floating columns interfere with the natural load path, resulting in irregular force transfer, elevated story drift, and possible torsional irregularities—each of which can greatly undermine the structural stability of a building during an earthquake. Various history's worst earthquake disasters in India have brought into focus the calamitous implication of disregarding such irregularities in building design.

In the context of these risks, the application of floating columns remains on the increase, mostly in the absence of proper structural evaluation or strengthening. This gap between architectural requirements and engineering safety protocol drove this research. The impetus for the study arises from the necessity to:

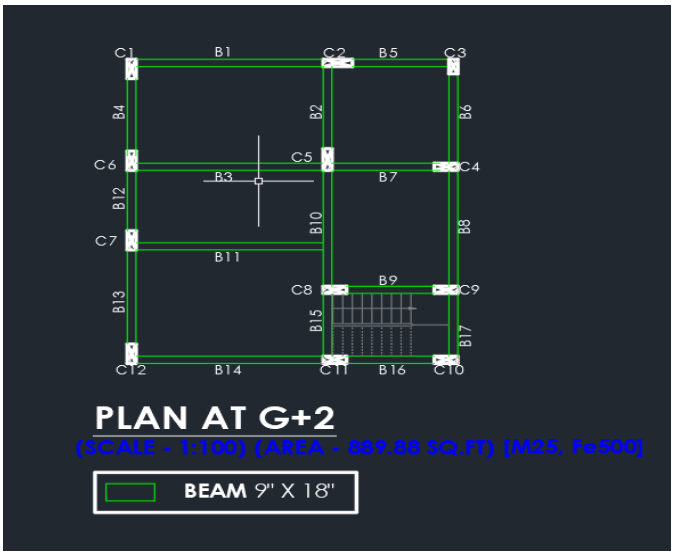
•\tAssess the structural consequences of applying floating columns in RC frame structures.

•\tMeasure the seismic susceptibility provided by floating columns.

•\tAssist engineers and architects in a balance between aesthetics and structural safety.

• Assist in safer earthquake-prone region design practices with applied knowledge and design suggestions.

Through a comparative study utilizing up-to-date analysis software like ETABS, this study hopes to present concise evidence and guidelines to help build the bridge between new architecture and structural safety



V. . RESULT

To assess the effect of floating columns on seismic performance, two G+2 RC frame models were analyzed—one with floating columns (FC) and one without floating columns (WFC). Both models were subjected to similar load conditions and analyzed for key structural parameters using ETABS. The following observations were made:

5.1 Base Shear

Parameter	With Floating Column (FC)	Without Floating Column (WFC)
Base Shear (kN)	254	254

Interpretation:
Base shear remained the same in both models, as the overall mass and seismic zone are identical. However, internal force distribution varies due to the altered load path in the FC model.

5.2 Maximum Story Drift

Story	FC Drift (mm/mm)	WFC Drift (mm/mm)
Terrace Cap	0.00038	0.000379
Terrace FLR	0.000347	0.000346
2nd Floor	0.00106	0.001027
1st Floor	0.001004	0.000998
Ground Floor	0.000399	0.000401
Base	0	0

Interpretation:
Slightly higher story drift is observed in the FC model, particularly at the second and first floors. This indicates more lateral displacement and reduced stiffness due to the interruption in load paths caused by floating columns.

5.3 Maximum Story Displacement

Story	FC (mm)	WFC (mm)
Terrace Cap	14.767	14.365
Terrace FLR	13.859	13.990
2nd Floor	10.58	10.716

Story	FC (mm)	WFC (mm)
	2	
1st Floor	5.630	5.652
Ground Floor	0.828	0.953
Base	0	0

Interpretation:
Although overall displacement is similar in both cases, marginal increases at certain levels in the FC model indicate higher flexibility and potential vulnerability during earthquakes.

5.4 Overturning Moment

Story	FC (kNm)	WFC (kNm)
Terrace Cap	−6,696,956	−4,018,174
Terrace FLR	−68,304,399	−40,982,602
2nd Floor	−164,756,578	−98,853,532
1st Floor	−250,326,542	−150,194,903
Ground Floor	−297,036,387	−178,194,409
Base	−299,874,165	−180,010,203

Interpretation:
Significantly higher overturning moments in the floating column model confirm that lateral stability is compromised, leading to increased risk under seismic loading.

5.5 Cost Analysis

Configuration	Estimated Cost (INR)
Without Floating Column (WFC)	₹11,14,905
With Floating Column (FC)	₹13,41,505

Interpretation:
Buildings with floating columns incur an additional cost of approximately ₹2.27 lakh, mainly due to

increased reinforcement requirements and complex load distribution. Despite this higher cost, the structural performance under seismic loads is inferior compared to conventional RC frames.

5.6 Summary of Findings

- The **FC model exhibits greater lateral displacement, drift, and overturning moments**, indicating higher seismic vulnerability.
- The **WFC model is structurally more stable** and cost-effective under the same conditions.
- Despite architectural advantages, floating columns introduce **serious seismic risks** that must be compensated through careful design or alternative layouts.

VI. CONCLUSION

This study has given an overall comparative evaluation of RC frames with and without floating columns in G+2 buildings for seismic performance in Zone III conditions (Pune area). Analyzing critical structural parameters like story drift, displacement, base shear, and overturning moment using ETABS software.

The findings evidently show that RC frames with non-floating columns have better seismic performance, with reduced lateral displacements and overturning moments. In contrast, structures having floating columns were more susceptible to vulnerabilities with inherent irregular load paths that resulted in higher stress concentrations and lateral instability. Further, the cost analysis indicated that floating column structures are much more costly, with increased reinforcement and construction complexity—without offering structural benefits.

Therefore, while floating columns are advantageous architecturally and functionally (e.g., open floors on lower levels), they must be utilized cautiously in seismically active regions. If inclusion is inevitable, proper seismic reinforcements like shear walls, bracings, or transfer girders need to be incorporated into the structure to counteract possible harm.

Key Takeaways:

- Floating columns cause story drift and overturning moment to decrease overall seismic stability.
- The cost goes up by around ₹2.27 lakh in floating column structures, without the corresponding structural advantages.
- Structures without floating columns are stronger and more economical in seismic areas.
- Enough design norms and code-based retentions must be followed while using floating columns.

This research adds to the knowledge of the structural engineering community and can serve to guide more efficient and safe building designs, particularly in seismically active areas such as the Pune area.

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