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Recommendation for Effects of Floating Column in Different Seismic Zones: A Review

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***Abstract*— Floating columns have become quite popular in India's urban development over the last decade, especially in commercial-residential buildings. The main reason is simple architects, developers want to open retail spaces on the ground floor and floating columns let them achieve that. While this sounds great from a business perspective, structural engineers have realized it comes with some serious challenges during earthquakes. Floating columns make buildings significantly more flexible, increasing natural vibration time periods by 5-27%. This increased flexibility means that buildings sway more during earthquakes by about 25-40% even more than normal buildings. Storey drift, which is the movement of floors from one to the next, increases by 20 to 35%. The most important thing is how the problem gets worse as you go to areas with a higher risk of earthquakes. Floating columns can work in areas with low risk if you plan carefully. But in high-risk seismic zones they become a serious concern. In Zones IV and V especially heavy strengthening with shear walls and special transfer beams, and many experts now recommend just avoiding them altogether in those zones. This review gives practical advice to engineers who need to decide whether floating columns make sense for a project.**

***Index Terms*— Floating columns, seismic zones, transfer girders, shear wall, bracing, IS 1893-2016, building safety.**

I. Introduction

The structural design of floating columns creates an interruption of the standard process which connects structural loads to the building foundation. In a conventional system, gravity loads are transferred through continuous columns directly to the foundation in a relatively straightforward manner, which generally results in a more uniform force distribution and predictable member behaviour. The load path experiences an abrupt change when floating columns end at transfer girders which results in high concentration loads on both the transfer girder and its supporting columns. The problem becomes worse during seismic events because transfer level points experience sudden strength or stiffness changes which create high force demands that can lead to dangerous seismic performance unless engineer's design proper safeguards. [3]

The designers face challenges because rapid urbanization together with population growth demands that multi-storey buildings should provide maximum space efficiency while maintaining their attractive design. The use of floating columns which architects refer to as hanging or stub columns represents a typical design choice that architects use in various urban projects throughout India.

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The column in this design starts at a specific floor level and delivers its vertical force through a large supporting beam which engineers call a transfer girder. Designers implement this planning method to maintain open space on lower floors which they use for parking and commercial spaces and entrance lobbies while creating obstruction-free layouts for upper floors. [8]

II. Literature Review

Priya Prasannan and Ancy Mathew (2017), The researchers studied how reinforced concrete buildings with floating columns at different height levels respond to seismic activity through their implementation of response spectrum analysis. The researchers examined a G+14 storey building situated in Seismic Zone III through their study which tested different building designs that included floating columns at ground level and the fifth and tenth and fifteenth floor levels. The research found that floating column placement directly determines how the building responds to seismic activity. The fifth floor showed maximum storey displacement together with inter-storey drift while ground-floor floating columns created the most serious structural stiffness breaks. The installation of diagonal shear walls at corner locations brought about a seismic performance improvement which resulted in a storey displacement reduction of approximately 27 through 39 percent together with a 40 through 50 percent decrease in inter-storey drift. The study established that corner shear walls function as the most powerful structural reinforcement method because they provide greater lateral load resistance compared to standard column systems. [1]

Kishalay Maitra and N.H.M. Kamrujjaman Serker (2018), The study evaluated seismic performance of multi-storey buildings which included floating columns and buildings without floating columns through linear static and dynamic analysis methods. The research demonstrated that storey displacement increased by 7 percent when floating columns were placed along one building edge but when floating columns were spread across all building edges building displacement showed a 57 percent increase compared to standard buildings. The study identified torsional irregularity as a major concern particularly in cases of asymmetric floating column placement which activated torsional modes at early stages of seismic response. The fundamental time period increased which demonstrated that lateral stiffness had decreased. The ground-floor column size enhancement measure reduced storey displacement through its strengthening effect but the impact remained limited. The authors showed that symmetric floating column placement together with larger column dimensions would decrease the negative effects of seismic activity. [2]

Lallawmkimi and Pankaj Kumar (2023), The authors conducted a comprehensive evaluation of existing research about how high-rise buildings with floating columns respond to seismic activity. Their research found that floating column structures experience greater lateral movement during earthquakes than traditional building designs which makes them more susceptible to earthquake damage. The most important structural element for seismic assessment was found to be ground-floor corner floating columns, whereas interior floating columns experienced lower seismic forces. The review found that all floating column arrangements exhibit undesirable seismic properties which remain true for all their installed positions. The authors demonstrated that floating column buildings require expensive construction upgrades which make them financially unfeasible. The review recommended using bracing systems with specially located shear walls to minimize displacement and drift, while it suggested structural alternatives which would remove the requirement of using floating columns. [3]

Noufiya Ashraf et al. (2022), Researchers performed a seismic evaluation of G+5 and G+14 buildings which included both floating columns and non-floating column designs through ETABS software and response spectrum analysis. The study demonstrated that the presence of floating columns increases storey displacement by approximately 35 to 56 percent which depends on building height and column location. The ground-floor floating column design proved to be the most vulnerable configuration because it created major stiffness discontinuities. The analysis further showed that floating column buildings located in higher seismic zones (Zones IV and V) fail to satisfy acceptable performance criteria. The transfer girders that supported floating columns experienced major increases in bending moments which made it necessary to build deeper beams. The authors strongly recommended that floating column designs should use dynamic analysis methods which comply with IS 1893:2016 standards. [4]

Ayush U. Atkari et al. (2025), The research conducted dynamic tests to evaluate the earthquake resistance of RC buildings which employed floating columns as their structural design. The research assessed how seismic excitation affected the structural stability of systems that experienced disruptions in their load transfer paths. The research findings showed that columns which support floating structural elements experience increased axial and shear forces while transfer beams obtain larger bending moments than standard building designs. The authors asserted that building projects need to install wider transfer girders together with columns which require additional structural support. The research study established 600×600 mm as the minimum column size requirement and mandated complete dynamic testing which included the analysis of torsional effects and force distribution. [5]

Sreekanth Gandla Nanabala et al. (2014), The researchers executed seismic tests to evaluate the performance of standard RC structures and structures equipped with floating columns. Their findings demonstrated that buildings with floating columns showed greater horizontal movement and higher vertical building movement throughout their entire height, with increased movement at locations where floating columns existed. The transfer beam areas showed extremely high bending moments, which created multiple points of potential structural failure. The research found that floating column structures in Seismic Zone V present safety hazards because their design leads to progressive collapse starting from structural discontinuity points. [6]

Gaurav Pandey and Sagar Jamle (2018), Researchers examined how the position of floating columns affected their ability to resist seismic forces. The research demonstrated that upper floor floating columns provide superior seismic performance when compared to both ground and intermediate floating column systems. The study found that symmetric floating column arrangements decreased torsional effects more than asymmetric configurations did, but all floating column systems proved to be weaker than standard building systems. The authors reached the conclusion that optimized placement decreases seismic demand yet floating columns should not be used in areas that experience earthquakes. [7]

Shashikumar N.S.et al.(2018) The research investigated the performance of inverted V-bracing systems in 30-storey buildings that have floating columns. The research demonstrated that bracing systems improve lateral stiffness because they decrease building displacement by 10 to 30 percent according to response spectrum testing and equivalent static testing. Struts installed under floating columns provided assistance in maintaining stable internal force distribution within the structure. The study showed that increased material usage and complex structural design resulted from the research findings. The authors recommended using combined bracing systems with enhanced transfer beams and columns to achieve better seismic performance. [8]

Sarita Singla and Ashfi Rahman (2015), The researchers investigated how floating columns affected the seismic response in RC frame structures. The analysis found that floating columns make structures less stiff which results in longer fundamental time periods and increased lateral movement. The researchers found that inter-storey drift exceeded permissible limits throughout Seismic Zone III and higher zones. The maximum drift values occurred at the floating column level or slightly above it which demonstrated how vertical stiffness irregularities affected performance negatively. [9]

A nonlinear pushover analysis study conducted in (2017), evaluated the seismic behaviour of RC buildings with and without floating columns. The results showed that floating column buildings sustain substantial structural damage at their points of structural discontinuity which results in lower energy absorption capacity. The observed soft-storey mechanisms caused buildings to collapse after they reached their maximum load capacity without providing enough strength to withstand intense ground movements. The study found that floating column buildings need additional capacity to maintain equivalent safety standards while it recommended improved ductile design methods for situations where floating columns must be used. [10].

III. FLOATING COLUMN

A. Definition

A floating column functions as a vertical structural element which supports a beam or slab at an intermediate storey without direct ties to the foundation. This structure operates as a concentrated load which applies pressure to its supporting horizontal member. The system redistributes its loads to the ground through the supporting beams and columns which exist beneath it.

Fig 1: Floating Column

B. Floating Column Configuration and Structural Characteristics

The structural behavior of floating columns varies significantly depending on their location within the building plan as well as their position along the height of the structure. Floating columns receive their common classification from their horizontal and vertical positioning according to research observations documented in the literature. The building plan designates internal floating columns to exist within its core areas which extend through central grid lines and core-perimeter frame boundaries. The symmetric arrangement of columns creates better seismic performance because it enables more balanced distribution of both gravity and lateral forces.

External floating columns -The construction site boundary markers show established outer limits which extend from the building perimeter. The structural configurations there display increased vulnerability to seismic damage because they create uneven stiffness distribution and concentrate stress through their design.

Corner floating columns - The most important earthquake design configuration for the building structure has been established through research which has conducted tests at two different locations. The specific building formation which exists on the site produces high levels of lateral displacements together with inter-storey drifts, which make the building structure extremely susceptible to damages during seismic events.

Edge floating columns- The seismic performance of building edges shows better results than corner setups but worse results than internal building setups which create an intermediate level of danger for street performance. The vertical position of floating columns which exists above ground level determines how a structure will respond to different forces according to the plan location. The introduction of floating columns at ground storey level causes severe vertical stiffness discontinuities which result in soft-storey behavior that reduces lateral resistance. The seismic performance of floating columns which exist above ground level shows better results than lower-level floating columns yet their structural performance remains unacceptable.

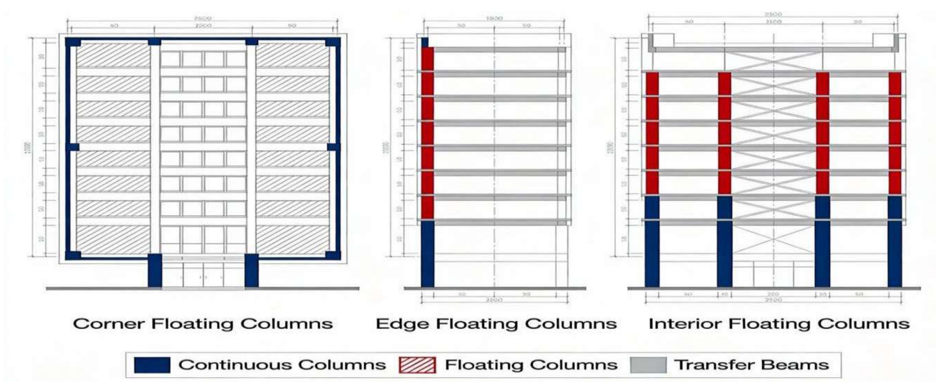

Fig 2: Floating Column Positions

C. Load Transfer Mechanism

The upper floors distribute their weight to the floating column which connects to the transfer beam which leads to the intermediate columns that support the lower level columns which extend down to the foundation which reaches the ground.

The diverted load path generates three essential outcomes which show its importance.

The supporting beam needs larger beam sections because it receives point load instead of distributed load which creates concentrated loads.

The transfer beam columns experience higher axial forces which exceed normal building standards by 40 to 60 percent.

Transfer beams create substantial cantilever moments which need additional reinforcement to handle the load.

IV. Effects of Floating Columns in Different Seismic Zones

TABLE I: SEISMIC ZONING OF INDIA BASED ON IS 1893:2016

Seismic Zone	Zone Factor (Z)	Design Base Shear Factor	Intensity Category	Typical Regions
II	0.10	Low	Moderate	Parts of North India, parts of Central India
III	0.16	Medium	High	Western India, parts of Northern India
IV	0.24	High	Very High	Himalayan region, parts of Gujarat
V	≥0.36	Very High	severe	Andaman Nicobar, parts of Bhuj region

TABLE II: STRUCTURAL RESPONSE PARAMETERS (FLOATING COLUMNS VS CONVENTIONAL)

Parameter	Seismic Zone II- III	Seismic Zone IV	Seismic Zone V	Key Observation
Storey Displacement	15%-25% Increases; Maximu m typically at top floor(20-40mm in 6-16 storey building)	20%–35% increase; cumulative displacements can govern functional performance; differential settlement considerations become important.	Often unsafe even with increased member sizes; displacement increase can exceed 50%;design becomes economically unreliable unless major structural modifications are adopted.	The demand for displacement increases significantly when the floating column reaches its operational height and continues to rise until it reaches maximum height. Displacement demands increase by 30 to 40 percent when floating columns get installed on ground or first floor levels instead of upper floor locations.
Storey Drift	10%–25% increase; generally within permissible limits (1/500 to 1/250, material dependent), but safety margin reduces.	25%–45% increase; frequently exceeds permissible limits; needs about 15%–20% increase in member sizes to control drift.	45%–70% increase; almost always exceeds permissible limits; requires 25%–40% increase in member dimensions (impractical); frame action compromise becomes inevitable.	The maximum inter-storey drift value normally occurs at storeys next to the floating column position because those areas experience sudden decreases in local stiffness, which makes them important for controlling drift and showing damage accumulation.
Base Shear	Base shear typically educes by 8%–12% (general trend 5%–15% reduction).	Base shear reduction about 10%–18%; combined with higher displacement increases vulnerability.	Base shear reduction about 15%–25%; significant loss of lateral load resistance capacity.	The decrease in base shear should not be perceived as a betterment of seismic performance because it actually demonstrates a reduction in lateral stiffness together with a rise in overall flexibility which results in increased deformation requirements and more force distribution on specific load-bearing structures.
Fundamental time period (T1)	5%-15% increase in T1.	12%-25% increase in T1.	20%-35% increase in T1.	The basic time period increase shows that structural strength has decreased. The extended response time of a building system results from short-period ground movements, but it increases seismic requirements when the building's dynamic properties match long-period earthquake ground motion patterns.

V. RECOMMENDATION (GUIDELINES BY SEISMIC ZONE)

For Zone II (Low Seismicity):

- The standard design modifications allow floating columns to be constructed with the following requirements.
- The transfer beams need a depth of at least 600 mm and their reinforcement needs to be precisely designed for the junction area. Support columns require an expansion of 15 percent beyond their initial size which must include ductile connection design.
- Infill walls create advantages when they can be constructed according to architectural design standards.
- The analysis uses linear dynamic analysis through the response spectrum method for its evaluation. The existing construction inspection procedures meet requirements for standard construction inspection needs.

For Zone III (Moderate Seismicity):

Floating columns permitted only with comprehensive mitigation:-

- Transfer beam: minimum 600 mm depth; enhanced reinforcement (20% above standard).
- Support columns: enlarged 25-35%; full ductile detailing per IS 13920.
- Shear walls: Strongly recommended; if absent, diagonal bracing mandatory.
- Infill walls: Beneficial; preferred over blank infill.
- Analysis: Nonlinear static (pushover) analysis mandatory; verify all elements remain in acceptable range.
- Inspection: Enhanced during construction; NDT testing of concrete at transfer beam and support columns.

For Zone IV (Severe Seismicity):

- Floating columns only if internal to building plan (not at edges/corners)

- Comprehensive mitigation package mandatory:
  - Shear walls (multiple, in both directions) minimum 25% plan coverage.
  - Support column enlargement: 35-50%.
  - FRP strengthening of support columns: minimum two-layer wrap.
  - Diagonal bracing (inverted-V preferred): in soft-story level and one level above.
  - Ductile detailing per IS 13920 throughout.
- Maximum building height: G+7 or G+8; taller buildings not recommended.
- Analysis: Nonlinear pushover analysis with multiple lateral load patterns; time history analysis recommended.
- Inspection: Intensive; third-party inspection of all critical connections.
- Seismic dampers: Consider if displacement predictions exceed 2% of story height.

For Zone V (Very Severe Seismicity):

- The rules forbid floating columns to be used in construction.
- Buildings which exist currently must undergo seismic evaluation according to IS 1893:2016 standards.
- The following retrofitting solutions exist for current building structures

Option A: Base isolation (if economically feasible and space available)

Option B: Structural redesign eliminating floating columns

Option C: Demolition and rebuild without floating columns

VI. CONCLUSION

Low to moderate seismic zones allow floating columns only if the design includes transfer level protection together with vertical support system protection which requires proper assessment through structural evaluation methods. High seismic areas should avoid using these systems which create load path interruptions that lead to excessive force and deformation at the transfer storey. Floating columns can be used for Zone II when the transfer beam and supporting columns have been designed to support the weight at that location and the building response has been validated through linear dynamic analysis during standard design assessments. Floating columns should be allowed in Zone III only when organizations implement stronger risk management procedures which include a new lateral-force-resisting system together with shear walls or bracing and they must use ductile design approaches for testing purposes which will verify that transfer-storey demand exceeds safe limits for that area. Zone IV: Floating columns should be used only in exceptional cases with strict configuration control (preferably away from edges/corners) and only after comprehensive strengthening and advanced nonlinear verification since studies indicate that floating-column configurations can perform poorly in strong shaking especially when placed near the perimeter. Building designers should avoid using floating columns in new structures while existing buildings with floating columns need assessment through IS 1893:2016 standards which will determine appropriate retrofit or redesign strategies based on the assessment results.

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