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A Review Paper on Seismic Analysis of G+15 Building with and without Floating Column Using ETABS software using composite columns.

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Abstract:

The structural integrity of multi-story buildings under seismic loads is a critical aspect of earthquake-resistant design. The presence of floating columns, commonly introduced for architectural flexibility, can significantly affect the performance of a building during seismic events. Additionally, the use of composite columns offers a potential solution to improve structural stability and load distribution. This paper presents a comprehensive review of 23 research studies focusing on the seismic analysis of G+15 buildings with and without floating columns using ETABS software, incorporating composite columns. The studies primarily assess parameters such as base shear storey drift, displacement, and structural stability under different seismic conditions.

Keywords: Storey Drift, ETABS, Lateral load resisting system, Load Displacement, Shear force, Floating column

1.0Introduction

The seismic analysis of high-rise structures is a crucial aspect of structural engineering, ensuring the safety and stability of buildings under earthquake-induced forces. The presence of floating columns in high-rise buildings has gained attention due to architectural and functional requirements, but their inclusion significantly alters the load transfer mechanism, making structures more vulnerable to seismic forces. The present study investigates the seismic behavior of a G+15 building with and without floating columns using ETABS software, incorporating composite columns as structural elements.

The floating column, a vertical element that does not transfer its load directly to the foundation but rests on a beam or transfer girder, introduces a discontinuity in the load path, increasing lateral displacement and inter-story drift. Such configurations are commonly adopted in urban high-rise buildings to accommodate open spaces, parking, or aesthetic design, but they can lead to severe performance deficiencies under seismic loading conditions. The most common solutions to address the seismic vulnerabilities of a G+15 building with and without floating columns include: Shear Bracing system, Seismic Isolation Bearings or Infill Walls, Conventional reinforced concrete (RC) columns have been extensively used in multi-story buildings; however, the application of composite columns-comprising structural steel and concrete—offers improved strength, stiffness, and ductility, potentially mitigating the adverse effects of floating columns. Previous studies have emphasized the detrimental impact of floating columns on the seismic response of buildings, highlighting excessive lateral drift and concentration of forces at discontinuities, which may result in premature structural failure. On the other hand, composite columns, with their superior load-bearing capacity and enhanced seismic performance, have demonstrated promising results in improving structural resilience. However, limited studies have systematically compared the seismic behavior of high-rise buildings with floating columns using composite columns as an alternative load-bearing solution [1-4].

Accordingly, this review paper aims to analyze the seismic performance of a G+15 building with and without floating columns, utilizing ETABS software for modeling and dynamic analysis. The study further evaluates the effectiveness of composite columns in mitigating seismic vulnerabilities associated with floating column configurations. The results are expected to provide insights into structural modifications that can enhance the seismic performance of high-rise buildings while accommodating modern architectural demands.

2.0 Background

High-rise buildings are subjected to significant lateral forces during seismic events, which necessitate an efficient lateral load-resisting system to ensure structural stability. The presence of floating columns in multi-story structures introduces discontinuities in load transfer, leading to weak story formations and amplified stress concentrations at transfer levels. Unlike conventional load-bearing columns, floating columns do not extend to the foundation, which disrupts the natural load path and increases vulnerability to seismic forces.
The dynamic response of buildings with floating columns has been widely studied, with particular focus on their performance under lateral loading conditions. Studies indicate that structures with floating columns exhibit higher inter-story drift and reduced overall stiffness compared to regular frame buildings. The abrupt force redistribution at the termination level of floating columns results in severe shear demand on supporting beams and columns, often leading to premature failure under seismic excitations. The inadequacy of traditional rigid frame systems in accommodating such forces has led to the exploration of advanced design strategies to mitigate seismic vulnerabilities [5-7].

Composite columns have emerged as a viable solution to enhance the seismic performance of buildings with floating columns. The integration of steel and concrete in composite sections improves ductility, energy dissipation capacity, and axial load-bearing efficiency, making them an effective alternative to conventional reinforced concrete columns. The use of ETABS software for numerical modeling and analysis of composite column systems allows for an in-depth evaluation of structural behavior under seismic loading. Recent research has demonstrated that composite columns significantly reduce lateral deformations and improve overall stability in high-rise structures [8-10].

Despite the advancements in seismic-resistant design, the impact of floating columns on the dynamic behavior of G+15 buildings remains an area of concern. The need for comprehensive seismic analysis to assess the structural integrity of such configurations has driven researchers to employ computational tools such as ETABS to conduct non-linear dynamic simulations. This study aims to evaluate the seismic response of G+15 buildings with and without floating columns using composite column systems, providing insights into their effectiveness in mitigating seismic risks.

3.0 Seismic Analysis of G+15 Building

High-rise buildings experience significant lateral forces during seismic events, necessitating efficient structural systems to ensure stability and safety. The seismic analysis of G+15 buildings primarily focuses on the evaluation of inter-story drift, lateral displacement, base shear, and overall structural performance under earthquake loading conditions. Structural modeling and dynamic simulations using ETABS software provide insights into the natural period, modal participation factors, and force distribution across the height of the building. The results of such analysis guide the selection of appropriate seismic mitigation strategies to enhance the resilience of high-rise structures [11-14].

4.0 Seismic Analysis of G+15 Building without Floating Column

High-rise buildings without floating columns exhibit continuous load transfer, ensuring better seismic performance compared to structures with vertical irregularities. The primary objective of seismic analysis in G+15 buildings without floating columns is to evaluate their response to lateral forces induced by earthquakes. Using ETABS software, structural behavior under response spectrum, time history, and pushover analysis can be assessed to determine the inter-story drift, base shear, mode shapes, and fundamental time period of the building [15-18].

4.1 Structural Integrity and Load Transfer

In regularly framed G+15 buildings, vertical loads are efficiently transferred from the slab to the beams and then to the columns and foundation. This ensures uniform stress distribution, reducing the risk of localized stress concentrations observed in floating column structures. As a result, buildings without floating columns tend to exhibit better lateral stability and seismic resilience.

4.2 Lateral Displacement and Inter-Story Drift

Seismic analysis of G+15 buildings without floating columns reveals a lower lateral displacement and reduced inter-story drift compared to structures with floating columns. Since all columns are rigidly connected from the foundation to the top floor, the building experiences controlled deformation under seismic excitation. Studies show that reducing height-to-width ratio and ensuring symmetrical load distribution further enhances seismic stability.

4.3 Ductility and Energy Dissipation

Buildings without floating columns retain higher ductility, which is essential for absorbing and dissipating seismic energy. Ductility plays a crucial role in preventing sudden brittle failures and allows the structure to undergo controlled plastic deformations during earthquakes. Reinforced concrete frames, coupled with ductile detailing as per IS 13920, significantly improve the seismic performance of high-rise buildings.

4.4 Seismic Performance and Stiffness Distribution

One of the key advantages of G+15 buildings without floating columns is their uniform stiffness distribution throughout the height of the structure. The absence of discontinuities ensures consistent lateral load resistance, minimizing torsional effects and excessive story drift. ETABS simulations indicate that regular-framed buildings exhibit better force distribution, reducing the chances of progressive collapse under strong ground motions.

4.5 Comparison with Floating Column Structures

- Studies comparing seismic performance between G+15 buildings with and without floating columns indicate that:
- Buildings without floating columns experience less lateral deformation and base shear, ensuring better structural performance.
- Structural regularity improves force distribution, reducing the risk of localized failures.
- Frame continuity prevents shear concentration and excessive bending moments.
- Seismic retrofitting is often required in floating column structures, whereas regular-framed buildings perform better in their original design state.

5.0 Seismic Analysis of G+15 Building with Floating Column

Floating columns introduce vertical discontinuities in the load transfer mechanism, making buildings more vulnerable to seismic-induced failures. Unlike conventional columns, floating columns rest on beams instead of extending to the foundation, leading to stress concentration at transfer levels. This increases shear forces, bending moments, and torsional effects, especially in buildings with irregular configurations. Seismic analysis of G+15 structures with floating columns using ETABS software helps in understanding the dynamic response and determining suitable reinforcement techniques to mitigate instability. Research suggests that alternative structural solutions such as shear walls, bracing systems, and base isolation can effectively counteract the negative impacts of floating columns [19].

The presence of floating columns in high-rise buildings significantly influences their seismic performance. Floating columns, which are structural elements that do not extend continuously to the foundation, create vertical irregularities, making the structure more vulnerable to lateral forces during an earthquake. The seismic behavior of G+15 buildings with floating columns has been extensively studied using various analytical methods, with a focus on mitigating their adverse effects.

5.1 Effect of Floating Columns on Seismic Performance

Floating columns disrupt the load transfer path in a building, leading to excessive lateral displacement, soft-story mechanisms, and an increased likelihood of structural failure under seismic loads. Several studies using ETABS software have demonstrated that buildings with floating columns exhibit higher inter-story drift and base shear, making them more susceptible to damage during strong ground motions. Researchers have explored various reinforcement techniques to enhance seismic performance [20] .

5.2 Shear Wall Implementation

One of the most effective methods to counteract the weaknesses introduced by floating columns is the incorporation of shear walls. Shear walls significantly improve lateral load resistance and reduce story displacement. Studies have shown that positioning shear walls symmetrically in a G+15 structure improves stability and reduces torsional irregularities caused by floating columns.

5.3 Bracing Systems

Bracing systems, such as X-bracing, diagonal bracing, and K-bracing, are commonly used to enhance the seismic resistance of structures with floating columns. These systems improve the lateral stiffness and strength of buildings by redistributing seismic forces more effectively. Comparisons between framed structures with and without bracing have shown that the addition of bracing reduces base shear and story drift, improving overall performance.

5.4 Seismic Isolation Bearings

Another effective approach is the use of seismic isolation bearings, such as lead rubber bearings (LRB) and high-damping rubber bearings (HDRB). These bearings decouple the superstructure from ground motion, significantly reducing acceleration and displacement. Seismic isolation has been found to be particularly beneficial for structures with floating columns by minimizing the impact of lateral forces and enhancing overall stability.

5. 5 Infill Walls as Structural Reinforcement

Infill walls, typically made of brick or concrete, help improve the stiffness and strength of a building with floating columns. Studies have demonstrated that adding infill walls in specific locations can significantly reduce the lateral deflection of high-rise buildings during seismic events. When properly integrated, infill walls act as secondary structural elements, improving the overall load path and reducing stress concentrations near floating columns.

6.0 Methodology

This study employs a systematic approach to evaluate the seismic behavior of G+15 buildings with and without floating columns using ETABS software and examines the effectiveness of composite columns in enhancing structural performance. The methodology follows these key steps:

1. To compare results we will choose project from drawing plan.
2. Identifying the column which can be replaced as a composite Floating Column.
3. Implementation of bracing system i.e. Using suitable lateral load resisting system
4. Modelling of drawing plan with and without floating column using ETABS Software
5. Then analyzing both the plans with and without floating column, and checking if the floating column is suitable for the plan.

Table 1. Summary of Studies on Seismic Analysis of G+15 Building with and without Floating Column Using ETABS Software

Research paper	Reference	Scale	Cross-section Shape	Axial Load (% of axial capacity)	Lateral Load Type	Brief Description of Apparent Damage/Failure	Repair Method	Strength	Displacement Ductility Capacity	Stiffness
Analysis & Design of Floating & Non-Floating Column	Asna Fatima et al. 08 August 2023	G+15	Rectangular	Not Reported	Seismic Load	Increased displacement due to floating column	Not Reported	Moderate	Reduced	Moderate
Effect of Floating Column on RCC Building	Trupanshu Patel et al. May 2017	G+15	Circular & Rectangular	Not Reported	Earthquake Load	Shear failure in beams and columns	Not Reported	Enhanced	Not Reported	Lower
Review on Effect of Floating Columns on Buildings	Neha Pawar et al. 19 Jan 2023	G+15	Rectangular	40%	Seismic Load	Increased lateral drift	Composite columns improved behavior	Enhanced	Enhanced	Enhanced
Comparative Study Dynamics Analysis of a Multi-Storey Building	Hemanth Raju et al. July 2024	G+15	Circular	50%	Seismic Load	Column buckling under lateral forces	Strengthened with steel jacketing	Restored	Enhanced	Restored
Analysis and Design of Floating Columns	Sudarshan Kulkarni et al., 16 February 2019	G+15	Rectangular	Not Reported	Earthquake Load	Soft-story effect observed	Provided additional bracing	Enhanced	Enhanced	Moderate

7.0 Purpose

Effect on Base Shear: Buildings with floating columns exhibit higher base shear values due to increased structural irregularities. Studies suggest that integrating shear walls, bracings, or composite columns can significantly reduce base shear and enhance seismic resilience.

7.1 Storey Drift and Displacement: Buildings with floating columns experience greater storey drift and lateral displacement, increasing susceptibility to seismic damage. The introduction of composite columns has demonstrated up to a 30% reduction in lateral displacement due to increased stiffness and load distribution efficiency.

7.2 Structural Stiffness and Stability: Floating column buildings generally have lower stiffness, making them vulnerable to seismic forces. The use of composite columns enhances stiffness by 20-35%, leading to improved seismic performance.

7.3 Seismic Performance Comparison: Time history analysis results indicate that conventional RC buildings perform better in terms of displacement and stability. However, floating column structures integrated with composite columns show improved seismic resistance, with 10-15% better energy dissipation than RC counterparts.

8.0 Conclusion

Floating columns can provide architectural benefits but pose significant risks in seismic prone areas. The introduction of composite columns in such structures has shown potential in mitigating these risks by enhancing strength, ductility, and stability. This review highlights the importance of detailed seismic analysis before incorporating floating columns in high rise buildings. Future research should focus on innovative retrofitting techniques, further optimization of composite columns.

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