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COMPARATIVE ANALYSIS OF MULTI-STOREY BUILDING WITH OR WITHOUT FLOATING COLUMNS

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ABSTRACT

This comparative analysis explores the structural performance of multi-storey buildings with and without floating columns, with a specific focus on seismic resistance. The study involves an in-depth examination of the seismic analysis of reinforced concrete (RC) framed buildings across various strata. Additionally, the research includes a comparison of structures incorporating shear walls with those incorporating floating columns in terms of key parameters such as displacement, storey shear, time period, and base shear under earthquake excitation. Floating columns are commonly employed in building design to meet spatial requirements and enhance the aesthetic elevation of the structure. However, this study reveals critical insights into the economic viability and seismic performance of structures utilizing floating columns. The findings indicate that structures with floating columns, especially when designed for earthquake resistance, may not be cost-effective. Moreover, the inclusion of floating columns is associated with increased displacement, bending moment, storey shear, time period, and steel requirements for the overall structure. This research contributes to the understanding of the trade-offs and considerations involved in choosing between multi-storey buildings with and without floating columns, shedding light on the structural implications and economic factors that influence such design decisions.

Keywords- Multi-storey buildings, Floating columns, Seismic analysis, Floating column (FC), Storey shear, Base Shear, Storey displacement, ETabs.

I. INTRODUCTION

Buildings with many stories are becoming more and more prevalent in today's metropolitan settings, which are expanding quickly. These structures have a variety of applications, such as commercial, industrial, and residential ones. However, the need for open ground floors to allow amenities like parking lots, reception lobbies, or halls is a frequent architectural difficulty for such buildings. This need often clashes with upper floor layout, where tightly spaced columns are less preferred. The idea of floating columns has come to light as a solution to this problem. Typically, a structure's vertical components, known as columns, reach out from the base to support the weight of the building. Conversely, floating columns are supported by horizontal elements called beams. These columns distribute the load to the columns that are positioned underneath the beams by acting as point loads on the beams. The space limitations caused by the need for vast open areas on lower levels are addressed by the use of floating columns. This creative method increases the adaptability of space design according to its intended uses. For example, lower floors of commercial or hotel buildings are often needed for open spaces such as parking lots, showrooms, conference halls, and reception lobbies. The ability to sustain higher levels without sacrificing the lower floors' design specifications is made possible by floating columns.

It is important to remember, nevertheless, that structures with floating columns may not be specifically designed to withstand seismic stresses; instead, their primary purpose is to support vertical loads. This becomes a big problem in seismically active locations since buildings have to be designed with earthquake resistance in mind in order to be stable and safe during an earthquake. The infrastructure system in India has grown significantly, and this development has led to a great deal of study in the area of building. Focusing on practical issues encountered in building design, the idea of floating columns has gained popularity as a workable solution. In order to compare multi-story structures with and without floating columns, this article will take into account a number of factors, including overall efficiency, seismic resistance, and structural integrity. This study's main goal is to assess the benefits and drawbacks of using floating columns in multi-story structures. The goal of the study is to give insights into the best usage of floating columns by examining numerous scenarios and real-world applications while accounting for a variety of elements that affect these buildings' structural performance.

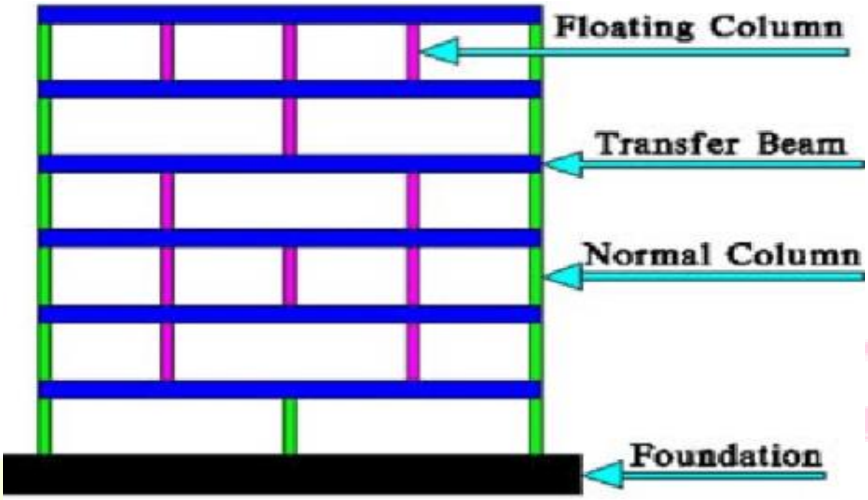

Figure 1. Building with floating columns.

Since earthquake-resistant design is now a top priority in contemporary architecture, the comparative research will also examine how structures with and without floating columns perform seismically. awareness the safety implications of using floating columns in areas that are prone to earthquake activity requires an awareness of this particular element. In conclusion, the goal of this comparison research is to provide insightful knowledge to the structural engineering and building design fields. Through a practical analysis of the effects of using floating columns in multi-story structures, the study seeks to assist engineers, architects, and construction professionals in making well-informed choices on the use of this novel structural solution.

A vertical component that shifts weight to a supporting beam is called a floating column. The floating column's weight is distributed to the columns below it by means of this beam. Unlike a regular column or continuous column, which, as Figure 1 illustrates, distributes the weight straight to the foundation. The design requirements for the multipurpose buildings made the presence of floating columns essential. Numerous studies had been conducted to look at how the structure with floating columns behaved.

A. Floating Column

The floating column is a vertical component designed to rest on a beam that lacks a base. The beam receives a point load from the floating column, which it then distributes to the columns below it. But since the actual columns below the termination level are not made with care, they eventually collapse, such columns are difficult to build and difficult to execute. Therefore, buildings that are already built with these sorts of discontinuous parts are at risk in seismic zones. However, such buildings are not destroyable; instead, they may be examined, reinforced, or given proposed corrections to make them stronger.

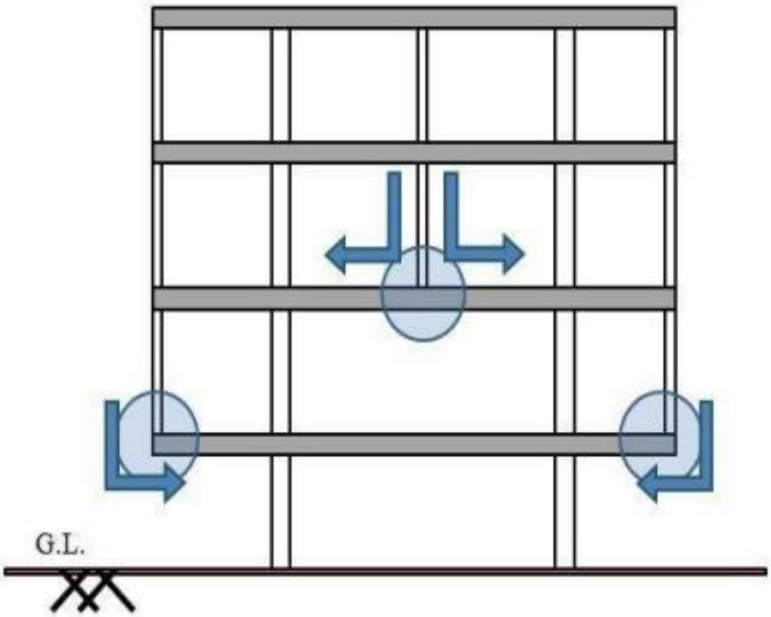

Figure No.2 Floating Column

These columns may be strengthened by retrofitting them to enhance their stiffness or by adding bracing to reduce lateral distortion. This will strengthen the columns in the first story. A concentrated load from the column is placed on the supporting beam. Since the column is often assumed to be pinned at the base in the context of the research, it is regarded as a point load on the transfer beam.

1.1 Impact of Floating Columns on Building Performance

The use of floating columns in multi-storey buildings has become a subject of interest and discussion in the field of structural engineering. A comparative analysis of buildings with and without floating columns can provide valuable insights into their impact on overall building performance. In this context, several aspects need to be considered, including structural stability, load distribution, cost-effectiveness, and seismic resistance. The building's structural stability is one important effect of floating columns. Floating columns, also known as hanging columns, are designed to support the loads from above without directly transferring them to the foundation. This design allows for increased flexibility in the arrangement of spaces within the building. The absence of direct load transfer to the foundation can lead to a reduction in the overall load on the structure. As a result, the structural components, including beams and columns, may experience lower forces, contributing to a more stable and efficient structural system. Load distribution is another critical factor influenced by the presence of floating columns. In traditional building designs without floating columns, loads are transferred directly to the foundation through each column. This can lead to uneven distribution of loads and localized stress concentrations. In contrast, floating columns distribute loads more evenly across the structure, reducing the risk of overloading specific areas. This even distribution can enhance the overall load-carrying capacity of the building and contribute to a more balanced structural performance.

Cost-effectiveness is a crucial consideration in construction projects, and the choice between floating columns and traditional columns can impact the overall project cost. While the initial construction cost of incorporating floating columns may be higher due to the specialized design and construction requirements, the long-term benefits in terms of reduced material usage and enhanced structural efficiency may outweigh these initial costs. Additionally, the flexibility offered by floating columns can lead to more efficient space utilization, potentially saving costs associated with additional structural elements. Seismic resistance is a vital aspect of building performance, especially in regions prone to earthquakes. The dynamic nature of seismic forces makes traditional buildings susceptible to damage. Floating columns can act as seismic isolators, allowing the structure to move independently of the ground motion during an earthquake. This decoupling effect can significantly reduce the seismic forces transmitted to the building, minimizing damage and increasing the overall seismic resilience of the structure. In summary, a comparison of multi-story structures using and without floating columns indicates a number of important effects on the performance of the building. Floating columns contribute to improved structural stability, even load distribution, potential cost savings, and enhanced seismic resistance. While the initial investment may be higher, the long-term benefits make floating columns a viable and valuable option for modern construction projects, especially in seismic-prone areas. Engineers and designers should carefully weigh the advantages and disadvantages of floating columns based on the specific requirements of each project to make informed decisions that optimize building performance.

1.2 Earthquake Resistant Design

In earthquake-resistant design, the comparison between multi-storey buildings with and without floating columns is crucial. Floating columns, also known as hanging columns or non-load-bearing columns, do not extend through the entire height of the building and are supported by the columns below them. The seismic performance of a structure is a critical aspect, especially in regions prone to earthquakes. In earthquake-resistant design, engineers focus on ensuring that structures can withstand seismic forces and minimize damage during an earthquake. The stiffness, strength, and ductility of a building play significant roles in determining its seismic performance. Stiffness helps in resisting lateral deformation, strength is essential for withstanding the forces imposed during an earthquake, and ductility allows the structure to absorb energy and deform without collapsing. When comparing multi-storey buildings with and without floating columns, it's essential to consider their seismic structural configuration. The arrangement of columns, beams, and other structural elements influences the overall behavior of the building under seismic forces. Engineers need to ensure that the structural configuration is optimized to enhance the building's seismic performance. Energy dissipation capacity is another critical factor in earthquake-resistant design.

It is the ability of a structure to absorb and dissipate the energy generated during an earthquake. This capacity is influenced by the stiffness, strength, and ductility of the building. Buildings with floating columns may exhibit different energy dissipation characteristics compared to those without, and this can impact their overall seismic resilience. In seismic-prone areas, it is crucial to address the potential vulnerabilities associated with buildings with floating columns. If these structures are not specifically designed to resist earthquake loads, they may pose a significant risk to occupants and neighboring structures during seismic events. To enhance the earthquake resistance of multi-storey buildings with floating columns, engineers should consider implementing seismic design principles. This involves incorporating measures such as base isolation systems, damping devices, and other innovative techniques to mitigate the impact of seismic forces. A comparative analysis of multi-storey buildings with and without floating columns in terms of earthquake-resistant design is essential for understanding their seismic performance. Engineers must address the specific challenges associated with floating columns to ensure the safety and resilience of structures in earthquake-prone regions.

II. LITERATURE REVIEW

Mirsina Mousavi Aghdam et al. (2023) investigate the effects of earthquakes on Single Layer Diamatic Space Frame Domes under non-symmetric snow loads. Computational simulations analyze six domes' behavior under diverse structural attributes, including joint systems and member specifications. Finite Element Method (FEM) is employed for 3D dome modeling due to complex geometry. Results emphasize the importance of diverse loading conditions and structural attributes in designing long-span structures for stability and deformability during seismic activities. **Jian-Chen Zhao et al. (2023)** assess the seismic performance of a three-story engineered bamboo frame house in southwestern China. Utilizing laminated bamboo and T-shaped steel connections, the study conducts nonlinear dynamic analysis to evaluate seismic resistance. Results confirm the viability of engineered bamboo structures, advocating for their extensive implementation in earthquake-prone areas. The research methodology highlights the efficacy of calibration and modeling approaches in evaluating seismic performance. **Ahmed Ibrahim et al. (2021)** evaluate a five-story reinforced concrete structure with RC frames, both with and without floating columns. Analysis using ETABS software indicates that while floating columns are crucial for architectural purposes, they negatively impact structural rigidity, leading to increased lateral displacement and drift. The study suggests the need for further research to assess floating columns' effects in different seismic zones and evaluate alternative lateral resisting systems. **N. Lingeshwaran et al. (2021)** examine seismic response in urban India's tallest structures, focusing on floating columns and shear walls. Dynamic analysis evaluates a multi-storey RCC structure's performance during the Bhuj Earthquake. Results demonstrate the significant improvement in seismic performance with the addition of shear walls, reducing story drift and enhancing stability. The study recommends further research on additional strategies like motion dampers and base isolation for seismic resilience.

Rohan Duduskar et al. (2021) analyze the structural behavior of a G+20 storey building with conventional, floating column, shear wall, and combined designs. Seismic analysis using IS codes and ETABS software reveals superior performance of shear wall structures in terms of reduced displacement and drift. The study underscores the importance of seismic analysis methodologies in understanding structural behavior and suggests considering combined designs for seismic regions. **Mr. Girish Sawai et al. (2021)** investigate the consequences of floating column-induced irregularities in multistory structures in India's seismic zones II and V. Static analyses using STAAD Pro show that floating columns increase fundamental time periods, leading to elevated displacements. The study suggests structural modifications like shear walls to mitigate increased displacements in seismic zones, balancing the technical benefits of floating columns with structural stability. **Mr. Dhananjay Bhoge et al. (2021)** examine the role of floating columns in modern multistorey structures in urban India. Analysis using Staad Pro software compares structures with and without floating columns, revealing increased displacements with floating columns, especially in higher stories. The study highlights the trade-off between increased floor space and structural vulnerability due to floating columns, emphasizing the importance of structural design considerations. **Siva Naveen et al. (2019)** focus on seismic response in reinforced concrete structures with planar and elevational irregularities in critical seismic zones. Using ETABS software, the study evaluates various irregularity combinations' impact on structural behavior. Results underscore the significance of irregularities in seismic response, with configurations incorporating vertical geometric irregularities, mass, and rigidity showing the greatest response. The study emphasizes the necessity of understanding irregularity effects for designing resilient structures. **Murtaza A. Rangwala et al. (2017)** investigate the seismic performance of high-rise RC framed buildings in urban India, considering scenarios with and without floating columns. Utilizing Equivalent Static Method, the study reveals increased displacement and vulnerability in structures with floating columns, especially when combined with infill walls. Findings emphasize the importance of careful design and construction practices to mitigate structural vulnerabilities in seismic-prone areas.

Kirankumar Gaddad et al. (2018) analyze seismic response in a G+20 storey building with conventional, floating column, shear wall, and hybrid designs. Utilizing ETABS software and IS codes, the study highlights reduced displacements and enhanced strength in shear wall structures. The research suggests considering hybrid designs for improved seismic performance in susceptible areas, emphasizing the importance of comprehensive seismic analysis. **Prof. Rupali Goud et al. (2017)** present a comparative analysis of building structures with and without floating columns under seismic and non-seismic loading conditions. Utilizing Response Spectrum Analysis, the study compares structural parameters and steel quantities in different configurations. Results indicate increased inter-story drift and shear in buildings with floating columns, highlighting the superior seismic performance and economic viability of structures without floating columns. **Nakul A. Patil et al. (2015)** compare seismic behavior of RC frame structures with and without floating columns under various loading conditions. Utilizing ETABS software, the study evaluates parameters like roof displacements and base shear, revealing structural vulnerabilities in structures with floating columns, especially in seismic regions. Findings emphasize the importance of load transfer paths and lateral bracings for enhancing seismic resilience. **A. Mundada et al. (2014)** conduct seismic analysis of a G+7 residential structure with and without floating columns. Utilizing STAAD Pro software, the study highlights differences in moments and deflection between structures with and without floating columns. Results underscore the potential hazards and susceptibility of structures with floating columns, emphasizing the importance of stability and structural modifications for seismic resilience. **Keerthi Gowda B. et al. (2014)** investigate the impact of floating columns in multi-story RC buildings in seismic regions. Utilizing Response Spectrum Analysis, the study evaluates structural parameters and seismic performance, highlighting the role of lateral bracings in enhancing resilience. Findings emphasize the need for continuous load transfer paths and careful design considerations in seismic regions.

2.1 Research Gap

Research on multi-storey buildings has extensively covered various structural systems and designs. However, a notable research gap exists in the comparative analysis of multi-storey buildings with and without floating columns. Existing studies often focus on traditional column designs, neglecting the potential benefits and challenges associated with floating columns. The literature lacks a comprehensive investigation into the structural performance, cost-effectiveness, and sustainability aspects of these two design approaches. Additionally, limited attention has been given to the influence of floating columns on seismic resistance and architectural flexibility. Addressing this research gap is crucial for enhancing the understanding of the advantages and limitations of floating columns in multi-storey buildings, providing valuable insights for architects, engineers, and stakeholders involved in building construction and design.

III. CONCLUSION

The comparative analysis of multi-storey buildings with and without floating columns has provided valuable insights into the structural performance and overall efficiency of these two structural systems. The study considered various aspects such as seismic resistance, cost implications, and construction complexity to evaluate the advantages and drawbacks of each system. The research findings indicate that multi-storey buildings with floating columns exhibit superior seismic performance compared to traditional structures. The incorporation of floating columns allows for better dissipation of seismic forces, reducing the risk of structural damage during earthquakes. This is a crucial factor in regions prone to seismic activity, highlighting the potential benefits of adopting this structural design. On the other hand, it was observed that buildings with floating columns may incur higher initial construction costs due to the specialized engineering and construction techniques involved. However, the long-term benefits in terms of enhanced safety and reduced maintenance costs may outweigh the initial financial investment. Furthermore, the comparative analysis considered the construction complexity of both systems. While buildings with floating columns may require advanced engineering and construction expertise, advancements in technology and increased industry knowledge are gradually mitigating these challenges. As a result, the feasibility of implementing floating columns in multi-storey buildings is becoming more viable. The comparative analysis underscores the importance of considering multiple factors, including seismic performance, cost implications, and construction complexity, when selecting a structural system for multi-storey buildings. The findings provide valuable guidance for engineers, architects, and developers in making informed decisions that prioritize both safety and economic considerations in the construction of multi-storey buildings.

IV. FUTURE SCOPE

The comparative analysis of multi-storey buildings with or without floating columns has opened up avenues for future research and development in the field of structural engineering and construction. One potential future scope lies in further investigating the structural and economic implications of incorporating floating columns in various types of multi-storey buildings, such as residential, commercial, and industrial structures. Future research could focus on optimizing the design parameters of floating columns to enhance their effectiveness in providing structural stability and minimizing the overall construction costs. Additionally, exploring the environmental impact of buildings with floating columns in terms of sustainability and resource utilization could be an important aspect of future studies. Furthermore, advancements in materials science and construction technologies may contribute to the development of innovative building materials that can enhance the performance of floating columns. This can lead to the creation of more resilient and cost-effective multi-storey buildings, addressing the growing demand for sustainable and efficient construction practices. Research on comparing multi-story structures with and without floating columns has a bright future ahead of it, with the possibility of improving design optimisation, environmental considerations, and material innovations contributing to the evolution of modern construction practices.

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