INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)
(Int Peer Reviewed Journal)
Vol. 04, Issue 11, November 2024, pp : 1674-1679
www.ijprems.com
editor@ijprems.com
e-ISSN : 2583-1062
Impact Factor : 7.001

A REVIEW ON DESIGN AN EFFICIENT AND FUNCTIONAL MULTISTORY BUILDING SUPPORTED BY A SINGLE COLUMN

Golu Dhakad[1], Dr. Vivek Soni[2]

[1]M. Tech. Scholar, Madhyanchal Professional University, Faculty of engineering & Technology, School of civil engineering Bhopal, M.P., India.

[2]Assistant Professor. Madhyanchal Professional University, Faculty of engineering and Technology, School of Civil Engineering, Bhopal, M.P, India.

ABSTRACT

Designing and constructing a single-column multistory building is highly innovative and reflects a forward-thinking approach to maximizing spatial efficiency and addressing urban challenges such as population growth and land scarcity. To design an efficient and functional multistory building supported by a single column. To maximize the use of available space while ensuring structural stability and user safety. Focus on key parameters like bending moments**,** stress distribution**,** shear forces**,** and displacement behavior.

Use high-strength, lightweight materials like high-performance concrete (HPC**)** or fiber-reinforced polymers to reduce dead loads. Displacement and vibration under service loads must remain within acceptable limits. Proposed Solution: Analyze the structure's natural frequency and damping using dynamic analysis tools to mitigate resonance and sway effects. The project has the potential to make significant advancements in construction technology, particularly for urban settings where land use is constrained.

By addressing structural, environmental, and functional requirements comprehensively, the design can serve as a benchmark for innovative architecture. Performing a cost-benefit analysis to ensure the feasibility of the design. Conducting a comparative study with traditional multistory buildings to highlight the advantages of the single-column approach.

Key words:- Single-Column, Multistory Building , Innovative architecture, High-strength, Lightweight

1. INTRODUCTION

A single-column multistory building is a unique structural design characterized by all its floors being supported by a central column. These types of buildings demand meticulous architectural and engineering considerations due to the challenges in load distribution, stability, and functionality. Single-column structures are a unique architectural and structural innovation, often adopted for specific applications where maximizing open space or achieving a distinct visual appearance is a priority. Here's a breakdown of the key features, benefits, and considerations for single-column designs in multi-story buildings.

Cost: The design and materials required can be costlier compared to conventional multi-column systems.

Maintenance: Concentrated stress on a single structural element may require regular inspections and maintenance.

Limitations in Scale: There is a practical limit to the height and size of such structures based on material and engineering constraints. A single-column design is not just an engineering feat but a statement of innovation and creativity, blending form with function to meet modern urban needs.

Applications

Commercial Buildings: Offices, observation towers, or showrooms in high-density urban areas.

Residential Buildings: Compact housing solutions, particularly in areas with limited land availability.

Landmarks: Unique architectural designs that serve as city icons or tourist attractions.

Efficient Use of Space: By consolidating structural support into a single column, the design maximizes usable floor space, offering flexibility for interior layouts.

Reduced Land Costs: The minimal footprint of a single-column design reduces land requirements, making it an attractive option in high-density urban areas.

Ease of Construction: Pre-fabricated construction techniques can simplify assembly and streamline construction processes.

Aesthetic Appeal: Such buildings can provide unique architectural styles, panoramic views, and opportunities for innovative interior designs.

Innovative Engineering: This concept pushes the boundaries of modern engineering, fostering advancements in materials and structural systems.

2. LITERATURE REVIEW

Harsh Soni et al (2024) the principle cause of this study is to lay out a whole building relaxation on a single column. The rapid increase in population and scarcity of land tends to the development of construction technology and high- rise commercial structures. The building plays a vital role in improving various activities in the late world. The Aim of present study "Analysis and design of high rise building by stead pro is to define proper technique for creating Geometry, cross sections for column and beam etc., developing specification and supports conditions, types of Loads and load combinations. In this study a 30- story high rise structure is analyzed for seismic and wind load combination using sated pro and comparison is drawn. Currently, there are four mosques on Java Island recognized as Sake Tunggal Mosques, which employ a single wooden column as the main column, placed at the center of the prayer hall to support the roof. This unique structural system, when compared to the traditional four-column system, is remarkable even if its style is exceptional for mosques on Java Island. This study aims to provide scientific data and promote the local government's understanding about the importance of the Sake Tunggal Mosques by focusing on the one in Banyu as, which is placed at a cultural heritage site, founded in 1871. The rapid increase in population and scarcity of land tends to the development of construction technology and high-rise commercial structures. Building plays a vital role for improving the various activities. In the late world, prompt to action of peoples from one place to another is of great extent mainly for earnings. In building more facilities like financing section, computer section, administration section, design section and drawing section are provided. The aim of the project is to analyses and design of multi-story building resting on the single column by using different code provisions. A lay out plan of the proposed building is drawn by using AUTO CADD. The structure consists of ground floor plus five floors, each floor having the one house. Staircase must be provided separately. The planning is done as per Indian standard code provisions. The building frames are analyzed using the various text books. Using this so many standard books analysis of bending moment, shear force, deflection, end moments and foundation reactions are calculated. Detailed structural drawings for critical and typical R.C.C. members are also drawn. Recent studies regarding progressive collapse resistance of buildings considered only single critical column removal scenario. However, limited investigations have been conducted so far to assess multi-column removal scenarios. Hence this study is made to compare progressive collapse resistance of a multi-story building under both single and multi-column removal scenarios. An eight-story reinforced concrete building was analyzed by using linear static analysis procedure and DCR values of the members are calculated to investigate the potential of progressive collapse as per GSA guideline.

Shubham Kumar Binjhwar et al (2023) the project aims to provide a comprehensive and innovative solution for the construction of a single column multistory building that meets the needs and requirements of the modern world. The project focuses on the design and construction of a single column multistory building. Due to the continuous growing population and land scarcity tends to the advancement in construction technology and high-rise buildings. The objective is to create an efficient and functional building that maximizes the use of available space while ensuring structural stability and safety. Bending moment, stress, shear force, structural modelling and displacement design considerations for the structure is provided in this paper which is analyzed using STAAD Pro. The project includes detailed structural analysis and design, as well as consideration of various factors such as soil conditions, wind loads, seismic loads and other environmental factors. The building will be designed to meet local building codes and regulations, while incorporating sustainable and energy-efficient features. The process throughout the Structural planning and designing is not only demand awareness and intellectual thinking but also adequate knowledge of structural engineering along with the knowledge of practical aspects such as relevant design codes backed up by example experience. Moreover, the scope of a single column building project is to create an efficient, functional, and aesthetically pleasing building that meets the needs of its users, while ensuring structural stability, safety, and compliance with relevant regulations and standards**.**

Pooja A. Dhande et al (2023) this project focuses on the analysis and design of multi-story mono-column structures under seismic loads, considering the effect of different plan configurations (square, circular, and rectangular) on the behavior of the structure. Mono-column structures are increasingly being used in urban environments due to their ability to provide more space for services like parking and their efficient use of foundation area. The project evaluates three different plan shapes (square, circular, and rectangular) that all have the same total plan area but differ in geometry. This allows for a detailed comparison of their seismic performance. The structure's response to earthquake loads is a central aspect of the analysis. The study investigates how each plan shape behaves under seismic forces. The lateral displacement of each floor under earthquake loads. The moment generated at the base due to lateral forces, which is critical for stability. The modeling and analysis of the mono-column structure are performed using STAAD Pro, a widely used structural analysis and design software. The software enables detailed seismic analysis, including the calculation of maximum displacement, shear, and moment values. The results from the seismic analysis of each plan configuration are compared to determine which shape performs best in terms of stability, resistance to lateral forces, and overall structural performance. The project aims to identify the most effective configuration and the most vulnerable shape for use in seismic areas. The primary goal of this project is to understand how different plan geometries of mono-column structures react to seismic forces and identify which configuration is most effective and which is most vulnerable. This will provide valuable insights into the design of mono-column buildings in earthquake-prone areas, helping to optimize their structural performance for safety and efficiency. By studying the effects of these shapes under seismic loads, the project contributes to the development of safer and more efficient mono-column buildings that can be used in rapidly urbanizing areas with limited space.

Harinarayanan N et al (2023) this project focuses on the design and analysis of an RCC (Reinforced Cement Concrete) structure supported by a single column. The analysis uses STAAD Pro software, a widely used tool for structural modeling and design. Below is an outline of the process involved. The first step is creating a geometric model of the RCC structure, where the dimensions, layout, and positioning of the single column are defined. Material properties for concrete (e.g., compressive strength, Young's Modulus) and steel reinforcement (e.g., yield strength) are specified. The section properties of the column (e.g., dimensions, type) and beams are defined to represent the structural members accurately. The supports for the structure are fixed, typically at the base of the column, where boundary conditions (e.g., fixed, pinned) are specified based on how the structure is supported in reality. Load combinations are then generated based on the relevant design codes, accounting for the possibility of multiple loads acting simultaneously. STAAD Pro offers special commands for unique situations, such as modeling the column's behavior under dynamic loads, the influence of lateral forces, and other advanced analysis requirements. The analysis is specified in STAAD Pro, ensuring that the software performs static and dynamic analyses (if required) and considers all load combinations. The primary analysis includes static loading, where the effect of the applied loads (self-weight, floor load, wind, and earthquake) is evaluated. Both bending and axial stresses to determine whether the column can withstand the applied forces. The moment generated by lateral loads, which induces bending in the column and connected beams. The shear forces that act on the column due to vertical and horizontal loads. The movement of the structure under load, which helps in assessing its stability and performance. This involves a more concentrated load on the column and is typically simpler but may experience higher stresses and displacement due to the lack of distributed support. Involves multiple columns, providing more distributed support, leading to lower stresses, bending moments, and deflections, making it more stable under applied loads. After performing the analysis, STAAD Pro generates the design based on the results. The program checks the design for structural safety according to relevant codes and standards (e.g., IS 456 for RCC design in India). The design output includes detailed checks for the strength and stability of the single-column structure, ensuring it can safely carry the loads. This project integrates several aspects of structural design and analysis, from modeling to load application, and uses STAAD Pro for advanced computational analysis. The comparison between RCC single-column and multi-column designs provides valuable insights into their performance under various load scenarios.

Mayuri Jadhav et al (2022) comparing mono-column and multi-column RCC frame structures using STAAD Pro is both innovative and practical. It addresses the challenges and opportunities of different structural configurations, especially for G+3 buildings. To analyze and compare the structural performance of mono-column and multi-column RCC frame structures using STAAD Pro, considering static analysis and code provisions as per IS standards. The study focuses on space utilization, structural stability, and empirical performance. This approach ensures a comprehensive analysis, enabling clear insights into the trade-offs between mono-column and multi-column RCC structures. Discuss advantages and limitations of mono-column vs. multi-column designs. Ensure precision in load application, boundary conditions, and meshing. Reduced space efficiency but higher stability and redundancy. High susceptibility to lateral forces, requiring robust shear wall design. Validate both designs against IS code requirements for safety and serviceability. Multi-column structures provide better load distribution but require more space. Mono-column structures offer greater space but may face challenges with stability.

A. Mrs. shilpa valsakuma et al (2022) The literature review highlights the unique structural benefits of mono-column buildings, including their aesthetic appeal and efficient use of ground space, especially in areas like parking. Mono-column structures are also known for their ability to withstand various loads, such as seismic and wind forces, making them suitable for diverse environments. In the analysis, both a rectangular and a circular mono-column building were examined to compare their performance under loading conditions. The **rectangular mono-column structure** exhibited **less deformation** compared to the **circular mono-column structure**, indicating better resistance to displacement under load. The shear forces in the X direction were slightly higher for the rectangular structure, though both configurations showed similar values in the Y direction. This analysis suggests that while both shapes are viable, the rectangular mono-column may offer advantages in terms of deformation control, which could be particularly important for the structural stability and functionality of the building.

Sijin Johnson et al (2022) mono column structures, often referred to as tree-like structures, have a single central column supporting the entire building. This design creates a high vulnerability to eccentric loading, which can cause twisting in any direction and ultimately lead to failure. Since the structure relies on a single column, all other members act as cantilevers, making them susceptible to excessive deflection, high story displacement, and increased story drift. Furthermore, seismic analysis reveals that the shear forces and bending moments in the members are significantly higher compared to non-seismic analysis, exacerbating the potential for structural failure. Due to these challenges, mono column structures are generally more costly and prone to seismic damage compared to conventional building designs. The plan configuration of the building plays a crucial role in its seismic performance. Asymmetric or irregularly shaped plans are particularly prone to severe damage during seismic events, primarily due to torsional responses and stress concentrations. These irregularities cause a change in the lateral deformation of the structure, increasing the likelihood of failure under lateral forces like seismic and wind loads.

In contrast, diagram structural systems offer significant advantages. The diagram design, characterized by its triangular configuration, improves the seismic performance of buildings by providing greater stiffness and reducing the overall weight. This system enhances lateral stability, making the building more resistant to seismic and wind forces. Additionally, the diagram structure reduces the number of structural elements, leading to a more efficient design with fewer potential failure points. Studies have shown that diagram structures decrease story displacement, story drift, and base shear compared to conventional systems, offering both enhanced performance and a more aesthetically pleasing appearance.

Amogh et al (2021) this summary outlines the design, analysis, and strengthening of a unique **Mon column structure** using advanced software tools like **STAAD-Pro (or STRAP)** and IS code standards. Below are key aspects of the design and analysis process. Entire structure is supported on a single column (monocolumn), making it crucial for overall stability. Other structural members act as cantilevers, requiring precise analysis of eccentric loading to prevent twisting or system failure. Shear walls are integrated into the model with defined thickness and material properties. Performance of different configurations is compared in terms of stress reduction, drift control, and displacement behavior. Results are visualized in tabular and graphical formats for better interpretation. This study provides insights into optimizing monocolumn structures against eccentric loading and seismic forces. It also highlights the importance of shear walls and their strategic placement for structural resilience. To delve deeper into any specific aspect, such as STAAD modeling steps, IS code provisions, or shear wall configurations.

Gomasa Ramesh et al (2021) Focuses on the engineering and design of multi-story buildings with single-column structural systems, particularly under the influence of static and earthquake loads. The study concluded that multi-story buildings with a single-column design can be engineered successfully to withstand all applied loads, including those from earthquakes. This suggests that such structures can be designed with adequate strength and stability, even under dynamic loading conditions. Under static loading conditions, the RCC (Reinforced Cement Concrete) columns perform well, indicating they can bear the design loads without failure. The study emphasizes the use of STAAD-Pro software, which is recognized for its ability to provide a fast, reliable, and accurate platform for structural analysis and design. The software aids in meeting the ultimate strength and serviceability requirements of the structure. It stresses that the planning, study, and construction of framed structures are essential skills for civil engineers, highlighting the importance of careful design and evaluation during the project lifecycle. The study suggests that the project work should involve selecting a problem related to the study and design of a commercial framed structure, likely pointing towards the practical application of design principles and software in real-world scenarios. This study emphasizes the importance of advanced tools like STAAD-Pro in modern structural engineering and reinforces the need for proper design practices to ensure safety, serviceability, and performance of buildings under different loading conditions.

CVK Sarath et al. (2020) explores the design and analysis of a G+8 single-column multistory building using **STAAD Pro** software. The research demonstrates the advantages of using STAAD Pro for structural design and analysis, highlighting its efficiency compared to manual processes. The study focuses on various structural parameters, including. The vertical displacement of the structural members under applied loads. The internal moment induced in structural members due to external loads. The force that causes one part of a structural element to slide relative to another. The systematic arrangement of structural elements to ensure stability and functionality. STAAD Pro simplifies and speeds up the design and analysis process, especially for complex structures like G+8 buildings. The software provides precise calculations for critical structural parameters, ensuring safety and reliability. Designing single-column multistory buildings is more feasible using STAAD Pro due to its computational capabilities and user-friendly interface. The results obtained (deflection, bending moment, and shear force) were analyzed to validate the structural performance and compliance with design standards. This research reinforces the importance of advanced structural analysis tools in modern engineering practices, offering significant advantages in terms of time, cost, and accuracy over traditional manual methods. If you'd like, I can elaborate further on the study's methodology or findings.

Basavaraju et al. (2020) focuses on a comparative analysis of multi-story single-column structures subjected to wind and seismic loads, evaluating their performance across six distinct plan configurations. To examine how plan configurations with the same area influence the structural response under seismic and wind loading. These forces are critical in the design and analysis of tall structures as they determine the overall stability, deformation, and structural efficiency. The paper analyzes the effect of these forces on single-column structures, providing insights into the geometric optimization of buildings to withstand such environmental factors. The geometric configuration significantly affects the structure's ability to resist lateral forces. Different shapes provide varying levels of stiffness, stability, and resistance, leading to unique structural responses. The research sheds light on the influence of **plan shape** in determining structural efficiency and highlights the importance of considering **seismic and wind effects** in structural design. Would you like further details about the methodology, findings, or design recommendations.

Sahu et al. (2020) highlights how STAAD Pro has leveraged its latest features to outperform earlier versions and competing software in structural analysis and design. A key advantage noted in their study is its data sharing capabilities, particularly its seamless integration with major applications like **AutoCAD**, which enhances its versatility and utility in multidisciplinary design workflows. Additionally, the software demonstrated **high** accuracy in structural designs, making it a preferred choice for engineers seeking reliable and precise solutions for structural engineering projects. This combination of features underscores STAAD Pro’s standing as a robust and efficient tool in the field.

Savadi et al (2019) highlight the advantages of composite structures over conventional RCC and steel structures. Here's a breakdown of their findings. Composite structures are more economical compared to RCC (Reinforced Cement Concrete) and steel structures. The cost savings arise from a combination of reduced material usage and construction efficiency. Composite structures use lightweight materials like steel and concrete synergistically, reducing the overall dead load. This reduction has significant implications for structural design, particularly for foundations and seismic considerations. The decreased dead load translates to reduced internal forces, such as bending moments and shear forces, acting on structural elements. This reduction enhances the design efficiency and potentially lowers the required dimensions or reinforcement for beams and columns. Composite structures are particularly advantageous for high-rise buildings due to their ability to handle large loads efficiently, reduced construction time, and overall weight optimization. These benefits make them a preferred choice for modern urban development.

3. CONCLUSION

The project demonstrates the efficiency of STAAD. Pro in designing and analyzing complex multi-story structures. The software’s capabilities streamline the design process, reduce the likelihood of errors, and enable early detection of potential failures. This project has provided hands-on experience with structural modeling, load application, and safety assessments, ensuring a deep understanding of building design and analysis processes.

4. REFERENCES

[1] Harsh Soni “Analysis of G+2 Residential Building on a Single Column on Staad Pro” Volume 13 Issue 5, May 2024 Fully Refereed | Open Access | Double Blind Peer Reviewed Journal Paper ID: SR24524235542 DOI: https://dx.doi.org/10.21275/SR24524235542.

[2] Shubham Kumar Binjhwar*1, Sourabh Agrawal*2, Abhishek Sahu*3, Shubham Singh Deohari*4, Shailesh Kumar Nayak “Design and analysis of single column multistory building (g+8) using staad pro” International Research Journal of Modernization in Engineering Technology and Science (Peer-Reviewed, Open Access, Fully Refereed International Journal) Volume:05/Issue:04/April-2023 Impact Factor- 7.868 www.irjmets.com.

[3] Pooja A. Dhande, Nandkishor Sinha “Comparative Analysis of Single Column Square, Rectangular, Circular Shape Structure” https://doi.org/10.22214/ijraset.2023.54464 Paper Id : IJRASET54464 Publish Date : 2023-06-27 ISSN : 2321-9653

[4] Harinarayanan N1 , Dr.K.Sudha “Design of a RCC Structure Supported on a Single Column” July 2023| IJIRT | Volume 10 Issue 2 | ISSN: 2349-6002 IJIRT 160969 international journal of innovative research in technology

[5] Mayuri Jadhav3, Pallavi Parit4 , Prof. M. Y. Jadhav “Analysis of Mono Column Building by Using STAAD Pro” International Research Journal of Modernization in Engineering Technology and Scienc\ 2022.

[6] Amogh1, Chiranjeevi Joshi2, Sharanabasappa3, Vikas Patil Okaly4, Ravikiran S Wali “Analysis and Design of Mono-Column Building” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072.

[7] G.Pradeep, Dr.H.Sudarsana Rao Dr.Vaishali.G.Ghorpade “Design of a structure supported on a single column” www.ijcrt.org © 2018 IJCRT | Volume 6, Issue 1 February 2018 | ISSN: 2320-2882.

[8] V. Nagaraju1, N. Vedakala , Y. Purnima, Ajay Kumar, Y Sudheer Babu, “Analysis and design of multi - storey building under load combination” International Research Journal of Engineering and Technology, Vol. 5,no. 3, Mar, ISO 9001:2008,2018.

[9] Vikrant Trivedi, Sumit Pahwa, “Wind Analysis and Design of G+11 Storied Building Using STAAD-Pro”, International Research Journal of Engineering and Technology, Vol. 5, no. 3, Mar-2018.

[10] SK Saleem, B. Ravi Kumar, “Analysis and Design of Multi Storeyed Building by Using STAADPRO”, Anveshana’s International Journal of Research in Engineering and Applied Sciences, Vol. 2, no. 1, Jan, ISSN-2455-6300, 2017.