Comparative Study Of Reinforced Concrete Oblique Columns And Y-Shaped Columns For High-Rise Structures By Using Etabs

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Abstract- *This study presents a comparative analysis of high-rise reinforced concrete (RC) structures incorporating regular columns, oblique columns, and Y-shaped columns using ETABS. With the growing demand for innovative architectural forms and efficient structural systems, unconventional column configurations are being explored to enhance both functionality and aesthetics. The research focuses on a G+20 storied RC structure analyzed under seismic loading conditions as per IS codes. Three structural models—regular, Y-shaped, and oblique—were developed and evaluated for critical performance parameters, including displacement, storey drift, base shear, time period, and frequency. The analysis results reveal that the oblique column system (diagrid) exhibits superior stiffness and lateral stability, demonstrated by reduced displacements and shorter time periods. The Y-shaped column system provided balanced performance, offering effective control of storey drift with moderate stiffness, making it a practical alternative for seismic resistance. In contrast, the regular column system exhibited higher displacements and longer time periods, indicating lower seismic efficiency. Overall, the findings emphasize that adopting oblique and Y-shaped column systems can significantly enhance the seismic performance, stability, and architectural flexibility of high-rise structures, thereby offering promising alternatives to conventional vertical column systems in modern construction.*

Keywords- Reinforced concrete, oblique columns, Y-shaped columns, high-rise structures, ETABS, seismic analysis

I. INTRODUCTION

Columns are essential structural elements in buildings, serving as vertical members that transfer loads from slabs, beams, and roofs to the foundations. Also referred to as prisms, columns provide stability and strength to a structure while ensuring efficient load distribution. Structurally, a column is designed to resist axial compressive forces, bending moments, or a combination of these, depending on the loading and support conditions. In addition to their structural role, columns often contribute to the architectural aesthetics of a building, featuring symmetry, proportion, and decorative elements.Columns can be classified in multiple ways, including their shape, slenderness ratio, support conditions, loading types, and building materials. Based on reinforcement, columns are typically categorized into tied columns, spiral columns, and composite columns. Tied columns are the most common in reinforced concrete construction, where closely spaced transverse ties hold the longitudinal reinforcement in place, preventing buckling under axial loads. Spiral columns, in contrast, use continuous helical reinforcement, enhancing ductility and lateral confinement, making them suitable for high-load or seismic conditions. Composite columns combine concrete and steel, leveraging the advantages of both materials to achieve higher load-carrying capacity, improved ductility, and fire resistance.

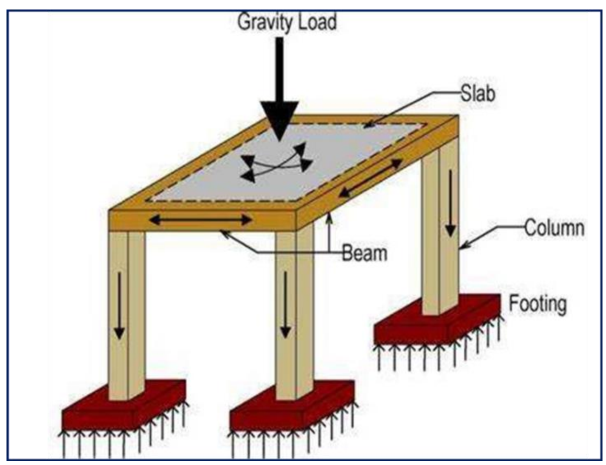

Fig 1. Columns
https://www.irjmets.com/uploadedfiles/paper//issue_7_july_2024/60001/final/fin_irjmets1720612752.pdf

From the perspective of loading, columns are further classified as axially loaded, uniaxially eccentrically loaded, or biaxially eccentrically loaded. Axially loaded columns carry vertical loads along their centroid, while eccentric columns experience moments due to the offset between the applied load and the column's centroid. Biaxial eccentric columns, often found at building corners, experience moments along two axes, influencing their design and stability.In modern high-rise structures, innovative column forms such as oblique and Y-shaped columns are increasingly adopted to optimize structural performance and architectural flexibility. These column configurations improve load transfer efficiency, enhance lateral stability, and reduce material usage. The comparative study of reinforced concrete oblique columns and Y-shaped columns, particularly using structural analysis software such as ETABS, allows for a detailed evaluation of their behavior under axial and eccentric loading conditions. Such studies enable engineers to determine the most effective column configuration for high-rise structures, considering factors such as load-carrying capacity, deflection, ductility, and constructability. Understanding the classification, behavior, and design principles of reinforced concrete columns is critical for ensuring the safety, economy, and longevity of high-rise buildings. This chapter provides a foundational overview of columns, their types, and their structural functions, forming the basis for a comparative analysis of oblique and Y-shaped columns in reinforced concrete high-rise structures.

1.1 Problem statement

Sophisticatedconstructionindustryisrapidlyincreasing duetothedevelopmentsanddemands for population. The walls won't be straight up and down in the new plan. With angled beams, we can build houses with more than one floor. But the results in earthquakes should be looked at to see if these new building methods can be used. Because when there is an earthquake, a high-rise, a mid-rise, and a low-rise building will all not react the same way at different points. Because of this, it is very important to look into how well different kinds of buildings stand up to earthquakes and compare them to the usual way of building. If it can be used instead of regular buildings and has more benefits, it will be a huge step forward in the field of civil engineering.

1.2 Objectives

1. To analyse G+20 storied reinforced concrete (RC) structure under seismic loading withoblique columns.
2. To analyse G+20 storied reinforced concrete (RC) structure under seismic loading withY-shapedcolumns.
3. ComparativeanalysisofobliquecolumnsandY-shapedcolumnsunderseismicloadingwithrespecttodisplacement,baseshear,storeydrift,stiffnessandtimeperiod.
4. ComparativestudyG+20storiedreinforcedconcrete(RC)structurewithobliquecolumns and Y-shaped columns under seismic loading with respect to displacement, base shear, storeydrift,stiffness and time period.

II. LITERATURE REVIEW

Jaiswal, A.U.H.N. (2024) investigated the comparative behavior of reinforced concrete (RC) columns in high-rise structures, focusing on oblique and Y-shaped columns versus regular vertical columns. The study analyzed 20-story buildings using ETABS 2016 to evaluate structural responses such as displacement, story drift, base shear, and frequency. Results indicated that regular columns exhibited greater displacement and frequency, while oblique and Y-shaped columns reduced displacements by 26–57% and provided aesthetic architectural advantages. The study highlighted that oblique columns had lower base shear and story drift compared to Y-shaped and regular columns, suggesting their potential for both structural efficiency and design appeal.https://www.irjmets.com/uploadedfiles/paper//issue_7_july_2024/60001/final/fin_irjmets1720612752.pdf

Naktode, P.L. (2022) conducted a comparative study on the behavior of oblique and Y-shaped reinforced concrete (RC) columns in high-rise structures. The research focused on 6-story residential buildings, emphasizing the need to enhance usable floor area, given the high cost of residential RC construction. The study explored alternatives to conventional rectangular and square columns, including floating columns, central core columns, and cantilever beam structures. Using ETABS 2013 for analysis and design, the research compared oblique and Y-shaped columns in terms of structural performance and efficiency, highlighting their potential to optimize space utilization while maintaining stability and safety.https://www.ijtsrd.com/papers/IJTSRD50099.pdf

Hussain, S.N. (2022) investigated the structural behavior of high-rise buildings using oblique columns to enhance both aesthetics and performance. The study modeled the building plans in AutoCAD and conducted linear static and Response Spectrum Analysis in ETABS. Outer columns were considered as oblique columns with inclinations of 30°, 60°, and 90°, and their performance was compared with conventional vertical columns. Key parameters such as time period, base shear, storey displacement, and storey drift were evaluated, and the variations in results across different inclinations were presented through graphical representations. The study highlighted the significant influence of column inclination on structural response.https://ijarsct.co.in/Paper5970.pdf

Nandakumar, A. (2020) studied the seismic performance of high-rise buildings incorporating Y-shaped oblique columns.

Using ETABS 2016, the research analyzed storey displacement, storey drift, and storey stiffness to evaluate seismic resistance. The study compared structures with Y-shaped oblique columns, conventional columns, and shear walls, finding that Y-shaped oblique columns improved space utility and offered better seismic performance than conventional columns, though shear walls provided superior resistance. The study highlighted that Y-shaped columns are an efficient alternative for enhancing seismic resistance without significantly increasing concrete usage.https://www.ijirset.com/upload/2020/july/12_Analysis_NC.PDF

Wadekar, A. (2022) investigated improvements to the portal method for analyzing statically indeterminate building frames subjected to lateral loads such as wind, earthquake, and blast. The study proposed a "modified portal method" to enhance accuracy for one-bay multi-story frames. Analysis of twenty-seven building frames with varying bays and stories was performed using the finite element method in ETABS 2017, and results from the portal method, modified portal method, and finite element method were compared. The findings indicated that the modified portal method improved accuracy for single-bay frames but showed limited improvement for frames with multiple bays, highlighting its applicability for preliminary design and quick structural assessments.https://ijcrt.org/papers/IJCRT2201233.pdf

III. RESEARCH METHODOLOGY

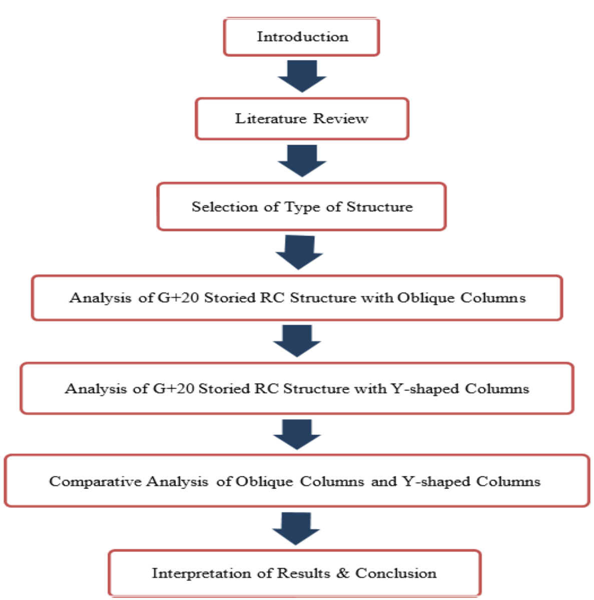

Fig 2. Layout of the Project

This study focuses on the comparative seismic performance of reinforced concrete (RC) structures with oblique and Y-shaped columns using STAAD.Pro. The methodology was designed to systematically achieve the research objectives through modeling, analysis, and evaluation.The research begins with a comprehensive literature review to understand the seismic behavior of unconventional column configurations and identify gaps in existing studies. Following this, two structural models of a G+20 storied RC building were developed: one with oblique columns and another with Y-shaped columns. Both models were subjected to seismic loading as per IS codes, including dead loads, live loads, and the weight of filler walls.

A linear elastic analysis method was adopted to evaluate the overall performance. To capture realistic seismic response, Time History Analysis was performed, focusing on critical structural parameters such as displacement, base shear, storey drift, stiffness, and time period.The results obtained from both models were systematically compared to assess the differences in performance under seismic excitations. Finally, the findings were interpreted to draw meaningful conclusions regarding the suitability and efficiency of oblique and Y-shaped columns as alternatives to conventional vertical columns in high-rise buildings.

IV. MODELING STRUCTURE IN ETABS

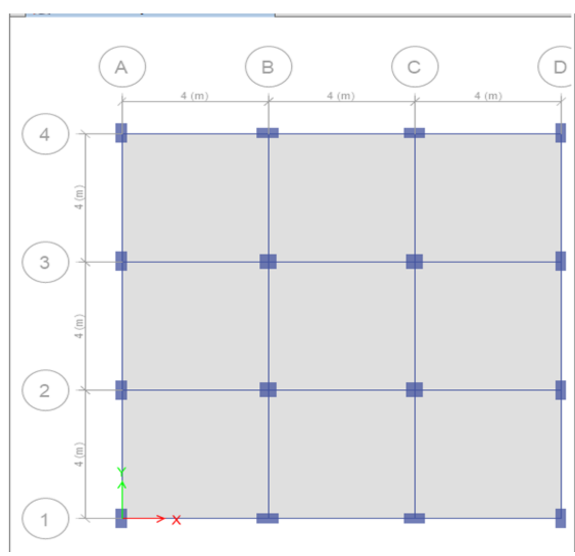

Fig 3. Plan view of the model

The image shows a structural grid layout of a building with 4×4 meter bays in both X and Y directions, forming a 4×4 column grid. The red and green arrows at point A1 represent boundary conditions or constraints, possibly indicating fixed or pinned supports in a structural analysis model.

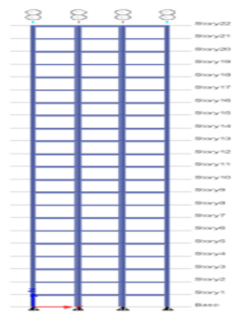

Fig 4. Front view of regular model

The image depicts a 22-story structural elevation view with vertical frames extending from the base to the top. Boundary conditions at the base suggest fixed supports, and the red and blue arrows indicate applied lateral loads or displacements, likely representing a seismic or wind load scenario.

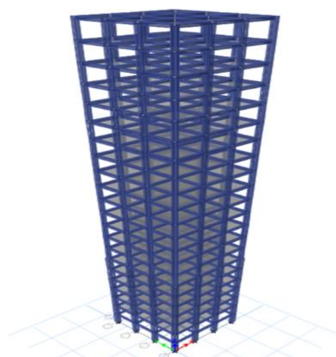

Fig 5. 3D view of regular model

The image shows a 3D structural model of a high-rise steel frame building, likely 22 stories tall, with a regular grid and moment-resisting frame system. The consistent bay spacing and bracing indicate it's designed to resist both gravity and lateral loads (e.g., wind or seismic forces).

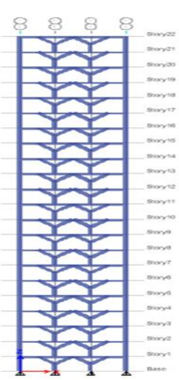

Fig 6. Front view of Y shaped column model

The image shows an elevation view of a 22-story building with diagonal bracing (likely chevron or X-bracing) in each bay, indicating a braced frame system for enhanced lateral load resistance. The applied lateral load (red arrow) and support conditions at the base suggest a structural model for seismic or wind analysis.

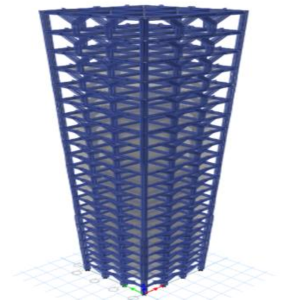

Fig 7. 3D view of Y shaped column model

This image shows a 3D view of a 22-story steel braced frame structure with diagonal (X-type) bracing on all exterior faces, forming a robust lateral load-resisting system. The uniform grid and bracing pattern suggest the structure is designed for high seismic or wind zones to ensure stability and stiffness.

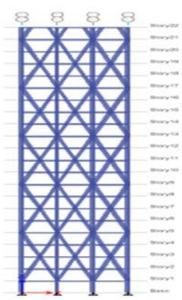

Fig 8. Front view of oblique column model

This image shows the elevation view of a 22-story building with a diagonal bracing system in a zigzag (inverted V and V) configuration, forming a diagonal braced frame. The structure is supported at the base and subjected to lateral loading, making it suitable for resisting seismic or wind forces efficiently by distributing loads through the braced elements.

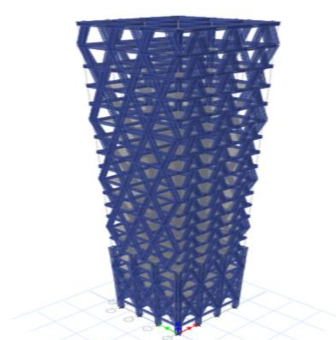

Fig 9. 3D view of oblique column model

This 3D model shows a 22-story diagonally braced tube structure with a diagrid system—a highly efficient structural design where diagonals form triangular modules on the exterior. This configuration minimizes the need for internal columns and enhances lateral stiffness, making it ideal for tall buildings in seismic or high-wind regions.

V. RESULT AND DISCUSSION

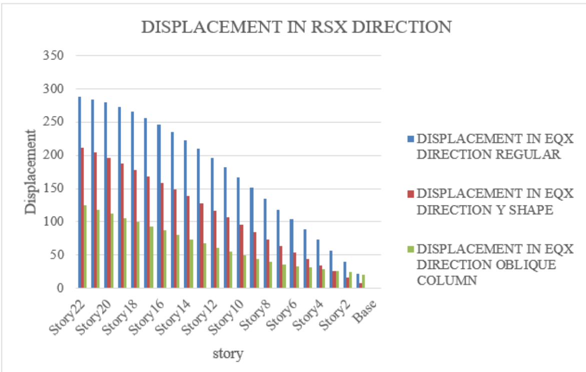

Fig 10. Displacement in RSX Direction

The graph compares lateral displacements in the RSX direction for three structural systems. The regular frame shows the highest displacement, followed by the Y-shaped braced frame, while the oblique column (diagrid) system has the least displacement, indicating the best lateral stiffness and seismic performance.

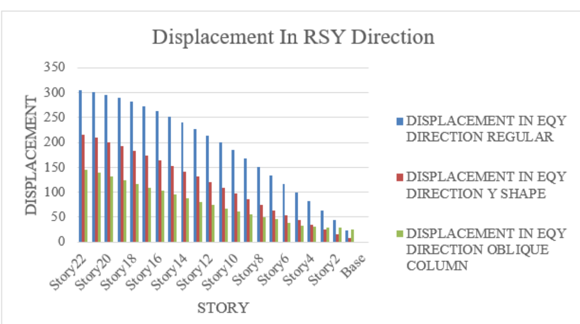

Fig 11. Displacement in RSY Direction

This chart shows displacement in the RSY (earthquake Y) direction for three structural systems. The regular frame (blue) again exhibits the highest displacement, while the oblique column system (green) has the lowest, confirming it provides the best lateral stability and performance under seismic loading in both directions.

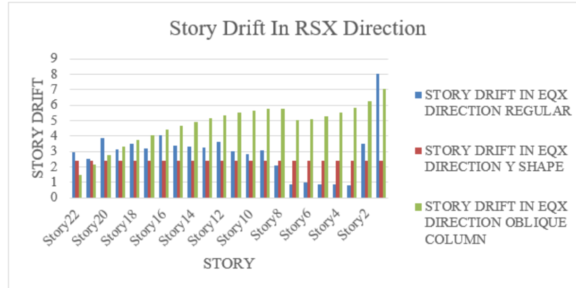

Fig 12. Story Drift in RSX Direction

The graph shows that the Y-shaped braced frame has the lowest story drift in the RSX direction, indicating better lateral stability. The regular frame has moderate drift, while the oblique column system experiences the highest drift, suggesting it may be less effective in controlling inter-story movements.

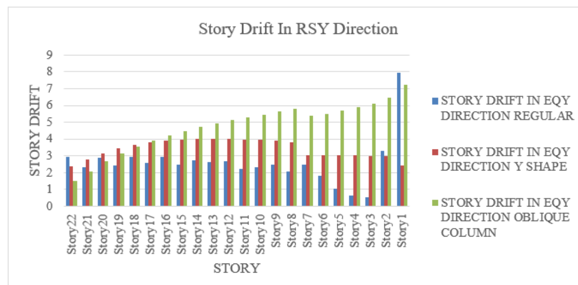

Fig 13. Story Drift in RSY Direction

The graph shows story drift in the RSY direction for three structural systems. The Y-shaped braced frame exhibits the lowest and most uniform drift, indicating better control of lateral deformation. The regular frame has moderate drift, while the oblique column system shows the highest drift, especially in the lower stories.

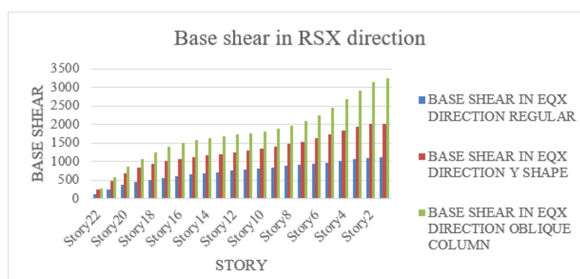

Fig 14. Base Shear in RSX Direction

The chart shows base shear distribution in the RSX direction for three structural systems. The oblique column system (green) experiences the highest base shear, indicating it carries the greatest lateral load. The Y-shaped braced frame (red) has moderate base shear values, while the regular frame (blue) carries the lowest base shear, reflecting its lower stiffness and load resistance capacity.

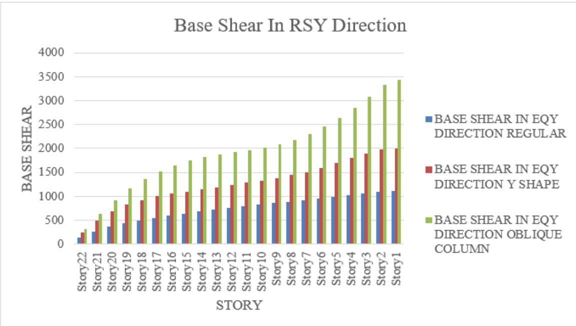

Fig 15. Base Shear in RSY Direction

The graph illustrates base shear distribution in the RSY direction for three structural systems. Similar to the EQX direction, the oblique column system (green) carries the highest base shear, followed by the Y-shaped braced frame (red), while the regular frame (blue) experiences the lowest base shear. This highlights the superior lateral load resistance of the oblique column configuration in both directions.

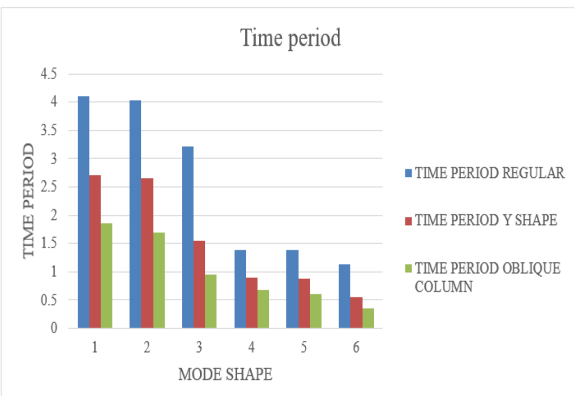

Fig 16. Time Period

The graph shows the time periods for the first six mode shapes of three structural systems. The regular frame has the longest time periods, indicating it is the most flexible. The Y-shaped braced frame has shorter time periods, showing increased stiffness. The oblique column system has the shortest time periods, reflecting the highest stiffness and fastest vibration response among the three.

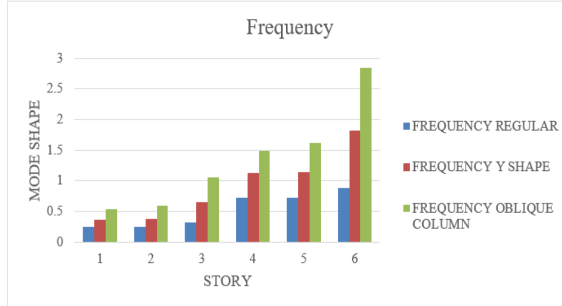

Fig 17. Frequency

The graph shows the natural frequencies of the first six mode shapes for three structural systems. The oblique column system (green) has the highest frequencies, indicating it is the stiffest. The Y-shaped braced frame (red) has moderate frequencies, while the regular frame (blue) has the lowest frequencies, reflecting its more flexible nature. Higher frequency means quicker response to dynamic loads.

VI. CONCLUSION

This study presented a comparative analysis of reinforced concrete high-rise buildings with regular vertical columns, Y-shaped columns, and oblique columns (diagrid system) using ETABS. The seismic performance of the three structural systems was evaluated under critical parameters, including displacement, storey drift, base shear, time period, and frequency.The results demonstrate that the oblique column system exhibits superior stiffness and lateral stability, as indicated by its lowest displacement values and shortest time periods. This system also carried the highest base shear, highlighting its enhanced capacity to resist seismic forces. However, the oblique system showed higher storey drift in certain directions, which may require additional considerations for serviceability and occupant comfort.The Y-shaped column system provided balanced performance, showing reduced story drift compared to the oblique system while maintaining moderate stiffness and base shear. This indicates that Y-shaped configurations are efficient in controlling inter-story deformations and can serve as a practical alternative to conventional designs.The regular column system, while simplest in design, exhibited the highest displacements and longest time periods, making it the least efficient under seismic conditions.Overall, the findings suggest that adopting oblique and Y-shaped column systems can significantly improve the seismic resilience of high-rise structures, offering both structural and architectural advantages.

VII. FUTURE SCOPE

The present study focused on the comparative seismic performance of reinforced concrete high-rise structures with oblique and Y-shaped columns using ETABS. While the findings highlight the advantages of these unconventional column systems over regular columns, several areas remain open for further research and practical application.Future work can explore the performance of such systems under nonlinear analysis methods, including pushover analysis and nonlinear time history analysis, to capture inelastic behavior and ultimate load-carrying capacity. The influence of different seismic zones, soil conditions, and foundation flexibility can also be studied to provide a more comprehensive understanding of structural behavior in real-world conditions. Additionally, varying the inclination angles of oblique columns or geometrical configurations of Y-shaped columns could help identify the most efficient designs for specific building heights and functions.From a practical perspective, research should also focus on construction techniques, material optimization, and cost-benefit analysis, as these innovative column systems may affect labor requirements, construction timelines, and material consumption. Integration with sustainable practices, such as the use of high-performance concrete or composite materials, may further enhance their viability.Thus, expanding the study in these directions will contribute to developing safer, more economical, and architecturally versatile high-rise structures for future urban environments.

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