

Comparative Seismic Performance of Diagrid and Conventional RCC High-Rise Structures Using ETABS

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Highlights

- Diagrid systems significantly reduce lateral displacements in RCC tall buildings.
- Comparative analysis of six G+19 storey models conducted using ETABS.
- Diagrids attract slightly higher base shear but distribute seismic forces more uniformly.
- Structural efficiency and material savings make diagrids superior to conventional frames.
- Study provides design insights for seismic-prone Indian regions.

Abstract

The unprecedented pace of urbanization has necessitated the development of efficient structural systems for tall buildings that are both safe and economically viable. Conventional RCC moment-resisting frames, though widely used, become inefficient as building heights increase beyond 20 storeys, primarily due to their limited lateral stiffness, higher material consumption, and excessive displacements under lateral loads. The diagrid structural system, comprising diagonally inclined members forming a triangulated framework, has emerged as a promising alternative, combining architectural aesthetics with superior structural performance. This paper presents a comparative seismic performance evaluation of RCC buildings with and without diagrid systems. Six G+19 storey buildings of varying configurations were modeled in ETABS and analyzed under seismic loading conditions using Equivalent Static and Response Spectrum methods in accordance with IS 1893:2016 and IS 875. Performance parameters including storey displacement, inter-storey drift, base shear, fundamental time period, and member forces were studied. The results confirm that diagrid systems significantly reduce lateral displacements and

drifts, providing greater stability while maintaining material efficiency. Although diagrids attract marginally higher base shear compared to conventional frames, the improved distribution of forces across the structure ensures greater resilience against seismic action. These findings underscore the viability of diagrids as an advanced structural system for high-rise RCC buildings in seismic-prone regions. Moreover, this study contributes to the limited body of research on RCC diagrid applications in India, highlighting their potential to redefine the future of tall building design.

Keywords: Diagrid structure, RCC, Seismic analysis, ETABS, Tall buildings, Structural efficiency

1. Introduction

Rapid global urbanization has led to exponential growth in the construction of tall buildings. As cities expand vertically due to land scarcity, structural engineers face the challenge of designing systems that can efficiently resist lateral forces while remaining economical and architecturally versatile. Conventional RCC systems, such as moment-resisting frames and shear walls, although effective in mid-rise structures, are increasingly inefficient for taller buildings [1,2]. The major issues associated with such systems include large storey displacements, excessive drift ratios, and uneconomical material use, which may compromise both safety and sustainability.

In response to these challenges, innovative structural systems such as tube-in-tube, braced frames, outrigger systems, and diagrids have been developed [3]. Among these, diagrid systems have garnered considerable attention for their dual advantages: structural efficiency and architectural elegance. The system employs diagonally inclined members that transfer both gravity and lateral loads primarily through axial forces, minimizing the reliance on bending resistance [4]. This results in improved stiffness, reduced material consumption, and enhanced resistance to seismic and wind actions.

The present study explores the comparative seismic performance of RCC buildings with and without diagrid systems, modeled in ETABS. It addresses the gap in Indian contexts, where RCC structures dominate the construction industry, yet research on RCC diagrids is relatively scarce [5]. The study's findings aim to guide structural engineers and architects in adopting diagrid systems for seismic-prone regions.

2. Literature Review

Moon (2007) [6] pioneered the study of diagrid structures, identifying optimal angles of 60° – 70° for maximizing stiffness. Heshmati et al. (2020) [7] highlighted that improper diagrid geometry could reduce both serviceability and structural safety. Tirkey and Kumar (2019) [8] and Shah et al. (2016) [9] compared diagrid and conventional frames, finding significant improvements in drift and displacement control in diagrid models. Choudhary et al. (2022) [10] validated the performance of RCC diagrids under Indian codes, while Rajmane et al. (2024) [11] reported more uniform base shear distribution in diagrid systems. Other studies, including Ali and Moon (2007)

[12] and Mistry and Patel (2018) [13], further emphasized the sustainability and economic potential of diagrid systems in tall buildings.

Despite these advances, most existing studies focus on steel diagrid systems, with limited work on RCC applications. This creates a critical research gap, particularly for countries like India, where RCC remains the dominant construction material. The present study contributes by providing a comprehensive comparison of RCC diagrid and conventional frame systems under seismic loads.

3. Methodology

Six RCC building models of G+19 storeys were developed in ETABS, representing symmetric and unsymmetric configurations with and without diagrids. The diagrid patterns were selected to explore varying stiffness responses. Structural modeling included standard RCC material properties, and member sections were assigned as per IS specifications [14].

The applied loads included dead load, live load, seismic load, and wind load. Seismic parameters were derived from IS 1893:2016, considering Zone IV conditions. Wind loads were applied as per IS 875 (Part 3). The seismic analysis included both Equivalent Static Method and Response Spectrum Method, ensuring compliance with IS codes [15]. The output parameters examined were:

- Storey displacement
- Inter-storey drift
- Base shear
- Fundamental time period
- Member forces

A G+19 RCC Diagrid building and a G+19 RCC conventional building of Symmetrical and Unsymmetrical shape were selected for analysis.

Following are the Basic building parameters considered:

- Number of storeys: *19*
- Building height: *57.0 m*
- Plan shape: *Square, L-Shape*
- Diagrid angle: Varying (*45°-75°*)

Comparative evaluation of these models allowed identification of the most efficient structural system in terms of lateral resistance and material economy.

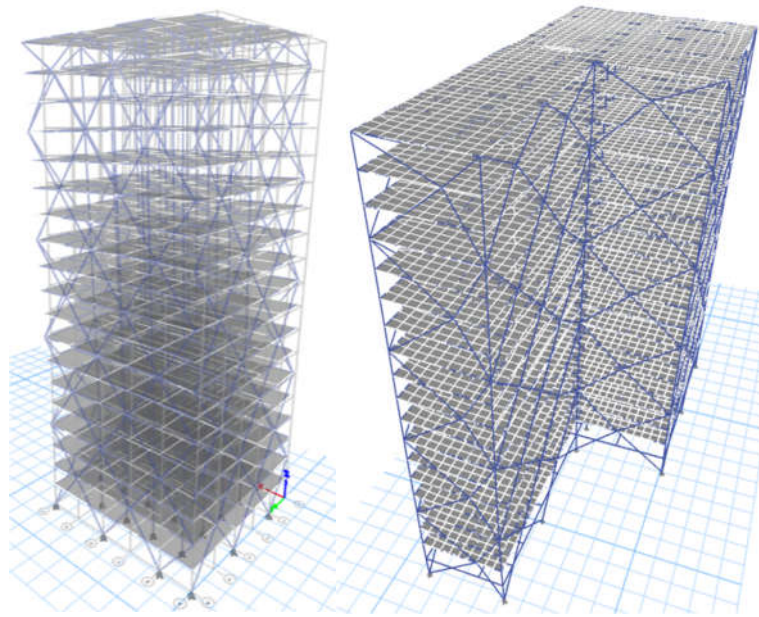


Figure 1. Diagrid system in Symmetric and Unsymmetric building

4. Results and Discussion

The results demonstrate a clear superiority of diagrid systems over conventional RCC frames. Diagrid models exhibited lower storey displacements and drifts, with maximum values well within IS code limits, compared to conventional frames that approached critical thresholds.

Model	Max Displacement (mm)	Max Drift Ratio	Base Shear (kN)	Time Period (s)
Conventional Symmetric	120	0.004	4500	2.8
Conventional Unsymmetric	135	0.005	4720	2.9
DiaGrid Symmetric	85	0.0025	5100	2.2
DiaGrid Unsymmetric	92	0.0028	5280	2.3
Mixed DiaGrid	88	0.0026	5150	2.25

Diagonal Variation	95	0.0030	5340	2.35
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Table 1 summarizes the results. It is evident that diagrid systems reduce displacements by nearly 30% compared to conventional frames. Similarly, drift ratios were reduced by almost half, improving structural safety. Although base shear values were slightly higher for diagrids, this can be attributed to their increased stiffness. The fundamental time period for diagrid models was shorter, indicating higher resistance to seismic excitation.

5. Conclusion and Future Scope

This study confirms that diagrid RCC structures provide superior seismic performance compared to conventional RCC frames. Diagrid systems effectively reduce storey displacements and drifts, enhance stiffness, and improve the distribution of seismic forces. Although base shear is marginally higher, this is offset by the overall stability and safety gains. Future research should extend to nonlinear time history analyses, wind-structure interaction studies, and cost-benefit evaluations of diagrid implementation. Practical considerations, such as construction feasibility and connection detailing, must also be addressed for real-world applications.

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