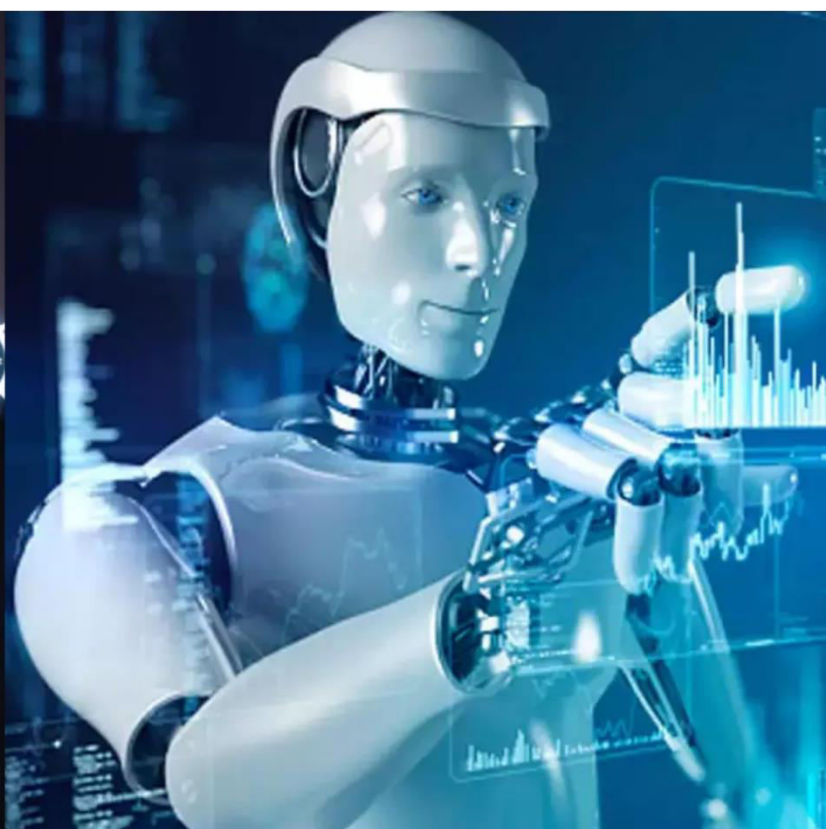




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Comparative Study on Seismic Behaviour of G+15 Storey Composite Structure with and without Bracing System using the Time History Analysis

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ABSTRACT: This project presents a comprehensive seismic performance evaluation of a G+14 story asymmetric, L-shaped RC building using advanced structural analysis. High-rise asymmetric structures are highly susceptible to torsional effects and severe damage during seismic events due to the eccentricity between the centre of mass and the centre of rigidity. To mitigate these hazards, this study investigates the effectiveness of different structural steel bracing systems. Three distinct structural configurations are modelled and simulated using the state-of-the-art finite element software ETABS: a bare frame model with no bracing, a model incorporated with X-bracing, and a model featuring single diagonal bracing. All three models are assumed to be located in Seismic Zone IV of India as per the provisions of IS 1893 (Part 1): 2016. To capture the exact dynamic behaviour of the buildings under realistic, time-dependent ground motions, a rigorous dynamic analysis is conducted using the Time History Method.

KEYWORDS: High Rise Structure, Bracing, Time History Analysis.

I. INTRODUCTION

Urbanisation and population growth have triggered a global surge in high-rise constructions. Modern architectural and functional needs often demand asymmetric building layouts. Among these shapes, L-shaped configurations are highly popular for optimizing urban land use and facilitating natural lighting. However, high-rise buildings constructed in seismically active regions face substantial design challenges. Asymmetric configurations create an inherent mismatch between the building's centre of mass (CM) and centre of rigidity (CR). This physical eccentricity triggers a severe torsional response under lateral seismic loads, inducing uneven stresses across structural components that often lead to sudden localized failures.

India features a highly volatile seismic profile divided into four distinct seismic zones. Seismic Zone IV denotes a "High Damage Risk Zone" featuring a severe Zone Factor ($Z = 0.24$). Major cities and expansive regions located within this zone face a high likelihood of experiencing intense ground shaking. Standard RC bare frame systems often lack the necessary lateral stiffness and torsional resistance to limit drift deformations during Zone IV seismic events. Consequently, engineering designs must utilize supplemental structural systems—such as structural steel bracings—to absorb and distribute destructive lateral forces safely down to the foundations

Steel bracings offer an efficient, economical, and high-performance solution for retrofitting or designing seismic-resistant high-rise structures. They drastically reduce lateral displacement and inter-story drift limits. They form a clear, dedicated path for lateral load transfer. They add immense structural redundancy, which directly helps counter structural torsion in asymmetric L-shaped layouts.

This project evaluates the performance of two prominent bracing styles: X-Bracing: Provides robust bidirectional structural stiffness. Diagonal Bracing: Delivers target stiffness along specific directional lines

II. OBJECTIVES

- Examine the seismic behaviour of a G+14 composite structure through time history analysis for seismic zone IV.
- Create and assess 3 composite buildings one without bracing second with x bracing and third with diagonal bracing systems.
- Analyse the impact of bracing on floor displacement and inter-storey drift.
- Investigate the changes in base shear and structural stiffness when subjected to earthquake forces.
- Evaluate the appropriateness of bracing systems for high-rise composite structures located in seismic zones IV.

III. METHODOLOGY

- A composite building model with 15 stories is created utilizing ETABS software for the purpose of seismic analysis.
- Three distinct structural models are developed: one without a bracing system another incorporating X bracing system and third one with diagonal bracing.
- Material characteristics, cross-sectional dimensions, and loading conditions are specified in accordance with the structural requirements, codes & standards.
- Seismic forces are applied and a time history analysis is performed using data from earthquake ground motion.
- The structural response metrics, including storey displacement, inter-storey drift and base shear are assessed.
- The results obtained are compared to examine the effect of the bracing system on seismic performance.

[Building Geometry Setup (L-Shape G+14)]



[Material & Section Properties (IS 456 & IS 800)]



[Load Assignments (Dead, Live, & Seismic Zone IV)]



[Apply Bracing Systems (None vs. X-Bracing vs. Diagonal)]



[Run Time History Analysis (Ground Motion Scaling)]



[Extract & Compare Structural Responses]

IV. FLOOR PLAN & MODELS

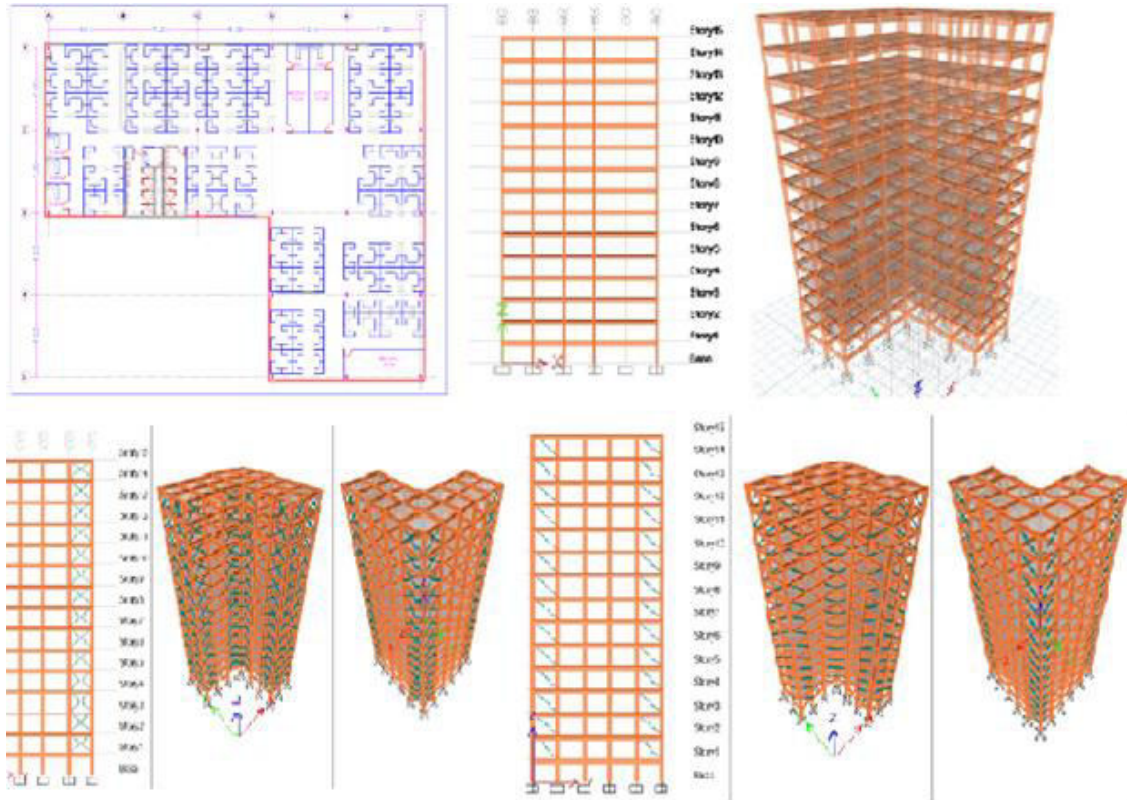


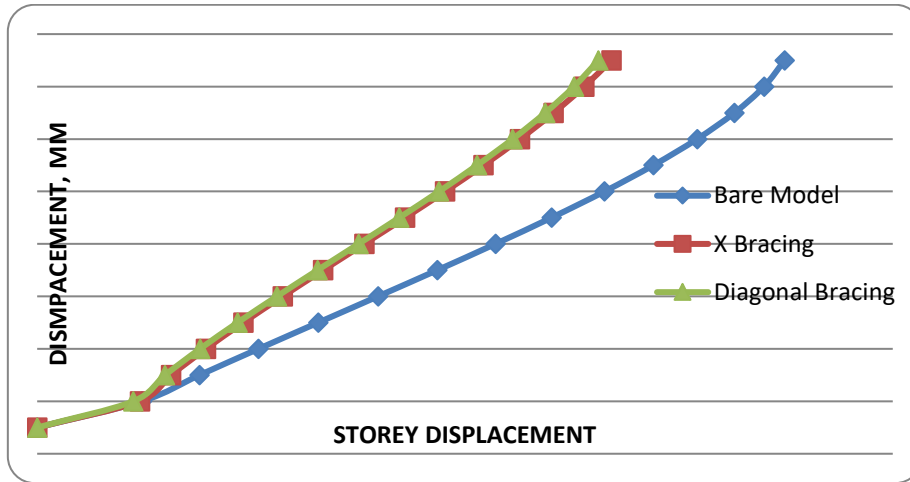
Figure 1: Floor plan, Bare frame, X bracing & Diagonal bracing model

V. EXPERIMENTAL RESULTS

1. Storey Displacement

Storey Displacement			
Story	Bare Model	X Bracing	Diagonal Bracing
15	43.682	33.553	32.801
14	42.478	31.969	31.374
13	40.749	30.182	29.692
12	38.568	28.212	27.791
11	36.012	26.086	25.708
10	33.153	23.838	23.484
9	30.055	21.501	21.16
8	26.781	19.113	18.78
7	23.386	16.714	16.384
6	19.918	14.344	14.013
5	16.422	12.043	11.711
4	12.936	9.856	9.516
3	9.492	7.828	7.472
2	6.116	6.007	5.62
1	0	0	0

Table 1 Storey displacement

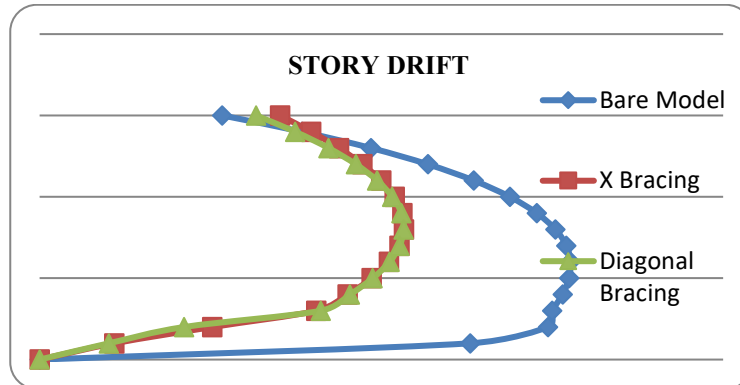


Graph 1: Storey Displacement

2. Storey Drift

Storey Drift			
Story	Bare Model	X Bracing	Diagonal Bracing
15	0.000401	0.000528	0.000475
14	0.000576	0.000596	0.000561
13	0.000727	0.000657	0.000634
12	0.000852	0.000708	0.000694
11	0.000953	0.00075	0.000741
10	0.001032	0.000779	0.000774
9	0.001091	0.000796	0.000794
8	0.001132	0.0008	0.000799
7	0.001156	0.00079	0.00079
6	0.001165	0.000767	0.000768
5	0.001162	0.000729	0.000731
4	0.001148	0.000676	0.000681
3	0.001125	0.000607	0.000617
2	0.001116	0.000379	0.000317
1	0.000945	0.0001643	0.000152
0	0	0	0

Table 2 Story drift



Graph 2: Storey Drift

3. Storey Shear

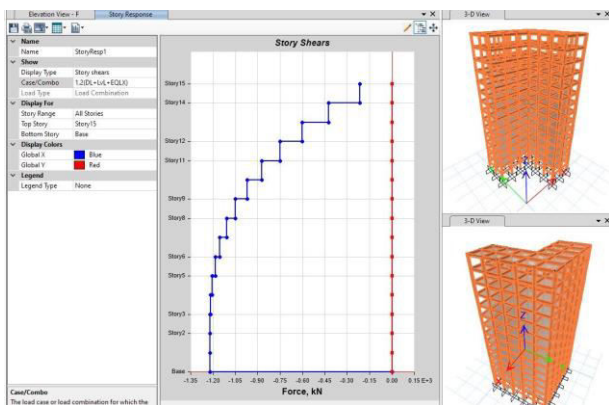


Figure 2: Storey Shear of Bare Frame

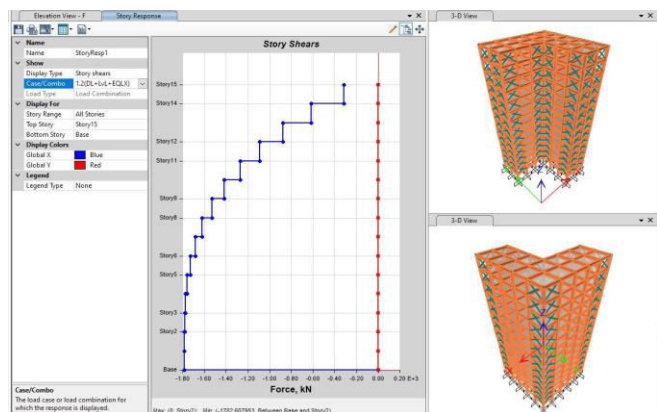


Figure 3: Storey Shear of X-Bracing Frame

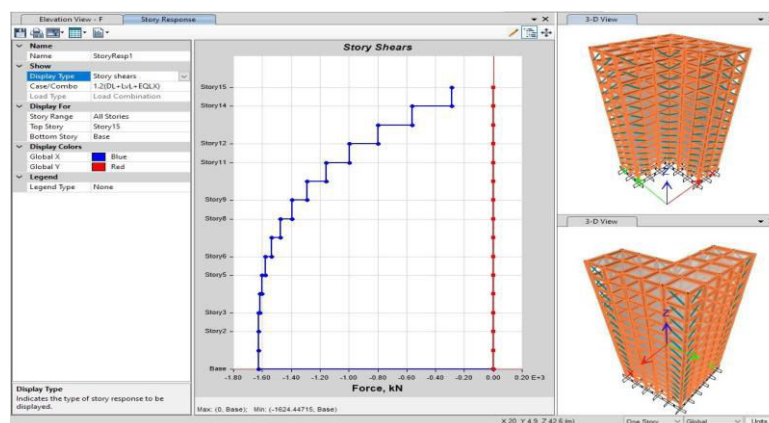


Figure 4: Storey Shear of Diagonal Bracing Frame

4. Overturning Moment

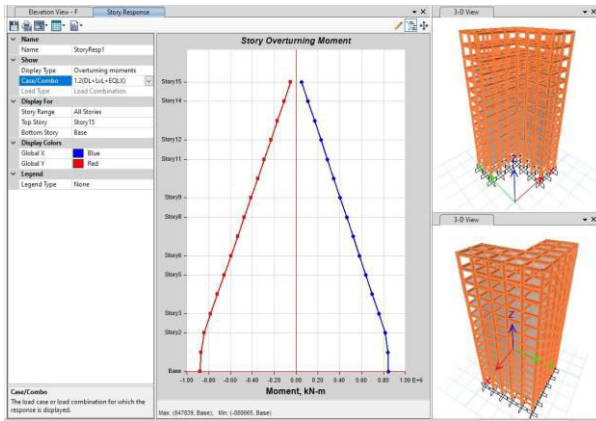


Figure 5: Overturning Moment of Bare Frame

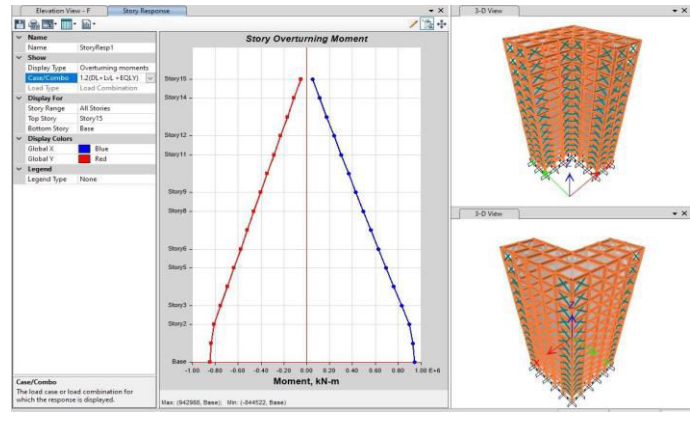


Figure 6: Overturning Moment of X-Bracing Frame

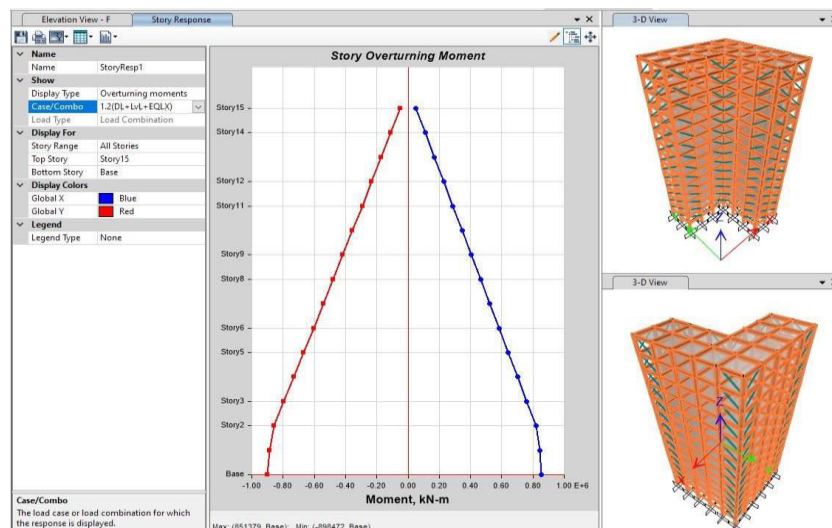


Figure 7: Overturning Moment of Diagonal Bracing Bracing Frame

VI. CONCLUSION

- **Displacement reduction:** Steel bracing systems significantly limit lateral movement. Diagonal bracing has reduced displacement in X-direction by 24.91% (32.801 mm), whereas X-bracing achieves a reduction of (23.19%) compared to the un-braced frame. Lateral deformation along the shorter Y-axis is effectively minimized. Diagonal bracing has reduced the deflection on the 15th floor to (25.645mm), representing a (24.32% reduction) compared to the bare structure at (33.885mm).
- **Compliance with code drift limits:** The maximum inter-storey drift values for all models remain comfortably within the safety limits established by IS 1893, staying well below the allowable threshold of (0.004 X story height = 0.004 x 45 m = 180mm).
- **Induced Overturning Moments:** The inclusion of rigid components increases the overall mass and base stiffness of the structure. Consequently, this results in a slight increase in the global overturning moments throughout the structural footprints. The highest overturning moment is recorded at (9,42,988 kNm) in the X-braced model when subjected to loading in the Y-direction. This demand necessitates substantial foundation sizing requirements.

VII. SCOPE OF FUTURE WORK

- **Asymmetric Optimization and Layout Planning:** Experimenting with shifted or strategically symmetrical configurations of bracings can bring down the issues arising from the eccentricity between the centre of mass and the centre of stiffness inherent in L-shaped designs.
- **Comparative cost and material optimization:** Conducting comprehensive cost analysis comparisons between concrete shear walls and steel bracing systems assesses the financial difference in regions facing significant seismic activity.
- **Advanced non-linear pushover performance:** Implementing non-linear static pushover procedures allows for the isolation of plastic hinge formulation tracking, thereby uncovering the actual ultimate collapse mechanisms present in various structural components.

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