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AN APPROACH FOR COMPARATIVE ANALYSIS OF HIGH-RISE STRUCTURES CONSIDERING VARIOUS TYPES OF TORSIONAL IRREGULARITIES UNDER WIND LOAD

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ABSTRACT

These types of torsional irregularities of high-rise buildings tend to have a major impact on how a building is affected with wind forces and may put the safety and function of the structure at risk. In this case, the focus is on the high-rise buildings with different kinds of torsional irregularities, which is now dissected concerning its behavior and the performance under wind loads. The analysis includes the computation of buildings with different mass, stiffness, geometric factors and their torsional response together with the wind load resistance factors. State-of-the-art methods of computational modeling and simulations are used to estimate displacements and rotations as well as the stress concentration and distribution. Parameters such as the torsional amplification factor or the dynamic response characteristics analyses are used where a dependency on the type and degree of irregularity is observed. The reveal of a high relevance of the torsional irregularities was demonstrated differently, for some configurations of the building irregularities increases the torsional effects and thus stress concentrations together with lateral displacements. Furthermore, design recommendations are given on how to minimize these unwanted torsional effects including the recommendations for the inspired symmetry of structure, optimal strength, and increased damping abilities. This work provides insights into the design and evaluation of high-rise structures to ensure their safety and resilience against wind loads, contributing to the development of improved design codes and practices for torsionally irregular buildings.

Keywords: High-Rise Structures, Torsional Irregularities, Wind Load, Structural Analysis, Dynamic Response And Lateral Displacement Etc.

I. INTRODUCTION

High-rise building design and construction also produce an important factor in skyscraper design and construction, namely, in urban development where it is common to have taller and thinner buildings. Despite that, wind loads are among the crucial environmental loads applied to high-rise buildings, which can massively induce lateral and torsional vibrations due to their intense and low-frequency action. Wind forces have a greater impact on torsionally irregular structures which can cause uneven stress distribution in structures, excessive deformation, and ultimately failure, if not sufficiently addressed. High-rise buildings are unique in that they present challenges for the structural design process, including the complexities of geometry, increasing heights, and the necessity to resist lateral forces such as wind and seismic loads. One of those forces are wind loads which significantly influence dynamic response and stability behavior of tall structures. Similar properties in the mass, stiffness or geometry that cause torsional irregularities become more unusual during wind, making the load uneven and leading to higher deformations and vulnerabilities. Hence, torsional irregularities need to be understood and their effects mitigated to safeguard the safety and performance of high-rise buildings.

Torsional irregularities

The structural imbalance known as torsional irregularity appears when building stiffness and mass distribution produce uneven twisting effects known as torsion during wind or earthquake events. High-rise and complex structures require particular attention to the oddities which play a key role in structural dynamics because they substantially influence seismic actions and stability performance. The cause of torsional irregularities

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originates from buildings that exhibit asymmetrical layouts during design. A building experiences lateral displacement when equipment and furniture are unbalanced on one side since their weight shifts the center of mass from center of stiffness. Building structures with lateral forces such as seismic activity produce rotational motion at the center of stiffness that results in increased displacement for specific building elements. Torsional imbalance in buildings occurs due to strange floor layout patterns including the combination of L-shaped or T-shaped elements and the uneven arrangement of bracing systems and shear walls. A building's stiffness reduces in proportion to unenclosed areas on a single facade including large windowpanes and unobstructed parking lots. This reduces overall torsional stability.

II. OBJECTIVES

Through this analysis, the research seeks to achieve the following objectives:

- High-rise structures with torsional irregularities need evaluation regarding wind-induced forces to understand their impact on stress distribution, lateral displacement and torsional moments along with overall stability.
- The study seeks to recognize particular torsional irregularity types like mass eccentricity and stiffness asymmetry and irregular building configurations which increase structural vulnerability when subjected to wind forces.
- The research compares different high-rise structures through performance analysis of their degrees and types of torsional irregularities to identify the most and least resilient configurations.

III. METHODOLOGY

In this section of study consider a G + 29 floor high rise structure for analysis with the help of SAP2000. Modeling and analysis work perform in SAP2000. There are total 4 models at initial case-1 have G+29 bare frame without any torsional irregularity, in case-2 prefer torsional Irregularity due to change in slab thickness, in case-3 torsional Irregularity due to increase alternate floor height, at last for case-4 consider torsional Irregularity due to consider cantilever projection. Compare all each case with bare frame and study that in which case torsional irregularity have maximum effect.

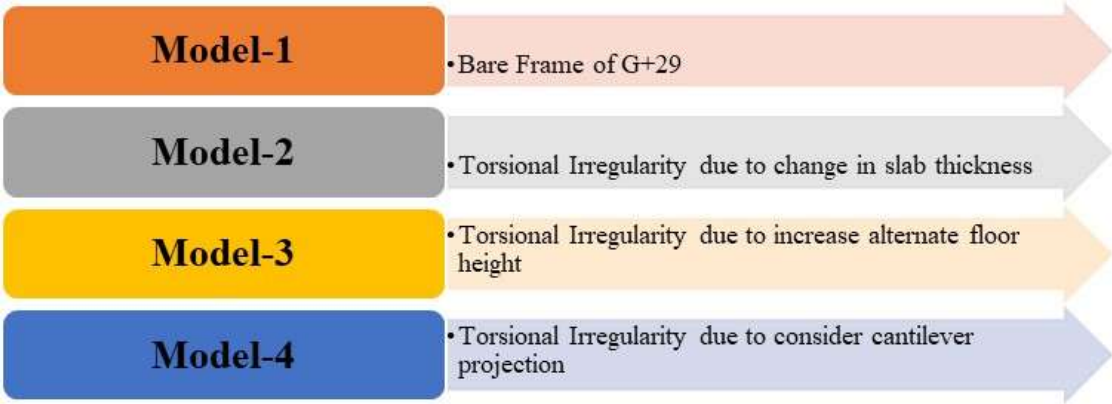

Figure 1: Research Cases

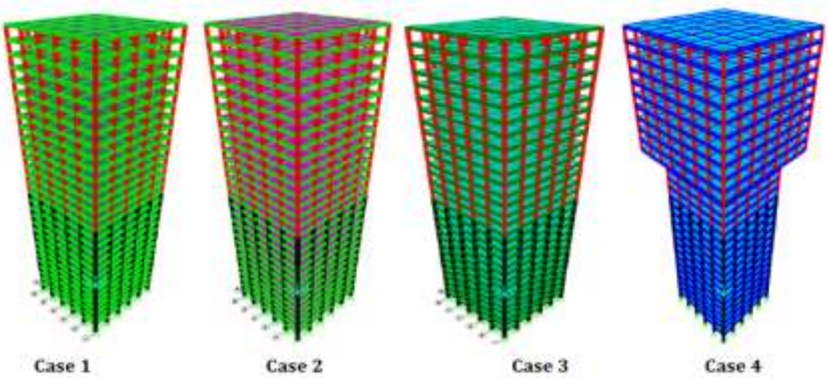

Figure 2: 3-D Views of Bare frame with Different Visuals

Table 1: Geometrical Specification

S No.	Data	Value
1	Grade of steel	HYSD 500
2	Grade of concrete	M30
3	No. of stories	G+29
4	No. of bay along X-direction	5
5	No. of bay along Y-direction	5
6	Span along X-direction	5m
7	Span along Y-direction	5m
8	Floor height	3m
9	Column size 700*700 mm	(1^{st} to 15^{th} floor)
10	Column size 600*600 mm	(16th to 30th floor)
	Beam size	600*500 mm
11	Depth of Slab	200mm
12	wall load	13.8 kN/m
13	Live load	3 kN/m^2
14	Software	CSI SAP 2000
15	Wind Load	IS 875-2015 (Part – 3)
16	Windward coefficient, Cp	0.8
17	Leeward Coefficient, Cp	0.25
18	Wind Speed	50
19	Terrain category	2
20	Importance factor	1
21	Risk Coefficient (K 1 factor)	1
22	Topography (K3 factor)	1

IV. RESULTS AND DISCUSSION

In this chapter, data from each model is collected after performing the structural analysis in SAP2000. The analysis results include various parameters such as lateral displacement, story drift, base shear, torsional effects, and overall structural stability under different conditions. Each model's performance is carefully recorded and documented to facilitate a comprehensive comparison. Once the necessary data is obtained, graphs are generated to visually represent the structural response of each case.

Results of Joint Displacement

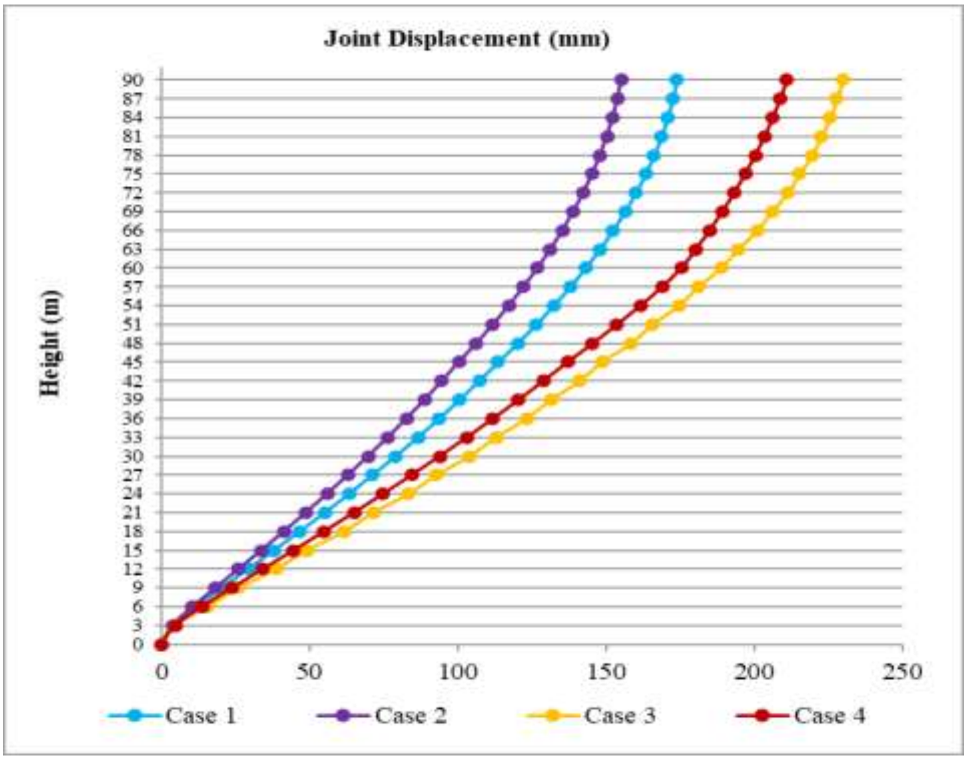

Figure 3: Joint displacement of model in Different cases caused by 1.5 (DL+LL+WL-X)

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Results of Storey Drift

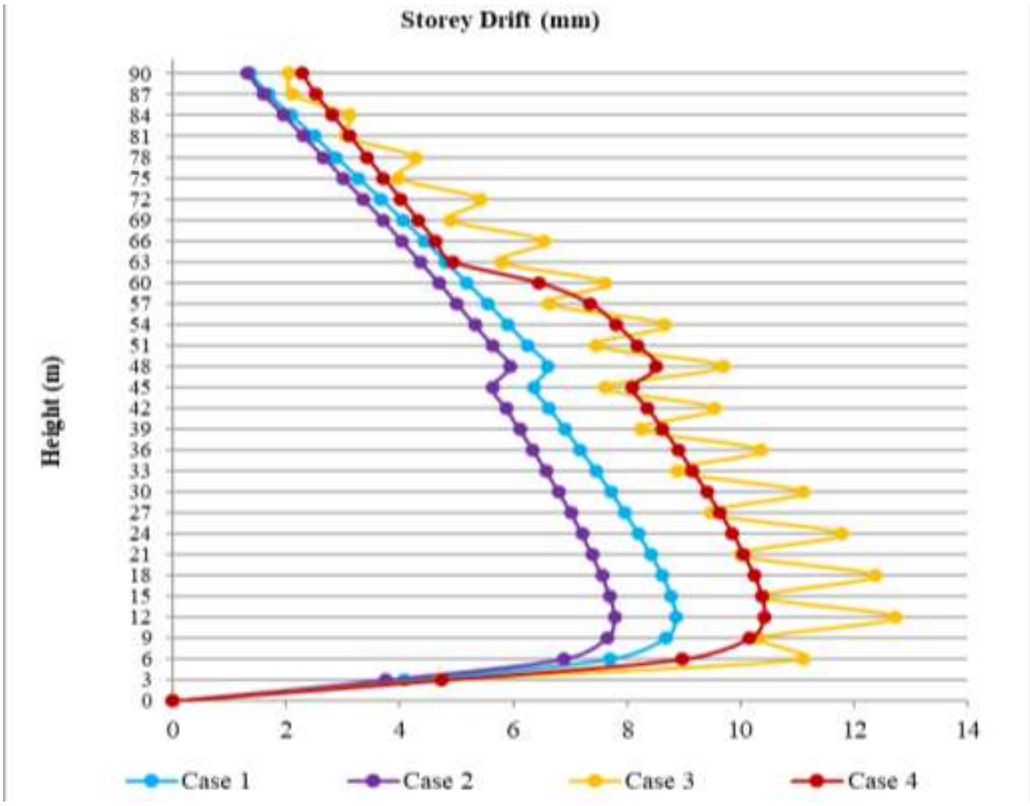

Figure 4: Storey drift of model in Different cases caused by 1.5 (DL+LL+WL-X)

Results of Bending moment

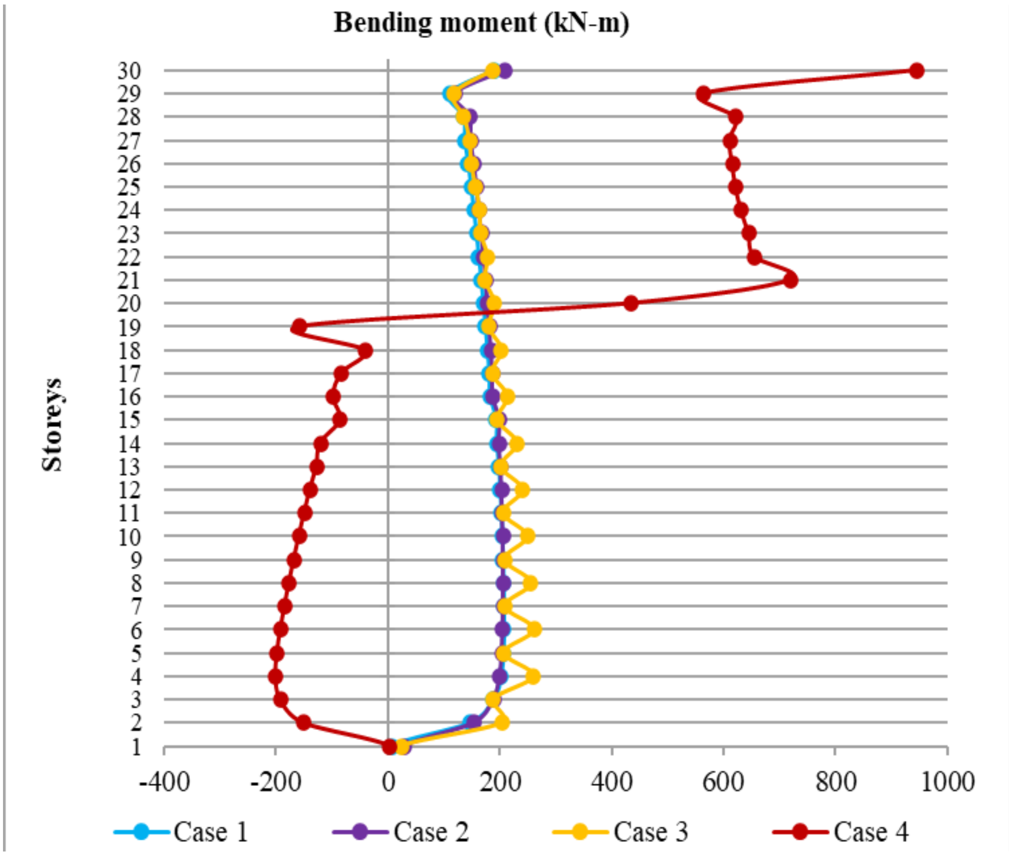

Figure 5: Bending moment of model in Different cases caused by 1.5 (DL+LL+WL-X)

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Results of Shear force

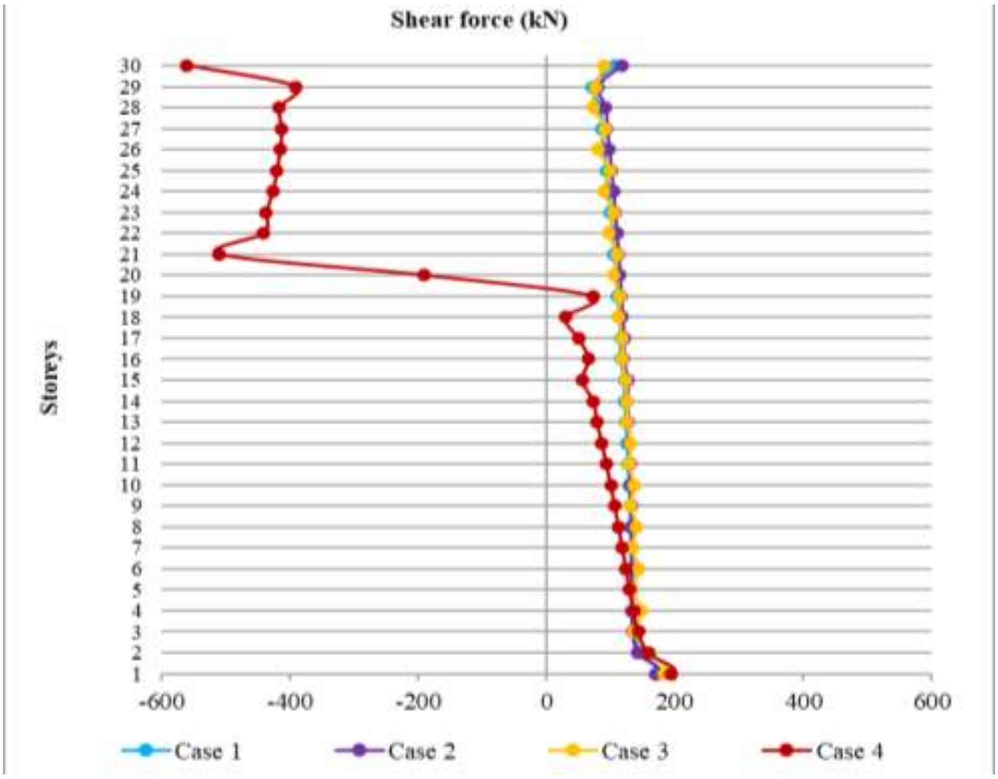

Figure 6: Shear force of model in Different cases caused by 1.5 (DL+LL+WL-X)

Results of Torsion

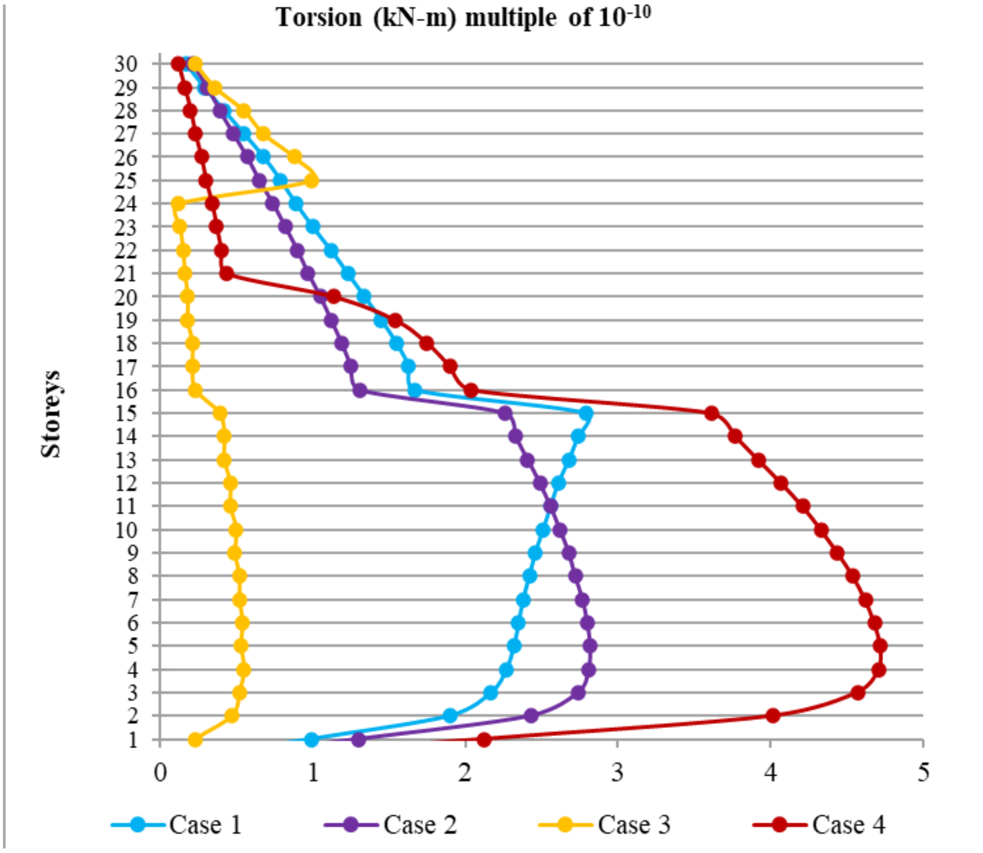

Figure 7: Torsion of model in Different cases caused by 1.5 (DL+LL+WL-X)

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Results of Base shear V/s Time Period

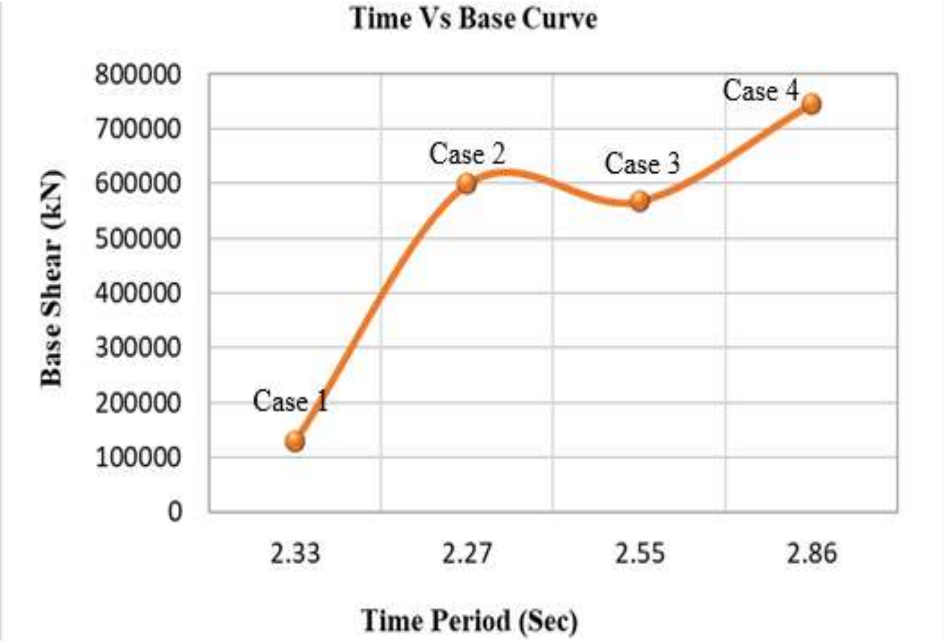

Figure 8: Time period vs Base shear of Model in All cases

V. CONCLUSION

The structural response of a G+29 frame varies significantly with torsional irregularities caused by slab thickness changes, alternate floor height variations, and cantilever projections.

- Joint Displacement decreased by 10.73% with slab thickness changes but increased by 32.21% and 21.39% with alternate floor heights and cantilever projections, respectively.
- Storey Drift reduced by 12.18% with slab thickness changes but increased by 39.61% and 17.49% in other cases.
- Bending Moment slightly increased by 0.87% with slab thickness changes but surged 26.00% and 356.70% with alternate floor heights and cantilever projections.
- Shear Force decreased by 1.61% with slab thickness changes but increased 6.60% and 225.18% in other cases.
- Torsion slightly increased by 1.07% with slab thickness changes but showed a 64.51% decrease with alternate floor heights and a 69.17% increase with cantilever projections.
- Base Shear & Time Period varied across cases, with the highest base shear (745,990.36 kN) and longest time period (2.86 sec) observed for cantilever projections.

Overall, torsional irregularities significantly impact structural behavior, with cantilever projections causing the most extreme effects on bending moments, shear forces, and torsion. Structural modifications should be carefully considered to optimize stability and performance.

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