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Analysis of a Multistory Commercial Building using ETABS

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Abstract

Shear walls are essential structural elements in RCC buildings, providing both vertical support and resistance to lateral forces. They enhance the strength and stiffness of high-rise buildings, especially when exterior walls can't provide enough support. This study focuses on determining the optimal location of shear walls in unsymmetrical high-rise buildings. Various shear wall locations and shapes are analysed using ETABS software for strength and stability. In this storey drift and storey displacement were studied.

Keywords: Shear walls, lateral forces, high-rise buildings, optimal location, story drift, story displacement, structural analysis, shear wall shapes & ETABS.

1. Introduction

Reinforced concrete shear walls are critical vertical elements in high-rise buildings, designed to resist lateral forces from wind and seismic activity while supporting gravity loads. Their shape and placement—such as rectangular, L-, T-, or U-shaped—play a vital role in providing lateral rigidity and minimizing torsional effects. Properly located shear walls ensure efficient lateral load resistance and structural stability. Story drift, measured as the inter-story drift ratio, reflects relative horizontal displacement between floors and is essential for evaluating potential damage. Story displacement indicates absolute floor movement and affects both structural performance and occupant comfort. These parameters are key to assessing deformation during seismic events.

ETABS software is a comprehensive tool used for structural modelling, analysis, and design, supporting both linear and nonlinear behaviour and international design codes. It enables accurate evaluation through methods like Response Spectrum Analysis (RSA), which estimates peak structural response using modal analysis and statistical techniques. For more realistic seismic performance, Nonlinear Response Spectrum Analysis includes inelastic material behaviour, aiding performance-based design. Together, these methods help engineers model and optimize building response to lateral forces effectively. Shear wall design, placement, and analytical evaluation are therefore fundamental to earthquake-resistant structure.

2. Literature Review

Rajiv Banerjee *et al* (2020) [1] "Defining Optimum Location of Shear Wall in an Irregular Building by Considering Torsion" This study identifies optimal shear wall placement strategies for irregular high-rise buildings, using ETABS v16 for dynamic analysis via Time History and Response Spectrum methods. It defines selection criteria, highlights torsional response factors, and demonstrates effective techniques to control torsion and story drift through strategic shear wall integration. Suman Bhattarani *et al* (2020) [2] "Study on Seismic Analysis of Multi Storey RCC Frame with and Without Shear Wall Using NBC 105:2020". This research analysis the seismic performance of G+9 RC buildings with and without shear walls using ETABS-based finite element modelling. Comparative dynamic analysis evaluates parameters such as natural frequency, base shear, drift, and lateral displacement. Findings show that shear wall integration significantly improves lateral stiffness, strength, and ductility, resulting in reduced seismic response and enhanced structural stability. These results support optimized design and retrofitting strategies for seismic resilience. Md. Kawsarul Islam kabbo *et al* (2024) [3] "Dynamic Analysis of a G+13 Storey RCC Building Using Shear Wall in Three Different Location on Various Seismic Zone". This study evaluates optimal shear wall placement in a G+13 RC residential building under seismic and wind loads, following IS 1893:2016. Three configurations—central core, perimeter corner, and hybrid—are analysed for performance in various seismic zones. Results show that hybrid core-corner arrangements offer superior lateral stiffness and displacement control. However, in high seismic zones (Zone V), even optimized layouts may fall short, highlighting the need for additional lateral resistance or damping systems. Vijayashree N *et al* (2022) [4] "Comparative analysis on seismic behaviour of multi storeyed RCC building in different soil strata considering the position of shear wall". This research examines seismic response optimization in a 15-story RC structure using varied shear wall configurations, modelled in ETABS 2016. Focusing on India's seismic context, the study evaluates performance across soil types (I, II, III) under Zone-II seismic parameters, using both static and dynamic analysis methods. Results highlight how structural irregularities and site conditions impact displacement, strength, and stability. Optimal shear wall placement significantly enhances performance, with findings presented through comparative tables and graphs to support design decisions for earthquake-resilient high-rise buildings. Rajiv Banerjee *et al* (2020) [5] "Seismic Response of Y-Shape Multi-Storey Building with Optimum Location of Shear Walls". This study explores optimal shear wall placement in a Y-shaped, G+14 irregular RC structure located in Seismic Zone IV, using ETABS v18.0.2. Fourteen configurations are analysed through Response Spectrum and Time History methods to assess parameters such as period (T_1), displacement (Δ_i), drift (θ_i), static eccentricity (e_s), and base shear (V). Results show that strategic shear wall positioning minimizes torsional effects, enhances lateral stiffness, and improves seismic performance in asymmetrical high-rise buildings. Optimization focuses on reducing displacements and drift while maximizing base shear capacity.

3. Objectives

i). Primary objective of this study is to analyze a G+30 commercial building using ETABS software.
ii). To carry out the design of key structural elements, including beams, columns, slabs, and other essential components.
iii). To study different parameter like story displacement, story drift.
iv). To study the difference between normal model to shear wall model.

4. Methodology

Study Objectives and Approach: To accomplish the research goals of analyzing and designing a commercial building using ETABS software while ensuring compliance with fundamental requirements including safety, durability, economic viability, aesthetic appeal, constructability, and practical implementation, the following systematic methodology has been established:

Primary Investigation Phase

Site Assessment: Detailed topographical surveys to inform layout and structural planning.
Geotechnical Investigation: Soil testing to determine key parameters such as moisture content, unit weight, and safe bearing capacity for foundation design.
Structural Layout Planning: Prepared using AutoCAD based on site data and architectural requirements.
ETABS-Based Structural Analysis and Design
Manual Design Verification: Cross-checking results against IS codes.
Construction Detailing: Preparation of drawings for implementation.

ETABS Modelling Procedure

i). **Material Property:** Concrete: M25, Steel: Fe550

Input via Define → Material Properties.

ii). **Property Assignment:** Structural members (beams, columns, slabs) modelled using Draw Line and Create Columns in Region tools.
iii). **Support Conditions:** Fixed supports assigned to column bases via Assign → Joint/Frame → Restraints (Supports).
iv). **Load Definitions:** Dead Load (230mm wall): 13.8 kN/m, Live Load: 2.0 kN/m², Floor Finish: 1.5 kN/m², Defined using Define → Load Cases.
v). **Structural Analysis:** Performed after input completion with error checks to ensure model accuracy.

Building Details

Table 1: Commercial Building

Building Category	Commercial building
Framing System	Moment Resisting Frame
Story Count	30 stories
Height of building	90m
Partition Wall Thickness	30 mm (exterior walls), 150 mm (interior partitions)
Live load	2KN/m2 – Balcony, Corridor 1.5KN/m2 – All rooms
Concrete Grade Specification	M25
Reinforcement Steel Grade	HYSD500
Brick Masonry Density	18KN/m3
Column Size Requirements	C1=230mmX300mm C2=230mmX450mm C3=230mmX525mm C4=230mmX600mm
Beam Dimensional Requirements	B1=230mmX300mm B1=230mmX450mm B2=230mmX525mm B2=230mmX600mm
Floor Slab Thickness	150mm
Shear wall thickness	150mm
Zone	3
Importance factor	1.5

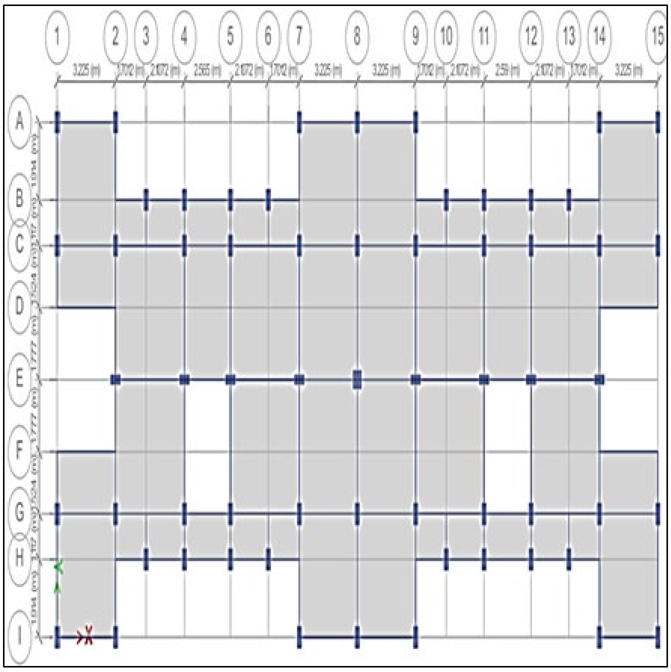

Fig 1: Model 1

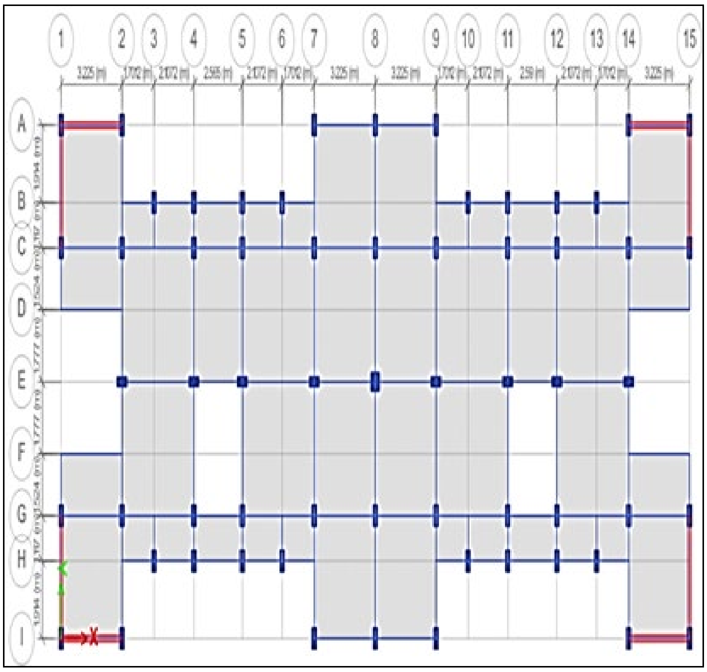

Fig 2: Model 2

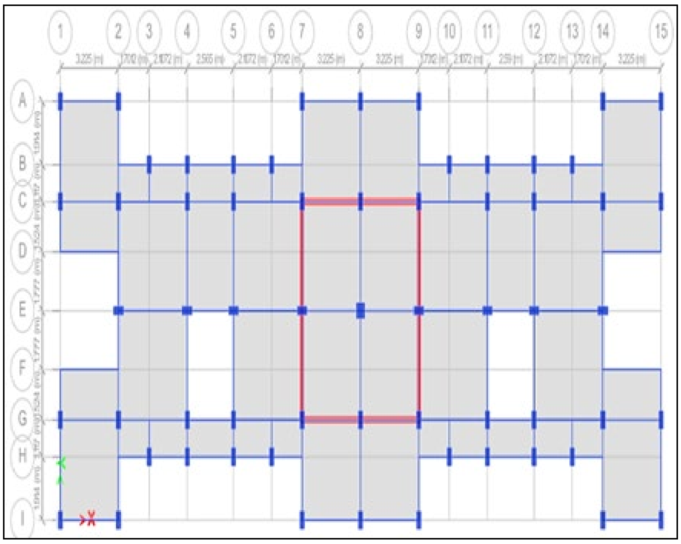

Fig 3: Model 3

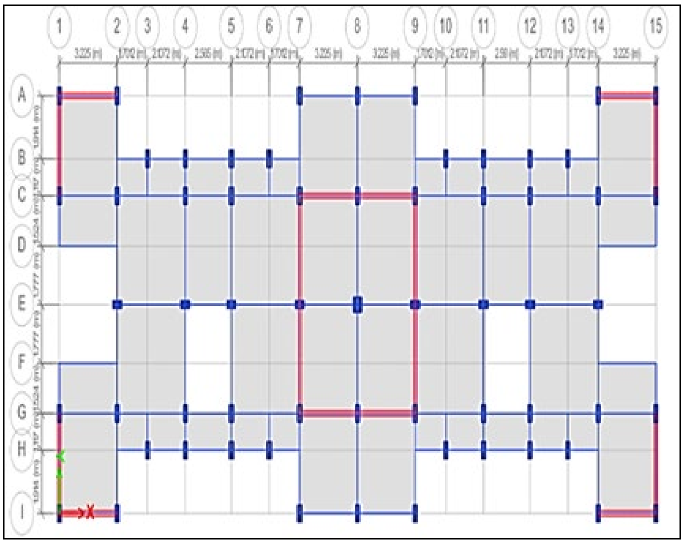

Fig 4: Model 4

5. Results and Discussion

Storey Displacement

Is defined as the absolute lateral movement of any floor level measured relative to the foundation. The following presents story displacement values (in mm) for various regular building configurations subjected to Equivalent Static Analysis along the Y-direction.

Table 2: Storey Displacement along Y Direction 1.5(DL+LL+EQY)

Story	Model: 1	Model: 2	Model: 3	Model: 4
BASE	0	0	0	0
G.L	0.57	0.461	0.363	0.294
Story1	1.826	1.466	1.113	0.902
Story2	3.562	2.894	2.147	1.74
Story3	5.56	4.603	3.376	2.75
Story4	7.762	6.552	4.775	3.913
Story5	10.129	8.705	6.323	5.212
Story6	12.635	11.037	8.006	6.634
Story7	15.258	13.516	9.813	8.171
Story8	17.982	16.119	11.73	9.807
Story9	20.791	18.826	13.742	11.535

Story10	23.672	21.617	15.84	13.342
Story11	26.61	24.477	18.12	15.221
Story12	29.595	27.39	20.249	17.162
Story13	32.612	30.342	22.879	19.156
Story14	35.652	33.318	27.245	21.196
Story15	38.701	36.307	29.641	23.273
Story16	41.748	39.295	32.055	25.379
Story17	44.782	42.271	34.475	27.506
Story18	47.79	45.222	36.896	29.646
Story19	50.76	48.137	39.307	31.793
Story20	53.684	51.007	41.7	33.939
Story21	56.559	53.819	44.068	36.077
Story22	59.364	56.567	46.405	38.2
Story23	62.089	59.24	48.704	40.304
Story24	64.723	61.832	50.96	42.381
Story25	69.685	64.337	53.67	44.428
Story26	72.001	66.077	55.323	46.44
Story27	74.206	71.314	57.425	48.415
Story28	76.308	73.469	59.474	50.351
Story29	75.108	74.126	60.168	52.249
Story30	78.33	75.552	61.474	54.108

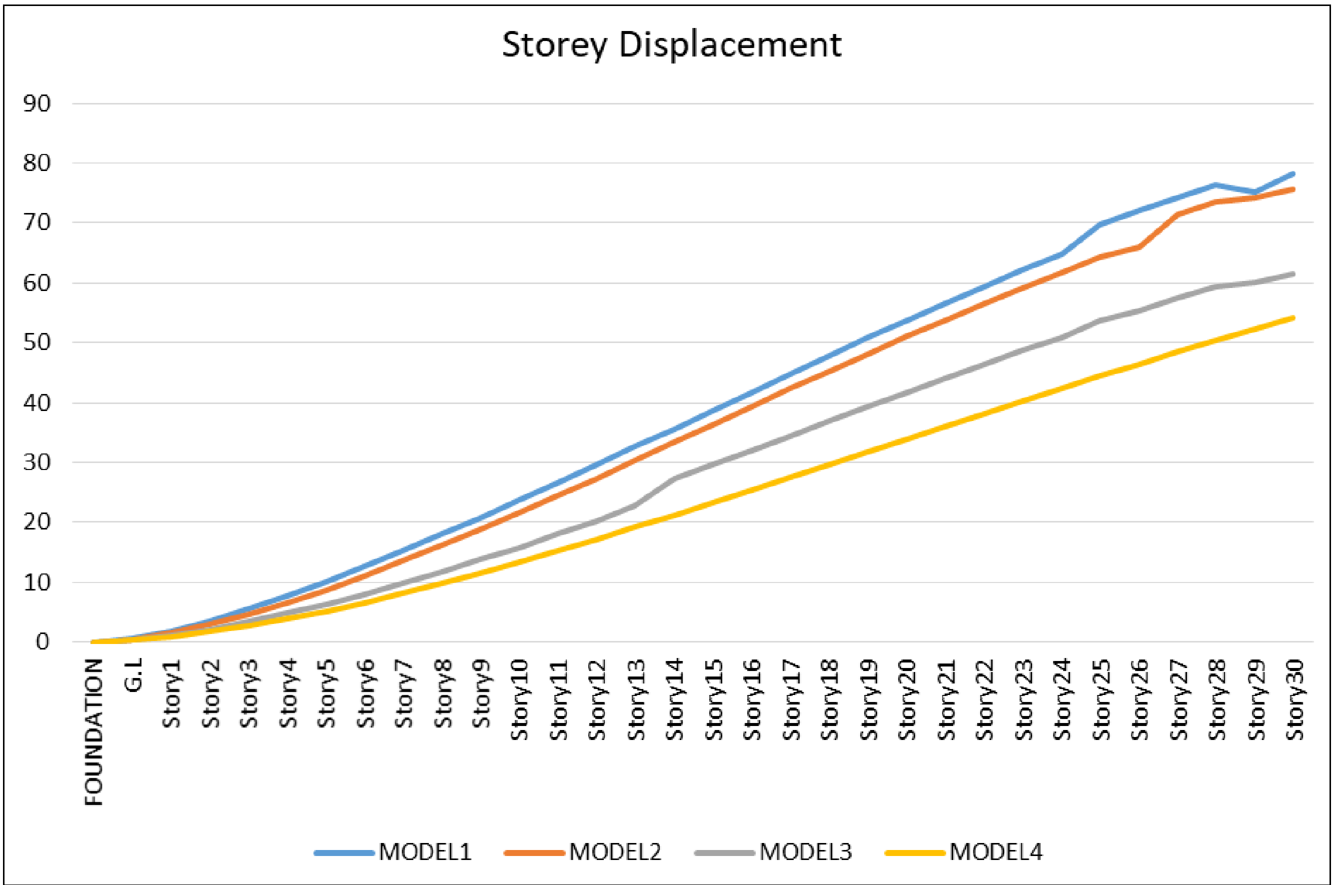

Fig 5: Storey Displacement

i). From the chart it is observed that storey displacement is 19.12% in model 2, 36.31% in model 3 & 48.42% in model 4 compared to model 1 at base level.

ii). The displacement is 6.18% in model 2, 29.60% in model 3 & 39.86% in model 4 compared to model 1 at 15th story.

iii). The displacement is 3.81% in model 2, 21.74% in model 3 & 31.11% in model 4 compared to model 1 at 30th story.

Storey Drift

Is defined as the ratio of relative displacement between consecutive floors to the corresponding inter-story height. The following presents story drift values (in meters) for various irregular building configurations subjected to Equivalent Static Analysis along the Y-direction.

Table 3: Storey Drift Along Y Direction 1.5(DL+LL+EQY)

Story	Model: 1	Model: 2	Model: 3	Model: 4
BASE	0	0	0	0
GL	0.00019	0.000154	0.000121	0.000098
Story1	0.000429	0.000344	0.000256	0.000206
Story2	0.000579	0.000476	0.000345	0.000279
Story3	0.000666	0.00057	0.00041	0.000337
Story4	0.000734	0.000651	0.000466	0.000388
Story5	0.000789	0.00072	0.000516	0.000433
Story6	0.000835	0.000777	0.000561	0.000474
Story7	0.000875	0.000826	0.000602	0.000512
Story8	0.000909	0.000868	0.000639	0.000546
Story9	0.000937	0.000902	0.000671	0.000576
Story10	0.000961	0.00093	0.000699	0.000603
Story11	0.000981	0.000953	0.000724	0.000626
Story12	0.000996	0.000971	0.000745	0.000647
Story13	0.001008	0.000984	0.000764	0.000665
Story14	0.001015	0.000992	0.000778	0.00068
Story15	0.001019	0.000996	0.00079	0.000692
Story16	0.001018	0.000996	0.000799	0.000702
Story17	0.001014	0.000992	0.000804	0.000709
Story18	0.001006	0.000984	0.000807	0.000714
Story19	0.000994	0.000972	0.000807	0.000716
Story20	0.000978	0.000956	0.000804	0.000715
Story21	0.000958	0.000938	0.000798	0.000713
Story22	0.000935	0.000916	0.000789	0.000708
Story23	0.000908	0.000891	0.000779	0.000701
Story24	0.000878	0.000864	0.000766	0.000693
Story25	0.000845	0.000835	0.000752	0.000682
Story26	0.000809	0.000805	0.000736	0.000671
Story27	0.000772	0.000775	0.000719	0.000658
Story28	0.000735	0.000745	0.000683	0.000645
Story29	0.000701	0.000718	0.000683	0.000632
Story30	0.000674	0.000695	0.000667	0.00062

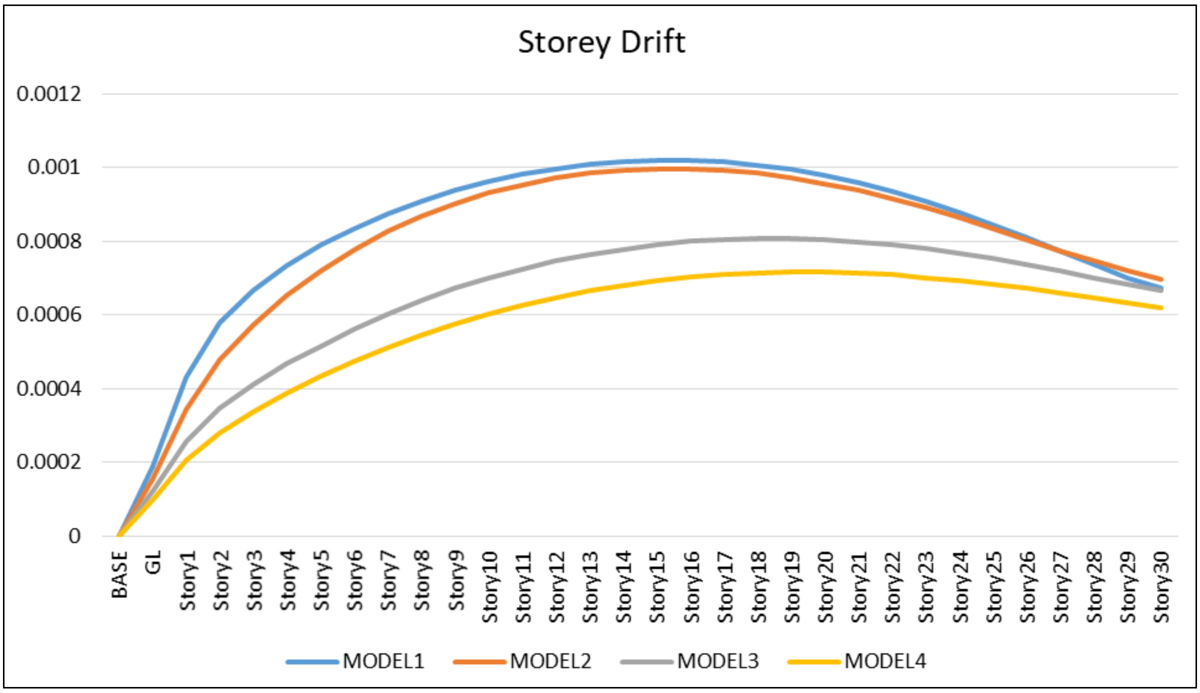

Fig 6: Storey Drift

i). From the chart it is observed that storey drift is 18.94% in model 2, 36.31% in model 3 & 48.42% in model 4 compared to model 1 at base level.
ii). The displacement is 2.25% in model 2, 22.47% in model 3 & 32.09% in model 4 compared to model 1 at 15th story.
iii). The displacement is 3.11% in model 2, 1.038% in model 3 & 8.01% in model 4 compared to model 1 at 30th story.

6. Conclusion

i). Storey displacement and drift increase significantly from Model 1 to Model 4 at Base storey.
ii). Model 2 shows a moderate increase (~19%), while Model 3 (~36%) and Model 4 (~48%) show substantial increases at base storey.
iii). Model 2 exhibits a small increase in displacement (~6%) at 15th storey.
iv). Model 3 and Model 4 show notable increases of ~30% and ~40%, respectively, indicating reduced stiffness at mid-height in these models at 15th storey.
v). Model 2 shows a minimal increase in displacement (~3.8%) at 30th storey
vi). Model 3 and Model 4 have increased displacement (~22% and ~31%) in the first set of data at 30th storey.

A second set shows even lower increases at the 30th storey: Model 2 (~3.1%), Model 3 (~1.03%), and Model 4 (~8.01%) at 30th storey.

Overall Trend

i). Displacement and storey drift increase progressively from Model 2 to Model 4 at all levels.
ii). Model 2 performs best in controlling displacement and drift.
iii). Model 4 shows the poorest performance, indicating less structural efficiency.
iv). Increased displacement and drift in higher models suggest reduced stiffness or less effective lateral load resistance.
v). Model 2 is structurally more efficient compared to Models 3 and 4.

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