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Response Spectrum Analysis FO MULTISTOREY Building With Different Flat Slab Configurations

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Abstract:
The necessity of large headroom is now a crucial consideration in architecture, and from a structural perspective, the best solution is to provide a flat slab. Eliminating beams can significantly impact different components of the structure. Various studies have shown that the stresses generated in flat slab systems need to be reduced to ensure the stability of the structure. This paper examines four cases for a 12-story residential building located in Seismic Zone Four:1. Simple flat slab with a shear wall at the lift core.2. Simple flat slab with shear walls at both the lift core and highly stressed sections.3. Flat slab with drop panels and a shear wall at the lift core.4. Flat slab with drop panels and shear walls at both the lift core and highly stressed sections. The flat slab panel's length-to-breadth (L/B) ratio is varied as 0.2, 0.8, 1.2, 1.5, and 2. Using dynamic analysis methods with STAAD Pro V8i, the study evaluates parameters such as node displacement, shear forces in columns, compressive and tensile stresses, story drift, von Mises stress, and principal stress values to determine the optimum structural case.
Keywords – *Flat slab, Shear wall, Dynamic Analysis, Stresses on flat slab.*

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I. INTRODUCTION

The demand for residential houses is increasing rapidly in the construction sector. Multistory buildings need to be economical and have fewer building components from an architectural perspective, making flat slab construction a preferred choice. A flat slab is a type of slab that does not have beams and directly transfers its load to the soil through vertical columns. There are two main types of slabs: R.C.C. (Reinforced Cement Concrete) slabs and flat slabs. An R.C.C. slab includes beams, while a flat slab does not.

Flat slabs are used in multistory buildings to increase headroom and reduce overall construction costs. The construction process for flat slabs is simpler compared to R.C.C. slabs. While the loading patterns in both types of slabs are similar, the load distribution differs. Flat slabs are generally distinguished by the presence of drop panels and column capitals. The construction of flat slabs typically includes drop panels or column heads, depending on the loading conditions. Simple flat slabs are used when the loading is low, whereas other types of flat slabs are considered for higher loading conditions.

When the load is significantly higher at the junction of the column and slab, a shear phenomenon called punching shear occurs, developing near the support due to the higher end moments.

II. OBJECTIVE

- This paper aims to determine the optimal building model of a flat slab system against seismic loading in Zone Four, focusing on the interaction between flat slabs and shear walls. Additionally, it analyzes the behavior of flat slabs with varying spans in multistory buildings, considering L/B ratios of 0.2, 0.8, 1.2, 1.5, and 2.
- The structure is analyzed using response spectrum analysis for seismic loading in STAAD Pro software. Different building plans are examined, and the results are compared based on various parameters such as principal stresses, von Mises stresses, story shear, and story drift.

- The analysis is conducted on a 12-story building designed with flat slabs. The building's panels are divided according to the plan area, accommodating the objective of varying spans. This approach allows for separate designs for the roof, external walls, and internal walls.

III. METHODOLOGY & STRUCTURAL MODELING

1. In this chapter, the flat slab is designed using the Equivalent Frame Method according to the guidelines provided in IS 456-2000. The design process involves transitioning all relevant data from manual calculations to software-based analysis. This includes determining the thickness of the flat slab, roof, external walls, and internal walls.
2. The initial design of the flat slab is carried out manually using the Equivalent Frame Method for various panels. The building, a 12-story structure, is divided into different panel numbers for analysis. Each story of the building is segmented into blocks to facilitate detailed examination and design.
3. The Equivalent Frame Method is applied to different panels for analysis and model development in STAAD Pro. This includes specifying construction configurations and geometrical details. Dynamic analysis is performed using the Square Root of the Sum of the Squares (SRSS) method to ensure accurate assessment of seismic responses.

IV. FLAT SLAB DESIGN DATA

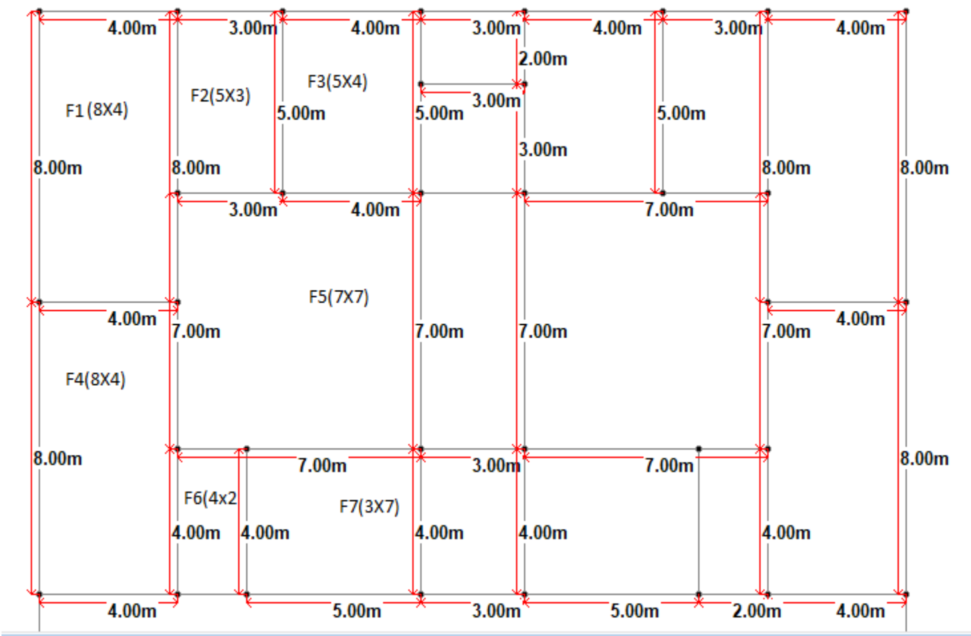


Figure 1 Panel Detail

Table 1 Panel Size Detail

Panel Size	L/B	Thickness (Longer Direction)	Thickness (Shorter Direction)
3X7	0.4	234	224
3X4	0.8	135	125
3x3	1	135	125
7X7	1	234	224
5X4	1.3	175	165
5x3	1.7	175	165
4X2	2	135	125
8X4	2	264	254

Table 2 Reinforcement Detail Due to Negative Moment

Reinforcement in Longer Direction				Reinforcement in Shorter direction	
Panel	L/B	Ast/m in Column Strip Due to Negative Moment (mm^2)	Ast/m in Middle Strip Due to Negative Moment (mm^2)	Ast/m in Column Strip Due to Negative Moment (mm^2)	Ast/m in Middle Strip Due to Negative Moment (mm^2)
3X7	0.4	850	290	340	270
3X4	0.8	300	170	240	150
3x3	1	162	162	175	150
7X7	1	850	281	381	291
5X4	1.3	440	210	370	200
5x3	1.7	440	212	265	200
4X2	2	311	162	150	150
8X4	2	1083	345	533	305

Table 3 Reinforcement Due to Positive Moment

Reinforcement in Longer Direction				Reinforcement in Shorter direction	
Panel	L/B	Ast/m in Column Strip Due to Positive Moment (mm^2)	Ast/m in Middle Strip Due to Positive Moment (mm^2)	Ast/m in Column Strip Due to Positive Moment (mm2)	Ast/m in Middle Strip Due to Positive Moment (mm^2)
3X7	0.4	350	290	270	270
3X4	0.8	170	170	150	150
3x3	1.0	162	162	150	150
7X7	1.0	350	281	270	270
5X4	1.3	210	210	200	200
5x3	1.7	212	212	200	200
4X2	2.0	162	162	150	150
8X4	2.0	450	320	305	305

V. TYPES OF CASES USED FOR ANALYSIS OF STRUCTURE

Following Building Cases used for design by using actual design data of flat sab design

Table 4 Model Description

Model 1	12 storey Flat Slab building having shear wall at lift core.
Model 2	12 storey Flat Slab building having shear wall at lift core and higher stress location.
Model 3	12 storey Flat Slab with drop building having shear wall at lift core.
Model 4	12 storey Flat Slab with drop building having shear wall at lift core and higher stress location.

Table 5 Design parameters

S.No	Particulars	Dimension/Size/Value
1	Model	12 Storied includes Ground floor
2	Seismic Zones	IVth
3	Floor height	3.8m
4	Depth of foundation	3m
5	Building height	46m
6	Plan size	25X35m^2
7	Size of columns	500mmX550mm
8	Earthquake load	As per IS1893-2002(part-I)
9	Type of soil	Medium soil Type-II
10	Live load	1.5KN/M^2 Roof & 2.5KN/M^2 Floor
11	Material used	Grade of Concrete **M30**& Steel **Fe415**
12	Dynamic Analysis	**Response Spectrum Analysis**
13	Fundamental natural period of building	Ta = 0.075 $h^{0.75}$
14	Zone factor Z	0.24
15	Response Reduction factor (RF)	4
16	Importance factor (I)	1
17	Rock and soil factor (SS)	II
18	Type of structures	1
19	Damping ratio (DM)	0.05

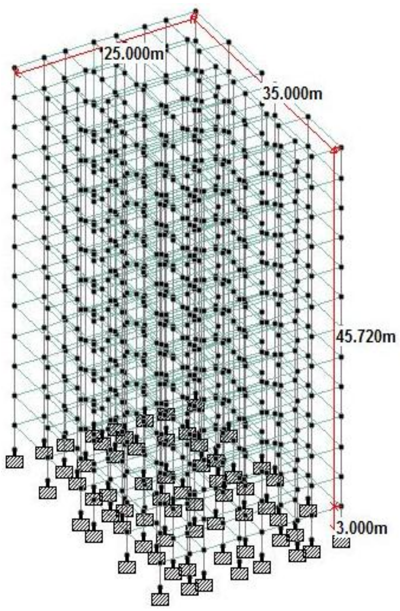


Figure 2 Model Dimensions

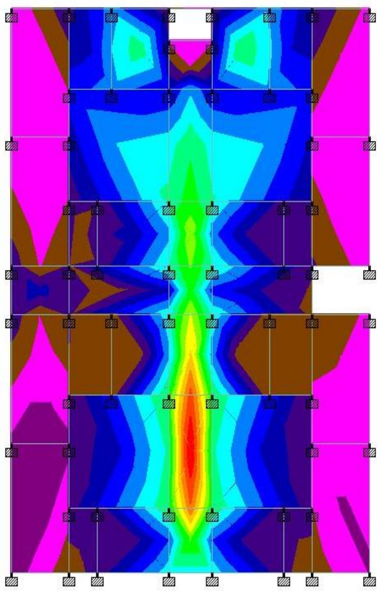


Figure 3 Stresses on Slab

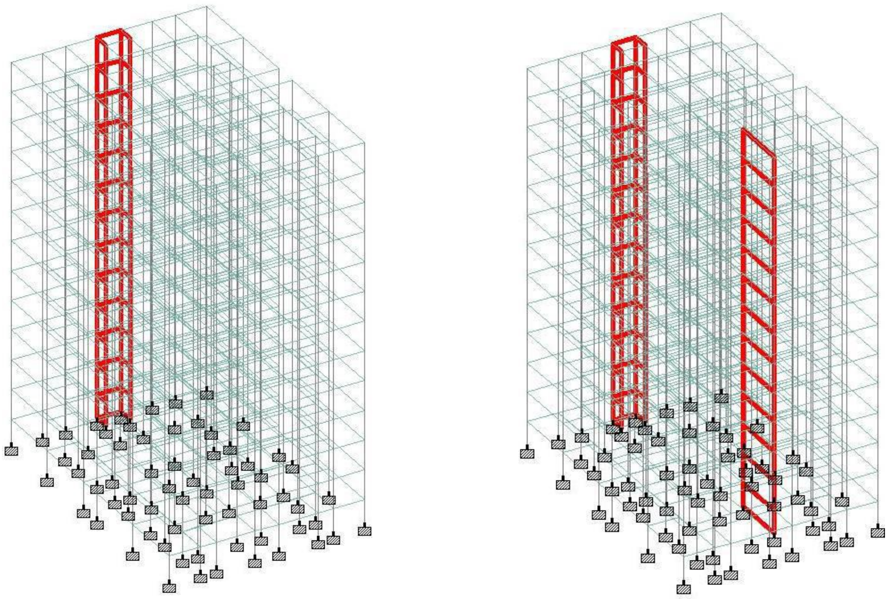
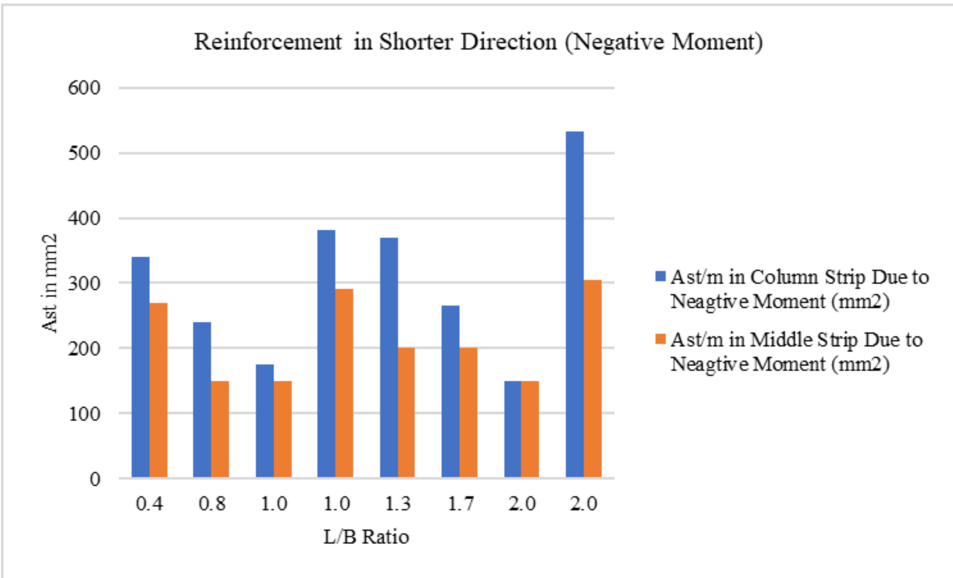


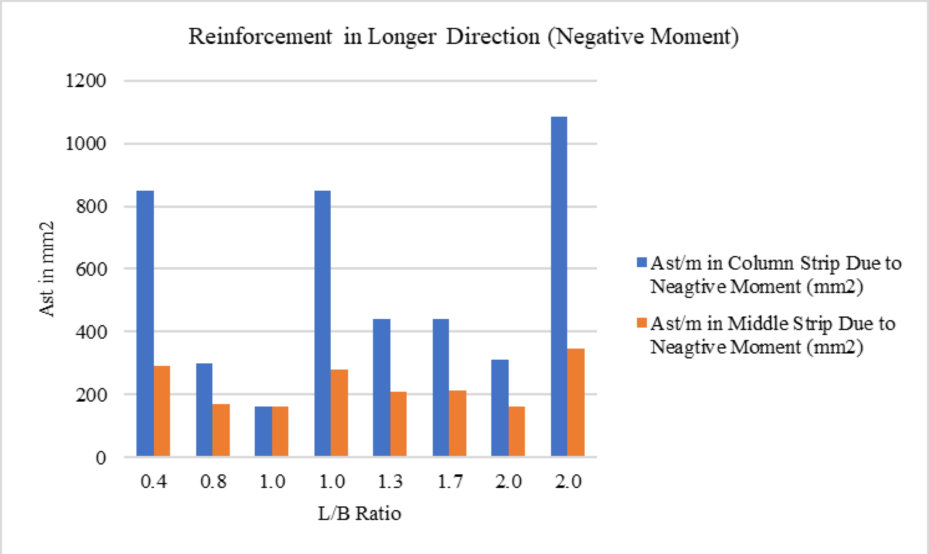
Figure 2 Shear Wall Locations

VI. Results

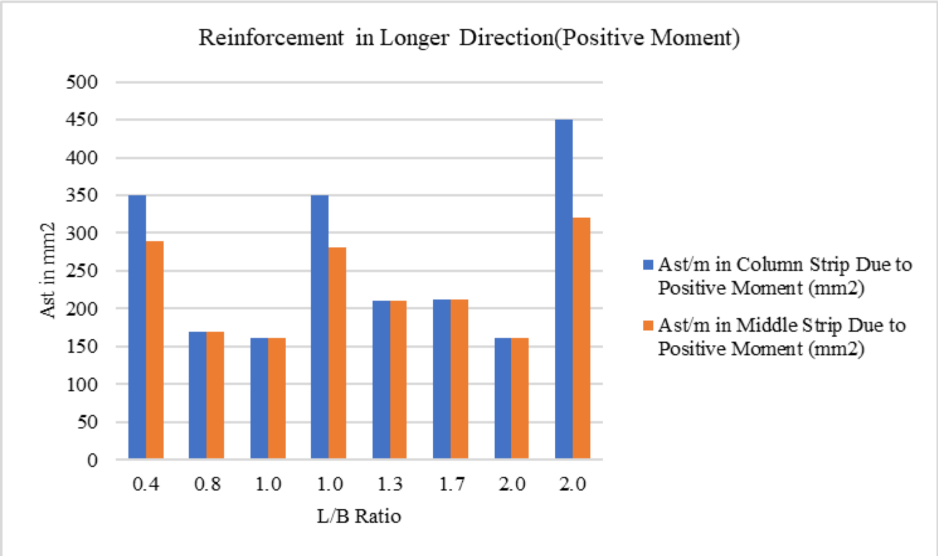
When the building is analyzed under seismic forces, the results of the four different building models are compared to identify the most economical model. According to the objective of this work, the obtained results are presented in graphical form for better clarity and comparison.



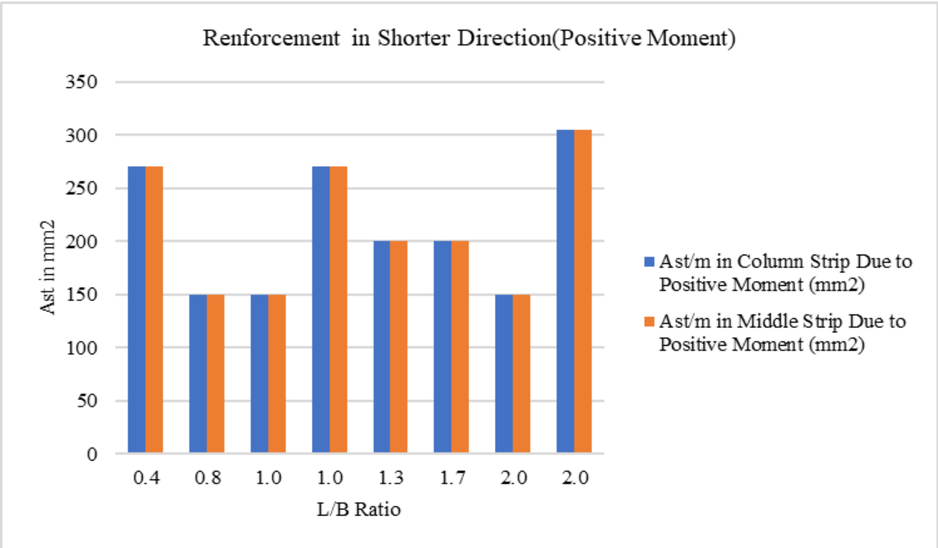
Graph 1 L/B Vs Ast/m



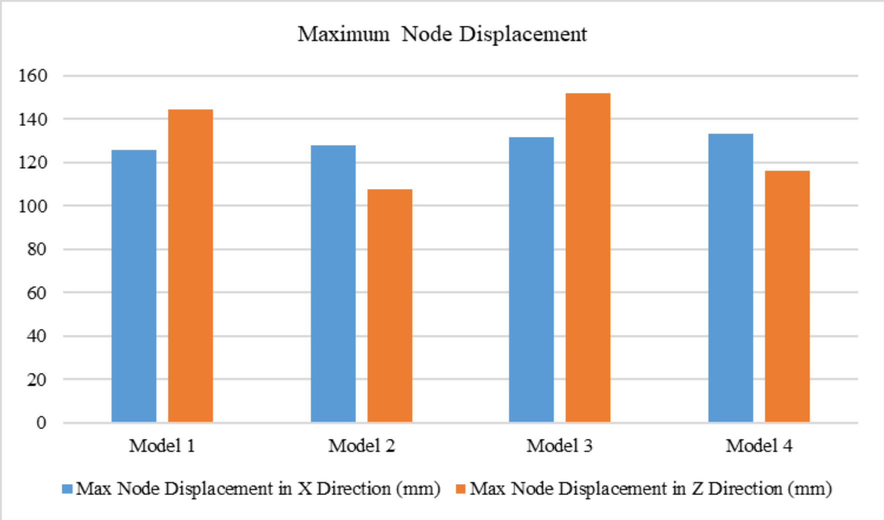
Graph 2 L/B Vs Ast/m



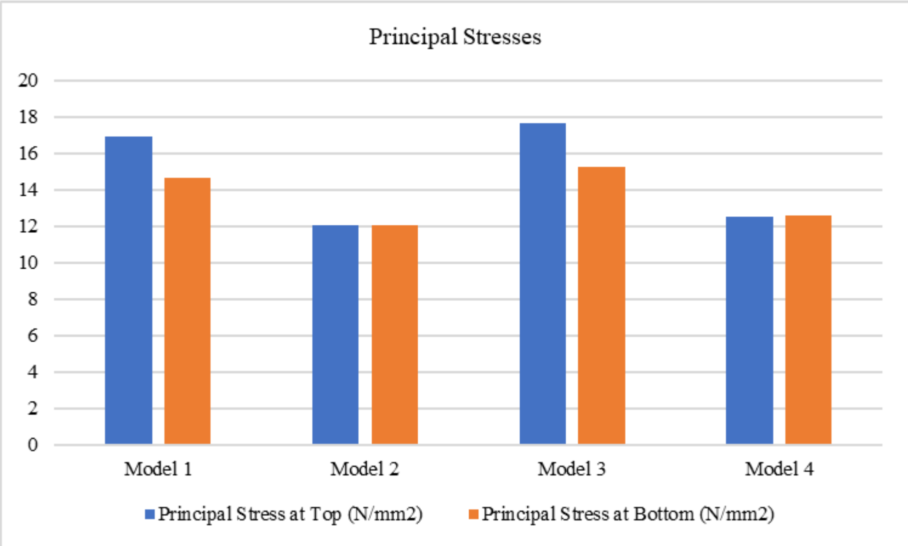
Graph 3 L/B Vs Ast/m



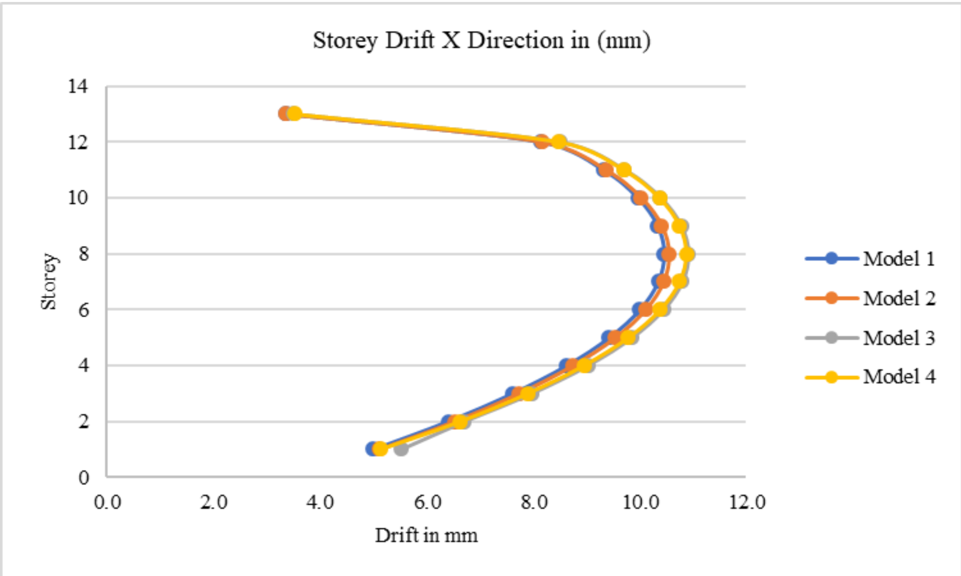
Graph 4 L/B Vs Ast/m



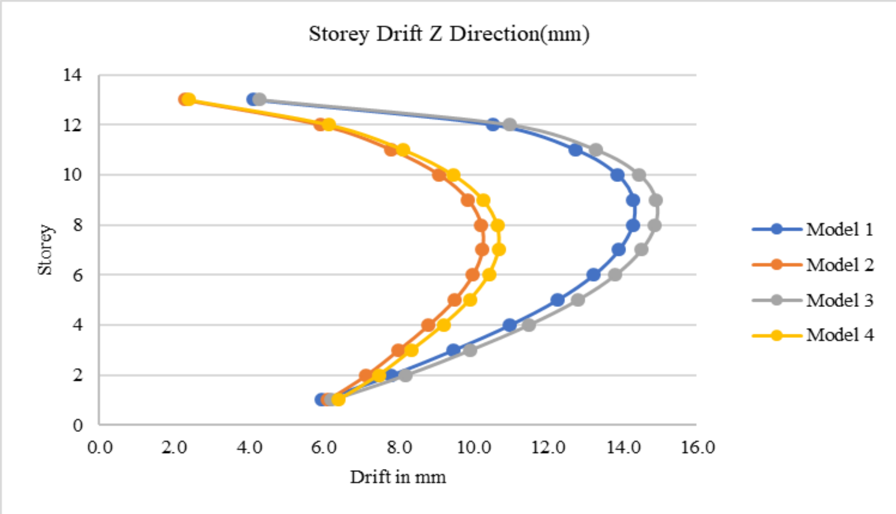
Graph 5 Maximum Node Displacement



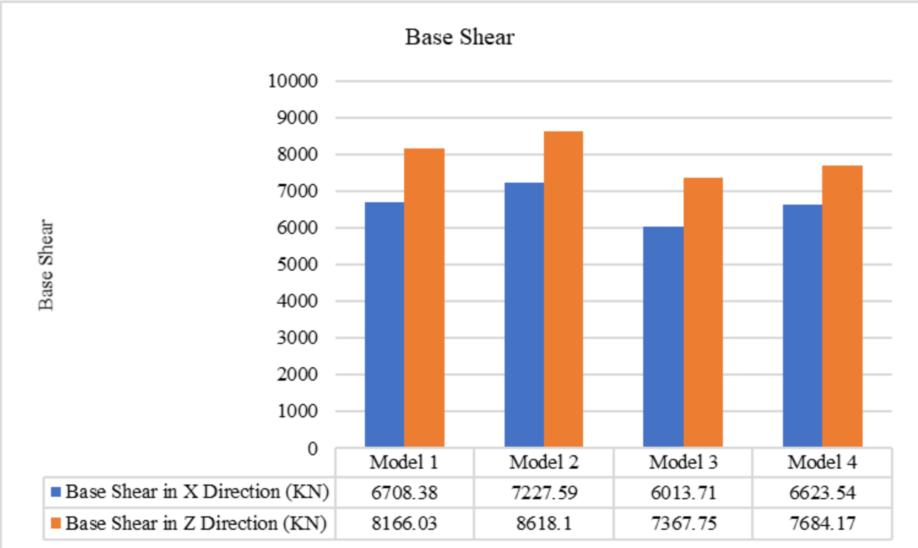
Graph 6 Principal Stresses



Graph 7 Storey Drift in X direction



Graph 8 Storey Drift in Z Direction



Graph 9 Base Shear

VII. Conclusions

- Building Model 2 is the optimal model in terms of nodal displacement in the X and Z directions, showing the minimum values compared to all other models.
- Base shear in the X and Z directions is lowest in Building Model 3 compared to all other models.
- Maximum von Mises stresses at the top and bottom are satisfactory in Model 2, outperforming the other models considered in this study.
- Principal stresses at the top and bottom are also satisfactory in Model 2 compared to the other models.
- For storey drift in the X and Z directions, Building Model 2 is the optimal model, with a minimum value of 102 mm, making it the most efficient model.
- The area of steel required per meter is higher for L/B ratios of 0.4, 1.0, and 2.0 compared to other panel sizes.
- In conclusion, a 12-story flat slab building with shear walls at the lift core and high-stress locations (Building Model 2) is preferred based on the comparative results of various parameters.

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