



“*BEHAVIOR OF SYMMETRIC AND ASYMMETRIC STRUCTURE IN HIGH SEISMIC ZONE 4 USING ETABS*”

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Abstract : This study investigates the seismic performance of symmetric (C-shape and I-shape) and asymmetric (L-shape and T-shape) reinforced concrete structures in a high seismic zone, following the guidelines of IS 1893:2002. The analysis was conducted using ETABS, considering dead load (1.0) and live load (1.5), with a seismic zone factor of 0.24, importance factor of 1.5, response reduction factor of 3, and site type 2. Nonlinear equivalent static analysis was employed, applying acceleration loads in X and Y directions with a scale factor derived from $a = I \cdot g / R_a = I \cdot g / R$, approximating the inelastic response of the structures. The results indicate that symmetric structures exhibit uniform load distribution, minimal torsional effects, and predictable story drifts, resulting in lower lateral displacements and more even base shear distribution. In contrast, asymmetric structures show significant torsional behavior, higher corner displacements, and stress concentrations, which can compromise structural safety under seismic excitations. The study highlights that while nonlinear equivalent static analysis provides a reasonable approximation of inelastic behavior, asymmetric configurations require additional structural interventions, such as shear walls or bracing, to achieve seismic resilience comparable to symmetric forms. Overall, the findings underscore that symmetric C-shape and I-shape layouts are more reliable and economical for high seismic regions, offering enhanced stability, reduced torsion, and efficient lateral load resistance.

I. INTRODUCTION

1.1 GENERAL

Earthquakes pose a significant threat to the stability and safety of buildings, particularly in regions classified as high seismic zones. The lateral forces generated during seismic events act simultaneously with vertical loads, producing complex structural responses such as displacement, torsion, and internal stresses. Ensuring seismic safety has therefore become a crucial aspect of structural engineering, emphasizing the need for rigorous design and analysis methods.

Reinforced concrete (RC) framed structures are widely adopted due to their strength, durability, and adaptability to various architectural forms. However, the seismic performance of such structures is strongly influenced by their plan configuration. Symmetric layouts, such as C-shaped and I-shaped structures, typically exhibit uniform stiffness and mass distribution, resulting in predictable and stable behavior under earthquake loading. In contrast, asymmetric configurations like L-shaped and T-shaped buildings often introduce eccentricities between the center of mass and the center of rigidity, leading to torsional responses, stress concentrations, and potential structural irregularities.

This study aims to evaluate and compare the seismic performance of symmetric and asymmetric RC framed structures using **nonlinear equivalent static analysis in ETABS**. The analysis parameters are based on **IS 1893:2002**, considering a high seismic zone factor (0.24), importance factor (1.5), response reduction factor (3), and medium soil conditions. The research focuses on evaluating **lateral displacement, base shear, torsional effects, and story drift** to understand how geometric irregularities influence overall performance.

The findings are expected to contribute to the development of safer and more economical seismic design strategies, emphasizing the role of plan geometry, material behavior, and code-based parameters in achieving resilient RC structures in earthquake-prone regions.

1.2 OVERVIEW OF EQUIVALENT STATIC AND NONLINEAR EQUIVALENT STATIC ANALYSIS

The **Equivalent Static Analysis (ESA)**, as prescribed in *IS 1893:2002*, is a simplified seismic analysis method used for regular structures. It estimates lateral forces based on the building's weight, response spectrum parameters, and fundamental natural period, assuming **linear elastic behavior** and uniform mass–stiffness distribution. However, it is less accurate for irregular, asymmetric, or high-rise buildings.

The **Nonlinear Equivalent Static Analysis (NL-ESA)** or **Pushover Analysis** extends ESA by incorporating **inelastic behavior** of materials. In this method, lateral loads are incrementally applied to simulate progressive yielding of structural members. The analysis generates a **capacity curve** (base shear vs. roof displacement) and identifies the **target displacement**, representing expected maximum deformation under design-level earthquakes. This approach provides deeper insight into a structure's performance and failure mechanism beyond the elastic range.

II. RESEARCH FRAMEWORK

2.1 OBJECTIVES OF THE STUDY

This study aims to develop a comprehensive understanding of the seismic behavior of RC structures in high seismic zones and to evaluate the impact of plan geometry using advanced analysis methods. The key objectives are:

Comparative Seismic Analysis: To compare the performance of symmetric (C-shape, I-shape) and asymmetric (L-shape, T-shape) RC structures under earthquake loading with respect to base shear, story drift, torsion, and overall stability.

Nonlinear Analysis Implementation: To perform nonlinear equivalent static (pushover) analysis in ETABS to capture inelastic behavior, plastic hinge formation, and progressive deformation.

Critical Member Identification: To determine the weak stories and structural elements prone to excessive displacement or failure, particularly in asymmetric layouts.

Evaluation of Design Parameters: To study the effects of seismic design parameters—zone factor, importance factor, response reduction factor, and soil type—on the overall seismic response.

Design Recommendations: To propose practical design interventions, such as shear walls or bracing systems, to enhance the seismic resilience of asymmetric structures while confirming the efficiency of symmetric layouts.

2.2 PROBLEM STATEMENT

Conventional seismic design methods often fail to capture the nonlinear behavior of reinforced concrete (RC) structures, particularly in asymmetric buildings. In high seismic zones, the interaction of lateral and vertical forces generates complex responses such as torsion, uneven story drift, and localized stress concentrations. While symmetric configurations distribute loads more uniformly, asymmetric layouts experience higher displacements and unequal shears due to geometric irregularities. Traditional linear or response spectrum analyses assume elastic behavior and cannot predict plastic hinge formation or inelastic deformations, leading to underestimation of structural demands. Therefore, a nonlinear analytical approach is essential to accurately evaluate and compare the seismic performance of symmetric and asymmetric RC structures.

2.3 PROBLEM SOLUTION

The project employs **ETABS software** to perform **nonlinear equivalent static (pushover) analysis** of symmetric and asymmetric RC buildings as per *IS 1893:2002*. By modeling realistic geometry and assigning nonlinear hinges to simulate inelastic behavior, seismic forces are applied incrementally to study plastic hinge formation, story drift, base shear, and torsional effects. This approach helps identify weak members and suggests structural improvements, such as **shear walls or bracing**, ensuring safer and more realistic seismic performance than conventional linear methods.

2.4 EXISTING SYSTEM

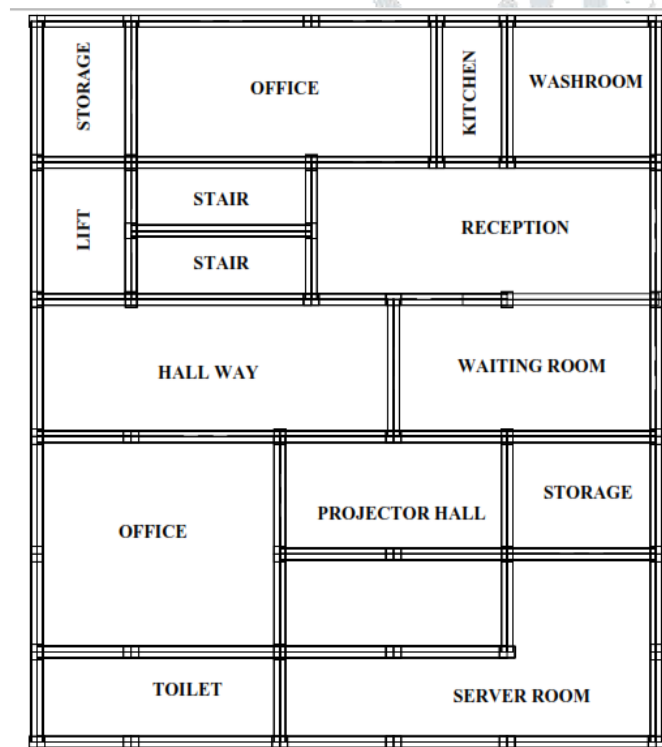
Current seismic analysis mainly uses **linear static** or **response spectrum methods** as per *IS 1893:2002*, assuming elastic behavior and uniform mass distribution. These approaches work for regular, symmetric buildings but are inadequate for **asymmetric or irregular structures**, where torsion and inelastic deformations are significant. They fail to capture **plastic hinge formation** and **progressive failure**, often leading to underestimated displacements and insufficient design accuracy.

2.5 PROPOSED SYSTEM

The proposed system uses **nonlinear pushover analysis** in **ETABS** to study material nonlinearity, plastic hinge behavior, and torsional effects in symmetric and asymmetric buildings. By applying incremental seismic loads, it identifies weak zones and evaluates story drift, base shear, and displacement, enabling **code-compliant and resilient** structural design with effective measures like **shear walls or bracing**.

III. METHODOLOGY

The study evaluates the seismic performance of symmetric (C- and I-shape) and asymmetric (L- and T-shape) reinforced concrete buildings using **ETABS** in accordance with **IS 1893:2002**. A **nonlinear equivalent static (pushover) analysis** is conducted to simulate inelastic behavior and identify weak members under seismic loading. The process includes defining building geometry, material properties (as per **IS 456:2000**), and seismic parameters such as zone factor (0.24), importance factor (1.5), soil type II, and response reduction factor ($R = 3$). Models are developed with realistic boundary conditions and nonlinear hinges assigned to beams and columns. Seismic loads are applied incrementally in both X and Y directions until target displacement is reached. ETABS results—including story drift, base shear, displacement, and hinge formation—are analyzed to compare the seismic performance of symmetric and asymmetric buildings. Findings are validated against IS code values to ensure reliability and support recommendations for structural enhancement.



3.1 APPROACH AND METHOD OF STUDY

Software and Approach

The study uses ETABS software to perform nonlinear equivalent static (pushover) analysis as per *IS 1893:2002*, enabling assessment of inelastic structural behavior under seismic loading.

Data Collection & Preliminary Design

Building geometries (C, I, L, and T shapes), story heights, and materials (M25 concrete, Fe500 steel) were defined as per *IS 456:2000*. Seismic parameters adopted were $Z = 0.24$, $I = 1.5$, $R = 3$, and Site Type II for high seismic zones.

Model Development in ETABS

3D models were created using frame and shell elements with **rigid diaphragm** slabs. **Nonlinear hinges** were assigned to beams and columns (FEMA-356 / *IS 13920*), and **eccentricity** between mass and rigidity centers was considered for asymmetric buildings.

Load Assignment & Analysis Setup

Gravity and lateral loads were applied in X and Y directions, and lateral forces were incrementally increased until target roof displacement was reached to simulate inelastic deformation and plastic hinge formation.

Nonlinear Static (Pushover) Analysis

The analysis monitored base shear, story drift, and roof displacement, tracking hinge development to identify weak stories. Symmetric buildings showed uniform response, while asymmetric models displayed torsional effects and higher drifts.

Post-Processing & Interpretation

Results included capacity curves, drift profiles, and hinge reports, used to assess seismic performance. Strengthening measures such as shear walls or bracing were suggested to enhance stiffness and reduce torsion.

Comparison & Validation

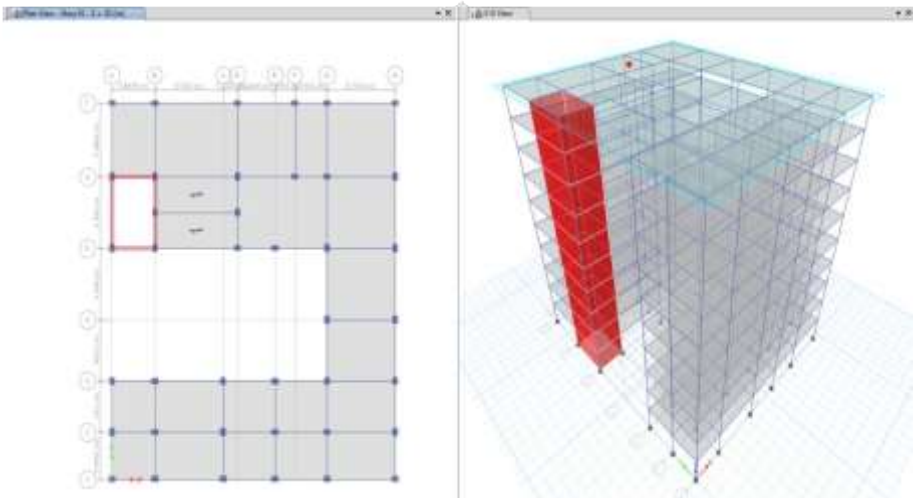
Performance of symmetric and asymmetric structures was compared based on base shear, drift, and displacement. Results from ETABS were validated against IS 1893:2002 calculations, confirming the accuracy of the nonlinear pushover approach.

Story	Elevation (m)	X-Dir (mm)	Y-Dir (mm)
Story 10	30	27.567	27.197
Story 9	27	26.771	26.432
Story 8	24	25.437	25.192
Story 7	21	23.579	23.469
Story 6	18	21.229	21.271
Story 5	15	18.412	18.601

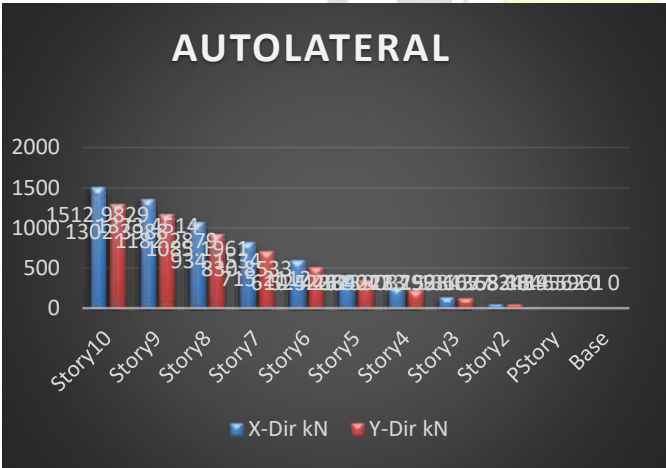
IV. ANALYSIS AND

4.1 SYMMETRIC

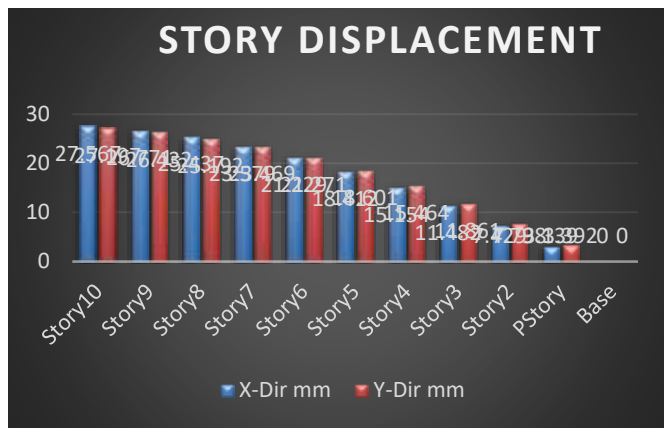
4.1.1 MODEL 1: C-



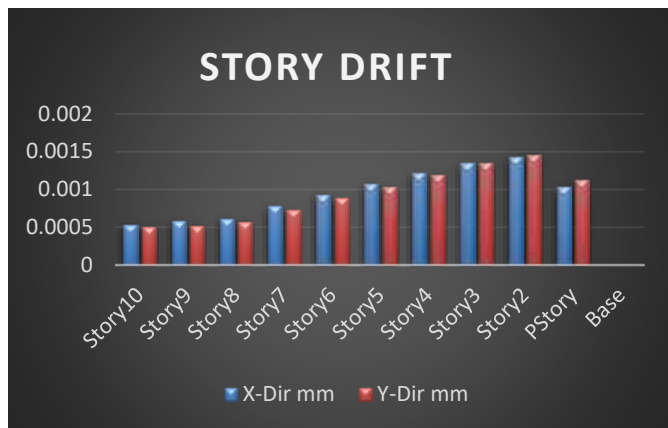
RESULTS
MODEL
SHAPE STRUCTURE



Story	Elevation (m)	X-Dir (KN)	Y-Dir (KN)
Story 10	30	1512.98	1302.39
Story 9	27	1373.45	1182.28
Story 8	24	1085.19	934.15
Story 7	21	830.85	715.21
Story 6	18	610.42	525.46
Story 5	15	423.90	364.90
Story 4	12	271.29	233.53
Story 3	9	152.60	131.36
Story 2	6	67.82	58.38
P Story	3	16.95	14.59
Base	0	0	0



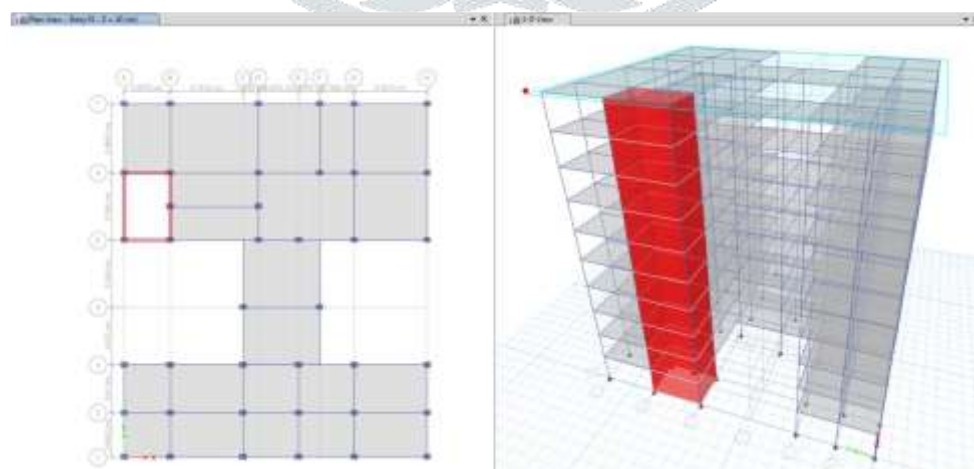
Story 4	12	15.154	15.464
Story 3	9	11.482	11.861
Story 2	6	7.429	7.798
P Story	3	3.139	3.392
Base	0	0	0

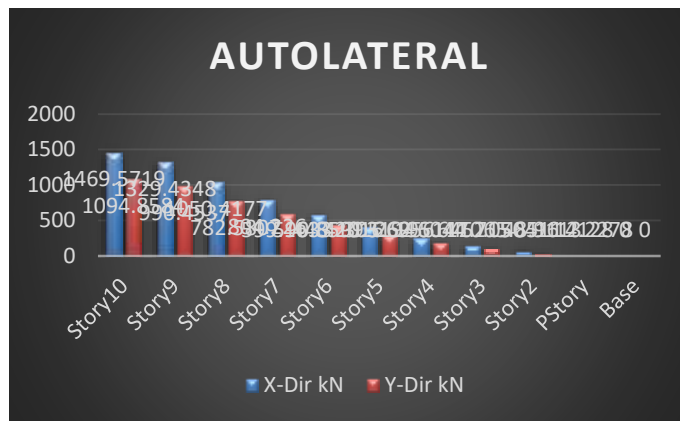


Story	Elevation (m)	X-Dir	Y-Dir
Story 10	30	0.000544	0.000511
Story 9	27	0.000587	0.000527
Story 8	24	0.000625	0.000578
Story 7	21	0.000786	0.000734
Story 6	18	0.00094	0.00089
Story 5	15	0.001086	0.001046
Story 4	12	0.001224	0.001201
Story 3	9	0.001351	0.001354
Story 2	6	0.001431	0.001469
P Story	3	0.001046	0.001131
Base	0	0	0

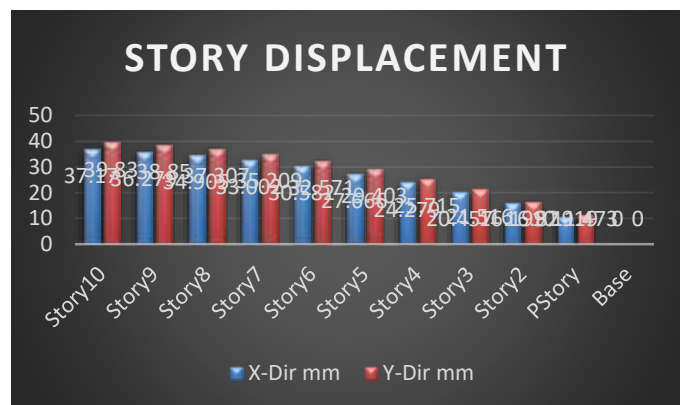
- Lateral forces:** Highest at top floor, decreasing downward. Base shear can be obtained by summing forces.
- Story displacement:** Increases with height; maximum at top floor ~27 mm.
- Story drift:** Maximum at lower floors (~0.14%), indicating effective shear wall performance, and very safe under lateral load.
- Structural behavior:**
 - o Stiff frame with shear walls.
 - o Low inter-story drift ensures minimal P-Delta effects.
 - o C-Shape asymmetric configuration shows balanced behavior in X and Y directions.
- Design implication:** Non-linear eustatic analysis is suitable for preliminary design checks. For detailed seismic design, dynamic analysis (response spectrum or time-history) can be conducted, but the current drift is well within limits, confirming safe structural performance.

4.1.2 MODEL 2: I-SHAPE STRUCTURE

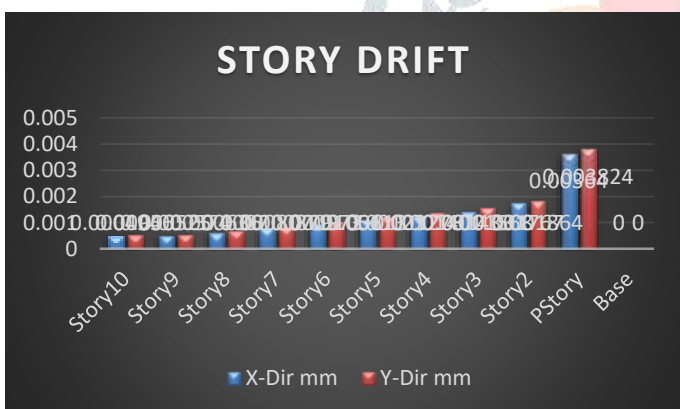




Story	Elevation (m)	X-Dir (kN)	Y-Dir (kN)
Story 10	30	1469.57	1094.86
Story 9	27	1329.43	990.45
Story 8	24	1050.42	782.58
Story 7	21	804.23	599.16
Story 6	18	590.86	440.20
Story 5	15	410.32	305.70
Story 4	12	262.60	195.65
Story 3	9	147.72	110.05
Story 2	6	65.65	48.91
P Story	3	16.41	12.23
Base	0	0	0



Story	Elevation (m)	X-Dir (mm)	Y-Dir (mm)
Story 10	30	37.17	39.83
Story 9	27	36.28	38.85
Story 8	24	34.91	37.31
Story 7	21	33.00	35.21
Story 6	18	30.58	32.57
Story 5	15	27.67	29.40
Story 4	12	24.28	25.72
Story 3	9	20.46	21.52
Story 2	6	16.20	16.82
P Story	3	10.92	11.47
Base	0	0	0



Story	Elevation (m)	X-Dir	Y-Dir
Story 10	30	0.000494	0.00056
Story 9	27	0.000525	0.000574
Story 8	24	0.000636	0.0007
Story 7	21	0.000807	0.000879
Story 6	18	0.000973	0.001056
Story 5	15	0.00113	0.00123
Story 4	12	0.001278	0.001401
Story 3	9	0.001433	0.001568
Story 2	6	0.001767	0.001864
P Story	3	0.00364	0.003824
Base	0	0	0

1. Structural Stiffness:

Higher stiffness observed along the X-direction, showing lower displacement and drift.

Y-direction is slightly more flexible due to geometry but remains within safe limits.

2. Load Distribution:

Lateral forces reduce progressively toward the base, confirming effective shear transfer.

Upper stories experience higher displacement, typical of high-rise structures.

3. Drift Behavior:

Maximum drift occurs at the lower floors, indicating mild soft-story tendency.

Overall drift values remain well below code limits (0.02–0.03), ensuring safety.

4. Displacement Behavior:

Maximum lateral displacement: ~38–40 mm at 30 m height.

Slightly higher displacement in Y-direction, suggesting possible use of bracing or shear walls for improved serviceability.

4.1.3 SYMMETRIC STRUCTURAL BEHAVIOR & INTERPRETATION

Aspect	C-Shape	I-Shape
Lateral Force Distribution	Slightly higher at top; asymmetry leads to load concentration	Lower; symmetric distribution reduces peak forces
Displacement	Lower overall; more stiffness; better top-floor control	Higher top displacement; flexible along Y-axis
Drift	Lower; podium and mid-floor drift well-controlled	Higher at lower floors; more soft-story tendency
Stiffness	Stronger along both axes; asymmetry compensated by shear walls	Stiffer in X, more flexible in Y
Seismic Performance	Excellent; reduced sway and inter-story drift	Good; small drift limits, but higher than C-Shape

Key Insights

C-Shape

Exhibits higher stiffness and better control of lateral sway. Although lateral forces are slightly higher, the drift remains low due to efficient shear wall placement—making it ideal where serviceability and displacement control are critical.

Structure:

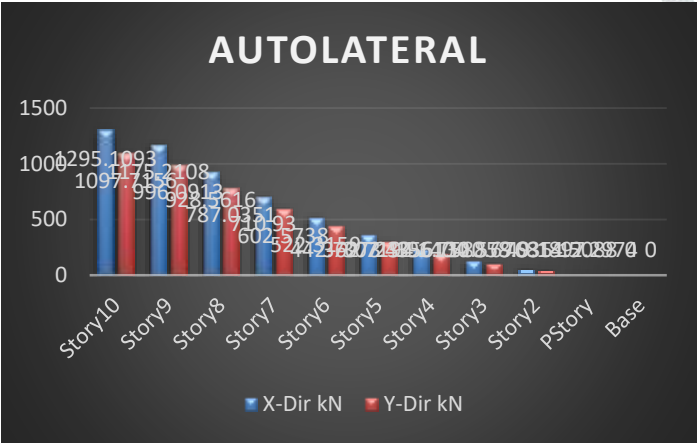
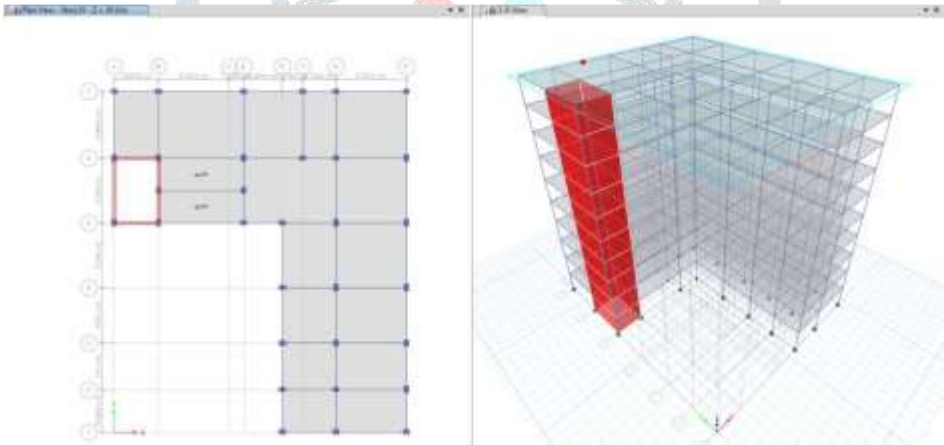
I-Shape

Shows more flexibility in the Y-direction, resulting in greater displacement and drift. While lateral forces are lower—benefiting material optimization and reduced load demand—it may require additional bracing or shear walls for stability along the Y-axis.

Structure:

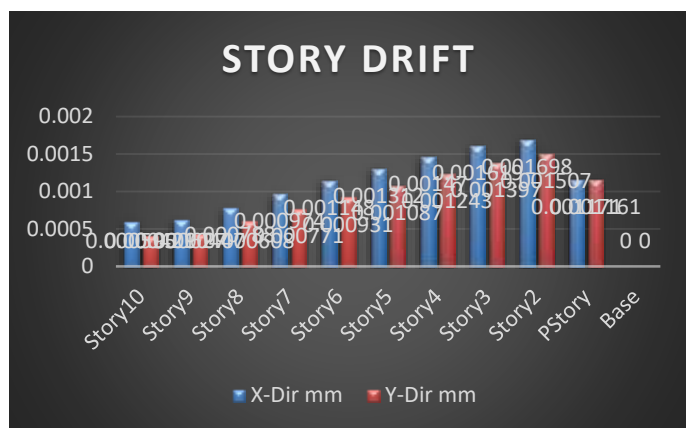
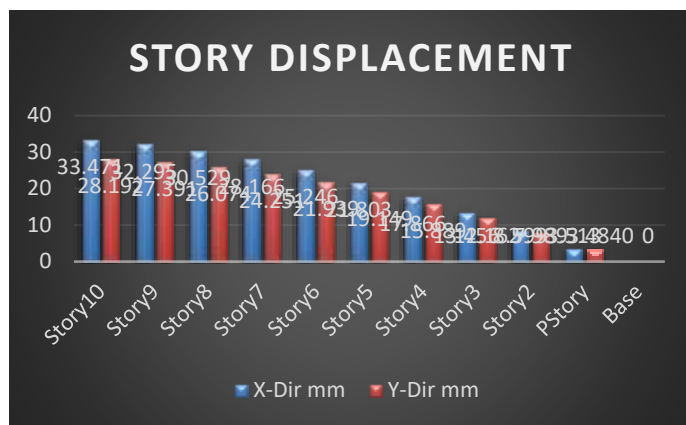
4.2 ASYMMETRIC MODEL

4.2.1 MODEL 3: L-SHAPE STRUCTURE



Story	Elevation (m)	X-Dir (KN)	Y-Dir (KN)
Story 10	30	1295.11	1097.72
Story 9	27	1175.21	996.09
Story 8	24	928.56	787.04
Story 7	21	710.93	602.57
Story 6	18	522.32	442.71
Story 5	15	362.72	307.44
Story 4	12	232.14	196.76
Story 3	9	130.58	110.68
Story 2	6	58.04	49.19
P Story	3	14.51	12.30
Base	0	0	0

Story	Elevation (m)	X-Dir (mm)	Y-Dir (mm)
Story 10	30	33.47	28.19



Story 9	27	32.30	27.39
Story 8	24	30.53	26.07
Story 7	21	28.17	24.25
Story 6	18	25.25	21.94
Story 5	15	21.80	19.15
Story 4	12	17.87	15.89
Story 3	9	13.46	12.16
Story 2	6	8.60	7.99
P Story	3	3.51	3.48
Base	0	0	0

Story	Elevation (m)	X-Dir	Y-Dir
Story 10	30	0.000595	0.000421
Story 9	27	0.000627	0.000447
Story 8	24	0.000788	0.000608
Story 7	21	0.000974	0.000771
Story 6	18	0.001148	0.000931
Story 5	15	0.001312	0.001087
Story 4	12	0.001470	0.001243
Story 3	9	0.001619	0.001397
Story 2	6	0.001698	0.001507
P Story	3	0.001171	0.001161
Base	0	0	0

1. Lateral Force:

X-direction forces are the lowest among all models, indicating reduced peak demand on members.

Y-direction forces are moderate, showing uneven load distribution due to asymmetry.

2. Displacement:

Maximum top displacement: ~33 mm (X) and ~28 mm (Y).

Values are lower than I-shape but higher than C-shape, confirming balanced flexibility.

Smooth displacement pattern indicates effective load transfer despite torsional tendency.

3. Story Drift:

Maximum drift occurs at mid-lower stories, slightly higher than C-shape but within safe limits.

X-direction drift > Y-direction drift, reflecting varied stiffness across axes.

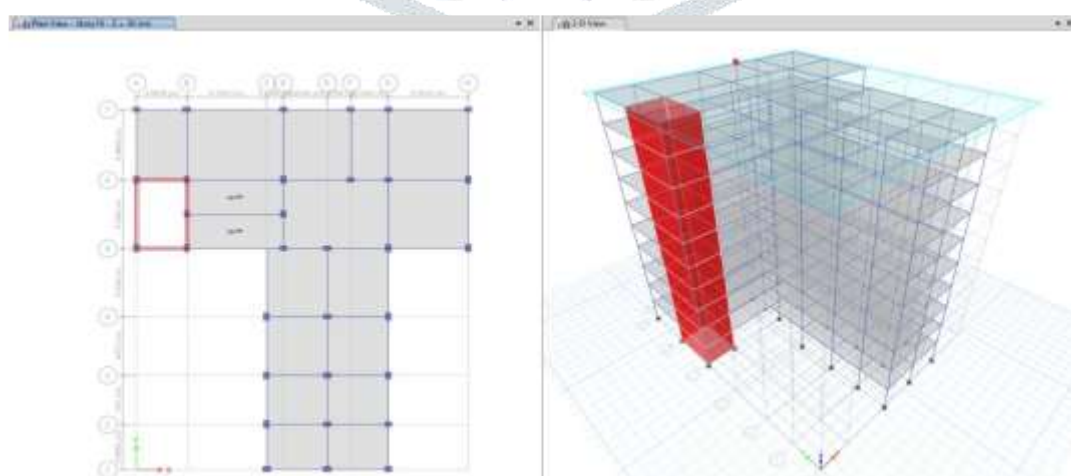
4. Asymmetry Effects:

L-shape geometry introduces torsional sensitivity around corner zones.

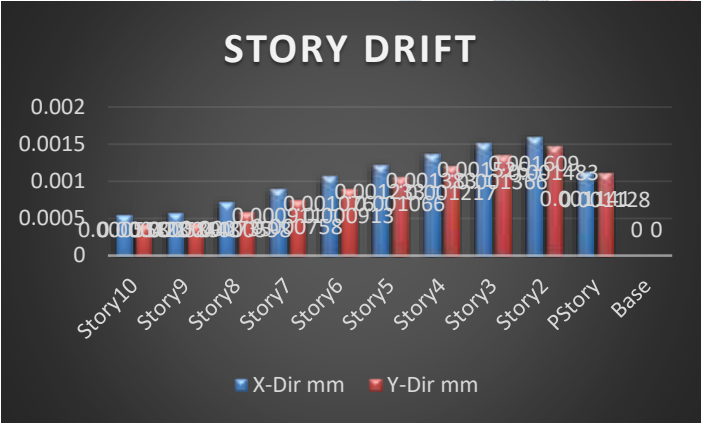
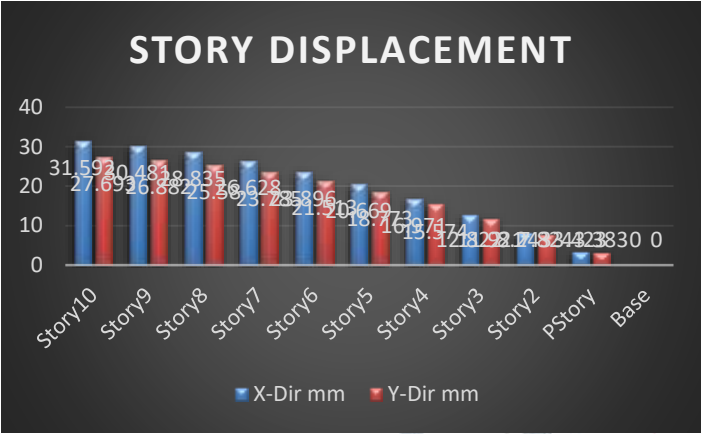
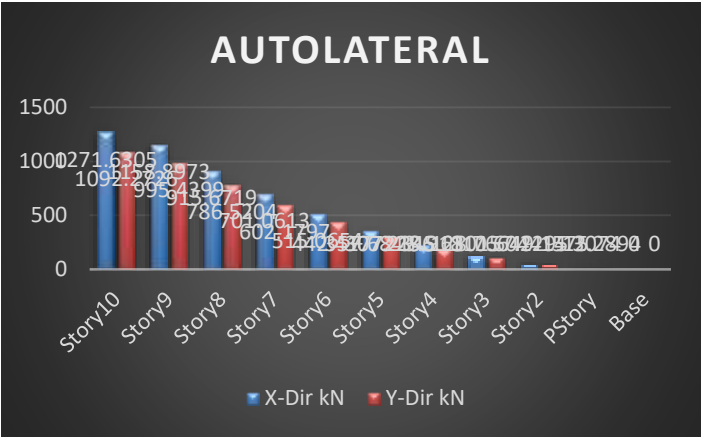
Requires careful design of corner columns and shear walls to resist torsional moments.

Overall, structure shows stable performance with controlled displacement and drift.

4.2.2 MODEL 4: T-SHAPE STRUCTURE



Story	Elevation (m)	X-Dir (KN)	Y-Dir (KN)
Story10	30	1271.63	1092.27
Story9	27	1158.90	995.44
Story8	24	915.67	786.52
Story7	21	701.06	602.18



Story6	18	515.07	442.42
Story5	15	357.68	307.23
Story4	12	228.92	196.63
Story3	9	128.77	110.60
Story2	6	57.23	49.16
P Story	3	14.31	12.29
Base	0	0	0

Story	Elevation (m)	X-Dir (mm)	Y-Dir (mm)
Story10	30	31.59	27.69
Story9	27	30.48	26.88
Story8	24	28.84	25.58
Story7	21	26.63	23.79
Story6	18	23.90	21.51
Story5	15	20.67	18.77
Story4	12	16.97	15.57
Story3	9	12.82	11.92
Story2	6	8.24	7.82
P Story	3	3.42	3.38
Base	0	0	0

Story	Elevation (m)	X-Dir	Y-Dir
Story10	30	0.000558	0.000428
Story9	27	0.000589	0.000448
Story8	24	0.000735	0.000598
Story7	21	0.000911	0.000758
Story6	18	0.001076	0.000913
Story5	15	0.001233	0.001066
Story4	12	0.001383	0.001217
Story3	9	0.001526	0.001366
Story2	6	0.001609	0.001483
P Story	3	0.001141	0.001128
Base	0	0	0

4.2.3 ASYMMETRIC STRUCTURAL BEHAVIOR & INTERPRETATION

Parameter	L-Shape	T-Shape	Conclusion
Shear Resistance	X-shear slightly higher → stronger along long leg	X-shear slightly lower → sufficient	L-shape marginally stronger in X-direction
Displacement	Higher top-floor displacement → more sway	Lower displacement → stiffer	T-shape better for lateral stability
Drift	Slightly higher in Y at top floors	Lower drift overall	T-shape safer for drift control
Torsion Sensitivity	Moderate torsion due to asymmetry	Moderate torsion, less than L in Y	T-shape slightly better torsion performance
Overall Safety	Safe under design loads, may need extra reinforcement in long leg	Safe under design loads, stiffer, less sway	T-shape preferred for stability and drift control

Key Insights

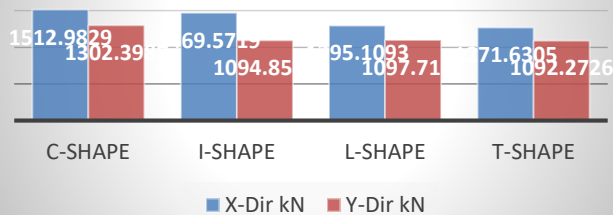
L-Shape: Stronger along the X-axis with moderate torsion; shows slightly higher lateral sway and drift in the Y-direction.

T-Shape: Exhibits lower top-floor displacement and drift, offering better lateral stability; slightly reduced shear in X-direction but remains structurally safe.

Recommendation: T-shape provides superior control over displacement, drift, and overall stability. L-shape can be preferred where X-axis shear resistance is critical, though additional reinforcement may be needed to counter torsion and top-floor sway.

V. RESULTS COMPARISON

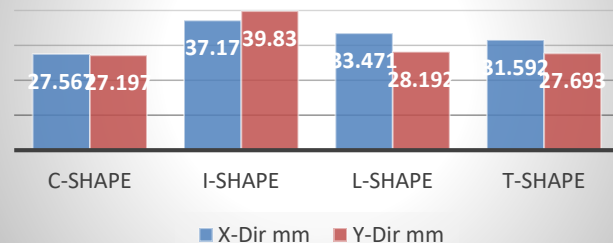
AUTOLATERAL



MODEL	X-Dir KN	Y-Dir KN
C-SHAPE	1512.9829	1302.3988
I-SHAPE	1469.5719	1094.8584
L-SHAPE	1295.1093	1097.7156
T-SHAPE	1271.6305	1092.2726

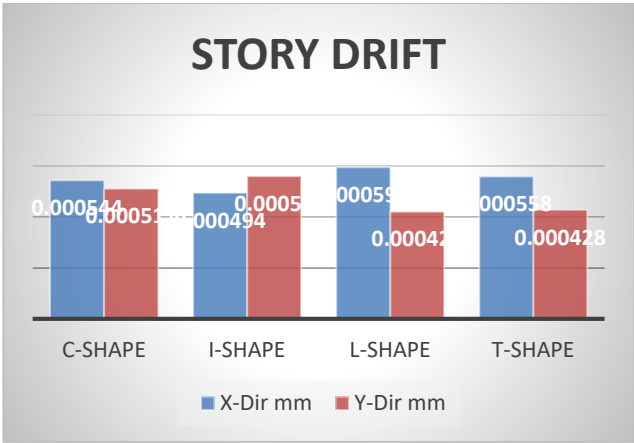
Model	X-Dir Shear (KN)	Y-Dir Shear (KN)	Observations
C-Shape	1512.98	1302.40	Maximum shear among all → strong lateral resistance; symmetric, so uniform shear distribution.
I-Shape	1469.57	1094.86	Slightly lower than C-Shape; less Y-shear → may experience torsion along Y.
L-Shape	1295.11	1097.72	Lower shear → asymmetry reduces load-resisting capacity along X, moderate torsion expected.
T-Shape	1271.63	1092.27	Lowest shear → asymmetry, but sufficient; torsional effect present, long leg carries X-shear.

STORY DISPLACEMENT



MODEL	X-Dir mm	Y-Dir mm
C-SHAPE	27.567	27.197
I-SHAPE	37.17	39.83
L-SHAPE	33.471	28.192
T-SHAPE	31.592	27.693

Model	X-Dir Displ (mm)	Y-Dir Displ (mm)	Observations
C-Shape	27.57	27.20	Lowest displacement → symmetric and stiff, best control of sway.
I-Shape	37.17	39.83	Maximum displacement → less stiffness, top floors sway more; prone to serviceability issues.
L-Shape	33.47	28.19	Moderate displacement; asymmetry leads to torsion and higher top-floor sway.
T-Shape	31.59	27.69	Slightly lower than L → stiffer along Y, better stability; torsion controlled.



C-SHAPE	0.000544	0.000511
I-SHAPE	0.000494	0.00056
L-SHAPE	0.000595	0.000421
T-SHAPE	0.000558	0.000428

Model	X-Dir Drift	Y-Dir Drift	Observations
C-Shape	0.000544	0.000511	Lowest drift → symmetric, uniform lateral behaviour safe for seismic conditions.
I-Shape	0.000494	0.000560	Slightly higher Y-drift → asymmetric along Y; torsion may develop.
L-Shape	0.000595	0.000421	Higher X-drift → asymmetry causes torsion; Y-drift lower than I.
T-Shape	0.000558	0.000428	Moderate drift; better torsion performance than L; safe under code limits.

5.1 OVERALL COMPARISON AND RECOMMENDATIONS

Parameter	Best Model	Comments
Shear Capacity	C-Shape	Strongest lateral load resistance; symmetric → uniform shear.
Top-Floor Displacement	C-Shape	Lowest displacement → least sway; ideal for tall buildings.
Inter-Story Drift	C-Shape	Lowest drift; symmetric, predictable behavior.
Torsion Control	T-Shape	Asymmetric but stiffer along critical axis; better than L.
Stability under Lateral Load	C-Shape	Overall safest and most stable.
Asymmetric Behavior	T-Shape	Better than L; I-Shape less stable along Y.

5.2 KEY SUMMARY

1. C-Shape (Symmetric)
Exhibits the highest stiffness and stability.
Minimal drift and torsion — most efficient and easy to reinforce.
2. I-Shape
Shows higher top-floor displacement and moderate drift.
Slight Y-direction asymmetry requires additional torsional reinforcement.
3. L-Shape
Experiences moderate displacement with higher torsional effects.
Asymmetry leads to increased drift along the X-axis.
4. T-Shape
Displays slightly lower shear and moderate displacement.
Drift and torsion are better controlled than in L-shape, making it the preferred asymmetric configuration.

VI. CONCLUSION

6.1 AUTO LATERAL LOAD

The C-shape model exhibits the highest lateral resistance in both directions (X: 1512.98 kN, Y: 1302.39 kN), indicating superior stiffness and strength. The I-shape shows slightly reduced forces (X: 1469.57 kN, Y: 1094.85 kN), reflecting lower stiffness in the Y-direction. The L-shape and T-shape, being asymmetric, attract comparatively lower lateral forces (L: 1295.10 kN, 1097.71 kN; T: 1271.63 kN, 1092.27 kN) due to torsional irregularities and uneven load distribution.

6.2 STORY DISPLACEMENT

The C-shape demonstrates the least displacement (27.56 mm X, 27.19 mm Y), confirming excellent rigidity. The I-shape shows the highest displacement (37.17 mm, 39.83 mm), indicating a more flexible structure. The L-shape records higher displacement in X (33.47 mm) but moderate in Y (28.19 mm), while the T-shape performs slightly better with 31.59 mm and 27.69 mm, showing improved balance.

6.3 STORY DRIFT

All models are within permissible drift limits. The C-shape maintains near-uniform drift (X: 0.000544, Y: 0.000511), reflecting structural stability. The I-shape shows balanced X-drift (0.000494) but higher Y-drift (0.000560). The L and T-shaped models display irregular drift patterns, with higher X-direction drift due to asymmetric stiffness.

6.4 CONCLUSION

The comparative analysis of lateral load, displacement, and drift shows that symmetric structures (C and I shapes) perform better than asymmetric ones (L and T shapes). Among all, the C-shape proves most efficient—offering maximum lateral resistance, minimum displacement, and uniform drift, ensuring superior seismic safety under equivalent static analysis. The I-shape, though symmetric, shows higher flexibility, while L and T-shapes are affected by torsional irregularities. Hence, the C-shape configuration is recommended for optimal seismic performance.

VII. REFERENCES

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