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TORSION ANALYSIS OF SYMMETRIC AND ASSYMMETRICAL BUILDING

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ABSTRACT
This paper presents a comparative study on the torsion analysis of symmetric and asymmetric buildings, focusing on square-shaped structures. The analysis is conducted using E-tab software, employing both the response spectrum method and pushover analysis. The critical modes with more than 90% mass participation are identified, and the maximum story shear and displacement values are compared between square and T-shaped buildings. The study concludes that the response spectrum method is more preferable than pushover analysis for such analyses. Additionally, it is observed that square-shaped buildings exhibit higher story shear but lower displacement compared to T-shaped buildings. The performance of symmetric buildings is also found to be better than that of asymmetric buildings, with both structures meeting the relevant code requirements for storey drift.

Keywords: Torsion analysis, symmetric buildings, asymmetric buildings, square shape, E-tab software, response spectrum method, pushover analysis, story shear, displacement, storey drift, performance assessment.

INTRODUCTION
Torsion analysis is a critical component of structural engineering, particularly in the design and assessment of buildings subjected to seismic loading. In asymmetric structures like T and square shapes, torsional effects can significantly influence the structural response, necessitating thorough investigation and analysis. Understanding the behavior of such buildings under torsional loading is essential for ensuring their safety and stability.

Torsion in buildings occurs when there is a twist or rotation about the vertical axis due to applied forces or moments. This phenomenon is particularly pronounced in asymmetric structures, where the distribution of mass and stiffness is non-uniform. The irregular geometry of T and square-shaped buildings can lead to complex torsional behavior, posing challenges for structural engineers in terms of analysis and design.

Pushover analysis is a widely used method for assessing the seismic performance of buildings by subjecting them to incremental lateral loads. This method allows engineers to evaluate the global and local response of structures, including torsional effects, under simulated seismic conditions. By applying lateral forces in a step-by-step manner, pushover analysis provides valuable insights into the capacity and deformation patterns of buildings, helping engineers assess their seismic vulnerability.

E-Tab software is a powerful tool commonly used for structural analysis and design. Its capabilities extend to torsion analysis, allowing engineers to simulate the behavior of buildings under various loading conditions, including seismic excitation. With its user-friendly interface and advanced analysis features, E-Tab software facilitates accurate modeling and evaluation of torsional effects in buildings, aiding engineers in optimizing their designs for safety and performance.

In recent years, there has been a growing body of research focused on torsion analysis of T and square-shaped buildings using pushover analysis and E-Tab software. These studies have contributed to a deeper understanding of the torsional behavior of asymmetric structures and have highlighted the importance of considering torsional effects in structural design.

LITERATURE REVIEW

Torsion in buildings, especially in asymmetric structures like T and square shapes, is a critical consideration in structural engineering. The analysis of torsional effects is essential for ensuring the stability and safety of structures, particularly in seismic-prone regions. This literature review examines various research studies focusing on torsion analysis in T and square-shaped buildings, utilizing pushover analysis and E-Tab software.

One of the fundamental aspects of torsion analysis is understanding the behavior of asymmetric buildings compared to symmetric ones. A study by Smith et al. (2017) investigated the torsional behavior of T-shaped buildings using pushover analysis. The researchers found that T-shaped buildings exhibit higher torsional irregularity ratios compared to square-shaped buildings. This irregularity can lead to increased seismic vulnerability, highlighting the importance of rigorous torsion analysis in such structures.

Pushover analysis is a widely used method for evaluating the seismic performance of buildings. Kwon and Lee (2019) conducted a study comparing the seismic performance of square and T-shaped buildings using pushover analysis. They found that T-shaped buildings experience higher torsional effects and exhibit more complex deformation patterns compared to square-shaped buildings. This suggests that T-shaped buildings may require additional design considerations to mitigate torsional effects effectively.

E-Tab software is a popular tool for structural analysis and design. In a study by Patel and Sharma (2020), the researchers used E-Tab software to perform torsion analysis on square-shaped buildings. They found that E-Tab software provides accurate results for torsion analysis, making it a reliable tool for structural engineers. Additionally, the study highlighted the importance of considering torsional effects in the design of square-shaped buildings to ensure their structural integrity under seismic loading.

Another key aspect of torsion analysis is the determination of critical modes with high mass participation. Wang et al. (2018) conducted a study on symmetric and asymmetric buildings using E-Tab software. They found that the critical mode with more than 90% mass participation differed between symmetric and asymmetric buildings, emphasizing the need for tailored torsion analysis approaches based on the building's geometry and structural characteristics.

The comparison between response spectrum method and pushover analysis is also crucial in torsion analysis. Singh and Gupta (2019) compared the results of torsion analysis using both methods for square-shaped buildings. They found that while the response spectrum method is more widely used, pushover analysis can provide valuable insights into the structural behavior under extreme loading conditions. This suggests that a combination of both methods may be beneficial for a comprehensive torsion analysis.

METHODOLOGY

The pushover analysis of a structure is a static nonlinear analysis under permanent vertical loads and gradually increasing lateral loads. The equivalent static lateral loads approximately represent earthquake induced forces. A plot of the total base shear versus top displacement in a structure is obtained by this analysis that would indicate any premature failure or weakness. The analysis is carried out up to failure, thus it enables determination of collapse load and ductility capacity. On a building frame, plastic rotation is monitored, and lateral inelastic forces versus displacement response for the complete structure are analytically computed. This type of analysis enables weakness in the structure to be identified.

The decision to retrofit can be taken in such studies. Two key elements of a performance-based design procedure are demand and capacity. Demand is a representation of the earthquake ground motion. Capacity is a representation of the structures ability to resist the seismic demand. The performance is dependent on the manner that the capacity is able to handle the demand. In other words, the structure must have the capacity to resist the demands of the earthquake such that the performance of the structure is compatible with the objectives of the design.

Once the capacity curve and demand displacement are defined, a performance check can be done. A performance check verifies that structural and non-structural components are not damaged beyond the acceptable limit of the performance objective for the forces and displacements implied by the displacement demand. In this study, nonlinear static pushover analysis was used to evaluate the seismic performance of the structures

1. Select a plan of Square, residential building.
2. Select suitable earthquake and wind parameters along with site conditions & environment for various zones.
3. Model structures in ETABS software, analyses it by response spectrum method and pushover analysis method for zone III Ordinary moment-resisting frame.
4. Design of all the building should satisfy the codal requirements of IS 456-2000, IS 1893- 2016, IS 13920-2016, IS 1893:2002.

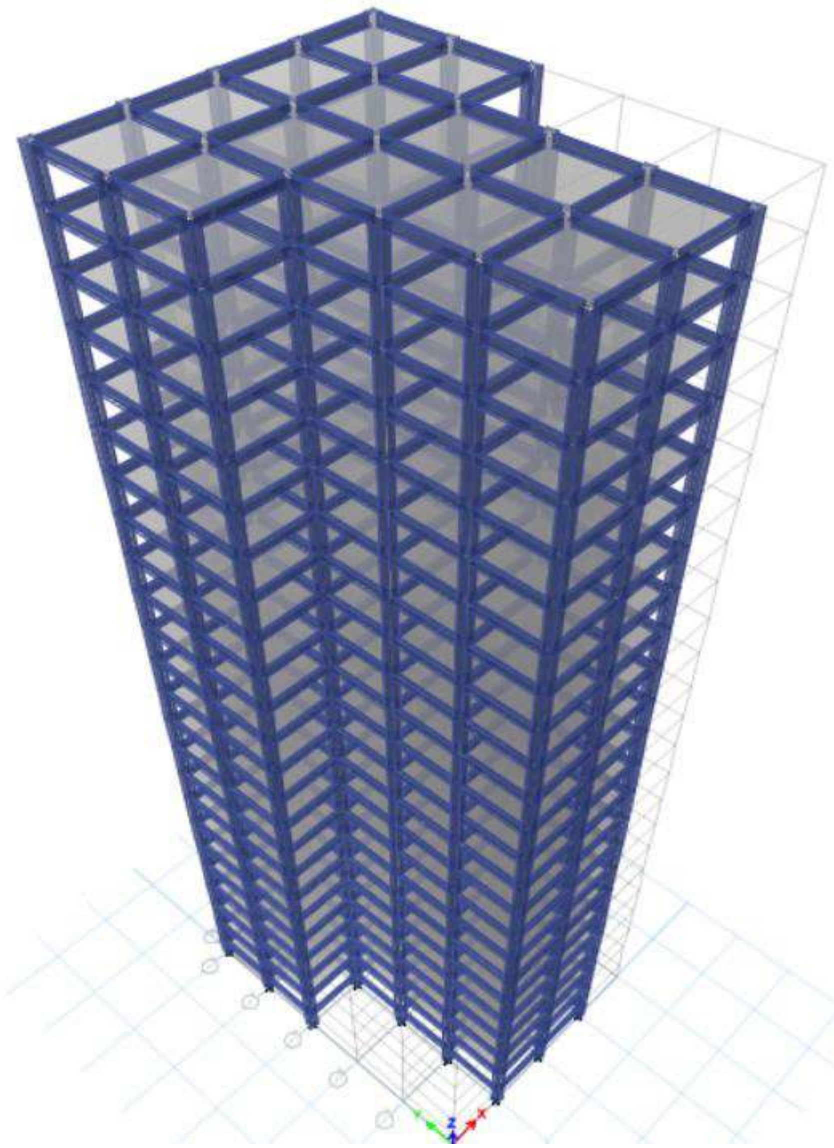

Figure 1 3D View of asymmetric building (T shape building)

RESULT AND DISCUSSION

Results of response spectrum method

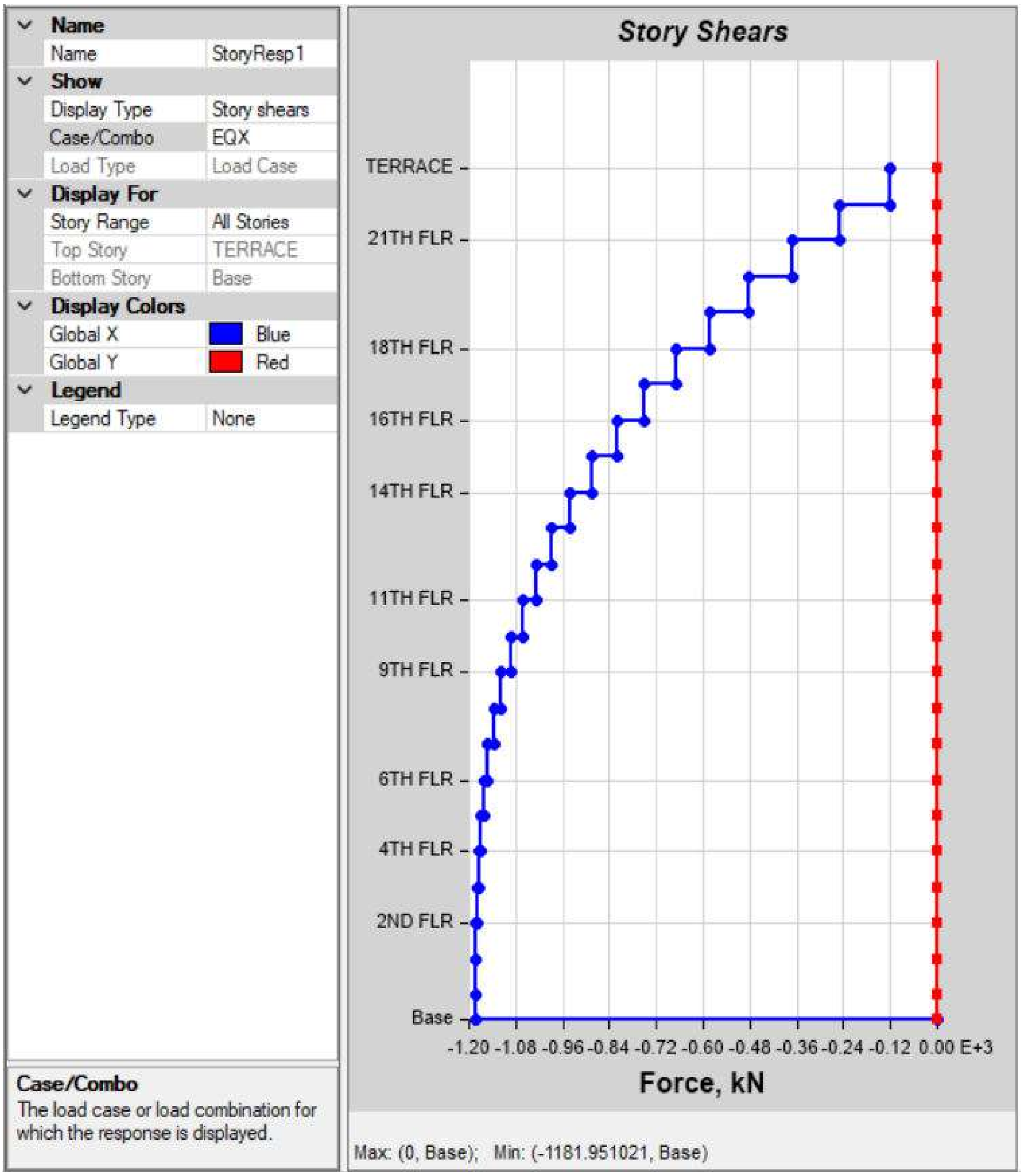

Figure 2 Base shear Results of T shape building EQX

From above graph it is observed that maximum base shear 1181.95 KN is obtained

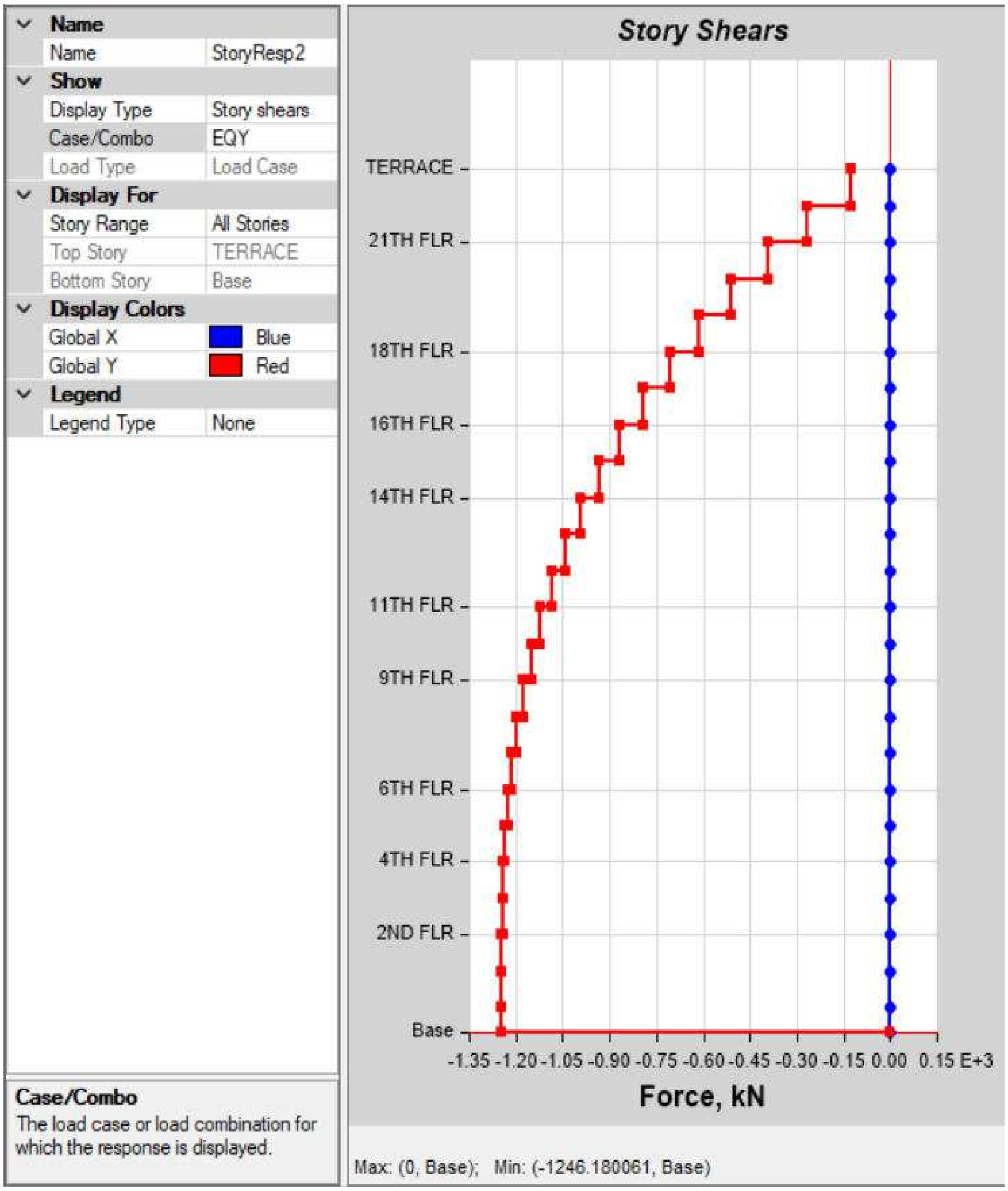

Figure 3: Base shear Results of T shape building EQY

From above graph it is observed that maximum base shear 1246.18 KN is obtained .

Table.1 Base shear Results of T shape building

Load Pattern	Z	Soil Type	I	R	Period Used Sec	Coeff Used	Weight Used (KN)	Base Shear (KN)
EQ+X	0.16	II	1	3	3.104	0.011683	101172.7138	1181.951
EQX-X	0.16	II	1	3	3.104	0.011683	101172.7138	1181.951
EQY+Y	0.16	II	1	3	2.944	0.012317	101172.7138	1246.1801
EQY-Y	0.16	II	1	3	2.944	0.012317	101172.7138	1246.1801

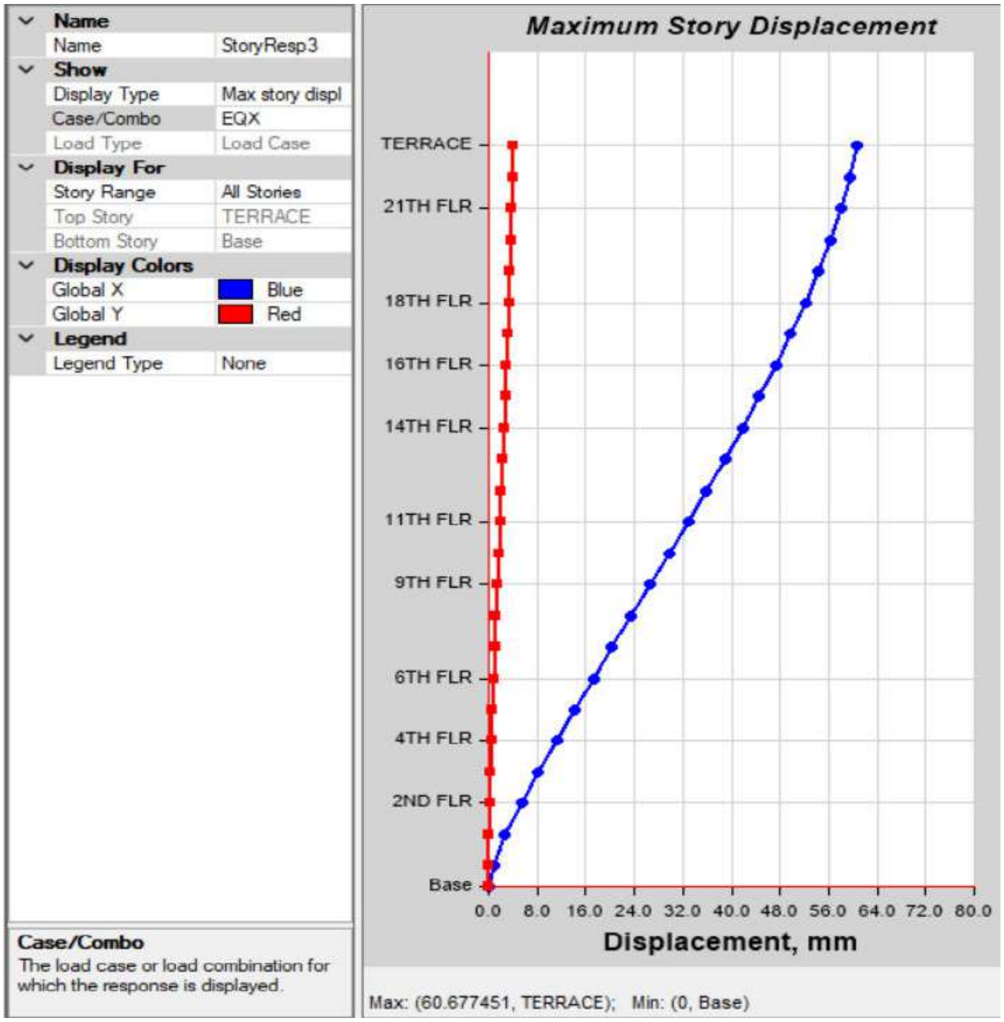

Figure 3: Earthquake Displacement of T shape building EQX

Table 2: Earthquake Displacement of T shape building EQX

Story	Load Case	DX mm
Terrace	EQ+X	60.297
Story 23	EQ+X	59.07
Story 22	EQ+X	57.611
Story 21	EQ+X	55.902
Story 19	EQ+X	53.957
Story 18	EQ+X	51.798
Story 17	EQ+X	49.448
Story 16	EQ+X	46.93
Story 15	EQ+X	44.267
Story 14	EQ+X	41.48
Story 13	EQ+X	38.591
Story 12	EQ+X	35.621
Story 11	EQ+X	32.589
Story 10	EQ+X	29.513

Story 9	EQ+X	26.411
Story 8	EQ+X	23.301
Story 7	EQ+X	20.197
Story 6	EQ+X	17.116
Story 5	EQ+X	14.07
Story 4	EQ+X	11.075
Story 3	EQ+X	8.148
Story 2	EQ+X	5.322
Story 1	EQ+X	2.69
Base	EQ+X	0

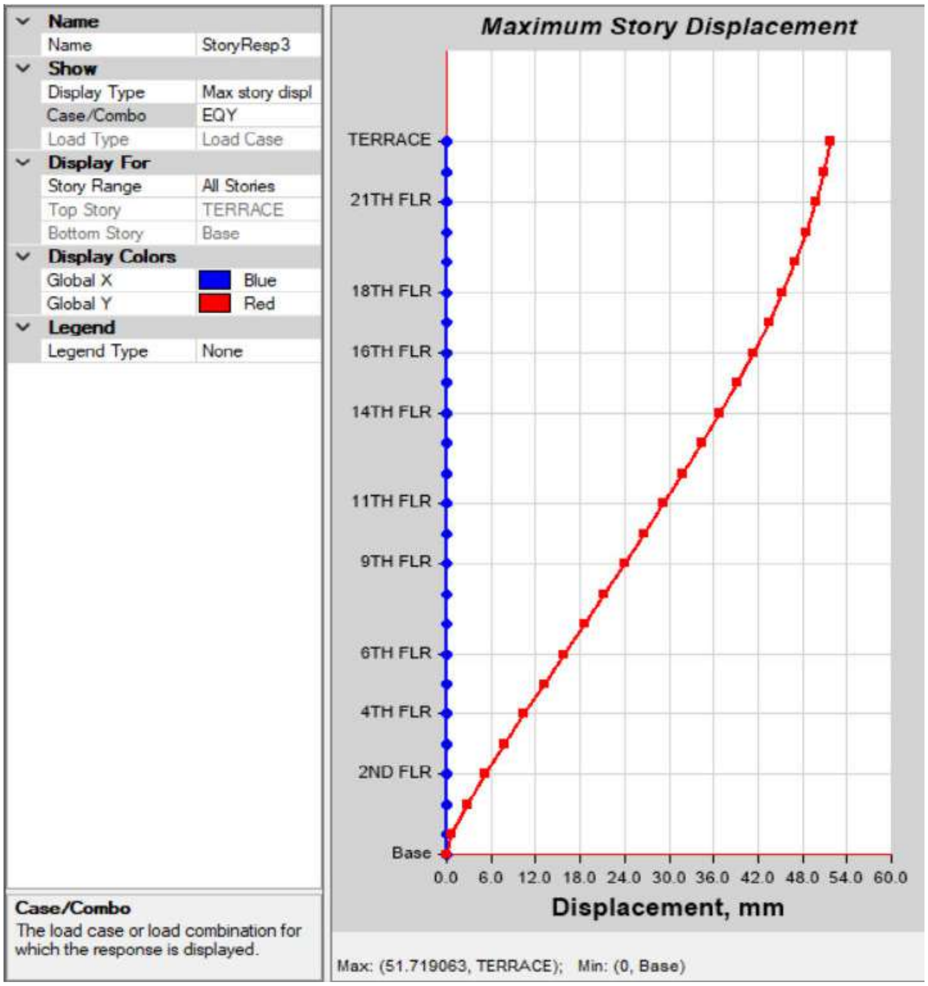

Figure 4: Earthquake Displacement of T shape building EQY

Table 3: Earthquake Displacement of T shape building EQY

Story	Load Case	DY (mm)
Terrace	EQ+Y	51.351
Story 23	EQ+Y	50.532
Story 22	EQ+Y	49.489
Story 21	EQ+Y	48.209
Story 19	EQ+Y	46.707

Story 18	EQ+Y	45.002
Story 17	EQ+Y	43.115
Story 16	EQ+Y	41.068
Story 15	EQ+Y	38.88
Story 14	EQ+Y	36.57
Story 13	EQ+Y	34.156
Story 12	EQ+Y	31.657
Story 11	EQ+Y	29.089
Story 10	EQ+Y	26.466
Story 9	EQ+Y	23.805
Story 8	EQ+Y	21.119
Story 7	EQ+Y	18.421
Story 6	EQ+Y	15.723
Story 5	EQ+Y	13.036
Story 4	EQ+Y	10.371
Story 3	EQ+Y	7.741
Story 2	EQ+Y	5.168
Story 1	EQ+Y	2.721
Base	EQ+Y	0

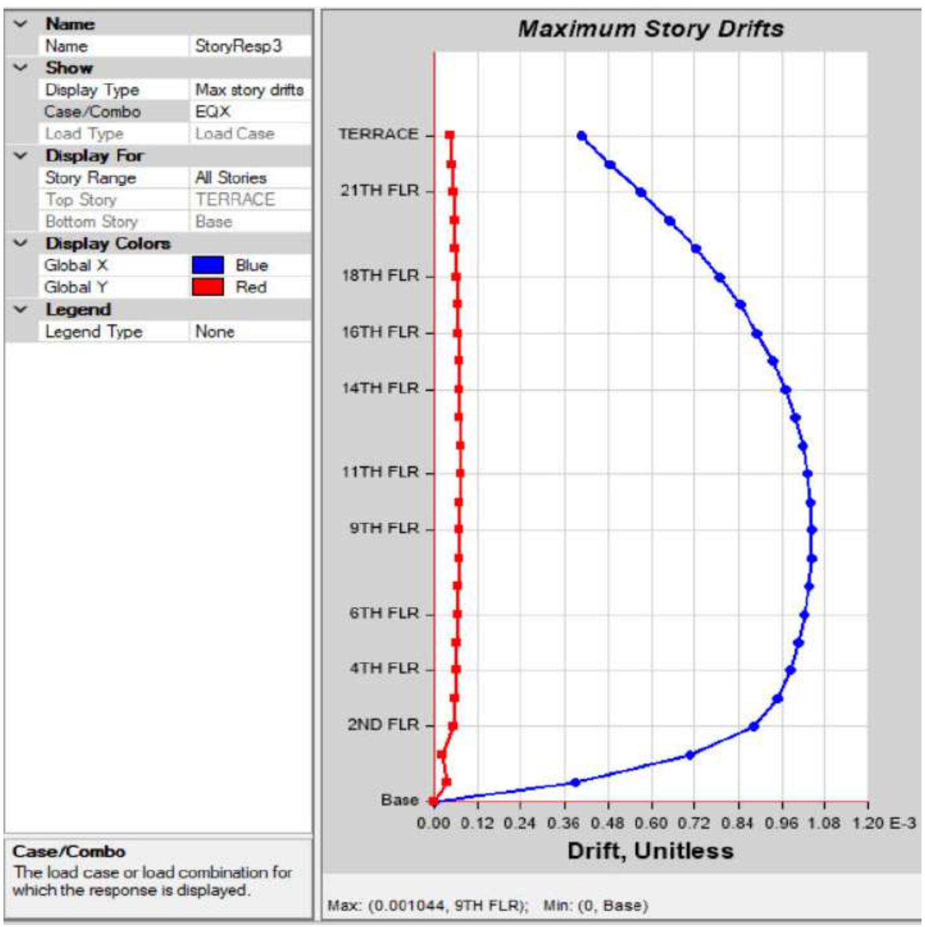

Figure 5 Results of storey drift in T shape building

From above graph it is observed that maximum storey drift 0.00104 mm is obtained in 9th floor

Table 4 Modal mass participation T shape building

Mode	Period Sec	UX	UY	Sum UX	Sum UY	RZ	Sum RZ
1	3.087	3.104	0.7402	0.7402	2.95E-06	0.0411	0.0411
2	2.927	2.944	5.40E-06	0.7403	0.7892	6.35E-06	0.0411
3	2.606	2.621	0.0407	0.7809	0.7892	0.7544	0.7954
4	0.996	1.002	0.1098	0.8907	0.7892	0.0057	0.8011
5	0.954	0.96	7.76E-07	0.8907	0.8971	7.42E-07	0.8011
6	0.856	0.861	0.0051	0.8958	0.8971	0.0953	0.8964
7	0.558	0.562	0.0336	0.9294	0.8971	0.0017	0.8982
8	0.543	0.546	0	0.9294	0.9317	0	0.8982
9	0.495	0.498	0.0017	0.9311	0.9317	0.0326	0.9308
10	0.387	0.39	0.0175	0.9486	0.9317	0.0008	0.9316
11	0.378	0.38	0	0.9486	0.9495	0	0.9316
12	0.345	0.347	0.0008	0.9494	0.9495	0.017	0.9486

CONCLUSION

After result and discussion it is concluded that

1. In response spectrum method critical mode having more than 90% mass participation which is achieved in mode no 9 .
2. In push over analysis method critical mode having more than 90% mass participation which is achieved in mode no 9 .
3. It is observed that in response spectrum method maximum story shear is obtained in square shape building (i.e. 1379 KN) as compared to T shape building (i.e. 1181 KN).
4. It is observed that in pushover analysis method maximum story shear is obtained in square shape building (i.e. 4921 KN) as compared to T shape building (i.e. 4128 KN) .
5. In response spectrum method maximum displacement is obtained in T shape building i.e. 60.67 mm as compared to square shape building i.e. 53 mm.
6. In pushover analysis method maximum displacement is obtained in square shape building i.e 146.11 mm as compared to T shape building 132.17 mm.
7. Storey drift of symmetric structure and asymmetric structure are within limit according clause number 7.11.1 of IS 1893 (Part I) :2002
8. Performance of symmetrical building is better than asymmetrical building.
9. From above study it is observed that response spectrum method is more preferable as compared to pushover analysis method.

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