A Study on Seismic Analysis of Multistorey Structure With Different Shapes In Zone-III

Poojan Mistry[1], Mansi Prajapati[2]
[1]Dept of Civil Engineering
[2]HOD, Dept of Civil Engineering
[1, 2] Swarrnim Startup and Innovation University

Abstract- *In regions prone to earthquakes, it is essential to analyze multistorey structures to ensure their safety and structural integrity during seismic events. This research focuses on the seismic analysis of multistorey structures located in seismic zone-III, which have various shapes including rectangular, U-shaped, H-shaped, and T Shaped buildings. The analysis of the structures was conducted using ETABS, a software package based on the finite element method. The study aimed to compare and evaluate the seismic performance of the different shapes of buildings.*

Keywords- Multistorey, ETABS, seismic zone, Story Drift, Displacement, U Shape, T Shape, H Shape, Structural Analysis

I. INTRODUCTION

Seismic analysis plays a critical role in ensuring the safety and integrity of multistorey buildings in earthquake-prone regions. This research aims to assess the seismic performance of multistorey structures with different shapes in seismic zone III. The study's objective is to determine the most effective building shape and identify the design parameters that significantly impact seismic performance. The findings will provide valuable insights for engineers and designers involved in seismic design, facilitating the implementation of safer construction practices in earthquake-prone areas. The analysis will be conducted using the ETABS software, based on the finite element method.

II. MODELING OF BUILDING

In this study, we explore the behavior of various building shapes. i.e., U-Shape, H-Shape, T-Shape. ETABS Software is used for modeling and analysis. ETABS software, known for its user-friendly interface and versatility, has been utilized in this study. This program provides a broad range of capabilities, including static and dynamic analysis, non-linear dynamic analysis, and non-linear static pushover analysis, among others.

A) Table below shows the details and parameters of U,T and H-Shape building.

U,T,H-SHAPE G+10 BUILDING PARAMETERS		
NO	DATA	
1	Building	G+10
2	Story Height	3m
3	Total Height Of The Structure	33m
4	Depth Of Foundation Below N.G.L	-3 m
5	Slab Eliment	Shell
6	Shearwall Element	Shell
7	Diaphragm	Yes
8	Diaphragm Type	Rigid
9	Zone Factor (Z)	0.16
10	Response Reduction Factor (R)	5
11	Importance Factor	1.2
12	Soil Type	Medium
13	Mass Source For Earthquake Load	DL+0.25LL
14	Earthquake Starts From Level	Foundation Level
15	Frame Element Design	Ductile
16	Time Period Calculation	$T_a = \frac{0.09h}{\sqrt{d}}$
17	Column Size	300mmx900mm
18	Shearwall Thickness	300mm
19	Beam Size	300mmx600mm
20	Slab Thickness	150mm
21	Concrete Grade	M30
22	Steel Grade	Fe 500
23	Dead Load	1.5 kN/m²
24	Dead Load On Terrace	3.3 kN/m²
25	Live Load	2 kN/m²
26	Live Load On Terrace	1.5 kN/m²
27	Dead Load Of Wall (230Mm Thick)	11.73 kN/m
28	Dead Load Of Wall (115Mm Thick)	5.86 kN/m
29	Dead Load Of Parapet Wall (230Mm Thick) 1M Height	4.6 kN/m
30	Density of Brick	$20kN/m^3$

Table 1 Building Details

Plan Dimension of the H-Shape and U-Shape building is 16.0m x 17.5m and Plan Dimension of T-shape building is 20.0m x 17.5m.

B) U- Shape RC Building. The figure below shows the model of U-shaped G+10 building.

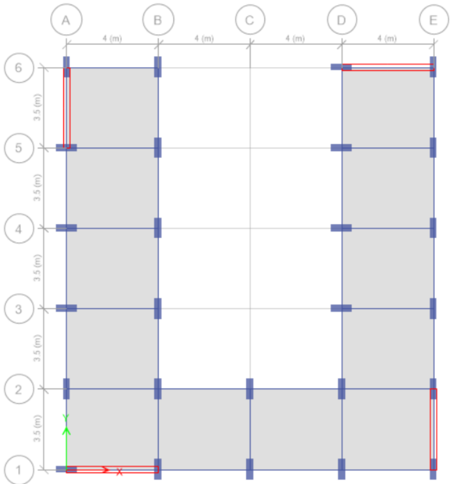

Figure 1. U-shape Building Plan View

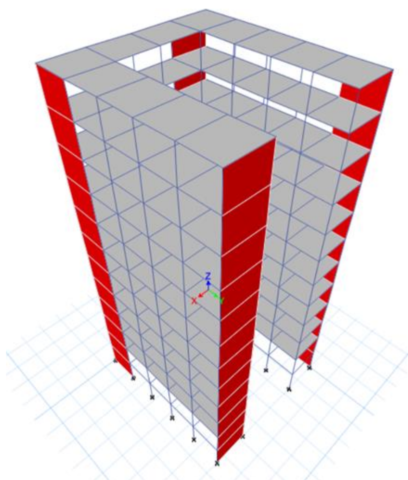

Figure 2. U-shape Building 3D View

C) T- Shape RC Building. The figure below shows the model of T-shaped G+10 building.

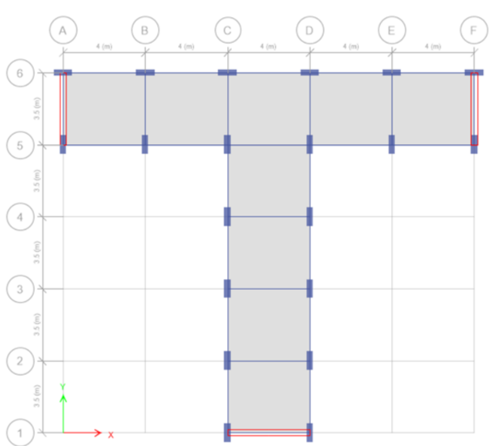

Figure 3. T-shape Building Plan View

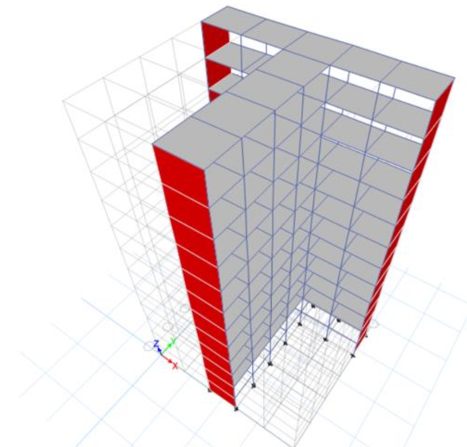

Figure 4. U-shape Building 3D View

D) H- Shape RC Building. The figure below shows the model of H-shaped G+10 building.

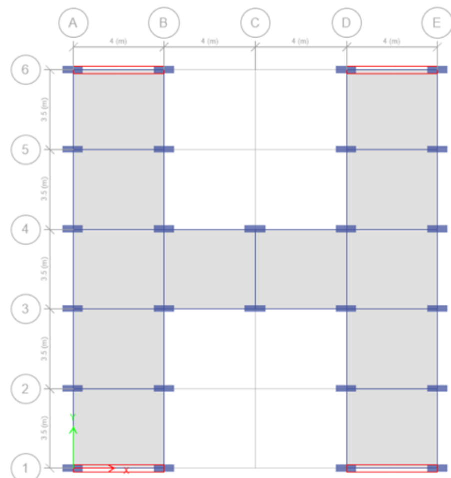

Figure 5. H-shape Building Plan View

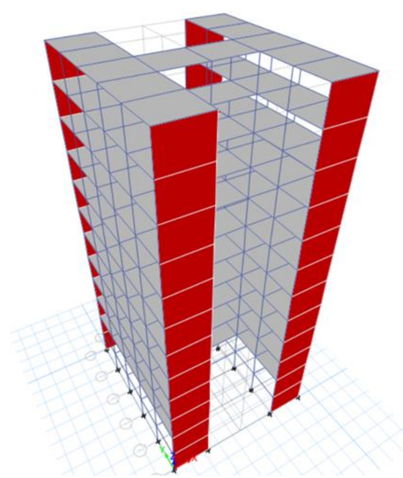

Figure 6. H-shape Building 3D View

E) Time Period Calculation of U-Shape,T-Shape andH-Shape Building. According to IS:1893 Part 1: 2016.

$$T_a = \frac{0.09h}{\sqrt{d}}$$

Where,
H= Height of the building
d= Base dimension of the building at the plinth level along the direction of earthquake considered.

- **U-Shape Time Period**

H = 33m+3m(Depth Below G.L.) = 33m
d along the X-dir = 16m
d along the y-dir = 17.5m

Ta(X-dir) = 0.6641 Sec.
Ta(Y-dir) = 0.7099 Sec.

- **T-Shape Time Period**

H = 33m+3m(Depth Below G.L.) = 33m
d along the X-dir = 20m
d along the y-dir = 17.5m

Ta(X-dir) = 0.6641 Sec.
Ta(Y-dir) = 0.7099 Sec.

- **H-Shape Time Period**

H = 33m+3m(Depth Below G.L.) = 33m
d along the X-dir = 16m
d along the y-dir = 17.5m

Ta(X-dir) = 0.7425 Sec.
Ta(Y-dir) = 0.7099 Sec.

III. METHODOLOGY

There are two primary methods of analysis commonly used in structural engineering: equivalent static force analysis and dynamic analysis.

1) Equivalent Static Method
2) Dynamic Analysis Method

1) Equivalent Static Method :

Equivalent Static Method is a simplified approach to assess the response of a structure to seismic forces. It involves approximating the dynamic effects of an earthquake by applying an equivalent static force that represents the maximum expected seismic force. This method relies on established code provisions and empirical formulas to estimate the structural response and design the building accordingly.

2) Dynamic Analysis Method :

Dynamic analysis is a more comprehensive and detailed approach. It takes into account the actual time history of ground motion during an earthquake and analyzes the structural response accordingly. Dynamic analysis considers factors such as the mass, stiffness, and damping properties of the structure to accurately simulate its dynamic behavior. By utilizing this method, engineers gain a deeper understanding of how the structure will perform under seismic loads, enabling them to design structures that can effectively withstand the anticipated forces.

In this study, the behavior of the structure is analyzed using the response spectrum analysis method, which falls under the category of dynamic analysis. This particular method has been specifically chosen to provide valuable insights into how the structure reacts and adapts to seismic or dynamic loads. By employing the response spectrum analysis, the researchers intend to gain a comprehensive understanding of the structural performance under varying loading conditions.

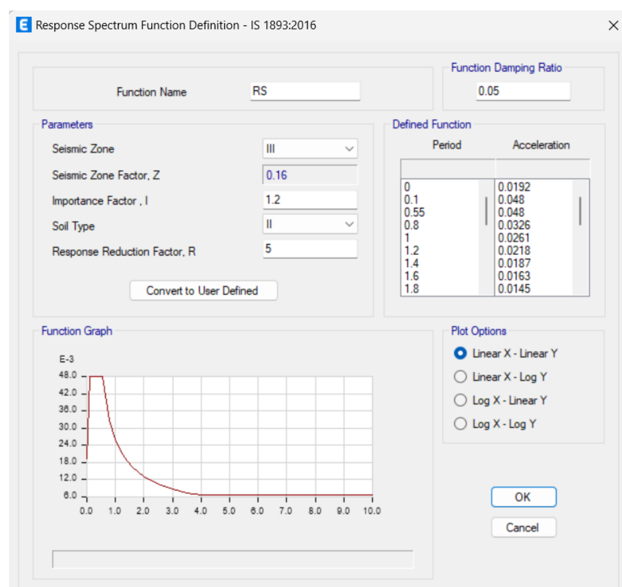

Figure 7. Response Spectrum Definition IS 1893 Part 1:2016

IV. RESULTS AND DISCUSSION

Following graphs are shows the comparison of Maximum Overturning Moments,Storey Shear, Drift and Storey Displacement/Deformation.

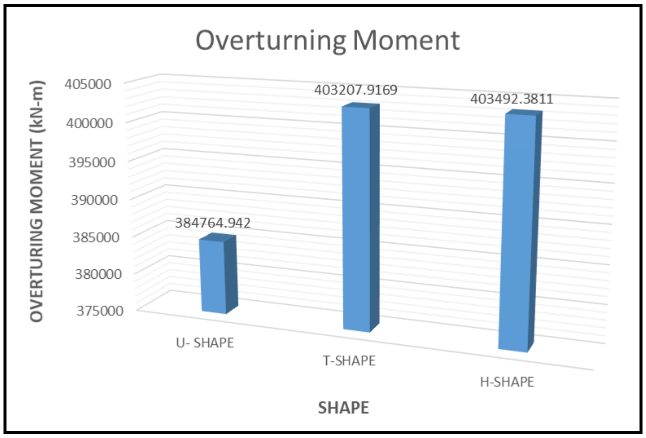

Figure 8. Overturning Moment

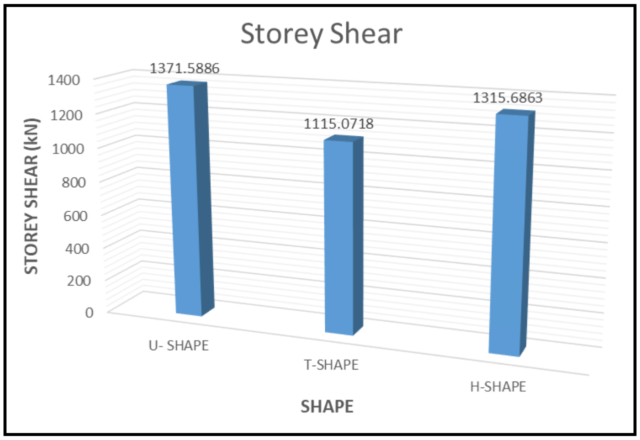

Figure 9. Storey Shear

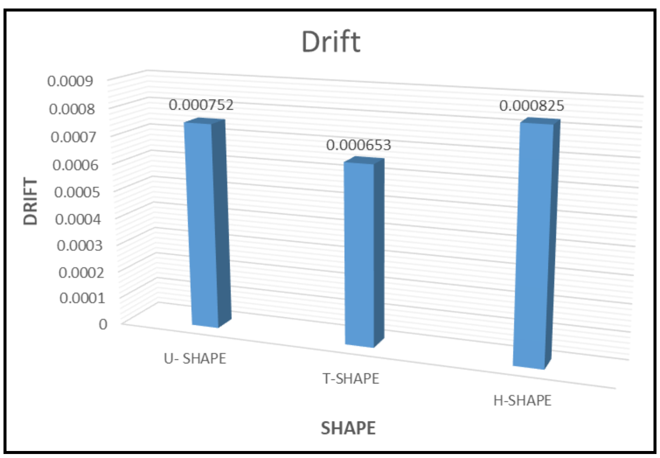

Figure 10. Drift

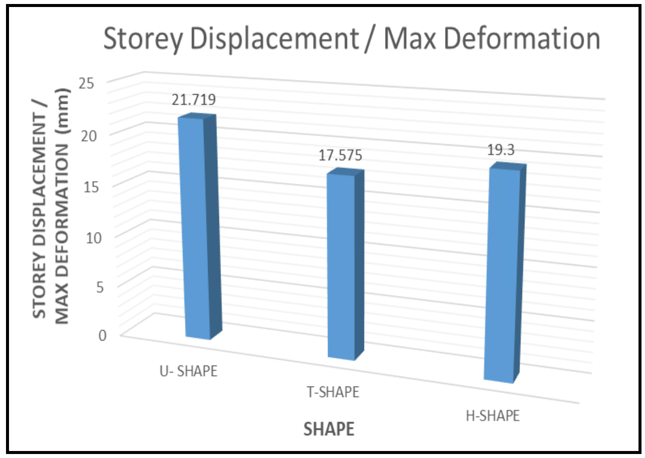

Figure 11. Maximum Storey Displacement / Deformation.

V. CONCLUSION

- U-shaped building is more resistant to overturning moments than the T- and H-shaped buildings. This is due to the symmetrical form of the U-shaped building, which provides superior stability and balanced distribution of lateral stresses during an earthquake. The T-shape and H-shape buildings, on the other hand, have asymmetrical designs that might result in torsion and increased overturning moments during seismic events. Furthermore, the T-shape and H-shape buildings have identical overturning moments, showing that both structures have equivalent resistance to overturning.
- T-shape building is more resistant to story shear than the U-shape and H-shape buildings. This is due to the central core of the T-shape building, which offers higher lateral stiffness and distributes shear stresses more uniformly over the structure. The U-shape and H-shape structures, on the other hand, have less centralization, resulting in stronger lateral deflections and story shears during an earthquake. It is also noticed that the story shears of the U-shape and H-shape buildings are equivalent, indicating that both structures have equal resistance to story shear.
- T-shaped buildings have less story shear than H-Shaped and U-Shaped buildings. Furthermore, T-shape and U-shape buildings have about the same drift as compared to the H-shape structure. These findings imply that in seismic zones, U-shape and T-shape buildings may perform better in terms of story drift and storey shear than H-shape structures.
- The most substantial story displacement is noted in the U-shape, T-shape, and H-shape buildings, with the T-shape building having the least displacement. In terms of displacement, the H-shape building lies between the U-shape and T-shape buildings, with displacement not being less than the T-shape building or higher than the U-shape building. As a result, if lesser displacement is needed, the

T-shape building is the best option among the three building forms. If displacement is not a big problem, the H-shape building can be considered because it lies in the middle of the other two forms in terms of displacement. If lower displacement is desired, the U-shape building should be avoided because it has the highest displacement among the three shapes.

- These insights can be useful for engineers and designers working on performance-based seismic design of multistorey structures.
- However, more research is needed to properly understand the seismic performance of various structure types, as other factors such as the design, materials, and location of the buildings may all have a substantial influence on their seismic resistance.

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