A Research on Modal Analysis of Symmetric and Asymmetric Building With And Without Shear Wall Under Indian Seismic Conditions

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Abstract: -The torsional effects of seismic events on multistory buildings are critically analyzed in this research paper. The twisting motion of buildings brought on by seismic forces is known as torsional effects, and it is crucial to the structural integrity of buildings. In order to design structures that can withstand seismic activity and guarantee occupant safety, it is imperative to comprehend these effects. The study draws attention to the complexity of torsional responses and how they affect how well buildings function during earthquakes. The study examines two different models that are symmetric and asymmetric high-rise buildings with and without shear walls in their structure in different Indian seismic zones. Analysis had been carried by modelling in ETABS. It was observed that the performance of any building depends very much on the torsional behavior of the structure.

***Key Words*: (Modal analysis), (Shear Wall), (Torsion), (Mass participation ratio), (Frequency) & (High rise).**

1.INTRODUCTION: -

India's vast and varied terrain is marked by different degrees of seismic hazard, which makes in-depth study of the evaluation of structures in seismic zones necessary. One frequent natural hazard in the area is earthquakes, which are extremely dangerous for both infrastructure and human life. Reducing the devastating effects of earthquakes requires an understanding of how various building types react to seismic stress in various regions. India has a wide range of seismic risk, from low-risk regions to high-intensity zones near plate borders. This emphasizes the need for thorough studies to guide building procedures and retrofitting techniques.

The study of modal analysis of structures is a fundamental aspect of structural engineering and seismic design, providing critical insights into the dynamic behavior of buildings and other constructions under various loading conditions. This analytical technique involves examining the natural frequencies, mode shapes, and damping ratios of a structure, which are essential for understanding how it will respond to dynamic forces such as wind, vibrations, and earthquakes. By identifying the primary modes of vibration and their associated mass participation factors, engineers can predict potential resonances and ensure that the structure can withstand and dissipate energy effectively. Additionally, parameters like storey drift and torsional stability are assessed to evaluate the overall performance and safety of the structure.

In the study of structural dynamics, modal analysis is an essential method for understanding how structures respond to vibrations. For the purpose of creating safe and effective structures, this analysis is crucial, especially in the fields of civil, mechanical, aerospace, and automotive engineering.

Understanding and enhancing the vibrational characteristics of structures is made easier with the help of modal analysis, a fundamental component of structural engineering. Through the identification of inherent frequencies and mode shapes, engineers are able to create more durable and resilient structures that guarantee performance and safety in a range of applications.

In conclusion, studies on the evaluation of Indian seismically vulnerable structures are essential to the preservation of infrastructure and human life. The country's varied seismic risk makes it necessary to take a nuanced approach to comprehending how different regions' buildings behave. These studies provide valuable insights that not only guide the design and construction of new buildings, but also play a major role in the development of robust building codes and retrofitting strategies. The knowledge gained from seismic research will be crucial in developing a built environment that is safer and more resilient as India continues to urbanize and grow.

2.Modelling: -

The current work can be categorized as a quantitative study since it primarily focuses on gathering numerical data for two distinct building plan configurations that are exposed to seismic loads. The analysis was carried out on reinforced concrete structures that were symmetrical and asymmetrical, measuring 38 x 38 m for square buildings and 68.5 x 48.5 m for L-shaped buildings. These plans have 13 standard stories, each measuring 3 meters in height, with a base story height of 3.5 meters. Every structural element is modeled exactly, including the placement and size of shear walls.

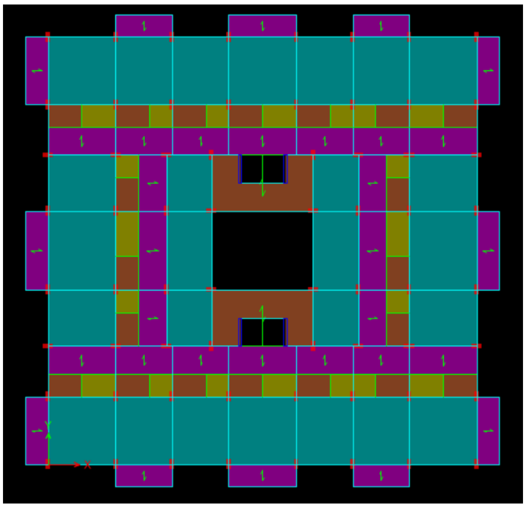

Figure 1(a): Plan of square building

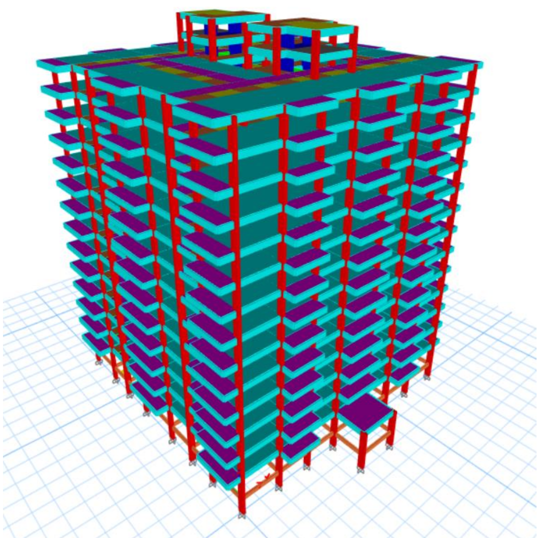

Figure 1(b): 3D view of square building

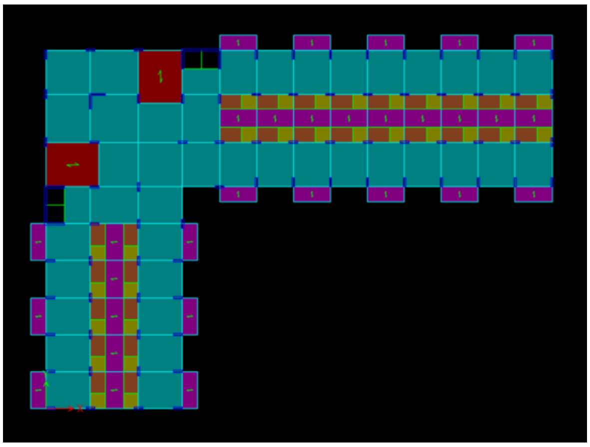

Figure 2(a): Plan of L-shape building

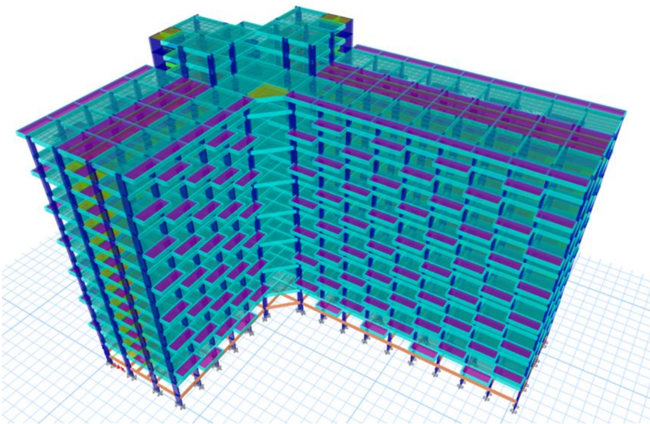

Figure 2(b): 3D view of L-shape building

Table I: Properties and data: -

Parameters	Value
Number of stories	G+13
Storey height (Gf, typical)	(3.5,3) m
Grade of Concrete in Beam & slab	M25
Grade of Concrete in Column	M35
Grade of Rebar	Fe500
Depth of Foundation	12.7 m
Live Load(rooms)	2 KN/m2
Live load (other)	3 KN/m2
Live load (terrace)	1.5 KN/m
Floor Finishing	1.5 KN/m^2
Slab (Thickness)	125 mm
Density of block masonry	7.5 kN/m^3
Density of Plaster	20 KN/m3
Density of Concrete	25 KN/m3
Load of wall (230 mm)	6.75 KN/m
Load of wall (100 mm)	4.3 KN/m
Parapet load (1.2 m)	1.75 KN/m
Sunk load	3.15 KN/m2
Importance Factor	1.5
Response reduction factor (column)	5
Response reduction factor (shear wall)	4

Time period for L-shape (Column)(X,Y)	(0.5317,0.6319) s
Time period for L-shape (Shear wall) (X,Y)	(0.5317,0.6319) s
Time period for Square-shape (COLUMN)	0.6774 s
Time period for Square (Shear wall) (X,Y)	(0.7224,0.7464) s

3.RESULTS & DISCUSSION: -

A. Base shear

Base shear in torsional analysis is the total horizontal force applied to a structure's base as a result of seismic activity. When determining the building's response to torsional effects—which happen when the center of mass and the center of rigidity do not line up—this force is essential. To effectively withstand seismic forces while minimizing damage, structures must be designed with an understanding of base shear in torsional analysis.

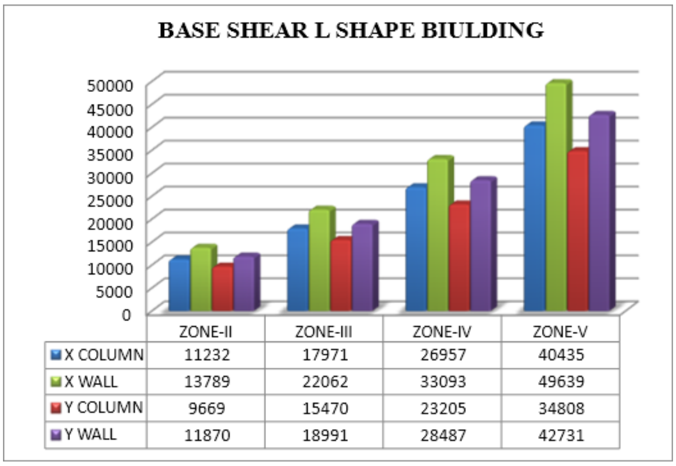

Figure 3: Base shear in L-shape building

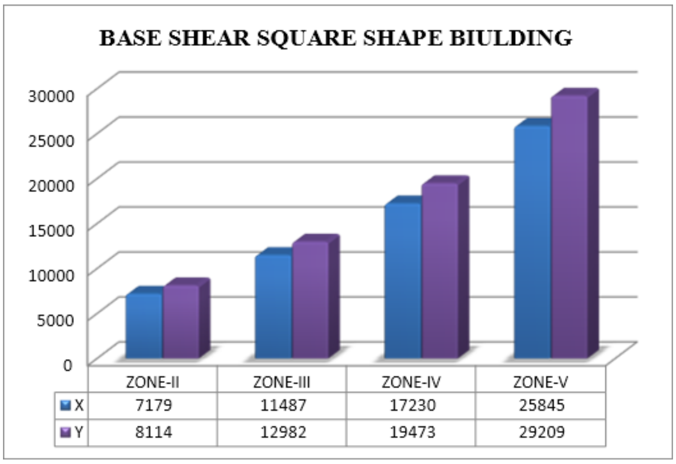

Figure 4: Base shear in square-shape building

B. Storey Drift

Storey drift in torsional analysis is the difference in lateral displacement between two floors that come after one another. It gauges the amount of movement caused by seismic forces between one floor and the next, which can cause torsion in the event of an uneven displacement.

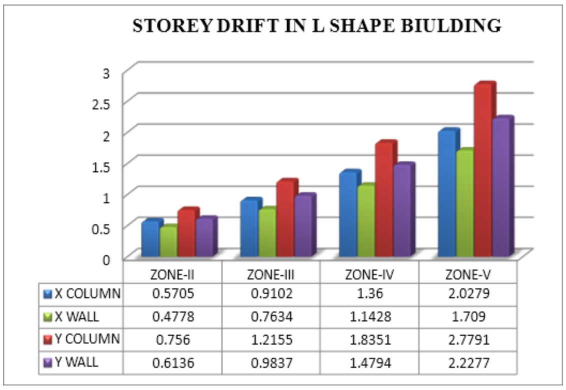

Figure 5: Storey drift in L-shape building

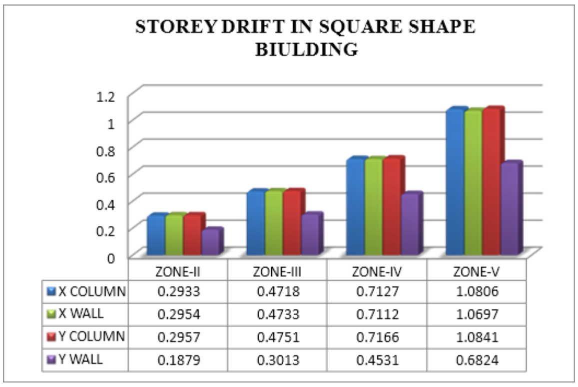

Figure 6: Storey drift in square-shape building

C. Modal Mass Participation Ratio

The modal mass participation ratio in torsional analysis shows the percentage of a structure's total mass that is involved in each mode of vibration. It assists in determining which modes have a major impact on how the building reacts to seismic forces. Even in asymmetrical buildings, torsional modes can show lower participation ratios and yet have a substantial effect. Reducing torsional response and enhancing seismic performance can be achieved by ensuring that the dominant modes are taken into account during the design phase.

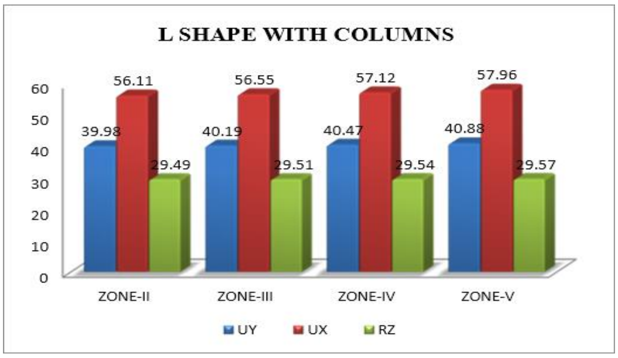

Figure 7(a): % Ratio for L-shape with column

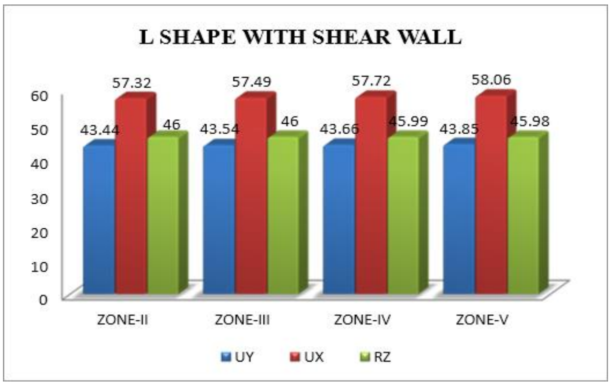

Figure 7(b): % Ratio for L-shape with shear wall

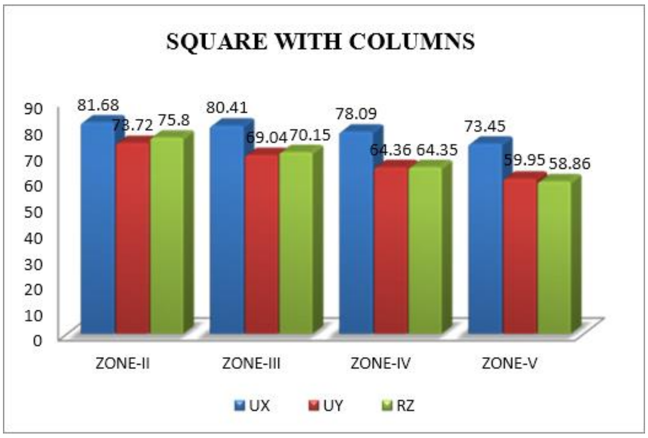

Figure 8(a): % Ratio for square-shape with column

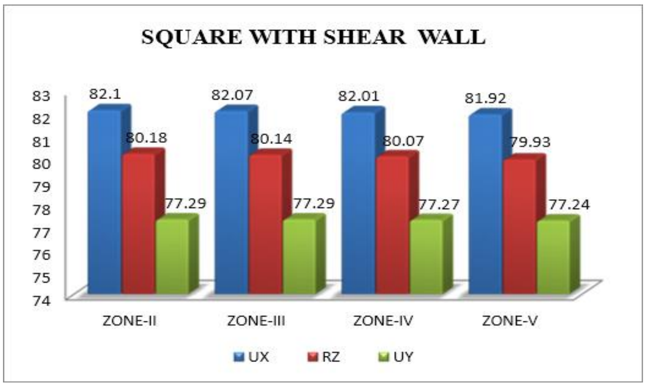

Figure 8(b): % Ratio for square-shape with shear wall

D. Modal Time Period

The modal time period in torsional analysis is the length of a single cycle of torsional vibration for a particular mode. It sheds light on how the structure responds dynamically to seismic forces, especially when torsional effects are substantial. Longer period modes have the potential to cause the structure to twist.

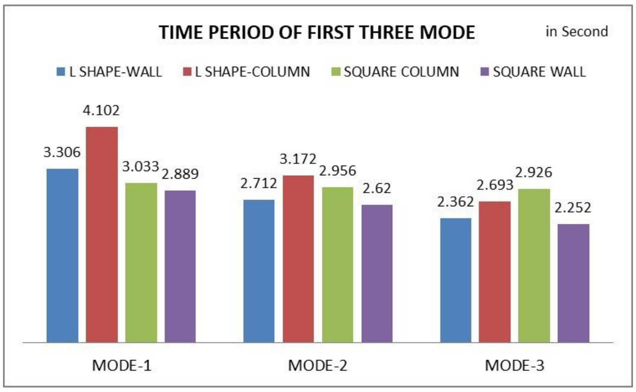

Figure 9: Time period

4.CONCLUSION: -

The following important conclusions can be drawn from the investigation that was done:

- Base shear increases with increase in seismic zone II TO V.
- Base shear is observed to be greater in buildings with shear wall compared to buildings with column in their structure.
- Time period is comparatively less in the first modes in buildings having shear wall.
- Storey drift in both x and y direction increase with increase in seismic zone in all types of buildings.

- It is observed that building with shear wall performs better than building with column in terms of storey drift.
- Modal mass participation increases in each governing top 3 modes in models having shear wall than models having columns.
- In L-shape building modal mass participation ratio increases in each governing top 3 modes with increase in seismic zones.
- The total of mass participation remains same in all seismic zones.
- The total all first three governing modes stays same in all seismic zones.
- In Square shape building modal mass participation ratio decreases in each governing top 3 modes with increase in seismic zones.
- In L-shape building it is observed that building with shear wall performs better.
- In square shape building it is observed that building with columns perform better.
- It is not always necessary that building with shear wall will perform better. Each and every other factor like orientation, structural grid, symmetry, etc. plays its role in performance of the building and equally affects the performance.

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