A Review on Seismic Performance of Plan Irregular Building With Different Structural Systems

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Abstract - *In today's world where architectural innovation knows no bounds, irregular-shaped buildings have emerged as captivating landmarks. Lack of available land in densely populated cities forces architects to think unconventionally. Buildings with asymmetrical plans, re-entrant corners, and unconventional mass distributions stand out. These structures become iconic, representing cities and their evolving narratives. Irregular shapes introduce unusual dynamic characteristics. Abrupt changes in structural resistance demand special design considerations. Irregular buildings face unique challenges during earthquakes. Engineers must devise strategies to mitigate these effects, ensuring safety and minimizing damage. Factors like base shear and time period reveal structural vulnerabilities. Irregularities in mass and stiffness require dynamic analysis for taller buildings in higher seismic zones. In this study etabs models of horizontally irregular buildings are designed and seismic behavior of these structure are studied. Different kind of structural systems are examined like shear wall, framed tube, tube in tube system. Then response spectrum analysis was carried out and all results were compared to identify the suitable structural system against seismic forces.*

Key Words: **irregular building, seismic behavior, response spectrum, shear wall, bare frame, framed tube, tube in tube system**

1.INTRODUCTION

- In an era where land scarcity and population density collide, high-rise buildings emerge as a requisite. They embody the spirit of vertical growth, allowing us to rise above constraints and create sustainable, vibrant urban environments. As more people flock to cities, these towering edifices will continue to shape our skylines and redefine modern living.

- India, with its burgeoning population, faces a unique set of challenges. Continuous migration to metropolitan areas, coupled with limited available land, has led to a congestion influx. In the bustling urban landscape of today, high-rise buildings have become an indispensable part of our architectural fabric. Cities like Delhi and Mumbai grapple with high population density, leaving little room for horizontal expansion. These soaring structures, often reaching far above the ground, serve as more than just landmarks—they are essential solutions to the challenges posed by rapid urbanization and population growth. As a result, the need for tall buildings has become paramount.

Figure 1 John Hancock Center in Chicago, example of the trussed tube structural design

- Present research is done to investigate the seismic perfomance of horizontally irregular structure. To understand different parameters which get affected by the irregularity of structure and how we can counter this effects by using different structural systems like shear wall, framed tube, tube in tube structural system. Parameters like story drift, story displacement, story shear, base shear and time period were calculated for different structural systems and most suitable system was identified.

1.1 Types of irregularity according to IS 1893(part-1) : 2016

Any building that meets any of the following criteria is considered as irregular building :-

- Torsion irregularities
- Re-entrant corner
- Floor slabs having excessive cut-outs
- Out of the plane offset in vertical elements
- Non parallel forces system

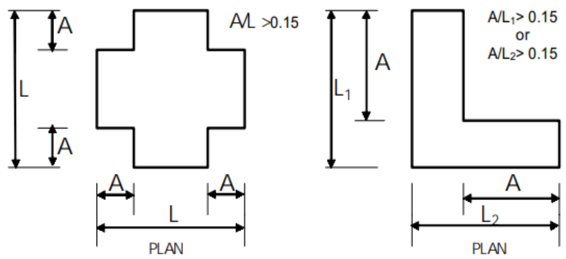

Figure 2 Re-entrant corner irregularity

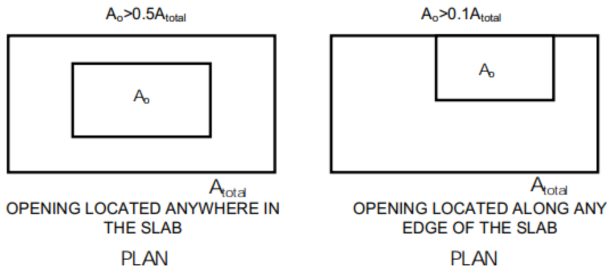

Figure 3 excessive cut-out in slab irregularity

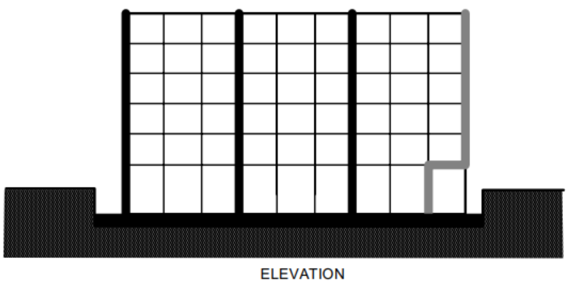

Figure 4 Out of the plane offset in vertical elements

1.2 objectives :-

1. To study the seismic behaviour of high rise buildings.
2. To identify the effects of plan irregularities on seismic response of the structure.
3. To study effectiveness of different structural systems against earthquake.
4. To study different structural parameters for different structural systems like Base shear, story shear, story displacement, displacement, etc.
5. To suggest optimum structural system for plan irregular buildings.

2. LITERATURE REVIEWS

[1] Abraham, N.M. and SD, A.K., 2019. "Analysis of irregular structures under earthquake loads. Procedia Structural Integrity", 14, pp.806-819.

This study analyzes the response of reinforced concrete structures with varying configurations of irregularities under earthquake loads. A 9-story regular frame was modified to incorporate different types of irregularities in plan and elevation, resulting in 34 single irregularity cases and 20 combination irregularity cases. The response of each case in terms of displacement, drift, base shear and overturning moment is determined through time-history analysis.

The result indicates that the presence of irregularities does not always amplify the response. Certain combinations of irregularities bring down the structural response. All the single irregularity cases analysed have shown an increase in response when compared to the regular configuration under seismic loads. Among these cases, the configurations with vertical geometric irregularity have given maximum response. The combination of stiffness and vertical geometric irregularities has shown maximum displacement response whereas the combination of re-entrant corner and vertical geometric irregularities has shown less displacement response.

[2] Krishnan, P.A. and Thasleen, N., 2020, June. "Seismic analysis of plan irregular RC building frames". In *IOP Conference Series: Earth and Environmental Science* (Vol. 491, No. 1, p. 012021). IOP Publishing.

This paper discusses the seismic analysis of reinforced concrete buildings with plan irregularities due to re-entrant corners. 10 models with different re-entrant corner configurations like L-shape, T-shape and + shape were analyzed using ETABS software. Pushover analysis was conducted to study storey displacements, stress concentrations and performance levels. Steel bracings are used for strengthening of models prone to failure. Various types of bracings are also used include V-shaped bracings, inverted V-shaped bracings, X-shaped bracings and ZX-shaped bracing.

This research concludes that Storey displacement was found to increase with increase in the amount of projections for L-shaped and P-shaped re-entrant corner models. But, No significant variation was observed for T-shaped models. High stress concentrations were observed at all the re-entrant corners in the various models analyzed. P-shaped models showed the maximum stress concentration while L-shaped models had higher displacements but lower stress concentrations and for model with bracings ZX bracing system is found to be most suitable. Also columns and other members closer to the re-entrant corners were found to fail first. In order to resolve this situation Appropriate strengthening techniques such as bracing systems need to be adopted for vulnerable structures.

[3] Firdose, H.A., Kumar, A.S., Narayana, G. and Narendra, B.K., 2022, March. "Study on Dynamic Behaviour of Irregular RC Framed Structures with Different Location of Shear Walls". In IOP Conference Series: Earth and Environmental Science (Vol. 982, No. 1, p. 012076). IOP Publishing.

This paper discusses the dynamic behavior of irregular reinforced concrete framed structures with different locations of shear walls. Eighteen models of a G+17 commercial building with irregular floor plans in the form of I, L and T frames are modeled and analyzed using ETABS software. The structures are analyzed for seismic zones 3 and 5 using linear dynamic response spectrum analysis. Parameters like storey displacement, storey drift, storey shear, base shear and time period are compared for models with shear walls at corners, periphery and without shear walls (bare frame).

The result indicates that Bare frame has the lowest base shear when considered with R.C Frame with shear walls. Where L frame has the highest base shear and T frame has the Lowest base shear between irregular shape building. L frame with shear wall at corner shows best reduction in storey displacement. This study shows shear wall is the best choice methods for the R.C frame irregular plans. Shear walls at corners is found as the best optimum location and positioning of shear walls.

[4] To, T.I., 2022. "A Comparative Study of Framed Structure, Frame Tube and Tube In Tube Structures Subjected To Lateral Load Under Zone Iii And Zone V". International Journal of Research in Engineering and Science, 10(4), pp.07-13.

This paper compares the seismic performance of framed, frame tube and tube-in-tube structures of G+39 and G+29 stories using ETABS software. Response spectrum analysis was carried out for Zone III and V. The primary goal of this research is to compare how structure behaves with respect to story drift, story shear and story displacement.

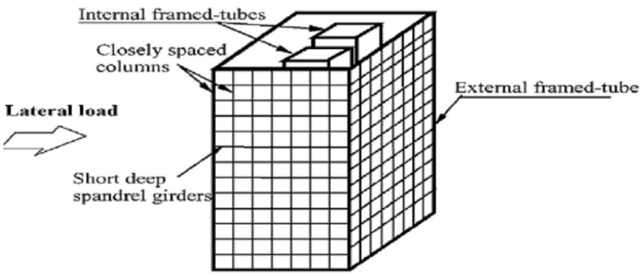

Figure 5 Tube in tube structural system

The study concluded that tube-in-tube structures are most effective in resisting lateral loads as tube-in-tube structures performed best with the least displacements and drifts followed by frame tubes, while framed structures exhibited the poorest seismic resistance.

[5] Ghasemi, A.H., 2016. "Evaluation of seismic behavior of irregular tube buildings in tube systems". Advances in Science and Technology. Research Journal, 10(29).

This paper evaluates the seismic behavior of irregular tube structures with tube-in-tube systems. Seismic performance is assessed for 40-story and 60-story reinforced concrete frame buildings with regular and irregular plans through nonlinear dynamic analysis. Parameters considered include overall story drift, inter-story drift and shear lag behavior.

The results show that increasing plan irregularity leads to higher story drifts and amplifies shear lag effects. The 60-story building exhibits more drift than the 40-story building as irregularity increases. Shear lag is more prominent in structures with single internal tubes compared to multiple tubes, which reduce its effect. Irregular structures also exhibit non-uniform column axial forces and nonlinear stress distributions.

3. CONCLUSIONS

Based on the above literature reviews the study concludes several points given below

- It is possible to get desired strength with different recycled materials for self-compacting concrete.
- At some percentage of recycled material it was observed to that recycled material perform better then regular materials. But, after 50% percentage if we still increase the recycled material content then it decreases performance of SCC.
- As for Self-compacting concrete flowability is very important, there are various recycled materials like glass powder and silica fume which we can use to enhance this property without causing any bad effect on other property.
- we can try to make better Self-compacting concrete mix design by using different recycled materials or combination of recycled materials with fibers to improve strength of Self-compacting concrete.

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