International Research Journal of Education and Technology

Peer Reviewed Journal, **ISSN 2581-7795**

LINEAR DYNAMIC ANALYSIS OF IRREGULAR SHAPED HIGH-RISE BUILDING

Balamurugan K[1], Ajay nivesh M[1],Nithisbala B[1],Rahul S[1] ,Rajendran M[2]

[1]*Under graduate student, Civil Engineering, Bannari amman Institute of technology, Sathyamangalam.*
[2]*Assistant Professor, Dept. of Civil Engineering, Bannari amman Institute of technology, Sathyamangalam.*

---***---

Abstract - *The **Linear Dynamic Analysis of Irregular-Shaped High-Rise Buildings** is crucial for assessing the structural response under seismic forces. This study utilizes the **Response Spectrum Method (RSM)** in **ETABS** to evaluate the seismic performance of a **G+20 high-rise building** with both **horizontal and vertical irregularities**. The analysis is conducted in **Seismic Zones 3, 4, and 5**, considering **medium-density soil conditions**. Various loads, including **dead load, live load, wind load (55 m/s in Wind Zone 5), and seismic load**, are assigned based on **IS 875 and IS 1893-2016**. A total of **26 load combinations** are considered as per **IS 456-2000**. The results focus on **story shear, overturning moment, story drift ratio, and maximum displacement** across different seismic zones. This comparative study helps optimize structural design for enhanced earthquake resistance. The findings will be compiled into a report and prepared for **journal publication** to contribute to seismic design research.*

***Key Words**: Linear Dynamic Analysis, Response Spectrum Method, ETABS, Seismic Zones, High-Rise Building, Structural Stability, Earthquake Resistance, Story Drift, Overturning Moment, Load Combinations.*

1.INTRODUCTION

High-rise buildings with irregular shapes pose significant structural challenges, especially in seismic-prone regions. Understanding their dynamic behavior is crucial for ensuring safety, stability, and performance under earthquake loads. This project focuses on the Linear Dynamic Analysis of a G+20 irregular-shaped high-rise building using the Response Spectrum Method (RSM) in ETABS. The analysis is conducted for Seismic Zones 3, 4, and 5, considering medium-density soil conditions to evaluate structural performance under varying seismic intensities.Loads are assigned based on Indian Standard Codes: Dead Load (IS 875 Part 1), Live Load (IS 875 Part 2), Wind Load (IS 875 Part 3), and Seismic Load (IS 1893-2016). A total of 26 load combinations are used as per IS 456-2000. Key parameters such as story shear, overturning moment, story drift ratio, and maximum displacement are analyzed. This study helps in optimizing the structural design and enhancing earthquake resistance for high-rise buildings.

1.1 BACKGROUND OF THE WORK

This project focuses on the building modelling and structural analysis of a high-rise building with horizontal and vertical irregularities to evaluate its behavior under seismic loads. The study begins with the design phase, where the building's geometric configuration, structural components, and irregularities are planned. Irregularities in high-rise buildings, whether in shape, mass distribution, or stiffness, significantly influence their seismic performance. Understanding these irregularities is crucial, as they can lead to uneven force distribution and increased vulnerability during earthquakes.Once the building model is designed, the next phase involves seismic analysis using linear dynamic methods. The primary objective is to examine how the building responds to seismic forces in different seismic zones and record key parameters such as story shear, displacement, and overturning moments. The analysis will highlight the structural behavior under varying seismic intensities, helping to assess whether the building can withstand critical conditions without failure.

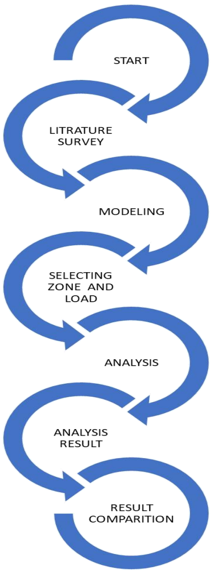

FIGURE No.2 -work flow

2. MODELING

We have to design a high-rise building with a total ground floor area of 384 m². The structural model follows a bay design, where the bays are arranged in an alternating pattern of 5 meters and 3 meters, ensuring an efficient distribution of loads. The ground floor consists of 12 bays on each side, forming a well-balanced grid system. As the building rises, certain bays are reduced every two floors to introduce irregularities, making the structure horizontally irregular. These irregularities influence the building's response to lateral forces, such as seismic and wind loads, and require a detailed analysis to ensure stability and safety. The variation in bay configuration leads to a more complex load transfer mechanism, affecting the lateral displacement, story drift, and overall behavior under dynamic loads. The total height of the building is 61 meters, with each floor having a height of 3 meters. This uniform floor height ensures that architectural and functional requirements are met while maintaining an efficient vertical load distribution. The columns, which play a crucial role in supporting both gravity and lateral loads, are designed with a 600mm × 600mm cross-section. This ensures adequate strength, stiffness, and stability, preventing excessive deformation under seismic and wind loads. The beams are sized at 600mm × 900mm, providing the necessary flexural and shear resistance to support slab loads and transfer forces efficiently across the structure. The slab depth is set at 150mm, ensuring sufficient strength and serviceability while keeping the dead load optimized for high-rise construction.For material selection, M40 grade concrete is used, which offers high compressive strength and durability. This choice is particularly suitable for high-rise buildings, as it enhances the load-bearing capacity and reduces the size of structural elements, leading to a more efficient design. The reinforcement steel is Fe500 grade, providing excellent tensile strength, ductility, and resistance against seismic forces. The combination of high-strength concrete and steel reinforcement ensures the structural integrity and resilience of the building under various loading conditions. These design considerations are crucial for optimizing the performance of the building in different seismic zones and wind zones, ensuring that the structure remains safe, stable, and efficient throughout its lifespan. This phase of the project is fundamental in establishing the key parameters for analysis, leading to a comprehensive study of the building's behavior under dynamic forces.

DESCRIPTION	VALUES
No. of story	G+20
Typical floor level	3m
Ground floor level	3m
building hight	61m
building width and length	48m *48 m
bays	3m and 4 m alternatively
no of bays on each side	12
Grade concrete	M40
irregularity	yes
Type of steel	Fe500
Thickness of section	150mm
Size of beam	600x600mm
Size of column	600x900 mm

TABLE No.-1BUILDING DETAILS

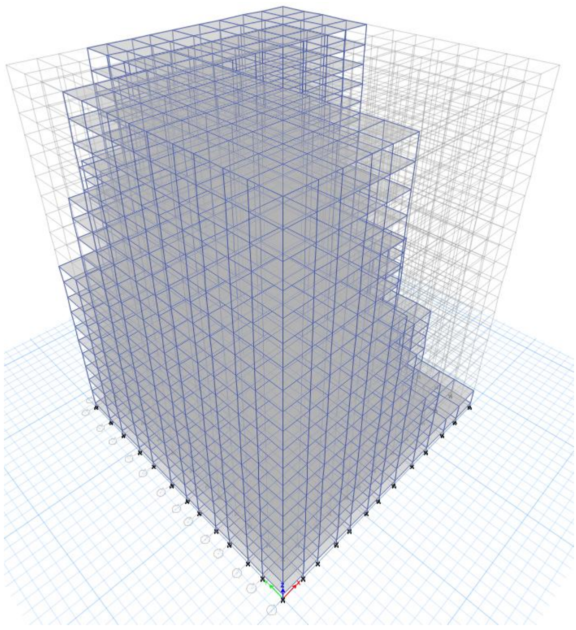

FIGURE No.2 3D VIEW OF HIGH-RISE BUILDING

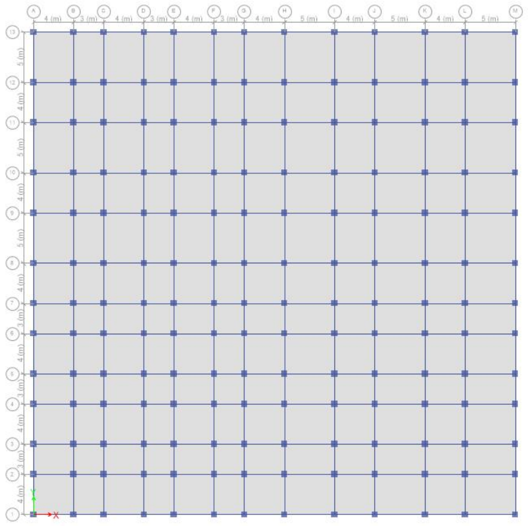

FIGURE No.4.1 GROUND FLOOR LAYOUT

2.1 **SESMIC ZONES AND LOADS**

We have to assign the dead load as per IS 875 Part 1, which specifies the self-weight of the structural elements based on the material used in construction. The dead load of each material is calculated using the formula:Dead Load=Breadth×Length×Density of the Material.This calculation helps determine the weight of different structural components, such as beams, columns, slabs, and walls. However, in ETABS, the software automatically calculates the dead load based on the assigned section properties and material densities. This simplifies the load assignment process and ensures accuracy in the structural analysis.The imposed load (live load) is assigned as per IS 1893-2016, with a standard value of 4 kN/m². Imposed loads represent the additional loads exerted by occupants, furniture, and other temporary elements within the building. These loads vary depending on the intended use of the structure and are crucial in evaluating the serviceability and strength of the building.For seismic analysis, we consider three seismic zones: Zone 3, Zone 4, and Zone 5. According to IS 1893-2016, the seismic intensity increases with the zone number, meaning that buildings in Zone 5 experience the highest seismic forces, while those in Zone 3 experience moderate seismic activity. The seismic intensity for each zone is assigned based on the seismic coefficient values specified in the code. To ensure realistic modeling, we assume the building is constructed on medium-density soil, as soil type significantly affects the seismic response of a structure.Additionally, we assign wind load as per IS 875 Part 3, considering Wind Zone 5, where the wind speed is 55 m/s. Wind loads play a critical role in designing high-rise structures, as they can cause significant lateral sway and structural instability. Proper wind load assignment ensures that the building can withstand lateral forces and maintain stability during extreme weather conditions.By carefully assigning dead load, imposed load, seismic load, and wind load as per the respective Indian Standard (IS) codes, we ensure that the structural model accurately represents real-world conditions. This step is essential in evaluating the building's performance under different loading scenarios, helping to design a structure that is both safe and resilient against seismic and wind forces

2.2 LOAD COMBINATIONS

DESCRIPTION	VALUES
Live load	4KN/m2
seismic zones	zone 3,4 and 5
wind speed	55m/s
Zone factor	1.15
Reaction decrease factor	5
type of soil	II (Medium)

TABLE No.4.2 LOAD DETAILS

We assign load combinations that include dead load, live load (imposed load), earthquake load, and wind load to ensure a comprehensive structural analysis. Load combinations are essential in structural design as they help evaluate how different loads interact and affect the building's stability and performance. These combinations consider various scenarios, such as normal operating conditions, extreme environmental forces, and accidental load cases, ensuring the structure remains safe under all possible conditions. In this project, we assign 26 different types of load combinations based on IS 456:2000, which provides guidelines for reinforced concrete structures. These combinations incorporate different proportions of dead load (DL), live load (LL), seismic load (EQ), and wind load (WL) to simulate various real-world loading conditions.

4.3 ANALYSIS

In structural analysis, there are two primary approaches for evaluating seismic performance: linear static analysis and linear dynamic analysis. The linear static method assumes that seismic forces remain constant over time, meaning the intensity of the earthquake does not change dynamically with time variations. This method provides a simplified approach but does not fully capture the real-time variations of seismic forces. On the other hand, the linear dynamic method considers the variation of seismic intensity with respect to time, making it a more accurate and realistic representation of how a structure responds to seismic activity. In our project, we are focusing on linear dynamic analysis to study the response of a high-rise irregular-shaped building under seismic loads. There are two primary methods available for performing linear dynamic analysis: the Time History Method and the Response Spectrum Method. The Time History Method evaluates the structure's response by applying actual recorded earthquake ground motions over time, making it computationally intensive. However, for our analysis, we have chosen the Response Spectrum Method, which provides a more efficient and simplified approach. The Response Spectrum Method records the maximum response of the building over time for different natural frequencies, enabling us to understand how the structure behaves under seismic excitation.

For the analysis, we consider three seismic zones: Zone 3, Zone 4, and Zone 5, based on IS 1893-2016. The seismic intensity increases with the zone number, meaning Zone 5 represents the highest earthquake-prone region, while Zone 3 has moderate seismic activity. Additionally, we assume the building is constructed on medium soil (Type-II), as defined in IS 1893-2016, which plays a crucial role in determining the seismic response. The key analysis results obtained from the Response Spectrum Method include:

- Overturning Moment – The moment that causes the building to tilt due to lateral seismic forces.
- Story Drift Ratio – The relative lateral displacement between consecutive floors, which helps assess flexibility and stability.
- Story Stiffness – The ability of a floor to resist lateral deformation.
- Story Shear – The lateral force exerted on each story due to seismic activity.

We compare the results across Zone 3, Zone 4, and Zone 5 to observe how the building responds under different seismic intensities. This comparison allows us to assess whether the structure can withstand higher seismic forces and determine necessary reinforcements for improved safety and stability.

3.1 RESULT

Story shear is a crucial parameter in structural analysis that represents the horizontal force acting on each floor due to lateral loads such as earthquakes and wind forces. It is calculated as the sum of all lateral forces above a given floor level and helps engineers evaluate the force distribution throughout the height of the building. In seismic analysis, story shear is particularly significant as it determines how much lateral force a structure experiences at different heights. Typically, the lower floors experience higher story shear because the cumulative effect of the lateral forces from upper floors increases as it moves downward. Below the table shows the story shear in the modul on sesmic zone 5. Other zone resut has been attached in appendix.

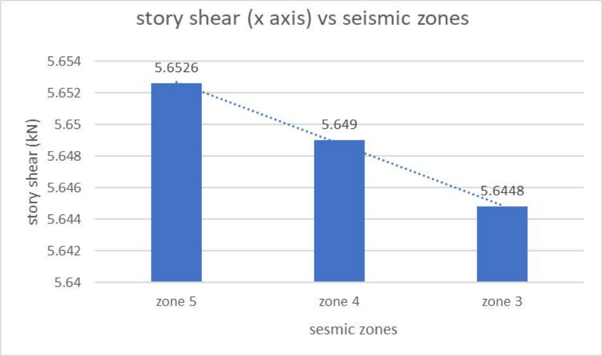

FIGURE No.5.1 STORY SHEAR VS SEISMIC

Overturning moment in high-rise buildings occurs due to lateral forces, primarily from seismic and wind loads, and is influenced by seismic zones, building height, and structural irregularities. Higher seismic zones (III, IV, V) experience greater seismic forces, increasing overturning tendencies. Taller buildings have a higher centre of mass, amplifying the overturning moment. This comparison shows overturning movement changes based on the seismic zones. Below the table shows the overturning moment the building experice in sesmic zonze 5. Other zone resut has been attached in appendix.

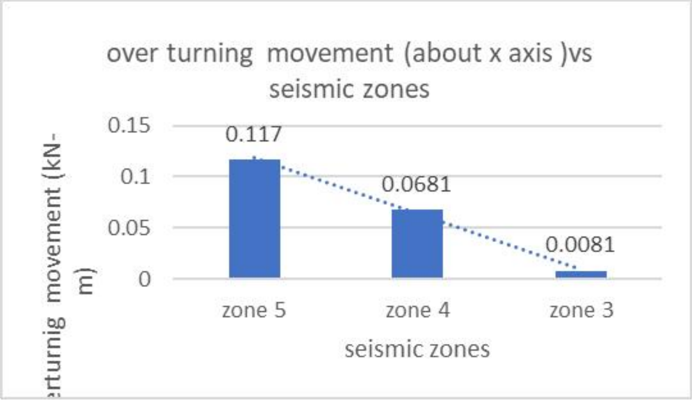

FIGURE No.5.3 OVERTURNING MOVEMENT VS SEISMIC ZONE

Here we attached our building drift result. The table shows zone 5 building result other result has been attached in apendix.

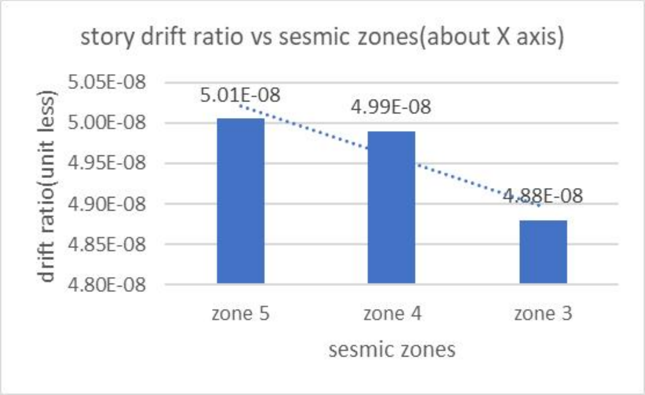

FIGURE No.5.6 STORY DRIFT VS SEISMIC ZONE

CONCLUSION

The linear dynamic analysis of irregular-shaped high-rise buildings was carried out using the Response Spectrum Method in ETABS, focusing on different seismic zones to understand how variations in seismic intensity affect structural performance. The study aimed to analyze the seismic behavior of a G+20 building with irregular geometry under different loading conditions. Various parameters such as story shear, overturning moment, story drift ratio, and maximum displacement were examined to determine how the structure responds to different seismic intensities. The linear static approach does not account for the time-dependent nature of seismic forces and is not suitable for high-rise buildings with irregularities. Instead, the linear dynamic method was used to consider how the structure reacts to changing seismic intensities over time. There are two primary approaches within linear dynamic analysis: the Time History Method and the Response Spectrum Method. The Time History Method involves applying recorded earthquake ground motions to the model and analyzing the time-dependent response of the structure. However, this method requires extensive computational resources and is not always practical for preliminary design. Therefore, the Response Spectrum Method was chosen.The results of the analysis revealed a progressive increase in structural response as the seismic zone intensified. A 20% increase in response parameters was observed when moving from one seismic zone to the next, demonstrating the substantial impact of increased seismic intensity on the building's behavior. The results emphasize the importance of considering seismic zone variations in high-rise building design, particularly for irregular structures where force distribution is not uniform.

In conclusion, the Linear Dynamic Analysis of Irregular Shaped High-Rise Buildings demonstrated that seismic zone intensity has a direct and significant impact on structural response. The 20% increase in response parameters per seismic zone reinforces the importance of site-specific design strategies to ensure the stability, safety, and durability of high-rise structures. By utilizing the Response Spectrum Method, a detailed evaluation of the building's seismic behavior was achieved, allowing for informed design decisions and structural improvements. The study serves as a valuable reference for engineers and researchers working on seismic-resistant high-rise buildings, emphasizing the necessity of advanced analysis techniques, proper load combinations, and material selection to mitigate the risks associated with seismic activity.

ACKNOWLEDGEMENT

The Authors thanks the Department Civil Engineering, Bannari Amman Institute of Technology, for providing the resources and infrastructures. We extend our graduate to our Guide Mrs. Ranjitham M,assistant professor For their valuable guidance and support throughout this project. Special thanks to the laboratory staff for their assistance with the Synopsys tools and to our peers and family for their continuous encouragement

REFERANCES

1.Sharma, S. P., & Bhandari, J. P. (2017). Literature Review on the Seismic Performance of Multi-Storey Building with Different Locations of Shear Wall and Diagrid. International Journal of Science and Research (IJSR), 6(6), 583-586. www.ijsr.net

2.Zagade, K. A., Patil, A., & Galatage, A. (2021). Linear Dynamic Analysis of High-Rise Building Using ETABS. International Journal of Advances in Engineering and Management (IJAEM), 3(8), 1009-1018. https://doi.org/10.35629/5252-030810091018​:contentReference[oaicite:1]{index=

3.Department of Civil Engineering, NHCE. (Year Unspecified). Dynamic Analysis of Irregular Structures Using ETABS Software. Unpublished Report. NHCE, Bangalor

4.Nimade, A., Soni, N., Patidar, M., & Joshi, V. (2018). Dynamic Analysis of Flat Slab System in Vertical Irregular Building with & without Shear Wall. International Journal of Research and Scientific Innovation (IJRSI), 5(1), 132-139. Retrieved from www.rsisinternational.org

5. Datta, T. K. (2010). Seismic Analysis of Structures. John Wiley & Sons (Asia) Pte Ltd. ISBN: 978-0-470-82461-0.