Analysis & Design of G+30 Residential Building using ETABS forvarious Frame Structure in Zones IV & V

Puppala Harshanth[1], Katukoori Veda Samhitha[2] ,M.Tech

[1]M.Tech Scholar, Department of Civil Engineering, Siddhartha Institute of Technology and Sciences (SITS), Hyderabad,India (puppalaharshanth@gmail.com)

[2]Assistant Professor, Department of Civil Engineering, Siddhartha Institute of Technology and Sciences (SITS), Hyderabad,India (sits.vedasamhithakatukoori@siddhartha.co.in)

---***---

Abstract

The growing demand for high-rise residential buildings in earthquake-prone areas necessitates a thorough understanding of functional planning and structural behavior. This study focuses on the design, static analysis, and seismic performance evaluation of a G+30 residential building using ETABS software, targeting seismic Zones IV and V. These zones are highly vulnerable to earthquakes, making stability and safety under seismic forces essential. The research follows IS 1893:2002 guidelines, simulating low, medium, and high ground motion frequencies to assess the building's seismic response. Static analysis of key structural components, including beams, columns, and slabs, is conducted. Different frame sections are compared to determine configurations with optimal lateral stiffness and ductility, critical for absorbing and dissipating seismic energy to minimize damage. The study also evaluates the effects of load distribution, earthquake forces, and wind loads on structural stability.

ETABS simulations provide insights into the performance of the G+30 building under various seismic conditions, identifying frame sections with superior ground motion resistance. Recommendations for optimal material use and design strategies are offered to enhance the resilience and integrity of high-rise buildings. This research benefits structural engineers and designersby improving the seismic safety of residential buildings.

Keywords: *G+30 residential building, ETABS, seismic Zones IV & V, static analysis, structural design, earthquake resistance, IS1893:2002, ground motion, ductility, lateral stiffness, high-rise buildings.*

1. INTRODUCTION

The perspective of a structural engineer, high-rise buildings (HRBs) are significantly affected by lateral forces such as wind and seismic activity, which influence their structural design and behavior [1]. Ancient constructions like the Egyptian pyramids highlight the long-standing need for stable and functional tall structures [2]. The challenges of urbanization, especially in seismic-prone areas like India, demand innovative solutions for resilient designs [3]. Seismic Zones IV and V, as classified by IS 1893, require advanced planning due to their heightened earthquake risks [4].

Recent advancements, such as cold-formed steel frames and high-strength materials, have enhanced lateral resistance in HRBs [5]. Base isolators and vibration-controlled systems have further improved stability and reduced seismic impact [6][7]. Technologies like ETABS facilitate detailed static and dynamic analysis, optimizing building designs for safety and efficiency [8]. Studies emphasize the importance of integrating braced frame structures and tuned dampers to improve seismic resilience in high-risk zones [9][10].

This research focuses on utilizing these technologies to propose design strategies for G+30 residential buildings in Zones IV and V, enhancing their structural performance and safety under dynamic conditions.

2. OBJECTIVES OF THE WORK

- The Principal Objective of this Project is to Plan, Static analysis and Design a G+30 Residential Building in ETABS.
- To understand the basic concepts of principles of planning which are required for functional design of building.
- To examine the structure utilizing the seismic zones in Zones 4 and 5.

- To determine how buildings will react to low, middle, and high frequency ground motions, among other types of ground motion.
- To conduct research utilizing IS 1893:2002 code.
- To present the Results and Findings of the Project.

3. SCOPE OF THE WORK

This study's scope is limited to the use of ETABS software for the analysis and design of a G+30 residential structure, with a focus on different frame structure located in seismic Zones IV and V.

- *Purpose of the Research*

Seismic Analysis: To evaluate how the building will react to seismic forces in accordance with IS 1893:2002, taking into account lateral load and dynamic impacts.

Load Evaluation: The purpose of load evaluation is to examine how different loads—such as seismic, wind, dead, and live loads—affect the building's structural soundness.

Design Optimization: By concentrating on materials and reinforcing details, frame sections can be optimized for improved performance against lateral stresses.

- *Methodological Framework*

Modelling in ETABS: To assess the G+30 building's performance in seismic scenarios, a comprehensive 3D model of the structure is made in ETABS, integrating different frame types (such as steel and reinforced concrete frames).

Load Combinations: To replicate real-world situations and make sure the structure can support the highest anticipated loads, the study incorporates a variety of load combinations.

- *Measures of Performance Structural factors*

The building's performance in seismic circumstances is assessed by evaluating important factors such base shear, lateral displacements, storey drift, and moments.

Compliance Checks: The study makes sure that all design outputs adhere to IS 1893 for seismic design and IS 456:2000 forconcrete structures.

- *Geotechnical Aspects to Take into Account*

Evaluation of Soil Type: The analysis takes into account medium soil conditions (Soil Type II), as defined by IS 1893, whichhave an effect on the structure's seismic reaction.

- *Comparative Analysis*

Frame Section Variability: The study looks at various frame sections (braced frames, shear walls, etc.) to see how well theycan withstand lateral stresses at different building heights.

In conclusion, by investigating cutting-edge approaches for creating earthquake-resistant buildings with contemporary software tools like ETABS, this study aims to make a significant contribution to the area of structural engineering.

4. THEORY AND METHODOLOGY

The methodology for analysing and designing a G+30 residential building in seismic zones IV and V involves structural modelling, load analysis, and design checks using ETABS. This includes creating a 3D model, defining material properties as per IS 456:2000, and calculating loads (dead, live, seismic, and wind) as per IS standards. Both static and dynamic analysis methods, such as the Response Spectrum Method, are applied. Detailed reinforcement designs ensure safety and adherence to codes, with ETABS providing comprehensive reports. This systematic approach guarantees seismic resilience and compliance with relevant standards (11,12,13).

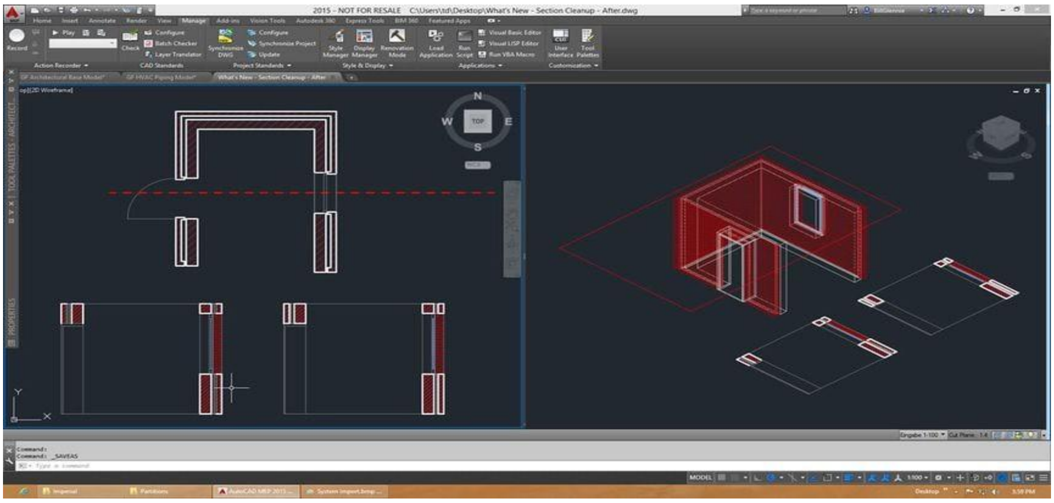

Fig .1 Auto CAD Interface

AutoCAD facilitates efficient drafting and visualization of 2D/3D models, offering features like powerful drafting tools, object analysis, and extensive plug-in support. It enables integration with various utilities and benefits from widespread training resources.

4.1 SOFT WARE USED:

Developed by Autodesk, AutoCAD is a popular computer-aided design (CAD) program used for 2D and 3D design creation and editing. It has been a vital tool for many industries, including engineering, construction, and architecture, since its introduction in 1982. It makes it easier to create accurate models and blueprints. By enabling users to effortlessly edit and share designs across several platforms, AutoCAD's automation, customization, and collaboration tools boost productivity.

ETABS is a powerful 3D modelling software used for the analysis and design of multi-story buildings. It allows for efficient structural modelling, including beams, columns, slabs, and shear walls, using graphical inputs. ETABS supports seismic, wind, and load analysis, incorporating standards such as IS codes. The software simplifies complex calculations, facilitates quick design modifications, and enhances productivity through tools like template libraries, automated reinforcement calculations, and similar story concepts. ETABS is widely used in iconic projects, offering accurate modelling, load analysis, and advanced design features for both steel and RC structures.

Model Data:

4.2 DETAILS OF THE BUILDING

Building Type:	R.C. Frame building
Number of Floors:	G+30
Location:	Hyderabad
Total Height:	96 m from ground level
Number of Columns:	36
Foundation Depth:	3 m below ground level
Footing Type:	Isolated footing & Combined footings
Plinth Level:	0.5 m above ground level
Beam Size:	0.3 m x 0.45 m
Column Size:	0.5 m x 0.5 m
Slab Thickness:	150 mm
Wall Type:	Ordinary clay brick walls
Wall Thickness:	6” for outer walls, 4.5” for inner walls
Staircase Type:	Dog legged staircase
Concrete Grade:	M30
Steel Grade:	Fe 500

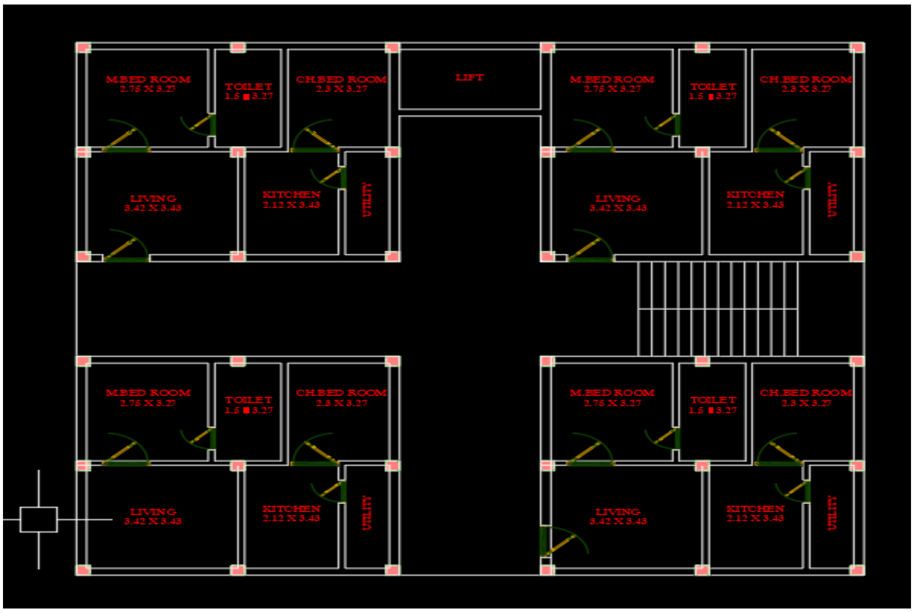

Fig.2 : Auto CAD plan view of model

4.3 FUNCTIONAL DESIGN OF BUILDING

The principles of building planning are essential for ensuring functionality, comfort, and efficiency. Key principles include aspect, which refers to optimizing the placement of doors and windows for natural light and ventilation; prospect, focusing on creating a pleasing external view and concealing undesirable ones; privacy, ensuring both internal and external privacy; and grouping, which arranges rooms for convenience and comfort, minimizing circulation. Roominess emphasizes maximizing space through room proportions, while furniture requirements ensure adequate space for essential furniture. Circulation involves easy access between rooms, with horizontal and vertical movement well-planned. Sanitation ensures proper ventilation, lighting, and cleanliness to maintain hygiene. Flexibility in design allows for future adaptations, and elegance enhances the building's aesthetic appeal. Finally, economy ensures cost-effectiveness by maximizing space utility and minimizing unnecessary elements. Effective planning optimizes space and ensures the building meets both functional and aesthetic needs.

4.4 Load Combinations

For Gravity Analysis, the applied load combination is 1.5(DL + LL) [12]. In Equivalent Static Analysis, the combinations include 1.5(DL ± EQX), 1.5(DL ± EQY), 1.2(DL + LL ± EQX), 1.2(DL + LL ± EQY), and 0.9DL ± 1.5EQX/EQY [13]. For Wind Load Patterns, the combinations are 1.5(DL ± WLX), 1.5(DL ± WLY), 1.2(DL + LL ± WLX), and 1.2(DL + LL ± WLY) [14].

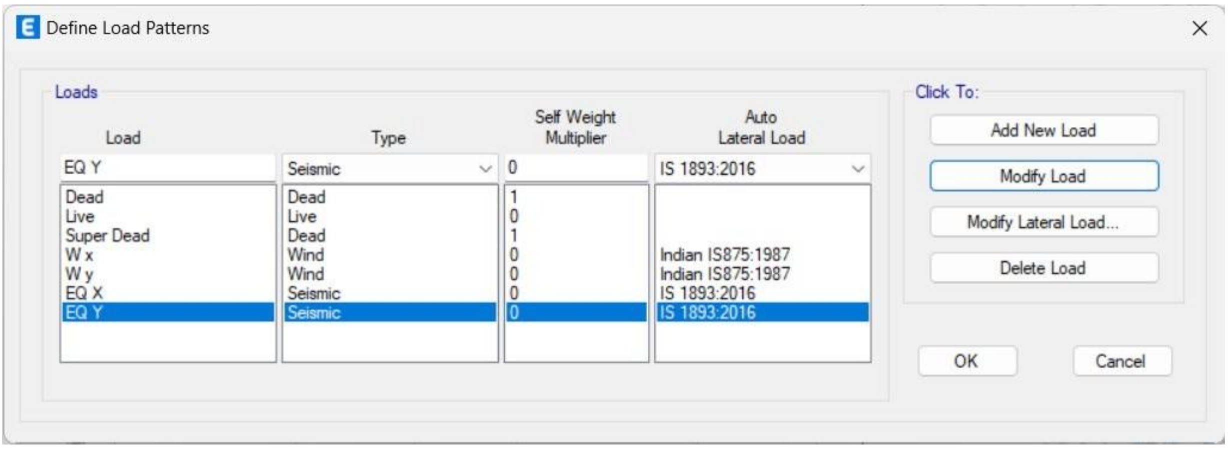

Fig-3: load combination

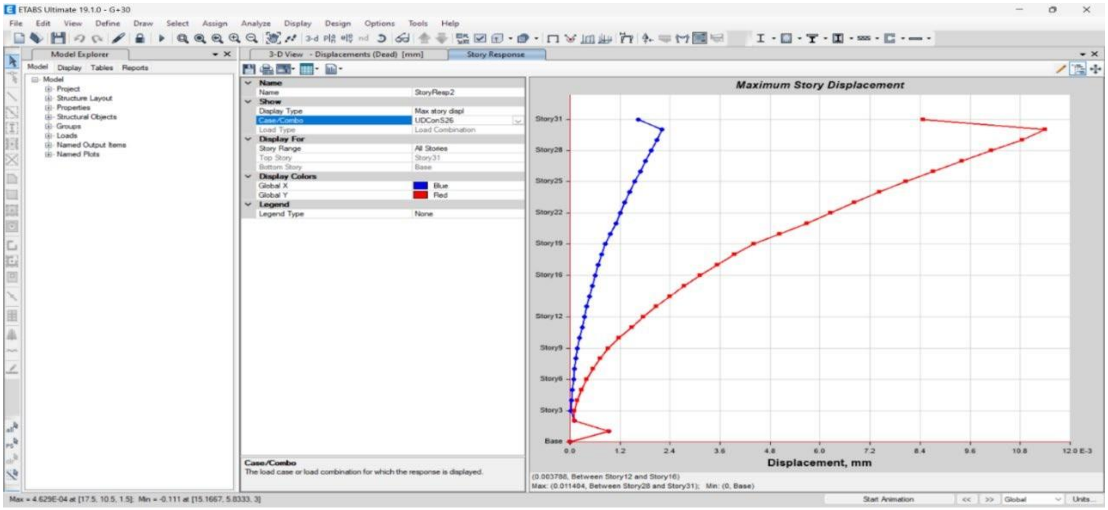

Fig.4 Displacement (Dead) Story Response

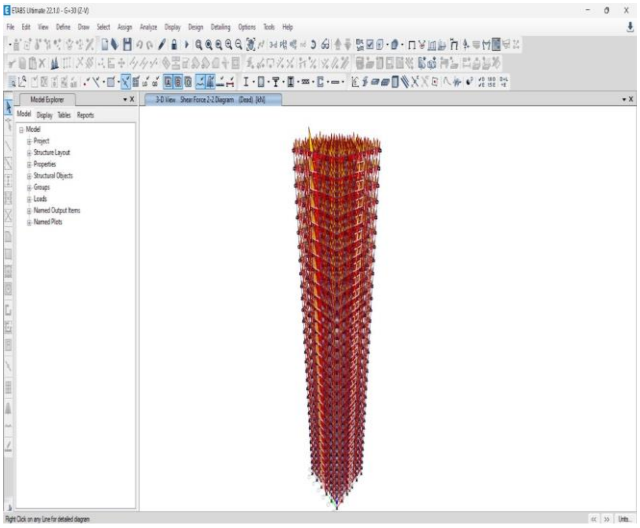

Fig.5 Shear force

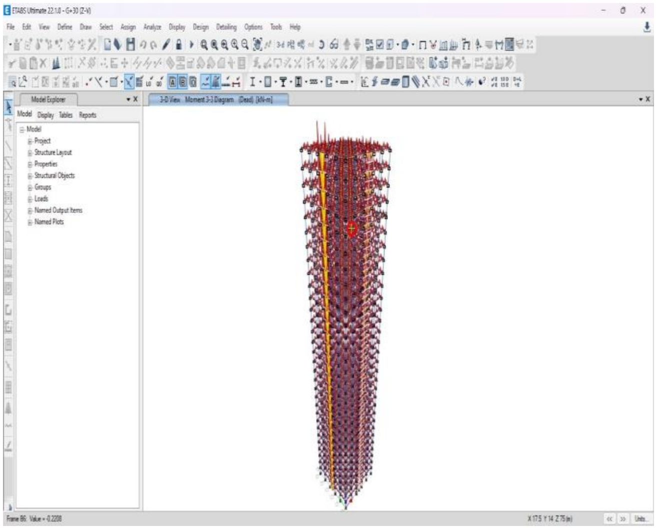

Fig.6 moments

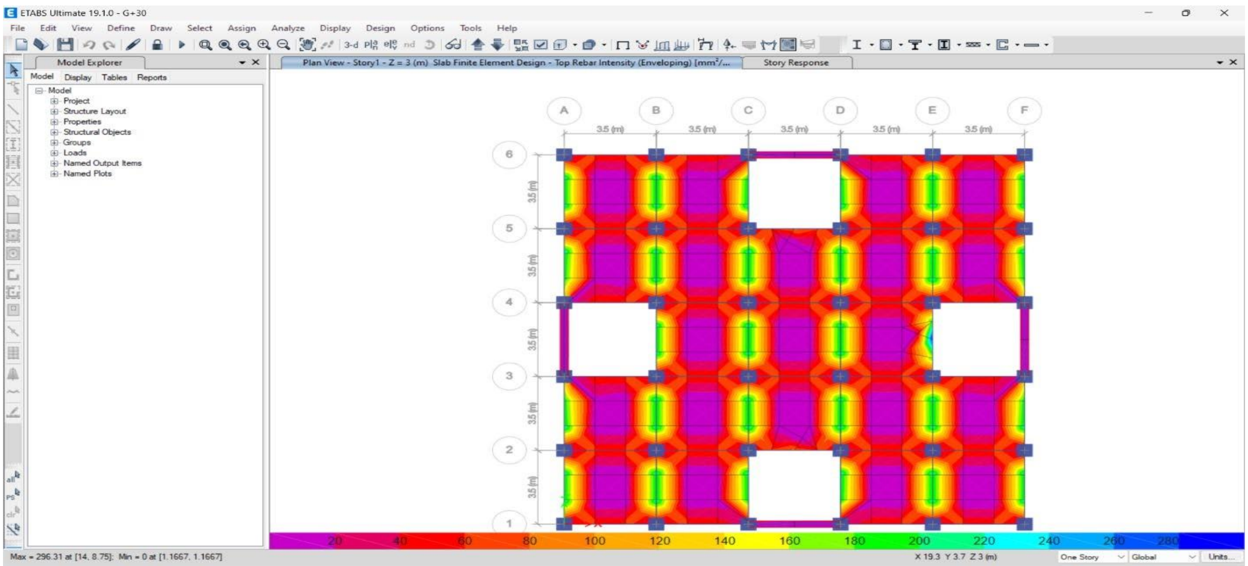

Fig .7 Slab Finite Element Design

5. RESULTS AND DISCUSSIONS

In the analysis of Zone 5 and Zone 4, the results show notable similarities and differences in the reaction forces and moments under various load cases. For Dead Load and Live Load, both zones experience identical results. The forces in the z-direction (Fz) are the same: 113,873.45 kN for Dead Load and 44,100 kN for Live Load. The moments in the x and y directions (Mx and My) also remain consistent between the two zones [14][15].

However, there are significant differences in the Seismic Loads. Zone 5 experiences higher seismic forces, with a force of - 1,326.4762 kN in the x or y direction, compared to Zone 4's -884.3175 kN. The moments in Zone 5 are notably larger in all directions. For example, the moment in the x-direction (Mx) for Zone 5 is 90,389.3333 kNm, significantly higher than Zone 4's 60,259.5555 kNm. Similarly, the moments in the y and z directions are also higher in Zone 5. This indicates that Zone 5 is subjected to a higher seismic response due to its increased seismic forces and moments [16][17].

For the Combined Load Case (Comb1), both zones show identical results. The force in the z-direction (Fz) is 157,973.45 kN, and the moments in the x and y directions (Mx and My) are 1,895,681 kNm and -2,369,602 kNm, respectively, with no moment in the z-direction (Mz). This consistency in results suggests that under combined load conditions, the structural reactions are similar for both zones [18].

In summary, while Zone 5 and Zone 4 exhibit the same reactions for Dead Load, Live Load, and Combined Load Case, Zone 5 experiences significantly higher seismic forces and moments, indicating a more substantial seismic impact compared to Zone 4.

6.CONCLUSION

- In seismic Zones IV and V, the study and design of a G+30 residential structure utilizing ETABS is a crucial undertaking to guarantee structural integrity and safety in areas that are prone to earthquakes. The performance of various frame sections under seismic stresses as specified by Indian norms has been investigated in this study. The results highlight the significance of choosing suitable structural configurations and materials to improve resilience against probable seismic events, given the high seismic risk associated with these zones.
- The Functional Designing i.e., the Planning of the Building has been completed as per the Building Bye-laws, Regulations and Principles of planning.
- The Modelling, Analysis and Design of the Building frame has been completed using ETABS software.
- The Reinforcement scheduling of Slab, Staircase and Columns has been done as per Standards.
- Zone 5 demonstrates a higher seismic response compared to Zone 4. The forces in the x and y directions are larger in Zone 5, and the moments in all directions are significantly greater than in Zone 4. This indicates that Zone 5 experiences a more intense seismic impact, making it more susceptible to larger deformations or movements during an earthquake.
- From a structural performance perspective, Zone 4 is better in terms of seismic load resistance. It experiences lower forces and moments, which could indicate that buildings in Zone 4 are less likely to suffer from severe seismic damage compared to Zone 5. Zone 4's lower forces and moments suggest a more stable reaction under seismic conditions, making it preferable for minimizing structural stress during an earthquake.
- Thus, Zone 4 is better suited for resisting seismic forces due to its lower load reactions, while Zone 5 faces higher seismic impacts that demand stronger reinforcements or seismic design considerations.

6.1 FUTURE OF THE STUDY

- Future research and development opportunities abound in the analysis and design of G+30 residential buildings in seismic Zones IV and V utilizing ETABS. This section lists possible directions for future research that could improve knowledge and use of earthquake-resistant design concepts.

research.

- Integration of Smart technology: One important area for future research may be the integration of smart technology into building design, such as real-time structural health monitoring systems. During seismic events, these devices can offer useful data that improves safety and allows for improved reaction plans.

16. Desai, D., & Jadhav, V. (2020). Seismic Load Analysis for Buildings in Different Seismic Zones. Civil Engineering Journal, 8(5), 501-515.

17. National Building Code of India (NBC 2016). (2016). General Provisions and Building Materials. Bureau of Indian Standards.

18. Khan, M., & Sharma, R. (2018). Designing for Earthquake Resistance in High Seismic Zones. Journal of EarthquakeEngineering, 22(3), 370-380.