DESIGN OF COMMERCIAL BUILDING USING ETABS

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ABSTRACT

With the rapid growth of urbanization and limited availability of land, the construction of multi-storeyed buildings has become essential. However, as the height of buildings increases, their susceptibility to seismic forces also increases, making earthquake-resistant design a critical aspect of structural engineering. This project focuses on the design and analysis of a G+17 reinforced concrete (RCC) commercial building using ETABS to evaluate its performance under seismic loading conditions. The building is modeled with M30 grade concrete and Fe500 steel reinforcement, having plan dimensions of 21 m × 17.5 m and a total height of 51.5 m. The analysis is carried out for seismic Zones III, IV, and V as per IS 1893 (Part 1):2002 using the response spectrum method. The study considers various load combinations, including dead load, live load, and earthquake loads in both X and Y directions. Key structural parameters such as storey displacement, storey drift, storey shear, lateral loads, base reactions, bending moments, shear forces, and axial forces are evaluated. The results show that as the seismic zone increases, the intensity of forces acting on the structure also increases, leading to higher displacements, drifts, and internal forces. It is observed that maximum displacement occurs at the top storey, while maximum shear forces are concentrated at the base. Additionally, lateral loads are found to be higher in the X-direction compared to the Y-direction. The analysis highlights the importance of considering seismic effects during the design of high-rise buildings to ensure structural safety and serviceability. The response spectrum method proves to be effective in capturing the dynamic behavior of the structure under earthquake loading. The study concludes that proper design, detailing, and use of advanced software tools can significantly enhance the performance of buildings in earthquake-prone regions.

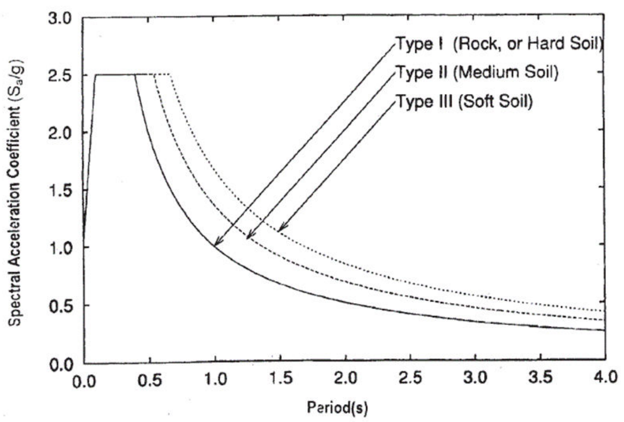
Keywords: ETABS, Seismic Analysis, Multi-storey Building, Response Spectrum Method, Storey Displacement, Storey Drift, Base Shear, Earthquake Load, RCC Structure, Structural Design

I. INTRODUCTION

The rapid growth of urban population and increasing demand for commercial infrastructure have led to the construction of multi-storeyed buildings across urban regions. As land availability becomes limited, vertical expansion has become the most practical solution. However, as the height of buildings increases, their structural behavior becomes more complex, especially under lateral loads such as earthquakes. Earthquakes are natural phenomena caused by sudden movements in the earth's crust, leading to ground vibrations that can severely damage structures. The primary cause of casualties during earthquakes is not the ground motion itself but the collapse of poorly designed buildings. Therefore, it is essential to design structures that can withstand seismic forces and ensure safety and serviceability. This project focuses on the design and analysis of a G+17 reinforced concrete (RCC) commercial building using ETABS. The study aims to evaluate the performance of the structure under earthquake loads in different seismic zones of India, namely Zones III, IV, and V, as specified in IS 1893 (Part 1):2002. The response spectrum method is adopted for analysis, which is widely used for dynamic analysis of structures. This method considers the contribution of multiple modes of vibration, providing a more accurate representation of structural behavior under seismic loading. By analyzing parameters such as storey displacement, drift, and base shear, the study helps in understanding the impact of earthquakes on tall buildings and highlights the importance of proper structural design.

The concept of earthquake-resistant design is based on the principle that structures should be able to absorb and dissipate energy generated during seismic events without collapsing. Reinforced concrete structures are widely used in multi-storey buildings due to their strength, durability, and flexibility in design. In this project, the building is modeled with M30 grade concrete and Fe500 steel reinforcement, ensuring adequate strength to resist applied loads. The structure has plan dimensions of 21 m × 17.5 m and a total height of 51.5 m, with fixed support conditions at the base. Various loads, including dead load, live load, and earthquake load, are considered in the analysis. Load combinations are applied as per IS code provisions to evaluate the worst-case scenarios. The ETABS software is used to perform the analysis efficiently, reducing manual effort and minimizing errors. It provides detailed outputs such as bending moments, shear forces, axial forces, and displacement values, which are essential for design and safety assessment. The use of advanced software tools has significantly improved the accuracy and reliability of structural analysis, making it possible to design complex structures with confidence. This study emphasizes the importance of considering seismic effects in the design process to ensure the safety of occupants and the longevity of structures.

Furthermore, the project investigates the variation of structural response across different seismic zones to understand how increasing seismic intensity affects building performance. The results show that as the seismic zone increases from III to V, there is a significant increase in storey displacement, storey drift, lateral loads, and base shear. The maximum displacement is observed at the top storey, while the maximum shear forces occur at the base, indicating the critical regions of the structure. It is also observed that lateral loads in the X-direction are generally higher than those in the Y-direction, influencing the design of structural members. Shorter columns tend to attract higher forces due to increased stiffness, requiring special attention during design and detailing. The study highlights the need for proper structural configuration, material selection, and adherence to design codes to achieve earthquake-resistant structures. Overall, this project provides a comprehensive understanding of seismic analysis and demonstrates the effectiveness of ETABS in analyzing and designing multi-storeyed buildings under earthquake loads.



II. LITRATURE REVIEW

Balaji U., Selvarasan M. (et.al) conducted a study on the seismic analysis of a G+13 multi-storey building using ETABS software. The objective was to evaluate the behavior of structures under both static and dynamic loading conditions. The analysis considered different seismic zones and soil types, focusing on parameters such as storey displacement, base shear, and drift. The results indicated that as the height of the building increases, the lateral displacement also increases significantly. It was observed that dynamic analysis provides more realistic results compared to static analysis, especially for high-rise structures. The study emphasized the importance of considering seismic forces during the design stage to ensure safety and stability. It concluded that ETABS is an efficient tool for performing accurate seismic analysis and helps in optimizing structural design under varying load conditions.

Siva Kiran Kollimarla, Chadalawada Jagan Mohan (et.al) presented a comparative study of seismic analysis methods for multi-storey buildings. The research focused on comparing equivalent static analysis and response spectrum analysis as per IS 1893:2002 provisions. The study highlighted that equivalent static analysis is suitable for low-rise regular structures, whereas response spectrum analysis is more appropriate for high-rise and irregular buildings. Various parameters such as storey drift, displacement, and base shear were analyzed. The results showed that response spectrum analysis captures the dynamic behavior of the structure more accurately by considering multiple modes of vibration. The study concluded that for tall buildings, dynamic methods should be preferred to ensure better safety and performance. It also emphasized the importance of proper modeling and load application in structural analysis using ETABS.

Deepmala Pandey (et.al) carried out the analysis and design of a G+5 residential building subjected to seismic loads using STAAD.Pro software. The study involved calculating various loads such as dead load, live load, and earthquake load, followed by structural analysis and design based on Indian Standard codes. The results were presented in terms of bending moments, shear forces, and deflections. It was observed that seismic loads significantly influence the design of structural members, especially in higher seismic zones. The study also compared manual calculations with software results, showing that software provides more accurate and time-efficient solutions. The research concluded that proper seismic analysis is essential to ensure the safety and durability of structures. It also highlighted the importance of using advanced software tools for complex structural analysis.

B.G. Birajdar, S.S. Nalawade (et.al) studied the seismic performance of buildings resting on sloping ground using response spectrum analysis. The research considered different building configurations such as step-back, set-back, and step-back set-back models. The analysis was performed using ETABS software, focusing on parameters like base shear, storey displacement, and time period. The results indicated that buildings on sloping ground experience higher torsional effects due to irregular geometry. Among the configurations studied, step-back set-back buildings showed better performance compared to step-back structures. The study concluded that structural configuration plays a significant role in seismic performance. It also emphasized the need for careful design and detailing, especially for buildings constructed on uneven terrain, to reduce the risk of failure during earthquakes.

Likhitharadhya Y R, Praveen J V, Sanjith J, Ranjith A (et.al) analyzed the seismic behavior of multi-storey buildings on both flat and sloping ground conditions. The study considered a G+10 RCC building and performed response spectrum analysis as per IS 1893:2002. Key parameters such as storey displacement, acceleration, base shear, and time period were evaluated. The results showed that buildings on sloping ground are more susceptible to seismic forces due to irregular stiffness distribution. It was observed that shorter columns experience higher forces, making them critical elements in the design. The study concluded that slope angle significantly affects the seismic response of structures and must be carefully considered during design. It also highlighted the importance of using proper analysis techniques to ensure structural safety.

Manjunath C S, Siddu Karthik C S (et.al) investigated the effect of different bracing systems on the seismic performance of RCC buildings. The study considered various bracing configurations such as X-bracing, K-bracing, V-bracing, and inverted V-bracing for a 12-storey building. Nonlinear pushover analysis was carried out to evaluate structural performance under seismic loads. The results indicated that buildings with bracing systems show improved strength and stiffness compared to bare frame structures. Among the configurations, inverted V-bracing provided better performance in terms of displacement control and load resistance. The study concluded that incorporating bracing systems is an effective way to enhance the seismic resistance of buildings. It also emphasized the importance of selecting appropriate structural systems for improving overall performance under earthquake loading conditions.

III. WORKING METHODOLOGY

The methodology adopted in this project focuses on analyzing the seismic behavior of a multi-storeyed RCC building using advanced computational tools like ETABS. Earthquake engineering has evolved significantly over the years, leading to the development of various analytical techniques to evaluate the response of structures under seismic forces. The Indian Standard Code IS 1893 (Part 1):2002 provides comprehensive guidelines for earthquake-resistant design, which forms the basis of this study. The primary objective of the methodology is to understand how a G+17 building responds to seismic forces in different zones (III, IV, and V) and to ensure that the structure remains safe and stable under such conditions. The building is modeled with defined geometry, material properties, and loading conditions to simulate real-life behavior. The methodology emphasizes the importance of dynamic analysis, as seismic forces are time-dependent and vary with structural characteristics such as mass, stiffness, and damping. By incorporating these parameters, the study aims to accurately predict the structural response. The use of ETABS simplifies the modeling and analysis process by providing an integrated platform for defining loads, performing analysis, and designing structural components. This approach reduces manual errors and enhances the accuracy of results. The methodology also includes the application of load combinations as per IS codes to evaluate critical conditions. Overall, this section outlines the systematic procedure followed in the project to achieve reliable and efficient seismic analysis, ensuring that the building design meets safety and performance requirements under earthquake loading conditions.

Seismic Analysis Methods and Modeling

In this project, different methods of seismic analysis are considered to evaluate the behavior of the structure under earthquake loading. Initially, the building is modeled in ETABS by defining grid systems, storey heights, and structural elements such as beams, columns, and slabs. Material properties like M30 concrete and Fe500 steel are assigned, and support conditions are considered fixed at the base. The loads applied include dead load, live load, and earthquake load, which are defined as per IS code provisions. Among the various analysis methods, linear dynamic analysis using the response spectrum method is adopted, as it provides a more accurate representation of structural behavior compared to linear static analysis. The response spectrum method considers multiple modes of vibration, allowing for a better understanding of how different parts of the structure respond to seismic forces. In contrast, linear static analysis is limited to regular structures and does not account for higher mode effects. Nonlinear methods such as pushover and time history analysis are also discussed, but they are more complex and require detailed input data. The response spectrum method is chosen for its balance between accuracy and computational efficiency. Modal combination techniques such as SRSS (Square Root of Sum of Squares) and CQC (Complete Quadratic Combination) are used to combine responses from different modes. This ensures that the overall response of the structure is accurately captured. The modeling process also includes defining seismic parameters such as zone factor, importance factor, response reduction factor, and soil type, which influence the magnitude of seismic forces acting on the structure.

Response Spectrum Analysis and Evaluation

The response spectrum analysis is the core methodology used in this project to evaluate the seismic performance of the building. This method involves determining the maximum response of the structure based on its natural frequencies and mode shapes. The analysis begins by calculating the natural period and mode shapes of the building, which are essential for understanding its dynamic behavior. The seismic forces are then obtained from the design response spectrum specified in IS 1893 (Part 1):2002. These forces are applied to the structure, and the responses such as displacement, storey drift, and base shear are calculated. The results from different modes are combined using modal combination techniques like SRSS and CQC to obtain the overall response. The analysis is performed for different seismic zones (III, IV, and V) to compare the effect of increasing seismic intensity on the structure. The results are presented in the form of tables and graphs for better interpretation. It is observed that as the seismic zone increases, the structural response parameters such as displacement, drift, and shear also increase. This highlights the importance of considering seismic effects during the design stage. The final step involves evaluating the results and ensuring that they are within permissible limits as per IS code provisions. If necessary, design modifications are made to improve the performance of the structure. This methodology ensures a comprehensive and accurate assessment of the building's seismic behavior, leading to a safe and efficient structural design.

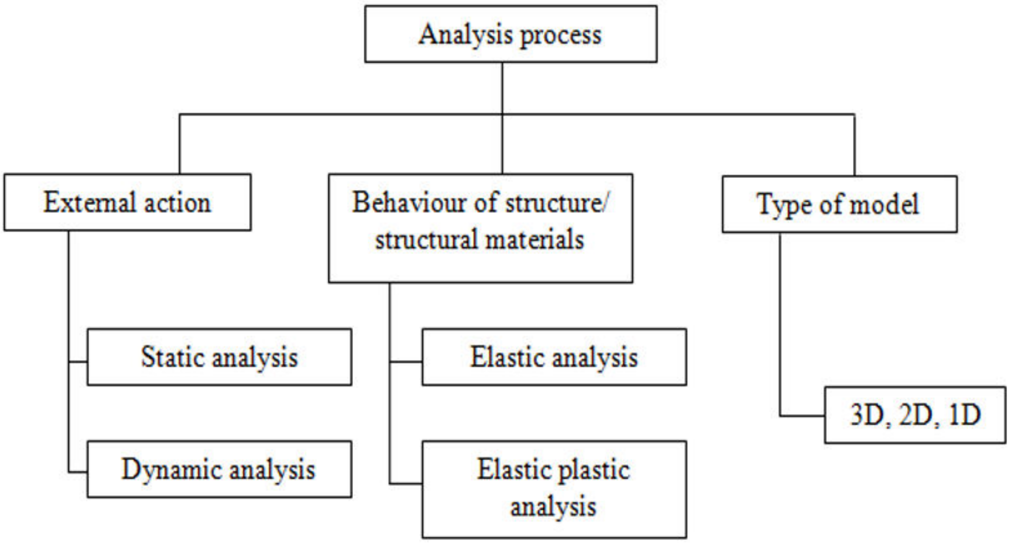


Fig 2:Method of Analysis Process (Syrmakezis, 1996)

modeling of structures

In the present study three G+17 structure models with foundation depth of 1.5m and bay widths in length and width directions of 3m and 3.5m each respectively, support conditions are assumed to be fixed at the bottom or at the supports/footings. The structures having length = 7x3 = 21m, width = 5x3.5 = 17.5m and height = 51.5m. The structureis modeled in ETABS (structural analysis and design software) by considering various loads and load combinations by their relative occurrence are considered the material properties considered are M30 grade concrete and Fe500 reinforcing steel bars. Methods of analysis considered are response spectrum method.

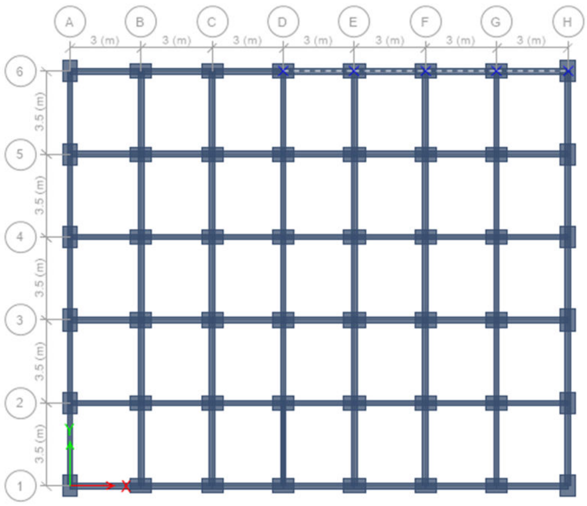


Fig : 3 Floor plan of G+17 building

This image shows the modeling and analysis of a multi-storey building in ETABS. It is divided into two main views that help engineers understand both the plan and the 3D structure. On the left side, you can see the plan view (top view) of one floor (Story 17). It displays a grid system with labeled axes (A–H and 1–6), which helps in placing structural elements accurately. The small square nodes represent columns, and the connecting lines represent beams. The spacing between grids (3 m × 3.5 m approx.) defines the structural layout. This view is mainly used to assign loads, define beam and column sections, and check alignment of structural members. On the right side, the 3D view of the entire G+17 building is shown. It clearly represents how beams and columns are connected vertically to form the full structure. The blue dots indicate joints, and the vertical members represent columns carrying loads down to the foundation. This view helps visualize the overall geometry, height (~51.5 m), and structural behavior under loads. From an engineering perspective, this model is used to apply loads (dead, live, earthquake), perform analysis, and obtain results like displacement, base shear, bending moment, and drift. It is a crucial step in ensuring the building is safe and stable under seismic conditions.

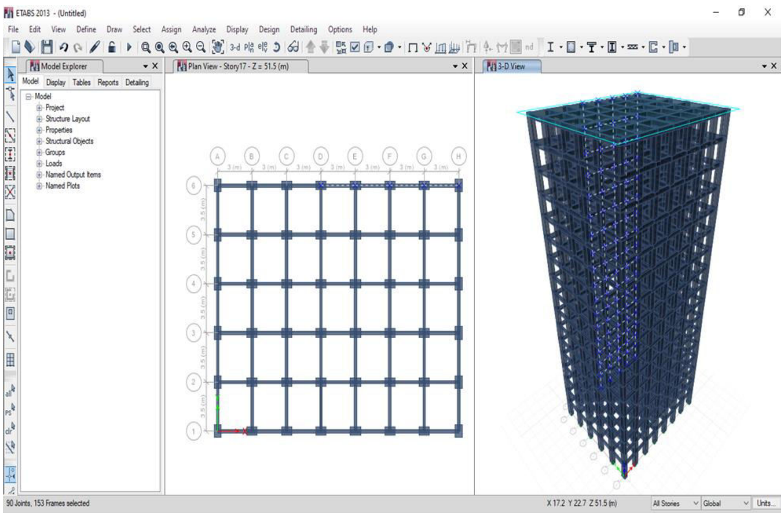


Fig4 :Three dimensional view of G+ 15 structur

CONCLUSION

The present study focuses on the design and seismic analysis of a G+17 multi-storeyed commercial RCC building using ETABS. The building was analyzed under earthquake loading conditions for seismic Zones III, IV, and V as per IS 1893 (Part 1):2002 using the response spectrum method. The results obtained from the analysis provide a clear understanding of the structural behavior under varying seismic intensities. It is observed that as the seismic zone increases, the structural response parameters such as storey displacement, storey drift, lateral loads, base shear, bending moments, and axial forces also increase significantly. This indicates that higher seismic zones demand stronger and more ductile structural design.

The analysis shows that maximum displacement occurs at the top storey, while maximum storey shear is concentrated at the base of the building. Lateral loads are found to be higher in the X-direction compared to the Y-direction, which influences the design of structural members. It is also observed that shorter columns attract higher forces due to increased stiffness, making them critical elements that require careful design and detailing. The response spectrum method proved to be effective in capturing the dynamic behavior of the structure by considering multiple modes of vibration, providing more accurate results than static methods.

The study highlights the importance of proper modeling, load application, and adherence to Indian Standard codes such as IS 1893, IS 456, and IS 13920. The use of ETABS significantly simplifies the analysis and design process, reduces manual errors, and ensures reliable results. Overall, the project concludes that seismic analysis is essential for high-rise buildings, and proper design techniques must be adopted to ensure safety, stability, and serviceability under earthquake conditions.

REFERENCES

1. IS 1893:1984,"Criteria for earthquake resistant design of structures", Bureau of Indian Standards, New Delhi, India.
2. IS 1893(Part1):2002,"Criteria for earthquake resistant design of structures -General provisions and buildings", Bureau of Indian Standards, New Delhi, India.
3. IS 456: 2000,"Plain reinforced concrete-code of practice", Bureau of Indian Standards, New Delhi, India.
4. IS 13920: 1993,"Ductile detailing of reinforced concrete structures subjected to seismic forces-code of practice", Bureau of Indian Standards, New Delhi, India.
5. IS 875 Part I for Dead load calculations.
6. IS 875 Part II for live load calculations.
7. B.G. Birajdar1, S.S. Nalawade2" seismic analysis of buildings resting on sloping ground"
8. Likhitharadhya Y R1, Praveen J V2, Sanjith J3, Ranjith A4 "Seismic Analysis of Multi-Storey Building Resting On Flat Ground and Sloping Ground"
9. Dr. R. B. Khadiranaikar1 and Arif Masali2 " Seismic performance of buildings resting on sloping ground a review"
10. Manjunath C S1, SidduKarthik C S2 "seismic performance of r c buildings on sloping grounds with different types of bracing systems"
11. P. R. Patil, M. D. Pidurkar, R. H. Mohankar studied(2013) on "Comparative Study of End Moments Regarding Application of Rotation Contribution Method (Kani's Method) & Moment Distribution Method for the Analysis of Portal Frame" (Volume 7, Issue 1)IOSR-JMCE
12. Balaji.U, Mr. Selvarasan M. studied (2016) "Design and analysis of multi storied building under static and dynamic loading conditions using ETABS" (Volume 4, Issue 4) International Journal of Technical Research and Applications e-ISSN: 2320-8163.
13. Siva KiranKollimarla, ChadalawadaJagan Mohan studied (2016)"Seismic Analysis of a Multi Storey Plane Frame using Static & Dynamic Methods Comparison of Equivalent Static Force & Response Spectrum on Frame with & without Infill's" (Vol. 5 Issue 04) (IJERT)
14. DeepmalaPandey (2016) on" Analysis& Design of G+5 Residential Building with Seismic Load Using STAAD .Pro "(Vol-2, Issue-8) (IJIR)
15. Aman, ManjunathNalwadgi , Vishal T, Gajendra studied (2016) " Analysis and design of multistorey building by using STAAD Pro"(Volume: 03 Issue: 06) (IRJET)
16. J. D. Holmes, "Wind loading of structures," CRC Press, 2015.

17. A. K. Chopra, “Dynamics of structures: Theory and applications to earthquake engineering,” 4th Edition, Pearson Education, 2012.
18. H. K. Duggal, “Earthquake resistant design of structures,” Oxford University Press, New Delhi, India, 2013.
19. S. Taranath, “Wind and earthquake resistant buildings: Structural analysis and design,” CRC Press, 2016.
20. N. Subramanian, “Design of reinforced concrete structures,” Oxford University Press, New Delhi, India, 2013.
21. M. L. Gambhir, “Fundamentals of reinforced concrete design,” PHI Learning Pvt. Ltd., New Delhi, India, 2012.
22. B. C. Punmia, A. K. Jain, and A. K. Jain, “Reinforced concrete structures,” Laxmi Publications, New Delhi, India, 2009.
23. V. N. Vazirani and M. M. Ratwani, “Analysis of structures,” Khanna Publishers, New Delhi, India, 2010.
24. Computers and Structures Inc., “ETABS integrated building design software – user guide,” Berkeley, California, USA, 2013.
25. International Code Council, “ASCE 7-16: Minimum design loads and associated criteria for buildings and other structures,” USA, 2016.