ANALYSIS AND DESIGN OF RESIDENTIAL BUILDING BY USING ETABS

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ABSTRACT

The rapid growth of urban population and limited availability of land have increased the demand for multi-storeyed residential buildings in metropolitan cities. Manual analysis and design of such structures are time-consuming and less efficient, which has led to the adoption of advanced structural engineering software like ETABS. This project focuses on the analysis and design of a G+5 residential building consisting of 2BHK flats using ETABS software, ensuring accuracy, efficiency, and compliance with Indian Standard codes. The structural modeling of the building is carried out in ETABS, which provides an integrated platform for modeling, analysis, design, and detailing. The design is performed using the limit state method in accordance with IS 456:2000. Various loads such as dead load, live load, wind load (IS 875), and seismic load (IS 1893) are applied to evaluate the structural performance under different conditions. Both linear static and dynamic analyses are considered to understand the behavior of the structure under various loading scenarios. The results obtained from the software include bending moments, shear forces, axial forces, and displacements, which are used for designing structural components like beams, columns, slabs, and foundations. The study ensures that all components satisfy strength, stability, and serviceability criteria. The use of ETABS significantly reduces design time while improving accuracy and reliability. The project demonstrates that modern software tools play a crucial role in efficient structural design and help engineers achieve safe, economical, and optimized building solutions.

Keywords: Multi-storeyed building, ETABS, Structural analysis, Limit state method, Load combinations, Seismic analysis, IS 456:2000, IS 875, IS 1893, Reinforced concrete design

I. INTRODUCTION

The initial stage of the project involves careful planning, data collection, and preparation of the building layout as per the requirements of a G+5 residential structure. The process begins with selecting a suitable site and gathering essential data such as soil properties, bearing capacity, and environmental conditions. Based on this information, a structural plan is prepared following the guidelines of the National Building

Code (NBC) of India. The architectural layout, including room arrangements for 2BHK flats, is developed using drafting tools like AutoCAD to ensure accuracy in dimensions and alignment. Grid lines are established to define column positions, beam layout, and slab configuration. Proper spacing between structural elements is ensured to maintain load distribution efficiency and structural stability. The selection of materials such as concrete grade (M30) and steel grade (Fe415) is finalized according to IS standards. Preliminary sizing of structural components like beams, columns, and slabs is carried out based on experience and codal provisions. This stage ensures that the building plan is functionally efficient, structurally feasible, and compliant with safety regulations. Proper documentation of design assumptions and parameters is also carried out before moving to the modeling phase.

The second stage involves modeling and analysis of the building using ETABS software. The prepared plan is imported or recreated in ETABS by defining grid systems and story data corresponding to the G+5 structure. Material properties and section properties for beams, columns, and slabs are defined as per IS 456:2000 guidelines. Structural elements are then modeled by assigning appropriate sections to beams and columns. Support conditions, typically fixed supports at the base, are applied to simulate real-world conditions. Loads are defined and assigned, including dead load (self-weight and wall loads), live load (as per IS 875 Part 2), wind load (IS 875 Part 3), and seismic load (IS 1893). Load combinations are generated to evaluate the structure under different critical scenarios. After completing the modeling and load assignment, the analysis is performed using linear static and dynamic methods. The software computes various results such as bending moments, shear forces, axial forces, and displacements. These results are carefully reviewed to ensure that the structure behaves within permissible limits. Any modeling errors or warnings are corrected before proceeding to the design phase.

The final stage focuses on the design and validation of structural components based on analysis results. Using ETABS design modules, beams, columns, and slabs are designed according to the limit state method specified in IS 456:2000. Reinforcement requirements are calculated for each structural element to ensure safety against bending, shear, and axial loads. The design is checked for serviceability criteria such as deflection limits and crack control. Structural elements that do not meet design requirements are revised by modifying dimensions or reinforcement details. Detailed outputs such as bending moment diagrams (BMD), shear force diagrams (SFD), and reinforcement detailing are generated. The results are interpreted to confirm that the structure is stable, safe, and economical. Additionally, load transfer mechanisms from slabs to beams, beams to columns, and columns to foundation are verified. Final documentation, including design reports, drawings, and analysis summaries, is prepared. This stage ensures that the building design meets all safety, durability, and performance requirements. The use of ETABS enhances efficiency, reduces manual errors, and provides a reliable platform for structural design, making it an essential tool in modern civil engineering projects.

II. LITRATURE REVIEW

Varalakshmi V et.al (2014) analyzed a G+5 storey residential building and designed the various components like beam, slab, column and foundation. The loads namely dead load and live load were calculated as per IS 875(Part I & II)-1987 and HYSD bars i.e. Fe 415 are used as per IS 1986- 1985. They concluded that the safety of the reinforced concrete building depends upon the initial architectural and structural configuration of the total building, the quality of the structural analysis, design and reinforcement detailing of the building frame to achieve stability of elements and their ductile performance.

Chandrashekar et.al (2015) analyzed and designed the multi-storeyed building by using ETABS software. A G+5 storey building under the lateral loading effect of wind and earthquake was considered for this study and analysis is done by using ETABS. They have also considered the chances of occurrence of spread of fire and the importance of use of fire proof material up to highest possible standards of performance as well as reliability. They suggested that the wide chances of ETABS software which is very innovative and easier for high rise buildings so that time incurred for designing is reduced.

Balaji.U and Selvarasan M.E (2016) worked on analysis and design of multi-storeyed building under static and dynamic loading conditions using ETABS. In this work a G+13 storey residential building was studied for the earth quake loads using ETABS. They assumed that material property to be linear, static and dynamic analyses were performed. The non-linear analysis was carried out by considering severe seismic zones and the behaviour was assessed by considering type II soil condition. Different results like displacements, base shear were plotted and studied.

P.P. Chandurkar et. al. (2013): Study of G+9 building: Had presented study of G+9 building having three meters height for each storey. The whole building design had carried out according to IS code for seismic resistant design and the building had considered fixed at base. Structural element for design had assumed as square or rectangular in section. They had done modelling of building using ETAB software in that four different models were studied with different positioning of shear walls.

Mohit Sharma et.al. (2015): To study the dynamic analysis of multi-storeyed Building: He considered a G+30 storied regular reinforced concrete framed building. Dynamic analysis of multi-storeyed Building was carried out. These buildings have the plan area of 25m x 45m with a storey height 3.6m each and depth of foundation is 2.4 m. & total height of chosen building including depth of foundation is 114 m. The static and dynamic analysis has done on computer with the help of STAAD-Pro software using the parameters for the design as per the IS:1893-2002 Part-1 for the zones- 2 and 3. It was concluded that not much difference in the values of Axial Forces as obtained by static and dynamic analysis.

M. S. Aainawala et. al. (2014): Comparative study of multi-storeyed R.C.C. Buildings with and without Shear Walls: He did the comparative study of multi-storeyed R.C.C. Buildings with and without Shear Walls. They applied the earthquake load to a building for G+12, G+25, G+38 located in zone II, zone III, zone IV and zone V for different cases of shear wall position. They calculated the lateral displacement and story drift in all the cases. It was observed that Multistoreyed R.C.C. Buildings with shear wall is economical as compared to without shear wall. As per analysis, it was concluded that displacement at different level in multistoreyed building with shear wall is comparatively lesser as compared to R.C.C. building without shear wall. Which is important for building design and use of shear walls.

M. Mallikarjun et. al. (2016): on analysis and design of a multi-storied residential building of ung-2+G+10: Carried study on analysis and design of a multi-storied residential building of ung-2+G+10 by using most economical column method and the dead load and live load was applied on the various structural component like slabs, beams and found that as the study is carried using most economical column method this was achieved by reducing the size of columns at top floors as load was more at the bottom floor. The economizing was done by means of column orientation in longer span in longer direction as it will reduce the amount of bending and the area of steel was also reduced.

III. WORKING METHODOLOGY

The working methodology of this project begins with the collection of preliminary data and planning of the G+5 residential building. The architectural layout of a 2BHK flat system is prepared based on functional requirements and National Building Code (NBC) guidelines. Grid lines and story heights are defined to establish the structural framework. Soil investigation is considered to determine safe bearing capacity, which is essential for foundation design. Based on these inputs, preliminary dimensions of beams, columns, and slabs are assumed using standard engineering practices. Material properties such as M30 grade concrete and Fe415 steel are selected according to IS codes. The entire building layout is drafted using AutoCAD to ensure dimensional accuracy. This stage ensures that the building is structurally feasible, safe, and suitable for further modeling. Proper planning at this stage reduces design errors and improves the efficiency of the overall project.

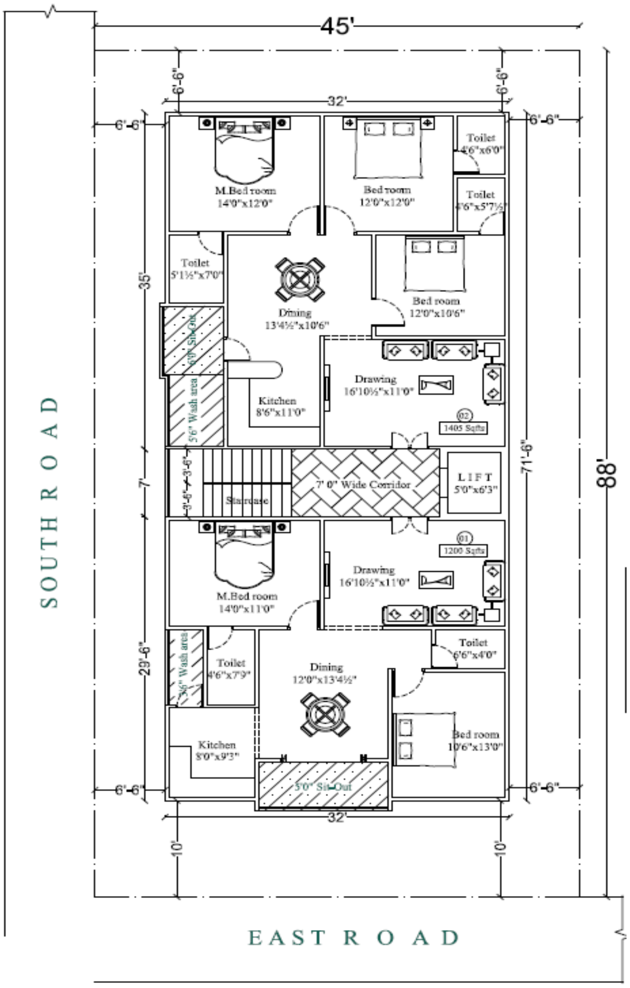

Fig1 :AutoCAD plan

The next phase involves modeling and analysis of the structure using ETABS software. A new model is created by defining grid systems and story data corresponding to the G+5 building. Material properties and sectional properties for beams, columns, and slabs are defined and assigned. Structural elements are modeled using frame and area elements. Supports are assigned as fixed at the base to simulate real conditions. Various loads such as dead load (self-weight and wall loads), live load (as per IS 875 Part 2), wind load (IS 875 Part 3), and seismic load (IS 1893) are defined and applied. Load combinations are generated based on limit state design principles. The structure is then analyzed using linear static and dynamic methods to obtain results like bending moments, shear forces, axial forces, and displacements. These results are reviewed carefully to ensure the structural performance is within permissible limits.

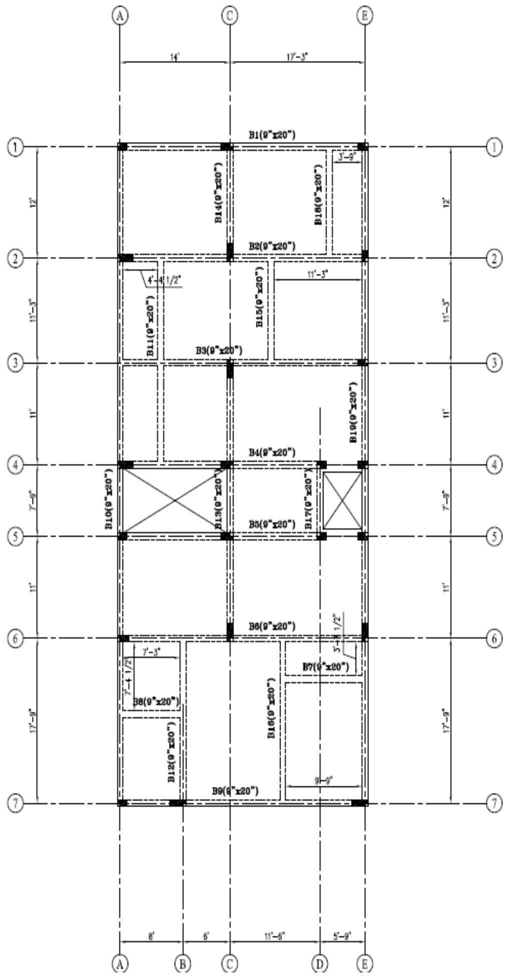

Fig2: Centre line diagram of plan

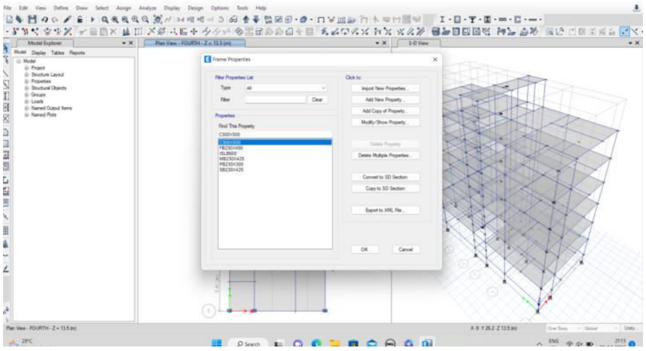

Fig3: Section Properties

The section properties figure represents the geometric and material characteristics assigned to different structural elements such as beams, columns, and slabs in the ETABS model. It includes details like cross-sectional dimensions (width and depth), material type (e.g., M30 concrete), and reinforcement parameters. These properties are essential for determining the stiffness, strength, and load-carrying capacity of each structural member. Proper definition of section properties ensures accurate analysis results, as the software uses these values to calculate internal forces such as bending moments, shear forces, and axial loads. Any change in section size directly affects the structural behavior, making this step critical in design.

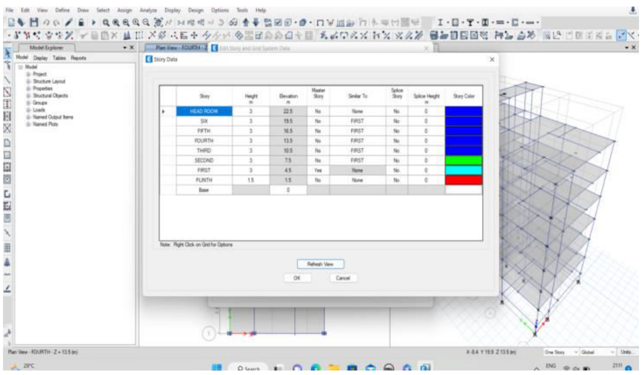

FIGURE 4: STOREY DATA

The storey data figure shows the vertical configuration of the building, including the number of floors, storey heights, and elevation levels. For a G+5 structure, it defines the ground floor and subsequent floors with uniform or varying heights (typically around 3 meters each). This data helps in establishing the three-dimensional model of the building in ETABS. Storey information is important for load distribution, especially for seismic and wind loads, as these loads depend on building height and mass distribution. It also helps in analyzing storey drift, displacement, and overall structural behavior across different levels.

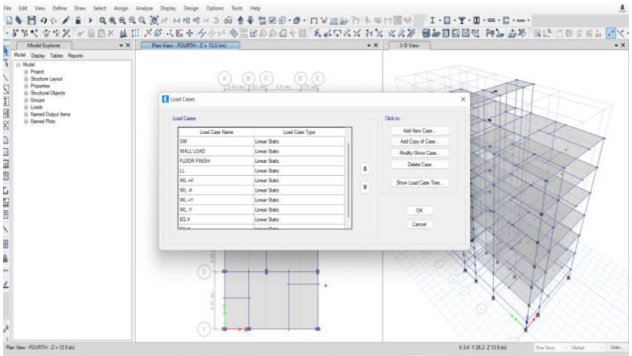

Fig : Load cases

The load cases figure illustrates the different types of loads applied to the structure during analysis. These typically include dead load (self-weight and permanent loads), live load (occupancy loads), wind load, and seismic load. Each load case is defined separately in ETABS to analyze how the structure responds under individual loading conditions. These loads are later combined using load combinations to simulate real-life scenarios where multiple loads act simultaneously. Proper definition of load cases is crucial for ensuring the safety and stability of the structure, as it helps engineers evaluate the most critical conditions affecting the building.

IV. CONCLUSION

The project successfully demonstrates the analysis and design of a G+5 multi-storeyed residential building using ETABS software in accordance with Indian Standard codes. The use of advanced software has significantly reduced the complexity, time, and effort involved in manual structural design while improving accuracy and reliability. Through proper planning, modeling, and analysis, all structural components such as beams, columns, and slabs were designed using the limit state method as per IS 456:2000. The structure was analyzed under various loading conditions including dead load, live load, wind load, and seismic load as per IS 875 and IS 1893 provisions. The results obtained from ETABS, such as bending moments, shear forces, axial forces, and displacements, were carefully evaluated to ensure structural safety and stability. It was observed that all members satisfied both strength and serviceability criteria, including deflection limits and reinforcement requirements. The project also highlights the importance of proper load combinations and realistic modeling in predicting the actual behavior of the structure. The load transfer mechanism from slabs to beams, beams to columns, and columns to the foundation was effectively validated. Additionally, the design proved to be economical by optimizing material usage without compromising safety. Overall, the study confirms that ETABS is a powerful and efficient tool for structural analysis and design of multi-storeyed buildings. It enables engineers to achieve safe, durable, and cost-effective designs while complying with codal standards. This project provides a strong foundation for understanding real-world structural design practices and the application of modern engineering tools in the construction industry.

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