Design and Analysis of High-Rise Building using ETAB'S

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Abstract - *The rapid growth of urbanization has increased the demand for high-rise buildings, highlighting the importance of structural design and analysis. This project focuses on the design and analysis of a multi-storey high-rise building using ETABS software to ensure safety, serviceability, and cost-effectiveness while complying with IS codes. A structural model is developed with realistic dimensions, materials, and loading conditions, including dead, live, wind, and seismic loads. Key parameters such as displacement, bending moment, shear force, and axial load are evaluated. Emphasis is placed on seismic performance, with results confirming compliance, stability, and efficiency, demonstrating ETABS as an effective tool*

***Key Words*: Bending moment, Shear force, Axial load, Displacement, Response Spectrum**

1. INTRODUCTION

The increasing need for urban space has led to the emergence of tall structures, making the design and study of high-rise buildings a vital feature of modern construction. These structures need to be safe, cost-effective, and able to support a variety of loads, such as earthquake, wind, dead, and living loads. A popular program for structural modelling and design, ETABS (Extended Three-Dimensional Analysis of Building Systems) provides precise analysis of multi-story buildings in real-world scenarios. In this project, ETABS is used to model and analyse a high-rise structure. Shear walls, beams, columns, and slabs are among the structural elements that are developed in accordance with applicable codes. The study shows how well ETABS works in high-rise building design while ensuring that the structure satisfies stability, strength, and serviceability requirements.

1.1 LOADS AND LOAD COMBINATIONS

Loads are the external forces or actions applied to a structure that cause stress, deformation, or displacement. These include dead loads (permanent/static loads like self-weight), live loads (temporary or movable loads such as people or furniture), wind loads, earthquake loads, and snow loads. Each type of load affects the structure differently and must be considered during design. Load combinations are sets of various loads applied together to simulate real-life conditions. They help engineers ensure that the structure remains safe and stable under multiple loading scenarios. Codes such as IS 456 and IS 875 provide guidelines for determining these combinations. By analysing load combinations, designers can assess the most critical conditions and design the structure for maximum safety and performance.

2. LITERATURE REVIEW

1.Jenita Kuriakose, et al. (2023): The report says that a comprehensive design and analysis of a high-rise building utilizing ETABS software, with a particular emphasis on the effects of wind load. The phenomenon of rapid urbanization in cities such as Mumbai has resulted in a scarcity of available space, thereby rendering vertical construction viable solutions. ETAB'S facilitates the efficient modelling, designing, and analysis of structures subjected to both static and dynamic loads in accordance with Indian Standard (IS) codes. The methodology employed involves the preparation of architectural plans using AutoCAD, followed by their importation into ETAB'S, the modelling of structural components, the assignment of various loads, and the analysis of structural performance. The proposed building is designed using M40 concrete and Fe600 steel, considering dead, live, wind, and seismic loads. Wind loads are checked according to IS 875 (Part 3). The analysis results indicate that displacements and story shear increase with ascending wind speeds, particularly impacting the upper stories of the structure.

2.Wakale Yogesh Namdev, et al. (2022): The study says that the study uses ETAB'S to analyses and design a G+26-story office building with an emphasis on wind and seismic load performance. Structural modelling, analysis, and member design were done with ETAB'S, foundation design was done with CSI SAFE, and reinforcement detailing was generated with CSI Detail. The design took into account earthquakes, wind, dead, and live loads in accordance with IS regulations, namely IS 1893, IS 875, IS 456, IS 13920, and IS 16700. The project location has a zone factor of 0.16 and is in seismic zone III. RC moment-resisting frames, robust diaphragms, and economically optimal column sizing were all included in the modelling. Torsion, base reactions, displacement, and tale drift were among the main findings. Story drift, displacement, torsion, and base reactions were among the main outcomes, all of which were below acceptable code bounds. Under seismic loading, displacement rose from the first to the top story.

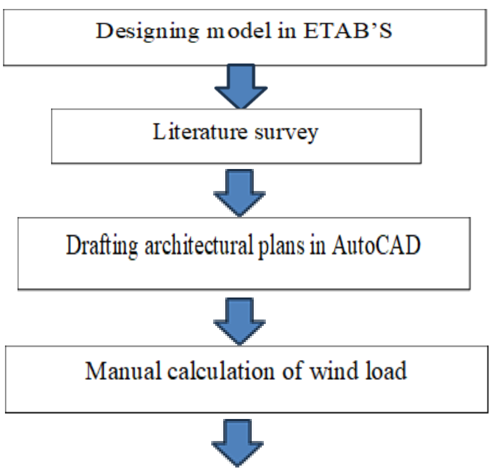
3.B.Vamsi Krishna, et al. (2020): This study uses ETAB'S software to analyze, optimize, and design shear walls in high-rise reinforced cement concrete (RCC) structures. In compliance with IS 1893:2002, a Ground plus Ten (G+10) structure model is analyzed for Seismic Zone III, accounting for both dynamic and static loads. To improve structural stability and lateral load resistance, shear walls were positioned, and their thickness was optimized. The study concentrated on a few important factors, such as support responses, shear pressures, displacement, and story drift. When compared to asymmetric structures, the results showed that symmetric shear wall layouts considerably increased stability.

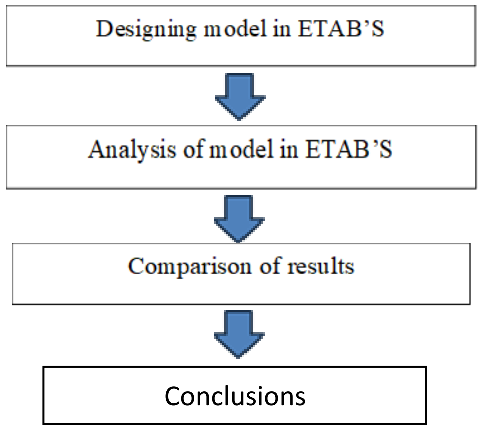
4.Shobha Ra, et al. (2021): The study uses ETAB'S with response spectrum analyzes to examine a 16-story RC-framed structure located in seismic zones II–V. The findings indicate that base shear and story displacement rises sharply with increasing seismic zones, peaking in Zone V. story drift decreases at the upper floor after increasing to the fourteenth story. The results indicate that regarding maintain stability and safety, increased seismic activity necessitates corresponding increases in strength characteristics.

3. OBJECTIVES

- To analyse and design structural members (columns and beams) of a high-rise building using both manual calculation and ETAB's software.
- To compare the results of shear force (SFD), bending moment (BMD) and axial force obtained manually with the software outputs.
- To understand the accuracy and efficiency of ETAB'S in analysing complex high-rise structures.
- To validate the reliability of manual calculation against software results for practical implementation.

4. METHODOLOGY





5. PRELIMINARY DATA REQUIRED FOR ANALYSIS

Table -1: Design parameter

Parameters	**Values**
Height of the structure	71.050 m
Story height	a. 4 m b. 3.6 m c. 3 m
Dimension of building	32.250*19.555 m
Beam dimension 1. Size of peripheral beams 2. Size of main beams	a. 400*750 mm b. 450*900 mm
Column dimension	a. 1000*1000 mm b. 1000*500 mm c. 750*900 mm d. 500*1000 mm
Earthquake zone	IV
Thickness of slab	125 mm
Number of story	16
Soil type	Terrain 3
Importance factor	1.2
Response reduction factor	5
Live load	4 KN/m^2
Codes used	IS 456:2000 IS 800:2007 IS 1893-part 1 (2016) IS 875-part 3

5.1 Architectural plan

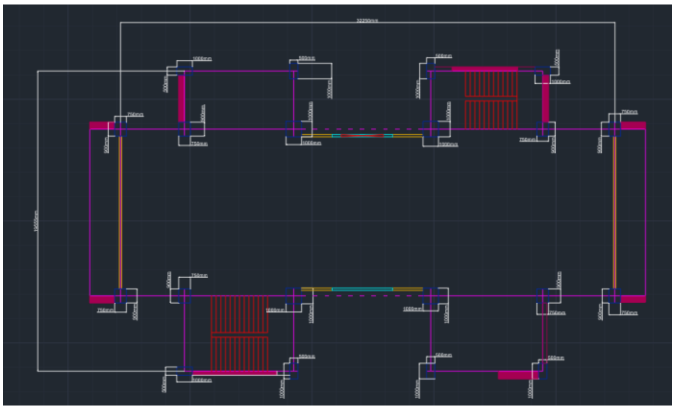


Fig -1: Plane of building

5.2 Structural analysis in ETAB'S

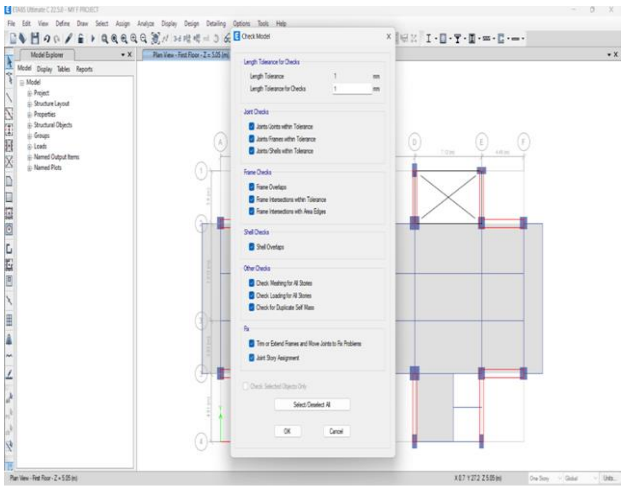


Fig -2: Check for errors

6. RESULTS

The design and analysis of high-rise building of g+16 was carried out in ETAB'S software. And a test beam and test column was selected to compare the results of manually calculated bending moment, shear force and axial load and the results got from the ETAB'S software.

6.1 Beam results

- Manual calculation:

  SF = 54.47 kN
  BM = 64.64 kN-m

- ETABS calculation:

  SF = 66.7656 kN
  BM = 66.3037 kN-m

6.2 Column results

- Manual calculation:

  Axial Force = 2030.25 kN

- ETABS calculation:

  Axial Force = 2021.1127 kN

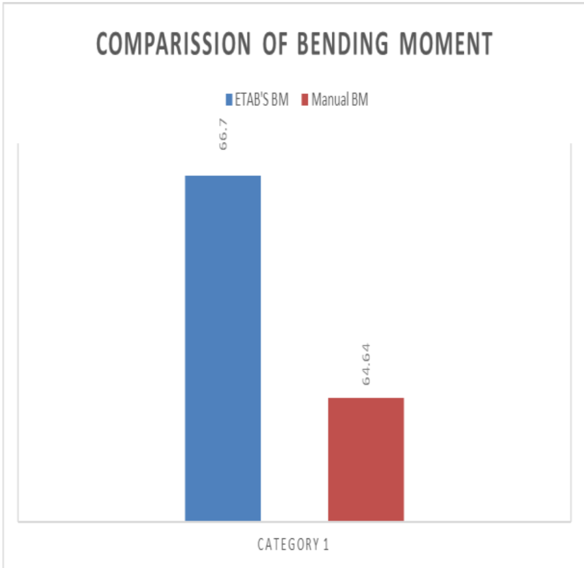


Chart-1: Comparison of bending moment of test beam

The graph shows a comparison of bending moments obtained from ETABS analysis and manual calculations for a test beam. The ETABS bending moment value is nearer at 66.7 kN-m compared to the manual value of 64.13 kN-m.

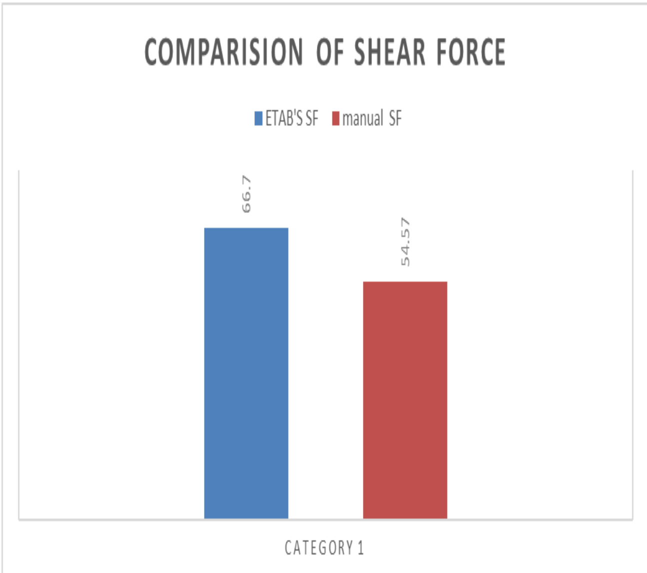


Chart-2: Comparison of shear force of test beam

The graph shows a comparison of shear force obtained from ETABS analysis and manual calculations for a test beam. The ETABS shear force value comparison is ok at 66.7 kN compared to the manual value of 54.57 kN.

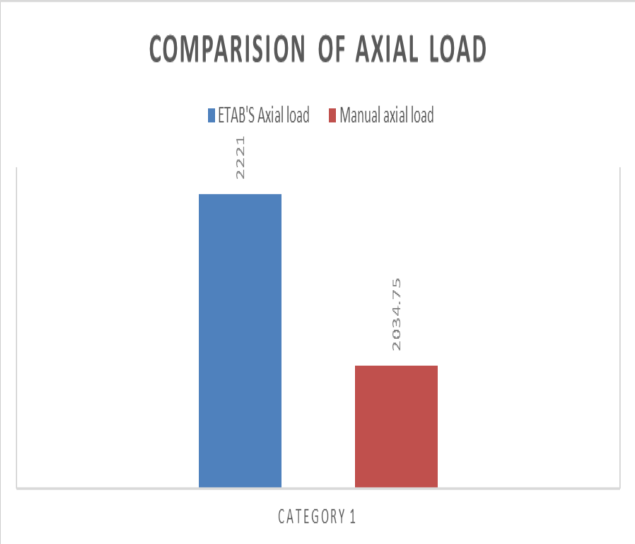


Chart-3: Comparison of axial load on test column

The graph shows comparison from software and manually obtained is ok to have this result it is nearer such slight differences happen software's data is 2221 kN and manual is 20334.75 kN.

7. CONCLUSIONS

The analysis comparing the values obtained through manual calculations with the output from ETABS software indicates minor discrepancies in the results concerning bending moment, shear force, and axial force. These variations can be linked to the assumptions and simplifications inherent in manual calculations, such as neglecting secondary effects, employing approximate methods or presuming ideal support conditions. Conversely, ETABS conducts a more thorough analysis, taking into account elements such as load combinations, stiffness distribution, and actual boundary conditions, resulting in more precise and comprehensive outcomes. The values for bending moment and shear force are relatively similar, demonstrating the manual method's adequacy for preliminary assessments. However, the notable difference in axial force points to the impact of additional factors such as load path, frame interaction, and higher-order effects that manual techniques may not adequately address. This underscores the necessity of utilizing structural analysis software like ETABS for the validation of final designs, particularly in intricate structures. Nevertheless, manual calculations continue to hold significance for comprehending structural behavior and corroborating software outputs. The bending moment values from manual and ETABS are nearly the same, showing good agreement. However, shear force values differ significantly, indicating that software provides a more precise distribution for complex loading.

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