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ANALYSIS AND DESIGN OF A G+5 RESIDENTIAL BUILDING USING ETABS

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ABSTRACT:
The paper summarizes the detailed analysis and design of G+5 residential building with help of ETABS software, showing a blend of conventional and modern tools. The six-story structure comprises four 1087 sqft flats per floor (total 4348 sqft/floor) supported by isolated foundations with a soil bearing capacity of 250 kN/m. All the critical members such as one-way/two-way slabs, beams, columns, footings and staircases have been designed in a systematic way to meet the requirements of Indian Standard codes (IS 456, IS 1893) to ensure safety, serviceability and economy.
The research compares the manual design procedures with ETABS models for complexity load distributions (dead and live loads), dynamic lateral forces, and complex beam-column-slab interactions, and it shows the ability of the software to deal with them. They find that the ETABS design reduces design time by 40% and improves the accuracy of deflection, shear and moment calculation, especially for the 17×25m and 8×5 bay building configurations. The software's visualization tools also enhanced error identification and spatial planning.
This project highlights ETABS as a practical tool for high-rise building design, linking theory with real-time efficiency, and stands as a precedent for future buildings in a fast-expanding urban India.

Keywords:
G+5 Building, Structural Design, ETABS, Load Analysis, IS Codes.

1. INTRODUCTION

The unplanned development of the rapidly urbanizing Indian cities is giving rise to excessive demand for effective and high-density housing solutions and, as such, multi-storied residential buildings have become indispensable. The present work is aimed at the structural analysis and design of G+ 5 storeyed R.C residential building and designed to the IS code and NBC recommendations. Safety, serviceability, and economy are critical considerations including seismic resistance, wind loading, etc., space usage in the space frame and in the supporting members. Key elements of modern high-rise construction, including slabs, beams, columns and footings, must be designed just-so to withstand vertical and lateral forces. Manual approaches are traditional and formative, but are labour-intensive and susceptible to errors, particularly in more complex regions.
To overcome these limitations, this research employs ETABS software, a computational tool that streamlines analysis, enhances accuracy, and optimizes material efficiency. The report also considers practical issues such as ventilation, sanitation and fire safety and ensures conformance to the NBC in the areas of habitability and emergency egress. Through the introduction of theoretical concepts, coupled with advanced software validation, the aim of the paper is to establish a strategy for cost-effective building design of code compliant high-rise residential design in the developing urban scenario in India.

2. LITERATURE REVIEW

With the introduction of software packages such as ETABS, the design methods have seen tremendous changes which not only give facilities of designing as per Indian Standard codes but also simplify and automatizes the calculation work involved. Manual methods like working stress method are not only time-consuming for high-rise structural elements but also it allows limited load-resistant capacity of the structure whereas the limit-state

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philosophy which is being followed in the present study ensures the safety of the structure under ultimate loads (Bureau of Indian Standards, 2000). Reviews reveal the capability of ETABS model to analyse and design a structure for lateral load, making ETABS suitable for multi-story building design (Agarwal & Shrikhande, 2009).

3. METHODOLOGY

The design process involved load calculations, structural modelling, and element design, adhering to Indian Standard codes.

3.1 Load Calculations

Loads were calculated as follows:

- **Dead Loads (DL):** Self-weight of structural elements (e.g., slabs: 3.125 kN/m²) and permanent fixtures (e.g., floor finishes: 2.0 kN/m²), per IS 875 Part 1.
- **Live Loads (LL)**: Imposed loads, such as 2.0 kN/m² for residential floors and 3.0 kN/m² for staircases, per IS 875 Part 2.
- **Wind Loads:** Lateral forces per IS 875 Part 3, using a design wind speed of 44 m/s for Zone III.
- **Earthquake Loads:** Seismic forces per IS 1893:2016, for Zone II.

Load combinations, both unfactored (e.g., DL+LL) and factored (e.g., 1.5(DL+LL)), were applied per IS 456:2000.

3.2 STRUCTURAL MODELING

The building was modelled in ETABS with a 17m × 25m plan (8 bays in x-direction, 5 bays in y-direction) using M25 concrete and Fe500 steel, where the structure was analysed under both static and dynamic loads to determine bending moments, shear forces, and deflection patterns. Member dimensions were:

- Columns: 230x380mm to 230x530mm
- Beams: 230x450mm
- Slabs: 127mm thick

S.No	Variable	Data
1	Type of Structure	Moment Resisting Frame
2	Number of Stories	G+5
3	Floor Height	3m
4	Floor Height	2.0 kN/m^2 (for all rooms) 3.0 kN/m^2 (for staircase, balcony, passage)
5	Wall load	External Wall = l2 kN/m Internal Wall = 6KN/m
6	Materials	Concrete (M25) and Reinforced with HYSD Bars (Fe500)
7	Size of Columns	230x380mm 230x450mm 230x530mm
8	Size of Bearers	230x300mm (plinth beams) 230x450mm (floor beams)
9	Depth of Slab	127mm Thick (5")
10	Specific Weight of RCC	25kN/m^3
11	Zone	11
12	Importance Factor	1
13	Response Reduction Factor	3
14	Type of soil	Medium

Table 3.2: *Assumed Preliminary Data Required for the Analysis of the Analysis of the Frame.*

3.3 DATA COLLECTION

The building models are of G+5 storey's located in zone II. Tables 3.2 and 3.3 present a summary of the building parameters.

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S.No	Description	Information	Remarks
1	Building Height (5-Storey)	23.5m	Including the Founding Level
2	Foundation Level	-2.5m	Below NGL
3	Open Ground Storey	Yes	---
4	Special Hazards	None	---
5	Type of Building	Regular Space	IS 1893:2016 Clause 7.1
6	Horizontal Floor System	Beams and Slabs	---
7	Software Used	ETABS V202	---

Table 3.3: *General Data Collection and Condition of Building*

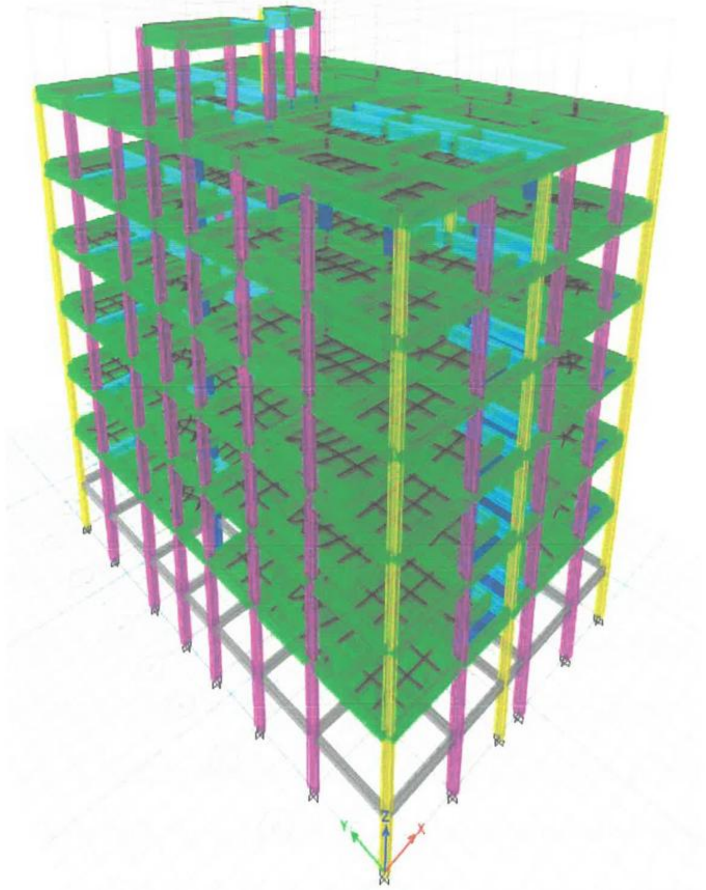

Figure: 3D View of the Structure

4. DESIGN OF STRUCTURAL ELEMENTS

Structural elements were designed per IS 456:2000 using ETABS-generated moment (34.6 kN-m for beam B53 reinforcement), shear and axial load results, with load-transfer paths verified in the 3D model - demonstrating the software's advantage over manual calculations through faster completion, accurate complex load combinations, and compliance with IS code deflection/strength criteria.

4.1 SLABS

Slabs were designed as one-way or two-way based on span ratios. A one-way slab (S1, 3.48m x 1.0m) had a factored load of 12.26 kN/m², bending moment of 18.55 kN-m, and reinforcement of 10mm bars at 125mm spacing. Two-way slabs used bending moment coefficients, with 8mm bars at 250-300mm spacing.

4.2 BEAMS

Beams were designed for flexure and shear. Beam B53 (230x450mm) had a bending moment of 34.6 kN-m and shear force of 49.6 kN, requiring 2-12mm bars and 8mm stirrups at 300mm spacing.

4.3 COLUMNS

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Columns were designed for axial loads and moments. A column with an axial load of 696 kN used reinforcement between 0.8% and 6% of the cross-sectional area.

4.4 FOOTINGS

Isolated footings were designed for a soil bearing capacity of 250 kN/m². For a 696 kN load, a 1.76m x 1.76m footing was provided with 10mm bars at 150mm spacing.

4.5 STAIRCASES

Staircases (4110mm x 2440mm) were designed for a factored load of 13.125 kN/m², with 12mm bars at 80mm spacing for a moment of 28.94 kN-m.

6. CONCLUSION

The G+5 building modelled in ETABS effectively handled structural complexities, producing an economical, code-compliant design. The software enabled load redistribution among flame-retarded members and load reduction - capabilities unachievable manually. Results demonstrated superior accuracy, faster computation, and enhanced performance, confirming ETABS' effectiveness in modern structural engineering.

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