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ANALYSIS AND DESIGN OF A G+12 RESIDENTIAL BUILDING USING ETABS

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ABSTRACT:
The paper summarizes the detailed analysis and design of G+12 residential building with help of ETABS software, showing a blend of conventional and modern tools. The thirteen-story structure comprises four 922 sqft flats per floor (total 1376 sqft/floor) supported by isolated foundations with a soil bearing capacity of 200 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 study contrast manual calculation with ETABS outputs, particularly under varied loading scenarios including dead loads, live loads, and dynamic lateral forces. The software enhanced the precision in determining structural behaviour like bending, shear, and deflection in large-scale configuration (37m x 36m, 8 x 5 bays). It also facilitated spatial planning through effective visual modelling. The project illustrate ETABS as a valuable tool for designing high-rise buildings in rapidly urbanizing areas in india
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+12 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+ 12 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. Traditional manual design, though educational, becomes inefficient and error-prone for complex structure, to address this, ETABS – a comprehensive analysis and design software – is employed to streamline workflows and enhance reliability. The work also addresses important aspects of habitability, including fire safety, sanitation, and emergency planning, with the ultimate goal of establishing a standardized approach to economical and code-compliant urban housing,

2. LITERATURE REVIEW

Modern structural design has significantly benefited from software like ETABS, which align well with Indian standards and automates complex calculation. Traditional working stresses methods, while foundational, are limited in handling high-rise design and often lack sufficient load-bearing efficiency. In contrast, the limit state method, as used in this study, improves the design's ability to handle extreme loads (BIS, 2000).
Prior studies highlights ETAB'S proficiency in managing lateral loads, making it a suitable tool for multi-storey building design (Agrawal & Shrikhande,2009). The software allows for efficient assessment of dynamic and seismic responses, which are critical for modern high-rise development

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3. METHODOLOGY

The design accounted for various loads using IS codes:

3.1 Load Calculations

Loads were calculated as follows:

- **Dead Loads (DL):** Self-weight of structural elements (e.g., slabs: 3.75 kN/m²) and permanent fixtures (e.g., floor finishes: 1.0 kN/m²), per IS 875 Part 1.
- **Live Loads (LL)**: Residential floors considered at 2.0 kN/m^2, staircases at 3.0kN/m^2, 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 37m × 36m plan (8 bays in x-direction, 8 bays in y-direction) using M30 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: 450x350mm
- Beams: 230x450mm
- Slabs: 150mm thick

S.No	Variable	Data
1	Type of Structure	Moment Resisting Frame
2	Number of Stories	G+12
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 = 13.8 kN/m Internal Wall = 6.9KN/m
6	Materials	Concrete (M30) and Reinforced with HYSD Bars (Fe500)
7	Size of Columns	450x350mm 450x350mm 450x350mm
8	Size of Bearers	230x450mm (plinth beams) 230x450mm (floor beams)
9	Depth of Slab	150mm 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+12 storey’s located in zone II. Tables 3.2 and 3.3 present a summary of the building parameters.

S.No	Description	Information	Remarks
1	Building Height (12-Storey)	23.5m	Including the Founding Level
2	Foundation Level	-3.5m	Below NGL
3	Open Ground Storey	Yes	---
4	Special Hazards	None	---
5	Type of Building	Regular Space	IS 1893:2016 Clause 7.1

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6	Horizontal Floor System	Beams and Slabs	---
7	Software Used	ETABS 21	---

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

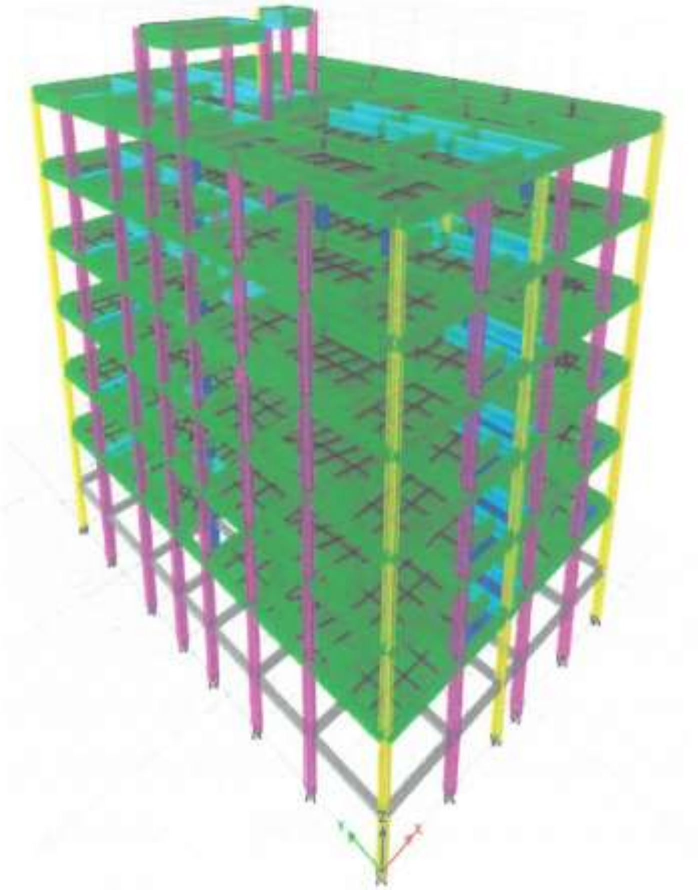

Figure: 3D View of the Structure

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, 24.28m x 3.048m) had a factored load of 10.875 kN/m², bending moment of 12.63 kN-m, and reinforcement of 10mm bars at 250mm spacing. Two-way slabs used bending moment coefficients, with 0mm bars at 300-400mm 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 125mm spacing.

4.3 COLUMNS

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 200 kN/m². For a 1674.06 kN load, a 3.43m x 2.68m footing was provided with 20mm bars at 240mm spacing.

4.5 STAIRCASES

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Staircases (3090mm x 5180mm) were designed for a factored load of 15.36 kN/m², with 10mm bars at 300mm spacing for a moment of 26.49 kN-m.

6. CONCLUSION

The G+12 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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