COMPARATIVE DESIGN AND ANALYSIS OF A G+15 REINFORCED CONCRETE RESIDENTIAL BUILDING USING STAAD.PRO & ETAABS

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Abstract: This study focuses on the analysis and design of a G+15 reinforced concrete residential structure using two widely adopted structural analysis platforms, STAAD.Pro and ETABS, with the objective of comparing their structural responses in terms of strength performance, load-resisting capacity, and overall design effectiveness. A regular RC frame building was independently modeled in both software environments, and relevant gravity and lateral loads, including dead, live, wind, and seismic loads, were applied in compliance with the provisions of IS 875 and IS 1893. The structural behavior was assessed under various load combinations to evaluate stability and performance, while STAAD.Pro was employed for the design of key structural elements such as beams, columns, slabs, and footings based on limit state design principles. ETABS was used to develop a detailed analytical model that enabled better interpretation of lateral load behavior, particularly with respect to storey displacement, storey drift, and seismic performance. The combined use of both tools facilitates a clearer understanding of their respective strengths and limitations for high-rise reinforced concrete buildings, with the comparison carried out using parameters including bending moments, shear forces, axial forces, storey shear, storey drift, and reinforcement demand.

Key words :
High-Rise RC Residential Structure, Structural Modeling Software, STAAD.Pro–ETABS Comparison, Load Combination Analysis, Seismic Performance Evaluation, Storey Drift Behaviour, Bending Moments, Shear Forces, Axial Forces, Storey Shear.

Introduction: Designing reinforced concrete buildings of significant height calls for a dependable and well-structured analytical methodology, since the influence of vertical and horizontal loading becomes increasingly pronounced as the structure grows taller. With additional storeys, structural elements are exposed to elevated internal forces, increased lateral deformation, and more intricate load transfer mechanisms, all of which govern the building's stability, usability, and safety. To address these challenges, contemporary structural engineering practice depends strongly on sophisticated computer-based modeling and design systems that are capable of predicting realistic structural responses under varied loading situations while conforming to established national design regulations.

In the present work, a ground-plus-fifteen residential reinforced concrete structure is adopted as a typical tall-building case and is examined separately using STAAD.Pro and ETABS to allow an impartial technical comparison. Independent three-dimensional models of a regular RC framing system, consisting of beams, columns, slabs, and foundations, are formulated within each platform. Both vertical and horizontal loading conditions are introduced in line with the relevant Indian Standard specifications, accounting for material characteristics, occupancy requirements, seismic zoning, and soil conditions. STAAD.Pro is primarily employed for component-level design following limit state concepts, whereas ETABS is utilized to evaluate the overall structural response, with particular emphasis on behavior under lateral actions. Comparative assessment is performed using response measures such as inter-storey drift, storey displacement, storey shear, bending moments, shear forces, axial forces, and reinforcement demand, thereby revealing differences in analytical behavior, modeling philosophy, and design effectiveness between the two tools

Structural layout:

The structural model has been developed separately in STAAD.Pro and ETABS by assigning appropriate material properties, member dimensions, and support conditions. Dead loads, live loads, wind loads, and seismic loads have been applied in accordance with the relevant Indian Standard (IS) codes. The adopted structural layout ensures adequate strength, stiffness, and serviceability, making the building safe and efficient under various loading conditions throughout its service life

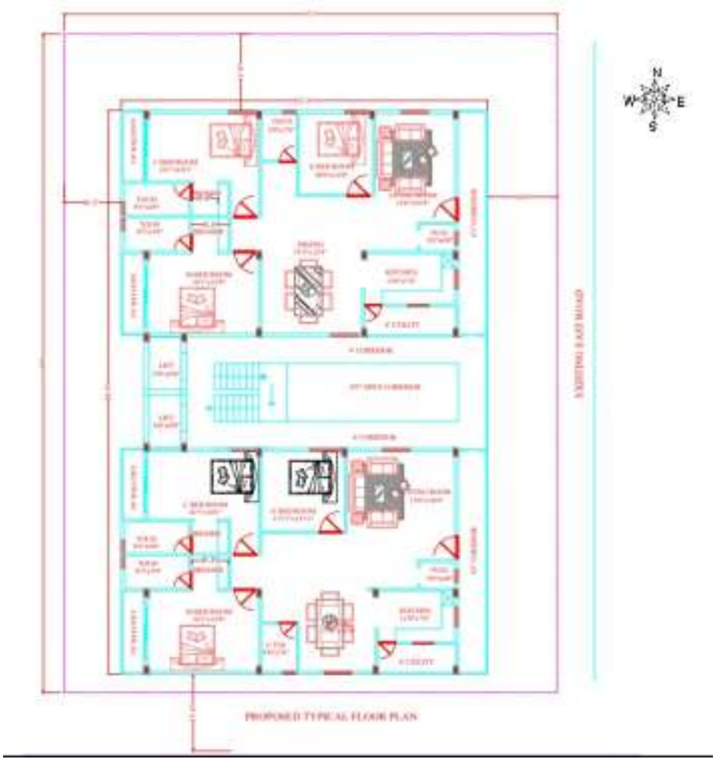

Fig. 1 Floor Plan.

Earthquake loads:

The design loads shall be calculated as described in the following sections. Dead load consists of the self-weight of various structural elements indicated in Table 2.

Live loads are gravity loads produced by the use and occupancy of the building or the structures. This includes the weight of all movable loads such as personal, tools miscellaneous equipment, movable partitions, storage material etc. Live loads considered in the structure as per IS 875 Part 2 Code are tabulated in Table 3.

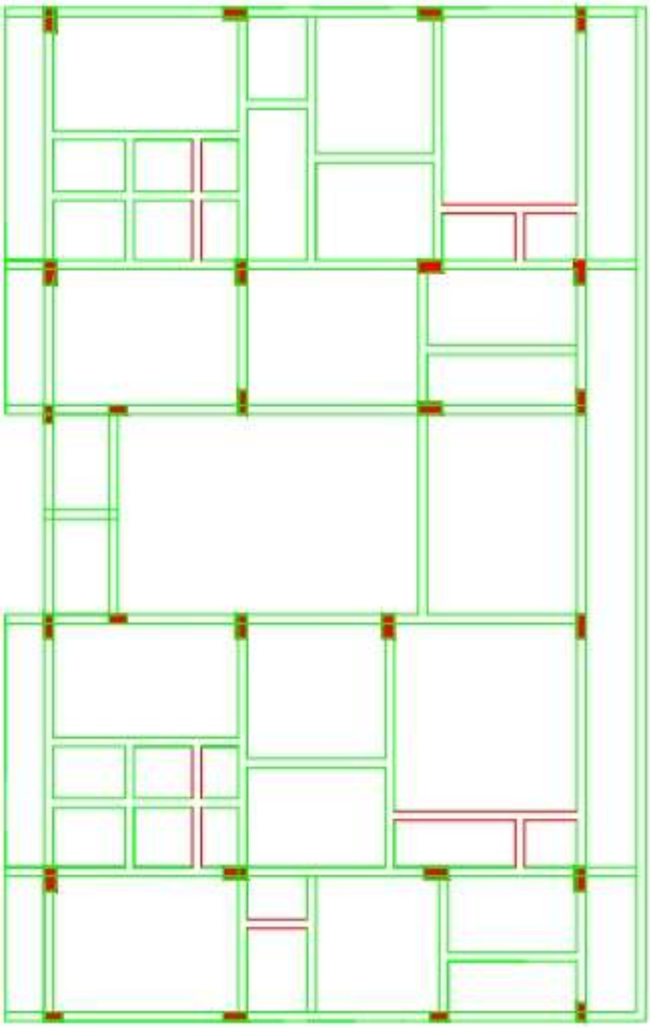

Fig .2 Center Line

Wind loads:

The loads due to wind are calculated as per the provisions specified in IS 875 (Part 3)

. Wind load parameters are given in Table 5, Design Wind pressure is calculated as: Pd = - kd × ka × kc × 0.6 V2, the internal pressure coefficient considered,

Cpi = +/— 0.5

Loads and combinations :

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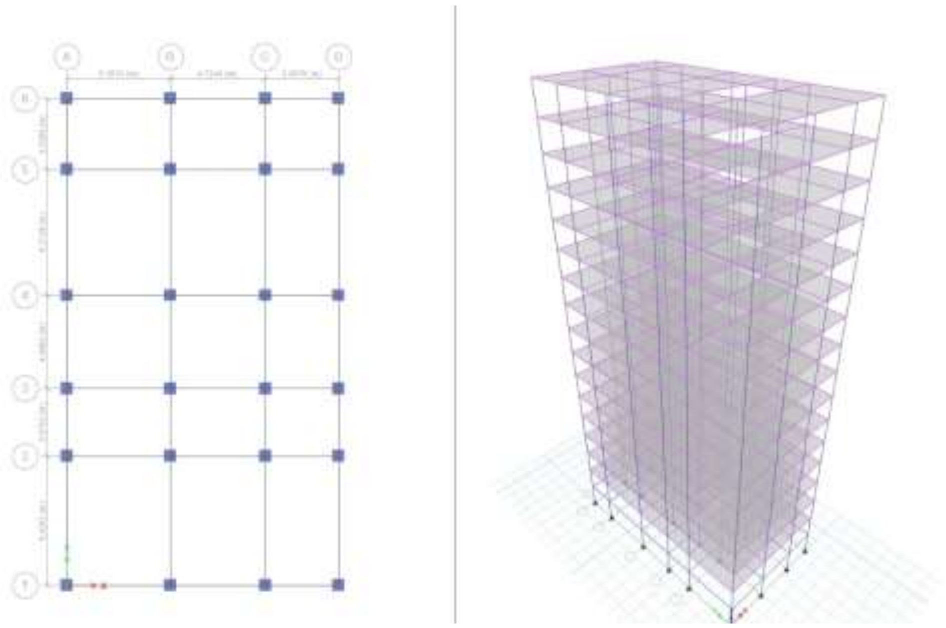

Fig.3. Plan View and 3D view in ETABS.

Table 1
Structure Description (Staad.Pro & ETABS).

SI. No	DESCRIPTION	DETAILS
1	Length * Width	21.6 m * 30 m
2	Height	50 m

Table 2
Dead Loads (Staad.Pro & ETABS).

SI. No	ITEMS	WEIGHT
1	Self-weight factor	1.0
2	Slab load Including Floor Finish	1.5 kN/m2
3	External Wall load (3 m height wall)	21.3 kN/m
4	Internal Wall load (1 m height wall)	3 kN/m
5	Stair case	22 kN/m

Table 3
Live Loads (Staad.Pro & ETABS).

SI. No	ITEMS	WEIGHT
1	Live load (G + 15) all the slabs	3.0 kN/m
2	Roof Live	3.0, 2.0 kN/m

Table 4
Earthquake Loads (Staad.Pro & ETABS).

Zone	Zone Factor	Importance Factor	Response Reduction Factor	Damping Ratio
II	0.16	1.5	5	0.05

Table 5
Wind Load Parameters (Staad.Pro & ETABS).

Parameters	
Regional basic wind	50 m/s
Terrain Category	1
Risk Coefficient, K1	1.0
Terrain, Height and Structure size factor, K2	As per building height
Topography factor, K3	1.0
Importance factor for Cyclonic region K4	1.0
Directionality factor, Kd	0.9
Area Averaging Factor, Ka	0.9
Combination Factor, Kc	0.9
Design life of the building	50
Percentage of opening in the building	5-20%

Table 6

Load Combinations

STRENGTH DESIGN	SERVICEABILITY DESIGN
1. 1.5 DL + 1.5 LL	1. 1.0 DL + 1.0 LL
2. 1.2 DL + 1.2 LL + 1.2 WL/EL	2. 1.0 DL + 0.8 LL + 0.8 WL/EL
3. 1.5 DL + 1.5 WL/EL	3. 1.0 DL + 1.0 WL/EL
4. 0.9 DL + 1.5 WL/EL	

Abbreviations: DL = Dead Load, LL = Live Load, WL = Wind Load, EL = Earthquake Load.

Load combinations:

Structure has to be designed for both strength and serviceability criteria. For the strength design, load combinations as specified in IS 456–2000 shall be used. For ascertaining safety under service load conditions, the unfactored load combinations as specified in the IS Code shall be used. These combinations are primarily framed for serviceability condition requirements, such as member local deflections and overall structural deflection checks. Various load combinations as per the partial safety factors given in IS 456–2000 are listed below for strength and serviceability criteria, and it’s shown in Table 6.

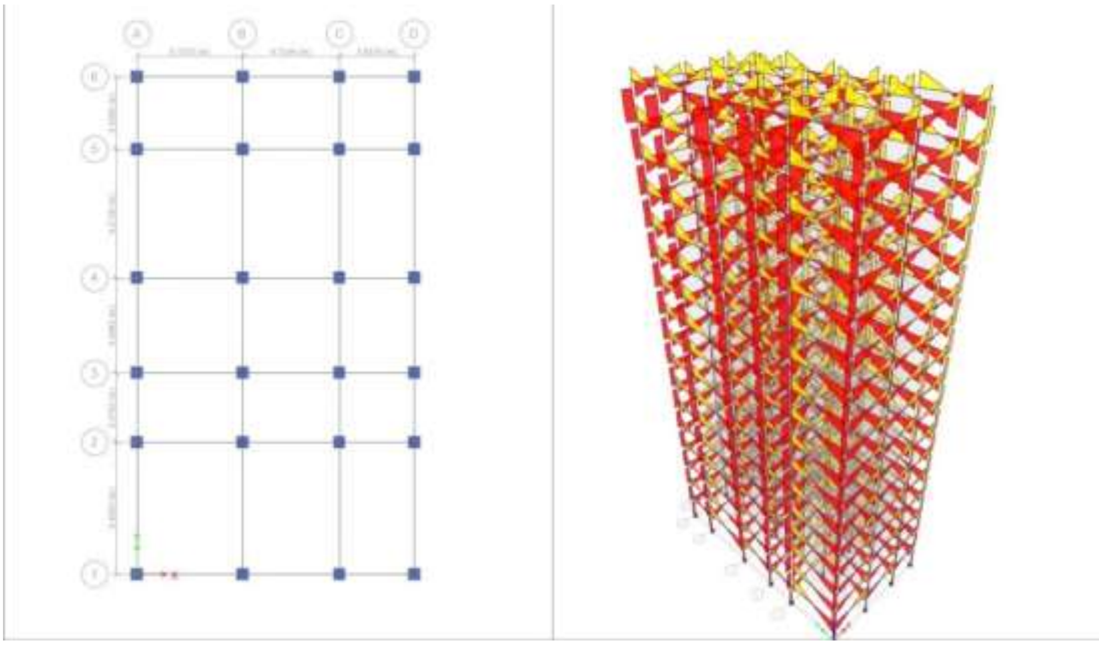

Fig.4 Shear force **diagram in Etabs**

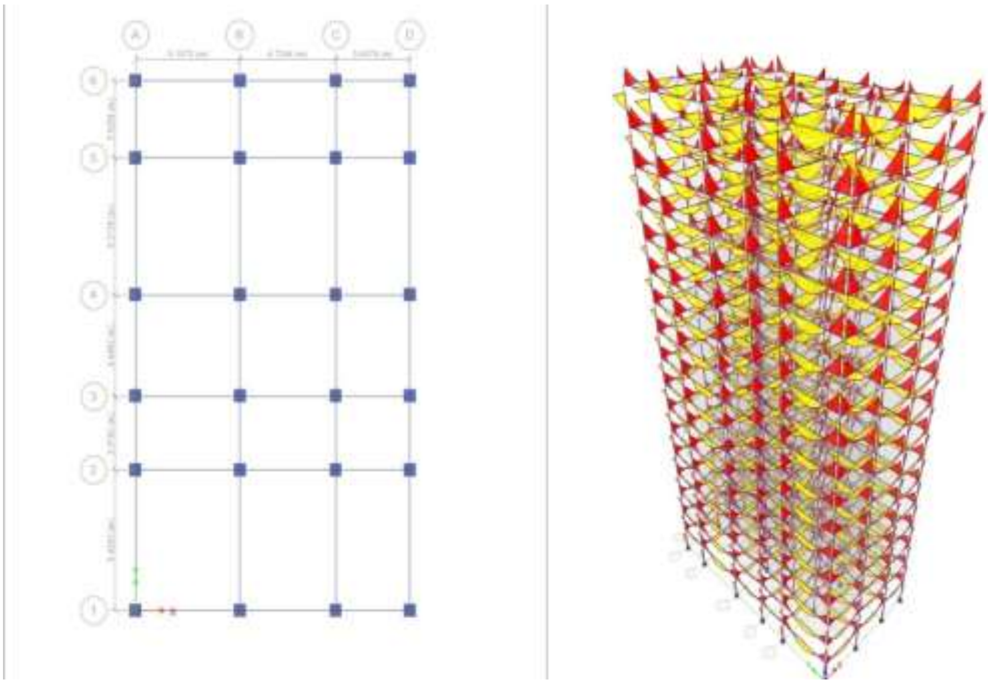

Fig.5 Bending moment diagram in Etabs

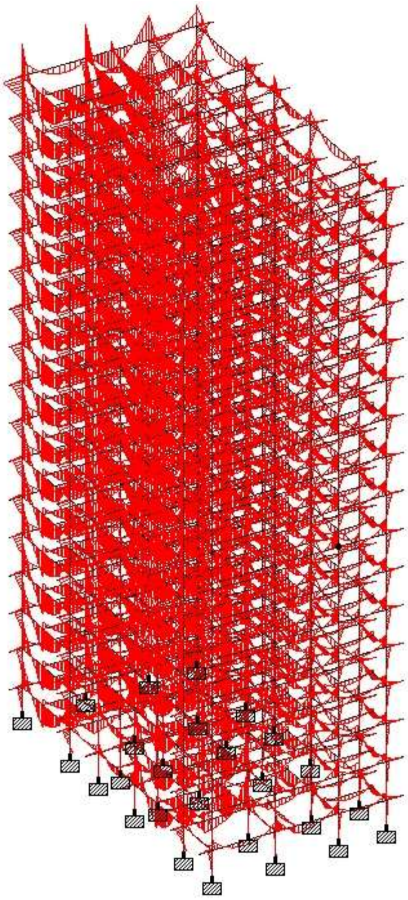

Fig. Bending moment in staad pro

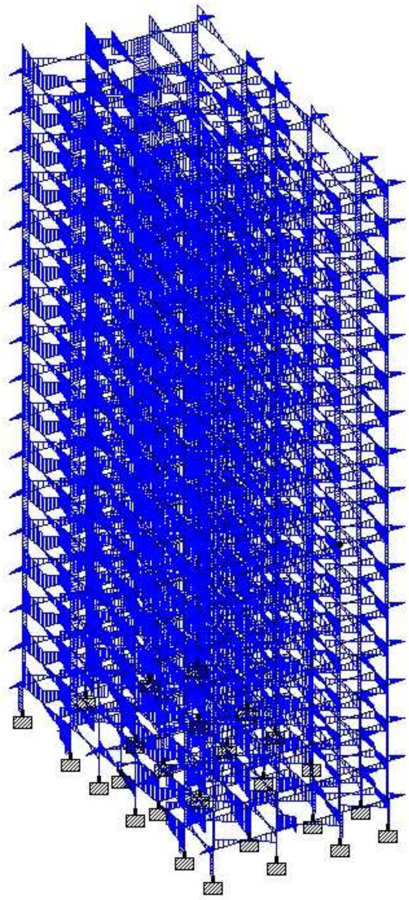

Fig. Shear force in staad pro

Results and discussions :

The evaluation of the G+15 reinforced concrete structure using STAAD.Pro and ETABS indicated that both platforms captured comparable global response behavior under vertical and lateral loading, although noticeable differences appeared in specific response quantities due to variations in modeling strategies and computational procedures. ETABS generally produced higher lateral deformation responses at upper storeys, suggesting a more refined representation of overall stiffness distribution and diaphragm behavior in tall buildings, whereas STAAD.Pro yielded relatively lower displacement values and more conservative force demands in certain members. Although the trends of bending moments, shear forces, and axial forces were broadly consistent between the two tools, discrepancies in peak responses highlighted the sensitivity of outcomes to modeling assumptions. STAAD.Pro proved more convenient for detailed member-level design and reinforcement detailing, while ETABS offered clearer interpretation of global and seismic response, and the combined use of both platforms strengthened result validation through cross-checking.

Conclusion:

1. The findings indicate that both **STAAD.Pro** and **ETABS** can be effectively employed for evaluating and designing G+15 reinforced concrete buildings when appropriate modeling procedures are followed.

2. While the general response patterns under gravity and lateral actions were comparable, noticeable differences in peak internal forces and deformation demands arose from distinct modeling assumptions and solution strategies. ETABS enabled clearer interpretation of global and seismic behavior, whereas STAAD.Pro was better suited for detailed member-level design tasks.

3. The study emphasizes that cross-checking results between both platforms strengthens design reliability and reduces uncertainties associated with software-dependent modeling.

References:

Codes and standards:

These are the codes and standards for the analysis and design of the Proposed

G + 15 RCC Building.

- IS 456: 2000 - Code of Practice for Plain and Reinforced Concrete.
- IS 875 (Part 1) — 1987, Code of Practice for Design Loads (other than Earthquake) for buildings & structures - Dead loads.
- IS 875 (Part 2) — 1987, Code of practice for Design Loads (other than earthquake) for buildings & structures - Imposed Loads.
- IS 875 (Part-3) — 2015, Code of practice for Design Loads (other than earthquakes) for buildings & structures - Wind loads.
- IS 1893 (Part-1) — 2016 Criteria for Earthquake-resistant design of structures: General provisions and buildings.
- IS 1786:2008 - High Strength Deformed Steel Bars and Wires for Concrete Reinforcement specification.

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