Computational Modeling and Structural Assessment of a G+6 Residential Building Using STAAD.Pro and ETABS as per IS Codes

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Abstract - Abstract -The structural design of multi-storey residential buildings plays a crucial role in ensuring safety, serviceability, and cost-effectiveness. This study focuses on the comparative analysis and design of a G+6 reinforced concrete residential building using STAAD.Pro and ETABS software. The primary objective is to evaluate the structural behavior, load distribution, and design efficiency provided by these two widely used structural analysis tools. The building under consideration is designed in accordance with Indian Standard (IS) codes, including IS 456:2000 for reinforced concrete design, IS 875 (Part 1–5) for dead, live, wind, and seismic loads, and IS 1893:2016 for earthquake-resistant design.

The study highlights the advantages and limitations of STAAD.Pro and ETABS in terms of analysis accuracy, design optimization, user interface, and time efficiency. The findings indicate that while both tools yield similar structural responses, ETABS offers enhanced capabilities for dynamic analysis and earthquake load modeling, whereas STAAD. Pro provides flexible modeling options for complex geometries.

This research serves as a comprehensive reference for engineers and researchers in selecting appropriate structural analysis software and ensures compliance with IS codes for safe and economical design of G+6 residential buildings.

Key Words: *Reinforced Concrete, Structural Analysis, STAAD.Pro, ETABS*

1. INTRODUCTION

Homes stand at the heart of how communities grow. Though often overlooked, people spend most of their lives inside buildings. Progress in housing shapes the future of society. Instead of old methods, fresh ideas now drive construction forward. With technology like Staad. Pro, designing adapts to real needs. Time changes how we build - efficiency matters more each year. Money, speed, comfort - all shape today's homes. Because life evolves, so must the way structures rise. New tool shelp meet rising demands across regions. What once took weeks now finishes faster, without loss of strength. Behind every wall lies planning shaped by modern software One way it helps is by setting up the framework first. After that, users can pick how loads go on the structure. Instead of just one method, rules from groups like ACI or IS fit in smoothly.

Faster computers changed how buildings are designed. Because of this shift, tools like STAAD. Pro help spot weaknesses before construction begins. One after another, calculations that once took days now finish in minutes. Thanks to digital models, mistakes show up early. When forces act ona frame, simulations reveal where stress builds

1.2 Structural Analysis Software

Tall structures need strong frames; that is where ETABS steps in, calculating loads and stresses with precision. Another tool, STAAD.Pro, handles similar jobs, especially when dealing with complex shapes or heavy conditions.

1.2.1 STAAD.Pro

Used for structural analysis and design of buildings.

Checks bending moment, shear force, axial force, and deflection.

ETABS

Mainly used for multi-storied building analysis.

Suitable for RCC and steel structures.

1.3 Residential buildings overview

1.3.1 Multi-Storey Residential Buildings

A building intended primarily for human habitation is called a residential building. These structures could be multi-story residential complexes, single-family homes, apartments, or hostels. Residential buildings with multiple stories offer a number of benefits, including:

1. Effective use of land
2. Improved urban design
3. lower cost per unit of infrastructure

4. Enhanced facility accessibility

Dead load, live load, wind load, and seismic load must all be carefully taken into account when designing multi-story buildings.

1.4 Need for the Study

With the increasing demand for residential infrastructure, proper structural design is essential to ensure safety and serviceability. The use of Staad. Pro and ETABS allow s engineers to efficiently analyze complex building structures and obtain accurate design results. This study focuses on the analysis and design of a G+6 residential building using Staad .Pro and ETABS in accordance with Indian Standard codes and comparision of Software tools.

2.1 LITERATURE REVIEW

Evaluation and Optimization of RC Building Seismic Performance Using ETABS Author: Dharmesh N., et al., 2025. In summary, this study used ETABS to assess and improve the seismic performance of reinforced concrete structures. The earthquake forces on the structure were evaluated using the Equivalent Static Lateral Force Method. The study demonstrated how contemporary computational tools, such as ETABS, enhance seismic analysis accuracy and facilitate the creation of safer and more effective estructural designs.

Design and analysis of a six level residential building with ETABS Author: Mohammed Zaker et al.,Year: 2024

Summary: Not far off from usual practice, the work looked at how a six-story home structure behaves when built with help from ETABS software. Shaped into a 3D version first, the building faced tests involving its own weight, everyday usage pressures, plus forces seen during

Seismic Evaluation and Optimization of RC Buildings with ETABS Author: Arjun P. et al.,Year: 2023

Summary: Looking into how well reinforced concrete buildings handle earthquakes, this work used ETABS as a main tool. Instead of guessing, the method chosen was the Equivalent Static Lateral Force approach - to figure out just how strong quake forces act on a building. Tools today, especially software such as ETABS, bring sharper results when checking shaking effects, making it easier to shape structures that perform better under stress. With these advances, designing becomes less about assumptions, more about precise modeling. Safety grows quietly behind smarter calculations.

Aman et al., (2019) : Starting off, the study looked at a six-story mixed-use building using Indian Standard guidelines through STAAD.Pro tools. Instead of complex inputs, just dead and live loads shaped what came next - meaning force mix ended up as one point five times their total sum. below ground level while stairs linked levels step by step. Deflection numbers ranlow, staying under twenty millimeters sideways movement overall. Safety stayed intact without overspending on materials or size choices. Little need existed for changes beyond that stage

Borugadda Raju et al., (2018) : From ground up, a G+30 tall structure took shape using STAAD.Pro through limit state design. Though packed with tools, the software runs on a straight forward layout - helping model creation flow smoothly. Inputs like loads and measurements Slip into place without hassle. Reinforced concrete elements get shaped complete with bar arrangements and cover specs. At first, only flat frame systems face evaluation. Later, scrutiny shifts toward complex stacked layouts, both in plane and full volume setups across shifting force patterns.

D.Ramya, et al., (2017) : A look at how STAAD.Pro and ETABS shape a building with ten floor splus ground level. This study checks which software handles structural tasks better by measuring results across both tools. One finding stood out - even though STAAD. Useful at times, Pro gets picked regularly. Often seen in practice, ETABS handles many jobs. For this structure, live load matters just as much as dead load does - wind force plays a role too

2.2 Problem Statement

1.Need for accurate analysis of structures such as multi-storey buildings

2.Comparison of different structural analysis software tools

3. Efficient design for safe and economic design And so on.

2.3 Study Goals

1.To create a model of a residential building using structural analysis software

2.To analyze the building for different load combinations

3.To compare the results obtained from different software tools

4.For safety in how the building is planned

2.4 Scope of the Study

The study focuses on structural analysis and design of high-rise buildings using modern software. It involves:

- ❖ Creating digital building models
- ❖ Running simulations
- ❖ Checking results

- ❖ Designing structural elements like beams, columns, slabs, and foundations

Each structural component is tested against different loads to ensure safety and usability

3.1 METHODOLOGY

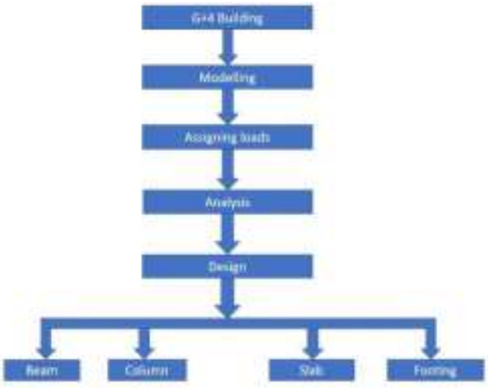

Image No : 3.2 Flow Chart of Methodology

3.2.1.1 Softwares

The following softwares are used for the design of G+4 Residential building in this project.

1.AUTOCAD Software.

2.ETABS Software.

3.STAAD Pro

4.STAAD Foundation.

3.2.2Plan of the Building

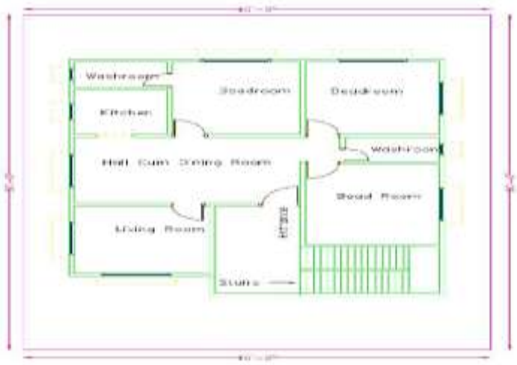

Image No : 3.4 Plan of the Building

3.4.4 Information of the Building

- Area of the site: 40 × 60 ft^2
- Building Height: 24 m
- Number of Storey: Ground + Six
- Type of construction: R.C.C Framed Structure
- Shape of Building: Rectangular
- Supports: Fixed Supports
- Number of staircases: Seven
- Type of Walls: Brick Wall
- Thickness of Slab: 140mm
- Thickness of Wall: 230mm
- Thickness of parapet wall = 203mm
- Dimensions of Beams: 300× 400 mm
- Dimensions of Column: 450×450 mm
- Allowable Bearing pressure for site = 20 T/m^2

Materials:

- Concrete grade: M30
- Steel grades: Fe415 grade

4. ANALYSIS AND DESIGN OF THE BUILDING

4.1.2 Steps involved in STAAD. Pro

1. Generation of Nodes
2. Modelling of the Structure
3. Assigning of the structural members
4. Restraints
5. Application of loads
6. Run analysis

4.2.2.2 Modeling of Structure

Image No : 4.2.2.2 A) Modelling of Structure

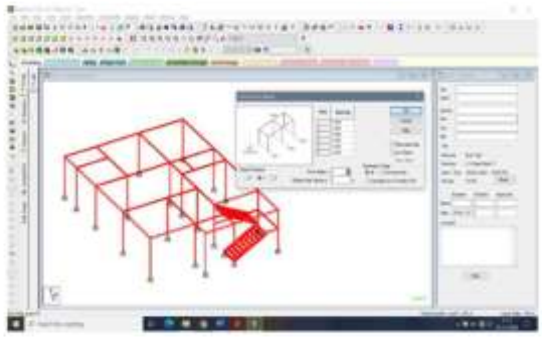

Image No : 4.2.2.2 B) Translational repeat

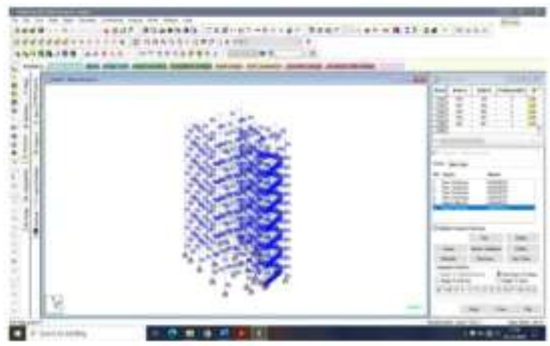

Image No : 4.2.2.2 C) Structural properties

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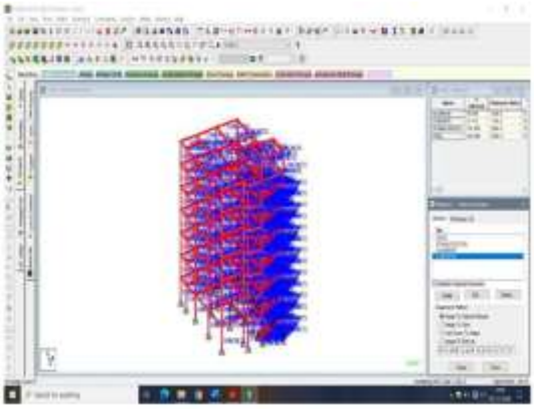


Image No : 4.2.2.2 D) Structural Material

4.2.2.5 Utilization of Loads

During structural analysis, a variety of loads that affect a structure must be taken into account. The following loads are examined in this study:

- Dead load,
- Live load,
- Wind load
- Seismic load.

4.2.2.6.1 Dead Load

1. Self weight for Slab = Unit Weight of concrete × thickness.
= 25 kN/m3 × 0.14 m
= 3.5 kN/m2
2. Self weight for Beam = Unit Weight of concrete × Dimension of beam (b × D)
= 25 kN/m3 × 0.4 m × 0.3 m
= 3 kN/m
3. Self weight for Column = Unit Weight of concrete × Dimension of beam (b × D)
= 25 kN/m3× 0.45 m × 0.45 m
= 5.0625 kN/m
4. Self weight for Landing Slab of Stairs = Unit Weight of concrete × thickness
= 25 kN/m3 × 0.25 m
= 6.25 kN/m2
5. Self weight for External and partition wall = Unit Weight of brick × thickness × effective height of wall
= 19.2 kN/m3 × 0.23 m × (3-0.4) m
= 11.48 kN/m
6. Self weight for Stairs wall = Unit Weight of brick × thickness × effective height of wall
=19.2 kN/m3 × 0.23 m × (1.5-0.4) m
= 4.8576 kN/m
7. Self Weight for Waist Slab of stairs = Thickness of waist slab × 25 × √ 2+ 2
= 0.175 m × 25 × √0.152+ 0.32
= 4.891 kN/m2
8. Self Weight for Steps of Stairs
= 0.5 × 0.15 m × 25 kN/m3
= 1.875kN/m²
9. Self weight for Parapet = Unit Weight of brick × thickness × effective height of wall
= 19.2 kN/m3× 0.203 m × 1 m
=3.8976 kN/m

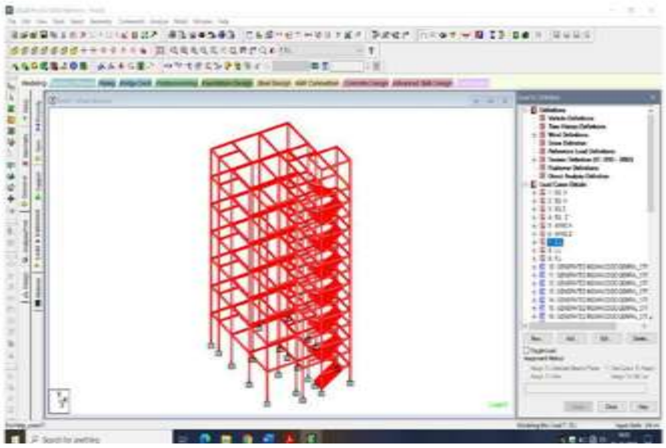
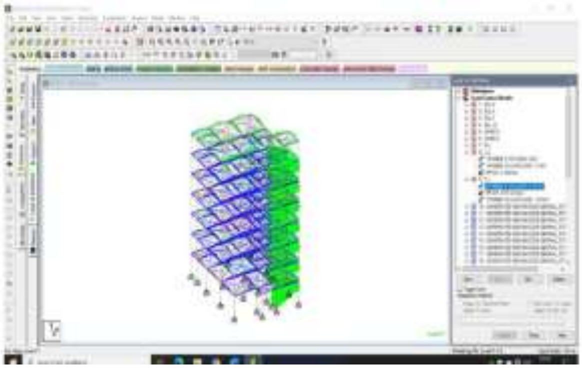


Image No:4.2.2.6.1B) Dead Load

4.2.2.6.2 Live Load

Floor Load

Tile Load Intensity 0.2 kN/m^2
Ceiling Plaster Load Intensity 0.25 kN/m^2
Load intensity floor screeding 0. kN/m^2
Waterproofing Load Intensity 1 kN/m^2
On middle levels, the full floor weight handled comes to 0.75 kN/m^2



4.2.2.6.3 Wind Load

Wind Intensity Calculation

Table No: 4.2.2.6.3 Wind Load Intensity Calculation

S.No	Height	Vb	k1	k2	k3	k4	Vz= Vb ×k1× k2×k3× k4	Pz= 0.6Vz^2
01	G floor	3	39	1	1	1	39	912.6
02	1st floor	6	39	1	1	1	39	912.6
03	2nd floor	9	39	1	1	1	39	912.6
04	3rd floor	12	39	1	1	1	39	912.6
05	4th floor	15	39	1	1	1	39	912.6
06	5th floor	18	39	1	1	1	39	912.6
07	6th Floor	21	39	1	1	1	39	912.6
08	Terrace	22	39	1	1	1	39	912.6

Table No: 4.2.2.6.3 Wind Load Intensity Calculation

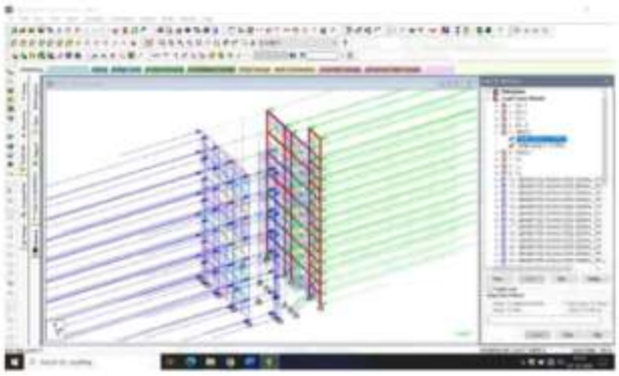


Image No: 4.2.2.6.3 A) Wind Load in X direction

4.2.2.6.4 Seismic Load Considerations

Image No: 4.2.2.6.4 A) Seismic Parameters

Distribution of horizontal Earthquake force along height of building

Table No: 4.2.2.6.4 Seismic Load Calculation

Wind Intensity Calculation

Table No: 4.2.2.6.3 Wind Load Intensity Calculation

S.No	Height	Vb	k1	k2	k3	k4	$V_z = V_b \times k1 \times k2 \times k3 \times k4$	$P_z = 0.6V_z^2$
01	G floor	3	39	1	1	1	39	912.6
02	1st floor	6	39	1	1	1	39	912.6
03	2nd floor	9	39	1	1	1	39	912.6
04	3rd floor	12	39	1	1	1	39	912.6
05	4th floor	15	39	1	1	1	39	912.6
06	5th floor	18	39	1	1	1	39	912.6
07	6th Floor	21	39	1	1	1	39	912.6
08	Terrace	22	39	1	1	1	39	912.6

4.2.2.7 Load Combinations

1. 1.5 (Dead Load + Live Load)
2. 1.2 (Dead Load + Live Load + EQX + EQZ)
3. 1.2 (Dead Load + Live Load − EQX − EQZ)
4. 1.5 (Dead Load + EQX + EQZ)
5. 1.5 (Dead Load − EQX − EQZ)
6. 0.9 Dead Load + 1.5 (EQX + EQZ)
7. 0.9 Dead Load − 1.5 (EQX + EQZ)
8. 1.0 (Dead Load + Wind Load)
9. 1.0 (Dead Load + Live Load + Wind Load)

Image No : 4.2.2.8 3-D rendering view of building

4.2.2.9.1.1 Design data of Beam generated by Staad.Pro

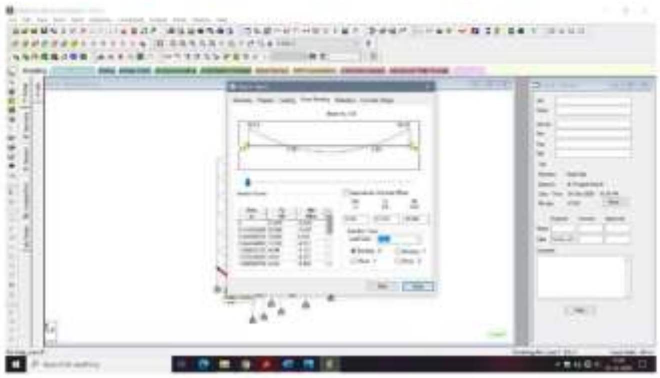
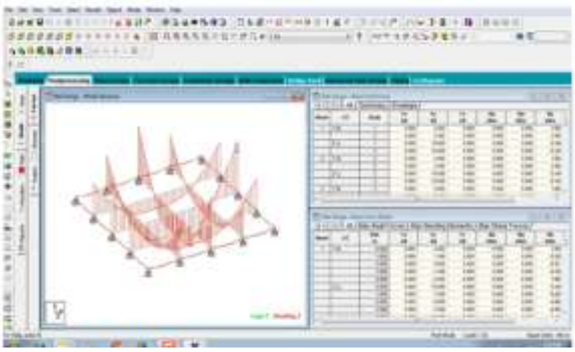


Image No : 4.2.2.9.1.2 S F & B M diagram for beam

4.2.2.9.3 Slab

1. Definition of material properties
2. Assignment of section properties (slab thickness, beam and column dimensions)
3. Structural modeling
4. Assignment of support conditions
5. Definition of load patterns
6. Application of loads on the structure
7. Definition of load combinations
8. Execution of analysis



4.2.2.9.4.4Design Parameters Used for Isolated Footing

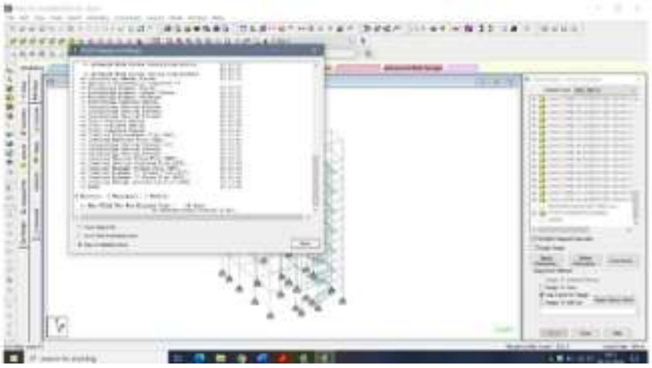


Table No: 4.2.2.9.4.5 Steel Reinforcement Data of Isolated Footing

S.No	Footing No	Steel Reinforcement of Footing	
		Bottom (Mz)	Top (Mx)
1	1	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
2	2	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
3	3	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
4	4	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
5	5	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
6	6	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
7	7	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
8	8	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
9	9	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
10	10	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
11	11	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
12	12	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
13	13	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
14	14	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
15	15	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
16	16	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
17	17	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
18	18	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
19	19	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c
20	20	Ø12 @ 65 mm c/c	Ø12 @ 55 mm c/c

4.3 Design Using by ETABS

4.3.2 Procedure of ETABS

1. Creation of grid system and storey levels
2. Definition of material properties
3. Assignment of section properties (slab thickness, beam and column dimensions)
4. Structural modeling
5. Assignment of support conditions
6. Definition of load patterns
7. Application of loads on the structure
8. Definition of load combinations
9. Execution of analysis

4.3.2.1 Creation of grid system and storey levels

After opening ETABS, create a new model by entering the grid dimensions and storey details of the building. This helps generate the layout.

4.3.2.2 Definition of material properties

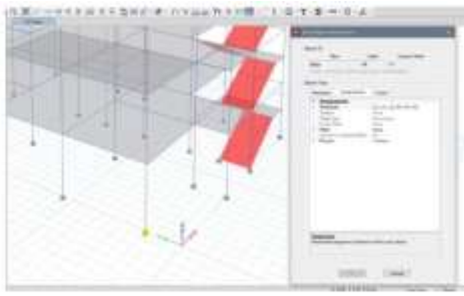
Once the model is initialized, material properties are defined from the Define Menu Material Properties, where appropriate materials are assigned to structural components such as beams, columns, and slabs.

4.3.2.3 Assignment of section properties

Then define section properties. I use Frame Sections .Slab Sections options for this. enter beam and column dimensions and slab thickness Subsequently, section properties like beam and column dimensions and slab thickness are defined using the Frame Sections and Slab Sections options. the Frame Sections and Slab Sections options.

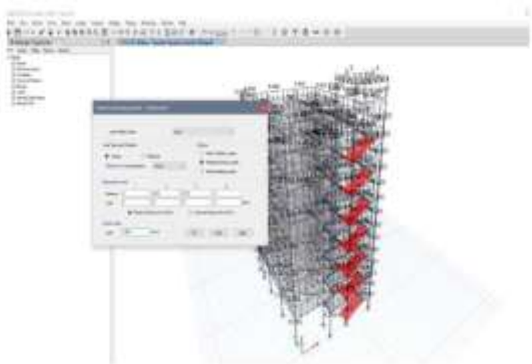
4.3.2.5 Assignment of support conditions

After assigning these properties, support conditions are provided by assigning fixed supports at column locations to represent the foundation.



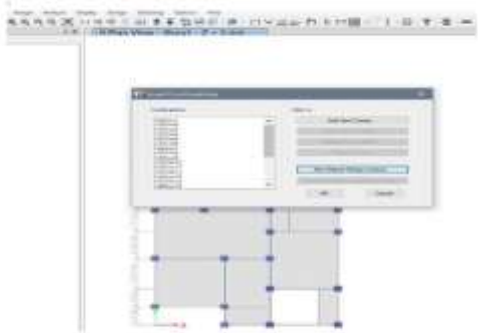
4.3.2.7 Application of loads on the structure

All structural elements, including beams, columns, and slabs, must have their self-weight and loads computed and applied to the model in ETABS.

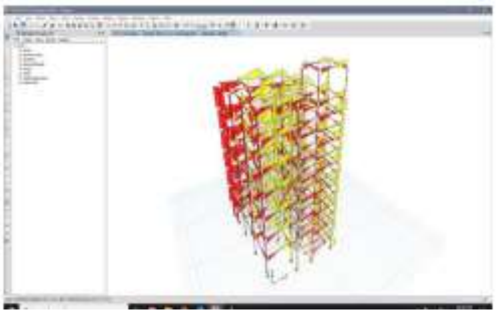


4.3.2.8 load combinations

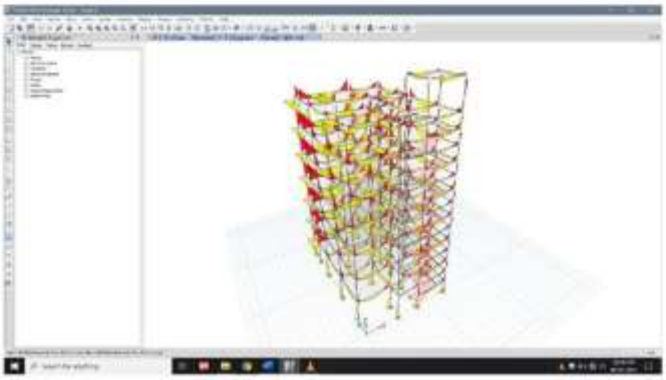
Load combinations are automatically generated as per Indian Standard codes using the load combination option



4.3.3.3 Diagram of Shear Force (SFD)



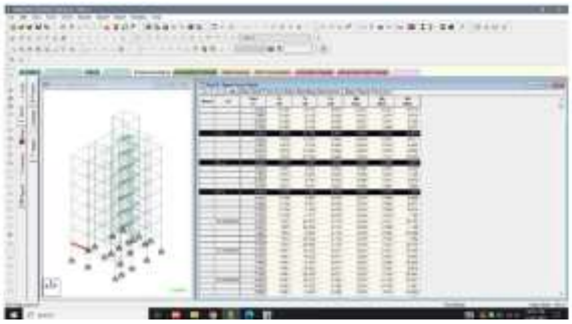
4.3.3.4 Bending Moment Diagram (BMD)



5.0 COMPARATIVE ANALYSIS

By comparing STAAD.Pro and ETABS like this we can see what each one is good at and what it is not so good at. This helps engineers pick the tool, for the job so they can design structures that are safe and reliable. STAAD.Pro and ETABS are both tools and engineers need to know which one to use.

5.3.1 Results Generated by STAAD.Pro for Column



5.3.2 Results Generated by ETABS for Column

Table No: 5.3 Column on the basis of Axial Force, Shear Force and Bending Moment

S.No	Force	STAAD. Pro			ETABS		
		D L	L L	F L	D L	L L	F L
1	Axial force Fx (kN)	779.79	60	28.00	685	63	30
2	Shear force Fy (kN)	16.37	1.560	0.671	13.67	1.770	0.64
3	Shear force Fz (kN)	1.230	0.051	0.090	11.30	0.1	0.09
4	Bending moment Mx (kNm)	0.030	0.020	0.001	0.307	0.00	0.02
5	Bending moment My (kNm)	2.34	0.20	0.095	2.10	0.50	0.3
6	Bending moment Mz (kNm)	35.562	3.25	1.20	22.01	2.90	0.50

5.6 Comparative analysis of Reinforcement area

Table No: 5.6.1 Comparative analysis of Reinforcement area of Column

S.No	Reinforcement	STAAD. Pro	ETABS
1	Diameter	12 mm	16 mm
2	Number of Bars	16	12
3	Letral Tie diameter	8 mm	10 mm
4	Spacing C/C	190 mm	100 mm
5	(Ast) Required	1782 mm2	1620 mm2
6	(Ast) provided	1850 mm2	2471mm2

5.6.2 Beam

S.No	Force	STAAD. Pro			ETABS		
		DL	LL	FL	DL	LL	FL
1	Axial force Fx (kN)	0.700	0.602	0.156	0	0	0
2	Shear force Fy (kN)	28.122	4.12	1301	34.12	3.32	1.52
3	Shear force Fz (kN)	0.084	0.02	0.010	0	0	0
4	Bending moment Mx (kNm)	0.0670	0.10	0.034	0.1285	0.090	0.032
5	Bending moment My (kNm)	0.20	0.060	0.018	0	0	0
6	Bending moment Mz (kNm)	20.12	3.12	13.28	8.40	2.14	1.15

S.No	Reinforcement	STAAD. Pro	ETABS
1	Diameter	12 mm	16 mm
4	Bottom	3 – 12 mm	4- 16 mm
5	Letral Tie diameter	8 mm	10 mm
6	Spacing C/C	145 mm	150 mm
7	(Ast) required at top	1059 mm2	998 mm2
8	(Ast) provided at top	1150 mm2	1030 mm2
9	(Ast) required at bottom	560 mm2	530 mm2
10	(Ast) provided at bottom	950 mm2	630 mm2

6.1 CONCLUSION

1. ETABS gives us a cost-effective design for the reinforcement.
2. ETABS often used for designing high-rise buildings
3. However STAAD.Pro gives us accurate results.
4. The results were very similar. Infact the STAAD.Pro results were very precise.
5. This shows that we can rely on STAAD.Pro for analysis.

6.2 FUTURE SCOPE

1. Analyze and design high-rise buildings (G+15 or more).
2. Study performance of ETABS and STAAD.Pro under wind and earthquake loads.
3. Evaluate structural behavior under real earthquake conditions.
4. Compare different structural systems like shear walls, braced frames, and compositestructures.
5. Study efficiency and performance of each structural system.
6. Explore use of alternative materials like fiber-reinforced concrete and geopolymer concrete.
7. Use recycled materials to improve environmental sustainability.
8. Integrate Building Information Modeling (BIM) for better planning and coordination.
9. Improve visualization and project management using BIM tools.
10. Conduct detailed cost analysis of structures.
11. Perform life-cycle assessment to evaluate environmental and economic impact.

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