DESIGN OF EARTHQUAKE RESISTANT BUILDING USING STAAD.PRO AND E-TAB

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Abstract- **Earthquakes pose a significant challenge to structural engineers, requiring innovative solutions for designing buildings capable of withstanding seismic forces. This study explores the design and analysis of a G+10 earthquake-resistant building using STAAD.Pro and E-TAB. These advanced tools facilitate detailed modeling, analysis, and simulation, enabling engineers to predict and optimize building performance under seismic loads.The primary objective is to develop a structural system that balances safety, functionality, and cost-effectiveness while adhering to Indian Standards (IS) codes, including IS 1893 for seismic considerations, IS 456 (2000) for reinforced concrete, and IS 13920 code 2016 for ductile detailing. The design process involves architectural modeling, static and dynamic analyses, and detailed structural design. Staad.Pro handles load calculations and static analysis, while Etab performs advanced dynamic analysis, such as modal and response spectrum methods. Seismic performance is assessed through parameters like base shear, story drift, and lateral displacements, ensuring the building can absorb and dissipate seismic energy. The Response Spectrum method evaluates responses to varying seismic intensities, for different seismic zones in India. The study incorporates reinforced concrete shear walls and optimized beam-column connections to enhance stability and ductility.**

A key aspect of the project involves a comparative analysis of results obtained from Staad.Pro, Etab, and manual calculations, highlighting the respective strengths and limitations of each method in terms of accuracy, efficiency, and applicability to different structural scenarios. This ensures accurate and reliable designs while identifying areas for improvement. The combined use of these tools demonstrates a robust methodology for earthquake-resistant structures, optimizing material usage and improving structural detailing for safety and cost efficiency.In conclusion, this research highlights the importance of integrasting advanced tools and seismic provisions to design earthquake-resistant buildings. One of the outcome of this project is a comparative analysis of the results from Staad.Pro and Etab, providing insights into the strengths and limitations of each software. This comparison ensures the accuracy and reliability of the design while identifying potential areas for improvement.

Index Terms- **Earthquake-resistant design, STAAD.Pro, ETABS, Structural analysis, Seismic load, IS 1893, IS 456:2000, IS 13920:2016, Reinforced concrete, , Comparative analysis, Structural software, Structural engineering.**

I. INTRODUCTION

With the increasing urbanization and energy demands, the need for sustainable infrastructure has never been greater. Roads, which consume vast land and materials, can be repurposed into energy-generating platforms using solar roadway technology. Solar roads not only support vehicular movement but also generate clean, decentralized electricity. This dual-purpose infrastructure is pivotal for smart cities and climate resilience.

The literature reveals ongoing global interest in solar road panels, with a focus on photovoltaic efficiency, structural integrity, and integration into existing transportation networks. However, practical demonstrations and load-bearing validations remain limited, especially under real-world conditions involving environmental stressors like freeze-thaw cycles.

This study aims to bridge that gap by designing a smart solar road panel prototype and evaluating its performance through structural, environmental, and terrain-based analysis. The hypothesis is that a multi-layer solar road system using tempered glass and embedded electronics can withstand real-life loads while maintaining electrical performance and safety.

II. OBJECTIVES

The primary objectives of this research are as follows:

- **Generating Structural Framing Plan**: Develop a detailed structural framing layout for the G+10 building, ensuring effective load transfer, structural stability, and adherence to functional and aesthetic requirements.

- **Creating the Model in Staad.Pro and E-TAB**: Construct a comprehensive 3D model of the multi-storey building in Staad.Pro and E-tab, incorporating accurate material properties, loading conditions, and geometric configurations.
- **Structural Analysis**: Perform a detailed analysis of the building to evaluate its response to various forces, including dead loads, live loads, wind loads, and seismic forces, following the provisions of IS 875:1987 (Part III) and IS 1893:2002.

2.1 About Staad Pro

This project focuses on the design and analysis of a G+10 earthquake-resistant building using STAAD.Pro, a versatile and user-friendly structural engineering software. STAAD.Pro was chosen for its advanced analysis capabilities, support for Indian Standard Codes (IS 456:2000, IS 875:2015, IS 1893:2016), and intuitive 3D modeling environment. The software facilitated precise load calculations, static and dynamic analyses, and optimization of member sizes for a cost-effective and safe design. Key parameters such as displacements, support reactions, and base shear were evaluated. The response of the structure to seismic and wind loads was thoroughly assessed, confirming the reliability and efficiency of STAAD.Pro in structural design.

2.2 About ETAB

ETABS is a specialized tool for multi-storey building design, used here for seismic analysis and design of the G+10 structure. Its building-specific features and integration with Indian codes make it ideal for high-rise construction. ETAB offers efficient 3D modeling, dynamic analysis (including response spectrum and time history methods), and automated design of structural elements like beams, columns, and shear walls. The software provides advanced visualization tools and supports wind and seismic load assessments as per IS 875 and IS 1893. ETAB ensured structural safety, compliance, and economy, highlighting its value in modern structural engineering practice.

2.3 Loads Considered

2.3.1 Dead Load

Dead loads include all permanent structural components such as walls, floors, and finishes, which affect the building's stability and strength. These are calculated using element dimensions and standard unit weights as per Indian Standards (e.g., RCC = 25 kN/m³). Each component's load is computed by multiplying its volume by its unit weight. These loads are input into E-TAB for accurate structural analysis. Proper dead load consideration ensures safety, serviceability, and compliance with seismic and wind design codes..

2.3.2 Imposed Load (Live Loads)

Imposed (live) loads are variable forces from building usage, such as people, furniture, and equipment, and are crucial for ensuring structural safety. These loads vary based on occupancy and are calculated using standard values depending on the function of each space. Dynamic effects like vibration and impact from movement or machinery are also considered. Imposed loads are modeled in software like E-TAB and combined with other loads for accurate structural analysis. They ensure the G+10 building meets safety, serviceability, and code compliance throughout its lifespan.

2.3.3 Seismic Loads (Earthquake Loads)

Seismic loads are a crucial consideration to ensure the safety and stability of the structure in the event of an earthquake. Seismic loads arise from the ground motion during an earthquake, and their magnitude and direction can vary significantly based on factors such as the earthquake's intensity, location, and the building's characteristics.In conclusion, seismic load analysis is a critical component of the design process to ensure the structure can withstand earthquake-induced forces. By integrating these loads into the structural model using E-TAB and adhering to the applicable Indian standards, the G+10 building is designed to meet safety requirements and provide protection for both the structure and its occupants during seismic events.

2.4 Analysis of G+10 Rcc Framed Building Using Staad.Pro

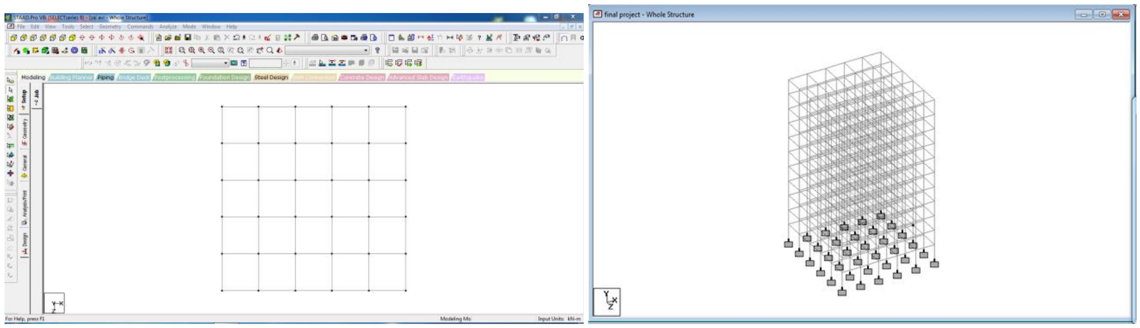


Fig. 2.1 Plan of the G+10 storey building in Staas.pro and E-Tab

Figure show the plan of the G+10 storey building in Staad.pro and E-tab, respectively.

All columns = 0.23 m X 0.60 m
All beams = 0.23 m X 0.50 m
All slabs = 0.150 m thick
Used M25 concrete and Fe 415 steel.

Length = 20 m
Width = 20 m
Height = 3m + 10 storeys @ 3 m = 33 m

2.5 Assignment of member properties in structural model

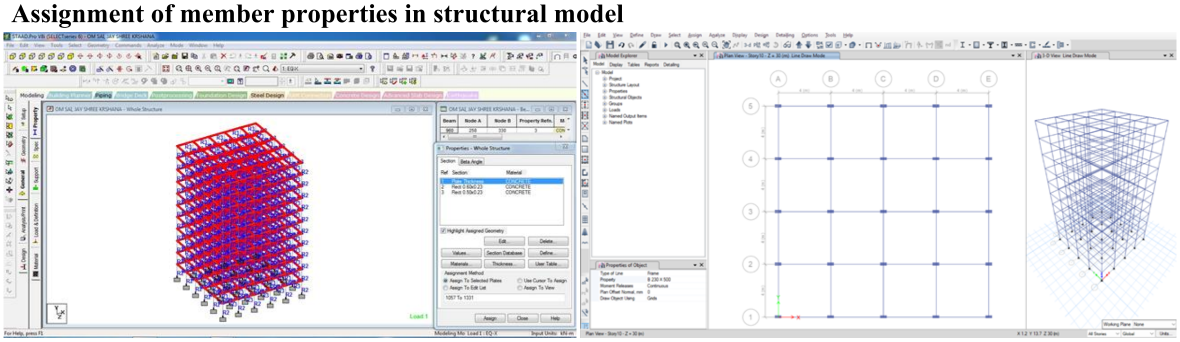


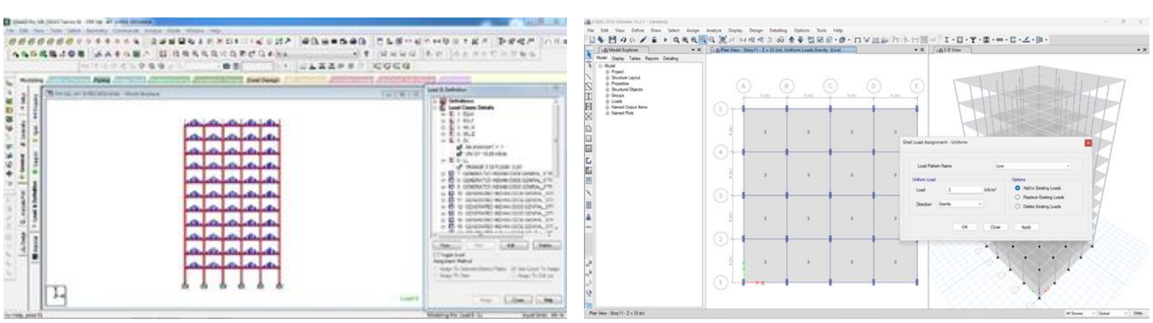
Fig. 2.2 Assignment of member properties in Staad.pro and E-tab

Beams: The beams in the structure have a cross-sectional dimension of 0.23 m × 0.5 m. These dimensions are entered into the Staad.pro member properties window to define the beam sections for the analysis and design of the building.

Columns: The columns in the building are designed with a cross-sectional dimension of 0.23 m × 0.6 m. These column properties are specified in the member properties window to define the column sections that will be used in the structure's seismic analysis.

Live load: The live load of 2.0 kN/m² applied on each floor is based on IS 875 (Part 2):1987, which provides guidelines for imposed loads on buildings. This value is standard for residential structures to ensure safety and serviceability.

Fig.2.3 ComponentsofSolarRoad



Wind load: The wind load values were automatically generated by the software in accordance with IS 875.Under the Define Load command, within the wind load category, the wind load definition was provided. The wind intensities at various heights were manually calculated and input into the software.

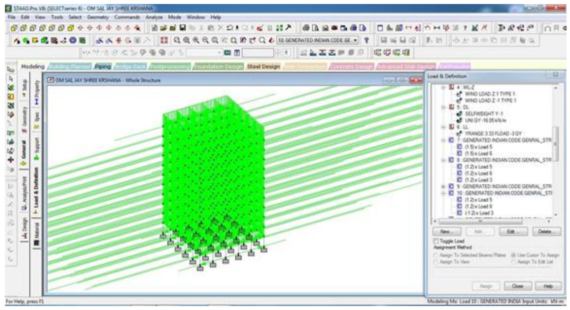


Fig.2.4 Wind load effect on structure

Seiesmic load

The seismic load values for the G+10 building were calculated in accordance with the provisions of IS 1893 (Part 1):2016 Staad.pro offers a Seismic Load Generator that is fully compliant with this Indian Standard.

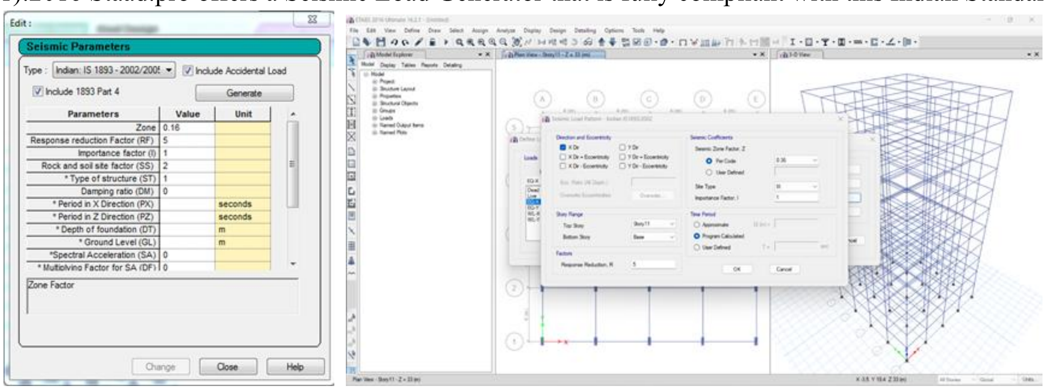


Fig2.5 Seismic load defination

Load Combination

The structure has been analyzed for various load combinations, ensuring the proper ratios of the different loads. In the first load combination, self-weight, dead load, live load, and wind load were considered. In the second combination, seismic load was used in place of the wind load.

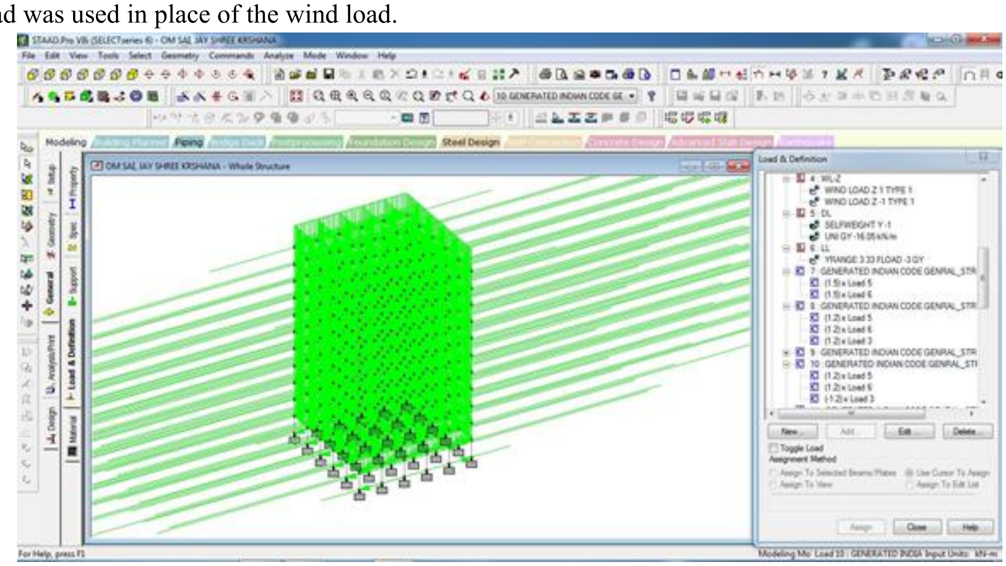


Fig2.6 Combination under wind load

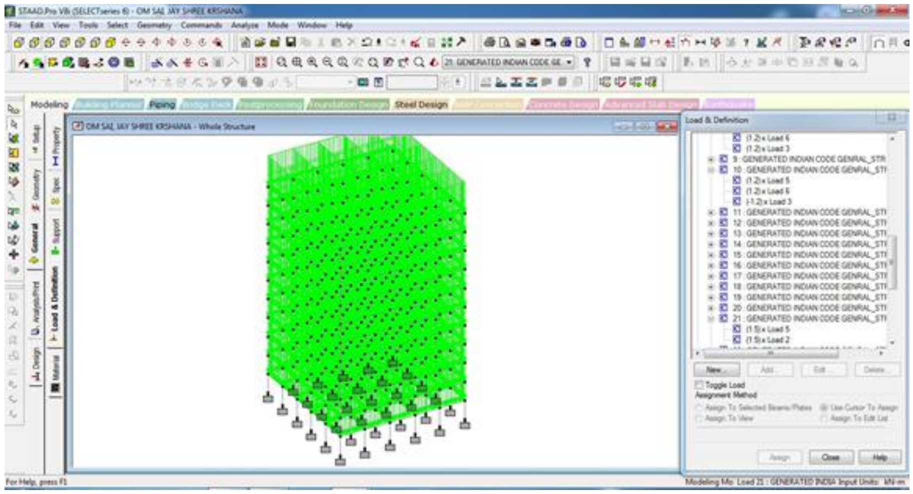


Fig.2.7. Combination under seismic load

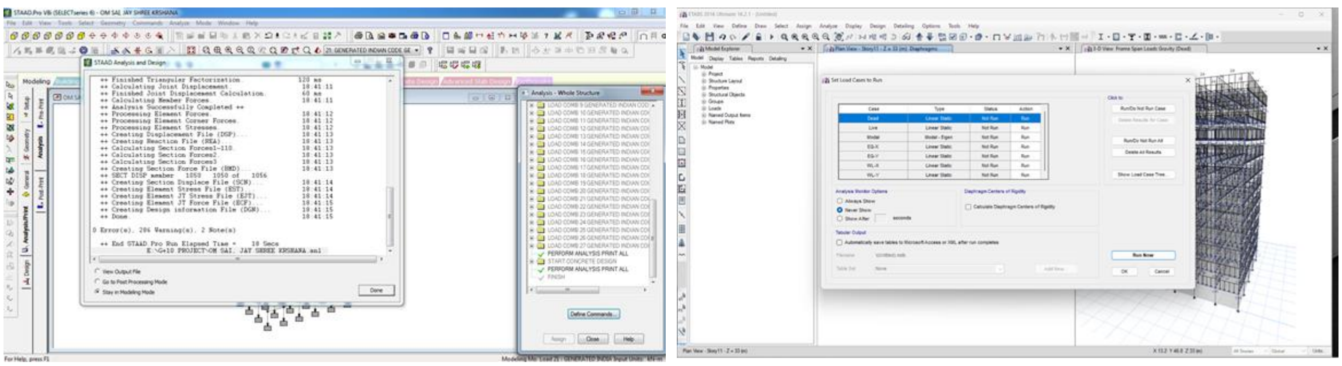


Fig.2.7. Showing the analyzing window in Staad Pro and etab

2.6 Design of G+10 RCC Building

Beams in Staad.Pro are designed using the IS 456:2000 for reinforced concrete structures. There are two types of reinforced concrete beams that are commonly used:

Single Reinforced Beams: In singly reinforced simply supported beams, steel reinforcement is placed near the bottom of the beam where it is most effective in resisting tensile bending stress. These beams are designed for scenarios where the bending moments are primarily tensile in nature.

Double Reinforced Beams: Double reinforced beams are provided with reinforcement in both the compression and tension regions of the beam. The need for steel reinforcement in the compression region arises for two main reasons:When the depth of the beam is restricted and cannot accommodate sufficient reinforcement in the tension region. When the strength provided by a singly reinforced beam is inadequate to resist the required bending moment.In such cases, additional reinforcement is provided in the compression zone to enhance the beam's strength and ensure it can resist both tensile and compressive stresses effectively.

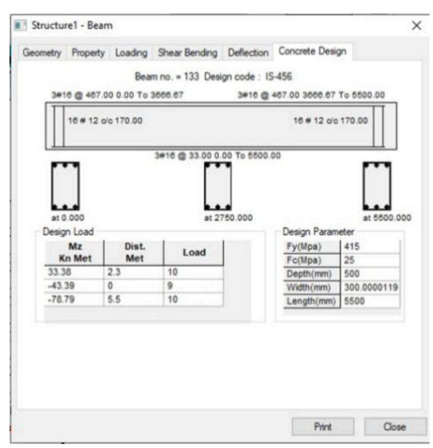


Fig2.8 Beam design

Column Design

A column is an element primarily designed to support axial compressive loads and typically has a height at least three times its lateral dimension. The strength of a column is influenced by several factors, including the material properties, the shape and size of its cross-section, its length, and the degree of proportional and rotational restraints at its ends.

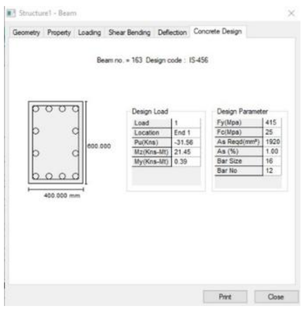


Fig.2.9. Column design

III. RESULT AND DISCUSSION

3.1 Moment Due to Dead Load

In both Staad.Pro and E-TAB, dead loads are applied to the structure to simulate the weight of permanent elements like walls, floors, and roofs. These loads generate bending moments (moments) in structural members like beams and columns. Both software tools calculate the distribution of dead loads and resulting moments throughout the structure, allowing engineers to design and analyze the structural components for stability and strength under these permanent forces. The tools help ensure that the structure can withstand the bending effects created by dead loads according to design codes. Figures 4.1 and 4.2 show the dead load moment in Staad.pro and E-TAB, respectively

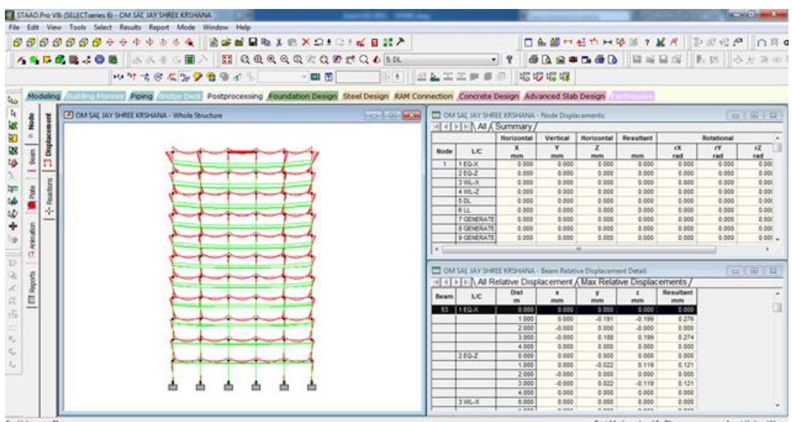


Fig. 3.1 Dead load moment in Staad.pro

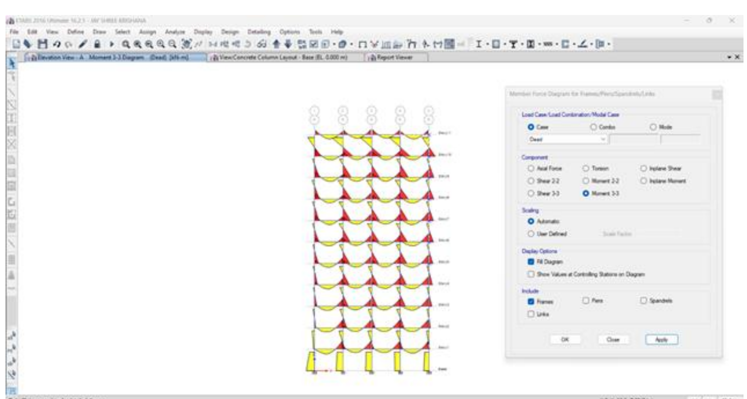


Fig3.2 Dead load moment in E-TAB

3.2 Moment Due to Dead Load

Seismic loads cause lateral displacement in structures, generating bending moments, shear forces, and torsion. In Staad.Pro and E-TAB, seismic forces are calculated based on the building's design and seismic zone. These Moments result in bending of beams, shear forces in columns, and possible twisting in irregular structures. The software helps design structures to withstand these forces and ensure safety during earthquakes.

Seismic analysis considers factors like zone factor, importance factor, and response reduction factor as per IS 1893:2016. Both STAAD.Pro and E-TAB use the Response Spectrum Method to simulate the building's behavior under varying seismic intensities. Proper analysis ensures the structure can dissipate energy without collapsing. Reinforced concrete shear walls, ductile detailing, and proper load combinations are incorporated for improved resilience. These steps help meet safety requirements and minimize structural damage during seismic events.

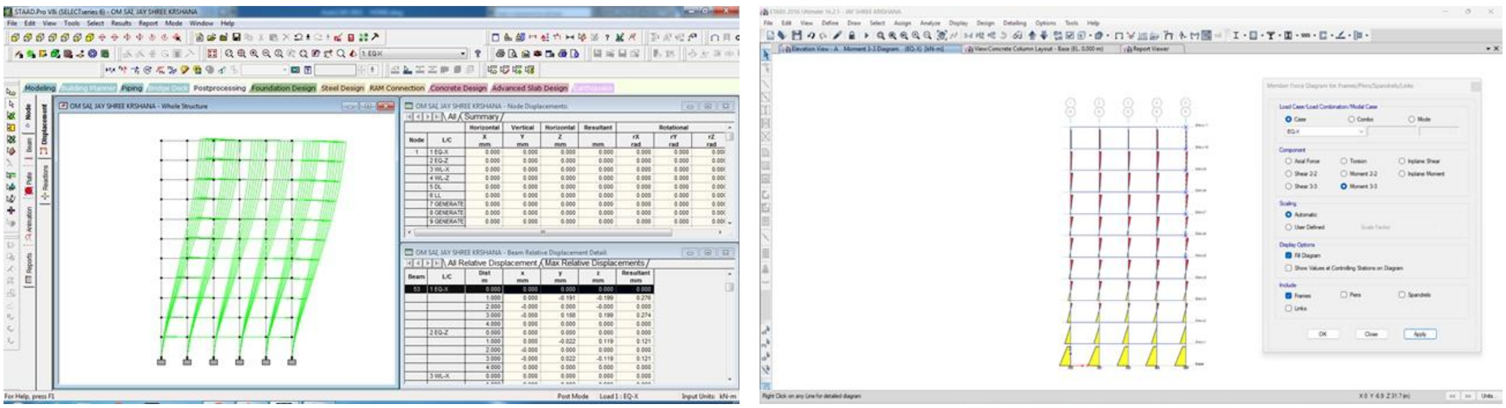


Fig. 3.3. Seismic load moment in Staad.pro and E-TAB

3.3 Moment Due to Wind

Wind loads cause lateral Moment, generating bending moments, shear forces, and torsion in structures. In Staad.Pro and E-TAB, wind loads are calculated based on factors like building height and location. These Moments are analyzed to ensure the structure can safely withstand wind forces.

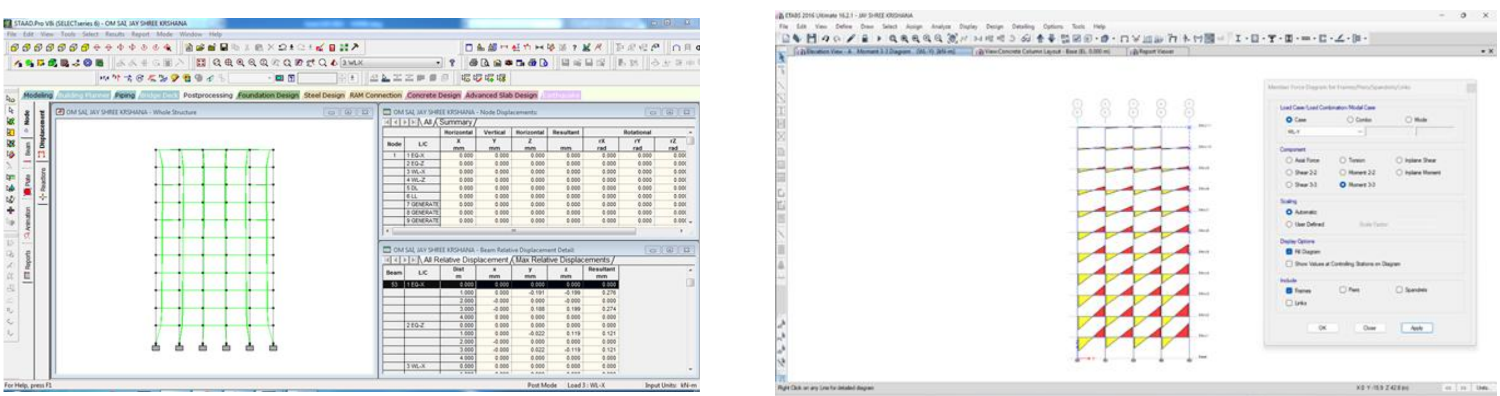


Fig3.4 Seismic load moment in Staad Pro and Etab

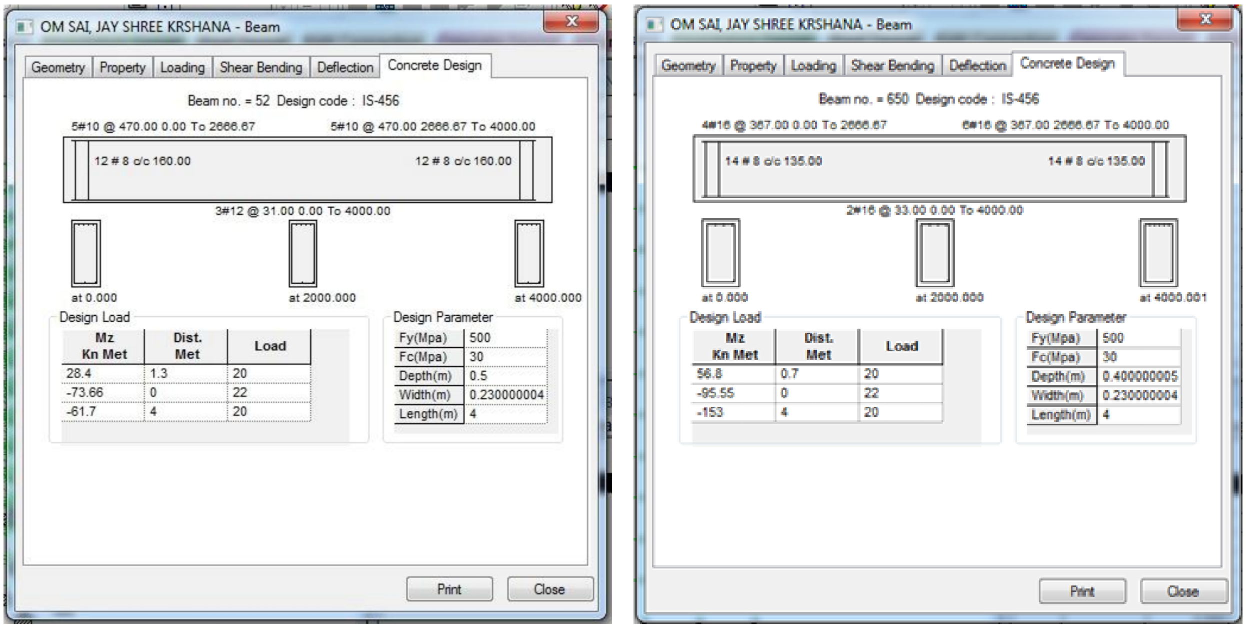


Fig3.5. Beam design Staad Pro

Factored Forces and Moments

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
-73.2201	0.3632	70.7016	0

Design Moments, M_{u3} & M_t

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
-73.2201	0.5852	0	-73.8053

Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	-73.8053		569	0	569	242
Bottom (-2 Axis)		0	285	0	0	285

Fig. 3.6. Beam design in E-TAB

The beam specifications you provided are as follows:

- Beam dimensions: 230 mm (width) x 300 mm (depth)
- Top reinforcement: 3 bars of T12 (12 mm diameter)
- Bottom reinforcement: 2 bars of T16 (16 mm diameter)
- Stirrups at both ends: 10 bars of T8 (8 mm diameter) spaced at 140 mm center-to-center (c/c).

Table No-01: Comparison of Columns Results Between Staad.pro and E-TAB.

Table No. 01 presents a comparison of column design results between Staad.Pro and E-TAB. It highlights differences in axial forces, moments, and reinforcement, reflecting variations in analysis and design assumptions.

Sr. No	Floor No	Column Position	Column No	Staad Pro		% Of Steel	E-TAB		% Of Steel	Difference
				Column Size MM	Main Steel		Column Size MM	Main Steel		
1	Footing To Parking/ Ground	Internal Column	C15	400 X 950	12-T25	0.15	400 X 900	14-T25	1.91	0.166667
		Internal Column	C22	400 X 950	12-T20	0.99	400 X 900	14-T25	1.91	0.822917
		External Columns	C6	350 X 950	12-T20	1.13	350 X 900	12-T25	1.87	0.5625
		External Columns	C33	350 X 950	24-T16	1.45	350 X 900	12-T25	1.87	0.220703
2	Ground To First Floor	Internal Column	C15	350 X 950	12-T25	1.77	400 X 900	12-T25	1.64	0
		Internal Column	C22	350 X 950	16-T20	1.51	400 X 900	12-T25	1.64	0.171875
		External Columns	C6	300 X 900	16-T16	1.19	350 X 900	16-T20	1.59	0.5625
		External Columns	C33	300 X 900	16-T20	1.86	350 X 900	14-T25	2.18	0.367188
3	First To Second Floor	Internal Column	C15	350 X 950	24-T16	1.45	350 X 850	16-T20	1.69	0.041667
		Internal Column	C22	350 X 950	24-T16	1.45	350 X 850	12-T25	1.98	0.220703
		External Columns	C6	300 X 800	20-T12	0.94	300 X 800	16-T20	2.09	1.222222
		External Columns	C33	300 X 800	16-T20	2.09	300 X 800	16-T20	2.09	0
4	Second To Third Floor	Internal Column	C15	350 X 950	20-T16	1.21	300 X 850	14-T20	1.72	0.09375
		Internal Column	C22	350 X 950	24-T16	1.45	300 X 850	14-T20	1.72	-0.08854
		External Columns	C6	300 X 700	16-T12	0.86	300 X 750	16-T25	3.49	3.340278
		External Columns	C33	300 X 700	12-T20	1.79	300 X 750	14-T25	3.05	0.822917
5	Third To Fourth Floor	Internal Column	C15	300 X 950	12-T25	2.07	300 X850	10-T25	1.92	-0.16667
		Internal Column	C22	300 X 950	12-T25	2.07	300 X 850	16-T16	1.26	-0.45387
		External Columns	C6	300 X 700	16-T12	0.86	300 X 700	16-T20	2.39	1.777778

		External Columns	C33	300 X 700	16-T20	2.39	300 X 700	16-T20	2.39	0

Table No-02: Comparison of Beam Results Between Staad.pro and E-TAB.

Table No. 02 shows the comparison of beam design results obtained from STAAD.Pro and ETABS. The differences in bending moments and reinforcement details highlight the variation in analysis approach between both software.

Sr. No	Floor No	Beam position	Beam no	staad pro				E-TAB			
				Beam size MM	Top Steel	Bottom Steel	STIRRUPS both end	Beam size MM	Top Steel	Botto m Steel	STIRRUPS both end
1	Parking/ ground Floor	Internal Beam	13	230 x 300	4-T12	4-T16	18 NO T8 @ 110 C/C	230 x 300	4-T12	3-T12	18 NO T8 @ 110 C/C
		Internal Beam	46	230 x 300	4-T12	4-T16	18 NO T8 @ 110 C/C	230 x 300	4-T12	3-T12	18 NO T8 @ 110 C/C
		External Beams	1	230 x 300	4-T12	3-T20	18 NO T8 @ 110 C/C	230 x 300	4-T12	3-T12	18 NO T8 @ 110 C/C
		External Beams	18	230 x 300	3-T12	5-T12	18 NO T8 @ 110 C/C	230 x 300	3-T12	3-T12	18 NO T8 @ 110 C/C
2	firstFloor	Internal Beam	13	230 x 300	3-T16	5-T16	18 NO T8 @ 110 C/C	230 x 300	3-T16	3-T16	18 NO T8 @ 110 C/C
		Internal Beam	46	230 x 300	3-T16	5-T16	18 NO T8 @ 110 C/C	230 x 300	3-T16	3-T16	18 NO T8 @ 110 C/C
		External Beams	1	230 x 300	3-T16	4-T16	18 NO T8 @ 110 C/C	230 x 300	3-T16	3-T16	18 NO T8 @ 110 C/C
		External Beams	18	230 x 300	3-T16	4-T16	18 NO T8 @ 110 C/C	230 x 300	3-T16	3-T16	18 NO T8 @ 110 C/C
3	Second Floor	Internal Beam	13	230 x 300	3-T16	3-T20	18 NO T8 @ 110 C/C	230 x 300	3-T16	4-T16	18 NO T8 @ 110 C/C
		Internal Beam	46	230 x 300	2-T20	3-T20	18 NO T8 @ 110 C/C	230 x 300	2-T20	3-T20	18 NO T8 @ 110 C/C
		External Beams	1	230 x 300	3-T20	4-T20	18 NO T8 @ 110 C/C	230 x 300	3-T16	4-T16	18 NO T8 @ 110 C/C

Sr. No	Floor No	Beam position	Beam no	staad pro				E-TAB			
				Beam size MM	Top Steel	Bottom Steel	STIRRUPS both end	Beam size MM	Top Steel	Bottom Steel	STIRRUPS both end
		External Beams	18	230 x 300	4-T16	4-T20	18 NO T8 @ 110 C/C	230 x 300	4-T12	4-T16	18 NO T8 @ 110 C/C
4	Third Floor	Internal Beam	13	230 x 300	4-T12	4-T16	18 NO T8 @ 110 C/C	230 x 300	3-T12	3-T12	18 NO T8 @ 110 C/C
		Internal Beam	46	230 x 300	4-T12	4-T16	18 NO T8 @ 110 C/C	230 x 300	3-T16	3-T16	18 NO T8 @ 110 C/C
		External Beams	1	230 x 300	4-T12	3-T20	18 NO T8 @ 110 C/C	230 x 300	3-T16	3-T16	18 NO T8 @ 110 C/C
		External Beams	18	230 x 300	4-T12	3-T20	18 NO T8 @ 110 C/C	230 x 300	4-T12	4-T16	18 NO T8 @ 110 C/C
5	Fourth Floor	Internal Beam	13	230 x 300	3-T12	5-T12	18 NO T8 @ 110 C/C	230 x 300	3-T12	3-T12	18 NO T8 @ 110 C/C
		Internal Beam	46	230 x 300	3-T16	5-T16	18 NO T8 @ 110 C/C	230 x 300	3-T16	3-T16	18 NO T8 @ 110 C/C
		External Beams	1	230 x 300	4-T12	4-T16	18 NO T8 @ 110 C/C	230 x 300	3-T12	3-T12	18 NO T8 @ 110 C/C

3.4 Manual Design of a Column

Manual design of a column (C15) of size 400 mm × 950 mm, with an unsupported length of 3 m, factored axial load of 2000 kN, using m30 concrete and fe500 steel, and effective length condition: held in position but not restrained against rotation.

Given:

Cross-section = 400 mm × 950 mm

Unsupported length L=3 m= 3000 mm

Axial Load P=2000 kN = 2,000,000

Concrete grade: M30 ⇒ fck=30 MPa

Steel grade: Fe500 ⇒ fy= 500 MPa

Column is held in position but not restrained against rotation ⇒ Effective Length Factor = 1.2 (as per IS 456:2000, Table 28)

Step 1: Calculate Effective Length

Leff=1.2×3000=3600 mm

Step 2: Slenderness Ratio

λ= l_eff / (least lateral dimension) = $\frac{3600}{400}$ =9<12(Short column limit)

Since λ>12\lambda > 12λ>12, it is a slender column. We must apply additional moment due to slenderness (but let's proceed with basic axial load design for now, assuming minimum eccentricity is considered).

Step 3: Axial Load Capacity Check

Assume minimum eccentricity check is not governing.

Use axial load capacity formula from IS 456:2000 (Clause 39.3):

Pu=0.4fckAc+0.67fyAsc

Where:

Ac=A_c =Ac= area of concrete

Asc=A_{sc} =Asc= area of longitudinal steel

Total gross area:

Ag=400×950=380000 mm^2

Let's assume reinforcement = 1.5% (trial):

Asc=0.015×380000=5700 mm^2

Concrete area:

Ac=Ag−Asc=380000−5700=374300 mm^2

Substitute in formula:

Pu=0.4·30·374300+0.67·500·5700

=6401.1kN

✅ Safe, since 6401.1 kN > 2000 kN.

Step 4: Provide Reinforcement

Required steel area: approx 5700 mm²

Use 20 mm diameter bars → Area = 314 mm²/bar

No. of bars= 5700/314 = 18

→ Use 18 bars of 20 mm dia (or 6 on each face × 3 faces)

Step 5: Transverse Reinforcement

As per IS 456:2000 (Clause 26.5.3):

Minimum spacing of ties:

Least of:

300 mm,16×diaofsmallestlongitudinalbar,leastlateral dimension

→ Least = min(300, 16×20 = 320, 400) = 300 mm

Provide 10 mm dia ties @ 250 mm c/c (conservative)

Table No. 03 shows the comparison of column design results between STAAD.Pro, ETABS, and manual calculations.

Table No-03: Comparison Columns Between Staad Pro, E-TAB and Manual.

Aspect	**STAAD**	**E-TAB**	**Manual Calculation**
Column ID	C15	C15	C15
Cross-Section (mm)	400 × 950	400 × 900	400 × 950
Longitudinal Bars	12-T25	14-T25	18-T20

E-TAB design is the best option—it provides optimal reinforcement (14-T25) with efficient use of concrete and higher safety margin. It balances structural strength, code compliance, and construction practicality better than STAAD and manual design.

3.5 Manual Design of a Beam

Reinforced Concrete Beam Design Report of B13

Given Data

Beam size: 230 mm 300 mm (width depth)

Clear span: 4.0 m

Effective depth: d = 270 mm (after cover and half bar dia deduction)

Concrete grade: M30 (fck = 30 MPa)

Steel grade: Fe500 (fy = 500 MPa)

Step 1: Load Calculations

Dead Load (DL):

- Self-weight of beam = 0.23 0.30 25 = 1.725 kN/m
- Wall load = 0.23 2.6 20 = 11.96 kN/m
- Slab load = 0.15 1 25 = 3.75 kN/m
- Finishing load = 1.0 kN/m

Total DL = 18.435 kN/m

Live Load (LL): 2.0 kN/m

Step 2: Factored Load

Factored Load:

wu = 1.5 (DL + LL) = 1.5 (18.435 + 2.0) = 30.65 kN/m

Step 3: Bending Moment and Shear Force

Mu = (wu L) / 8 = (30.65 4) / 8 = 61.3 kNm

Vu = (wu L) / 2 = (30.65 4) / 2 = 61.3 kN

Step 4: Limiting Moment Check

Mlim = 0.138 fck b d = 69.45 kNm

Since Mu < Mlim, singly reinforced section is sufficient.

Step 5: Area of Steel (Ast)

Ast = Mu / (0.87 fy j d) = 579.1 mm (approx)

Provide: 3 bars of 16 mm dia 603 mm (satisfactory)

Step 6: Shear Check

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v = Vu / (b d) = 0.99 MPa

c (for M30 and ~0.5% steel) = 0.42 MPa

Since v > c, shear reinforcement is required.

Step 7: Shear Reinforcement

Vus = Vu c b d = 35,254 N

Use 2-legged 8 mm stirrups (Asv = 100.6 mm)

Spacing = (0.87 fy Asv d) / Vus = 334 mm

Provide @ 300 mm c/c

Table No. 04 shows the comparison of Beam design results between STAAD.Pro, ETABS, and manual calculations.

Table No-04: Comparison Beam Between Staad Pro, E-TAB and Manual.

Aspect	**STAAD**	**E-TAB**	**Manual Calculation**
Beam ID	Beam 13	Beam 13	Beam 13
Cross-Section (mm)	230 × 300	230 × 300	230 × 300
Top Reinforcement	4-T12	4-T12	3-T16
Bottom Reinforcement	4-T16	3-T12	3-T16
Stirrups (Shear Rein.)	8mm@110mm c/c	8 mm@110 mm c/c	8mm 2-legged @ 300 mm c/c

E-TAB design is the most economical and balanced, with adequate reinforcement and practical stirrup spacing. Manual design is also safe and conservative, ideal if simplicity and safety margin are preferred.

IV. CONCLUSIONS

This project successfully addressed the key objectives involved in the design and analysis of a G+10 storied building. The following conclusions summarize the outcomes of the completed work.

- **Structural Framing Plan:**
  A detailed structural framing plan was developed to ensure efficient load transfer, structural stability, and compliance with both functional and aesthetic requirements. The design considerations led to a robust plan for a high-rise structure capable of withstanding various external loads.
- **Modeling in Staad.Pro and E-TAB:**
  The 3D model of the G+10 building was developed using both Staad.Pro and E-TAB, incorporating accurate material properties, loads, and geometric configurations. This enabled effective visualization and analysis of the building's response to different forces, ensuring accurate and reliable results.
- **Comprehensive Structural Analysis:**
  A detailed analysis was performed to evaluate the building's response to dead loads, live loads, wind loads, and seismic forces. The analysis followed the provisions of IS 875:2015 (Part III) and IS IS 1893 (Part 1):2016, providing a thorough understanding of the building's behavior under these loads.
- **Design of Structural Components:**
  The critical structural components, including beams, columns were designed using the Limit State Method. Both manual design calculations and software-based results from Staad.Pro and E-TAB were cross-verified, ensuring compliance with IS 456:2000 for reinforced concrete structures.

It has been observed that E-TAB software is user-friendly and particularly simple for RCC structure designs, while Staad.Pro offers a more comprehensive understanding for modeling and analysis, especially for G+10 buildings.

The project has been successfully completed, and a comparative analysis of Staad.Pro, E-TAB, and manual design methods has been conducted. Among the three, the E-TAB design emerged as the most economical and balanced, offering optimal reinforcement (14-T25), efficient concrete usage, and a higher safety margin. It provides an excellent balance between structural strength, code compliance, and construction practicality.

While the manual design is safe and conservative—making it suitable when simplicity and a higher margin of safety are preferred E-TAB is the preferred choice for projects that demand both efficiency and structural integrity. Compared to Staad.Pro and manual methods, E-TAB offers the most optimized and practical solution for high-rise buildings.

While it is a well-known fact that earthquake-resistant design is important for tall buildings, our conclusion is based on the results obtained from E-TAB and Staad.Pro analyses. The significant lateral displacements and base shear values observed during Response Spectrum and Time History Analysis highlighted the critical role of seismic design in ensuring the safety and stability of a P+10 structure.

Overall, the project met its objectives by providing an efficient, safe, and earthquake- resistant design for a G+10 building. The combination of manual calculations and advanced software tools ensured the structural integrity and safety of the design, addressing modern urban construction challenges while complying with relevant design codes and standards.

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