

Comparatives Structural Analysis of Industrial Shed using STAAD Pro & ETABS

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Abstract - This study presents a comparative structural analysis of a steel industrial shed using STAAD Pro [1] and ETABS [2]. A typical industrial shed was modeled and analyzed in both software platforms using identical geometry, material properties, support conditions, and loading criteria based on relevant Indian Standards. The analysis considered dead load, live load, and wind load combinations.

Key structural parameters, including support reactions, shear force, axial force, displacement, member utilization ratio, steel quantity were compared. The results show that both software programs produce safe and reliable structural designs, with minor variations due to differences in modeling and analysis approaches.

The study concludes that both software packages provide reliable and efficient results for steel industrial shed analysis and design. However, differences in modeling approaches, analysis techniques, and design algorithms lead to slight variations in output. The research helps engineers understand the comparative performance of both software tools and supports effective decision-making in practical structural engineering applications.

Key Words: Steel Industrial Shed, STAAD Pro [1], ETABS [2], Structural Analysis, Industrial Structures, Comparative Study.

1. INTRODUCTION

Steel structures play a significant role in modern industrial construction due to their high strength, durability, flexibility, and rapid construction capability. Among various steel structures, industrial sheds are extensively used for warehouses, manufacturing units, workshops, factories, and storage facilities. The increasing demand for economical and efficient industrial infrastructure has led to the widespread adoption of steel industrial sheds in the construction industry. Their ability to cover large column-free spaces with reduced self-weight makes them more advantageous compared to conventional reinforced concrete structures.

The structural performance of industrial sheds depends on accurate analysis and proper design under various loading conditions such as dead load, live load, wind load, and other environmental effects. With the advancement of computational technology, structural engineering software has become an essential tool for analyzing and designing complex steel structures. Among the widely used software applications, STAAD Pro [1] and ETABS [2] are recognized for their efficiency, reliability, and user-friendly modeling capabilities.

STAAD Pro [1] is commonly used for the analysis and design of various civil engineering structures, including industrial

structures, due to its versatile modeling and loading features. On the other hand, ETABS [2] is widely known for building analysis and design, offering advanced tools for structural modeling, load analysis, and design optimization. Although both software programs are extensively used in structural engineering practice, variations may occur in analysis results and design outputs due to differences in modeling approaches, analysis algorithms, and design procedures.

This study focuses on the comparative structural analysis of a steel industrial shed using both software platforms. The industrial shed is modeled with identical geometry, material properties, support conditions, and loading criteria based on relevant Indian Standards. The analysis includes the evaluation of structural parameters such as support reactions, shear force, axial force, displacement, member utilization ratio and steel quantity.

The primary objective of this study is to compare the analytical behavior and design efficiency of both software applications and identify the similarities and differences in their structural responses. The findings of this research will help structural engineers and researchers understand the practical applicability of both software tools in the design and analysis of steel industrial structures and assist in selecting suitable software for engineering projects.

2. LITERATURE REVIEW

2.1. COMPARATIVE STUDIES OF STAAD PRO AND ETABS

Researchers have conducted several comparative studies to evaluate the efficiency, accuracy, and structural behavior predicted by these software platforms.

Lallotra, Singhal (2017) [3] carried out a comparative review of different structural analysis software packages. The study highlighted that more flexibility in modeling the structures and design details are provided by ETABS [2]. STAAD Pro [1] integrates design provisions from various standards, which leads to more precise and reliable results.

Himanshu Yadav and Ramanuj Jaldhari [4] performed a comparative study of STAAD Pro and ETABS for multi-storey buildings. The researchers compared bending moments, shear forces, axial forces, and displacement responses. The study concluded that both software packages provide comparable results with minor variations attributable to modeling techniques and internal computational procedures.

Iván Alejandro Porras Rodríguez [5] conducted a comparative investigation on the modeling, analysis, and design of an industrial shed using ETABS and STAAD Pro. The study highlighted differences in user interface, modeling

procedures, design workflow, and generated results. The research concluded that both programs are suitable for industrial steel structures while exhibiting slight differences in force distribution and displacement predictions.

Researchers [6] investigating pre-engineered and conventional steel buildings observed that pre-engineered structures generally provide lower material consumption, reduced construction time, and improved economic efficiency when compared with conventional steel buildings of similar dimensions.

A comparative assessment [7] of mono-slope and dual-slope industrial PEB sheds demonstrated that dual-slope configurations provide improved structural efficiency and lower steel consumption under identical loading conditions. The authors attributed this improvement to a more efficient load transfer mechanism.

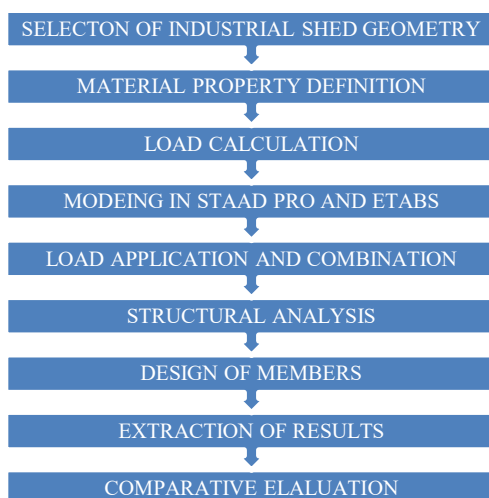
2.2. RESEARCH GAP

From the reviewed literature, it is observed that although numerous studies have been carried out on RCC buildings (Residential and commercial), limited research has specifically focused on the comparative structural analysis of industrial steel structures using both STAAD Pro and ETABS under identical loading and geometric conditions. Therefore, the present study aims to bridge this gap by performing a detailed comparative analysis of industrial shed structures using both software platforms and evaluating their structural response, design efficiency, and analytical performance.

3. METHODOLOGY

This chapter describes the systematic procedure adopted for the analysis and design of a steel industrial shed using STAAD Pro [1] and ETABS [2]. The methodology includes selection of structural parameters, modeling, load application, analysis, design, and comparison of results.

The study aims to ensure uniform input conditions in both software platforms so that the comparison remains consistent and reliable.



4. ANALYSIS AND RESUTS

4.1. STRUCTURAL MODEL DESCRIPTION

A 50.4m x 21.6m steel industrial shed is considered for this study. Spacing of each bay is 7.2m. Eave height is 5.85 and ridge height is 6.07m. 3D rendered view from STAAD Pro [1] and ETBAS [2] is shown in figure.



Fig -1: Rendered view from STAAD Pro



Fig -2: Rendered view from ETABS

4.1.1. GEOMETRICAL DETAILS

Table -1: Geometric Details of Industrial shed

Parameter	Description
Length of shed	50.4 m
Width of shed	21.6 m
Eave height	5.85 m
Ridge height	6.07 m
Bay spacing	7.2 m
Number of bays	7
Type of structure	Steel portal frame

4.1.2. MATERIAL PROPERTIES

Table -2: Material Properties of Industrial shed

Property	Value
Grade of steel	YST 310
Young's Modulus	2×10^5
Poisson's Ratio	0.3
Density of steel	78.5 kg/m ³
Yield Strength	310 MPa

4.1.3. LOADING CONSIDERATION

The following loads were considered during analysis and design:

Dead Load (DL)

Dead load consists of self-weight of the structure including connections and immovable fixtures like roof sheet. It is calculated according to IS 875 Part-1 2026 [8].

10% additional self-weight considered for connections.

Dead load of roof sheet:

Unit weight of roof sheet = 0.5 kN/m^2

Influence width = 7.2 m

Uniformly Varying Load on Top Chord member = $0.5 \times 7.2 = 3.6 \text{ kN/m}$

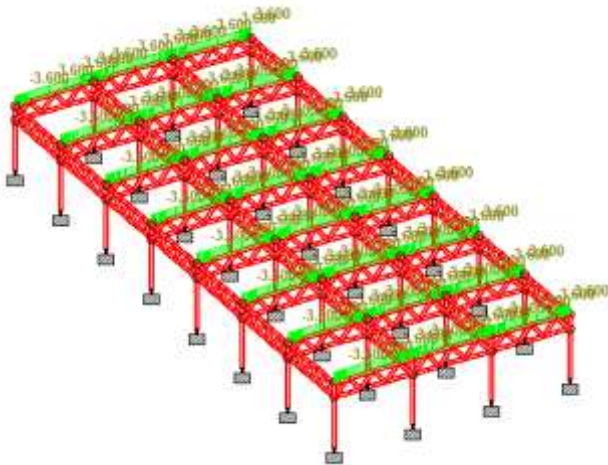


Fig -3: Dead load application in STAAD Pro

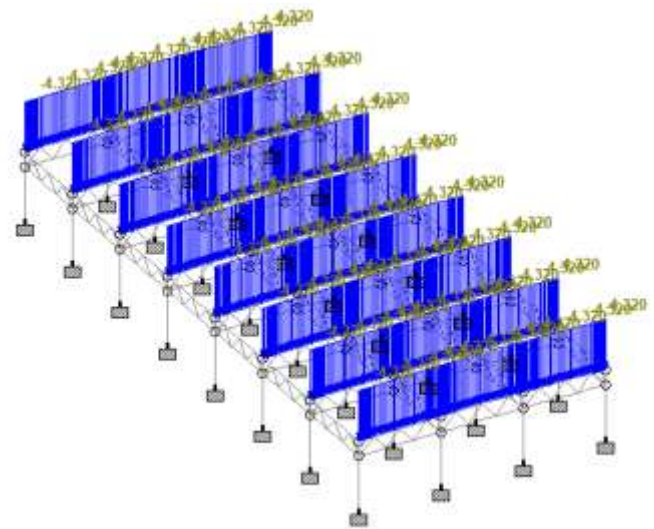


Fig -5: Live load application in STAAD Pro

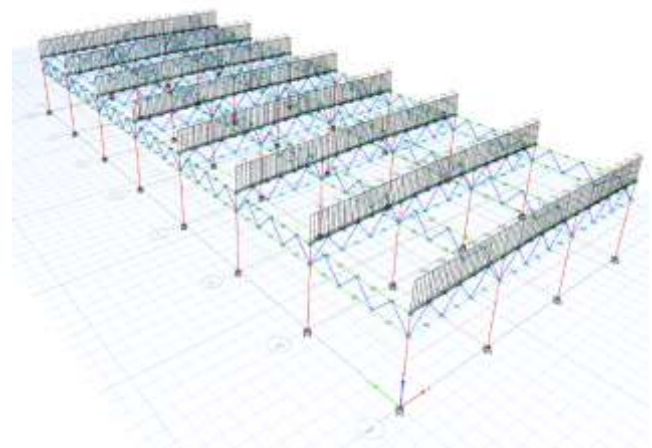


Fig -6: Live load application in ETABS

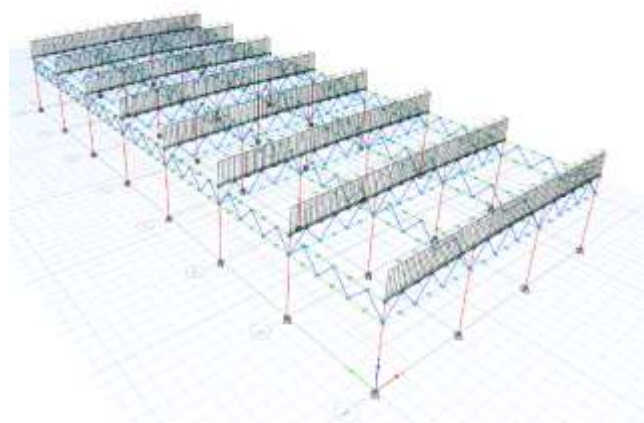


Fig -4: Dead load application in ETABS

Live Load (LL)

Live load on roof = 0.6 kN/m^2

Influence width = 7.2 m

Uniformly Varying Load on Top Chord member = $0.6 \times 7.2 = 4.32 \text{ kN/m}$



Fig -7: Wind load +X application in STAAD Pro

Wind Load (WL)

Wind load is calculated as per IS 875 Part-3 2015 [9]

For steel design IS 800: 2007 [10] has been used.

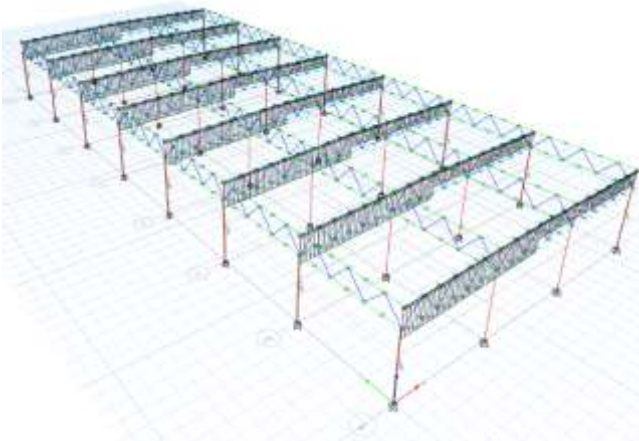


Fig -8: Wind load +X application in ETABS

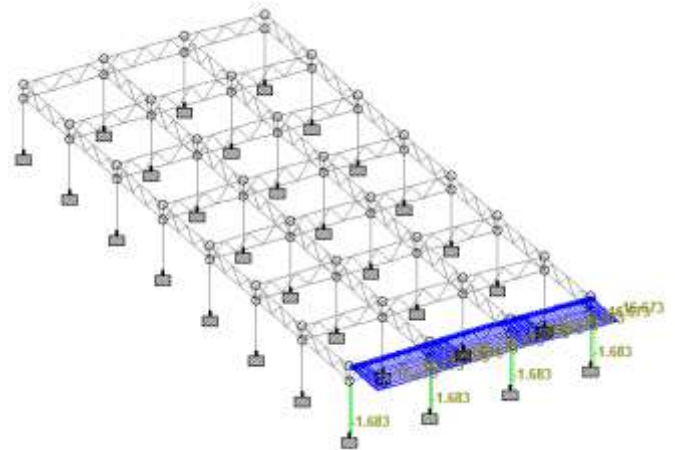


Fig -11: Wind load Z application in STAAD Pro

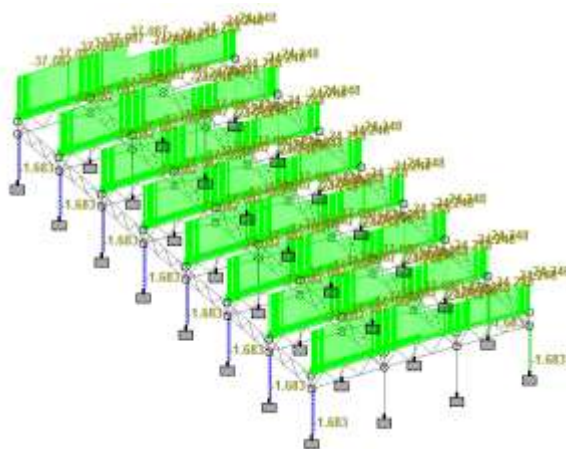


Fig -9: Wind load -X application in STAAD Pro

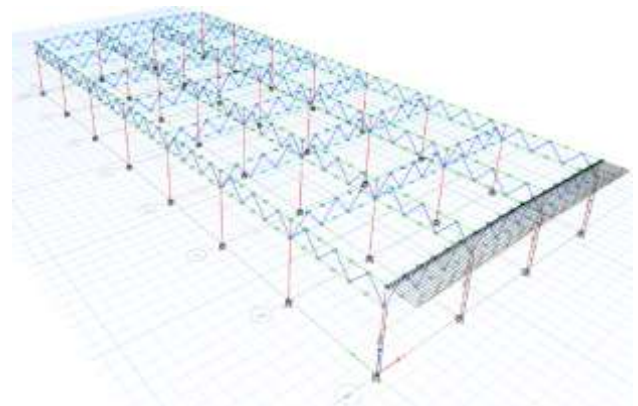


Fig -12: Wind load Z application in ETABS

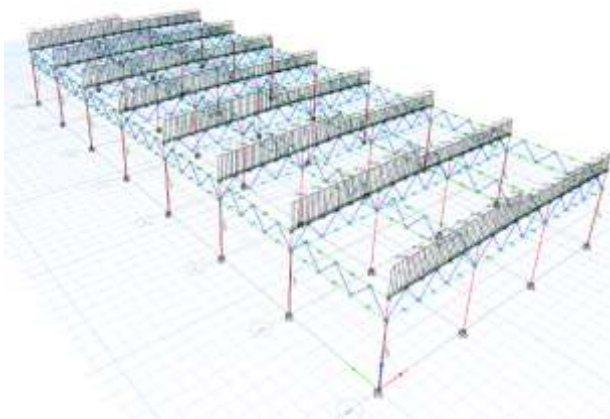


Fig -10: Wind load -X application in ETABS

4.2 MODELING PROCEDURE IN STAAD PRO

The structural model of the industrial shed was created in STAAD Pro [1] by defining nodes, beam elements, supports, material properties, and loading conditions. The following steps were adopted during modelling:

- Generation of nodal coordinates.
- Creation of beam and column elements.
- Assignment of steel sections.
- Definition of support conditions.
- Application of dead load, live load, and wind load.
- Generation of load combinations.
- Execution of analysis.
- Steel design as per IS 800: 2007 [10].

The software automatically computed member forces, displacements, reactions, and design adequacy ratios.

4.2.1. STAAD PRO ANALYSIS OUTPUT

The following outputs were extracted from the software:

- Maximum nodal displacement
- Axial force in columns
- Shear force distribution
- Support reactions
- Steel member utilization ratio
- Structural weight

4.3 MODELING PROCEDURE IN ETABS

The same industrial shed geometry was modelled in ETABS [2] to maintain consistency in comparative evaluation.

The modelling steps in ETABS included:

- A. Grid generation.
- B. Definition of steel materials.
- C. Assignment of frame sections.
- D. Modelling of portal frames and bracings.
- E. Assignment of loads and load combinations.
- F. Analysis and design execution.
- G. Extraction of structural response parameters.

4.3.1. ETABS ANALYSIS OUTPUT

The following parameters were extracted from ETABS:

- A. Storey and joint displacements
- B. Axial force distribution
- C. Shear force values
- D. Base reactions
- E. Demand-capacity ratios
- F. Total steel quantity

4.4. LOAD COMBINATIONS USED

The combinations are considered as per IS 800: 2007 [10].

Table -3: Load Combinations

Serviceability Combinations	
SL. No.	Load Combinations
1	1 DL + 1 LL
2	1 DL + 1 LL + 1 WL +X
3	1 DL + 1 LL + 1 WL -X
4	1 DL + 1 LL + 1 WL Z
5	1 DL + 1 WL +X
6	1 DL + 1 WL -X
7	1 DL + 1 WL Z
Strength Combinations	
SL. No.	Load Combinations
1	1.5 DL + 1.5 LL
2	1.2 DL + 1.2 LL + 0.6 WL +X
3	1.2 DL + 1.2 LL + 0.6 WL -X
4	1.2 DL + 1.2 LL + 0.6 WL Z
5	1.5 DL + 1.5 WL +X
6	1.5 DL + 1.5 WL -X
7	1.5 DL + 1.5 WL Z
8	0.9 DL + 1.5 WL +X
9	0.9 DL + 1.5 WL -X
10	0.9 DL + 1.5 WL Z

Where, DL = Dead Load, LL = Live Load, WL = Wind Load

4.5. ANALYSIS RESULTS

4.5.1. NODAL DISPLACEMENT

Table -4: Maximum Nodal Displacement

Software		Max deflection (mm)	Load Combination	Location
STAAD Pro	Horizontal	25.313	1 DL + 1 WL Z	Top Chord member
	Vertical	3.817	1 DL + 1 LL + 1 WL -X	Top Chord member
ETABS	Horizontal	26.89	1 DL + 1 LL + 1 WL Z	Top Chord member
	Vertical	3.9	1 DL + 1 LL + 1 WL -X	Top Chord member

Discussion: The maximum Horizontal displacement shows a variation of nearly is 6.2 % less in STAAD Pro and Vertical displacement is 2.2 % less in STAAD Pro [1]. Furthermore, in STAAD Pro [1] the maximum Horizontal deflection is recorded for load combination 1 DL + 1 WL Z but in ETABS [2] the maximum horizontal displacement is recorded for load combination 1 DL + 1 LL + 1 WL Z.

4.5.2. SUPPORT REACTIONS

Table -5: Support Reactions

Software		Maximum reactions (kN)	Load Combinations
STAAD Pro	Horizontal	30.19	0.9 DL + 1.5 WL Z
	Vertical	488.07	1.5 DL + 1.5 WL -X
ETABS	Horizontal	30.64	1.5 DL + 1.5 WL -X
	Vertical	497	1.5 DL + 1.5 WL Z

Discussion: In STAAD Pro [1] the maximum Horizontal and vertical reaction is 1.5% and 1.8% less respectively.

4.5.3. AXIAL FORCE

Table -6: Maximum Axial Force

Software	Max Compression Force (kN)	Max Tension Force (kN)
STAAD Pro	488.07	369.59
ETABS	497.42	380.07

Discussion: The maximum compression force shows a variation of nearly 1.8% less in STAAD Pro [1] and maximum tension force shows a variation of nearly 3% less in STAAD Pro [1]

4.5.4. SHEAR FORCE

Table -7: Maximum Shear Force

Software	Max Shear Force (kN)
STAAD Pro	77.36
ETABS	79.2

Discussion: The maximum shear force shows a variation of nearly 2.4% less in STAAD Pro [1]

4.5.5. UTILIZATION RATIO

Table -8: Maximum Utilization Ratio

Software	Maximum Utilization Ratio
STAAD Pro	0.769
ETABS	0.786

Discussion: The maximum utilization ratio shows a variation of nearly 2.2% less in STAAD Pro [1]

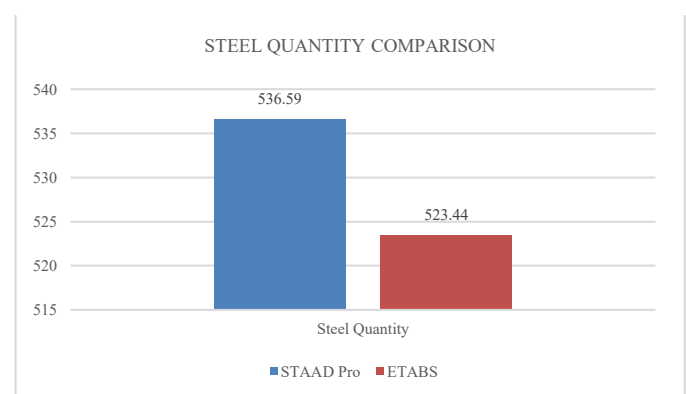
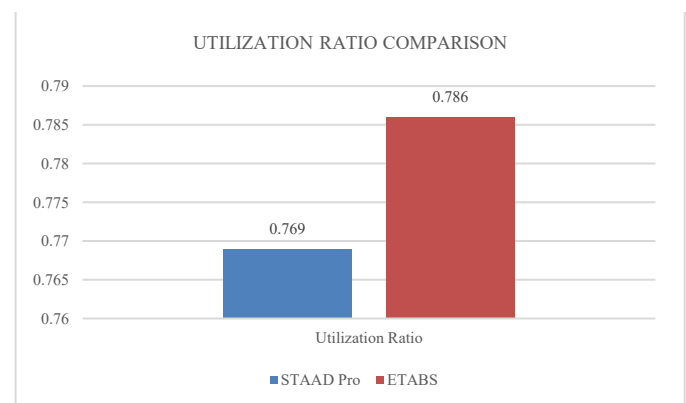
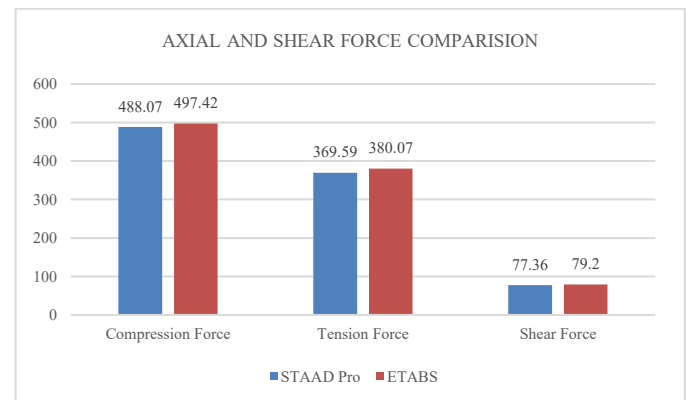
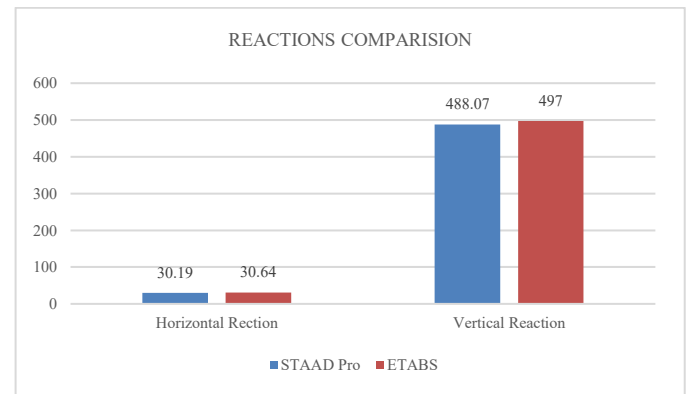
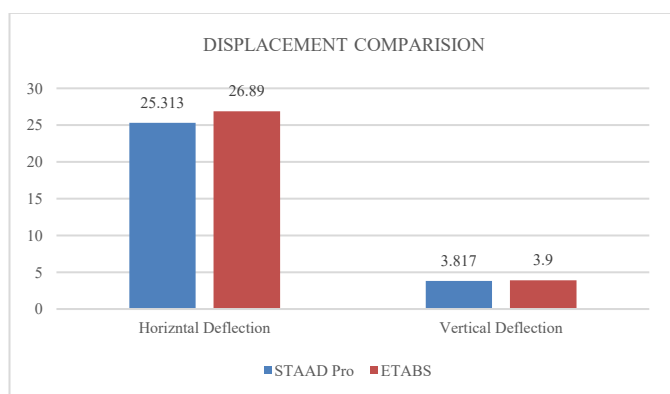
4.5.6. STEEL QUANTITY COMPARISON

Table -9: Steel Quantity

Software	Estimated Steel Quantity (MT)
STAAD Pro	536.59
ETABS	523.44

Discussion: The steel Quantity shows a variation of nearly 2.5% less in ETABS [2]

4.6. GRAPHICAL REPRESENTATION OF RESULTS



5. CONCLUSIONS

The present study carried out a comparative structural analysis and design of a steel industrial shed using STAAD Pro and ETABS to evaluate the variation in structural response, member forces, utilization ratio, and material consumption under identical loading and design conditions. The analysis results obtained from both software platforms

indicate that although the overall structural behavior remains similar, slight variations are observed due to differences in modelling approach, analysis algorithms, and design interpretation adopted by the software.

From the analysis, it was observed that the maximum horizontal displacement obtained from STAAD Pro [1] is approximately 6.2% lower than that obtained from ETABS [2], while the vertical displacement is about 2.2% lower in STAAD Pro [1]. This indicates that STAAD Pro [1] predicts comparatively stiffer structural behavior for the industrial shed model.

The support reaction comparison shows that the maximum horizontal and vertical reactions in STAAD Pro [1] are approximately 1.5% and 1.8% lower, respectively, than those obtained in ETABS [2]. Similarly, the maximum compression force, tension force, and shear force are found to be nearly 1.8%, 3%, and 2.4% lower in STAAD Pro [1]. These minor differences demonstrate that both software programs produce closely comparable analytical results, thereby validating the reliability of the structural analysis.

The utilization ratio obtained from STAAD Pro [1] is approximately 2.2% lower than ETABS [2], indicating a slightly more economical and conservative member performance prediction.

Based on the overall findings, it can be concluded that both STAAD Pro [1] and ETABS [2] are efficient and reliable software tools for the analysis and design of steel industrial sheds. STAAD Pro [1] demonstrates comparatively lower displacement and force values, whereas ETABS [2] results in slightly reduced estimated steel quantity. Therefore, the selection of software may depend on the designer's project requirements, design preference, ease of modelling, and optimization objectives. The study also confirms that the variation between the two software packages is relatively small and remains within acceptable engineering limits, making both suitable for practical industrial shed design applications.

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AUTHOR'S BIOGRAPHY



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His research interest includes Industrial Steel Structures, Steel Structure Analysis and design in STAAD Pro and ETABS software. His current research work focuses on the “**Comparatives Structural Analysis of Industrial Shed using STAAD Pro & ETABS**”.

His aim is to contribute to the development of safe, economical, and efficient structural design practices through advanced analytical tools and modern engineering methodologies. He has also achieved the status of Chartered Engineer, reflecting his professional dedication and technical expertise in the field of civil and structural engineering.