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Comparative Analysis of Shed-Type Structures

Mr. Adarsh Perge[1], Prof. Pallavi Bhende [2], Prof. Gaurav Hingwe[3]

[1]Research Scholar (M.Tech in Computer Aided Structural Engineering (CASE), Civil Engineering Department, Wainganga College of Engineering & Management, Nagpur

[2]Assistant Professor & Head of Department, Civil Engineering Department, Wainganga College of Engineering & Management, Nagpur

[3] Assistant Professor, Civil Engineering Department, Wainganga College of Engineering & Management, Nagpur

Abstract- Construction projects involve multiple critical decisions, among which the selection of an appropriate structural system plays a vital role in ensuring efficiency, economy, and performance. Industrial shed structures are widely used in manufacturing, storage, and logistics sectors, where large column-free spaces and cost-effective solutions are essential. Traditionally, Conventional Steel Buildings (CSB) have been used for such applications; however, with advancements in structural engineering, Pre-Engineered Buildings (PEB) have emerged as a modern and optimized alternative. The present study focuses on the comparative analysis of shed-type structures, specifically PEB and CSB systems, to determine the most efficient structural solution. The analysis is carried out using STAAD Pro V8i software, considering various parameters such as span (5 m to 40 m), height (4 m to 10 m), and loading conditions as per relevant Indian Standard codes (IS 800, IS 875, and IS 1893). The structures are analyzed under dead load, live load, wind load, and seismic load conditions, with wind load considered as the governing factor. The results obtained from the analysis include key structural parameters such as bending moment, shear force, axial force, deflection, and steel weight. These parameters are systematically compared to evaluate the structural performance of both systems. The study reveals that PEB structures exhibit lower bending moments, reduced axial forces, and significantly lesser deflection compared to CSB structures. Furthermore, PEB systems demonstrate 20% to 30% reduction in steel weight, leading to considerable savings in construction cost and improved efficiency. The findings indicate that PEB structures provide better structural performance due to the use of tapered built-up sections and optimized design, whereas CSB structures, with uniform sections and truss configurations, result in higher material consumption and internal forces. Additionally, PEB structures offer advantages such as faster construction, improved durability, and sustainability. Based on the comparative analysis, it can be concluded that Pre-Engineered Buildings are more economical, efficient, and suitable for modern industrial shed construction, particularly for long-span applications.

Keywords: Pre-Engineered Building (PEB), Conventional Steel Building (CSB), STAAD Pro V8i, Industrial Shed, Structural Analysis, Bending Moment, Deflection, Steel Optimization.

I. INTRODUCTION

The construction industry is one of the most significant contributors to the economic growth and development of any nation. It plays a crucial role in creating infrastructure for industrial, commercial, residential, and institutional purposes. With the rapid pace of industrialization and urbanization, particularly in developing countries like India, there has been a substantial increase in the demand for efficient, durable, and cost-effective construction systems. Among the various types of infrastructure required for industrial growth, large-span structures such as factories, warehouses, workshops, storage facilities, aircraft hangars, and industrial sheds occupy a prominent position. Industrial structures are fundamentally different from residential or commercial buildings due to their functional requirements. These structures often require large column-free spaces to accommodate machinery, storage, and operational activities. The absence of intermediate supports enhances flexibility in layout planning and improves operational efficiency.

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However, designing such large-span structures poses significant engineering challenges, including the need to withstand various loads such as dead load, live load, wind load, seismic load, and sometimes dynamic loads due to machinery and equipment. Shed-type structures have emerged as one of the most practical and widely adopted solutions for such applications. These structures are characterized by their simple geometry, sloping roofs, and efficient load transfer mechanisms. The design of shed structures allows for effective drainage of rainwater, proper ventilation, and natural lighting, making them suitable for industrial environments. Furthermore, their relatively simple structural configuration enables faster construction, reduced labor requirements, and lower overall project costs. Steel is the most commonly used material for the construction of shed-type structures due to its numerous advantages. It possesses a high strength-to-weight ratio, which allows for the design of lightweight yet strong structural elements. This characteristic is particularly beneficial for large-span structures, where minimizing self-weight is essential to reduce foundation loads and overall construction costs. Additionally, steel is a ductile material, which provides better performance under dynamic and seismic loading conditions. Its ability to undergo significant deformation before failure enhances the safety and reliability of structures.

II. METHODOLOGY

MODELING USING STAAD PRO V8I:

The structural modeling and analysis of the industrial shed structures are carried out using STAAD Pro V8i, which is one of the most widely used software tools in structural engineering practice. It provides a powerful platform for modeling complex structures, applying loads, and performing detailed analysis in accordance with design codes. In the present study, both Pre-Engineered Building (PEB) and Conventional Steel Building (CSB) models are developed using STAAD Pro V8i. The software enables accurate simulation of structural behavior under various loading conditions, thereby ensuring reliable and precise results.

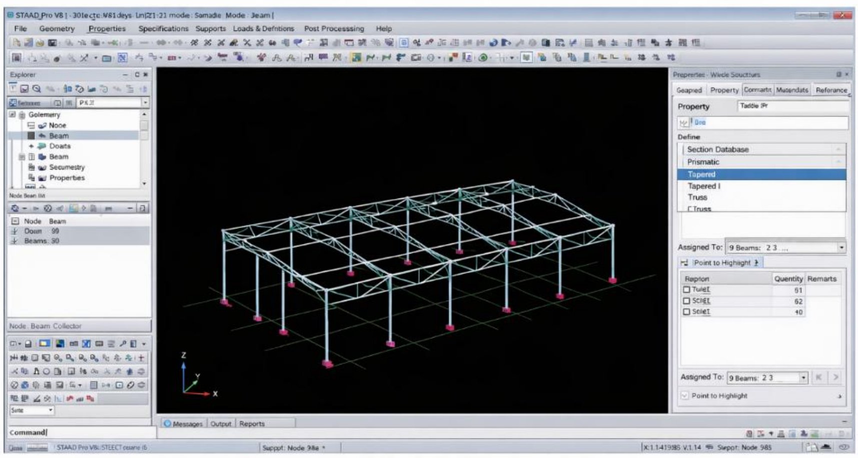
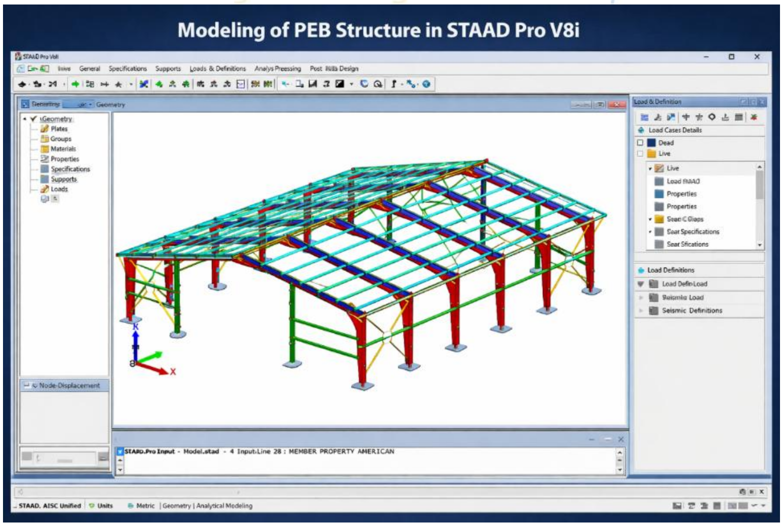


Figure 2.1: Working Interface of STAAD Pro V8i



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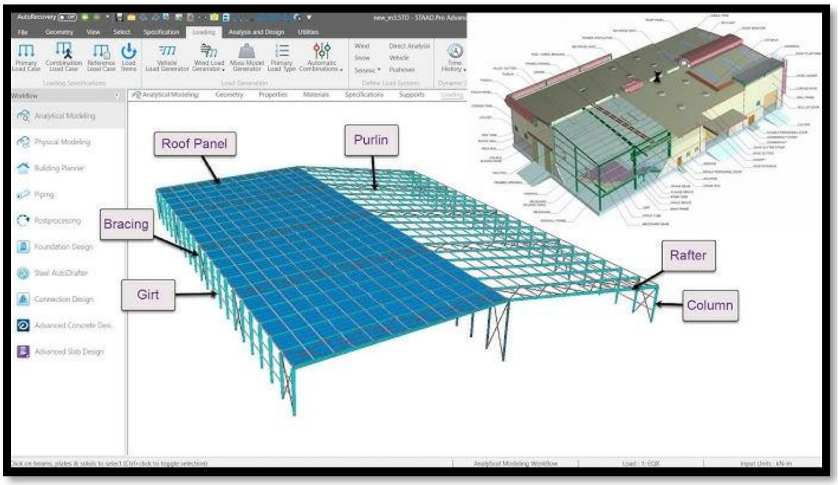

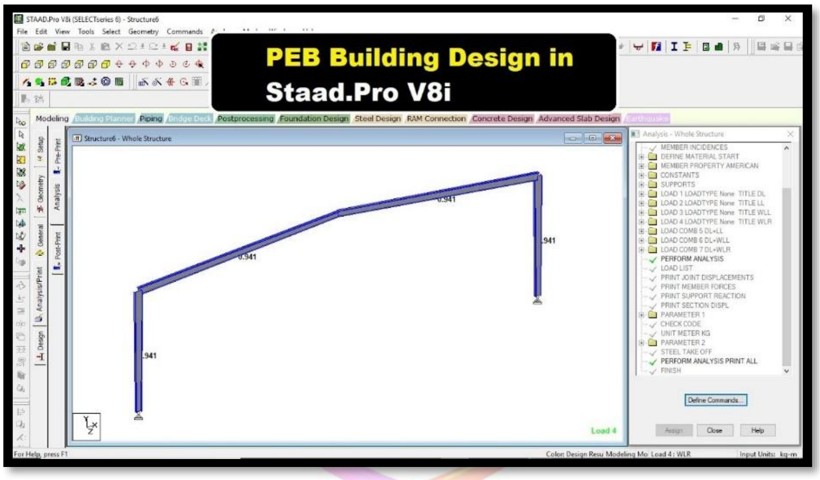

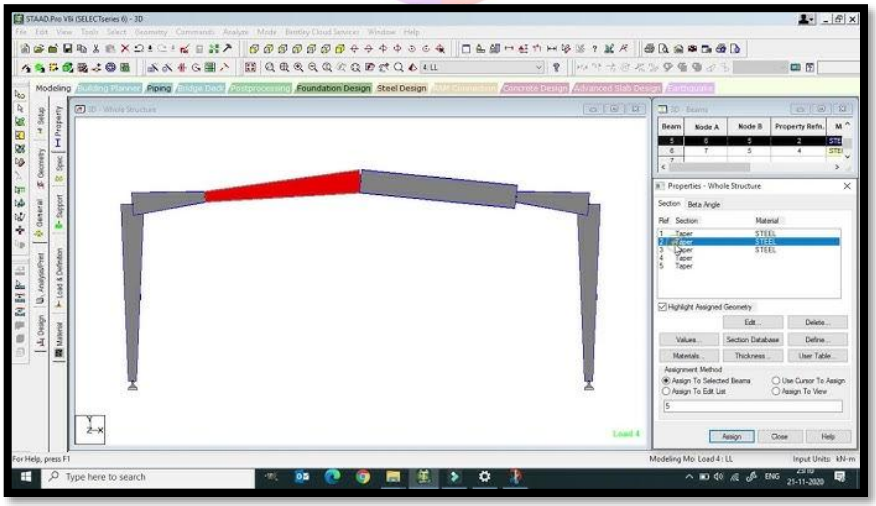

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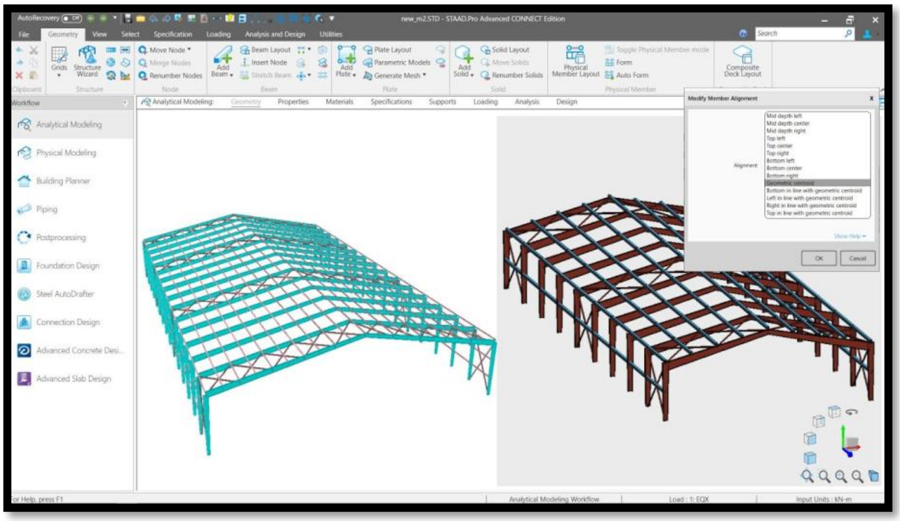


Figure 2.2: Software Modeling by using STAAD Pro V8i of PEB Structure

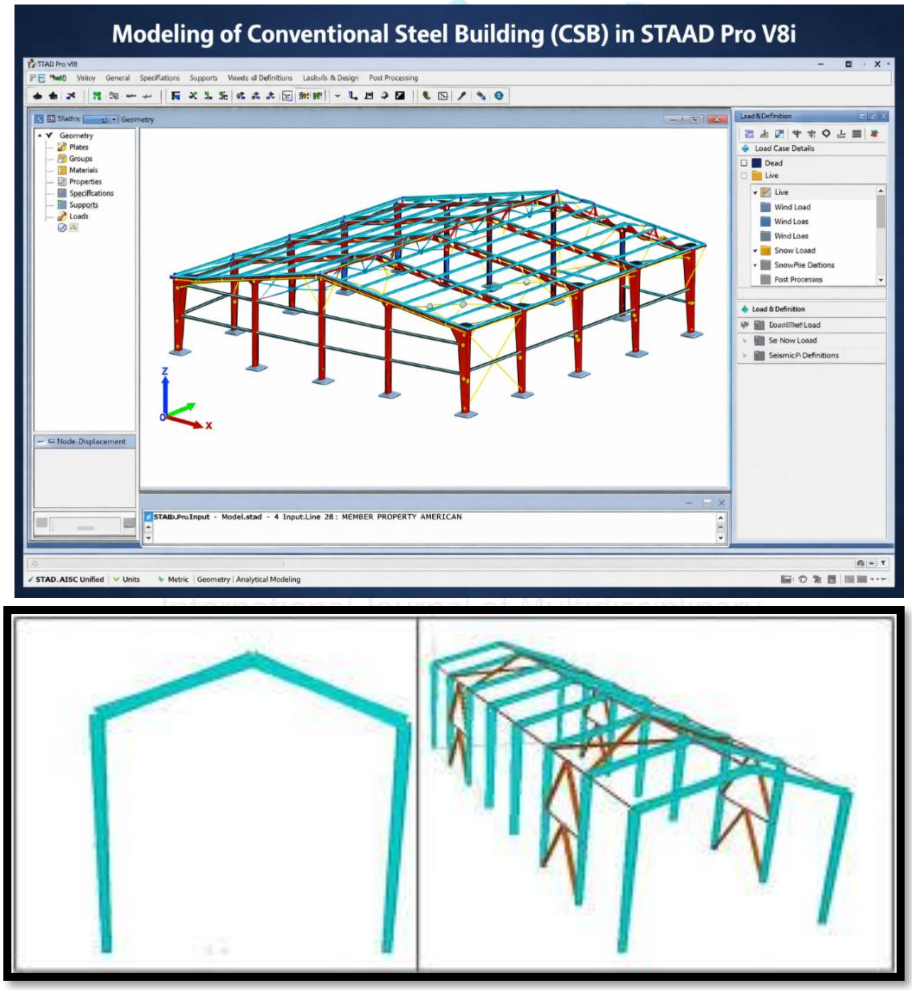
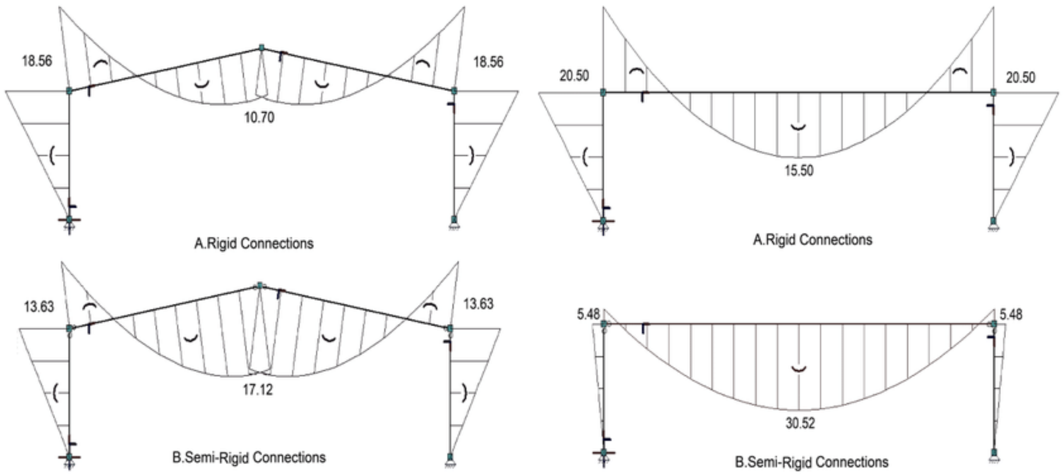


Figure 2.3: Software Modeling by using STAAD Pro V8i of CSB Structure

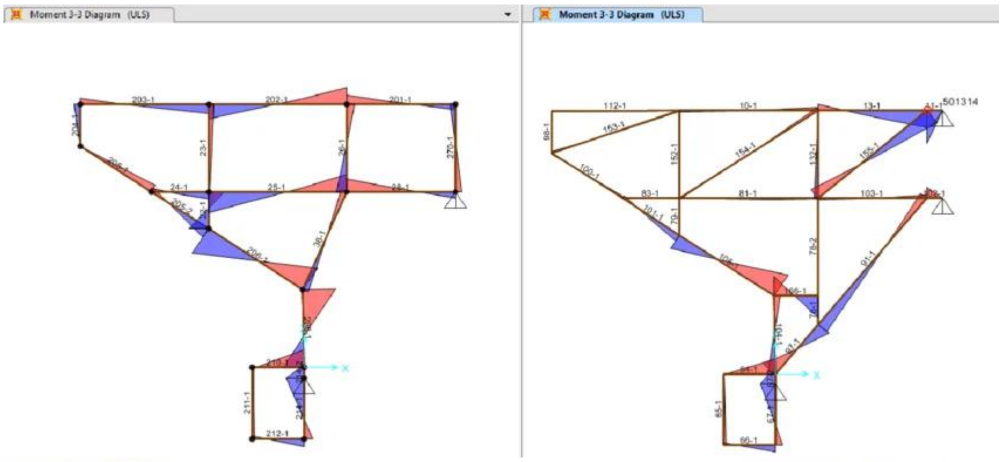
III. RESULTS AND DISCUSSION

BENDING MOMENT ANALYSIS:

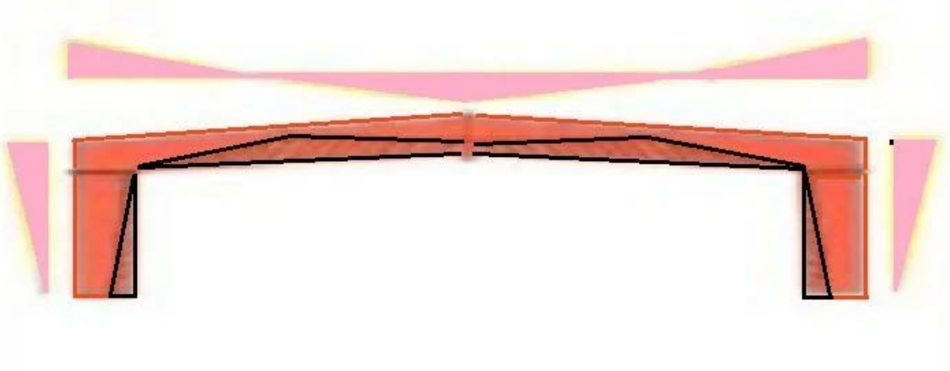
Bending moment is one of the most critical parameters in structural design as it governs the design of beams, rafters, and columns.

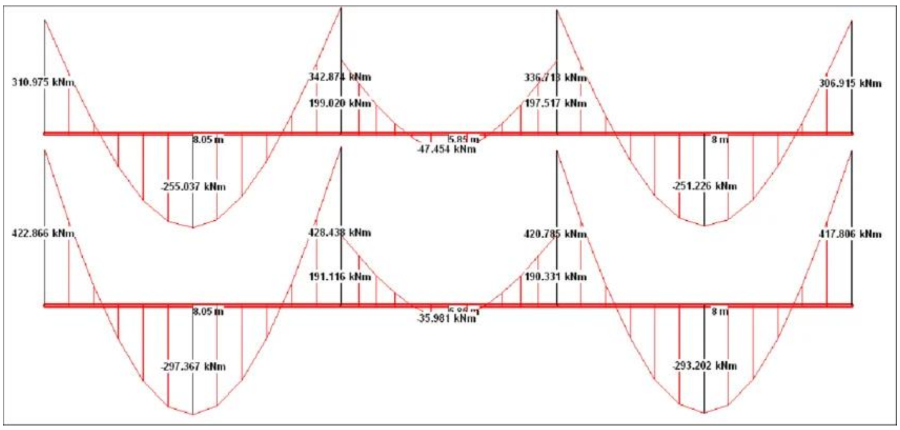


18.56
18.56
10.70
A.Rigid Connections
20.50
20.50
15.50
A.Rigid Connections
13.63
13.63
17.12
B.Semi-Rigid Connections
5.48
5.48
30.52
B.Semi-Rigid Connections



Moment 3-3 Diagram (ULS)
Moment 3-3 Diagram (ULS)





310.975 kNm
342.874 kNm
199.020 kNm
336.718 kNm
197.517 kNm
306.915 kNm
8.05 m
47.454 kNm
8 m
-255.037 kNm
-251.226 kNm
422.866 kNm
428.438 kNm
191.116 kNm
420.785 kNm
190.331 kNm
417.806 kNm
8.05 m
35.981 kNm
8 m
-297.367 kNm
-293.202 kNm

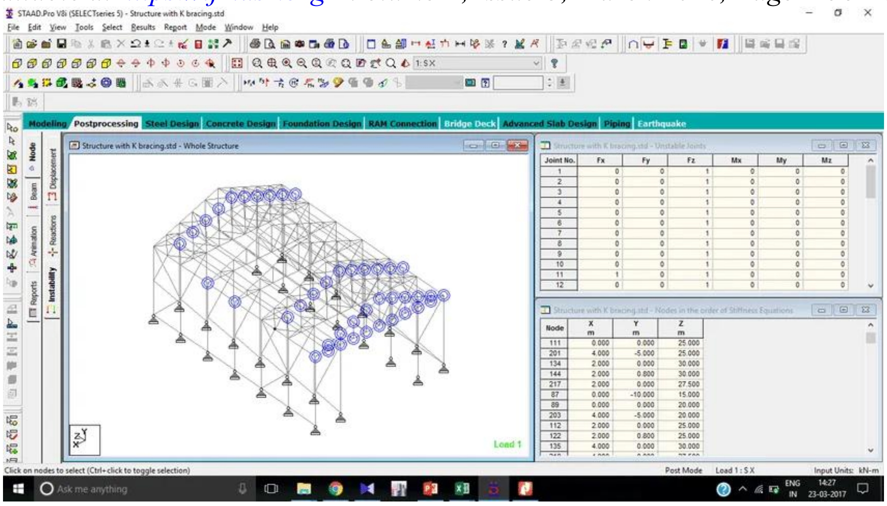
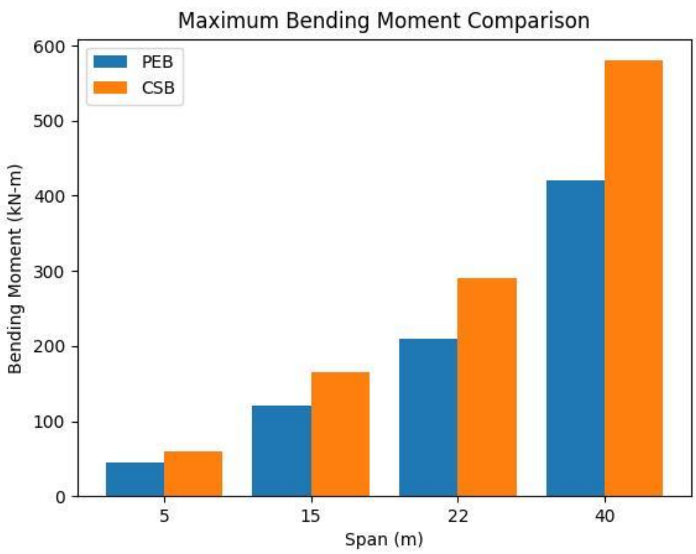


Figure 5.1: Bending Moment Analysis

Table 5.1: Maximum Bending Moment Comparison

Span (m)	PEB (kN-m)	CSB (kN-m)
5	45	60
15	120	165
22	210	290
40	420	580



Graph 5.1: Maximum Bending Moment Comparison between PEB and CSB

Observations:

- It is observed that the bending moment increases with increase in span for both PEB and CSB structures.
- For all span values, the bending moment in CSB is significantly higher than in PEB.
- The difference in bending moment becomes more pronounced as the span increases.

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- At a span of 40 m, the bending moment in CSB (580 kN-m) is considerably higher compared to PEB (420 kN-m), indicating a difference of approximately 25–30%.
- PEB structures consistently show lower bending moment values across all spans, indicating better structural efficiency.

SHEAR FORCE ANALYSIS:

Shear force indicates the internal force acting perpendicular to the member axis.

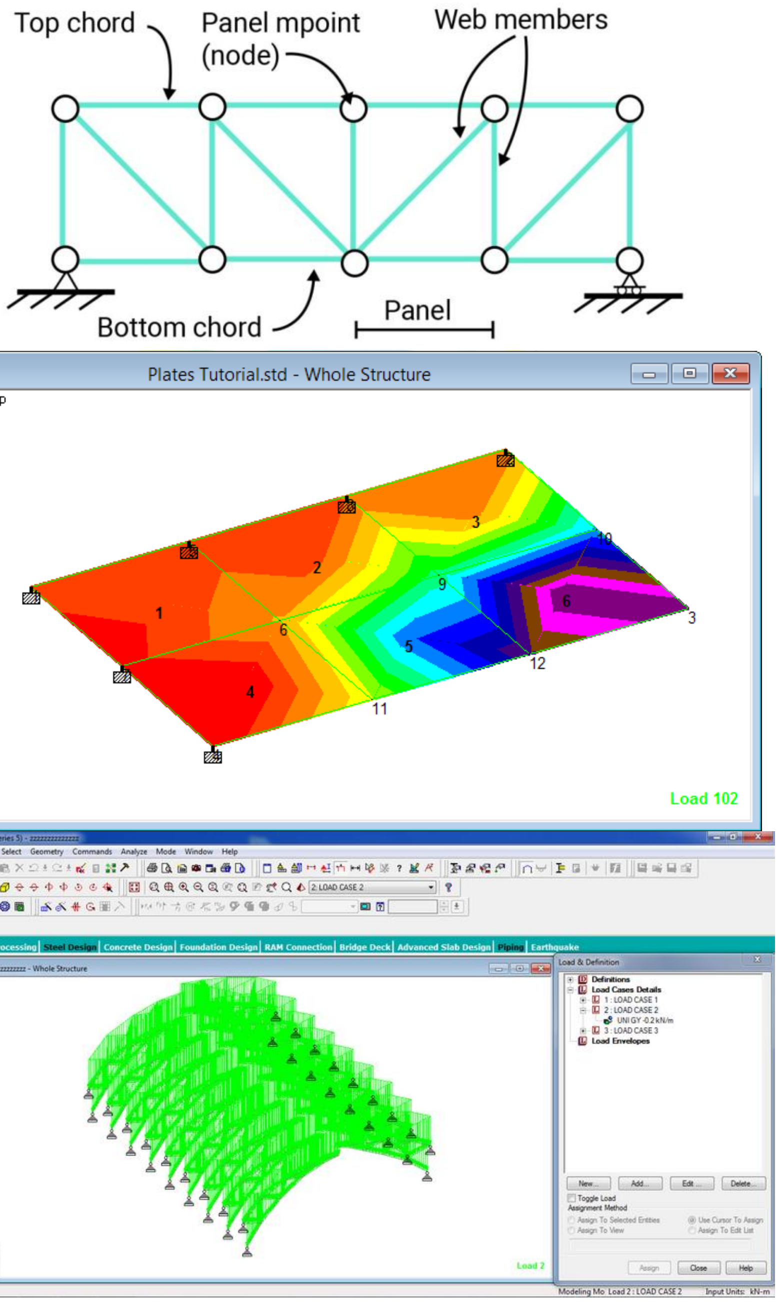
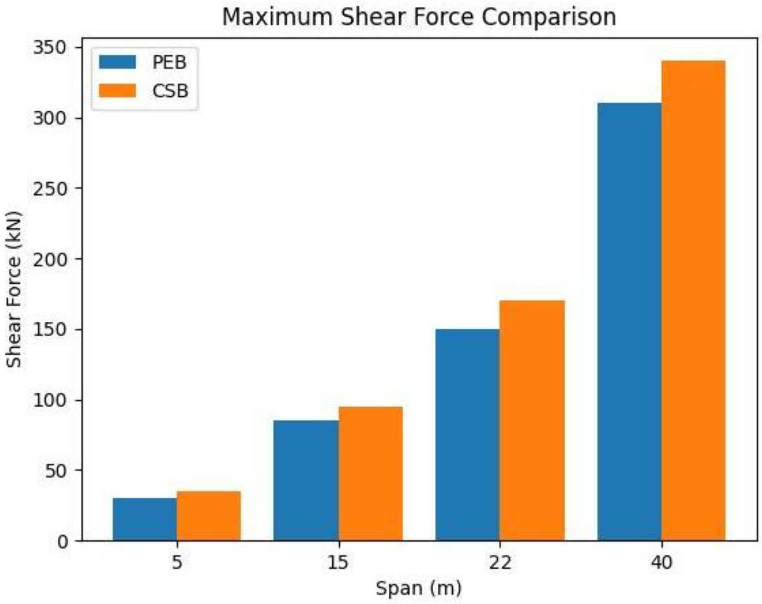


Figure 5.2: Shear Force Analysis

Table 5.2: Maximum Shear Force Comparison

Span (m)	PEB (kN)	CSB (kN)
5	30	35
15	85	95

22	150	170
40	310	340



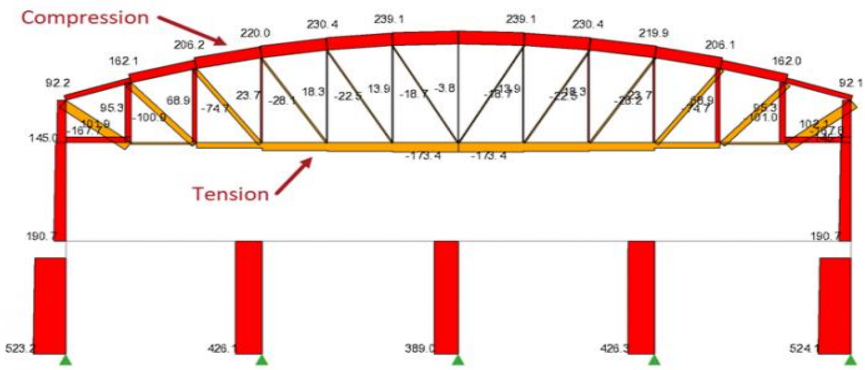
Graph 5.2: Maximum Shear Force Comparison (PEB vs CSB)

Observations:

- ❖ It is observed that the shear force increases with increase in span for both PEB and CSB structures.
- ❖ For all spans, the shear force in CSB structures is slightly higher than in PEB structures.
- ❖ The difference in shear force between PEB and CSB is relatively small compared to bending moment differences.
- ❖ At a span of 40 m, the shear force in CSB (340 kN) is higher than PEB (310 kN), showing a difference of approximately 8–10%.
- ❖ Maximum shear force occurs near the supports in both structural systems.

AXIAL FORCE ANALYSIS:

Axial force represents tension or compression in members.



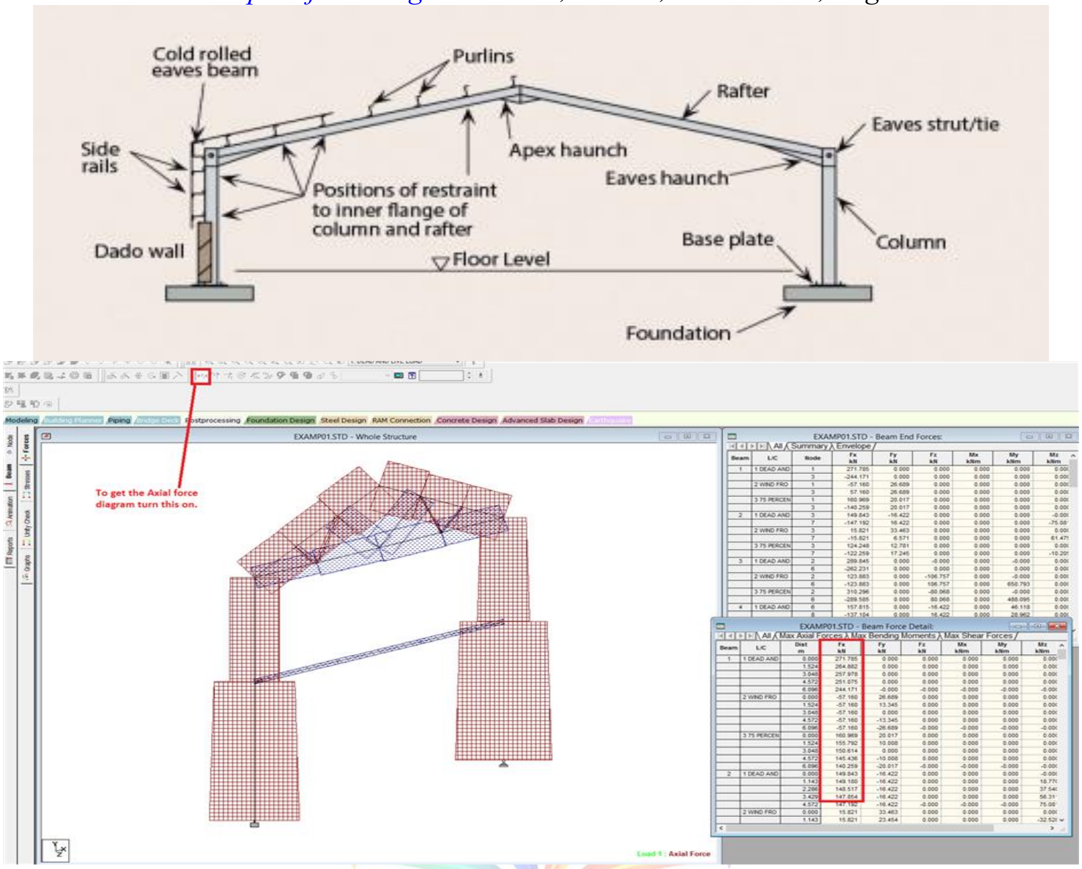
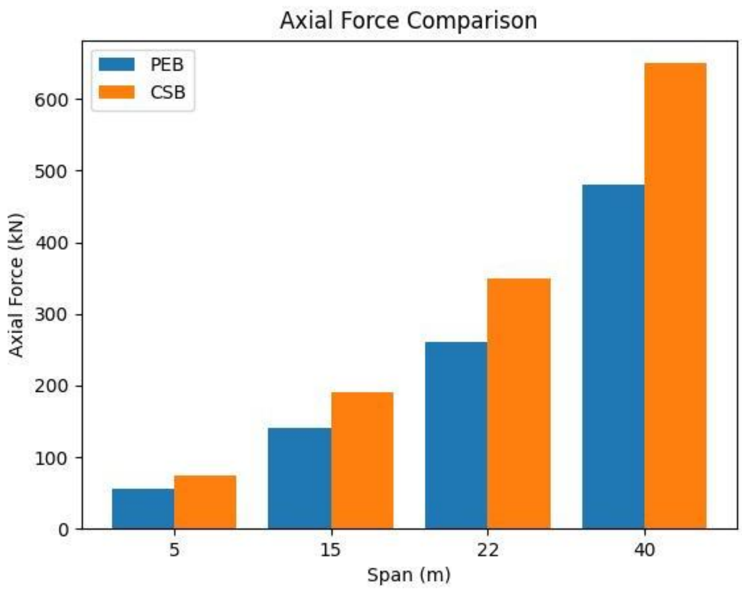


Figure 5.3: Axial Force Analysis

Table 5.3: Axial Force Comparison

Span (m)	PEB (kN)	CSB (kN)
5	55	75
15	140	190
22	260	350
40	480	650



Graph 5.3: Axial Force Comparison (PEB vs CSB)

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Observations:

- It is observed that the axial force increases with increase in span for both PEB and CSB structures.
- For all span values, the axial force in CSB structures is significantly higher than in PEB structures.
- The difference in axial force becomes more prominent at larger spans.
- At a span of 40 m, the axial force in CSB (650 kN) is considerably higher than in PEB (480 kN), showing a difference of approximately 30–35%.
- CSB structures exhibit higher axial forces in truss members, whereas PEB structures show more uniform force distribution.

DEFLECTION ANALYSIS:

Deflection is a key parameter for serviceability.

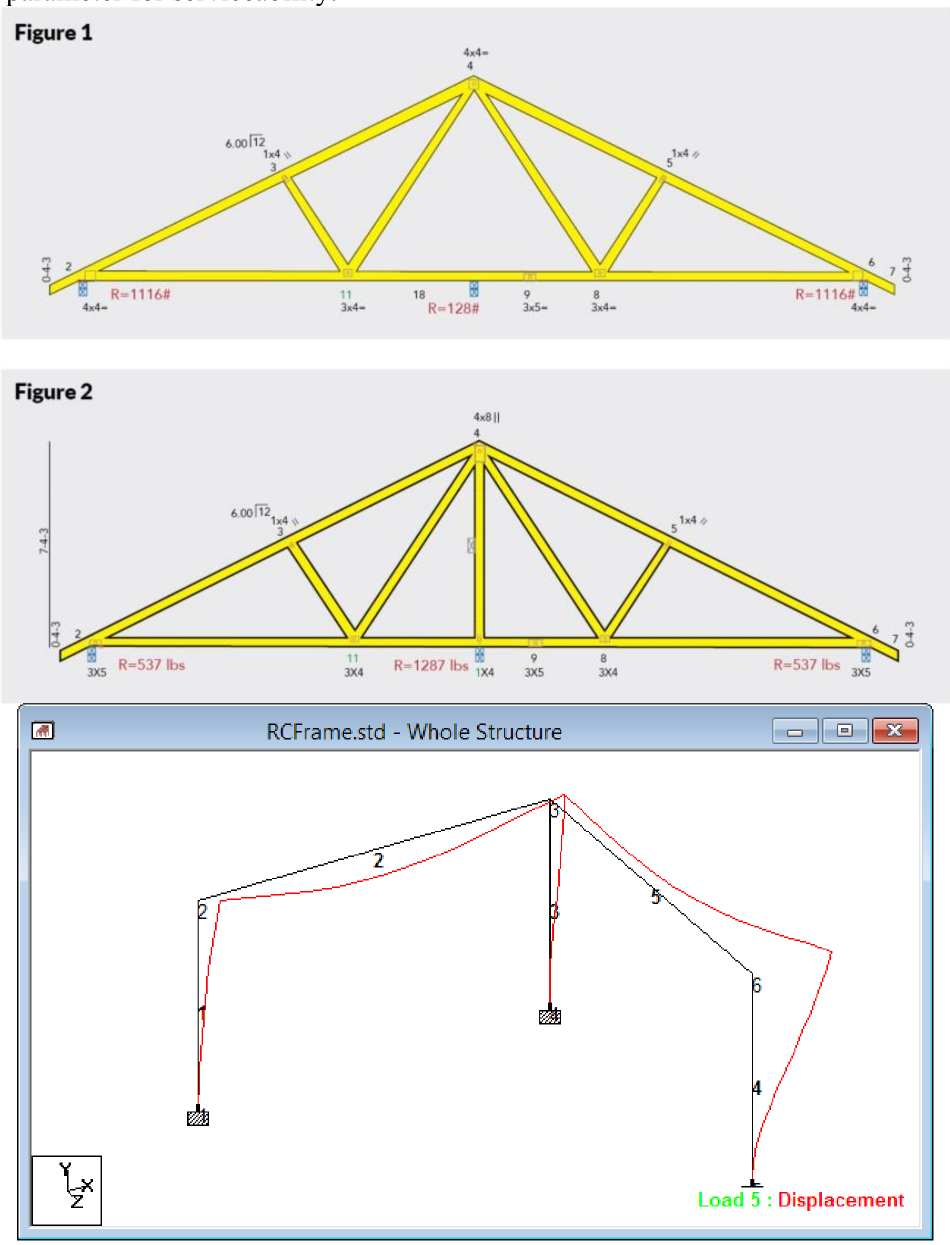
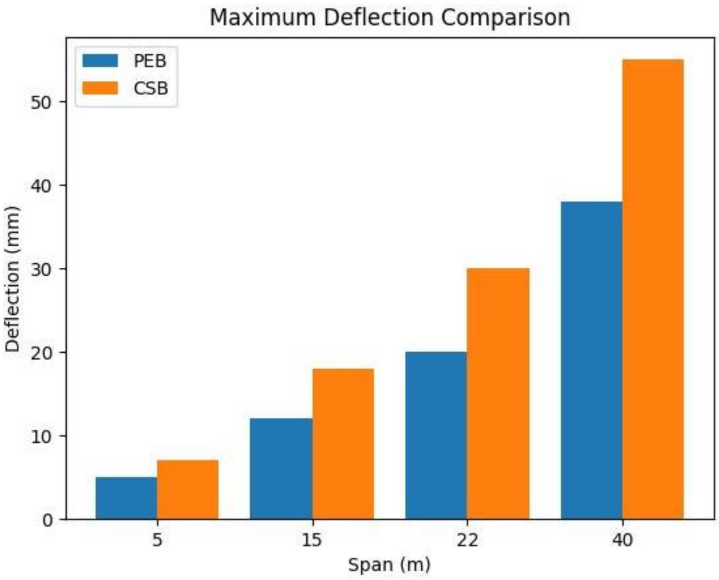


Figure 5.4: Deflection Analysis

Table 5.4: Maximum Deflection Comparison

Span (m)	PEB (mm)	CSB (mm)
5	5	7

15	12	18
22	20	30
40	38	55



Graph 5.4: Maximum Deflection Comparison (PEB vs CSB)

Observations:

- It is observed that the deflection increases with increase in span for both PEB and CSB structures.
- For all span values, the deflection in CSB structures is significantly higher than in PEB structures.
- The difference in deflection becomes more pronounced at larger spans.
- At a span of 40 m, the deflection in CSB (55 mm) is much higher compared to PEB (38 mm), indicating a difference of approximately 30–35%.
- PEB structures consistently show lower deflection values, indicating better stiffness.

CONCLUSION

Based on the detailed analysis and comparison, it is concluded that Pre-Engineered Building (PEB) structures perform more efficiently than Conventional Steel Buildings (CSB) in almost all aspects. PEB structures show better structural efficiency due to the use of tapered sections, resulting in lower bending moments (about 20–30% reduction), slightly lower shear forces, and more uniform axial force distribution, which reduces the risk of buckling. They also exhibit significantly lower deflection (around 25–35%), indicating higher stiffness and improved serviceability. In terms of economy, PEB structures achieve 20–30% reduction in steel weight, leading to lower construction and foundation costs, making them more sustainable and cost-effective. Additionally, PEB structures are highly suitable for large-span applications and offer faster construction due to prefabrication, whereas CSB structures are comparatively less efficient and more suitable for smaller spans.

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