Design And Analysis of a Clear Span PEB Structure by using Staad Pro Software

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Abstract—**The demand for economical, durable, and rapidly constructed buildings has encouraged the wide use of Pre-Engineered Buildings (PEBs) in industrial and commercial sectors. This study presents the structural design and analysis of a clear-span PEB using STAAD.Pro software. The aim is to evaluate the structure's performance under various loading conditions while ensuring safety, material efficiency, and compliance with both international and Indian standards. The design of the steel members follows AISC 360-16, while load combinations are based on ASCE 7-16. Wind and seismic loads are considered according to IS 875 (Part III): 2015 and IS 1893 (Part I): 2016.**
A single clear-span steel frame, without intermediate supports, is modelled to provide an unobstructed functional space suitable for industrial applications. The analysis results demonstrate that the selected sections and design approach achieve structural stability, efficient material usage, and cost-effectiveness. This work highlights the benefits of integrating computer-aided design tools with modern code provisions to produce reliable and optimized PEB structures.

Index Terms—**Pre-Engineered Building, STAAD.Pro, AISC 360-16, ASCE 7-16, IS 875, IS 1893.**

I. INTRODUCTION

In recent years, the construction industry has been moving toward solutions that combine structural efficiency, economic feasibility, and faster project execution. Among these modern methods, Pre-Engineered Buildings (PEBs) have become increasingly popular because they minimize material wastage, reduce construction time, and allow for large unobstructed spaces that are ideal for warehouses, factories, and industrial facilities. A clear-span PEB is a structural system that eliminates intermediate columns, creating an open floor area suitable for flexible usage and easy movement of machinery or materials. The main members of such structures are typically fabricated from tapered built-up steel sections, while secondary members consist of cold-formed elements that help in distributing loads and improving the overall stiffness of the frame. The evolution of computer-aided structural analysis tools has significantly improved the precision and efficiency of building design. Among these, STAAD. Pro stands out as a versatile software that allows engineers to model complex geometries, apply various load combinations, and verify compliance with multiple design codes.

In this study, the design and analysis of a clear-span PEB are performed using STAAD. Pro, following the standards of AISC 360-16 for steel member design and ASCE 7-16 for load combinations. To ensure that the structure reflects local environmental conditions, IS 875 (Part III): 2015 is used for wind load evaluation and IS 1893 (Part I): 2016 for seismic analysis. The primary objective of this work is to evaluate the performance and economy of a clear-span steel frame under various loading scenarios. The study emphasizes how integrating international steel design practices with Indian load criteria can yield a balanced, safe, and cost-effective structural solution suitable for modern industrial construction.

Components of steel building:
1. Primary Members:
   - Columns
   - Beams
   - Rafters
   - Bracing
   - Steel plates etc.,

2. Secondary Members:
- Purlins/Girts
- Flange Braces
- Sag Angles
- Channels etc.,

3. Sheeting Items:
- Panels
- Trims
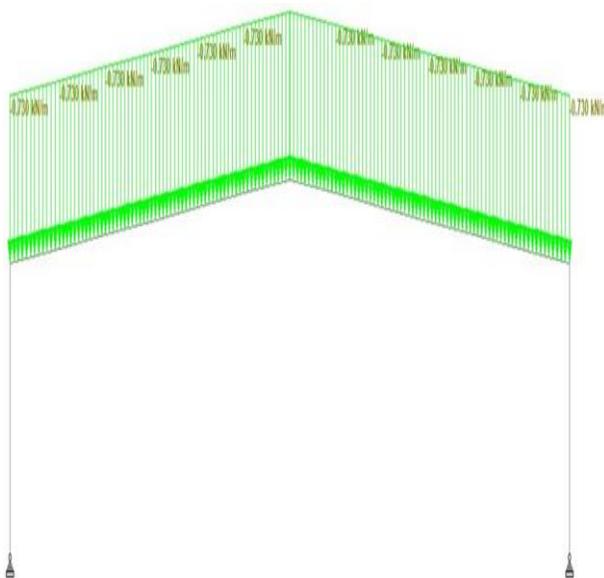- Flashings
- Straps etc.,

Building specifications:
- It is a Rigid Frame Building.
- Length of the Building = 58m.
- Width of the Building = 36.25m.
- Clear Height of the Building = 5.8m.
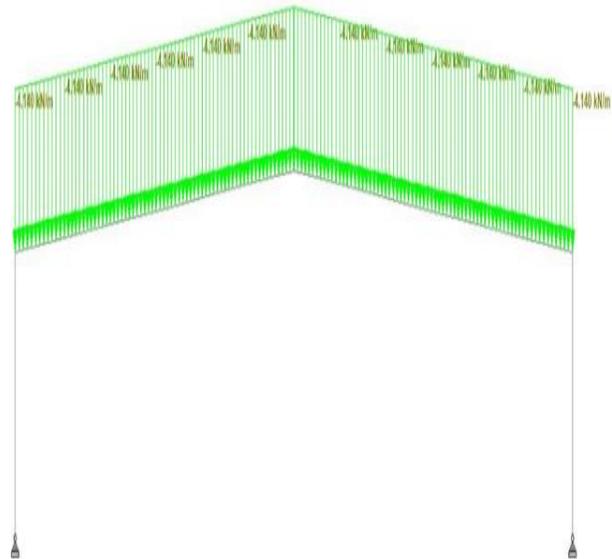- Bay spacing = 8@ 7.25 M

Loading Conditions:
- Dead Load = 0.1kn/m²
- Live Load= 0.57kn/m²
- Wind Load = As per IS875 part-III 2015
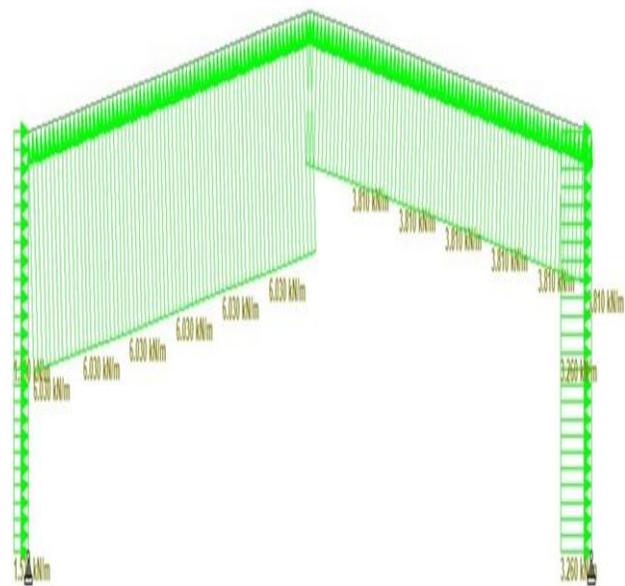- Standard =AISC (American Standard)

LOADINGS:
- Dead load = 0.1 kn/m²

- Live load = 0.57 kn/m²

- Wind Load As Per IS 875 Part –III (2015)

II. STAAD PRO ANALYSIS REPORT: MATERIAL PROPERTIES (ISOTROPIC STEEL)

Property	Symbol	Value
Elastic Modulus	E	2.05×10^8 kN/m²
Poisson's Ratio	ν	0.30
Density	ρ	76.8195 kN/m³
Coeff. of Thermal Expansion	α	1.2×10^{-5} /°C
Damping Ratio	D	0.03

i. MEMBER DETAILS:

Member Type	Member Nos.	Section Type	Depth (mm)	Flange Thk (mm)	Web Depth (mm)	Web Thk (mm)
Columns	1,2,5,6	Tapered	420–924	5–12	200	10–12
Rafters	3,4,7–16	Tapered	612–916	4–6	150–200	6–12

ii. SUPPORT CONDITIONS:

Joint No.	Type	Remarks
1	Pinned	Base
5	Pinned	Base

iii. LOAD DETAILS:

(a) Seismic Load (IS 1893 Zone II)

Parameter	Symbol	Value
Zone Factor	Z	0.10
Response Reduction	R	4.0
Importance Factor	I	1.0
Soil Type	-	Type II
Damping	-	0.02

(b) Dead Load

Type	Members	Direction	Magnitude (kN/m)
Self weight	All	Y	-1.0
Member Load	3,4,7–16	GY	-0.73

iv. LOAD COMBINATIONS:

Combo No.	Description	Included Loads
501	1 DL	3
502	1 DL + 1 LL	3,4
503–508	1 DL + 1 WL	3 + (5–10)
509–510	1 DL + 0.7 EQ	3 + (1,2)
511–516	1 DL + 0.75 LL + 0.75 WL	3,4 + (5–10)
519–524	0.6 DL + 1 WL	3 + (5–10)
525–526	0.6 DL + 0.7 EQ	3 + (1,2)

v. DESIGN PARAMETERS (AISC UNIFIED 2010 - ASD):

Parameter	Value	Members Applied
Design Code	AISC Unified 2010 (ASD)	All
Yield Strength Fy	345 MPa	All
Ultimate Strength Fu	490 MPa	All
Unbraced Lengths	LX=1.5m, LY=1.5m, LZ=6.3–18.215m	Columns/Rafters
KZ	1.5	Columns
CB	0	All
STP	2	All

DESIGN RESULTS (SUMMARY):

(a) Code Check Results

Member No.	Description	Utilization Ratio	Status
1	Column	0.78	OK
2	Column	0.83	OK
3	Rafter	0.69	OK
8	Rafter	0.72	OK

(b) Deflection Summary

Member No.	Max Deflection (mm)	Allowable Limit (mm)
3	18.2	25 (L/240)
7	16.5	25 (L/240)

(c) Steel Take-Off Summary

| Member Type	Total Length (m)	Weight (kg)
Columns	12.6	890
Rafters	36.4	2430

III. RESULTS

The structural model of the clear-span Pre-Engineered Building (PEB) was analysed in STAAD. Pro under various load combinations defined by the relevant design codes. The analysis included dead, live, and wind loads to evaluate the overall performance, stability, and safety of the structure. The main outcomes of the analysis are discussed below.

Utilization ratio:

The utilization ratio is a measure of how efficiently a structural member carries the applied loads relative to its design strength. It is the ratio of the actual stress or load to the allowable limit.

$$\text{Utilization Ratio} = \frac{\text{Actual Load or Stress}}{\text{Allowable Load or Strength}}$$

- UR < 1.0: Member is safe with reserve capacity.
- UR = 1.0: Member is optimally utilized.
- UR > 1.0: Member is overstressed and needs redesign.
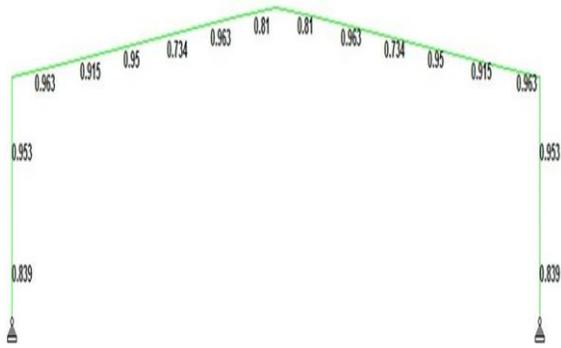
In this analysis, all members exhibited utilization ratios within safe limits, confirming that the selected sections are both structurally adequate and economical.

Support Reactions:

The structure was modelled with pinned supports at the base to simulate realistic boundary conditions. The resulting reaction forces were evenly distributed, indicating proper load transfer from the superstructure to the foundation. This balance validates the overall stability and adequacy of the support arrangement.
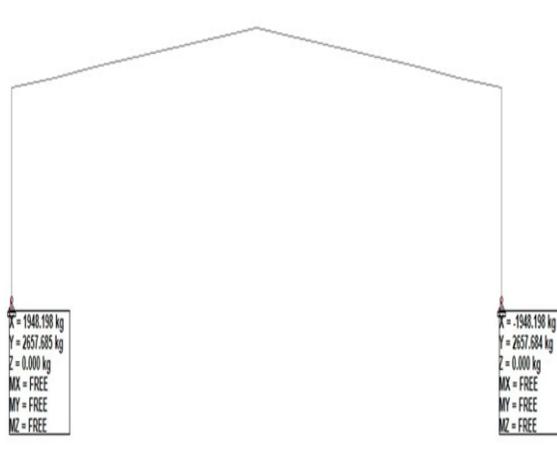

Beam Stress Diagram:

The beam stress diagram illustrates the variation of stresses along the rafter or beam under combined loading conditions. The STAAD. Pro output shows that the maximum bending stresses occur near the supports and gradually reduce toward the mid-span. All stress values fall within the permissible limits prescribed by AISC 360-16, ensuring safe and efficient performance of the primary frame members. This confirms that the selected beam sections are

neither under-designed nor excessively strong, optimizing both safety and economy.
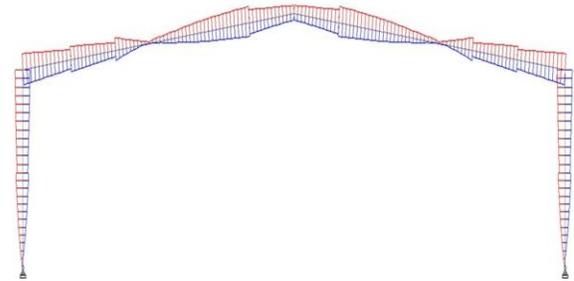
Bending Moment Diagram:
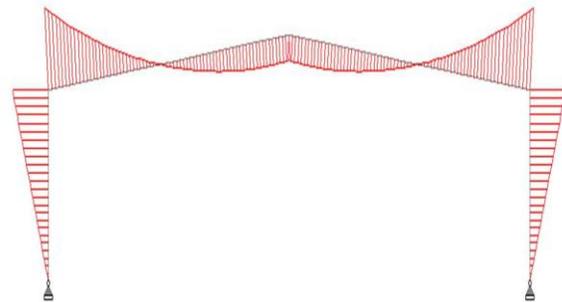
The bending moment distribution along the frame was analyzed for all critical load combinations. The maximum bending moment was observed near the mid-span for simply
supported regions and at the joints in rigid frame connections. The results show that the
moment capacity of the members is sufficient to resist the applied loads without exceeding allowable design limits. The bending moment diagram also helped in verifying the continuity and stiffness of the frame, confirming its structural integrity.

Shear Force Diagram:
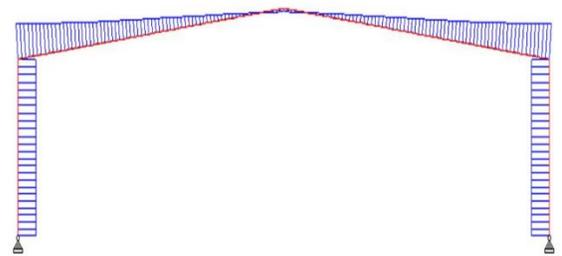
The shear force diagram describes how internal shear varies along each beam or rafter. The analysis revealed that the highest shear occurs near the supports, while it decreases toward the center of the span. All members successfully passed shear strength checks, with no risk of web buckling or yielding. The results confirm that the structure efficiently transfers vertical loads to the supports through a well-distributed load path.

ANCHOR BOLT PLAN

The both images are illustrating the structural framing for a steel building and the Anchor Bolt plan of a steel building which is including with Base Plate, steel column and bolts. Specifically, the rigid frame cross sections along designated grid lines. These frames represent the primary load bearing structure of the building, designs to support roof loads, wind loads and other lateral forces

RIGID FRAME CROSS SECTION @ GRID LINE - 2,3,4,5,6
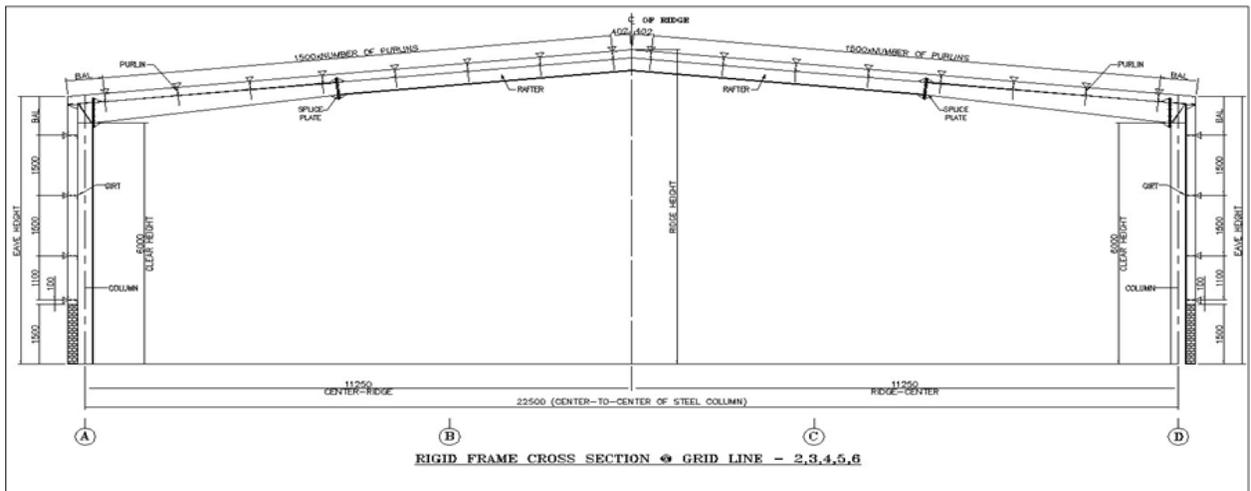
IV. CONCLUSION

This project successfully demonstrates the design and structural analysis of a clear-span Pre- Engineered Building (PEB) using STAAD.Pro software. The structure was evaluated under different loading conditions including dead, live, and wind loads, with design provisions based on AISC 360-16, ASCE 7-16, IS 875 (Part III): 2015, and IS 1893 (Part I): 2016.The analytical results confirm that all structural members columns, rafters, and purlins are within the permissible

stress limits, with utilization ratios well below unity. This indicates that the selected sections provide sufficient strength while maintaining material efficiency. The load transfer mechanisms, as shown through bending moment and shear force diagrams, validate the stability and stiffness of the frame under different load combinations. By integrating American and Indian design standards, the structure achieves a balanced combination of safety, efficiency, and economy, making it suitable for industrial and warehouse applications. The use of STAAD. Pro simplified complex analytical procedures, ensured accuracy, and enabled effective visualization of structural behavior under loads.

Overall, this study concludes that Pre-Engineered Building systems offer a reliable and cost- effective alternative to conventional steel structures. Their ability to deliver quick construction, optimized material use, and flexible space planning makes them an ideal solution for modern industrial construction practices.

REFERENCE

[1] Hubli, Kiran, and R. J. Fernandes. "Design of Pre-engineered Building (PEB) Structural Frame." In International Conference on Recent Advances in Civil Engineering, pp. 41-49. Singapore: Springer Nature Singapore, 2022.

[2] Kuralkar, Abhishek R., and Isha P. Khedikar. "Study on PEB Structure and Conventional Steel Building: A Review." In International Conference on Recent Trends in Infrastructural Development and Sustainable Materials, pp. 215-223. Cham: Springer Nature Switzerland, 2023.

[3] Aamir, Mohd, and Sheela Malik Ravinder. "Design of Pre-Engineered Building (PEB) Structure." (2022).

[4] Kumar, A. Sravan, Sanjeev Rao, Madan Mohan, and Dr Sreenatha Reddy. "Design and Analysis of Pre-Engineered Industrial Buildings (PEB)." Int. J. Appl. Sci., Eng. Manag 3, no. 06 (2014): 2320-3439.

[5] Saleem, Muhammad Umair, and Hisham Jahangir Qureshi. "Design solutions for sustainable construction of pre-engineered steel buildings." Sustainability 10, no. 6 (2018): 1761.

[6] Dilip, GiteKalyani, and M. P. Wagh. "Design and Analysis of PEB Warehouse: Using Staad-Pro."

[7] Shaik, Kalesha, Ratnamala Reddy BSS, and DurgaChaitanya Kumar Jagarapu. "An analytical study on preengineered buildings using staad pro." Materials today: proceedings 33 (2020): 296-302.