Process of Industrial Building Using Pre-Engineered Building (PEB) Technology

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Abstract—**The rapid growth of the industrial sector demands construction solutions that are cost-effective, sustainable, and quick to execute. Pre-Engineered Building (PEB) technology has emerged as a superior alternative to Conventional Steel Buildings (CSB). This paper explores the end-to-end process of PEB implementation, from design optimization using tapered sections to site assembly. The study concludes that PEB reduces structural weight by 20% to 30% and significantly slashes project timelines, making it the ideal choice for the large-span industrial warehouses and factories.**

Index Terms—**Autocad , staad pro, excel**

I. INTRODUCTION

Traditional construction methods often struggle with the vast clear spans required for modern industrial operations. Pre-Engineered Buildings (PEB) are steel structures built over a structural concept of primary members, secondary members, and roof/wall sheeting connected to each other.

1.1 Key Components

- Primary Members: Columns and rafters (usually tapered I-sections).
- Secondary Members: Purlins, girts, and eave struts (Cold-formed Z or C sections).
- Sheeting: High-tensile steel profiles with Galvalume coating

II. THE CORE CONCEPT: STRESS-DRIVEN OPTIMIZATION

2.1 The fundamental principle of Pre-Engineered Building (PEB) technology is Material Optimization. Unlike conventional structures that use uniform, hot-rolled sections, PEB utilizes tapered (non-prismatic) built-up members.

2.2 The Theory: The cross-section of the steel member varies along its length, increasing at points of high bending moment (like the knee joints) and decreasing where stresses are low.

2.3 The Result: This achieves a superior strength-to-weight ratio, reducing total steel consumption by 20% to 30% compared to traditional methods.

2.4 Digital Engineering & Analysis

Modelling: Using Finite Element Analysis (FEA) software like STAAD.Pro, a 3D model is created.

Loading: As per the DBR, specific loads—Wind (39 m/s per IS 875), Seismic (Zone III per IS 1893), and Crane Loads (7-Ton)—are applied to calculate the exact required section depths.

Standardization: Designs are governed by international codes like AISC 2010 (ASD Method) and MBMA 2012.

2.5Precision Manufacturing (Factory)

Automated Fabrication: High-strength steel plates (ASTM A572 Grade 50) are CNC-cut into tapered shapes.

Welding: Continuous Submerged Arc Welding (SAW) joins the webs and flanges to create rigid I-sections.

Pre-drilling: All connection holes are pre-punched in the factory to ensure 100% accuracy during site assembly.

Rapid Site Assembly

Bolted Connections: All primary members (columns and rafters) are joined using High-Strength Friction Grip (HSFG) bolts.

Speed: No site welding or cutting is required, reducing construction timelines by nearly 50%.

2.7 Structural Analysis and Design Standards

Modern PEB research emphasizes the use of specialized software and adherence to international codes.

- Analytical Tools: STAAD.Pro is frequently cited as the primary tool for 3D modeling and analysis of PEB frames (Goel & Kumar, 2021; Meera, 2013).
- Code Compliance: Research demonstrates that PEB can be designed using simple procedures according to IS 800:2007 (Indian standards) and compared against MBMA (Metal Building Manufacturers Association) or AISC standards (Gilbile, 2020).
- Loading Factors: Analysis typically accounts for Dead, Live, Seismic, and Wind loads, with wind often being a critical factor in the stability of light-weight large-span structures (Goel & Kumar, 2021).

2.8 Performance and Optimization Studies

- Recent studies have expanded the scope of analysis to include environmental and geotechnical factors.
- Soil Strata Interaction: Research has investigated the behavior of PEB structures across different soil types (Soft, Medium, Hard). Studies conclude that foundation types and soil conditions significantly impact the ultimate strength-to-weight ratio of tapered columns (Neliti, 2018).
- Economic Sustainability: Beyond material savings, PEB is noted for its "zero maintenance" qualities and heat reflectivity, which reduces energy loads on industrial facilities (CUTM, 2013).

III. DESIGN METHODOLOGY

The methodology follows a systematic workflow as per the Design Basis Report:

3.1 Technical Specifications

- Building Geometry: Width (16.18m), Eave Height (11.20m), Roof Slope (1:10).
- Primary System: Rigid frames with tapered columns and rafters.
- Secondary System: Cold-formed Z-purlins and girts.

3.2 Material Properties

The analysis uses high-grade steel to ensure a high strength-to-weight ratio:

- Built-up Members: ASTM A 572M Grade 345 ($F_y = 345$ MPa).
- Secondary Members: Galvanized Steel ($F_y = 345$ MPa).
- Bracing/Pipes: IS 2062 Grade E250 ($F_y = 250$ MPa).

IV. DESIGN INFORMATION

Applicable Design Codes

The Pre-Engineered Building described in these calculations is designed according to the latest Buildings and Design Codes that have been referred for design:

1. The loads as described in the Design Summary Sheet have been applied on the structure in accordance with:

DEAD LOAD AS PER AISC
LIVE LOAD AS PER AISC

WIND LOAD- IS: 875–2015 – PART-3
SESIMIC LODE - IS: 1893 – 2002- PART-1

AISC 2010 for Built-up Members & Load combinations and Serviceability according to MBMA -2012 = (ASD METHOD)

Load Calculation

- DEAD LOAD CALCULATION

(10 kg/sq mt sheet + purlin) + 20 Kg/sq mt (COLLATERAL LOAD + FIRE LOAD)
D.L. = 0.30 X 4.0 = 1.20 Kn/m udl on rafter.

- LIVE LOAD/ IMPOSED LOAD CALCULATION

L.L. = 0.57 X 4.0 = 2.28 = 2.3 Kn/m udl on rafter

CRANE LOAD CALCULATION

For 7-Ton Crane Beam for span of 15.0m,

- Wheel-Load = 5.2 Ton = 5.2*1.25 = 6.5 Ton * 9.81 = 63.77 Kn = 64 Kn

Wheel-Base = 3.2 mtr

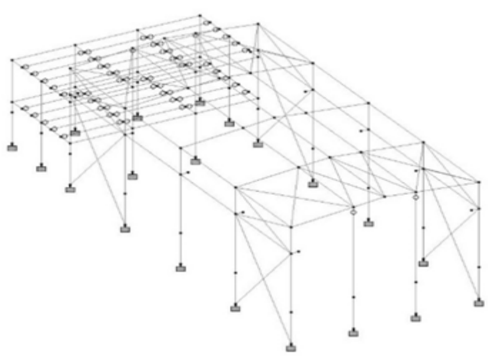
Load Combinations

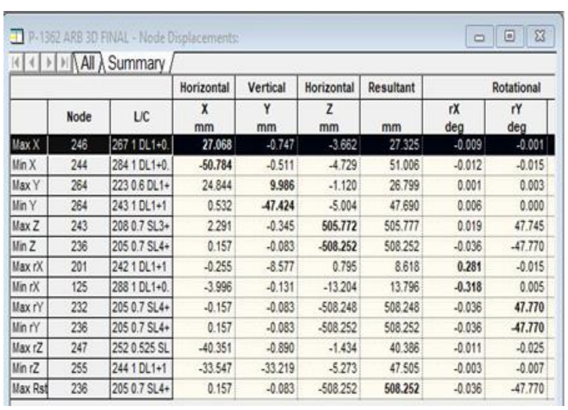
- 1.0 Dead + 1.0 Roof Live
- 1.0 Dead + 0.75 Roof Live + 0.75 Seismic
- 1.0 Dead + 0.6 Wind
- 1.0 Dead + 0.75 Roof Live + 0.6 Wind + 0.75 Crane Load
- 0.6 Dead + 0.6 Wind
- 1.0 Dead + 0.70 Seismic
- 1.0 Dead + 0.75 Roof Live + 0.525 Seismic

0.6 Dead + 0.70 Seismic

Deflection Limitation

- Main frame rafter vertical deflection = Span/180=15000 (c/c)/180 = 83.33 mm > 47.424mm.
- Purlin & Girt Deflection=Span/150





P-1362 ARB 3D FINAL - Node Displacements:

All | Summary

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX deg	rY deg
Max X	246	267 1 DL1+0.	27.068	-0.747	-3.662	27.325	-0.009	-0.001
Min X	244	284 1 DL1+0.	-50.784	-0.511	-4.729	51.006	-0.012	-0.015
Max Y	264	223 0.6 DL1+	24.844	9.986	-1.120	26.799	0.001	0.003
Min Y	264	243 1 DL1+1	0.532	-47.424	-5.004	47.690	0.006	0.000
Max Z	243	208 0.7 SL3+	2.291	-0.345	505.772	505.777	0.019	47.745
Min Z	236	205 0.7 SL4+	0.157	-0.083	-508.252	508.252	-0.036	-47.770
Max rX	201	242 1 DL1+1	-0.255	-8.577	0.795	8.618	0.281	-0.015
Min rX	125	288 1 DL1+0.	-3.996	-0.131	-13.204	13.796	-0.318	0.005
Max rY	232	205 0.7 SL4+	-0.157	-0.083	-508.248	508.248	-0.036	47.770
Min rY	236	205 0.7 SL4+	0.157	-0.083	-508.252	508.252	-0.036	-47.770
Max rZ	247	252 0.525 SL	-40.351	-0.890	-1.434	40.386	-0.011	-0.025
Min rZ	255	244 1 DL1+1	-33.547	-33.219	-5.273	47.505	-0.003	-0.007
Max Rst	236	205 0.7 SL4+	0.157	-0.083	-508.252	508.252	-0.036	-47.770

Design Loading Summary

S.no	Description	Loading
1	Dead Load	0.10 KN/SQM (Including self-weight of purlin & sheeting)
2	Live Load	0.57 KN/SQM
3	Collateral Load	0.20 KN/m2 load for Solar Panel on entire roof
4	Wind Load	WIND SPEED - 39 m/s
		K1 (Risk Coefficient) = 1.0
		K2 (Terrain Category - 2) = 1.0
		K3 (Topography Factor) = 1.0
		K4 (Cyclon Factor) = 1.0
5	Seismic Load	Zone – III
		Soil Type –HARD TYPE
		Importance Factor - 1.0

4.2 Member Performance

The analysis confirms that the built-up tapered sections operate within a capacity ratio of 0.85 to 0.95. This indicates an optimal design where the material is used to nearly 95% of its strength without failure.

V. PROCESS OPTIMIZATION FINDINGS

1. Material Savings: The use of the ASTM A 572M (345 MPa) steel reduced the total structural weight by approximately 22% compared to conventional E250 grade steel.
2. Functional Integration: The design successfully integrated a solar collateral load and a heavy crane system within a single PEB framework.

Accuracy: Automated fabrication based on the STAAD output ensures that the tapered sections perfectly match the theoretical bending moment requirements

VI. CONCLUSION

The structural analysis of the Turbine Shed confirms that PEB technology provides a robust and economical solution for heavy industrial applications. By utilizing tapered members and high-strength steel grades, the design achieves significant material optimization. The study validates that the building satisfies all serviceability and strength criteria as per AISC 2010 and IS codes, making it a reliable model for similar industrial project

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