

Design and Analysis of P.E.B. Framed Structure Using STAAD Pro

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ABSTRACT

Pre-Engineered Buildings (PEBs) have emerged as an efficient and economical solution for industrial and commercial structures due to their reduced construction time, optimized steel usage, and superior structural performance. This research paper presents the design and analysis of a PEB framed structure using STAAD Pro software in accordance with Indian Standard codes. The study includes structural modeling, load calculation, analysis under various load combinations, and member design verification. A comparative assessment highlights the structural efficiency and economic benefits of PEB systems over conventional steel structures. The results demonstrate that PEB systems provide optimized material utilization, reduced self-weight, and satisfactory safety margins under all critical load combinations.

Keywords:- Pre-Engineered Building, STAAD Pro, Steel Structure, Structural Analysis, Industrial Building
Software Used: STAAD Pro
Codes Followed: IS 800:2007, IS 875 (Part 1–5), IS 1893

1. INTRODUCTION

The construction industry has witnessed significant advancements in structural systems to meet growing demands for speed, economy, and sustainability. Pre-Engineered Buildings (PEBs) are steel structures that are factory-fabricated and site-assembled, offering advantages over conventional steel buildings. PEB structures consist of tapered built-up sections, rigid frames, purlins, girts, and bracing systems designed to efficiently resist applied loads. The use of advanced software like **STAAD Pro** enables accurate modeling, analysis, and design of these complex structures.

This paper focuses on the design and analysis of a typical industrial PEB frame using STAAD Pro and evaluates its performance under dead, live, wind, and seismic loads.

2. OBJECTIVES OF THE STUDY

The primary objectives of this research are:

1. To model a PEB framed structure using STAAD Pro
2. To calculate design loads as per IS codes
3. To perform structural analysis under various load combinations
4. To design steel members and connections
5. To study structural efficiency and safety of PEB systems

3. LITERATURE REVIEW

Several studies have demonstrated the advantages of PEB systems in terms of material optimization and cost reduction.

- **Zamil Steel (2014)** highlighted that PEB structures reduce steel consumption by 25–30% compared to conventional steel buildings.
- **Thakur and Singh (2016)** showed improved performance of tapered members in resisting bending moments.
- **Patil et al. (2018)** concluded that PEB structures are economical for spans greater than 20 m. These studies confirm the suitability of PEB systems for industrial applications.

4. METHODOLOGY

- **Design Process:** PEB Structures use a collaborative design approach in which architects and engineers collaborate to produce a unique building design. Detailed blueprints are frequently created using computer-aided design (CAD) software.
- **Manufacturing:** Structures such as columns, beams, purlins, and panels are produced in a factory setting under strict supervision. Because these parts are engineered to exact specifications, consistency and

quality are guaranteed.

- **Transportation:** After fabrication, the parts are packed and brought to the building site. Because they are pre-engineered, they can be transported efficiently and have less logistical obstacles.
- **Assembly:** Using bolts or welding, the prefabricated components are connected during on-site assembly. This technology often reduces building time and associated expenses since it is faster than traditional construction methods.
- **Cost-Effective:** Because PEB constructions need less work, take less time to construct, and waste less material than traditional buildings, they are frequently more affordable. There may be total project savings as a result of the expedited building process.
- **Construction Speed:** PEB structures are renowned for their quick construction. Most building components arrive at the construction site prepared for assembly, reducing construction delays and saving time.
- **Versatility in Design:** PEB constructions provide versatility in terms of building size, arrangement, and architectural features. Creative customization is possible due to the ability to support a variety of building shapes and designs.
- **Energy Efficiency:** Insulation, natural lighting, and ventilation systems are examples of energy-efficient elements that PEB buildings can be constructed to include, which can reduce operating expenses.
- **Sturdiness and Durability:** PEB components are designed to support particular loads, encompassing seismic, wind, and snow forces. This guarantees the building's durability and structural integrity.
- **Versatility:** PEB buildings may be used in a variety of settings, such as factories, warehouses, offices, sports facilities, and commercial areas.
- **Quality Control:** Compared to on-site construction, a better level of quality control is ensured in the regulated factory environment where PEB components are created.
- **Environmental Impact:** When compared to traditional building methods, the efficiency of PEB construction can result in less construction waste and a reduced environmental impact.

Table 1 - Structure specification

01	The span of the PEB	40 m
02	Spacing of the PEB frame	7.6 m
03	Height of column	5 m
04	Length of building	91 m
05	Rise of the PEB	7 m
06	Slope of the roof (θ)	10 degree
07	Length along the sloping roof	20. m
08	Length of each panel (c/c spacing of purlin)	7.6 m
09	Spacing of gable from PEB frame	7.4 m

II. MATERIAL REQUIRED

Table 2 -Material List by frame Section Property

TABLE: Frame Section Property Definitions - Steel I/Wide Flange								
Name	File Name	Section in File	Total Depth	Top Flange Width	Top Flange Thickness	Web Thickness	Bottom Flange Width	Bottom Flange Thickness
			Mm	Mm	mm	mm	mm	mm
col_400			400	300	16	8	300	16
col_750_depth			750	350	16	8	350	16
ISLB600	Indian	ISLB600	600	210	15.5	10.5	210	15.5
ISWB550	Indian	ISWB550	550	250	17.6	10.5	250	17.6

4.1 Structural System

- Rigid portal frames
- Tapered built-up columns and rafters
- Z-section purlins
- X-type bracing system

5. LOAD CALCULATIONS

Load calculations are carried out as per **IS 875** and **IS 1893**.

5.1 Dead Load (IS 875 Part 1)

Dead load of members the segment consists of the following two frames:

- 1) Gable end frame
 - 2) The center span frame or main frame
- Self-weight of steel members (Auto-calculated by STAAD)
 - Roof sheeting = 0.15 kN/m²

- Purlins and accessories = 0.10 kN/m²

5.2 Live Load (IS 875 Part 2)

- Roof live load = 0.75 kN/m²

5.3 Wind Load (IS 875 Part 3)

- Basic wind speed = 39 m/s
- Design wind pressure calculated based on height and terrain
- Wind loads applied in +X, -X, +Z, -Z directions

5.4 Seismic Load (IS 1893)

- Zone Factor = 0.10
- Importance Factor = 1.0
- Response Reduction Factor = 5

6. MODELING AND ANALYSIS USING STAAD PRO

6.1 Modeling Procedure

- Geometry creation
- Assignment of material properties
- Definition of supports (Pinned at base)
- Load assignment
- Load combination generation
- Analysis and design

6.2 Load Combinations

Typical load combinations used:

- (DL + LL)
- (DL + WL)
- (DL + LL + WL)
- (DL + EQ)

7. DESIGN OF STRUCTURAL MEMBERS

Design is performed as per **IS 800:2007 (Limit State Method)**.

7.1 Columns and Rafters

- Tapered built-up sections
- Checked for axial force, bending moment, and interaction ratio
- Maximum utilization ratio < 1.0

7.2 Purlins and Girts

- Z-sections designed for bending and deflection
- Deflection within allowable limits (L/180)

7.3 Bracing Members

- Designed for axial tension
- Slenderness within permissible limits

RENDERING -

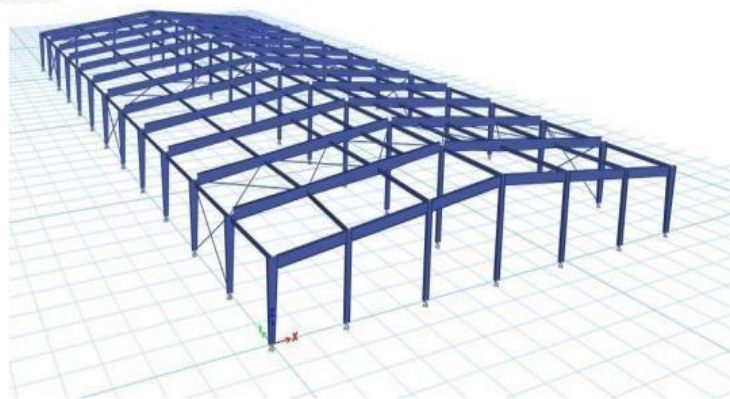


Fig 5- Render result of PEB structure using ETABS



Fig 6- Render result of PEB structure using Staad Pro

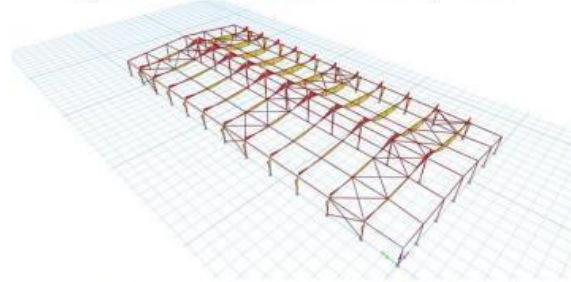


Fig 7- Bending Moment diagram using Etabs

8. RESULTS AND DISCUSSION

An optimal industrial building must have large, clear spans, which can be easily created with the aid of pre-engineered buildings. When building long span constructions, the structure's balance should be taken into account.

Pre-engineered structures are best suited for high strength steel plates, which increase the structure's capacity to support loads. Furthermore, galvalume profile sheets and cold form purlins, which are stronger but lighter in weight, are also often used in the construction of pre-engineered buildings. These materials give the construction increased tensile strength, reduced weight, and a pleasing appearance.

In order to get the most cost-effective value for our 80-meter span, we compare several bay spacings. The weights that were determined for each bay spacing are displayed in the Table Below.

Column 1 of this chart displays the bay spacing over an 88-meter length. Column 3 displays the weight for each plane frame at its appropriate spacing, whereas Column 2 displays the number of frames. The weight per frame multiplied by the number of frames yields the overall weight. Column 4 displays the overall weight of the estimated portions.

Table -3

Section	Object Type	No of Pieces	Length	Weight
			m	kN
member_700mm	Beam	34	154.098	166.0928
mem_1_prismatic_800mm_to_700mm	Beam	22	147.3982	173.1145
member_2_prismat_700mm_to_900mm	Beam	22	147.3981	227.7299
Column 400mm	Column	21	138.6	133.8249
Column middle	Column	26	130	124.8399
member_3_900_to_700	Beam	22	73.6992	113.8653
ISMC	Beam	104	791.54	273.43
ROD50	Beam	36	366.54	16.72
ROD50	Brace	12	109.83	5.08

9. CONCLUSION

- The results provided by both software programs are not exact, but they are comparable within a $\pm 5\%$ range.
- Although the ETABS software has a superior graphical user interface, it lacks the ability to construct connections and must rely on other programs to do so.
- The Staad Pro is capable of creating connections by using RAM Connection link to create generic connections inside the software.

- Both programs have the ability to transmit data between them.
- The design and analysis of the PEB framed structure using STAAD Pro confirms that PEB systems are structurally efficient, economical, and safe.
- The use of tapered built-up members leads to optimal steel utilization and reduced overall weight.
- The structure performed satisfactorily under all critical load combinations as per Indian Standard codes.
- PEB systems are highly suitable for industrial buildings requiring large column-free spans.

10. SCOPE FOR FUTURE WORK

- Comparison with conventional steel buildings
- Non-linear and dynamic analysis
- Optimization using advanced design techniques
- Sustainability and life-cycle cost analysis

11. REFERENCES

- [1] C. Meera, Pre-engineered building design of an industrial warehouse, *Int. J. Eng. Sci. Emerg. Technol.* 5 (2) (2013) 75–82.
- [2] G.S. Kiran, A.K. Rao, R.P. Kumar, Comparison of design procedures for pre-engineering buildings (PEB): a case study, *Int. J. Civ., Arch., Struct. Constr. Eng. (IJCASCE)* 8 (4) (2014) 4.
- [3] A.A. Zende, A. Kulkarni, A. Hutagi, Comparative study of analysis and design of pre-engineered-buildings and conventional frames, *IOSR J. Mech. Civ. Eng.* 2013 (2013) 2278–1684.
- [4] A.S. Kumar, et al., Design and Analysis of Pre-Engineered Industrial Buildings (PEB), *Int. J. Appl. Sci., Eng. Manag.* ISSN, 2320– 3439.
- [5] V. Bahadure, R. Prasad, Comparison between design and analysis of various configuration of industrial sheds, *Int. J. Eng. Res. Appl. (IJERA)* 3 (1) (2013) 1565–1568.
- [7] D.N. Subramanian, Pre-engineered buildings selection of framing system, roofing and wall materials, *Master builder* (2008) 48–56.
- [8] J.D. Thakar, P. Patel, Comparative study of pre-engineered steel structure by varying width of structure, *Int. J. Adv. Eng. Technol.* 4 (3) (2013) 56–62.
- [9] S. Wakchaure, N. Dubey, Design and comparative study of pre-engineered building, *Int. J. Eng. Dev. Res* 4 (2016) 2108–2113.
- [10] T. Mythili, Analysis and comparative study of conventional steel structure with PEB structure, *Int. J. Sci. Res. (IJSR)*, ISSN (Online) (2015) 2319–7064.
- [11] V.S. Thorat, A.G. Whatte, *IS: 800-General Construction in Steel and its Comparison with International Code*
- [12] Comparative Study of Analysis and Design of Pre-Engineered Buildings and Conventional Frames by Aijaz Ahmad Zende¹, Prof. A. V. Kulkarni², Aslam Hutagia subjected to *IOSR Journal of Mechanical and Civil Engineering (IOSR- JMCE)* ISSN: 2278-1684 Volume 5, Issue 1 (Jan. - Feb. 2013), PP 32-43 org.
- [13] C. Meera, Pre-engineered building design of an industrial warehouse, *Int. J.Eng. Sci. Emerg. Technol.* 5 (2) (2013) 75–82.
- [14] G.S. Kiran, A.K. Rao, R.P. Kumar, Comparison of design procedures for pre-engineering buildings (PEB): a case study, *Int. J. Civ., Arch., Struct. Constr. Eng. (IJCASCE)* 8 (4) (2014) 4
- [15] A.A. Zende, A. Kulkarni, A. Hutagi, Comparative study of analysis and design of pre- engineered-buildings and conventional frames, *IOSR J. Mech. Civ. Eng.* 2013 (2013) 2278– 1684
- [16] D.N. Subramanian, Pre-engineered buildings selection of framing system, roofing and wall materials, *Masterbuilder* (2008) 48–56.
- [17] J.D. Thakar, P. Patel, Comparative study of pre-engineered steel structure by varying width of structure, *Int. J. Adv. Eng. Technol.* 4 (3) (2013) 56–62.
- [18] J. Adv. Eng. Technol. 4 (3) (2013) 56–62.
- [19] S. Wakchaure, N. Dubey, Design and comparative study of pre-engineered building, *Int. J. Eng. Dev. Res* 4 (2016) 2108–2113