A REVIEW ON COMPARATIVE STUDY ON STRUCTURAL ANALYSIS AND DESIGN OF PRE-ENGINEERED STRUCTURE (PEB) AND CONVENTIONAL STEEL STRUCTURE (CSB)

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***Abstract**:* The Pre-Engineered and Conventional Steel Building became admired today. Before a few years, we are not recognizable with PEB and its capacity. However, today this is not seen, surely there is something very implausible in PEB. That is why the entire world construction switches over to PEB from the conventional method of building constructions. In recent years, the introduction of Pre-Engineered Building (PEB) design of structures has helped in optimizing design. The construction of PEB in the place of Conventional Steel Building (CSB) design concept resulted in many advantages, as the members are design as per bending moment diagram and thus reducing the steel requirement. In this study, an industrial structure PEB Frame & CSB Frames analyzed and designed according to the Indian standards, IS 800-1984, IS 800-2007. The economy of the structure is discussed in terms of its weight comparison, between Indian codes (IS800-1984, IS800-2007) & in between PEB & CSB building structure. Cost of steel is rising day by day and use of steel has become inevitable in the construction industry in general and in industrial building in particular. Hence, to achieve economic sustainability it is necessary to use steel to its optimum quantity. Long span, Column free structures are the most important in any type of industrial structures and Pre-Engineered Buildings (PEB) fulfill this requirement along with reduced time and cost as compared to conventional structures. This methodology is adaptable not only due to its quality pre-designing and pre-fabrication, but also due to its lightweight and economical construction.

Key Words: Pre-engineering building (PEB), Conventional steel building)(CSB), hot rolled sections, STAAD-pro V8i

1. Introduction:

Steel is the material of alternative for design because it is ductile and flexible. Steel industry is mounting rapidly in almost all the parts of the world. The use of steel structures is not only cost-effective but also ecological at the time when there is a threat of global warming.

Steel members have high strength per unit weight and the properties of the steel members mostly do not change with time. Also, addition and modification can be made easily in steel structures.

Typically, conventional construction occurs step by step excavation and foundations are constructed before framing begins. Each component must be completed before moving to the next step, so scheduling is dependent upon each trade’s efficiency. Design impacts schedule immensely, particularly if it is a complex design and because each component has designed from scratch, the project duration averages about six to ten months.

Conventional construction is ideal for complex designs. However, conventional construction not only takes longer, but it also costs more than pre-engineered construction.

Pre-engineered buildings are alternative option for Conventional steel buildings. Pre-engineered buildings are nothing but steel buildings in which surplus steel has avoided by tapering the sections as per the bending moment’s requirement. One may think about its possibility but it is a fact, many people are not aware about Pre-Engineered Buildings.

Pre-engineered construction eliminates the need for an architect or engineer. The design is rapid and efficient, while also being flexible, due to its smooth approach. Pre-engineered construction lends itself toward a simpler design.

1.1 Conventional steel structure:

Conventional steel buildings (CSB) are low-rise steel structures with roofing systems of truss with roof coverings. Different types of roof trusses can be used for these structures depending upon the pitch of the truss. For large pitch, Fink type truss can be used; for medium pitch, Pratt type truss can be used and for small pitch, Howe type truss can be used. Skylight can be provided for day lighting and for more day lighting, quadrangular type truss can be used. The selection criterion of roof truss also includes the slope of the roof, fabrication and transportation methods, aesthetics, climatic conditions, etc. Several compound and combination type of cost-effective roof trusses can also selected depending upon the usefulness. Standard hot-rolled sections are usually used for the truss elements along with gusset plates.

Fig.1 Conventional steel structure

1.2 Pre-engineering structure:

The pre-engineered or prefabricated building construction design mechanism are carried out by the manufacturer at their industrial setup. There are plentiful numbers of structures are available, and this can be manipulated according to our need. The materials are collected after completing the entire design. So, that we can collect the material of our requirement. The dispatched set of materials is brought to the site and we can assemble it accordingly. The foundation requirement of pre-engineered buildings is precisely known and calculated early as the time while the design is prepared. The primary and secondary frames are custom made for pre-engineered building. As an alternative of T section, strong, lightweight at the same time strong tampered members are used. And secondary members are steel C and Z sections.

As opposed to being on-site fabricated, PEBs are delivered as a complete finished product to the site from a single supplier with a basic structural steel framework with attached factory finished cladding and roofing components. The structure is erected on the site by bolting the various building components together as per provision.

Fig. 2 Pre-engineering structure

2. METHODOLOGY

In the present paper, comparative analysis of the Industrial warehouse structure located at Pune is performed by using STADD-pro. The structure is clear span framed of 25 meters wide and 30 meters long with 5 bays and sidewall bay spacing 6 m and each story height 5 meters. In this report, the analysis and design performed on the 3D PEB structure of 25-meter width are by adopting wind load as the critical load for the structure by using Indian code I.S 800:2007 Limit state method (LSM).

In addition, the CSB structure 3D frame having the same dimension is an analysis and designed by adopting an economical roof truss by using Indian standard code. All the above structures are designs then compared to determine the economic output. The comparative analysis is also done for the hot-rolled section used in CSB and cold-formed purlins used in PEB. The designs are performed by the Indian Standards and American Standard and by using STADD-Pro

3. OBJECTIVE

- The main objective of our project is to compare the design of pre-engineered steel structure with conventional steel structure system (industrial building) using IS 800:2007 IS 875 & IS1893.
- To provide stable and safe structure with economic perspective
- Design primary & secondary element of P.E.B & C.S.B and to study the optimized section of structure.
- Compare the weight of normal CSB structures to PEB structures.
- To give replacement to conventional steel structure by PEB structure.
- Compare the span length of CSB and PEB structure.
- To study of comparative costing of various types of system.
- To give advance or easier methods of construction.

4. Building Parameter:

Sr. No.	Description	
1	Type of structure	Single span Industrial Structure
2	Location	Pune
3	Area	750 m^2
4	Length	30 m
5	Width	25 m
6	Height	5 m
7	Bay Spacing	6 m
8	Slope of PEB	5.71 Degrees
9	Slope of CSB	11.30 Degrees
10	Support Condition	PEB- Fixed, CSB-Fixed
11	Wind Speed	39 m/s
12	Seismic Zone	III

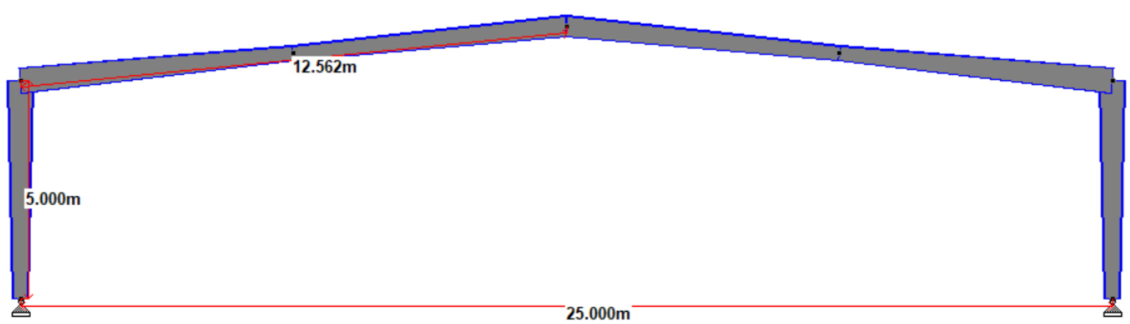


Fig. 3 Elevation of PEB

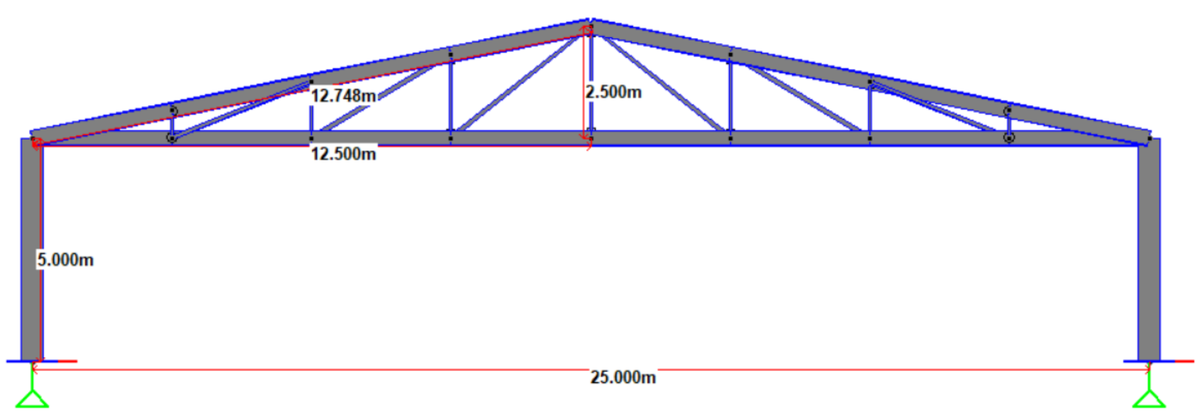


Fig. 4 Elevation of PEB

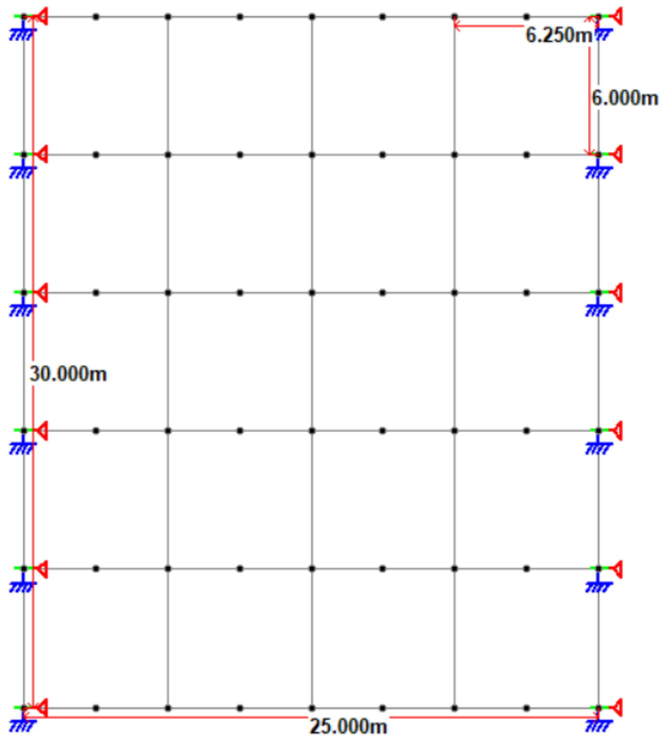


Fig. 5 Plan of Shed

4 Loading Calculations

4.1 Dead load:

Total dead load acting on rafter and column of PEB and CSV is calculated as per IS 875 Part I – 1987

Dead load acting on structure of GI sheet = 0.150 KN/m^2,Weight of purlins/ Side runner = 0.10 KN/m^2

Total dead load = 0.25 KN/m^2

Total load multiplied by span is applied as uniformly distributed load on rafter beam and column of PEB and CSV respectively.Selfweight is applied to all the members.

4.2 Live load:

Live load as per IS code 875 Part II for flat slopping or curved roof with slope up to 10^o (access not provided) taken as = 0.75 KN/m^2 , Total load multiplied by span is applied as uniformly distributed load on rafter beam and column of PEB and CSV respectively.

4.3 Wind load:

Wind pressure calculation as per IS 875 Part III, Wind Speed V_b = 39 m/sec (Risk coefficient k_1 = 1, Terrain, Ht& size factor k_2 = 0.88 (Category 3 class B), Topography Factor, k_3 = 1

Design Wind Speed, $V_z = V_b \times k_1 \times k_2 \times k_3$ = 34.32 m/s^2

Design wind pressure, P_z =0.6 x $(Vz)^2$ =0.707KN/m^2

Internal Pressure Coefficient for medium openings i.e. Openings between about 5% to 20% of wall area. (C_{pi}) = ±0.5,

External Pressure Coefficient for wall (C_{pe}), From design dimensions, h/w< 0.5 ,l/w = 1

Cpe for surface	A	B	C	D
When Wind angle is zero (0) degree	0.70	-0.20	-0.50	-0.50
When Wind angle is 90 degree	-0.50	-0.50	0.70	-0.20

Wind Load direction	Pressure Difference	A	B	C	D
WL_+X_+Cpi	Cpe-Cpi	0.20	-0.70	-1.00	-1.00
WL_+X_-Cpi	Cpe-Cpi	1.20	0.30	0.00	0.00
WL_-X_+Cpi	Cpe-Cpi	-0.70	0.20	-1.00	-1.00
WL_-X_-Cpi	Cpe-Cpi	0.30	1.20	0.00	0.00
WL_+Z_+Cpi	Cpe-Cpi	-1.00	-1.00	0.20	-0.70
WL_+Z_-Cpi	Cpe-Cpi	0.00	0.00	1.20	0.30
WL_-Z_+Cpi	Cpe-Cpi	-1.00	-1.00	-0.70	0.20
WL_-Z_-Cpi	Cpe-Cpi	0.00	0.00	0.30	1.20

Wind load is applied on structure asper 875 part III: (Cpe-Cpi)x Ae x Pz

4.4 Seismic load:

Seismic load calculations done as per IS1893 Part IV, Damping ratio: 2% (For steel structure), Location of structure:Pune ,Seismic Zone: III (Zone factor: 0.224), Importance factor:1,Category 4 and soil type medium. Response reduction factor =5 (For Steel moment resisting frame designed as per SP 6), Seismic load applied on structure by Static Method (Seismic Coefficient)

Horizontal seismic force Ah =Z/2 x I/R x Sa/G, Design base shear = Ah x W

5. Load Combination

Loads combinations can be taken as per IS: 800-2007 (LSM)., For Limit state of serviceability and Limit state of collapse

6. STAAD Pro Analysis Procedure:

Structure has been analyzed through STAAD.Pro V8i. Modeling of structure, properties, load and loading combination specification, applied analysis and design are carryout. The utilization ratio in the STADD Pro analysis shows the suitability of the component according to specified codes. If the value of unity check greater than 1 its shows the component is failed, and if less than 1 indicates under stress
and means it’s suitable for design.

All the components of Pre-engineered building are tapered using the in-built option of the Software. So as to reduce weight of structure Section profile of structure is made as per BM profile of the structure.i.e. Extra depth of section where BM is Higher (at Ends and at centre) and Narrow towards the point of contraflexure where BM is Minimum or Zero.

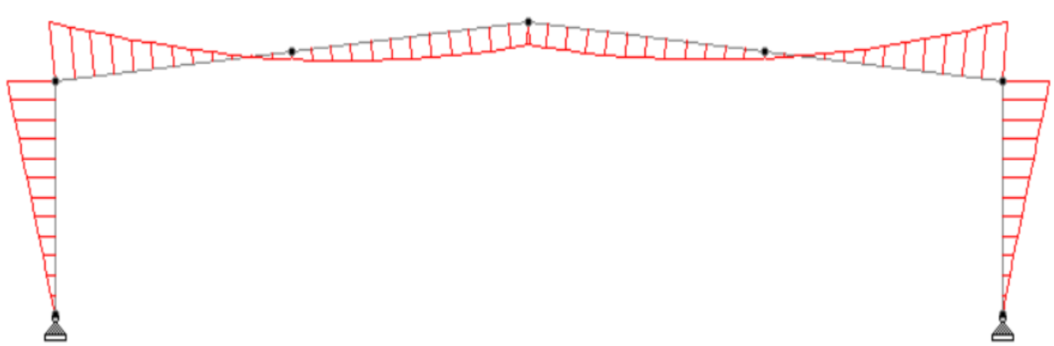


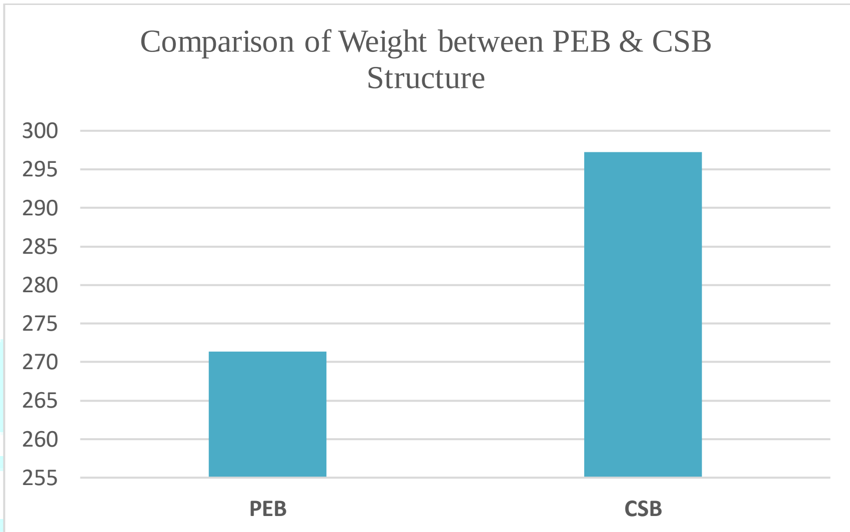
Fig. 6 Pre-Engineering Frame

7. Results:

7.1 Weight Comparison:

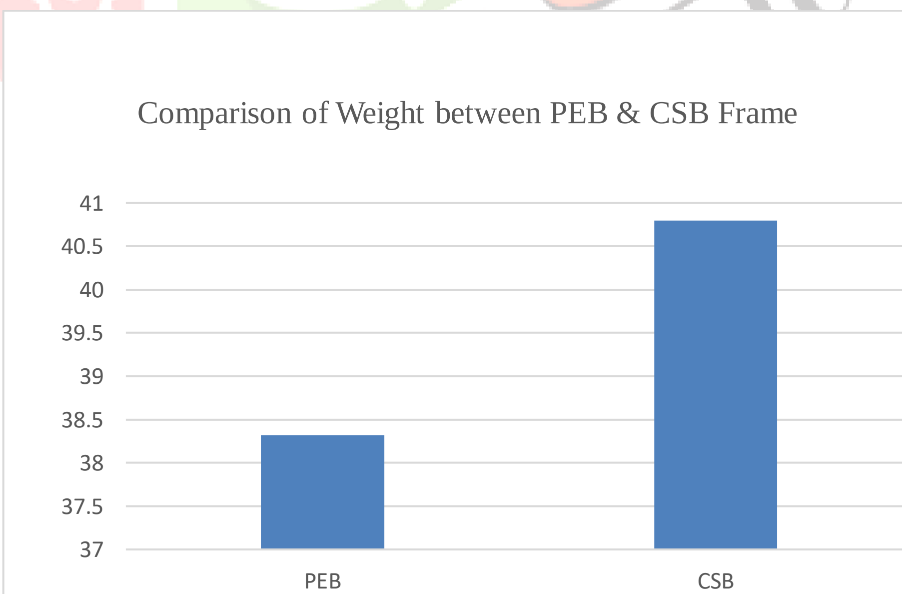
Comparison of Weight between PEB & CSB Structure

- PEB=271.32 KN
- CSB=297.21 KN



Comparison of Weight between PEB & CSB Single Frame

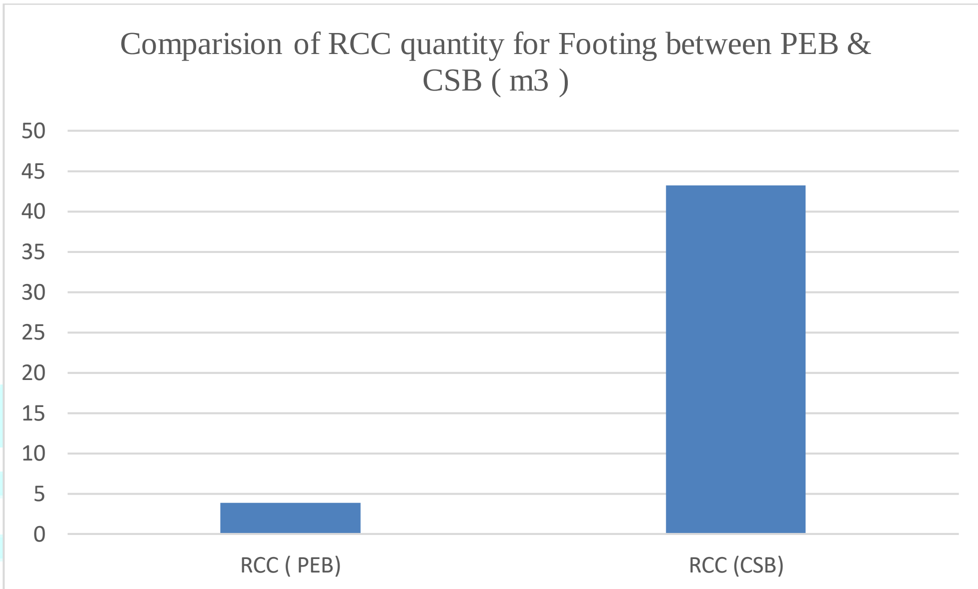
- PEB=38.4 KN
- CSB=40.8 KN



7.2 RCC Quantity Comparison:

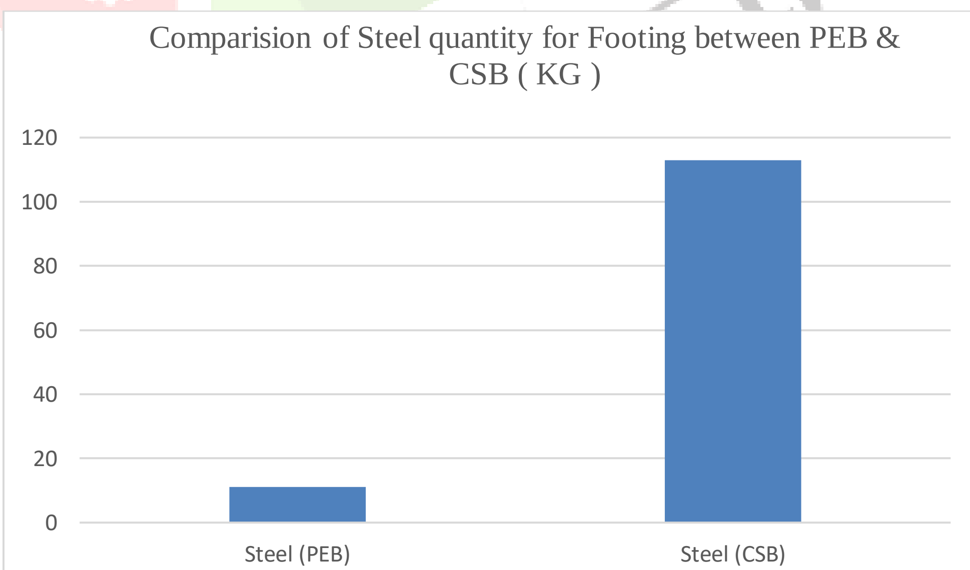
Comparison of RCC Quantity between PEB & CSB Structure

- PEB= $3.84M^3$
- CSB = $40.8\ M^3$



Comparison of Steel Quantity between PEB & CSB Structure

- PEB= 11.2 KG
- CSB = 113 KG



8 Conclusion:

1. PEB offers strength, durability, design flexibility and economical structure.
2. Due to reduction in size of member as per BM in section, Reduces weight of frame, hence optimizes the whole structure, here in our project total weight of PEB is 91.2 % of total weight of CSB.
3. By the reduction in the weight of structure. It reduces dead load on structure.
4. As total moment in the structure taken by the frame only pinned support is required as there is no moment at the support. So, the base plate and pedestal of small size is required. Whereas in CSB, Moments are at support, so fixed support is assigned. It requires base plate and pedestal of relatively larger size. So,there is overall saving in material. (Steel& RCC).
5. As there is no moment at foundation in PEB structure size of foundation required is very less as compared to CSB structure. Hence overall quantity required (Steel &RCC) for PEB is very less as compared to PEB
6. Here in our project overall quantity of RCC required for PEB is only 8.91 % of CSB structure and Weight of rebars required for PEB are 10 % of CSB structure.
7. Pre-Engineering Buildings are found to be economical for long span structures than Conventional steel buildings especially for low rise buildings spanning up to 90.0 meters with eave height up to 30.0 meters. PEB structures are found to be costly as compared to conventional structures in case of smeller span structures.
8. It is also seen that the weight of PEB depends on the Bay Spacing, with the increase in Bay Spacing up to certain spacing, the weight reduces and further increase makes the weight heavier.

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