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Comparative Study of Conventional Steel Structure and Pre-Engineered Steel Structure (PEB)

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Abstract: ***The present investigation is aimed at comparison of conventional steel building with pre-engineered buildings. The present construction methodology for buildings calls for the best aesthetic look, high quality & fast construction, cost effective & innovative touch and as Steel is a preferred material for construction, due to its various advantages like quality, aesthetics, economy and environmental conditions. In this investigation the portal frame of ware house of different spanning like 30 m, 25 m, 20m, 15m with the different crane capacity like 5 tons, 10 tons, 15tons, 20 tons on each span is carried out using standard computer software like STAAD PRO V8i. And the design calculation is done with the help of IS800-2007. As well as for the cold formed sections IS801-1975 is used. The design is done for both conventional steel structure and Pre-engineered steel structure for the all spans with crane load.***

Index terms - Conventional steel, Pre-engineered steel, crane load, Comparative Study.

I. INTRODUCTION

The scientific-sounding term *pre-engineered buildings* came into being in the 1960s. The buildings were “pre-engineered” because, like their ancestors, they relied upon standard engineering designs for a limited number of off-the-shelf configurations. Several factors made this period significant for the history of metal buildings. First, the improving technology was constantly expanding the maximum clear-span capabilities of metal buildings. Second, in the late 1950s, ribbed metal panels became available, allowing the buildings to look different from the old tired corrugated appearance. Third, coloured panels were introduced by Stran-Steel Corp. in the early 1960s, permitting some design individuality. At about the same time, continuous span cold formed Z purlins were invented (also by Stran-Steel), the first factory-insulated panels were developed by Butler, and the first UL-approved metal roof appeared on the market. And last, but not least, the first computer- designed metal buildings also made their debut in the early 1960s. With the advent of computerization, the design possibilities became almost limitless. All these factors combined to produce a new metal-building boom in the late 1950s and early 1960s. As long as the purchaser could be restricted to standard designs, the buildings could be properly called *pre-engineered.*

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II. FRAMING SYSTEM

Primary Framing System

1) Conventional Steel Frame

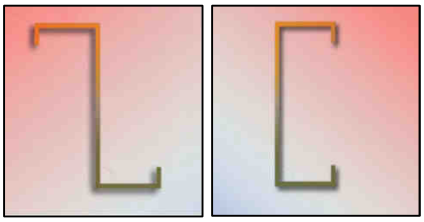
In conventional steel buildings, mill-produced hot rolled sections (beams and columns) are used. The size of each member is selected on the basis of the maximum internal stress in the member. Since a hot rolled section has a constant depth, many parts of the member (represented by the hatched area), in areas of low internal stresses, and are in excess of design requirements

2) Pre-engineered steel frame

Frames of pre-engineered buildings are made from an extensive inventory of standard steel plates stocked by the PEB manufacturer. PEB frames are normally tapered and often have flanges and webs of variable thicknesses along the individual members. The frame geometry matches the shape of the internal stress (bending moment) diagram thus optimizing material usage and reducing the total weight of the structure.

Secondary Framing System

“Z” shaped roof purlins and wall girts are used for the secondary framing. They are lighter than the conventional hot-rolled “I” or “C” shaped sections in conventional steel buildings. Nesting of the “Z” shaped members at the frames allows them to act as continuous members along the length of the building. This doubles the strength capacity of the “Z” shaped members at the laps where the maximum internal stresses normally occur.



Secondary Rolled Steel Sections

Secondary Cold Formed Sections

Advantages

- Cost and Load Efficiency
- Flexibility to low expansion
- Low maintenance
- Single Source Responsibility
- Faster project construction.

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Disadvantages

- Variable construction ability
- Lack of reserve strength
- Possible manufacturer's unfamiliarity with local codes

Scope of Present Work

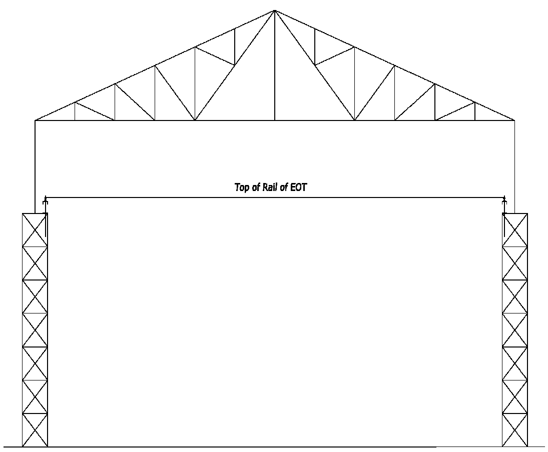
The present work aims at comparison of conventional steel building with Pre- Engineered steel buildings for industrial warehouses. An attempt is made to compare the structure in terms of:

- Steel Quantity – Amount of steel required for a structure with fixed width.
- Reduction in load – Reduction in the dead load of the structure due to use of tapered section and light weight secondary members.
- Cost comparison of the structure.
- Foundation size requirement.

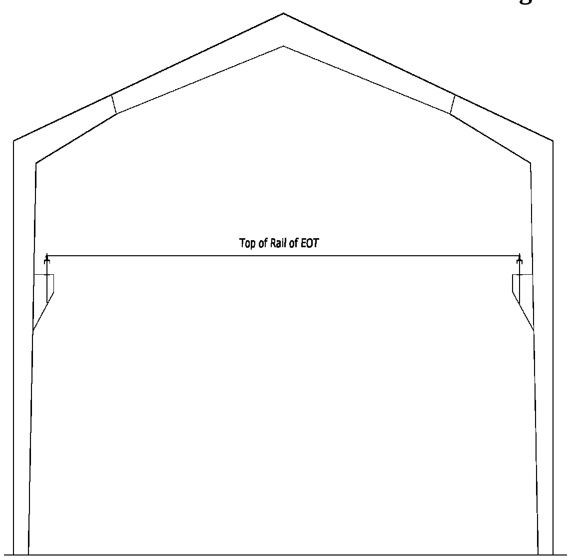
Design codes & Manuals Referred

1. IS: 800 – 2007 Indian Standard General Construction in Steel – Code of Practice.
2. IS: 801 – 1975 Code of practice for use of Cold formed light gauge steel Structural members in general building construction.
3. Analysis & Design software used is "STAAD PRO v8i

III. FRAMING SYSTEM ADOPTED



Basic Frame foe conventional Steel Building



Basic Frame foe Pre-Engineered Steel Building

LOAD COMBINATIONS

Limit state of strength	Limit state of serviceability
1.5DL + 1.5LL	1.0DL + 1.0LL
1.5DL+1.5LL+1.5CL	1.0DL+1.0LL+1.0CL
1.5DL + 1.5WL/EL	1.0DL+0.8LL+0.8CL+0.8WL
1.2DL+1.2LL+1.2CL+0.6WL	1.0DL+0.8CL+0.8WL
1.2DL+1.2LL+1.2CL+1.2WL	
1.2DL+1.2CL+1.2WL	
0.9DL+1.5WL	

IV. DESIGN DATA

1) Conventional Steel Frame

Basic Frame Data:

- Width of the frame = 30m
- Height of the frame at Gantry level = 8m
- Height of the frame at Eave level = 10m
- Length of the structure = 40m
- Bay spacing = 5m
- Slope of roof = 1: 2.5
- Basic wind speed = 44m/s
- Seismic zone = 3

2) PEB Steel Frame

Basic Frame Data:

- Width of the frame = 30m
- Height of the frame at Gantry level = 8m
- Height of the frame at Eave level = 10m
- Length of the structure = 40m
- Bay spacing = 5m
- Slope of roof = 6°
- Basic wind speed = 44m/s
- Seismic zone = 3

V. DESIGN SUMMARY

1) Conventional Steel Frame

For 30 meter span with 5 tons crane load

Member	Section
Built up Column	ISMC 250
Column lacing membe	ISA 60X60X8
Column supporting trus	ISMB 300
Principal Rafter	2 ISA 110X110X12
Bottom chord	2 ISA 110X110X12
Struts and Ties	ISA 110X110X10
Purlin	ISMC 100
Footing Size	3.2m x 1.8m x 0.4m

2) PEB Steel Frame

- Crane capacity = 5 ton
- Thickness of flange (t_f) = 12 mm
- Thickness of Web (t_w) = 8 mm

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- Width of flange (b_f) = 275 mm

Member	Sections	
Tapered Column	At Start	Depth 500mm
	At End	Depth 850mm
Rafter member 1	At Start	Depth 850mm
	At End	Depth 550mm
Rafter member 2	At Start	Depth 550mm
	At End	Depth 850mm
Purlin	Rectangular without lips 200x50x4	
Footing size	2.5m x 1.6 m x 0.4 m	

VI. DESIGN CALCULATIONS

1) Conventional Steel Frame

FOR 30 M SPAN & 5 TONS CRANE LOAD

Section	Area (m^2)	Length (m)	Density (t/m^3)	Total (Tons)
1) Laced column				
ISMC 250	3.78×10^{-3}	32	7.85	0.9506
ISA 60 x 60 x 8	8.76×10^{-4}	61.25	7.85	0.4216
2) Supporting column				
ISMB 300	5.51×10^{-3}	5.60	7.85	0.2422
3) Truss				
ISA 110 x 110 x 10	2.06×10^{-3}	97.07	7.85	1.5704
ISA 110 x 110 x 12	4.89×10^{-3}	61.62	7.85	2.3688
Total				**5.5536**
4) Purlin				
ISMC 100	1.17×10^{-3}	40 x 22	7.85	**8.0823**

- The current cost of steel in the market is Rs. 50 per kg
- Hence cost of one portal = 50 x 5.5536 x 1000 = Rs. 2, 77,680/-
- To cover 40m span of the structure 9 portal frames are required
- Hence total cost of the structure = 9 x 2, 77,680 = Rs. 24, 99,120/-
- Cost of Purlin = 50 x 8.083 x 1000 = Rs. 4, 04,115/-
- Hence total cost of structure = 24, 99,120 + 4, 04,115 = Rs. 29, 03,235/-

Concrete Quantity

- Size of footing = 3m x 1.8m x 0.4m
- Quantity of concrete = 3 x 1.8 x 0.4 = 2.16 m^3
- Total there are 18 footings
- Hence total Quantity of concrete = 18 x 2.16 = 38.88 m^3

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2) PEB Steel Frame

FOR 30 M SPAN & 5 TONS CRANE LOAD

Section	Area (m^2)	Length (m)	Density (t/m^3)	Total (Tons)
1) Tapered Column	11.55×10^{-3}	20	7.85	1.8142
2) Rafter 1	11.75×10^{-3}	30.17	7.85	2.787
3) Rafter 2	-----	----	-----	-----
Total				4.6012
4) Purlin	11.3×10^{-3}	40 x 22	7.85	7.8

2) PEB Steel Frame

FOR 30 M SPAN & 5 TONS CRANE LOAD

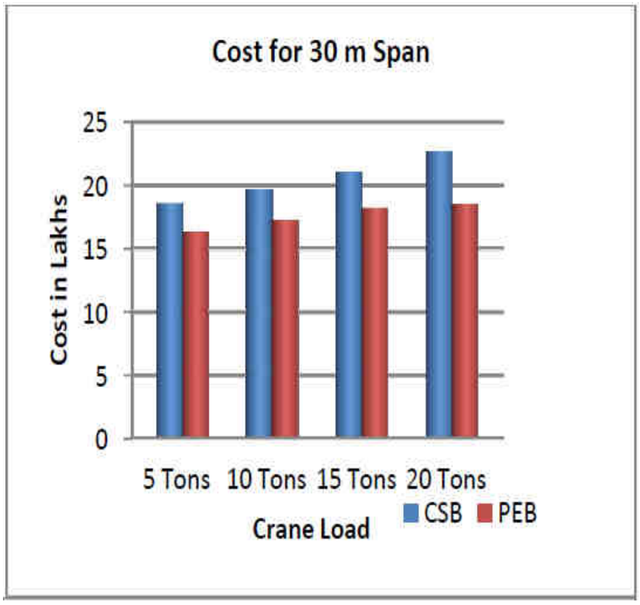
- The current cost of steel in the market is Rs. 50 per kg
- Hence cost of one portal = 50 x 4.6012 x 1000 = Rs. 2, 30,060/-
- To cover 40m span of the structure 9 portal frames are required
- Hence total cost of the structure = 9 x 2, 30,060 = Rs. 20, 70,540/-
- Cost of Purlin = 50 x 7.8 x 1000 = Rs.3, 90,000/-
- Hence total cost of structure = 20, 70,540 + 3, 90,000 = Rs. **24, 60,540/-**

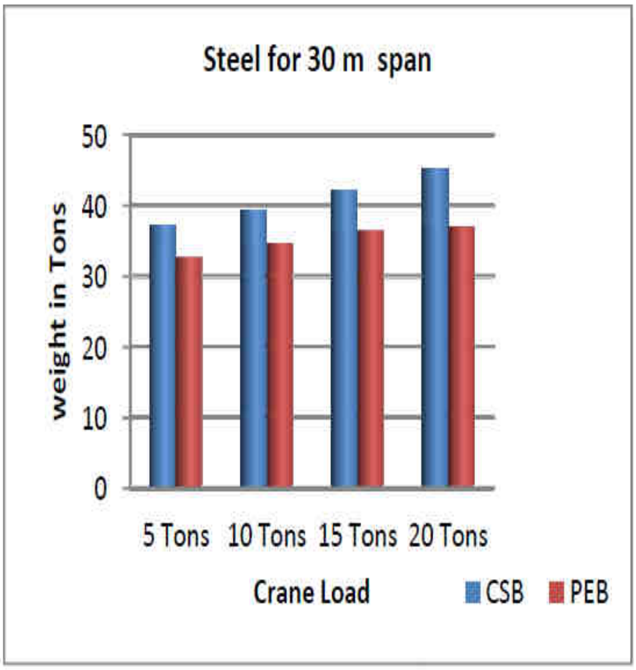
Concrete Quantity

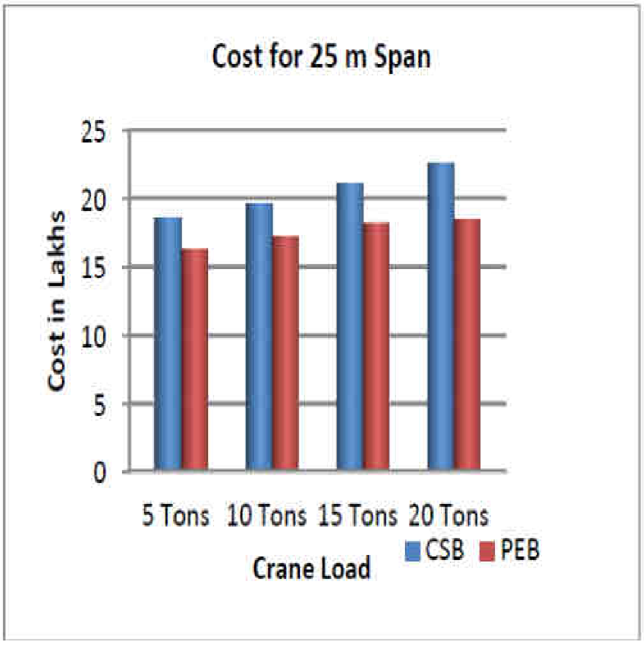
- Size of footing = 2.5m x 1.6m x 0.4m
- Quantity of concrete = 2.5 x 1.6 x 0.4 = 1.6 m^3
- Total there are 18 footings
- Hence total Quantity of concrete = 18 x 1.6 = **28.8 m^3**

VII. RESULT COMPARISON

The comparison of various parameters of Conventional Steel building and Pre – Engineered Steel building are summarized in graphical format as follows.







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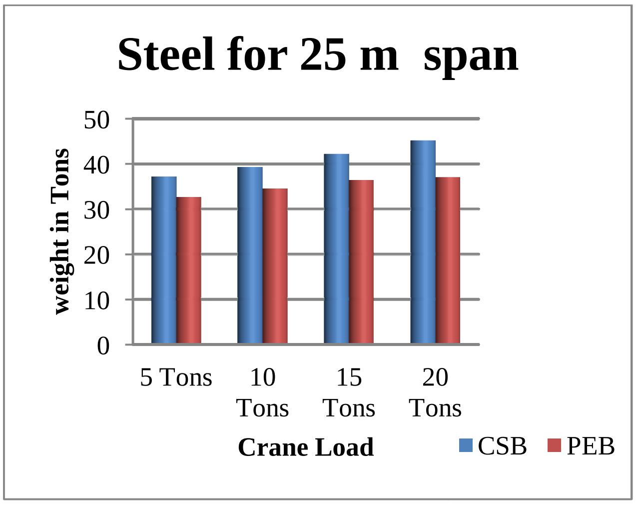

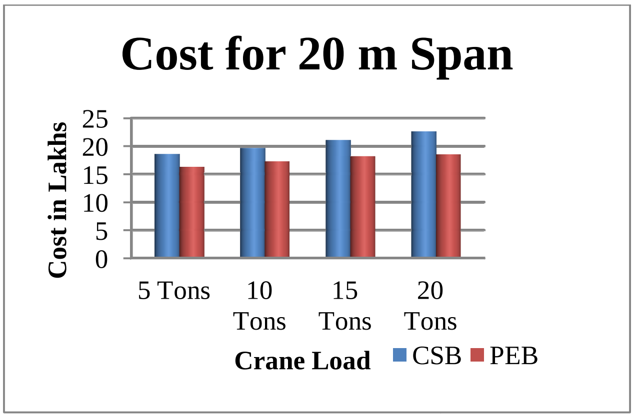

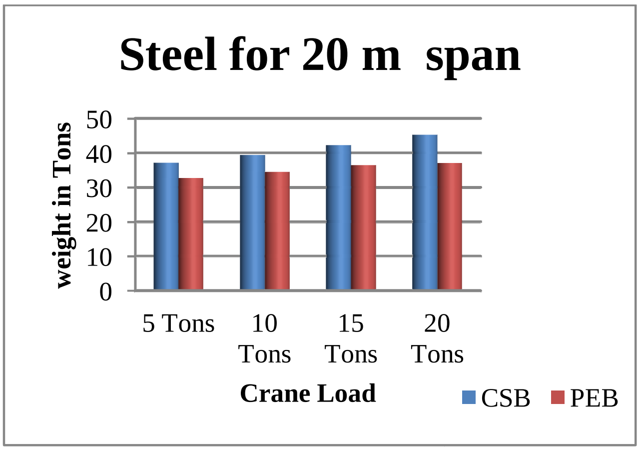

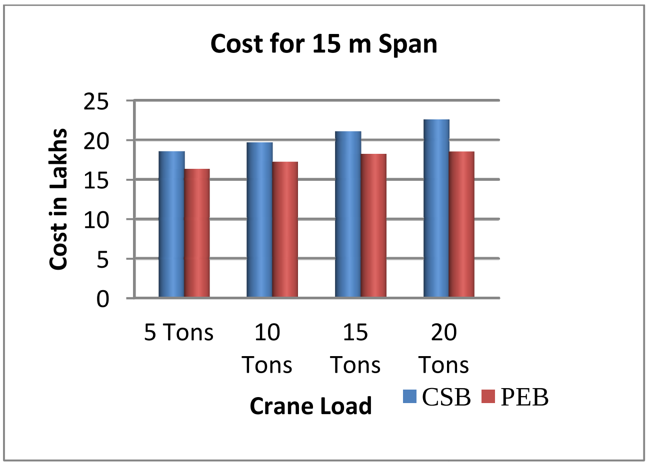

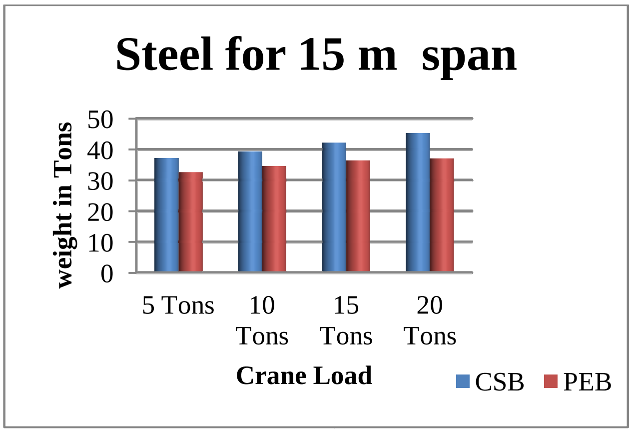

VIII. OBSERVATION & CONCLUSION

From the detail calculation and summary it is seen that the comparison between Conventional Steel Portal and Pre – Engineered Steel Portal shows following results on an average

PARAMETERS	REDUCTION
Steel Quantity	13 – 15 %
Concrete Quantity	30 – 35 %
Cost	13 – 15 %

And it is concluded that the comparative study on Conventional and Pre – Engineered portal leads to the conclusion that PEB proves to be relevant and beneficial for warehouses equipped with cranes and the advantages of having a PEB portal over a traditional steel portal are far too many. Apart from the main parameters like structural load, Steel Quantity, Concrete Quantity and Cost. Speed and Quality of construction are also the benefits.

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