A COMPARATIVE STUDY OF PRE-ENGINEERED BUILDING, AND CONVENTIONAL STEEL STRUCTURE

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ABSTRACT
The optimization of steel construction and its requirement has been aided by pre-engineered building (PEB) design of structures. This technique is adaptable not only because of its high-quality pre-designing and prefabrication, but also because of its light weight and cost-effectiveness. The principles include the method of delivering the best possible section based on the most important requirements. In this case study I studied, designed, and compared the pre-engineered building to the traditional steel building in this case study (CSB). We've also taken into account various pre-engineered building components. A framework with a length of 60 meters, a width of 20 meters, and a simple height of 6 meters, with a slope of 5.71 degrees for PEB and 11 degrees for CSB. Both definitions are based on ISO 800. The economy of structure is discussed in terms of its light weight comparison.

Keywords- Pre-Engineered Building, Conventional steel structure, STAAD pro

I. INTRODUCTION
The Pre-Engineered Building (PEB) has aided in the optimization of cost, time, and design in recent years. The use of PEB in place of conventional steel structures has many benefits, as the members are constructed according to the bending moment diagram, reducing the amount of material required. While its roots can be traced back to the 1960s, its full potential has only recently been realised. Pre-engineered structures were mainly used in North America and the Middle East until 1990. PEB has since spread across Asia and Africa, where the term is widely embraced and used. The first rigid-frame structures, which were introduced in the late 1940s, could only reach 40 feet. Buildings of 40, 50, 60, and 70 feet were possible within a few years. Rigid frames with spans of 100 feet were successful by the late 1950s. The first rigid-frame structures, which were introduced in the late 1940s, could only reach 40 feet. Buildings of 50, 60, and 70 feet were possible within a few years. By the late 1950s, rigid frames with 100-foot spans had been created, and ribbed metal panels had become available, enabling buildings to be distinguished from the tired corrugated look.

PEBs are steel structures in which excess steel is prevented by tapering the parts in response to the bending moment. Traditional steel buildings (CSB) have truss works that need a large amount of steel and are costly, while PEB concept configurations are simpler and we can save a lot of steel. However, PEB makes the structure extremely flexible and light. Steel structures are not only cost-effective, but also environmentally friendly, particularly in light of the threat of global warming. In this case, the term "economical" is described in terms of both time and cost. As a result, PEB’s total design is completed in the workshop, and structural design members are pre-fabricated and transported to the job site, where they are erected in 6-8 weeks. It is easy to remove a steel frame. As a result, steel can be reused after dismantling.

II. CATEGORIES OF BUILDING

1. Conventional Steel Structure
In the past, for the design building, the choice was normally between a concrete structure and a masonry structure. But now-a-days steel composite buildings are built across rapidly for commercial and industrial purposes. Steel offers speedy construction right from the start. Due to its important characteristics like ductility, flexibility etc., In the building industry, steel is commonly used. Low-rise steel structures with truss roofing systems and roof coverings are known as CSBs. Rolling parts are used in traditional steel structures, which raises the structure’s weight. The members are produced in factories and then transported to the construction site. Welding and cutting may be used to make adjustments during the erection process. In this scheme, trusses are usually used. Braced and unbraced framed structures are the two types of industrial buildings. The trusses in

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braced buildings are supported by hinged columns, and stability is provided by bracings in three mutually perpendicular planes.

2. Pre-Engineered Building

In any form of industrial structure, large span, column-free structures are important, and Pre-Engineered Buildings (PEB) meet this requirement while taking less time and expense than CSB and RCC. According to the bending moment diagram, PEB saves a significant amount of steel when the segment is tapered. I formed members, also known as I beams, are commonly used in pre-engineered buildings (primary members). In most cases, steel plates are welded together in the factory to create these beams. Manufacturers taper the segment, which means they reduce the size of the web at the bottom as per design to save weight and steel. Secondary components have lightweight cold moulded “Z” or “C” shaped parts to fasten and protect external cladding. There may be no other modifications possible on-site during erection, such as welding only cutting bolts, and welding is done to bind the members.

III. LITERATURE REVIEW

Neha R.Kolate, Shipa Kewate et.al, (2015) observes that comparison between pre-engineered building and conventional steel structure, have studied the importance of having long spans and structures having column free area in industrial structures and pre-engineered-building are the ones which can fulfill such requirements. PEB has several advantages over CSB such as superior strength and zero maintenance. The PEB system has protection against non-uniform weathering. This paper comparison between PEB and CSB for a 60m length and 30m width for a bay spacing 4m, 5m and 6m respectively and its analyzed and designed for wind zones (wind zone 2, wind zone 3, wind zone 4 and wind zone 5) by using STAAD Pro. Considering cases of wind zones from their research they found that CSB is 23% heavier than PEB and also steel wastage of pre-engineered-building is less, thereby reducing the cost of construction. They also concluded that conventional steel-building is used for clear spans up to 90m but pre-engineered-building is used for greater than 90m.

Hemant Sharma et.al, (2017) observes that comparison between pre-engineered building with conventional steel structure pre-engineered where the bending moments occur at different zones of the sections. Also considered various components of the pre-engineered building used at the site. To design and analyze the PEBand CSB they have taken length of 20m,18m width,8m height at a bay spacing of 4m using Stadapro as well as Indian standard codes and finally compared the two structures in terms of Economy and Time saving of construction. They tried truss systems for cladding and roofing system purposes. In the analysis they have analyzed and designed the Purlins, Girts, Eave Struts and Bracings. Where in terms of weight of steel section CSB is 40% heavier than PEB as comparison shows.

Md Shahid Wasim Chaudhary, Vishwajeet Kadlag, Nagesh Shelke et. al,(2019) observes the Comparison of Conventional steel structure and Pre-engineered buildings which can be extensively used for the construction of Industrial construction of Industrial and commercial purposes. These buildings can be multistoried (3-6). The adaptation of PEB in the place of CSB design results in many advantages including easier fabrication and economy. Construction of CSB incorporates the use of hot rolled sections, which have uniform cross-section throughout the length. However, PEB utilizes steel sections, however which are tailored and profiled based on the required loading effects. Due to lack of awareness and confidence in design and execution of PEB, still it is not the first preference of owner choice. This paper involves PEB and CSB for multi-storey building by analyzing and designing G+4 commercial buildings for a length of 140m, width 40m, eave height 18m, R slope 1/10 using STAAD Pro and Indian standard 800-2007. The study observed that the weight of the PEB model is lesser than that of the CSB model of the same length, width and height. Reduction in weight directly deals with the quantity of steel required, here in this study of G+4 commercial PEB structure reduces the quantity of steel by about 39% than that required by the G+4 commercial CSB structure.

Quazi Syed Shujat, Ravindra Desai et. al,(2019) observes the utilization ratio and weight in a comparative study of conventional steel structure, Tubular structure and Pre-engineered building. The design is as per Indian Standard 800-2007. Dead load, Live load and Wind load calculation as per Indian Standard 875 part I, II AND III respectively. The technique includes the best possible section according to the optimum requirement. This concept has many advantages over the Conventional steel structure concept of building with the roof truss. Analysis and Design is done for length 50m, width 20m, height 8m and with an 5m bay spacing. This study shows that 17.3% PEB is economical than CSB and avg utilization ratio for CSB is 0.45 and PEB0.52.
IV. PEB ADVANTAGE

4.1 Low initial cost: The primary members (column and rafter) usually results up to 40% of weight less for rigid frames as compared to CSB rigid frames. The use of cold formed “Z” or “C” shaped as secondary members in PEB whereas in CSB hot rolled channels is for purlins and girts results varies about 30% less in PEB. The PEB is lighter than other structures.

4.2 Large clear spans: Column free space can be done around 90m. This is one the most important features in PEB.

4.3 Low Maintenance: Roof panels require only periodic cleaning whereas no maintenance required for wall panels. The structure is painted with high quality of liquid for cladding and steel to suit different conditions as per site, which results in long durability and low maintenance coats.

4.4 Fast construction: PEB sections can be delivered to site around 8 weeks (including engineering time) and for “fast project” it can be around in matter of 6 weeks.

4.5 Seismic resistance: The structure is light in weight and flexible to resist greater seismic waves when compared to other structures.

4.6 Erection: Since the connection of components is standard erection is faster. Erection is done by the manufacturer itself. Erection is done faster and less equipment is required for erection.

4.7 Functional Versatility: Both the length and width can be explained for future scopes.

The present study includes the design of Industrial structure. The design is done for CSB and PEB.

The structure consists of
Length of the structure - 60m.
Width of the structure - 20m.
Height up to Eaves -6m.
Centre to Centre spacing of truss - 7.5m.
Location - Coimbatore.
Slope of roof for CSB and PEB - 11.37degree & 5.71degree.
Basic wind speed - 39m/s.
Type of sections - Hot rolled section.
Type of covering - GI sheeting.

Loads taken for the analysis of CSB and PEB are:
Dead load
Live load
Wind load 0º
Wind load 90º

Load combination taken are:
I. 1.5(D.L+L.L)
II. 1.5(D.L+W.L. 0º)
III. 1.5(D.L+W.L 90º)
Load calculation

Dead load
- Single skin sheet load = 0.05 KN/m²
- Purlin load = 0.05 KN/m²
- Frame weight = 0.10 KN/m²

Total load = 0.25 KN/m²

Live load
- Live load (no access) = 0.75 KN/m²
- Collateral Load = 0.25 KN/m²

Total load = 1.00 KN/m²

Figure 1: Geometry of Conventional steel structure

Figure 2: 3D view of Pre-engineered building
Wind Load

Wind load calculation involves as per the procedure from IS 875-2015(part-3) Taking the internal co-efficient factor as ± = 0.5

Finding out the design is done based on Suction condition (i.e., Cpi = -0.5)
Finding out the design wind speed (Vb) = 39 m/s (Coimbatore) Risk co-efficient (K1) = 1.0 (Table-1)
Terrain Factor (K2) = 0.93 (Table -2) Topography Factor (K3) = 1.0 (clause 6.3.3)
Importance Factor(K4) = 1.0 (clause 6.3.4) Vz = Vb x K1 x K2 x K3 x K4
Vz = 39 X 1 x 0.93 x 1 x 1
Vz = 36.27 m/s

Design Wind Pressure

Pd = Kd x Ka x Kc x Pz
Pz = 0.6 Vz² = 0.789 KN/m²
h/w = 6 / 20 (Table – 5) = 0.30 (h/w<= 1/2)
l/w = 60/ 30 (Table -5) = 3 (3/2<=l/w<4)

External co-efficient

Wind load on individual members is calculated by

\[ F = (C_{pe} - C_{pi}) \times A \times Pd \] (clause 7.3.1)

The below table shows the co-efficient for 0° (i.e., X- direction)

<table>
<thead>
<tr>
<th>Surface</th>
<th>Cpe</th>
<th>Cpi</th>
<th>Cpe - Cpi</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.7</td>
<td>-0.5</td>
<td>1.2</td>
</tr>
<tr>
<td>B</td>
<td>-0.25</td>
<td>-0.5</td>
<td>-0.25</td>
</tr>
<tr>
<td>C</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.2</td>
</tr>
<tr>
<td>D</td>
<td>-0.7</td>
<td>-0.5</td>
<td>-0.2</td>
</tr>
</tbody>
</table>

Co-efficient for 0° (i.e, X-direction)

The below table shows the co-efficient for 90° (i.e, Zdirection)

<table>
<thead>
<tr>
<th>90°</th>
<th>Surface</th>
<th>Cpe</th>
<th>Cpi</th>
<th>Cpe - Cpi</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.5</td>
<td>-0.5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>-0.5</td>
<td>-0.5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0.7</td>
<td>-0.5</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>-0.1</td>
<td>-0.5</td>
<td>0.4</td>
<td></td>
</tr>
</tbody>
</table>

Co-efficient for 90° (i.e, Z- direction)
The external coefficient is taken from the table IS 875 - part-3 Wind load on individual members is calculated by

\[ F = (C_{pe} - C_{pi}) \times A \times P_d \] (Clause 7.3.1)

The below table shows the co-efficient for $0^\circ$ (i.e., X-direction) (i.e., 0.5)

<table>
<thead>
<tr>
<th>Surface</th>
<th>$C_{pe}$</th>
<th>$C_{pi}$</th>
<th>$C_{pe} - C_{pi}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF</td>
<td>-1.11</td>
<td>0.5</td>
<td>-0.6</td>
</tr>
<tr>
<td>GH</td>
<td>-0.4</td>
<td>0.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

The below table shows the co-efficient for $90^\circ$ (i.e., Z direction) (i.e., 0.5)

<table>
<thead>
<tr>
<th>Surface</th>
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<th>$C_{pe} - C_{pi}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>EG</td>
<td>-0.78</td>
<td>0.5</td>
<td>-1.28</td>
</tr>
<tr>
<td>FH</td>
<td>-0.78</td>
<td>0.5</td>
<td>-1.28</td>
</tr>
</tbody>
</table>

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</tr>
<tr>
<td>GH</td>
<td>-0.4</td>
<td>0.5</td>
<td>-0.9</td>
</tr>
</tbody>
</table>

The below table shows the co-efficient for $90^\circ$ (i.e., Z direction) (i.e., 0.5)

<table>
<thead>
<tr>
<th>Surface</th>
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<td>-0.78</td>
<td>0.5</td>
<td>-0.28</td>
</tr>
</tbody>
</table>

\[ \text{Fig. 7.3 and 7.4 Rendered View and Section property of PEB} \]
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>CSB</th>
<th>PEB</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEEL WEIGHT</td>
<td>38 TON</td>
<td>30 TON</td>
</tr>
<tr>
<td>MATERIAL COST</td>
<td>2,204,000</td>
<td>1,740,000</td>
</tr>
</tbody>
</table>

From the study Pre-engineered buildings are proven to be more economical than Conventional steel structure and PEB results in a material saving structure than CSB. PEB cost is 21.1% lesser than CSB in this study.

V. CONCLUSION

From the past studies and present output, the PEB is proven to be more economical, resulting in time saving and material saving than CSB. The PEB can be designed by simple design procedure in accordance with Indian standard, speed in construction, energy efficient, saves cost, re-usable of steel, sustainable and reliable as compared to Conventional steel structure. Pre-engineered buildings are the best solution for longer spans without any interior columns. PEB can meet the requirements like large openings in buildings and flexible separation than other structures. The cross-sectional area of the column is small as compared to other structures. PEB frames are light and also foundation also. PEB is more flexible than conventional steel structure and its higher in resistance to seismic forces. Thus, PEB methodology must be implemented and researched for more outputs.

VI. REFERENCE


