Design and Analysis of Pre-Engineered Building with Subjected to Seismic Loads using E-Tabs

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Abstract— Pre-Engineered Building (PEB) concept is a new conception of single storey industrial building construction. This methodology is versatile not only due to its quality pre-designing and prefabrication, but also due to its light weight and economical construction. The concept includes the technique of providing the best possible section according to the optimum requirement. This concept has many advantages over the Conventional Steel Building (CSB) concept of buildings with roof truss. Technological improvement over the year has contributed immensely to the enhancement of quality of life through various new products and services. One such revolution was the pre-engineered buildings. Pre-engineered building creates and maintains in real time multidimensional, data rich views through a project support is currently being manually design and same has been verified with analytical software. E-Tabs software packages for design and simulation which is essential for concluding the suitability of the structure with respect the loading of wind, self-weight, seismic and snow load etc. My proposed plan is going to execute with all sort of design parameters in Salem city.

Key words: Pre-Engineered Building, light weight construction, ware house, Conventional Steel Building (CSB), E-Tabs

I. INTRODUCTION

Steel industry is growing rapidly in almost all the parts of the world. The use of steel structures is not only economical but also Eco-friendly at the time when there is a threat of global warming. Here, “economic” word is stated considering time and cost. Time being the most important aspect, steel structures (Pre-fabricated) is built in very short period and one such example is Pre Engineered Buildings (PEB). Pre-engineered buildings are nothing but steel buildings in which excess steel is avoided by tapering the sections as per the bending moment’s requirement. One may think about its possibility, but it’s a fact many people are not aware about Pre Engineered Buildings. If we go for regular steel structures, time frame will be more, and also cost will be more, and both together i.e. time and cost, makes it uneconomical. Thus in pre-engineered buildings, the total design is done in the factory, and as per the design, members are pre-fabricated and then transported to the site where they are erected in a time less than 7 to 9 weeks.

A. Pre-Engineered Buildings

Presently, large column free area is the utmost requirement for any type of industry and with the advent of computer software’s it is now easily possible. With the improvement in technology, computer software’s have contributed immensely to the enhancement of quality of life through new researches. Pre-engineered building (PEB) is one of such revolution. “Pre-engineered buildings” are fully fabricated in the factory after designing, then transported to the site in completely knocked down (CKD) condition and all components are assembled and erected with nut-bolts, thereby reducing the time of completion. Pre-Engineered Building concept involves the steel building systems which are predesigned and prefabricated. As the name indicates, this concept involves pre-engineering of structural elements using a predetermined registry of building materials and manufacturing techniques that can be proficiently complied with a wide range of structural and aesthetic design requirements, as in. The basis of the PEB concept lies in providing the section at a location only according to the requirement at that spot. The sections can be varying throughout the length according to the bending moment diagram. This leads to the utilization of non-prismatic rigid frames with slender elements. Tapered I sections made with built-up thin plates are used to achieve this configuration. Standard hot-rolled sections, cold-formed sections, profiled roofing sheets, etc.

B. Need for the Project

- The materials used in conventional steel building consume more cost, so to overcome this “PEB structures” are needed to reduce the cost of the project.
- In order to reduce the self-weight of conventional steel buildings PEB can be used. Generally PEB can reduce up to 35% of self-weight when compared to conventional steel buildings

C. Objective of Our Project

- Drafting of pre-Engineered building plan using the AutoCAD software.
- Manual load design of PEB structure.
- Foundation design of PEB structure
- To determine the seismic response of the PEB using ETABS.
- Comparison of results between CSB and PEB using ETABS analysis.

II. METHODOLOGY

The selection of the type of structure is selected and dimensions of the warehouse are done and mainly type of loads acted on the structure is studied. The warehouse is initially theoretically designed by using the IS methods. The analysis is carried out with the help of IS loading conditions and E-Tabs. The results are finally analyzed and compared to produce the better results.

III. DESIGN

A. Design Data (Ordinary Structure)
- Frame Type - Clear Span, Rigid Frame.
- Support- Pinned
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1) Calculation of Static Loads

Dead loads are considered as per Table-2 of IS 875 (Part-1) – 1987
- Weight of the G.I sheeting = 0.05 kN/m² (class 1 G.I sheeting, thickness 0.5 mm)
- Self-weight of section = 0.05 kN/m²
- Total weight = 0.10 kN/m²
- Spacing of purlin = 1.35 m
- Bay spacing = 6.46 m
- Total weight on frame = 0.10 x 6.46 = 0.646 kN/m
- Live load on the sloping roof = 0.75 kN/m²
- Live load on rafter = 0.75 x 6.46 = 4.845 kN/m

2) Earthquake Load

For seismic analysis, following data has been used as per IS 1893 Part I – 2002.
- Zone III (SALEM)
- Response reduction factor = 5 (For Steel frames with concentric braces)
- Importance factor, I, is taken as 1.0, though it is 1 as per IS code, to be on safer side.
- Damping ratio = 3 (For Steel Buildings)
- Time period in X and Y directions:
  \[ T_x = 0.085 H^{0.74} = 0.45s \]
  \[ T_y = 0.45s \]
- Therefore, \( S_a/g = 2.5 \)
- Horizontal Seismic Co-efficient, \( A_h = 0.04 \)

Therefore, Base Shear, \( V_b \)
\[ V_b = A_h \times W \]
\[ = 0.04 \times 1329.07 \]
\[ = 53.162 \text{kN} \]

3) Wind Pressure Coefficients

External and Internal wind coefficients are calculated for all the surfaces for both pressure and suction. Opening in the building has been considered less than 5% and accordingly internal coefficients are taken as +0.2 and -0.2. The external coefficients and internal coefficients calculated as per IS 875 Part III (1987). Wind load on individual members are then calculated as below.

\[ F = (C_p_e - C_p_i) \times P_z \]

Where, \( C_p_e \) and \( C_p_i \) are external coefficients and internal coefficients respectively and \( A \) and \( P \) are Surface Area in m² and Design Wind Pressure in kN/m² respectively.

\[ F = (-0.4+0.2) \times 6.46 \times 20.04 \times 1.44 = -74.91 \text{kN/m} \]
\[ F = (-0.6-0.2) \times 6.46 \times 20.04 \times 1.44 = -149.83 \text{kN/m} \]
\[ F = (-0.6+0.2) \times 6.46 \times 20.04 \times 1.44 = -37.45 \text{kN/m} \]

4) Member Design

1) 1.5 X 1.5 X 4.845 = 8.2365 kN (TENSION)
2) 1.2 X 1.2 X 4.845 + 1.2 X -262.2 = 306.40 kN
3) 1.5 X 1.5 X -262.2 = 392.33 kN
4) 0.9 X 1.5 X -262.2 = -392.72 kN (COMPRESSION)

5) Vertical Member

- Area = load / stress = 765.33 / 100 = 7653.3 mm²
- Let us assume ISHB300.
- Area = 7485 mm²
- Depth of section = 300 mm
- Width of flange = 250 mm
- Thickness of flange = 10.6 mm
- Effective length of rafter panel about:
  - Major axis = 0.85 L = 0.85 x 9500 = 8075 mm
  - Minor axis = 1 L = 9500 mm
  - \( L/r = 8075/129.5 = 62.36 \text{mm} \)

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IV. E-TABS REPORT

A. Structure Data (CSB Structure)

This chapter provides model geometry information, including items such as story levels, point coordinates, and model frame element connectivity.
B. Structure Data (PEB Structure)

This chapter provides model geometry information, including items such as story levels, point coordinates, and model frame element connectivity.

V. RESULTS AND CONCLUSION

A. Results

The Table 1 shows the difference between the Normal Structure and PEB Structures

<table>
<thead>
<tr>
<th>S.No</th>
<th>Factor</th>
<th>CSB</th>
<th>PEB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quantity of Steel</td>
<td>19.70 MT</td>
<td>9.10 MT</td>
</tr>
<tr>
<td>2</td>
<td>Bending Moment</td>
<td>3071.7 kN-m</td>
<td>1758.10 kN-m</td>
</tr>
<tr>
<td>3</td>
<td>Shear Force</td>
<td>1336.6 kN</td>
<td></td>
</tr>
</tbody>
</table>

B. Conclusion

A Pre-engineered steel structures building is to choose a material which offers low cost, strength, durability, design flexibility, adaptability and recyclability. Steel is the basic material that is used in the Materials that are used for Pre-engineered steel building. It negates from regional sources. Infinitely recyclable, steel is the material that reflects the imperatives of sustainable development. As it is seen in the present work, the weight of steel can be reduced for the building, providing lesser dead load which in turn offers higher resistance to seismic forces. PEB building cost is 35% lesser than the cost of CSB structure. For longer span structures, Conventional buildings are not suitable with clear spans. 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. To Conclude “Pre-Engineered Building Construction gives the end users a much more economical and better solution for long span structures where large column free areas are needed”.

REFERENCES

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