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A Comparative Study on Pre Engineered Building by using STAAD PRO

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Abstract - *Steel is the material of choice for design because it is inherently ductile and flexible. It flexes under extreme loads rather than crushing and crumbling. Structural steel's low cost, strength, durability, design flexibility, adaptability and recyclability continue to make it the material of choice in building construction. Fast construction lowers overhead expenses for construction management services. Steel is extensively used in the construction of industrial buildings of large spans with or without cranes (medium and heavy buildings), where the concrete construction is not feasible. In structural engineering, a pre-engineered building (PEB) is designed by a manufacturer to be fabricated using a pre-determined inventory of raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements.Pre engineered steel buildings can be fitted with different structural accessories including mezzanine floors, canopies, fascias, interior partitions etc. and the building is made water proof by use of special mastic beads, filler strips and trims. In pre-engineered building concept the complete designing is done at the factory and the building components are brought to the site in Knock down condition. An efficiently designed pre-engineered building can be lighter than the conventional steel buildings by up to 30%. Lighter weight equates to less steel and a potential price savings in structural framework.*

Key Words: Conventional steel structure, Pre- Engineered Buildings, Economy, STAAD Pro.

1. INTRODUCTION

An Industrial Warehouse is a storage building usually characterized as a single storey steel structure with or without mezzanine floors. The enclosure of these structures may be of brick masonry, concrete walls or GI sheet covering. The walls are generally non-bearing but sufficiently strong enough to withstand lateral Forces caused by wind or earthquake. The designing of industrial warehouse includes designing of the structural elements including principal rafter and roof truss, column and column base, purlins, sag rods, tie rods, gantry girder and bracings. A combination of standard hot-rolled sections, cold-formed sections, profiled sheets and steel rods are used for the construction of industrial steel structures.

Industrial buildings can be categorized as Pre-Engineered Building (PEB) and Conventional Steel Building (CSB) according to the design system involved in the built form. Steel is a material which has high strength per unit mass and therefore commonly used in construction of structures with large column-free space – a criterion most of the industrial structures require.

1.1 Pre-Engineered Building (PEB)

PEB involves a steel building system which is 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. 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 and profiled roofing sheets are also employed along with the tapered sections. The use of optimal least section leads to effective saving of steel and cost reduction.

1.2 COMPONENTS OF PEB

A typical assembly of a simple metal building system is shown below to illustrate the Synergy between the various building components as described below:

- Primary components
- Secondary components
- Sheeting (or) cladding
- Accessories

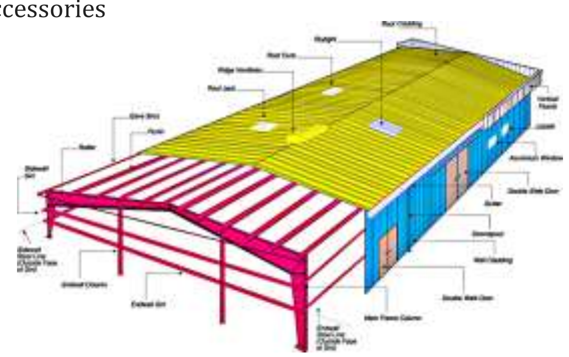


Fig -1: components of PEB

1.3 OBJECTIVES

Following are the main objective of this project:

1. To make a comparative study between pre engineered building & conventional steel building.
2. To prepare a model of P.E.B.
3. To analyze structure using Staad Pro.
4. To design sections, connections etc.
5. To study the effect of P.E.B. for following issues:
6. To reduce complexity on site.
7. To achieve High accuracy.
8. Speed of work.

2. METHODOLOGY

1. **Linear Static:** Linear analysis techniques give a good suggestion of elastic capability of the structures and indicate where first yielding will arise. The linear static method of analysis is limited to undersized, reliable buildings.

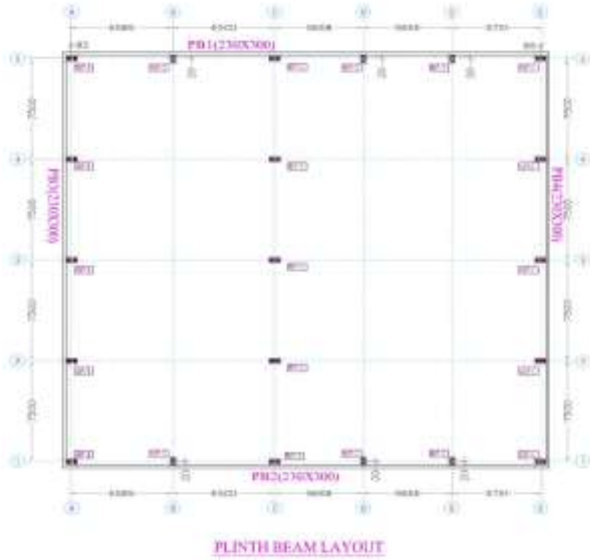
2. **Linear Dynamic:** In IS:1893,2002 (Part 1) two methods, one Seismic factor and other Response Spectrum method is described to carry out the analysis for Earthquake forces. One Table (in Clause 4.2.1) is also provided to decide upon the method to be used, depending upon structure elevation and seismic zone. At the lowermost of this table, it is evidently mentioned that structures with irregular shape and/or irregular dissemination of mass and stiffness in x and/or y plane, shall be analyzed as per Response Spectrum approach. For all practical reasons, no structure is uniform in all the respects (i.e. mass/stiffness, shape distribution in x and y plane). This means that for no structures, the Seismic Co-efficient method shall be helpful. Response Spectrum approaches, being time elapsing and tiresome process, mostly, computer applications are possible.

3. **Non-linear Static:** In a nonlinear static analysis technique the building model integrates directly the nonlinear force deformation features of individual components and elements due to inelastic physical response. Several methods (ATC40, FEMA273) existing and all have in common that the nonlinear force–deformation features of the building is characterized by a Pushover curve, PO curve of base shear vs. top translation, obtained by subjecting the building model to monotonically augmenting lateral forces or augmenting translations, distributed over the peak of the building in correspondence to the first mode of vibration until the building disintegrates. The maximum translation likely to be experienced during a given earthquake is determined using either highly damped or inelastic response spectra.

3. STAAD PRO.V8i

STAAD is computer program software used for structural design and analysis in the field of civil engineering. STAAD provides a flexible modelling space and a friendly user interface to work with. The program supports several material design codes such as steel (hot rolled and cold formed sections), concrete, aluminium and timber based projects. The software is incorporated with over 80 international codes, various unit systems and all the standardized steel cross sections to provide results to desired standards and specifications. The software helps to:

1. Design any type of structure regardless its shape and size.
2. Carries out analysis regardless the complexity of the structure.
3. It reduces duplication of iterations and minimizes errors.
4. It provides accurate analysed results.
5. Revisions can be easily incorporated and reanalyzed.



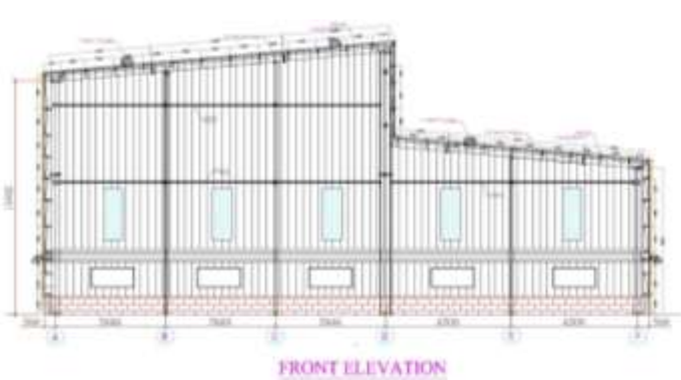


Fig -2: Front Elevation

4. LOADS

The load acting on the structure is considered as follows:
1. Dead loads: 0.150 kN/m2 [IS 875: (Part I)]
2. Live loads: 0.750 kN/m2 [IS 875: (Part II)]
3. Wind load: 0.795 kN/m2 [IS 875: (Part III) – 1987]

Load combinations

1. 1.0 (Dead Load + Live Load + Crane Load)
2. 1.5 (Dead Load + Live Load + Crane Load)
3. 1.2 (Dead Load + Live Load + Wind Load Pressure 0°) + 1.05 (Crane Load)
4. 1.2 (Dead Load + Live Load + Wind Load Suction 0°) + 1.05 (Crane Load)
5. 1.2 (Dead Load + Live Load + Wind Load Pressure 90°) + 1.05 (Crane Load)
6. 1.2 (Dead Load + Live Load + Wind Load Suction 90°) + 1.05 (Crane Load)
7. 1.5 (Dead Load + Wind Load Pressure 0°)
8. 1.5 (Dead Load + Wind Load Suction 0°)
9. 1.5 (Dead Load + Wind Load Pressure 90°)
10. 1.5 (Dead Load + Wind Load Suction 90°)

5. OBSERVATIONS AND RESULTS

a. Estimation of structural weight and its comparison between conventional steel structure and pre-engineered building.

Table 1: Steel estimate of conventional steel structure and pre- engineered building

Structure	**Purlins and girts**	**Quantity (kgs)**
Conventional steel	Hot rolled mild sections	44195.54
	Hot rolled tube sections	15453.25
Pre-engineered	Cold formed Z-sections	31516.34

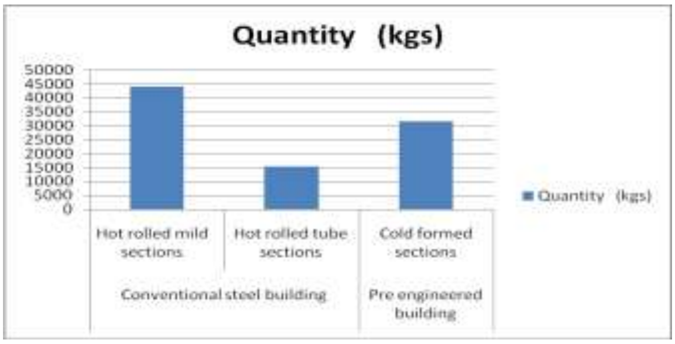


Chart 1: Structural weight comparison between conventional steel structure and pre- engineered building

- The difference in structural weight between conventional steel structure and pre- engineered structure has been estimated as 12679.2 kgs.
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- On replacing the ISMC sections by tube sections for purlin and girt components and varying the column sections depending on the magnitude of axial loads, the difference in structural weight has been estimated as 16063.09 kgs.

b. Estimation of dead load contributed by hot rolled & cold formed sections to the total weight of the structure.

Table 2: Dead Load estimate of hot rolled & cold formed sections

Purlins and girts	Section Members	Quantity (kgs)	Dead Load
Hot rolled mild sections	Tapered Section	21947.11	69.64%
Cold formed sections	Z-Section 200x60x2	9569.23	30.36%

Chart 2: Dead weight comparison between hot rolled & cold formed sections

- The cold formed sections contribute 30.36 % dead load to the total weight of the structure whereas mild steel sections contribute 69.64 % of dead load.

c. Cost estimation of structural steel and its comparison between conventional steel structure and pre-engineered building.

Table 3: Cost estimate of structural steel

Structure	Purlins and girts	Quantity (kgs)	Total cost(Rs)
Conventional steel	Hot rolled mild sections	44195.54	1988799.3
	Hot rolled tube sections	15453.25	695396.25
Pre-engineered	Cold formed Z- sections	31516.34	1638849.68

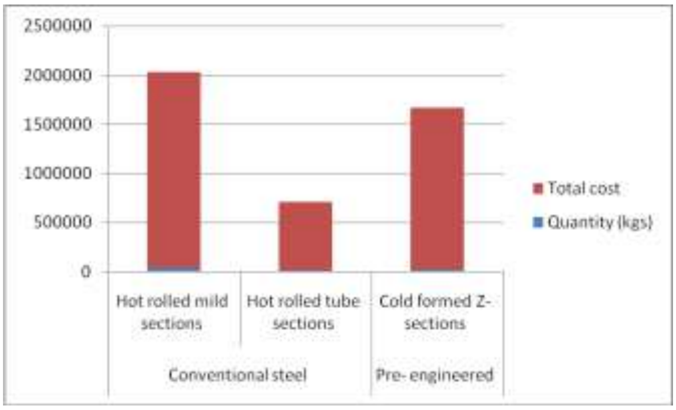

Chart 3: Cost comparison of structural steel between conventional steel structure and pre- engineered building

- The cost of steel for pre- engineered structure is found to be 26.38 % less than conventional steel structure due to the low structural weight of pre- engineered structures.

- The ISMC section adopted for purlins and girts when replaced by hollow tube sections and varying the column sections depending on the magnitude of axial loads, the overall structural weight of the conventional steel structure is reduced

6. CONCLUSIONS

- The weight of structural steel for pre- engineered building has resulted to be 30.00% less compared to conventional steel structure.
- Replacement of ISMC with tube (hollow) sections and varying the size of the structural components depending on the magnitude of oncoming loads has reduced the weight of the structure by 10.10 %. Thus proving that optimization of structural components based on magnitude of load helps to achieve an economical steel design.
- The cold formed sections contribute only 30.36 % dead load to the structure compared to mild steel sections that contribute 69.64 %. The cold formed sections are produced having low cross sectional area which leads to low unit weight of the components and hence contributes less dead load to the structure.
- Pre- engineered buildings prove to be light weight structures and can be highly adopted to replace conventional steel structures. The minimum number of structural components involved in the design and effectively optimizing the cross sections of the structural components based on concentration of forces and stresses developed helps achieving economy and consuming less material resource.

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