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Alternative Forms of an Industrial Ware House using PEB and CFS Sections

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Abstract:- As the cost of steel is increasing day by day and the use of steel is unavoidable in the industries. The construction practices calls for the best aesthetically look, high quality and speedy construction, economical with innovative ideas as the steel is mostly used construction material in industry. Hence to achieve the economy in the steel structure, it is necessary to use the optimum quantity of steel. In this study, an attempt to present comparative study of Conventional Steel Buildings (CSB), Pre Engineered Building (PEB) and Cold Formed Steel(CFS) Warehouses. The comparison has been done which includes the truss of span 20m, 25m and 30m with various column spacing and the length of shed is 60m. All the trusses are modelled, analyzed and designed by using STAAD-Pro V8i software. The economy of the structure is discussed in terms of quantity of steel.

Keywords:- *Ware House, CSB, PEB, CFS, Optimum, STAAD-Pro.*

I. INTRODUCTION

Warehouse is a large building where raw materials and manufacturing goods may be stored for the distribution purpose. Warehouse creates adequate environment for storing and provides protection from environmental factors and theft. For designing a warehouse various factors have to be considered such as the storage capacity, lifting and delivery arrangements, transport operations, additional needs of employees and workers, etc.

II. DESIGN OF VARIOUS TYPES OF WAREHOUSES

A. Conventional Steel Building (CSB).

Conventional steel trusses are produced with hot rolled sections such as angle sections, purlin sections, I-sections, etc. The sections of truss members (tie member, principal rafter, strut, sling) are selected on the basis of their maximum internal stresses .Maintaining the Integrity of the Specifications.

These trusses are erected on the site hence it is difficult to inspect and control the quality of work. These are costlier because of high steel quantity and more number of connections. Figure 1 shows the 3D view of conventional steel warehouse.

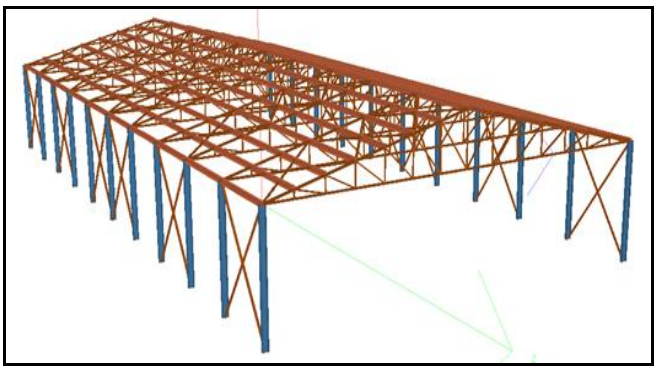

Fig 1:- 3D View of Conventional Steel Warehouse

B. Pre Engineered Building (PEB)

A pre-engineered metal building, also known as a pre-manufactured or pre-fabricated metal building, is designed to specification at the manufacturer. The members and panels are created as needed, minimizing the amount of steel required and resulting in a lighter-weight building. Every member of the truss is manufactured off site. Each member is rolled, cut, punched and marked to make assembly as easy as possible. The PEB can be used vey effectively with a wide range of structural and aesthetical requirement. Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

The basic principal of PEB structure is to provide section at any spot based on its structural requirement. Instead of standard angle, T-sections, tapered I-sections has been generally preferred for primary members those are varying linearly according to their bending moment diagram and secondary members are a Z or C section which makes the structure light in weight and leads to make speedy erection. Figure 2 shows the 3D view of pre- engineered building.

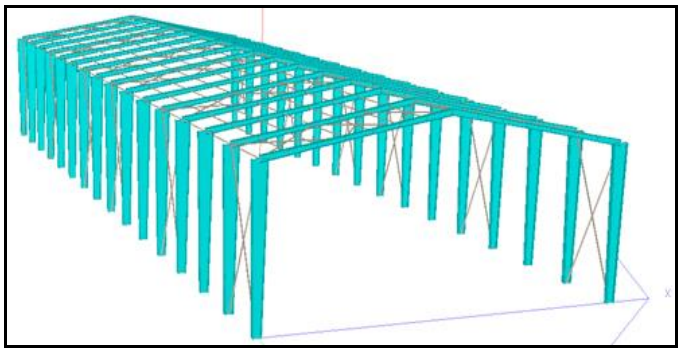

Fig 2:- 3D View of Pre- Engineering Building

C. Cold Formed Steel Trusses (CFS)

Cold formed steel members are made from the sheets of structural steel those are formed into various standard sections by means of compression. As no high temperature is involved in this process hence it is named as cold formed steel. CFS has many advantages as a construction material. It doesn't shrink and split, won't absorb moisture, resist warping, termites and fire. It is light in weight thus making easy to ship, handle and assemble. For making speedy construction the CFS sections are pre-punched holes to accommodate rapid mechanical, electric and plumbing installation after complete framing.

Because of all good properties of CFS, we replaced the purlins, struts, slings and bracings with the CFS section in the conventional roof truss which will made a good combination of hot rolled sections and cold formed sections. Figure 3 shows a 3D view of conventional steel truss with CFS.

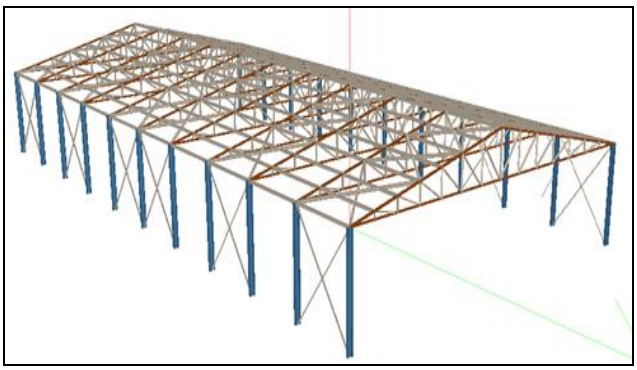

Fig 3:- 3D View of Conventional Truss with Cold Formed Steel

III. LOAD AND LOAD COMBINATIONS

Following loads were considered for the load calculations for the design of warehouses.

A. Dead Load

Dead load is the self weight of different components of the structure itself. Its magnitude and point of application does not appreciably change with time. Dead load on a truss will comprise of loads of roof coverings, perpendicularly running beams (purlins), connections, supporting elements (braces) and self load of the truss. Further, additional special dead loads such as truss supported hoist dead loads; special ducting and ventilator weight etc. could contribute to roof truss dead loads.

B. Live Load

The live load on roof trusses consist of the gravitational load due to erection and servicing as well as dust load etc. and the intensity is taken as per IS:875-1975. Additional special live loads such as snow loads in very cold climates, crane live loads in trusses supporting monorails may have to be considered.

C. Wind Load

The wind load on the roof trusses, unless the roof slope is too high, would be usually uplift force perpendicular to the roof, due to suction effect of the wind blowing over the roof. Hence the wind load on roof truss usually acts opposite to the gravity load, and its magnitude can be larger than gravity loads, causing reversal of forces in truss members.

D. Load Combinations

Following are the various load combinations considered in the design of warehouse according to IS 800:2007. The load combinations include the strength and serviceability criteria. Twenty two load combinations were considered for design and few of them were stated below:

1. LOAD COMBINATION 1: 1.5(DL+ LL)
2. LOAD COMBINATION 2 - 1.2 (DL + LL + WIND 0 & -VE)
3. LOAD COMBINATION 10 - 0.9DL + 1.5WIND 0 & -VE
4. LOAD COMBINATION 15 - DL + LL + WIND 0 & -VE
5. LOAD COMBINATION 19 - DL + WIND 0 & -VE

IV. DESIGN OF CONVENTIONAL STEEL WAREHOUSE

A. Data for Analysis and Design

Following considerations were made while designing the Conventional roof truss.

- Geometry of truss: Howe Truss
- Span of truss = 20m, 25m, 30m.
- Length of truss=60m
- Rise of truss=3.5m
- Spacing between two columns = 4m, 5m & 6m
- Height of column = 8m
- Location of building = Solapur
- Type of roofing = G.I. sheets
- Number of trusses= as per length.
- Permeability= Low permeability (Cpi=±0.2)

B. Load Calculations

- *Dead Load*

Dead loads on the roof truss are estimated as per the Indian standard code IS: 875-Part-I. The dead weight of sheeting, fastenings, bracings and self weight of purlins and self weight of truss are calculated as per geometry of the truss and applied as panel loads on the truss.

Load on each panel point = 4.0 kN
Load on each end panel point = 2.0 Kn

C. Live Load

Live loads on the roof truss are estimated as per the Indian standard code IS: 875-Part-II. Based on the slope of roof truss and access provision condition for maintenance, the live load intensity is calculated as per the code. The loads on the panel points of the truss are estimated and applied.

Live load on each intermediate panel point = 3.83 kN
Live load on end panel point = 1.92 kN

D. Wind Load

Wind loads on the roof truss are calculated as per the Indian standard code IS: 875-Part-III. Considering the location of ware house, slope, height and topography of the site, wind loads are calculated as per the code IS: 875-Part-III. The panel loads at intermediate and end positions are evaluated and applied normal to the sheeting.

Wind load on each intermediate panel point = -5.60 (Uplift)
Wind load on end panel point = -2.88 kN (Uplift)

Similarly loadings for all conventional trusses, pre-engineered building and conventional steel trusses with cold formed steel trusses and applied load on the panel points of trusses except PEB. In PEB trusses the uniformly distributed load is applied trusses. Figure 5&6 shows the loads applied on the conventional steel truss and PEB truss respectively.

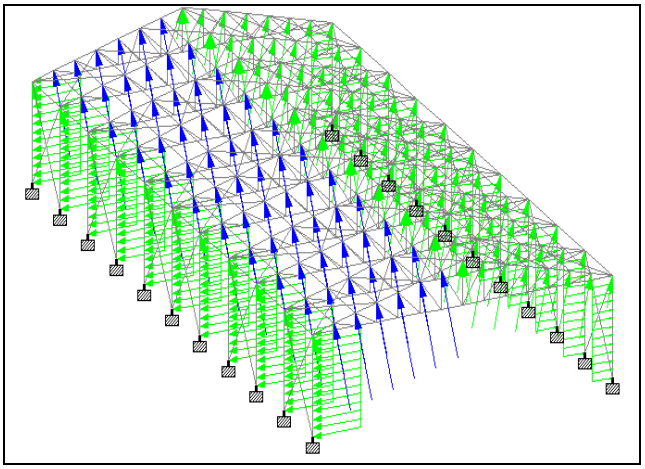

Fig 4:- Loading on Conventional Steel Truss

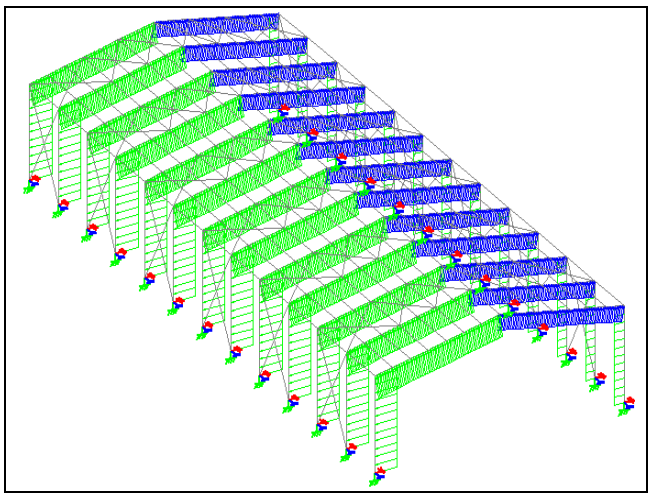

Fig 5:- Loading on Pre Engineered Building

V. RESULTS

All models of warehouse are analyzed and designed in STAAD-Pro software. For all the models, the variation of column spacing of 4m, 5m and 6m is considered in the analysis and optimization of structure has been carried out. Following tables show results of design parameters for all four type of warehouse structure. Table 1,2 &3 shows the quantity of steel obtained for 20m, 25m and 30m spans respectively.

Purlins are designed cold formed steel sections for optimizing the quantity of steel in PEB and conventional and CFS trusses. IS 801:1975 is used to design cold formed steel sections.

Spacing Of Truss	Conv. Truss	PEB Truss	Conv. + CFS Truss
4m	629.45	326.64	308.0
5m	619.03	315.58	263.185
6m	643.94	373.92	288.96

Table 1. Quantity of Steel (kN) For 20m Span of Truss

Spacing Of Truss	Conv. Truss	PEB Truss	Conv. + CFS Truss
4m	711.14	487.23	447.17
5m	770.78	451.70	424.09
6m	774.37	458.96	318.82

Table 2. Quantity of Steel (kN) For 25m Span of Truss

Spacing of Truss	Conv. Truss	PEB Truss	Conv.+ CFS Truss
4m	827.77	648.34	524.32
5m	774.37	529.77	441.66
6m	869.57	623.94	521.20

Table 3. Quantity of Steel (kN) For 30m Span of Truss

For better interpretation of the results, the tabular results are presented in terms of graphs. Figure 6,7 & 8 shows the graphs for quantity of steel for span 20m, 25m and 30m.

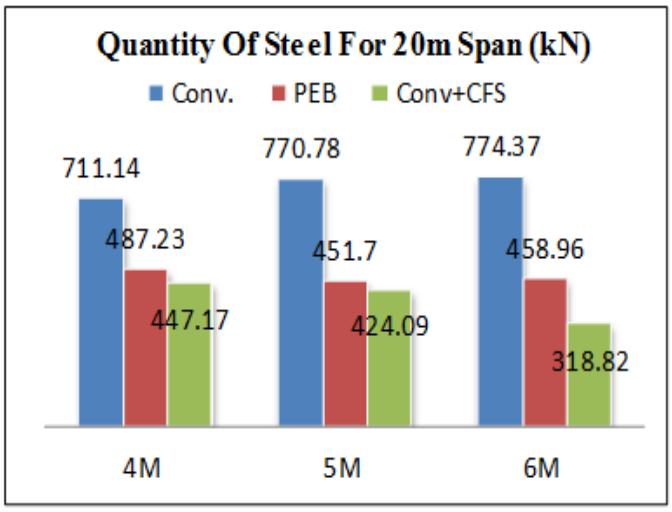

Fig 6:- Quantity of Steel for 20m Span

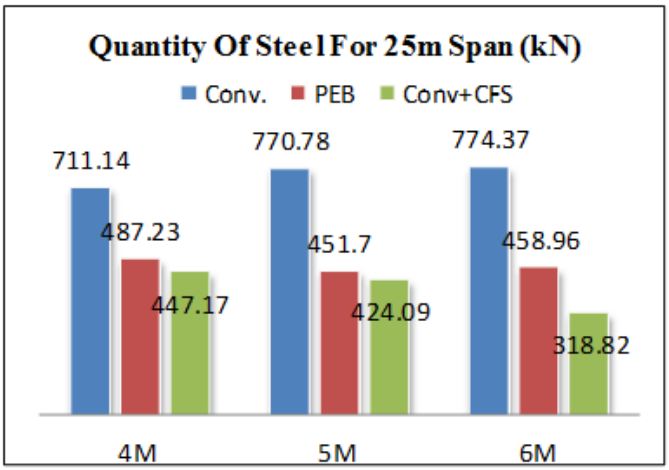

Fig 7:- Quantity of Steel for 25m Span

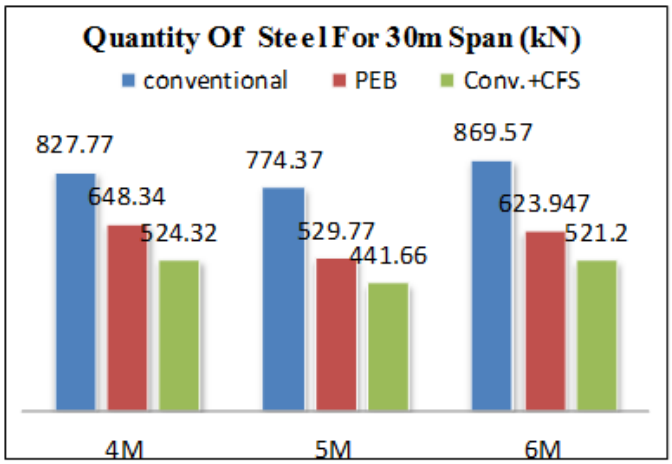

Fig 8:- Quantity of Steel for 30m Span

VI. CONCLUSIONS

From the results obtained of the present work following prominent conclusions have been made.

- Quantity of steel required for PEB trusses are 35% less than the conventional trusses. The second comparison the quantity of steel required for the conventional with CFS sections are 16% less than the PEB trusses. As in the third comparison in between conventional trusses and Conventional with CFS.
- It has been seen that conventional truss with CFS sections are around 45% economical than the conventional trusses. Further detailed comparisons come to conclude about the PEB trusses.
- For longer spans and more clear span between columns PEB trusses along with cold formed steel sections proven to be more economical.
- The secondary members i.e. purlins, bracings are used as the cold formed steel sections instead of hot rolled steel sections it becomes light in weight and provides more resistance to the external loads.
- All secondary members in the conventional roof truss (struts, slings, bracings and purlins) those are primarily provided in hot rolled sections are replaced by cold formed steel sections then the quantity of steel for conventional with CFS sections becomes less than the conventional trusses.
- PEB trusses are found to be uneconomical as compared to conventional trusses in case of smaller span structures.
- PEB structures and trusses with CFS seems to be economical than conventional trusses.

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