Comparative design and Study of Various Steel Sheds with Various Design Codes for selecting a better option For Construction of New Shed

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Abstract - *Construction projects require many decisions. A key decision is to find the most effective option, as well as determining which process could produce ideal results. Construction work is done mainly by two types, Steel structures and Concrete structures. In this paper steel sheds of various sizes are analyze by applying different codes such as IS-800, MBMA, etc . Different loading is also applied to them according to code. All this analysis is done with the help of software STAAD Pro.V8i. For this analysis detail study of that is done. After analyzing these sheds, results obtained from the STAAD are collected and compared, on the basis of this comparative study, for a particular requirement of steel shed, which is the best option is found out. The main aim of this paper is to find the optimum option of steel shed out of PEB steel structure (Pre-engineered Building) and CSB structures (Conventional Steel Structure).*

Key Words: Pre-Engineered Buildings, Conventional buildings, Staad-Pro, Steel take off, Tapered section.

1. 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 ecofriendly at the time when there is a threat of global warming. Here, "economical" 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 6 to 8 weeks. But when we talk about small sheds manufacturing cost of PEB is more same as transportation cost is also more because PEB factories are not available in all parts of country. So for small structure instead of PEB go for CBS.

The structural performance of these buildings is well understood and, for the most part, adequate code provisions are currently in place to ensure satisfactory behavior in high winds. Steel structures also have much better strength-to-weight ratios than RCC and they also can be easily dismantled. Pre Engineered Buildings have bolted connections and hence can also be reused after dismantling. Thus, pre-engineered buildings can be shifted and/or expanded as per the requirements in future. In this paper we will discuss the various advantages of pre-engineered buildings and also, with the help of three examples, a comparison will be made between pre-engineered buildings and conventional steel structures.

2. METHODOLOGY

The present study is included in the design of steel sheds with width varies from 5m to 40m and height varies from 4m to 10m, located at Nagpur. The structure length is considered as 37.5m with bay spacing of 7.5m i.e. 5 nos. of 7.5m bays. In this study, firstly PEB frame is taken into account and the design is carried out by considering wind load as the critical load for the structure. CSB frame is also designed for the same span considering an economical roof truss configuration. Both the designs are then compared to find out the economical output. The designs are carried out in accordance with the Indian Standards and then American standards and by the help of the structural analysis and design software STAAD pro v8i.

2.1. Pre-engineered building

Pre-Engineered Building concept involves the steel building systems which are predesigned and prefabricated. 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. is also used along with the tapered sections. The use of optimal least section leads to effective saving of steel and cost reduction. The concept of PEB is the frame geometry which matches the shape of the internal stress (bending moment) diagram thus optimizing material usage and reducing the total weight of the structure.

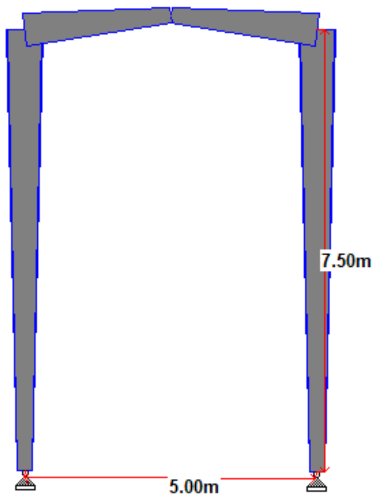


Fig. 1: PEB Frame

2.2. Conventional steel buildings

Conventional steel buildings (CSB) are low rise steel structures with roofing systems of truss with roof coverings. Various types of roof trusses can be used for these structures depending upon the pitch of the truss.

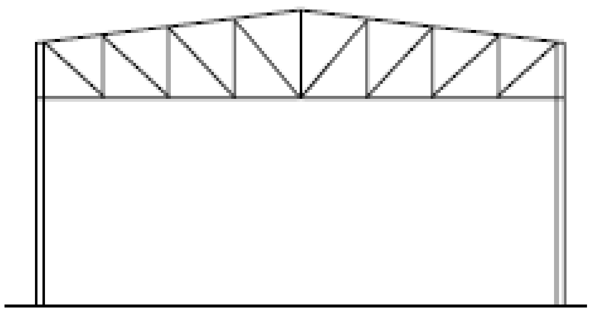


Fig. 2: CBS Frame

2.3. Cold form steel section

The high strength-to-weight ratio of cold-formed steel members provide substantial savings. As a result, they have become very popular in industrial structures, where usually heavy and bulky structures are required. In such structure utilization of high strength-to-weight ratio will leads to help in reduction of the total load on structure and saving of construction time & cost, as in [10].The easy availability of required shapes and sizes will help us in choosing the most economical cold-formed shape in design of structures. There are various shapes and cross section which can be formed easily and there is no limitation in forming the cross section of any type for column/portal, truss members, purlins / side girts & decking profiles /roofing sheet. Following are some of the typical cold formed section profiles readily available.

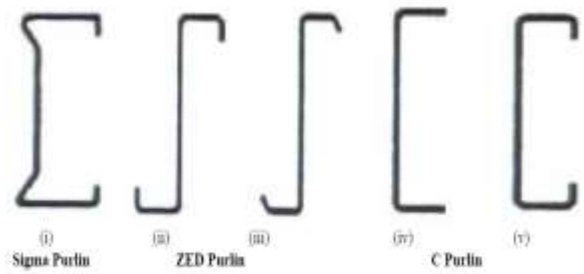


Fig. 3: Typical Cold Formed Section Profiles used for purlin

3. STRUCTURE CONFIGURATION DETAILS

3.1 Problem Statement

The conventional steel building and pre-engineered building is analyzed and designed using STAAD pro v8i software.

Location	Nagpur, India
Total bay length	37.5 m
Single bay length for CSB	3.75 m
Single bay length for PEB	7.5 m
Span Width	5m, 15m, 22m, 40m
Clear height	4m, 7.5m, 10m
Wind speed	44 m/sec
Wind terrain category	2
Wind class	C
PEB roof slope	5.710
CSB roof slope	Varies

Table -1: Structural Parameters

The design has been done taking into consideration the primary shape of the members. The dimension of I- Section at the two extreme corners of each members have been decided on the basis of the required section modulus to carry the prerequisite bending moment. The flexural formula forms on the basis in deciding the dimension of the members.

4. LOAD CALCULATIONS

The loads acting on the structure includes dead load, live load, wind load, as in [4].The load calculation for the structure can be carried out in accordance with IS : 875 – 1987 and MBMA1996 .For this structure wind load is critical than earthquake load Hence, load combinations of dead load, live load, and wind load are incorporated for design.

4.1. Dead load

Dead load comprises of self-weight of the structure, weights of roofing, steel sheets, purlins, sag rods, bracings and other accessories, in passing [5]. The dead load distributed over the roof is found to be 1.125 kN/m excluding the self weight. This load is applied as uniformly distributed load over the rafter while designing the 3D PEB structure by Indian code (IS 8002007) and American code (AISC-ASD). For 3D CSB concept the load is applied as equivalent point load of 0.884 kN at intermediate panel points and half the value at end panel points over the roof truss. Reference [5] shows the procedure for dead load calculation.

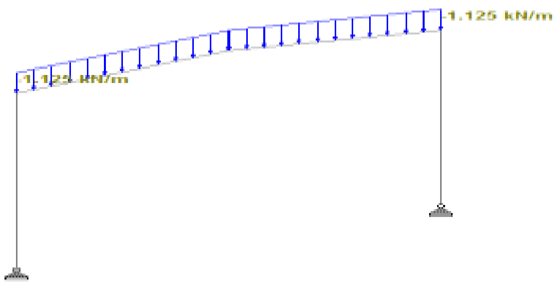


Fig 4: DL on Frame

4.2. Live load

According to IS : 875 (Part 2) – 1987, for roof with no access provided, the live load can be taken as 0.75 KN/m2 with a reduction of 0.02 KN/m2 for every one degree above 10 degrees of roof slope, explicitly as in [6]. Live load acting on the rafter of the PEB structure by Indian code (IS 800-2007) is 5.625 kN/m and by American code (AISC-ASD) is 4.275 KN/m .Similar to dead load, live load is also applied. Reference [6] shows the procedure for live load calculation.

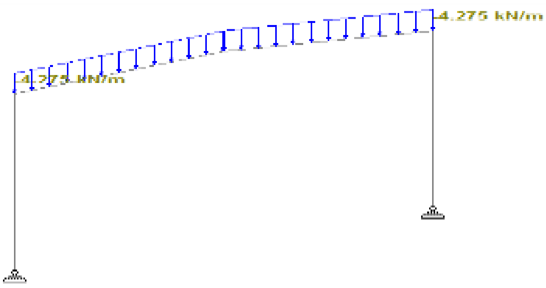


Fig 5: LL on Frame

4.3. Wind load

Wind load is calculated as per IS: 875 (Part 3) – 1987 and MBMA (1996). The basic wind speed for the location of the building is 44 m/s from the code, in passing [7]. The wind load over the roof can be provided as uniformly distributed load acting outward over the PEB rafter and as point loads acting outward over the CSB panel points. For side walls, the wind load is applied as uniformly distributed loads acting inward or outward to the walls according to the wind case.

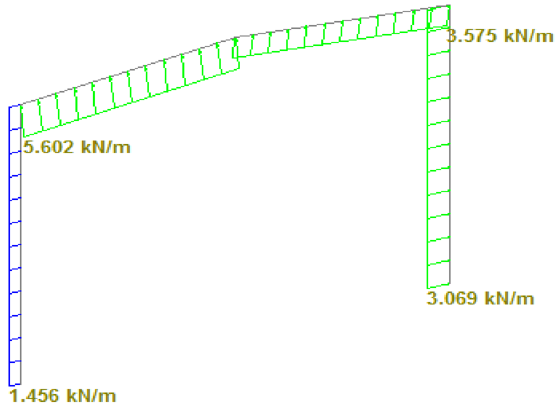


Fig. 6: Wind load on Frame

4.4. Load combination

Loads combinations can be adopted according to IS: 8002007.Thirteen different load combinations adopted for the analysis of the frame in both the concepts, as in [4] and Loads combinations can be adopted according to AISC-ASD. Twenty five different load combinations adopted for the analysis of the frame, as in [10].

5. STAAD .PRO PROCEDURE

The Staad.Pro software package is a structural analysis and design software which helps in modeling, analyzing and designing the structure. The software supports standards of several countries, including Indian standard. The procedure includes modeling the structure, applying properties, specifications, loads and load combinations, analyzing and designing the structure. This software is an effective and user friendly tool for three dimensional model generation, analysis and multi-material designs.

In STAAD Pro utilization ratio is the critical value that indicates the suitability of the member as per codes. Normally, a value higher than 1.0 indicates the extent to which the member is over-stressed, and a value below 1.0 tells us the reserve capacity available. Critical conditions used as criteria to determine Pass/Fail status are slenderness limits, Axial Compression and Bending, Axial Tension and Bending, Maximum w/t ratios and Shear. For static or dynamic analysis of Pre-engineered building

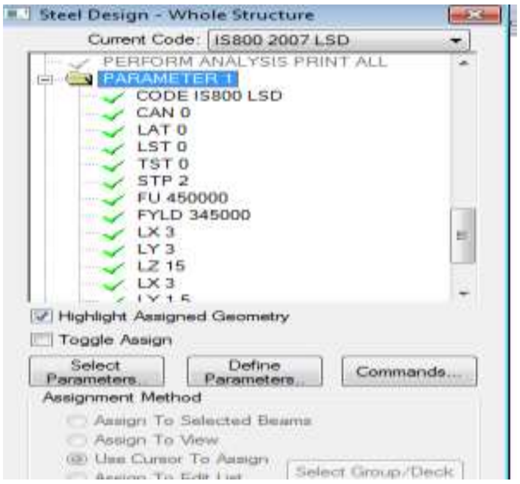
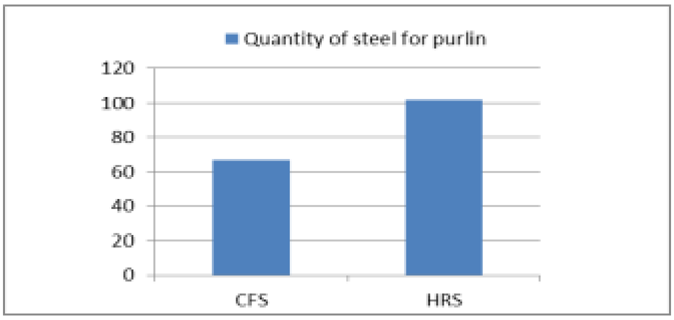


Fig 7: Defining parameters to Structure

6. RESULT

6.1Comparision in terms of Weights of Hot rolled and Coldform sections of Secondary members



6.2 Comparison In Terms of Weight of CSB and PEB Frame

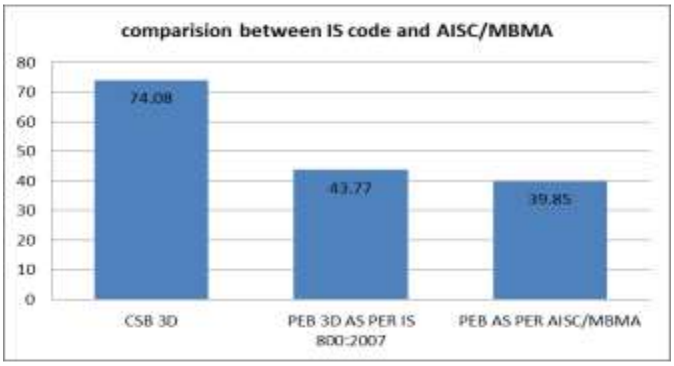


Chart 1: Total weight of shed w=22m, ht=7.5

Above chart shows that total tonnage of building increases when we go for Conventional steel building, it reduces by 30 to 35 % when we go for PEB, then again it reduces by 10% when the loading is as per American code.

7. CONCLUSIONS

1) As per Indian code, the classes of section considered for design are Plastic, Compact and Semi- compact, slender cross-section. It is well known that many PEB manufacturers use sections with very thin webs in order to reduce the weight of the section and be economical/competitive in their commercial offers, and these thin webs do not satisfy the codal provisions of IS 800: 2007.

2) For 3D PEB structure weight is 35 % lesser than the weight of CSB structure. Reason for higher weight in IS 800:2007 compared to AISC/MBMA is limiting ratio of the section.

3) 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 weight heavier.

4) Live load is 0.75 KN/m2 in IS code & whereas it is 0.57 KN/m2 in MBMA. Thus, concluded that loading as per Indian codes is greater than MBMA code.

5) One of the main reason to increase in weight in IS 800-1984 compared to IS 800-2007 is "Serviceability Criteria". Deflection limits by IS code (H/150) are higher than deflection limits by MBMA (H/60).

6) PEB roof structure is almost 30% lighter than conventional steel building. In Secondary members, light weight " Z" purlins are used for PEB structure.

7) Cost of manufacturing and transportation of PEB is high as compared to CBS because they are not locally available.

8) So, if you want to construct a small shed go for CBS where as if you want to construct a Big shed go for PEB with MBMA loading.

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