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Performance of Pre-Engineered Building over Conventional Steel Structures

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Abstract

The study intends to compare the performance between conventional steel structure and pre-engineered structure in terms of shear force, deflection, axial force, steel weight to obtain an economical design. It presents a design of different industrial building of dimensions width 35m,30m,20m and length 60m,55m,45m,30m,70,30m, and eave height 9m. The truss of the conventional steel structure has been designed with same span.The work is carried out with the design of conventional steel structure and pre- engineered components. Loads acting on the structure are calculated as per IS 875: 1987 (Part I) for dead loads, IS 875: 1987 (Part II) for live loads and IS 875: 1987 (Part III) for wind loads and the structure is designed as per IS 800: 2007 steel codesand also MBMA -2002 (Metal Building Manufacturer Codes) and AISC – 1989 (American Institute of Steel Construction Manual) are used. The proposed structure is modelled and analyzed in STAAD. Pro V8i, structural analysis software to obtain safe design.

Keywords*-STAAD PRO, Pre-engineered building (PEB*),*load, deflection*

1. Introduction

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. Within some geographic industry sectors these buildings are also called Pre-Engineered Metal Buildings (PEMB) or, as is becoming increasingly common due to the reduced amount of pre engineering involved in custom computer aided designs, simply, Engineered Metal Buildings (EMB). 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. This is very versatile buildings systems and can be finished internally to serve any functions and accessorized externally to achieve attractive and unique designing styles. It is very advantageous over the conventional buildings and is really helpful in the low rise building design. Pre-engineered buildings are generally low rise buildings however the maximum eave height can go up to 25 to 40 metres. Low rise buildings are ideal for offices, houses, showrooms, shop fronts etc. The application of pre-engineered buildings concept to low rise buildings is very economical and speedy. Buildings can be constructed in less than half the normal time especially when complemented with the other engineered sub systems. The most common and economical type of low rise buildings is a building with ground floor and two intermediate floor plus roof. The roof of low rise buildings may be flat or sloped. Intermediate floors of low rise buildings are made of mezzanine systems. Single storied houses for living take minimum time for construction and can be built in any type of geographical location like extreme cold hilly areas, high rain prone areas, plain land obviously and extreme hot climatic zones as well.

2. Problem formulation

The procedures and standards are adapted for analysis and design of pre-engineered buildings. The design is done by IS 800:2007, " Code of practice for General Construction in Steel Structures" as well as IS 875:1987(Part 1,2&3), "Indian Standard code of Practice for loads on Buildings and Structures". With the various combination as specified in Indian Standard Dead load , Live load and Wind load had been considered for structure and also MBMA -2002 (Metal Building Manufacturer Codes) and AISC – 1989 (American Institute of Steel Construction Manual).

Practice of Code – Steel Construction by Indian Standard (IS 800:2007):

The bureau of the Indian standards had adopted this Indian standard. This code had been considered by the experts in civil engineering divisional council after the methods and standards for construction are finalized by the engineers of structural department and the selection committee of structural sections.

In the year 1950 Indian standard institution was initiated the programme of steel economy by establishing rational, efficient and optimum steel product standards and their use. For general construction of steel basic code is I.S 800:2007. It is the suitable document for any design in structures. The other codes governing the design of other steel structures, such as bridges, towers, silos, chimneys, etc., has influenced by this code only. In the country and abroad the developments taking place and the consideration has been given to them. Any additive and changes to the code have been included to make more useful standard.

Manual for Metal Systems of Building (2002):

In this type of code practices the research is undertaken by MBMA that is metal building systems manual provides all details and design procedures for design of metal structures. The companies and other group of industries are the members of MBMA. In the load application aspects and design this provides the greater refinement and advances in loading methods. The MBMA low rise building system manual is replaced by this manual and represents the new way for criteria's of design.

When most of the municipalities comes to the building codes in the United States have adopted this system. In the past it won't allow to govern the design in the building code, in the MBMA low rise buildings the pre recommended loads were often specified. There is a decrease for MBMA loads after reorganization in the system. This manual now deals with how to deals with load apply under International building code and ASCE- 7 specified by them. This new manual system can be also deals with low rise buildings generally. This method of practices purely related to design, compliance of codes and metal building systems specifications. It purposes for design community.

Design procedure :PEB

LOCATION	KARNATAKA,INDIA
TOTAL BAY LENGTH	60M
WIDTH(SPAN)	30M
EAVE HEIGHT	9M
NUMBER OF BAYS	4
TYPE OF BUILDING	INDUSTRIAL WARE HOUSE
WIND SPEED	33M/SEC
ROOF SLOPE	1:10

PURLIN SPACING	1.5M
GIRT SPACING	1.5M
BAY SPACING	7.5M
CLASS OF WARE HOUSE	50 YEARS
TERRAIN	CATEGORY 2
PERMEABILITY	MEDIUM
ANGLE OF FRAME	5 DEGREES

Table 1: Structure configuration

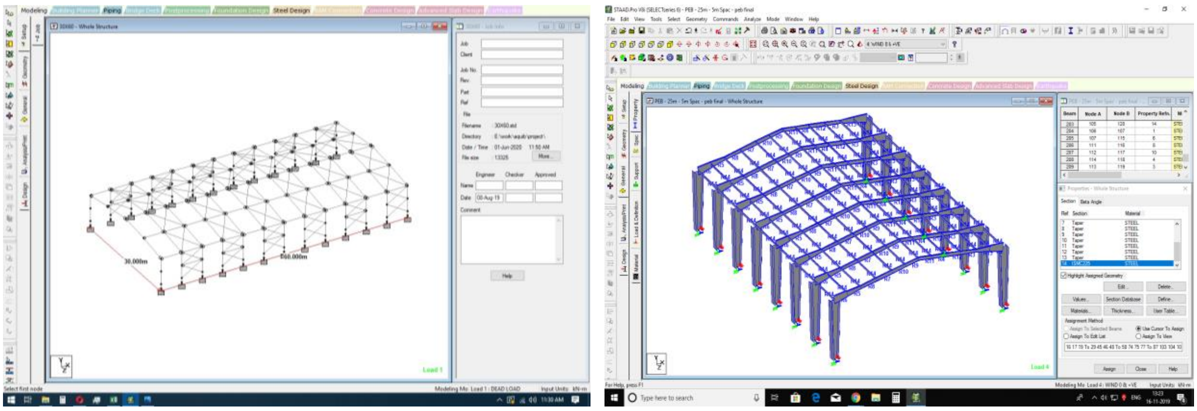

Fig1:Modelling of Structural Configuration: PEB Structure

3.1 PROPERTIES OF THE MATERIALS ASSIGNED

The materials used for the PEB structures are built up sections for primary and secondary frames, for the purlins and the grits channel section are provided. In this study of PEB structures the fabricated rectangular section and the tapered section which are referred as the built up section. The flanges of these members are welded to the web. At the end of the tapered section and rectangular sections splice plates are welded. By connecting the sections together the frame is erected by the bolting the splice plates. These sections are welded to make the rigid frames to form the built up "I" sections.

3.2 Load combinations

All dead loads, live loads, wind load, accidental load will be confirming to IS: 875-1987. Earthquake loads will be confirming to IS: 1893-2002 part-IV Load combinations considered

1. Self-Weight of structure

2. Weight of Purlins

3. Wind Force in X direction

4. Wind Force in Z direction

5. Negative Wind Pressure in X direction

6. Negative Wind Pressure in Z direction

7. Ground motion in X and Z direction

3.3 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.

Design Procedure as per MBMA -2002 (Metal Building Manufacturer Codes) and AISC – 1989 (American Institute of Steel Construction Manual):

Design procedure: CSB

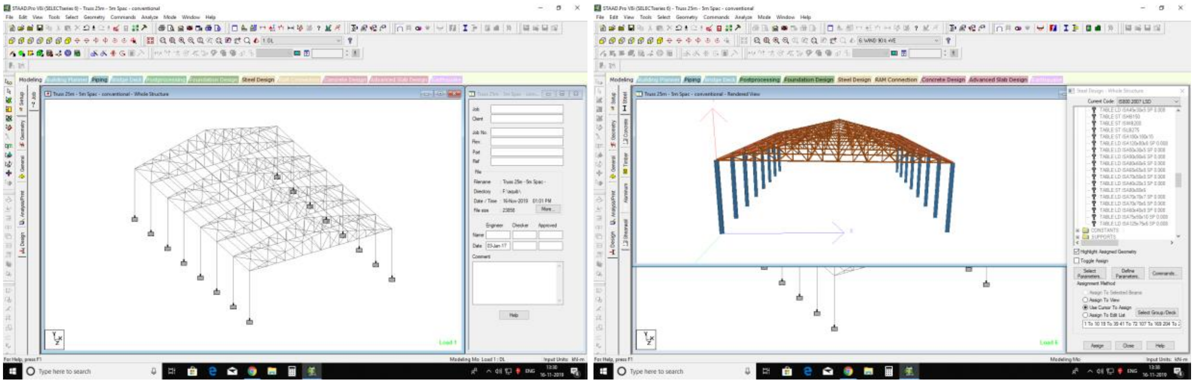

Fig:2 Modelling of Structural Configuration: CSB Structure

Steel structures are low rise with the truss system of roofing with roof coverings are termed as conventional steel buildings. For these kind of structures can be utilisation of various types of the roof trusses. According to pitch of truss the type of roof system is used. The steel structures also termed as metal structures. In this construction process producing the shapes of structural steel material used is steel. The shape of steel structure is unique, built with a specific cross section and also including certain chemical composition.

3. Results and Discussions

Table 2 : CALCULATION OF STEEL FOR CONVENTIONAL STEEL BUILDING 30x60

DESCRIPTION OF MEMBERS	LENGTH(M)	WEIGHT(KG)
END COLUMN	90	13320.12
INTERMEDIATE COLUMN	95	14618.23
MAIN RAFTER	100	15386.35
INTERMEDIATE BEAM	220	21069.72
PURLIN	450	5535.63
GIRT	160	2132.31
	TOTAL	72060.86

Table 3: CALCULATION OF STEEL FOR PRE ENGINEERED BUILDING 30x60

DESCRIPTION OF MEMBERS	LENGTH(M)	WEIGHT(KG)
END COLUMN	90	10784.56
INTERMEDIATE COLUMN	95	14618.23
MAIN RAFTER	100	12386.35
INTERMEDIATE BEAM	220	21069.72
PURLIN	450	5535.63
GIRT	160	2132.31
	TOTAL	66524.89

Details of each member is defined in these tables like columns, rafters, purlins, etc. Here conventional steel structure has truss while pre-engineered structure has tapered section.

DESCRIPTION OF RESULTS	CSB	PEB
STEEL TAKE OFF IN KN	706.681	652.464
SUPPORT REACTION IN KN	231.182	219.563
MAX DEFLECTION IN MM	40.866	42.090
MAX SHEAR FORCE IN KN	187.90	184.223

DESCRIPTION OF RESULTS	CSB	PEB
AXIAL FORCE IN KN	74.137	65.82
COLUMN SHEAR FORCE IN KN	85.350	79.28
BENDING MOMENT IN KN/M	52.17	92.456

Table 4: Results from STAAD Pro

Detailed comparison charts of different dimensions and aspect ratio has been given below:

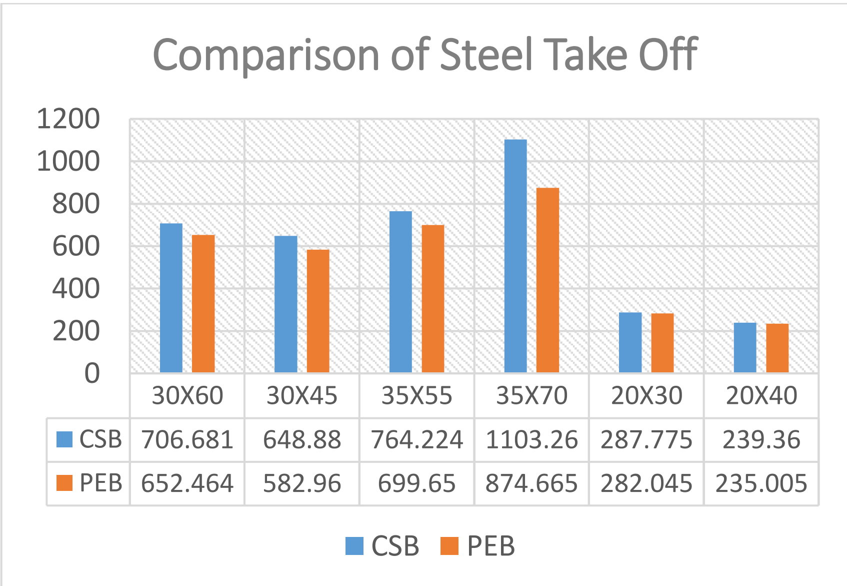

Table 4: Steel Take Off comparison table

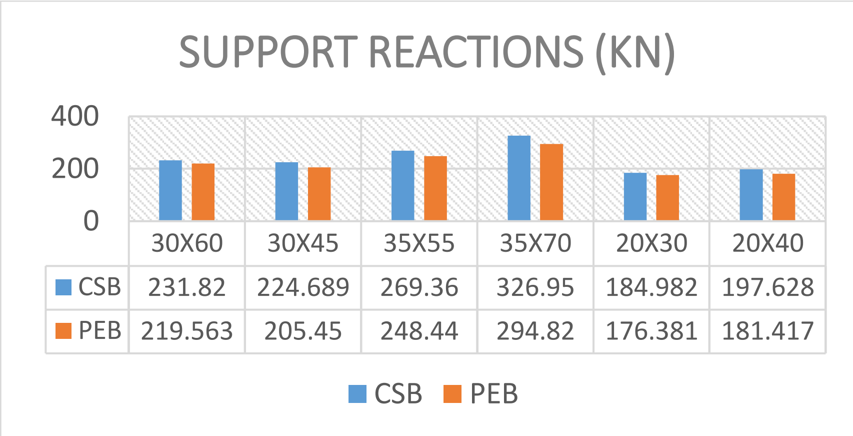

Table 5: End Support reactions comparison table

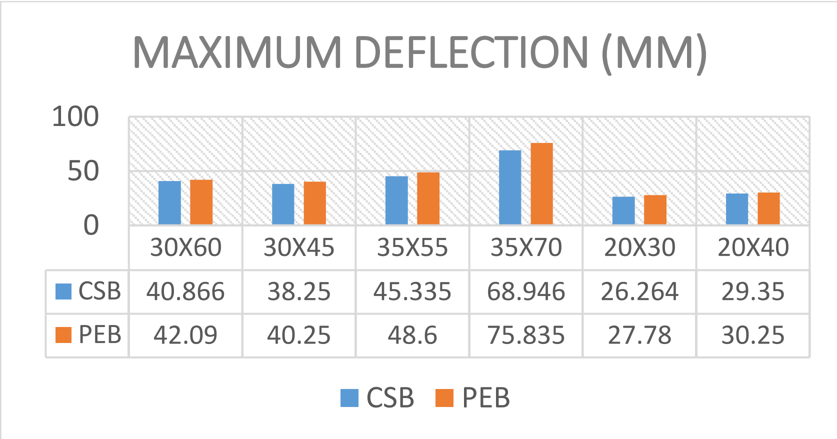

Table 6: Maximum Deflection comparison table

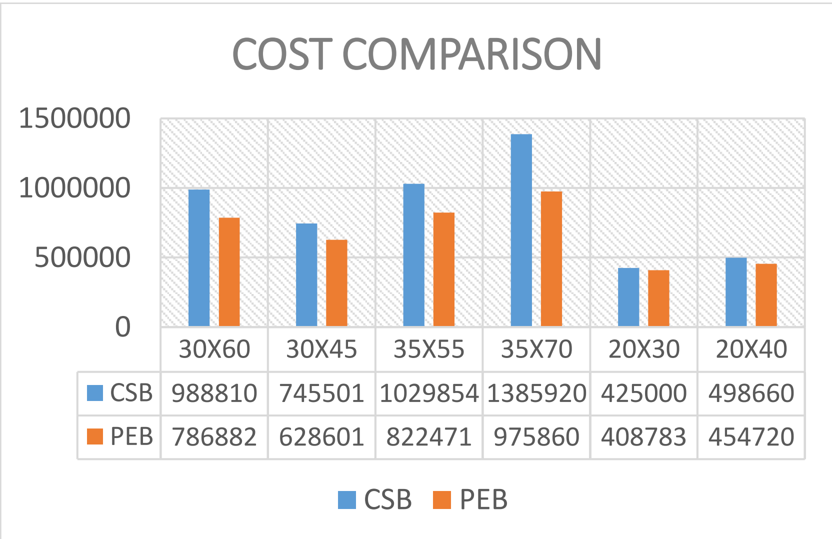

Table 7: Cost comparison table

4. Conclusion

GENERAL

The present work is focused on the study of performance of pre-engineered building over conventional steel structure on basis of different parameters like displacement, shear force, weightage, cost etc.Wind loading governs the structural response rather than earthquake loading, for the long (lengthwise) in Industrial sections.

1. Deflection values of Pre-engineered building and conventional steel building have been compared. It is found that Conventional Steel Building Sections have 10% more deflection than Pre Engineered Buildings.

2. It is noticed that the value of Support Reaction for Pre Engineered Buildings is less compared to Conventional Steel Buildings.

3. In Pre-engineered Building sections are prepared for the specific shed. So customization can be easily possible in this, while in conventional steel buildings sections are regular sections available in market, so customization is difficult

4. As the weight of the sections of PEB are less and well designed for the particular site, erection cost also decreases by 15% as compared to Conventional Steel Buildings.

5. Main advantage of PEB is that weight of the sections are less due to its tapered sections. It is observed that Pre-Engineered building reduces the steel quantity by an average value of 30% than that of required in Conventional steel structures

6. There's negligible wastage of PEB as it is factory designed and produced while every component has to be made on site in Conventional Steel Building .Wastage is easily reduced by 22% in Pre Engineered Buildings as compared to Conventional Building on site.

7. Analysis, design, production and erection is very precise in Pre-engineered building, so highly skilled and professional setup required. As customize prepared in factories. Aesthetics of Pre-engineered building is much superior as compared to conventional steel building. In today's era industry and corporate sectors are also keen about aesthetics of industrial building.

6. References

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