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Comparative Study of Design of Industrial Warehouse Using CSB, PEB and Tubular Sections

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ABSTRACT
This Paper provides the comparative study of Conventional steel building (CSB), Pre Engineered Building(PEB) and Tubular Structure. The design is made as per IS 800-2007. Dead load, Live load and wind load calculation is made IS 875 part I, II and III respectively. 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. Design and analysis is done with the help of STAAD Pro V8i Software.
***Keywords* -** Conventional Steel Building, Pre Engineered Building, Tubular Structure, STAAD, Indian Codes

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I. INTRODUCTION

Steel is a material which has high strength per unit mass. Steel as a construction material is one of the very important materials used in the industry, the reason is because of its characteristics and properties that it has. Steel is strong, hard, tough, ductile, fire resistant and has also got a very high melting point. The designing of industrial Steel Structure includes designing of the structural elements including principal rafter or roof truss, column and column base, purlins, sag rods, tie rods, gantry girder, bracings, etc.

India has the second fastest growing economy in the world and a lot of it, is attributed to its construction industry which figures just next to agriculture in its economic contribution to the nation. So, in regard of the same Steel industry is growing rapidly. 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.

Industrial building is generally classified as braced and unbraced framed structures. In braced buildings, the trusses rest on column with hinges and stability is provided by bracings in three mutually perpendicular planes. The basic function of a bracing is to transfer horizontal loads from frames i.e. loads like wind or earth quake or horizontal surge due to acceleration and breaking of travelling cranes over gantry girders to the foundation. The longitudinal bracing provides stability in longitudinal direction on each longitudinal end provides. The gable bracing provides stability in the lateral direction. The tie bracing at the bottom chord level transfers the lateral loads (due to wind or earthquake) of truss to the end gabble bracings and similarly the rafter bracing and the bracing system at bottom chords work. Whereas the purlin acts as the lateral bracings to the compression chords of the roof trusses which increase the compression chords design strength.

The unbraced frames such as portal frames are the most common type of frames used in industrial building construction because of its simple design, economy, easy and fast erection. This type of frames provides the large utility area with maximum column free space. In such type of structures the inner columns are eliminated, requires considerably less foundation and its area, the valley gutters and the internal drainage too. The portal frame is a rigid jointed plane made from hot rolled or cold rolled sections, supporting roofing and side cladding. Its typical span ranges from 30-40 m and its bay spacing could be 4.5-10 m.

Cost of steel is increasing exponentially with time. Also it is inevitable to use the steel particularly in Industrial steel building. So, it is necessary to use the steel quantity to its optimum quantity

II. LITERATURE SURVEY

1) Aijaz Ahmad Zende, Prof. A. V. Kulkarni, Aslam Hutagi (2013),"Comparative Study of Analysis and Design of Pre-Engineered-Buildings and Conventional Frames”, ISSN: 2278-1684 Volume 5, Issue 1 (Jan. - Feb. 2013), PP 32-43

The present work involves the comparative study of static and dynamic analysis and design of

Pre Engineered Buildings (PEB) and Conventional steel frames. Design of the structure is being done in Staad Pro software and the same is then compared with conventional type, in terms of weight which in turn reduces the cost. Three examples have been taken for the study. Comparison of Pre Engineered Buildings (PEB) and Conventional steel frames is done in two examples and in the third example, longer span Pre Engineered Building structure is taken for the study. In the present work, Pre Engineered Buildings (PEB) and Conventional steel frames structure is designed for dynamic forces, which includes wind forces and seismic forces. Wind analysis has been done manually as per IS 875 (Part III) – 1987 and seismic analysis has been carried out as per IS 1893 (2002). 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".

2) C. M. Meera (2013),"Pre-Engineered Building Design of an Industrial warehouse", International Journal of Engineering Sciences & Emerging Technologies, June 2013. Volume 5, Issue 2, pp.: 75-82

This paper is a comparative study of PEB concept and CSB concept. The study is achieved by designing a typical frame of a proposed Industrial Warehouse building using both the concepts and analyzing the designed frames using the structural analysis and design software Staad Pro. He concluded that PEB structures can be easily designed by simple design procedures in accordance with country standards. In light of the study, it can be concluded that PEB structures are more advantageous than CSB structures in terms of cost effectiveness, quality control speed in construction and simplicity in erection. The paper also imparts simple and economical ideas on preliminary design concepts of PEBs. The concept depicted is helpful in understanding the design procedure of PEB concept.

3) M.G.Kalyanshetti, G.S.Mirajkar, "Comparison between Conventional Steel Structures and Tubular Steel Structures" International Journal of Engineering Research and Application (Ijera) Vol. 2, Issue 6, November- December 2012

This research involves the economy, load carrying capacity of all structural members and their corresponding safety measures. Economy was the main goal of this study involving comparison of conventional sectioned structures with tubular sectioned structure for given requirements. For study purpose superstructure-part of an industrial building is considered and comparison is made. Research reveals that, up to 40 to 50% saving in cost is achieved for square and rectangular tubular sections.

4) Trilok Gupta, Ravi K. S Harma, "Analysis of Industrial Shed using Different Design Philosophies" International Journal of Research In Advent Technology, Vol.1, Iss Ue 5, Dec Ember 2013

The research involves various kinds of industrial roof trusses by using computer software. It also involves the knowledge regarding steel roof trusses and the design philosophies with worked examples. From the observations they concluded that, the sections designed using limit state methods are more economical than the sections using working stress method. It was observed that the tubular section designed by limit state method was the most economical among the three sections which were used

III. METHODS AND MATERIALS

1) Conventional Steel Building-

Conventional steel buildings (CSB) are low rise steel structures with roofing systems of truss with roof coverings. They are constructed with the traditional method. Conventional steel buildings use rolled sections and due to that the weight of the structure increases. With the passage of time the technology is emerging and as a outcome of that CSB is being replaced by PEB and tubular structures. Due to the following reasons the CSB is going to be replaced by PEB and tubular structure-

1) Design- Requires heavy detailing with modifications.
2) Foundation- Widespread foundations are required.
3) Structural weight- Conventional steel section are heavier in weight.
4) Erection cost and time- It takes time up to 10-12 weeks for erection and expensive.
5) Overhead space- Use of standard sections limits the overhead space.
6) Inside Space- Large spans CSB with interior columns reduces the inside space
7) Seismic Resistance- Rigid and heavy structural members do not perform well against the seismic reactions.
8) Performance- Faulty connections may leads to poor performance
9) Demountability- May takes more time for demounting

2) Pre Engineered Building-

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. If we go for regular building cost and time both will be more making it uneconomical. In pre-engineered buildings, complete designing is done in the factory, as per design, members are pre-fabricated and then transported to the site where they are erected in less time

Advantages of PEB

1) Steel arriving at the site is dry with no residual oil on the surface
2) PEB system is excellent resistant in transit to corrosion and storage strain
3) This system reduces energy loads on buildings due to long term bright surface that helps to retain heat reflectivity

Disadvantages of PEB

1) Susceptible to Corrosion: If not properly maintained the steel frames are susceptible to corrosion, thus special coatings becomes necessary to resist the corrosion of steel
2) Low Thermal Resistivity: Steel being a metal is good at conducting heat, thus it reduces the thermal comfort in the building.
3) Low Fire Resistance: During fire, this type of building becomes more susceptible to damage due its conductivity.

3) Tubular Structure

Supremacy of tubular or hollow structural can be ascertained by looking at nature. Nature is known to optimize on all kinds of material requirements, particularly of the important load supporting members. Its economy without sacrifice of usefulness is reflected in the hollowness of bones in the structural system of living beings specially human body.

Something that's trending extensively in the construction atmosphere is the use of tubular steel structures. The reason is because of its robust, long-lasting, and most importantly, customizable. In some cases, depending on the size and weight of tubular steel pipe vs. the same or similar size solid steel bar, the tubular steel might be stronger. The molecular structure of the solid steel have the molecules stacked close together, any shock or stress will compress the molecules closer together with no place to go unless the steel bends or breaks. A steel tube has the hollow area which allows shock or stress to be released, it will be less likely to bend or break. It also depends on what the application is, tubular steel will definitely be lighter in weight, can be filled. Cost is cheaper

Structural hollow sections are especially suitable for compressing and torsion members. In the tubular truss design, the amount of joints should be kept as small as possible to reduce the needed labour in machine workshop.

Advantages of tubular sections

1) Strength to weight ratio is more.
2)30 to 40% less surface area than that of an equivalent rolled section. Therefore the cost of maintenance cost of painting or protective coatings reduce considerably.
3) Compressive strength and torsional behavior. Because of that Tubular sections behave more efficiently than conventional steel section.
4) No Sharp Edges.

Problem Statement

The present study includes the design of Industrial warehouse. The design is done by CSB, PEB and Tubular sections. The structure consists of,
Height upto eaves – 8m
Total Height – 11m
Span of Warehouse – 20m
Centre to Centre spacing of truss – 5m
Length of warehouse – 50m
Basic wind speed – 50m/s
Type of covering – GI Sheeting

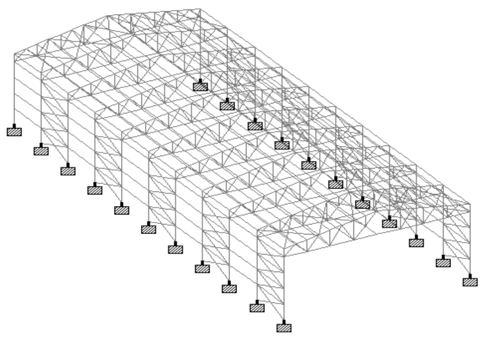

Fig.1 3D View of the structure

A) Designed Sections

Loading and Load Combinations-
Loads
1) Dead Load (DL)- GI Sheets.
2) Live load (LL)- IS 875 part 2.
3) Wind Load (WL)- IS 875 part 3.
Load Combinations
4)1.5(DL+LL)
5)1.5(DL+WL 0 DEG)
6)1.5(DL+WL 90DEG)

IV. RESULTS AND DISCUSSION

The weight and utilization ratio of each section is calculated and compared in the tabular format below,

Sr. No.	Member	Rolled	Tubular	PEB
Purlins	Purlin	ISMC100	ISMC100	ISMC100
Truss	Rafter	2 ISA100X100X8 SD	1651H	---
	Tie	2ISA150X90X15LD	PIP2730H	---
	Chords	2 ISA90X90X12LD	PIP1016H	---
	Verticals	2ISA110X110X10LD	PIP1016H	---
	Tie Member	ISA 200X150X10	PIP2730H	---
Bracings	Top Bracings	ISA180X180X18	PIP1397L	ISA180X180X18
	Side bracing	ISA200X150X12	PIP3239H	ISA200X150X12
Runner	Tie Runner	2 ISA90X90X6SD	PIP424L	---
	Side Runner	ISMC125	PIP424L	ISMC125
Columns	Columns	ISMB350	PIP3239H	---

Table No. 1- Designed Sections

B) **Details of tapered Section**

PEB									
	TOP MEMBER (m)					Column (m)			
	TAPER 1	TAPER 2	TAPER 3	TAPER 4	TAPER 5	TAPER 1	TAPER 2	TAPER 3	TAPER 4
F1	0.4	0.4	0.3	0.3	0.4	0.6	0.5	0.4	0.5
F2	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
F3	0.4	0.3	0.3	0.4	0.4	0.6	0.6	0.5	0.5
F4	0.3	0.3	0.3	0.3	0.3	0.21	0.21	0.21	0.21
F5	0.025	0.025	0.025	0.025	0.025	0.0203	0.0203	0.0203	0.0203
F6	0.3	0.3	0.3	0.3	0.3	0.21	0.21	0.21	0.21
F7	0.025	0.025	0.025	0.025	0.025	0.0203	0.0203	0.0203	0.0203

Table No. 2 Details of tapered sections

Table No. 3 Description of symbols

Sr. No.	Description	Symbol
1	Depth of Section at Start Node	F1
2	Thickness of Web	F2
3	Depth of Section at Start Node	F3
4	Width of Top Flange	F4
5	Thickness of Top Flange	F5
6	Width of Bottom Flange	F6
7	Thickness of Bottom Flange	F7

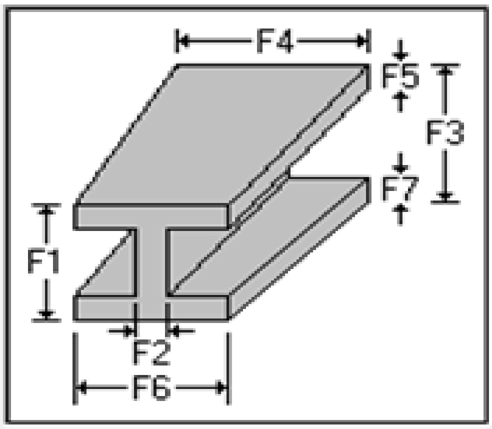

Fig. No. 2 –Tapered Sections

C) Results

1) Avg Utilization ratio

	Rolled	Tubular	PEB
Column	0.4	0.75	0.53
Truss/Tapered Member	0.5	0.66	0.6

Table No. 4 Average utilization ratio

2) Comparison of weights

Weights (KN)	Rolled	Tubular	PEB	% Saving tubular	% Saving PEB
Truss/ Tapered Member	383.75	196.34	350	48.84	8.80
Bracings	228.17	93.17	204.49	59.17	10.38
Column	125	118.17	90.85	5.47	27.32
Total	736.92	407.68	645.33	44.68	12.43

Table No. 5 Comparison of weights

D) Discussion

From the above study we can say that,

1) In case of warehouse PEB is 14.73% more economical than CSB
2) In case of warehouse Tubular Structure is 39.54% more economical than CSB
3) For warehouse average utilization ratio is 0.45 in CSB.
4) For warehouse average utilization ratio is 0.52 in PEB.
5) For warehouse average utilization ratio is 0.58 in tubular Structure

V. CONCLUSION

1) Pre-engineered building is more economical than conventional building and the saving depends on various parameters.

Also PEB requires special computer design, light in weight, aesthetically good and overall erection time is less that 6 weeks which makes it cost effective

2) Tubular trusses is more economical than pre-engineered building and this results in its effective utilization.

Since the restriction of sizes available in the market its use is not that much popular, but with the emerging technology and knowing the importance of tubular structure the use of the same will dominate in future.

3) Effective material utilization in tubular structure till certain limit as compared to PEB the reason behind it is availability of the standard tubular sections.

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