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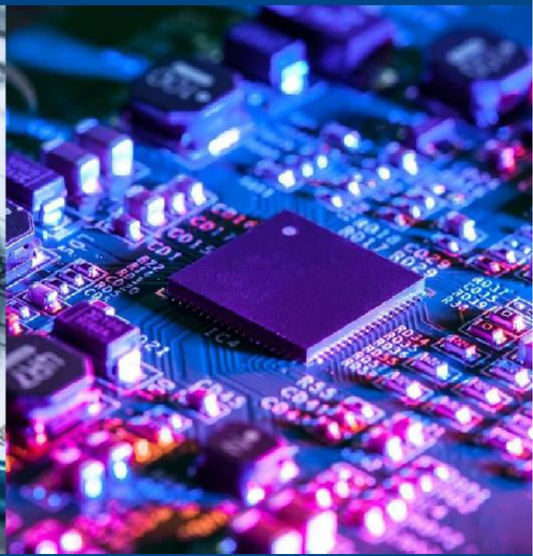

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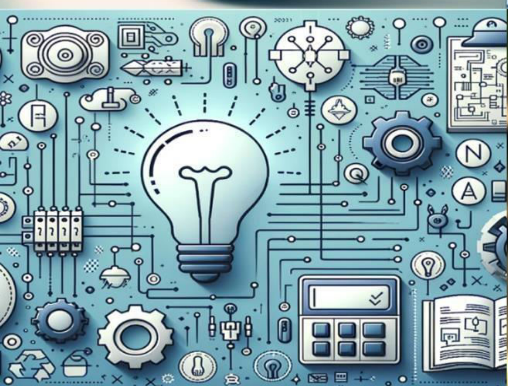

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Comparative Study between Pre-Engineered Building and Conventional Steel Building

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ABSTRACT: Cost of steel is increasing day by day and use of steel has increase in the construction industry. Hence to achieve economic sustainability it is necessary to use steel to its optimum quantity. Long span, Column free structures like complex industrial facilities, warehouses and distribution centres, stock house, shopping malls, resort, motor court, office, cabin, service complex, aircraft-hanger, athletics and fun stadium, study places, temples, hospitals, and any types of industrial structures are the most essential in any type, Hence in steel structures which type of structure is well efficient in less time consuming, cost and strength. Use Pre Engineered Buildings (PEB) and Conventional structure, which type of structure fulfil our requirement. These structures are analysing in seismic and wind loads with the help of STAAD.pro software.

KEYWORDS: Pre Engineered Building, Conventional Steel Building, STAAD Pro, Wind Analysis, Industrial Structure.

I. INTRODUCTION

Conventional Steel Building

Low-rise steel structures with truss roofing systems and roof coverings are known as CSBs. Rolling parts are used in traditional steel structures, which raises the structure's weight. The members are produced in factories and then transported to the construction site. Welding and cutting may be used to make adjustments during the erection process. In this scheme, trusses are usually used. Braced and unraced framed structures are the two types of industrial buildings. The trusses in braced buildings are supported by hinged columns, and stability is provided by bracings in three mutually perpendicular planes.The design of conventional industrial buildings is governed by functional requirements and the need for economy of construction. In cross section, these building will range from single or multi bay structures of large span when intended for use as warehouses or aircraft hangers to smaller span buildings as required for factories, assembly plants, maintenance facilities etc.

Pre-Engineered Building

In any form of industrial structure, large span, column-free structures are important, and Pre-Engineered Buildings (PEB) meet this requirement while taking less time and expense than CSB and RCC. According to the bending moment diagram, PEB saves a significant amount of steel when the segment is tapered. I formed members, also known as I beams, are commonly used in pre-engineered buildings (primary members). In most cases, steel plates are welded together in the factory to create these beams. Manufacturers taper the segment, which means they reduce the size of the web at the bottom as per design to save weight and steel. Secondary components have lightweight cold moulded “Z” or “C” shaped parts to fasten and protect external cladding. There may be no other modifications possible on-site during erection, such as welding only cutting bolts, and welding is done to bind the members. Pre Engineered Steel Buildings are manufactured or Produced in the plant itself. The manufacturing of structural members is done on customer requirements. The detailed structural members are designed for their respective location and are numbered, which cannot be altered; because members are manufactured with respect to design features. These components are made in modular or completely knocked condition for transportation. These materials are transported to the customer site and are erected. Welding and cutting process are not performed at the customer site. No manufacturing process takes place at the customer site.

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II. LITERATURE REVIEW

Neha R.Kolate *et al.* Observes that comparison between pre-engineered building and conventional steel structure, have studied the importance of having long spans and structures having column free area in industrial structures and pre-engineered-building are the ones which can fulfill such requirements. PEB has several advantages over CSB such as superior strength and zero maintenance. The PEBsystem has protection against no uniform weathering. This paper comparison between PEB and CSB for a 60m length and 30m width for a bay spacing 4m, 5m and 6m respectively and its analyzed and designed for wind zones (wind zone 2, wind zone 3, wind zone 4 and wind zone 5 by using STAAD Pro. Considering cases of wind zones from their research they found that CSB is 23% heavier than PEB and also steel wastage of pre- engineered-building is less, thereby reducing the cost of construction. They also concluded that conventional steel-building is used for clear spans upto 90m but pre-engineered-buildingis used for greater than 90m.

III. METHODOLOGY

Conventional Steel Structure

In Staad Pro, the modelling of Howe Type Steel Truss involves creating a detailed representation of the structure using nodes and elements. The process begins by defining the geometry of the truss, specifying the nodal coordinates and connecting them with appropriate beam elements. The next step is assigning material properties to the steel members, including their cross-sections and material grades. After defining support conditions and loading, the analysis can be performed to determine the internal forces and displacements. Engineers can then assess the truss's structural integrity and make necessary design modifications to ensure it meets safety and performance requirements. The front view of a steel truss provides a comprehensive representation of the structure, displaying its dimensions and overall geometry. When observing the front view, one can visualize the arrangement and positioning of the main components, such as the top and bottom chords, vertical and diagonal members, and any additional bracing elements. The dimension lines on the drawing highlight the length, height, and width of the truss.

Load Calculations for Conventional Steel Structure

The structure is analysed and designed using STAAD Pro based on the provisions of IS codes. The steel framed structure as shown in the following STAAD model has been subject to dead load, live load and wind loads. Several load combinations as detailed below have been made in STAAD for member design. The load calculations are as follows:

A) Dead load Calculations

Dead load is calculated according to IS 875 (Part I) 1987.
Self Weight of A.C Sheet = 150 N/m2
Total Self Weight of A.C Sheet = 150X94.8 Sqm (Slope Area)=14220 N Self Weight of Purlin = 120 N/m2
Total Self Weight of Purlin = 120X90 Sqm (Plan Area) Total DL = 14220+1080 = 15300 N
DL on Intermediate Panel Point = 15300/6 = 2550 N = 2.5 KN DL On End Pannel Point = 2.55/2 = 1.275 KN

B) Live / Imposed Load Calculations

Live load is calculated according to IS 875 (Part II)1987.
Live load on Slopping roof = 750 – 20(α -10) N/m2 = 750-20(18.44-10)
= 581.2 N/m2
= 2/3x581.2
Total LL=387.46X90 Sqm (Plan Area)
= 34874 N
LL on Intermediate Pannel Point = 34.87/6 = 5.80 KN LL on End Pannel Point = 5.80/2 = 2.90 KN

C) Wind Load Calculations

Wind load is calculated according to IS 875 (Part III) 2015 Basic Wind speed Vb = 39 m/sec (For Amravati)
K1 = 1.0 (For 50 Years Life Span)
K2 = 1.03 (Terrain Category 1 Class B) K3= 1.0 (Topography factor)
Design Wind Speed Vz = Vb.K1.K2.K3 = 40.17 m/sec Design Wind Pressure P = 0.06(Vz)2 = 968.18 N/m2
The Internal Coefficients are taken as +0.5 and -0.5 (5-20% Opening) F = (Cpe – Cpi) x A x P
Where,

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Cpe – External Coefficient
Cpi – Internal Coefficient A – Surface Area in m2
P – Design Wind Pressure in Kn/m2
F= -119318.50 N/m2 (-) Indicates Suction
WL On Intermediate Pannel Point = 119318.50/6 = 19.88 KN WL On End Pannel Point=9.94 KN
Load combinations of Conventional Steel Structure

1.5(DL+LL)
1.5(DL+LL)
1.2(DL+LL+WL)

Design of Conventional Steel Building
The design of steel structure member is governed by cross sectional area and section modulus. General analysis regarding steel sections some sections is more capable of compression some in tension, some common structural members in building like purlins, bracings, beams (which is used to connect gables or rafters). CHS pipe section (beams and bracings in conventional and pre engineered structure).

IV. PRE ENGINEERED BUILDING

Modeling a Pre-Engineered Building (PEB) in STAAD.Pro involves creating a structural model of the building and performing the necessary analysis and design.

Here's a step-by-step guide to modeling a PEB in STAAD.Pro.

1. **Define the Geometry**: Start by creating a new STAAD.Pro project and defining the units and coordinate system. Draw the geometry of the PEB, including columns, rafters, purlins, bracing, and other structural elements. You can use the STAAD.Pro graphical interface for this purpose. The Geometry of Pre Engineered Building is Shown in Fig 3.17.
2. **Assign Material Properties:** Define the material properties for the various structural components, such as steel grade and material properties for columns, rafters, etc.
3. **Assign Section Properties**: Specify the cross-section properties for the different members, such as column sections, rafter sections, and purlin sections. These properties include dimensions, area, moment of inertia, etc.
4. **Add Supports and Boundary Conditions:** Assign appropriate support conditions to the base of columns and any fixed supports or restraints required for the analysis.
5. **Define Loads:** Apply the various loads acting on the structure, such as dead loads, live loads, wind loads, snow loads, etc. PEBs typically have specific loadings, and you can refer to the relevant design codes or standards for load specifications.
6. **Set Up Analysis Parameters:** Choose the appropriate analysis method (e.g., static, dynamic, etc.) and specify any relevant analysis parameters like load combinations, load factors, etc.
7. **Perform the Analysis:** Run the analysis in STAAD.Pro to calculate the internal forces and displacements in the structure under the applied loads.
8. **Review and Interpret Results:** After the analysis is complete, review the results to ensure they are reasonable and physically meaningful. Analyze critical sections to check for excessive stresses or deflections.
9. **Design and Check:** Use the results from the analysis to design and check the members according to relevant design codes (e.g., AISC, Euro code, etc.). STAAD.Pro has built-in design modules that can assist with this process.
10. **Generate Reports and Drawings:** Generate detailed reports and drawings that document the analysis, design, and results of the PEB

Load Calculations for Pre Engineered Building

A) Dead load Calculations.
Dead load is Calculated according to IS 875 (Part I) 1987. Self Weight of A.C Sheet = 150 N/m2 Self Weight of Purlin = 120 N/m2
UDL On Main Rafter = Total Load x Bay Spacing = 0.270 Kn/m2 x 5m = 1.35 Kn/m DL On Gabble Rafter = 1.35/2 = 0.675 Kn/m

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B) Live / Imposed Load Calculations
Live load is calculated according to IS 875 (Part II) 1987
Total Live Load = 0.75 Kn/m2 = 0.75X5m (Bay Spacing) = 3.75 Kn/m LL On Gabble Rafter = 3.75/2= 1.875 Kn/m

C) Wind Load Calculations Wind load is calculated according to IS 875 (part III)2015 Basic Wind speed Vb = 39 m/sec (For Amravati)
K1 = 1.0 (For 50 Years Life Span)
K2 = 1.03 (Terrain Category 1 Class B) K3= 1.0 (Topography factor)
Design Wind Speed Vz = Vb.K1.K2.K3 = 40.17 m/sec Design Wind Pressure P = 0.06 (Vz)2 = 968.18 N/m2
The Internal Coefficients (Cpi) are taken as +0.5 and -0.5 (5-20% Opening) H/W = 0.55 AND L/W = 2.77
The External Coefficient (Cpe) is Calculated According to IS 875 (Part 3) – 1987.

Design of Pre Engineered Building

1. Column

Taper section = R1
Depth of section at starting node = 0.575 m Thickness of web = 0.008 m
Depth of section at end node = 0.925 m Width of top flange = 0.365 m
Depth of top flange = 0.016 m Width of bottom flange = 0.365 m
Depth of bottom flange = 0.016 m

2. Rafter

Taper section – R2 & R3
Depth of section at starting node = 0.375 m Thickness of web = 0.008 m
Depth of section at end node = 0.575 m Width of top flange = 0.365 m
Depth of top flange = 0.016 m Width of bottom flange = 0.365 m Depth of bottom flange = 0.016 m

3. Purlins

Channel Section ISMC400p

V. RESULTS ANALYSIS

The Following Result is obtained, Steel Take Off` It is observed that Pre-Engineered building reduced the steel quantity by an average value of 40% than that of required in Conventional steel structures as shown in table 4.1. This is the main reason for cost reduction of the structure. Thus, PEB proves to be a best possible way for material and cost saving. Hence heavier foundation can be avoided in case of PEB and overall cost of structure is reduced due to lighter foundation. A 18-meter span model of both the system is considered here for detailed calculation and designed and analyzed in STAAD Pro V8i Software and result obtained is shown in Table 4.1, 4.2 and 4.3

Table 4.1: Steel Consumptions of Conventional Steel Building

Sr No	Profile	Length (Meter)	Weight (KN)
1.	ISA180X180X15	654.60	261.991
2.	I80012B50012	220.00	654.041
3.	ISMC350	600.00	250.739
	TOTAL		1166.772

Total Weight of Conventional Steel Building = 1166.772 KN. Total Weight of Conventional Steel Building in Tons = 118.98 tons.

Table 4.2: Steel Consumptions of Pre Engineered Building

Profile	Length (Meter)	Weight (KN)
Tapered Member 1	220.00	294.471
Tapered Member 2	201.92	236.147
ISMC400	250.00	122.527
TOTAL		653.145

Total Weight of Pre Engineered Building = 653.145 KN Total Weight of Conventional Steel Building in Tons = 66.60 tons.

On comparing the result of both Building following Result Where Obtained as,

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Table 4.3: Comparison of Steel Consumptions

Building	Dimensions LxBxH (Meter)	Total Weight (Ton)
Conventional Steel Building	50x18x10	118.98
Pre Engineered Building	50x18x10	66.60

Table 4.4: Cost of Structure

Building	Total Weight (Kg)	Total Cost
Conventional Steel Building	118977.4x115 Rs Per/Kg	13682401 /-
Pre Engineered Building	66602.3x115 Rs Per/Kg	7659264 /-

Table 4.5: Maximum Support Reaction of PEB Vs CSB

Building	Maximum Support Reactions (DL)
Conventional Steel Building	61.944 KN
Pre Engineered Building	42.921 KN

Table 4.6: Minimum Support Reaction of PEB Vs CSB

Building	Minimum Support Reactions (DL)
Conventional Steel Building	56.201 KN
Pre Engineered Building	33.427 KN

Table 4.7: Maximum Bending Moment PEB Vs CSB

Building	Bending Moment
Conventional Steel Building	18.726 Kn.m
Pre Engineered Building	69.990 Kn.m

Table 4.8: Maximum Shear Force PEB Vs CSB

Building	Shear force (Fy)	Shear force (Fz)
Conventional Steel Building	1.742 KN	0.225 KN
Pre Engineered Building	23.635 KN	0.141 KN

Table 4.9: Length of Member

Building	Dimensions LxBxH (Meter)	Total Lenghts (Meter)
Conventional Steel Building	50x18x10	1474.6
Pre Engineered Building	50x18x10	671.92

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VI. CONCLUSIONS

The following conclusions are obtained,

1. From the past studies and present output, the PEB is proven to be more economical, resulting in time saving and material saving than CSB. The PEB can be designed by simple design procedure in accordance with Indian standard, speed in construction, energy efficient, saves cost, re-usable of steel, sustainable and reliable as compared to Conventional steel structure
2. In the comparison of Pre-engineered Buildings and Conventional Steel Buildings PEB structures are easy to design. These structures are more reliable than CSB. PEB structures are more advantageous than CSB structures in terms of cost-effectiveness, quality control speed in construction, and simplicity in an erection.
3. Pre Engineered Building cost is 30% to 40% lesser than the cost of CSB Structure. PEB construction is 30% to 40% faster than Conventional Steel Building. PEB offers strength, durability, design flexibility, adaptability, and recyclability. Therefore, a Pre- Engineered Building is preferable to a conventional steel building.
4. The Lighter weight of Pre Engineered Building puts less Stress and Loads on the foundation leading to potential savings in foundation construction cost.
5. PEB is more flexible than conventional steel structure and it's higher in resistance to seismic forces. Thus, PEB methodology must be implemented and researched for more outputs.
6. Cost of structure is totally dependent upon quantity of steel, hence lesser the quantity of steel, lesser the cost of structure and this makes pre-engineered building economical than conventional steel structure.

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