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"A Comparative Study between the Pre-Engineered Building and Conventional Steel Building''

Nikita D Radake[1], R V R K Prasad[2]

[1]*Post Graduate Student, KDK College of Engineering & Technology, Nagpur, Maharashtra.*
[2]*Associate Professor, KDK College of Engineering & Technology, Nagpur, Maharashtra. Department of Civil Engineering, K.D.K. College of Engineering, Nagpur-440009, India*

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ABSTRACT: This paper mainly focuses on the PEB concept and CSB concept. The Pre-Engineered Building (PEB) concept is a new conception of single-story industrial building construction. This methodology is versatile due to its lightweight and economical construction. This concept has many advantages over the Conventional Steel Building (CSB) concept of buildings with roof trusses. In this work, an industrial building, of length 21m and width is 83m. The slope of roof trusses is taken as 5.71degree. Eave height is 6m. These structures have been analyzed and designed by using STAAD pro v8i to compare the PEB and conventional steel truss. PEB design is based on the American code AISC 360:10 and CSB design is based on the Indian code IS800:2007. Loads considered in the analysis are dead load, live load, and wind load along with the various combinations as specified in IS800:2007 and AISC. Dead load is taken based on IS: 875 (Part 1)-1987. Live load is taken based on IS: 875(Part-2)-1987. Wind load is taken based on IS: 875 (Part 3)-2015. The structure is located at savner in the Nagpur district.

KEYWORDS: Pre-Engineered Building (PEB), Conventional steel building (CSB), Structure analysis and Design, wind load, tapered sections, STAAD PRO V8i

I. INTRODUCTION

PEB is modern technology introduced in steel structures. The steel industry is growing rapidly in almost all parts of the world. The use of steel structures is not only economical but also eco-friendly at a time when there is a threat of global warming. Here, the "economical" word is stated considering time and cost. Time is the most important aspect, steel structures (Pre-fabricated) are built in a very short period and one such example is Pre Engineered Buildings. If we go for regular steel structures, the time frame will be more, and also cost will be more, and both together i.e. time and cost, make it uneconomical. Steel concrete composite construction technique offers several advantages like increased load carrying capacity and stiffness, saving in weight of steel, reduction in the cost of the foundation, and most importantly a large saving in construction time. 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.

1.1 Concept Of Conventional Steelbuilding

Nowadays, steel is used worldwide due to its ductility and flexibility properties**.** Conventional steel buildings (CSB) are small rise steel buildings with roofing structures of truss with roof coverings. Steel roof trusses are normally used for industrial buildings, workshop buildings, warehouses, and even residential buildings. The selection criterion of roof truss also includes the slope of the roof, fabrication and transportation methods, aesthetics, climatic conditions, etc.

1.2 Concept Of Pre-Engineered Building

PEB is a rigid jointed plane frame from hot-rolled or cold-rolled sections. The pre-Engineered Building concept involves the steel building systems which are predesigned and prefabricated. Pre-Engineering Building is a combination of the tapered built-up section and cold-formed section material. Pre-Engineered steel structures are fabricated or created necessity in the plant itself. The production of structural members is done on customer requirements. The production of structural members is done to customer requirements. The section's sizes depend on the bending moment diagram. PEB provides lightweight, and less time-consuming, and it is advantageous over CSB when the span is large and column-free space is required. The design and manufacturing of structure members are done at the plant and later it's transported to the construction site and the erection process will take place.

APPLICATION

The pre-Engineered Building concept has wide applications including warehouses, factories, offices, workshops, showrooms, vehicle parking sheds, aircraft hangars, metro stations, schools, indoor stadium roofs, railway platform shelters, bridges, auditoriums, etc. PEB structures can also be designed as re-locatable structures.

Conventional steel building applications include multi-story buildings, heavy-loaded industrial facilities, special shapes for architectural features, etc.

AIM

Comparative study between the pre-engineered building and conventional steel building using software (STAAD Pro).

OBJECTIVE

- To study the concept of Conventional steel building.
- To study the concept of Pre-engineered building.
- To analyze structure using STAADPro.
- Comparison between Pre-engineered building and Conventional steel building.
- To analyze and design the building as per codes.
- Evaluate the steel consumption in both the design system.

MATERIALS

CODES AND STANDARDS

- IS 800:2007, " Code of practice for General Construction in Steel Structures"
- Code of Practice for Design loads (other than Earthquake) For Buildings and Structures part 1 Dead loads- IS 875(part 1):1987
- Code of Practice for Design loads (other than Earthquake) For Buildings and Structures part 2 Imposed loads- IS 875 (part 2):1987
- Code of Practice for Design loads (other than Earthquake) For Buildings and Structures part 3 Wind loads- IS 875 (part 3):2015
- AISC: American Institute of Steel Construction-2011, Manual of Steel Construction.
- Specification for Structural Steel Buildings - AISC 360:10

METHODOLOGY

- Study of pre-engineered building and conventional steel building properties
- Study of design parameters of STAAD PRO
- Manual design of PEB and CSB as percodes
- To design PEB and CSB using STAAD.PRO, American codes
- Preparation of STAAD models
- Design of PEB and CSB models
- Preparation of comparative statement

STRUCTURE PARAMETERS

- ❖ Type of building = Warehouse {Industrial building}
- ❖ Type of structure = Single storey industrial building
- ❖ Location=Savner
- ❖ Area of building =1808m.sq
- ❖ Eave height =6m
- ❖ Span width=21.616m
- ❖ Total length =83.662m
- ❖ Support conditions =Fixed
- ❖ PEB roof slope =5.71 degree
- ❖ CSB roof slope=5.71 degree
- ❖ Wind speed =44m/s
- ❖ Purlin spacing =1.5m c/c
- ❖ Type of roofing = GI sheet
- ❖ Column section (CSB) =ISMB
- ❖ Column section (PEB) =Tapered
- ❖ Rafter section (PEB) =Tapered

LOAD CALCULATIONS

DEAD LOAD

Dead load calculation as per IS875-part1-1987
The total load on the purlin
Weight of GI sheet = 0.131 Kn/m2
Weight of fixing = 0.025 Kn/m2
Weight of services = 0.1 Kn/m2
Spacing of purlin = 1.5 m
Total weight = 0.256 Kn/m2
Total weight on purlins = Total weight *spacing of purlin
= 0.256*1.5
= 0.384 Kn/m2

LIVE LOAD

Live load calculation as per IS875-part2-1987
Live load = 0.750 Kn/m2
Live load on purlin at 1.5 spacing
= 0.750*1.5
= 1.12 Kn/m2

WIND LOAD

Wind load calculation as per IS 875-part3-2015
Location = savner
Basic wind speed (Vb) = 44m/s

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Probability factor (k1) = 1
Terrain category and height factor (K2) =1
Topography factor (K3) =1.36
Cyclone factor (k4) = 1.15
Design wind speed (Vz) = Vb*K1*K2*K3*K4
= 44*1*1*1.36*1.15
= 68.816 m/s
Design wind pressure (Pz) = 0.6*(Vz) 2
= 2841 n/m2
Ratio = H/W = 0.32

Ratio = L/W = 3.87
Internal pressure coefficient = Cpi
External pressure coefficient = Cpe
Wind load (F) = Cpe-Cpi A*Pz
A = cladding unit area = 1.19 m

Wind load left
Wind angle = 0
The angle of roof slope = 5.71 degree
Cpi = 0.5

Description	Roof WW	Roof LL	Wall A	Wall B
Cpe	-0.9	-0.4	0.7	-0.25
Cpe-Cpi	-1.4	-0.9	0.2	-0.75
Wind load F kn/m	-4.73	-3.04	0.7	-2.54

Wind load left
Wind angle = 0
The angle of roof slope = 5.71 degree
Cpi =-0.5

Description	Roof WW	Roof LL	Wall A	Wall B
Cpe	-0.4	-0.9	-0.25	-0.7
Cpe-Cpi	0.1	-0.4	0.25	-0.2
Wind load F kn/m	0.34	-1.35	0.8	-0.68

Wind load right
Wind angle = 0
The angle of roof slope = 5.71 degree
Cpi= 0.5

Description	Roof WW	Roof LL	Wall A	Wall B
Cpe	-0.4	-0.9	-0.25	0.7
Cpe-Cpi	-0.9	-1.4	-0.75	-1.2
Wind load F kn/m	-3.04	-4.73	-2.5	-4.06

Wind load right
Wind angle = 0
The angle of roof slope = 5.71 degree
Cpi = -0.5

Description	Roof WW	Roof LL	Wall A	Wall B
Cpe	-0.9	-0.4	-0.7	-0.25
Cpe-Cpi	-0.4	0.1	1.2	0.25
Wind load F kn/m	-1.35	0.34	4.1	0.85

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Wind load parallel
Wind angle = 90 degree
The angle of roof slope = 5.71 degree
Cpi= 0.5

Description	Roof WW	Roof LL	Wall A	Wall B	Wall C	Wall D
Cpe	-0.8	-0.4	-0.5	-0.5	0.7	-0.1
Cpe-Cpi	-1.3	-0.9	-1	-1	0.2	-0.6
Wind load F kn/m	-4.40	-3.04	-3.38	-3.38	0.676	-2.028

Wind load parallel
Wind angle = 90 degree
The angle of roof slope = 5.71 degree
Cpi =-0.5

Description	Roof WW	Roof LL	Wall A	Wall B	Wall C	Wall D
Cpe	-0.4	-0.8	-0.5	-0.5	-0.1	0.7
Cpe-Cpi	0.1	-0.3	0	0	0.4	1.2
Wind load F kn/m	0.34	-1.01	0.00	0.00	1.35	4.06

Load Combinations
Load combinations as per codes

According to AISC-89	**According to IS800-2007**
Limit state of serviceability	Limit state of serviceability
DL+LL	DL+LL
DL+WLXP	DL+WLXP
DL-WLXN	DL-WLXN
DL+WLZP	DL+WLZP
DL-WLZN	DL-WLZN
Limit state of strength	Limit state of strength
0.75 (DL+LL)	1.5 (DL+LL)
0.75 (DL+WLXP)	1.5 (DL+WLXP)
0.75 (DL-WLXN)	1.5 (DL-WLXN)
0.75 (DL+WLZP)	1.5 (DL+WLZP)
0.75 (DL-WLZN)	1.5 (DL-WLZN)

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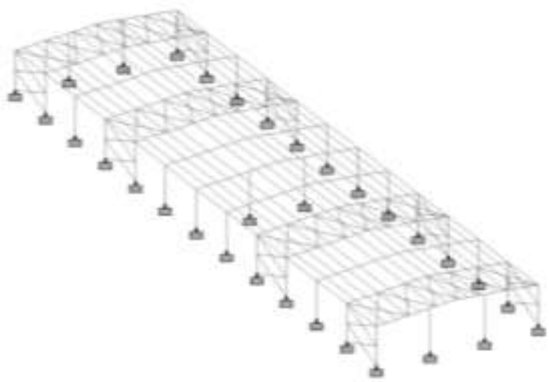
Staad Pro Procedure

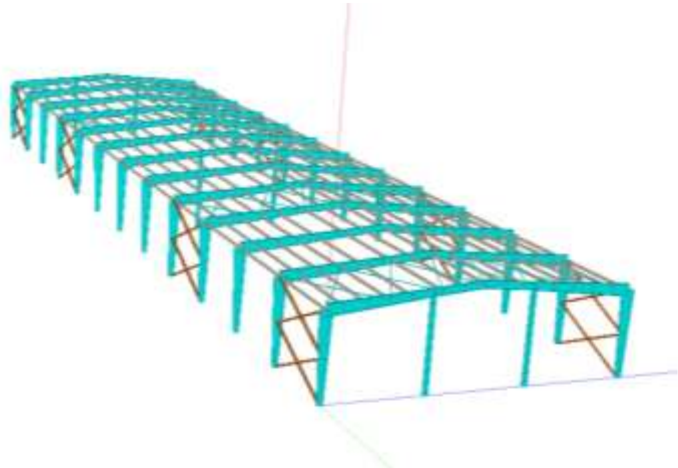
For design, analysis, and modeling of structure STADD Pro software is used. This software support several country standards including Indian standard. In this Software, the Modeling of structure, properties, load and loading combination specification, applied analysis and design are carried out.

Modelling

PEB 3D VIEW



PEB RENDERING VIEW



CSB 3D VIEW

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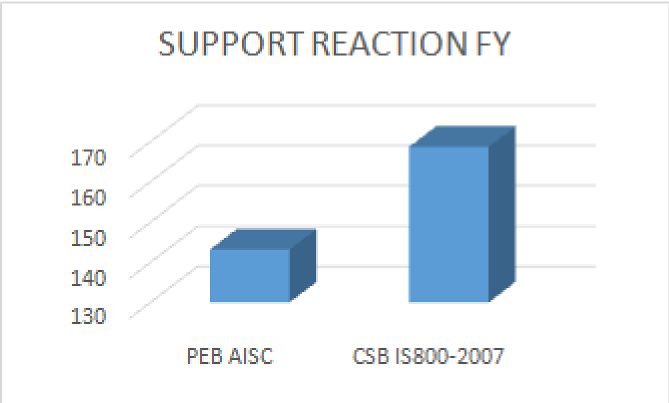
CSB Rendering View

II. RESULTS AND DISCUSSION

RESULTS

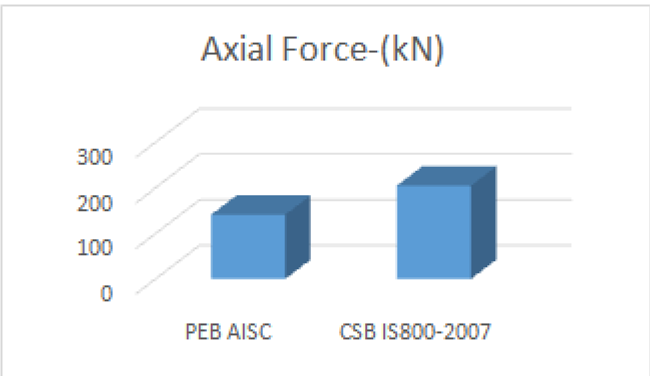
COMPARISON OF MAXIMUM SUPPORT REACTION

MODELS	SUPPORT REACTION IN KN
PEB (AISC)	143.218 (DL+LL)
CSB (IS 800 2007)	168.745 (DL+LL)



COMPARISON OF MAXIMUM AXIAL FORCE

MODELS	AXIAL FORCE IN KN
PEB (AISC)	141.558 (DL+LL)
CSB (IS 800 2007)	204.605 (DL+LL)



STEEL TAKE-OFF FOR PEB

To calculate the steel weight of PEB the following member properties are used. For columns and rafters, tapered sections are assigned. For the purlins, cold-formed "Z" sections are used. For bracings, angle sections are used. Now using the above parameters the lengths and weights are calculated accordingly.

SECTION DETAILS OF PEB –AS PER AISC360-10

PROFILE	**LENGTH (M)**	**WEIGHT (KN)**
Tapered Member No: 1	78.00	38.528
Tapered Member No: 2	78.00	47.516
Tapered Member No. 3	32.14	20.065
Tapered Member No: 4	94.08	38.335
Tapered Member No: 5	39.00	19.973
Tapered Member No: 6	40.03	9.964
Tapered Member No: 7	39.00	21.090
Tapered Member No: 8	39.00	22.209
Tapered Member No: 9	39.00	23.326
ST 8ZU1.25X090	167.32	7.553
ST 8ZU1.25X060	1087.61	32.967
ST L50505	242.31	115.395
PRISMATIC STEEL	376.82	9.094
	TOTAL	**406.015**

Steel Take-Off For Conventional Steel Building

To calculate the steel weight of a conventional steel building the following member properties are used, "I" sections are assigned for columns. For the top chord, bottom chord, and strut angle Indian standard double angles are used. For purlins and bracings ISMC ((Indian Standard Medium Channels) are used.

SECTION DETAILS OF CSB-AS PER IS800-2007

PROFILE	**LENGTH (M)**	**WEIGHT (KN)**
ST ISMB500	156.00	133.021
ST ISA150 X150X12	563.24	150.571
ST ISA75 X75X8	356.35	31.207
ST ISMB350	36.00	18.446
ST ISMC100	1254.93	117.612
ST ISMC150	619.13	101.306
	TOTAL=	**552.162**

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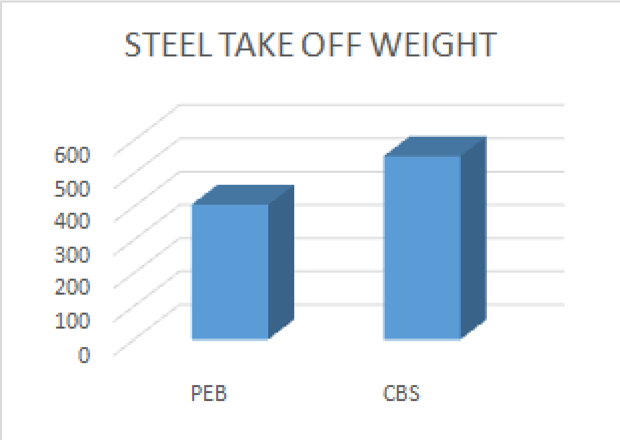
COMPARISON OF WEIGHT BETWEEN PEB AND CSB

MODELS	WEIGHT IN KN
PEB (AISC)	406.015
CSB (IS 800 2007)	552.162



III. DISCUSSION

From the comparison, it is observed that:
1. At rigid joint maximum bending will be high and in pin, the joint maximum bending moment will be less.
2. At rigid joint maximum shear force will be high than in pin joint.
3. At rigid joint maximum axial force will be less than pin joint.
4. After analysis results of structure and literature studies suggest that the PEB structure is more economical and advantageous than CSB.

IV. CONCLUSION

1. It is observed that the weight of PEB is 26% less than conventional steel buildings.
2. It is observed that the maximum support reaction of PEB is 15%less than Conventional steel building.
3. It is noted that the maximum axial force of PEB is 30% less than Conventional steel building.
4. Maximum bending moment will be high for PEB than for Conventional steel building.
5. Maximum shear force will be high for PEB than for Conventional steel building.

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