"COST COMPARATIVE STUDY ON THE STRUCTURAL ANALYSIS AND DESIGN OF PRE-ENGINEERD BUILDING WITH CONVENTIONAL STEEL BUILDING SUBJECTED TO CYCLONIC AND HIGH SEISMIC ZONE"

Vasudha S. Patil[1], Mr. Rohan K. Choudhary[2]

[1]M. Tech. Student, Department of Civil Engineering, School of Engineering and Technology, Sandip University, Nashik, Maharashtra, India
[2]Assistant Professor, Department of Civil Engineering, School of Engineering and Technology, Sandip University, Nashik, Maharashtra, India

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Abstract - *The cost and time of construction is more important for the client with the large working area. For reducing cost and less fabrication work, pre- engineered building system (PEBs) have many advantages. Pre-engineered buildings are more authentic for various uses like complex industrial facilities, warehouses, stock-house, shopping malls, resort, aircraft-hanger, stadium and any type of industrial structures. In the pre- engineered steel building system, the rigid frame consists of slab, walls are connected with primary member (beam and column). In PEB we can also maintain large spacing without any intermediate columns.it is also suitable for access point of view. Therefore, in this research work pre-engineered metal building with a span of 48 m analyzed in software STAAD PRO (CONNECT Edition22) and compared with conventional steel building of same size. The results were indicated that pre-engineered steel building is 50% more economical in substructure and superstructure with stable compared to conventional steel building.and its all good for all climetic conditions in any types of soil condition*

This research work was focused on design criteria, selection of structural members for analysis of Pre-engineered industrial shed building and Conventional industrial shed building with higher seismic zone & cyclonic zone as per updated IS codes.. In these reserch I also comapred the base shear(Vb) values as per respose spectrum analysis in seismic load and deflection of both structure .

***Key Words*: Pre-Engineered Building shed structure, Conventional Steel Building shed structure, Detail structural analysis and design, Deflection comparison, Base shear comparison, STAAD PRO, CONNECT Edition22.**

1. INTRODUCTION

Steel is a great collaborator, working together with all other materials to advance growth and development in all the parts of the world. The properties of steel structures are tensile, ductile, flexible, and cost effective. Here cost-effective word is stated considering time and economy-engineered buildings are the steel buildings in which were all truss members are reduced for avoiding axial force transformation to carried by tapering the sections as per the bending moment's requirement. If we go for conventional steel structures, time will be more, and also cost will be more, and both together i.e. due to all properties we save time and money. Thus, in pre-engineered buildings, the total design is done in the factory, and as per the design, all members are pre-fabricated on yard then transported to the site.

The structural performance of these buildings is best for heavy loading which is currently in place to ensure satisfactory behavior in cyclonic zone and higher seismic zone. Steel structures also have much better utilization ratios than RCC and they also can be easily dismantled. Pre-Engineered Buildings have bolted connections and hence can also be resusable and easy transformation for errection processin future .In this paper we will discuss the various advantages of Pre-Engineered Building structure and also, with the help of result, a comparison will be made between Pre-Engineered Building and Conventional Steel Building structure Steel buildings are used in all kind's types of industrial, commercial, institutional, agricultural building uses and their demand is increasing due to their properties. [3][4][5].

1.1. Conventional Steel Buildings (CSB)

Conventional steel buildings (CSB) are low rise steel structures with roofing systems of truss with sheeting.There are different type of roof trusses can be used for these structures depending upon the loading type on the roof. Conventional construction is a traditional or standard construction. It commonly involves all the traditional members like I-section for column and crane girder,C-section for purlins,angle section for bracing and all truss members according to there parameters.and they connected on site by bolting and welding in connection design [6].

Figure 1. Conventional Steel Buildings (CSB) structure modeling as per staad file.

1.2 Pre -Engineered Buildings (PEB)

PEB members are like column and rafter in that they are mainly designed to carry transverse loads along their length. These external load cause axial compressive and tensile force like shear and bending moment

A pre-engineered steel building is a modern technology where the complete designing is done at the fabrication yard and the building components are brought to the site and then connected at the site and raised with the help of cranes by errection process. An efficiently designed pre-engineered building can be lighter than the conventional steel buildings by up to 50%. Lighter weight equates to less steel and money savings in structural framework.

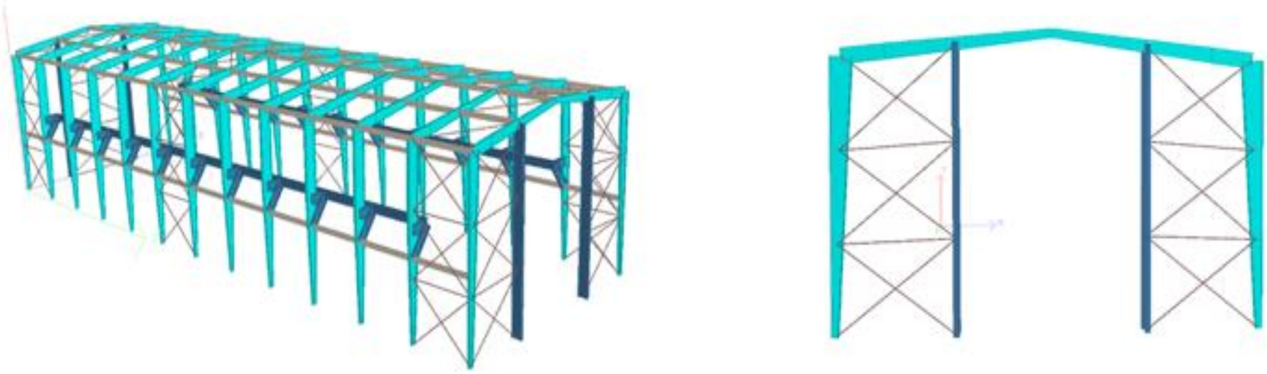

Figure 2. Pre -Engineered Buildings (PEB)structure modeling as per staad file

2. METHODOLOGY

The present study is included in the design of steel sheds with width 16m and height 11m, located at Kandla city, Gujarat. The structure length is considered as 48m with bay spacing of 4m i.e., 12nos. of 4m bays. In this study, firstly CSB structure is taken into account and the design is carried out by considering wind load (with cyclonic effect) and seismic load (for higher seismic zone) as the critical load for the structure. PEB structure is also designed for the same span considering with same location ana all configuration. Both the designs are then compared to find out the economic output for substructure and superstructure also. The designs are carried out in accordance with the updated Indian Standard and by the help of the structural analysis and design software STAAD-pro connect edition.22.

2.1. Problem Statement-

The conventional steel building and pre-engineered building structure is analysis and designed using STAAD pro connect edition.

location	**Kandla city, Gujarat, India**
Total bay length	**48m**
Single bay length structure	**4m**
Spacing between two purlins	**1.5m**
Span Width	**16m**

Clear height	**11m**
Roof slope for CSB	**1:4**
Roof slope for PEB	**1:10**
Wind speed	**50m/s**
Wind terrain category	**3**
Wind class	**Cyclonic zone**
Rise	**2m**
Seismic zone	**IV**
Occupancy category	**2**
Span of gantry girder	**4m**
Clear span of crane girder	**14.4m**
Minimum hook approach of crane girder	**1.2m**
wt. of crane girder	**180kN**
Crab with motor	**50kN**
Capacity	**200kN**
Crane is supported on gantry girder farther down to the bracket connected at	**7.5m**

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 member have been decided on the basis of the required section modulus to carry the prerequisite bending moment.

3. LOAD CALCULATIONS

The loads acting on the structure includes dead load, live load, wind load, seismic load, crane load as in [1] [10] [11] [12... The load calculation for the structure can be carried out in accordance with IS: 875:2015– part 1,2 and 3, IS:1893-2015/2016 part 1 and 2. The primary loads cases taken for the analysis and design of the CSB and PEB structure are as follows-
LOAD 1 DEAD LOAD
LOAD 2 LIVE LOAD
LOAD 3 WIND LOAD +X (EP + IP)
LOAD 4 WIND LOAD +X (EP + IS)
LOAD 5 WIND LOAD -X (EP + IP)
LOAD 6 WIND LOAD -X (EP + IS)
LOAD 7 WIND LOAD +Z (EP + IP)
LOAD 8 WIND LOAD +Z (EP + IS)
LOAD 9 WIND LOAD -Z (EP + IP)
LOAD 10 WIND LOAD -Z (EP + IS)
LOAD 11 CRANE LOAD
LOAD 12 SEISMIC LOAD X+
LOAD 13 SEISMIC LOAD Y+
LOAD 14 SEISMIC LOAD Z+
All the loads were worked out according to the IS codes and applied on the models and the analysis was carried out. Later, the structural designs were done using MS-Excel sheets.

3.1 Load combination-

Loads combinations can be adopted according to IS: 800-2007., table-4, 129 and 286 different load combinations adopted for the analysis of the shed structure in both the concepts. For limit state of serviceability and limit state of strength respectively [1].

4. STAAD .PRO PROCEDURE-

The Staad-Pro software package is a structural analysis and design software which helps in modelling, analyzing and designing the structure.

1. Complete the detail modelling in staad-pro
2. Give the boundary conditions by soil quality (supports)
3. Assign geometry as per slenderness ratio (properties)
4. All primary load calculations
5. Apply all specifications (releases, member truss, beta angle)
6. Load combinations
7. Design parameters (LSM)
8. 1st run for deflection check
9. 2nd run for strength check
10. Optimizations of file according to requirement
11. Calculations of steel consumption
12. Comparison of module 1 & 2

5. RESULT-

5.1 Steel take off

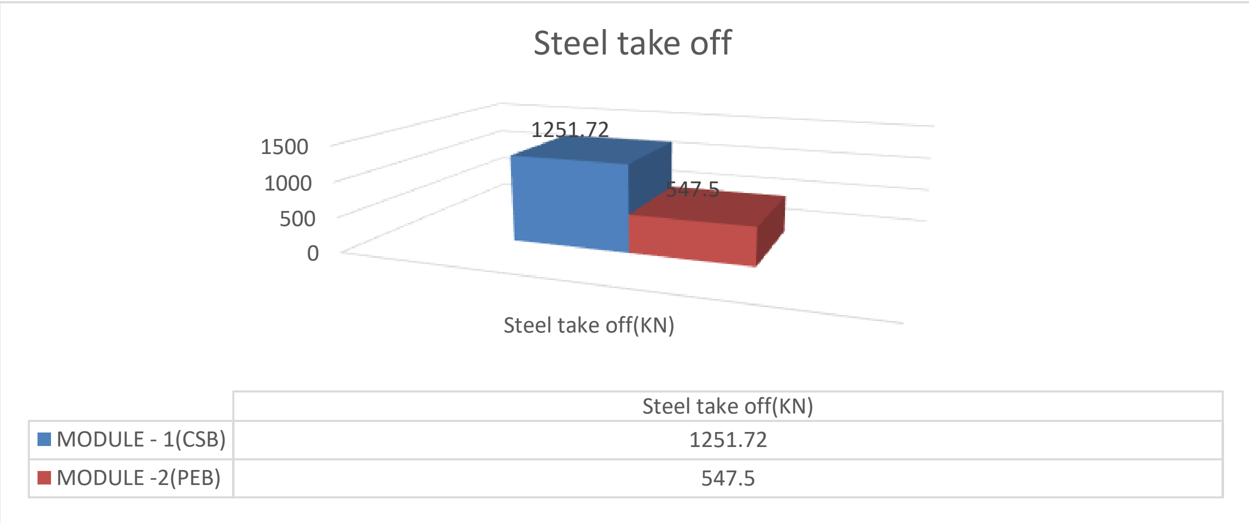

Figure 3. Comparison of consumption for CSB and PEB structure in Kg as per staad file

After studying the pre-engineered building and conventional steel building according to Indian standard code the result obtained that the steel takes off of structure of PEB is less than the CSB as per IS800:2007.as shown in Figure 5.

Member	Profile	Length(m)	Weight (KN)
SD	ISA80X80X10	224.80	52.153
SD	ISA150X150X12	286	76.511
ST	ISMC200	576.00	126.106
ST	ISMC150	828.90	135.628
ST	ISMC225	224.00	57.301
LD	ISA120X120X12	96.82	17.330
ST	ISA120X120X10	208.00	88.201
ST	ISA110X110X10	528.00	85.583

ST	ISA150X150X10	63.43	14.228
ST	ISA65X65X10	112.96	10.415
LD	ISA150X150X12	40.13	21.454
ST	ISMB450	44.00	31.198
ST	ISMB600	266.08	314.776
ST	ISMB400	24.08	14.512
ST	ISMB175	303.22	58.001
ST	ISMB550	26.40	26.770
ST	ISMB500	80.00	68.216
ST	ISMB225	32.00	9.759
			Total=1251.72

Table -2. Steel weight after optimization -For CSB

Member	Profile	Length(m)	Weight (KN)
ST	Tapered	272.42	209.691
SD	Tapered	39.43	25.970
SD	Tapered	155.09	82.088
ST	139.7X4.8CHS	84.00	13.125
ST	Tapered	70.37	18.651
ST	Tapered	33.36	21.975
ST	Tapered	131.23	69.459
SD	Tapered	146.69	94.880
ST	12ZS3.25X060	80.00	4.665
ST	Tapered	26.40	6.997
			Total=547.5

Table -3. Steel weight after optimization -For PEB

5.2 Base shear as per seismic properties

Behaviour of structure subjected to dynamic loading and with sufficient numbers of modal participating mass ratios (>90 %) by detailed method of calculations (CQC) in staad- pro. In table 4 and 5.

Base shear as per staad pro for CSB[staad file-1]

Maximum base shear	FX	FY	FZ
TOTAL CQC SHEAR	472.07	0.00	0.00
TOTAL CQC SHEAR	0.00	159.53	0.00
TOTAL CQC SHEAR	0.00	0.00	443.32

Table 4. Base shear (Vb) as per RSM for Conventional Steel Building.

Base shear as per staad pro for PEB[staad file-2]

Maximum base shear	FX	FY	FZ
TOTAL CQC SHEAR	174.40	0.00	0.00
TOTAL CQC SHEAR	0.00	73.66	0.00
TOTAL CQC SHEAR	0.00	0.00	113.15

Table 5. Base shear (Vb) as per RSM for Pre -Engineered Building.

- Base shear of X – direction frame is maximum than than Z and Y
- we concluded that all super structure members carry horizontal load so base shear will be decreased as compared to CSB structure.
- So no need to required heavy substructure design

5.3 Maximum Deflection

Maximum deflection chart after optimized file for module 1 (conventional steel building structure) in below fig.4 and module 2 (pre-engineered building structure) in below fig.5

All | Summary

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	341	273 0.9DL+1.	**23.943**	-4.060	-2.175	24.382	-0.000	0.000	0.011
Min X	367	275 0.9DL+1.	**-23.949**	-4.060	-2.176	24.388	-0.000	-0.000	-0.011
Max Y	758	273 0.9DL+1.	14.770	**33.220**	-1.645	36.392	-0.000	0.001	-0.000
Min Y	768	201 1.5DL+1.	0.291	**-18.003**	0.065	18.005	-0.000	-0.000	0.000
Max Z	709	264 1.5DL+1.	-0.001	-0.139	**13.529**	13.529	-0.001	-0.001	0.000
Min Z	717	275 0.9DL+1.	-2.412	0.745	**-13.141**	13.382	0.001	-0.001	0.000
Max rX	775	279 0.9DL+1.	1.227	13.650	-1.166	13.754	**0.004**	-0.000	-0.000
Min rX	752	273 0.9DL+1.	3.486	14.188	-2.541	14.829	**-0.005**	-0.000	-0.000
Max rY	126	285 0.9DL+1.	3.858	-0.086	4.334	5.803	0.000	**0.008**	0.000
Min rY	126	272 1.5DL+1.	-4.589	-0.178	-4.410	6.366	-0.000	**-0.008**	-0.000
Max rZ	1009	273 0.9DL+1.	20.588	0.408	-2.862	20.790	-0.001	-0.000	**0.013**
Min rZ	1022	275 0.9DL+1.	-20.593	0.408	-2.862	20.795	-0.001	0.000	**-0.013**
Max Rst	765	275 0.9DL+1.	-19.235	33.011	-1.537	**38.237**	0.000	0.000	0.000

Figure 4. deflection summary chart as staad pro for CSB[staad file-1]

All | Summary

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	791	253 1.2DL+0.	**109.443**	-8.443	8.541	110.100	0.001	0.002	0.002
Min X	617	268 1.5DL+1.	**-60.945**	-6.026	-1.030	61.251	-0.000	-0.000	-0.002
Max Y	622	275 0.9DL+1.	-38.561	**33.026**	-2.610	50.838	0.000	-0.000	-0.002
Min Y	737	254 1.2DL+0.	5.685	**-23.246**	252.095	253.228	-0.049	-0.163	-0.018
Max Z	736	257 1.2DL+0.	40.538	-10.080	**328.066**	330.715	0.046	-0.142	-0.007
Min Z	736	286 0.9DL+1.	-2.254	-0.368	**-86.656**	86.686	-0.000	-0.064	-0.000
Max rX	758	259 1.5DL+1.	33.857	0.556	-3.155	34.008	**0.702**	0.094	0.002
Min rX	760	259 1.5DL+1.	33.851	0.548	3.434	34.029	**-0.702**	-0.094	0.002
Max rY	610	257 1.2DL+0.	28.480	0.502	3.307	28.675	-0.001	**0.117**	-0.005
Min rY	616	258 1.2DL+0.	37.527	-1.343	8.295	38.456	-0.006	**-0.277**	-0.008
Max rZ	737	267 1.5DL+1.	38.331	11.822	0.657	40.118	0.001	0.000	**0.009**
Min rZ	737	254 1.2DL+0.	5.685	-23.246	252.095	253.228	-0.049	-0.163	**-0.018**
Max Rst	736	257 1.2DL+0.	40.538	-10.080	328.066	**330.715**	0.046	-0.142	-0.007

Figure 5. deflection summary chart as staad pro for PEB[staad file-2]

6. CONCLUSIONS

By comparing above two sheds structure type PEB require less steel as compare to CSB that means save 50% money. Part of PEB structure is also carry bending moments. steel take of PEB structure 547.5KN while CSB Howe type structure require 1251.72KN. So, we can save steel. As per Indian code, the classes of section considered for design are Plastic, Compact and Semi- compact, slender cross-section.

Each of the two models was modeled and analyzed using STAAD.Pro and designed using MS-Excel sheets. Later, the results obtained for the CSB and the PEB models were compared by using various parameters and the performance of the models was evaluated.

Following are the three parameters considered for the comparison of the results for CSB and PEB models-

- Weight of Steel required in PEB is only 40 % of CSB structure.
- Steel consumption according to volume of structure should also be 40 % of CSB structure in PEB structure.
- As per current rate, cost of PEB structure is 40% less as compared to CSB structure.
- PEB is more rigid structure as compare to CSB. so all members carry full weight of structure and substructure sizes are reduced as comapired to CSB
- Base shear (Vb) is also 70% minimum in PEB as compared to CSB as per response spectrum method (seismic analysis). So, we concluded that all super structure members carry horizontal load so base shear will be decreased as compared to CSB structure, So no need to required heavy substructure design.

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