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Comparative study of PEB by Indian and American Code

Nihar Shah[1], M.G.Vanza[2], Prasham Vora[3]

[1]*Student, L.D.College of Engineering, Gujarat, India*
[2]*Professor, Applied Mechanics Dept. of L.D.College of Engineering, Gujarat, India*
[3]*Director, P.Vora Design & Engineering Consultants, Gujarat, India*

Abstract -
In recent years, the use of Pre-Engineered Building (PEB) design of structures has helped in optimized design. The use of PEB in place of CSB (Conventional steel building) resulted in light weighted members and quick construction which ultimately decrease cost of construction. In the present study Pre-engineered Buildings are designed and studied in accordance with Indian Code and American Code. This comparative study is based on the analytical study of PEB models as per Indian and American codal provisions. Comparison will be made in terms of weight required per frame.

Key Words: PEB, Pre Engineered Building, IS 800,AISC, Welded Section

1. INTRODUCTION

Pre-engineered buildings (PEBs) are construction components produced and installed on site. PEBs are generally steel structures and can be used as an alternative to traditional steel structures. PEB structural components are made to exact size in the plant, transported to the premise and installed at the premises usually bolted.

The use of structural design (PEB) has contributed to optimized design in recent years. PEB is a factory manufactured sections used in construction. This kind of structural concept is commonly used in

- Industrial and Small Manufacturing Buildings
- Small Retail and Commercial Office Buildings
- Warehouses and Storage Units

Advantages of PEB

- Control of quality is the main advantage since all structural components are made in the factory.
- Reduced costs due to design savings, production and erection costs on site.
- Low service because paints are standard over steel members.
- Speedy constructions since all members are prefabricated and the work of expertise is used to connect various components.
- Light weight because the bending capacity results meet the section requirement.
- Since the super structure is weighted lightly, it reduces the foundation size ultimately.
- PEB warranty, mainly 20-year warranty given by PEB production companies

The adaptability of PEB in the place of Conventional Steel Building (CSB) design concept resulted in many advantages, including economy and easier fabrication & faster construction. PEB is a factory manufactured sections used in construction. There is no solid study has been done on the comparison of the design of PEB as per Indian standards and American standards.

2. FRAME VARIATION

In this chapter we are going to compare different PEB frames with variation of bay spacing and span length in terms of weight required for each frame.

2.1 Load Calculations

Dead Load Calculation as per IS 875 Part 1:1987

(1)Self weight = Factor -1

(2)Load due to roofing purlins (KN/m) = 0.05 .... (Table 1)

(3) Load due to GI sheet (KN/m) =0.05 x Bay spacing .... (Table 1)

Live Load Calculation as per IS 875 Part 2 :1987

(1)Load on rafter (KN/m) = 0.75 x Bay spacing ....(Table 2)

Wind Load Calculation as per IS 875 Part 3 :2015

(1) Wind Load = (Cpe - Cpi) x Pd x Bay Spacing

where

Cpe = External pressure coefficient................(Cl. 7.3.3, Table 5, Table 6)
Cpi = Internal pressure coefficient.................(Cl. 7.3.2)
Pd = Design wind pressure ....(Cl. 7.2)

Design wind pressure Pd

Pd= Ka x Kd x Kc x Pz

Where Ka= Area averaging factor............................(Cl.7.2.2)

Kd= Wind directionality factor........................(Cl. 7.2.1)

Kc= Combination factor...............................(Cl. 7.3.3.13)

Pz= Wind pressure at height z in KN/m2

=0.6 x Vz2

Vz= Design wind speed at height z (m/s)

= K1 x K2 x K3 x K4 x Vb

K1=Risk Coefficient ....(Cl 6.3.1 , Table 1)

K2=Terrain height factor ....(Cl 6.3.2.2 , Table 2)

K3=Topography factor ....(Cl 6.3.3)

K4=Importance factor for cyclonic regions.......(Cl 6.3.4)

Vb=Basic Wind Speed in m/s ....(Annex :A)

2.2 Modeling

Here, we will use STAAD Pro software for analysis and design. We will take different combination of PEB frames depending on bay spacing and span length and then design them on the basis of IS 800, AISC 360 LRFD method and AISC 360 ASD method. For this comparison we will use following bay spacing and span length of frames.

Table 1 Bay spacing variation

Bay Spacing
5 m
6 m
7 m
8 m

Table 2 Span length variation

Span Length
20 m
25 m
30 m
35 m

For example here we will discuss our first combination that is for 5m bay spacing and 20 m span length.

Geometry

Table 3 Basic information of model

Eaves Height	6 m
Width of PEB	20 m
Length of PEB	50 m
Roof Angle	1 : 10
Total Height	7 m
Bay Spacing	5 m
Location	Ahmedabad

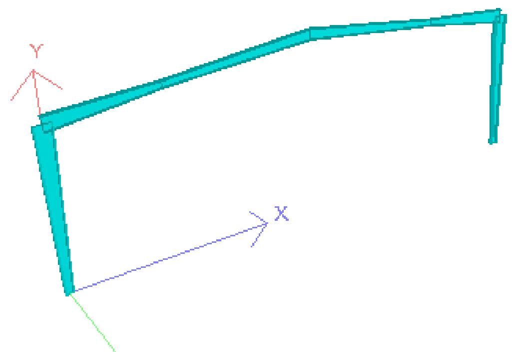


Figure 1: 20 m span frame

Loading

(A) Dead Load

1) Self weight = Factor -1

2) Load Due to purlins and roofing sheet

=0.1 x 5

=0.5 KN/m

(B) Live Load

=0.75 x 5

=3.75 KN/m

(C)Wind Load

Here we will consider wind speed for Ahmedabad region.

Basic Wind Speed = 39 m/s

K1=Risk Coefficient =1

K2=Terrain height factor =1

K3=Topography factor =1

K4=Importance factor =1

Vz= Design wind speed at height z (m/s)

= K1 x K2 x K3 x K4 x Vb

=1 x 1 x 1 x 1 x39

=39 m/s

Pz= Wind pressure at height z in KN/m2

=0.6 x Vz2

=912.6 N/m2

Ka= Area averaging factor =1

Kd= Wind directionality factor=1

Kc= Combination factor=1

Pd= Ka x Kd x Kc xPz

=912.6 N/mm2

Reduction in Wind Pressure as per Cl 6.3 = 20%

Final Design Wind Pressure =730 N/mm2

Cpi = Internal pressure coefficient

For Openings less than 5%

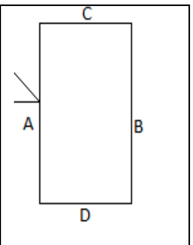
Cpi=+0.2 & -0.2

Cpe = External pressure coefficient

For Walls

Table 4 Cpe coefficients for walls

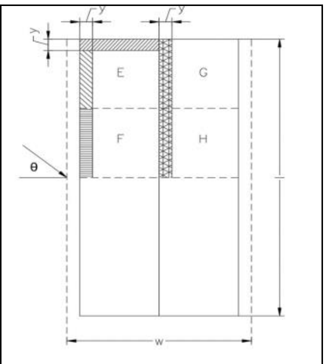
	0^0	90^0
A	0.7	-0.5
B	-0.2	-0.5
C	-0.5	0.7
D	-0.5	-0.2



For Roof

Table 5 Cpe coefficients for roof

WIND ANGLE 0^0	EF	-0.96
	GH	-0.4
WIND ANGLE 90^0	EG	-0.8
	FH	-0.44



Final Wind Force on frame calculated as

F= (Cpe – Cpi) x Pd x Bay Spacing KN/m

Load Combinations

Load combinations as per IS 800: 2007

1) 1.5DL + 1.5LL

2)1.5DL + 1.5WL

3)0.9DL + 1.5WL

4)1.2DL+1.2LL+1.2WL

5) DL + LL

6) DL + WL

7) DL + 0.8LL +0.8 WL

Load combinations as per ASCE 07 for LRFD Method

1)1.4 DL

2)1.2DL+0.5 LL

3)1.2DL + 1.6LL

4)1.2DL + 1.6WL +0.5 LL

5)0.9DL + 1.6WL

Load combinations as per ASCE 07 for ASD Method

1) DL

2) DL+ LL

3)0.6DL + WL

4) DL + 0.75WL +0.75 LL

5) DL + WL

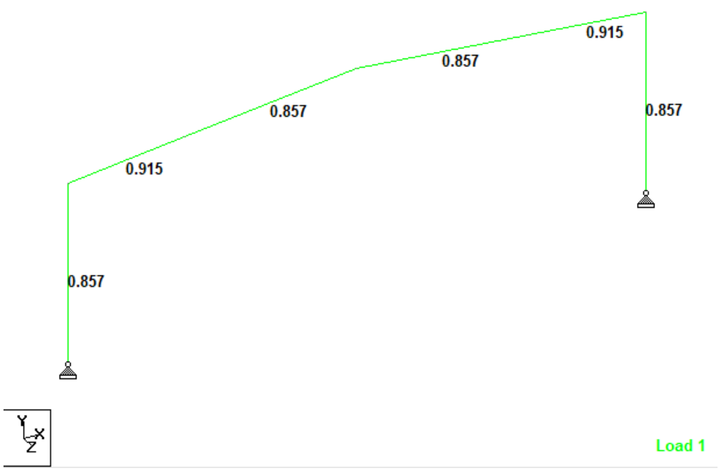


Figure 2 : Utilization Ratio

3. Results

Table 6 IS code vs. AISC LRFD

Span Length	Bay Spacing	Weight as per IS code (L/C) & Design parameter	Weight as per AISC LRFD code (L/C) & Design parameter	Difference
m	m	KN	KN	%
20	5	11.6	10.94	6.03
	6	11.91	11.28	5.59
	7	13.71	13.01	5.38
	8	14.09	13.51	4.29
25	5	16.29	14.02	16.19
	6	17.25	16.02	7.68
	7	18.37	16.92	8.57
	8	19.16	18.41	4.07
30	5	19.86	18.18	9.24
	6	22.35	20.86	7.14
	7	25.55	24.74	3.27
	8	27.6	26.15	5.54
35	5	28	27.15	3.13
	6	28.76	27.91	3.12
	7	35.92	34.74	3.40
	8	40.6	38.12	6.51

Table 7 IS code vs. AISC ASD

Span Length	Bay Spacing	Weight as per IS code (L/C) & Design parameter	Weight as per AISC ASD code (L/C) & Design parameter	Difference
m	m	KN	KN	%
20	5	11.6	10.23	13.39
	6	11.91	11.13	7.01
	7	13.71	12.87	6.53
	8	14.09	13.47	4.60
25	5	16.29	14.32	13.76
	6	17.25	15.95	8.15
	7	18.37	16.97	8.25
	8	19.16	18.36	4.36
30	5	19.86	18.37	8.11
	6	22.35	20.42	9.45
	7	25.55	24.47	4.41
	8	27.6	26.55	3.95
35	5	28	27.00	2.19
	6	28.76	28.03	2.68
	7	35.92	32.14	11.76
	8	40.6	38.96	4.21

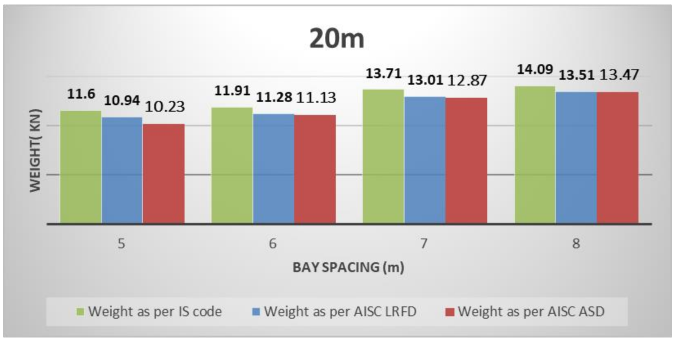


Figure 3 Weight vs. Bay spacing for 20 m span

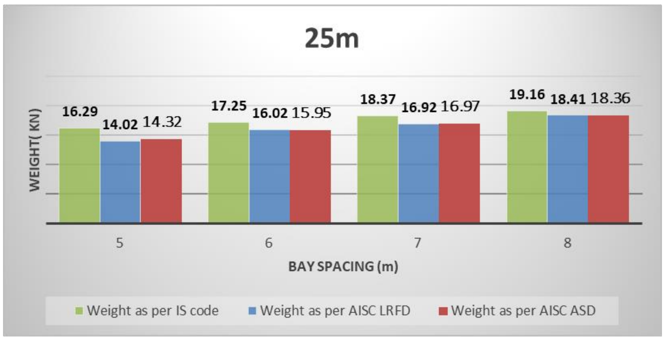


Figure 4 Weight vs. Bay spacing for 25 m span

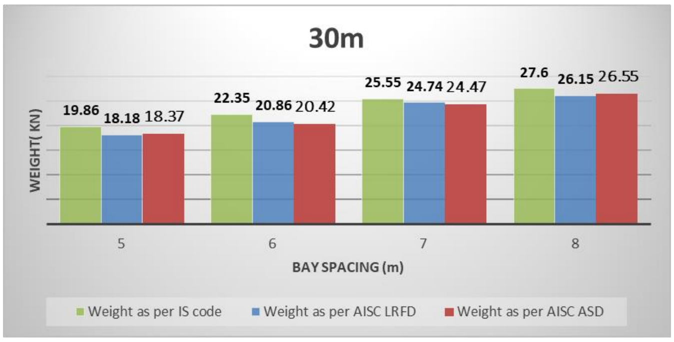


Figure 5 Weight vs. Bay spacing for 30 m span

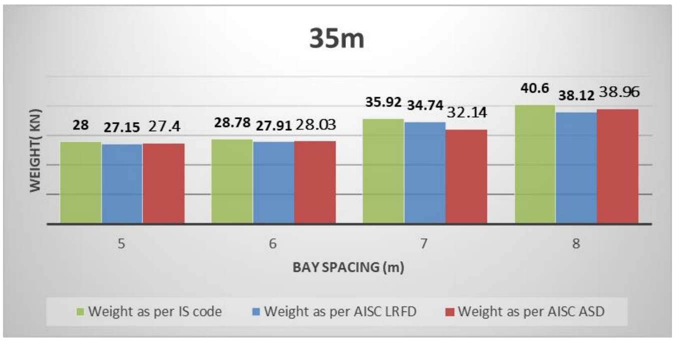


Figure 6 Weight vs. Bay spacing for 35 m span

Other ways of Optimization

In STAAD Pro during defining design parameter if we will not enter the method of design in AISC code and only enter the code name then STAAD Pro by default take it as LRFD method for design so if you enter the load combinations of ASD method and not define the method of design then STAAD Pro use LRFD method by default.

By using this approach one will enter lower value of load and assume higher design strength so it will produce lighter design.

Table 8 IS code vs. optimized design

Span Length	Bay Spacing	Weight as per IS code (L/C) & Design parameter	Weight as per AISC ASD code (L/C) & Design parameter as per AISC LRFD	Difference
m	m	KN	KN	%
20	5	11.6	9.85	17.77
	6	11.91	10.36	14.96
	7	13.71	11.90	15.21
	8	14.09	12.49	12.81
25	5	16.29	12.96	25.69
	6	17.25	15.10	14.24
	7	18.37	15.34	19.75
	8	19.16	16.88	13.51
30	5	19.86	15.88	25.06
	6	22.35	16.78	33.19
	7	25.55	19.73	29.50
	8	27.6	21.77	26.78
35	5	28	23.62	18.54
	6	28.76	26.15	10.06
	7	35.92	29.51	21.72
	8	40.6	32.33	25.58

4. CONCLUSIONS

- From the frame variations for different span length and bay spacing for AISC code and IS code we can see that AISC code gives 3% to 10% lighter section as compared to IS code.
- If we enter load combinations of ASD and do not enter the design method only enters design code (AISC 360) then we will get 15 to 30% lighter section as compared to IS code.
- During our experimental study we found that results obtained by experimental study are almost same as the analytical study.
- From this study we can conclude that AISC code will give us lighter sections as compared to Indian code.
- Different countries have different factor of safety in their code that depends on their execution of their work on site. American code has lower factor of safety as compared to Indian code so that is why it give us lighter section as compared to Indian.
- So it is wrong practice to use American code provisions in structures which will build in India. By this way you are dealing with the safety of the structure.
- One should use same codal provision as same as country. So by this way one can ensure the safety of the structure.

REFERENCES

[1] Shaik kalesha,B.S.S. Ratnamala Reddy, Durga Chaitanya Kumar Jagarapu "An analytical study on pre-engineered buildings using staad pro". Materials today , Elsevier,2020,4

[2] B.Harini,N.Lingeshwaran,K.Perumal,K.Aravinthan "Sustainable design of cold formed steel".Materials today , Elsevier,2020,06

[3] Nikitas Bazeos,Dimitris L. Karabalis "Efficient computation of buckling loads for plane steel frames with tapered members".Elsevier(Engineering Structures),2005,12

[4] Zhang Lei, Tong Geng Shu "Lateral buckling of web-tapered I-beams: A new theory". Elsevier(Journal of Constructional Steel Research),2008,01

[5] Muhammad Umair Saleem, Hisham Jahangir Qureshi "Design Solutions for Sustainable Construction of Pre Engineered Steel Buildings". MDPI(Sustainability),2018,05

[6] General Constriction in Steel - Code of Practice - IS 800:2007

[7] Specification for Structural Steel Buildings - AISC 360:16

[8] Companion to the AISC Steel Construction Manual , Vol. 1 , Version 15.1

[9] Code of Practice for Design loads (other than Earthquake) For Buildings and Structures part 1 Dead loads- IS 875(part 1):1987

[10] Code of Practice for Design loads (other than Earthquake) For Buildings and Structures part 2 Imposed loads- IS 875 (part 2):1987

[11] Code of Practice for Design loads (other than Earthquake) For Buildings and Structures part 3 Wind loads- IS 875 (part 3):2015

BIOGRAPHIES

Nihar Shah
M.E. Student
Structural Engineering
L.D.College of Engineering, Ahmedabad

M.G. Vanza
Associate Professor,
Applied Mechanics Dept.
L.D.College of Engineering, Ahmedabad

Prasham Vora
Structural Engineer
Director at P.Vora Design & Engineering Consultants, Ahmedabad