Analysis And Design of Pre-Engineered Building Using Indian And Equivalent American Code

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Abstract - *Pre-engineered buildings (PEBs) are structures that have been pre-engineered by a manufacturer to be constructed using a predetermined inventory of raw materials and manufacturing techniques that may effectively fulfil a variety of structural and aesthetically pleasing design criteria. Mezzanine floors, canopies, fascias, internal partitions, and other structural accessories can be added to pre-engineered steel buildings. The buildings can also be waterproofed using specific mastic beads, filler strips, and mouldings. Pre-engineered structures with efficient designs can be up to 30% lighter than traditional steel structures. Less steel is required when something is lighter, which might reduce the cost of the structural structure.*

***Key Words*: *pre-engineered building (PEB), conventional steel buildings, mezzanine floors, canopies, fascia*;**

1.INTRODUCTION

India is a developed country. Large-scale housing construction is taking place all over the country. Because her 30% of India's population lives in cities. Therefore, more will be built in urban areas. Pre-engineered steel structures are manufactured or manufactured in-house. Components are manufactured according to customer requirements. Detailed components are laid out and numbered in specific locations, but cannot be changed. Because the rod is made from the point of view of design function. These components are manufactured modular or completely disassembled for transportation. These materials are shipped to the customer site and set up. We do not perform welding or cutting at the customer's site. There is no manufacturing process at the customer's site. Pre-engineered Buildings (PEBs) are designed by manufacturers to be manufactured using predetermined inventories of raw materials and manufacturing methods that can efficiently meet a wide range of structural and aesthetic design needs. In some geographic industries, these buildings are also called pre-engineered metal buildings. Historically, the primary frame structure of pre-engineered buildings is an assembly of I-shaped members, often called I-beams. I-beams are commonly used in PEB by welding steel plates together to form an I-beam. The I-beams are then assembled on site (such as bolted joints) to form the overall frame of the pre-engineered building. Cold-formed Z-shaped and C-shaped members can be used as secondary structural members to attach and support siding. Building exteriors can be roll-formed profiled sheet steel, wood, upholstery, precast concrete, masonry blocks, glass curtain walls, or other materials.

1.1 Objectives of study

The purpose of this work is to focus on the analysis and design of PEB Shed using STAAD-PRO Connect Addition software.

Bulleted lists may be included and should look like this:

- The main objective of the this study is to prepare a report of Pre-Engineered steel building for Industrial shed using Staad Pro Connect Edition Software
- To design PEB Building with Indian code and equivalent American codes with use of Staad Pro Connect Edition Software, By considering uniform flange profile and compare its result related to weight ratio in percentage.
- To design PEB Building with equivalent American codes with use of Staad Pro Connect Edition Software, By considering different flange profile and compare its result related to weight ratio in percentage.

2. LITERATURE REVIEW

An extensive study of literatures is carried out to understand the concept of sequential analysis and the effects of it on structure. In addition to this, literatures related to structural load path irregularities are reviewed and behavior of structure is understood.

2.1 Review of Literatures

1. **Zende, et. al. [1]** dealt with comparative study of analysis and design of Pre-Engineered-Buildings and conventional frames. Staad Pro software has been used in order to analyze and design Pre-engineered building structures and conventional structures, authors considered 3 examples. In

the first example, a 3D model of a Hostel building has been designed and compared with conventional structure using conventional steel. It is seen that the weight of tapered PEB sections are 369.24kN whereas for conventional building, it is found to be 491.64 kn. Pre-Engineered Building weighs 25% less than that of conventional building. In the second example, a 2D plane frame of width 44m for both PEB and conventional has been designed and comparison has been made in terms of weight of steel. PEB structure is designed for a clear span of 44m without any column in between, as not in case of conventional frame, where it is not possible to provide a clear span truss and hence an interior column is provided. It is noticed that, even though PEB structures provides clear span, it weighs 10% lesser than that of conventional buildings. Some examples of how your references should be listed are given at the end of this template in the 'References' section, which will allow you to assemble your reference list according to the correct format and font size.

2. **Pérez [2]** dealt with design and analysis of an industrial steel building. Limit states, stability check. Work done by authors focused on the design of a structural steel industrial building of double-T type section located in an industrial area of Valladolid (Spain). Firstly, a linear analysis was carried out in past to dimension the structure and check that it resists according to the established regulations, the Technical Building Code, the national adaptation of the Euro codes. In the second place, a nonlinear analysis is performed with the objective of verifying the Ultimate Limit State of stability of the structural elements and of the industrial building as a whole. Authors summarizes the methodology of the nonlinear analysis of the spatial structures of beams, which allows problems of instability with bending and/or torsion deformations to be solved, calculating the critical moment of lateral buckling for any load case and support conditions.

3. **Sai Kiran et al. [3]** studied the Comparison of Design Procedures for Pre-Engineering Buildings. The economy of the structure is discussed in terms of its weight comparison, between Indian codes (IS800- 1984, IS800-2007) and American code (MBMA-96), and between Indian codes (IS800-1984, IS800- 2007). The main difference between the Indian Code (IS800- 2007) to the other equivalent American Codes are in the classification of the cross-section of the steel member. As per Indian code, the classes of section considered for design are Plastic, Compact and Semi-compact, slender cross-section. It is well known that many PEB manufacturers use sections with very thin webs in order to reduce the weight of the section and be economical/competitive in their commercial offers, and these thin webs do not satisfy the codal provisions of IS800: 2007.

2.2 Research Gap

- Sufficient literature is available on analysis and design of PEB structures, but using same sizes of flanges of element effectively It will definitely help to achieve great economy of project which ultimately affect overall project. Hence more attention is required towards this issue.

- Available literature shows that, for analysis, mostly uniform flange profile is used while it is not necessary at every moment hence it will be more realistic to use section with full capacity.

3. METHODOLOGY

Metal construction of pre-engineered can be optimized to meet specific design criteria. Recent days, most Indian consultants and his PEB Vendors providers largely follow Indian and American design practices.

The design cycle consists of the following steps: 1.Set section sizes and brace locations based on the geometry and loads specified in the frame design. 2.Calculate the moment, shear force, and axial force at each analysis point for each load combination. 3.Compute the allowable compressive and tensile shear, axial and bending stresses at each analysis point. 4. Based on the actual and allowable stresses, calculate the corresponding shear, axial, and bending stress ratios, and calculate the bond stress ratio. 5. Design the optimal splice site and ensure that the predicted size meets manufacturing constraints. 6. Use pass optimization mode to achieve optimal pass depth for next cycle and update member data file. 7. At the end of every design cycle, an analysis is performed to achieve optimization of the flange brace. Rigid frames.

Frame Geometry: The program has the ability to handle different types of frame geometry, such as: Rigid frames, frames with multiple internal columns, single slanted frames, slanted frames, etc. Frames with different spans, different heights, different slopes, etc. H. Articulated supports, fixed supports, subduction supports, and supports with a certain degree of freedom. Asymmetric frames, such as off-center, unequal modules, or different slopes. Custom purlin and flange spacing and flange brace locations.

Design Codes: Contains the service requirements that the design must meet. Implementation standards for design loads (other than earthquakes) of buildings and structures. It helps determine these loads on the building being measured. The key design codes commonly used are: AISC: American institute of steel construction manual AISI: American iron and steel institute specifications MBMA: Metal building manufacturer's code ANSI: American national standards institute specifications ASCE: American society of civil engineers 35 UBC: Uniform building code IS: Indian standards (IS1893-2002 PART 1 FOR EQ) and (IS 875 PARTIII FOR WIND).

4. DESIGN PHILOSOPHY

The design under consideration is an industrial shed with a free span of 35 meters. The shed was designed in 3D using STAAD software, with the load he distributed evenly across the three coordinate systems. H. Simulate X, Y, Z correctly. Dead, live, wind, temperature, earthquakes, etc. were considered when designing the frame. It has a structure that can receive the wind load caused by the opening and closing of the large shed door both in the closed state and the open state. Load calculations are performed in the same way as for normal frames. The (DL+WL) or (DL+LL) condition is usually the key case driving the design because the PEB slope is small (e.g., 1 in 10). Support conditions are usually fixed, but selective use of fixed conditions can be advantageous, resulting in a combination of base plate and anchor bolts. In the pivoted base state, the section typically tapers downward and is bolted to the base. All other connections are usually designed as rigid connections and steel connections are moment connections that transmit axial, moment and shear values between the connected sections. Wind load calculations should refer to IS-875 pt.3 latest edition to achieve design wind pressure after careful analysis and combination of internal and external pressure or force coefficients. Appropriate load combinations with wind loads, seismic loads and crane loads should be considered. The basic idea of rigid frame design is to employ a "fixed" or "pinned" strut base condition. A sturdy stanchion base is a stable frame at all times and helps control the allowable deflection (lateral fluctuation) of the frame. Steel designers always prefer fixed base frames to fixed base frames. On the contrary, foundation design becomes a nightmare for foundation planners, especially for buildings with large spans. In a fixed base design, the frame is rigid, but heavy moments are transferred to the foundation. Weak ground makes foundation design a tedious task. Similarly, with pinned supports, the frame does not transfer moments to the foundation, only vertical and horizontal reaction forces affect the design of the foundation. It looks simple, but due to the long span, controlling the frame deflection with a pinned base is a difficult task. Combined stresses are typically checked using interactive software that calculates section utilization efficiency and compared to limits (LSD or WSD). H. An actual stress/allowable stress of 0.95 means that the section is used to 95% of its strength. For this, the total weight of the frame is calculated. Many such that the sections are designed with variables such as flange thickness, web thickness, flange width, web depth, etc. so that the whole frame is theoretically safe and has a minimum weight. Trail runs. Deflection testing is the next step. The easiest way to control this deflection is to increase the geometry/section size of the frame, but that would increase the overall building tonnage, which would increase not only the seismic force but also the later cost, so it is not recommended. Not recommended. I need a solution that allows me to control frame sway and does not increase the section size. The best method we have been able to find is to "brake" the frame to control excess deflection. In this example, stiffeners (reinforced eaves) were installed at the height of the eaves on both sides of the structure in the longitudinal direction. The span of this eaves brace is approximately L/10 on each side. In the example below, you can see how eaves braces can be very helpful in controlling horizontal deflection, making foundation design easier. Some vendors use 90% of the sections and leave 10% for possible manufacturing, transportation, assembly and assembly errors. But this competition has led people to believe that there is no problem anywhere! The next important step is to design the weld between the flange and the web. Again, the efficiency of the weld seam plays an important role. Therefore, PEB manufacturers avoid on-site welding because a 4.5mm weld in the workshop may be better than a 6 or 8mm weld in the field. The next step is to design the field joints (where the parts will be assembled on site). The forces produced at the joints are known. Bolted connection preferably perpendicular to the plane of the frame to utilize the tensile capacity of the BM bolt instead of shear capacity. Therefore, the number of screws required for connection is reduced. Many span reduction and lateral support techniques such as sag bars, knee braces and pull bars can be used to optimize the section.

4.1. Building Input Data

Width = 35 meters, Length = 75.50 Meters, Eave Height = 24 Meters, End Bay no. and Spacing = 2 no. @ 7.62 Meters, Intermediate Bay no. and Spacing = 2 no. @ 7.62 Meters, Brick work = 3.00 Meters, Roof Slope = 1 in 10, Location = Wada, Maharashtra Clear height of Structure = 9.75 m, Ridge height of Structure = 1.075 m.

4.2. Dead Load Calculations

Sheet weight = 4.57 kg/m^2, Purlins =5 kg Bracing and Sagging = 9.5 kg, The total load transferring from these components are 1.0 KN/M^2, Total Dead load = 1.0*7.5(Bay Spacing) = 7.5 KN/M^2

4.3. Live Load Calculations

Live Load is considered from the crane loading and manual loading during erection and is 0.57 according to MBMA code of chapter 4, Live Load = 0.57*7.5 = 4.275 KN/M^2.

4.4. Seismic Load Parameters

Wada comes under zone –III, i. Z = seismic zone coefficient = 0.16 (table 2 of IS 1893 PART 1 -2002), ii. I = depend upon functional use of the structures = 1(from table 6 of IS 1893), iii. R = response reduction factor = 5 (table 7 of IS 1893 PART 1 -2002).

4.5. Wind Load Calculations

Wind Pressure Calculations = Wind Speed, Vb = 44 m/sec, Risk coefficient, k1 = 1.00, Terrain, Ht and size factor, k2 = 0.98 (Terrain = 2), Topography Factor, k3 = 1.00 (class = c), Design wind Speed, (vz) = Vb* K1* K2* K3 = 44.00 * 1.00* 0.98 * 1.00 = 40.92 m/sec, Design wind pressure, Pz = 0.6*Vz^2 =0.6*40.92^2 = 1004.67 N/m2 = 1.00KN/M^2, Element wind Load = Pz* Bay Spacing = 1.00*7.53 = 7.53 KN/M, Internal Pressure Coefficient (Cpi) = +/- 0.5, External Pressure Coefficient from IS 875 –III tables (Cpe):

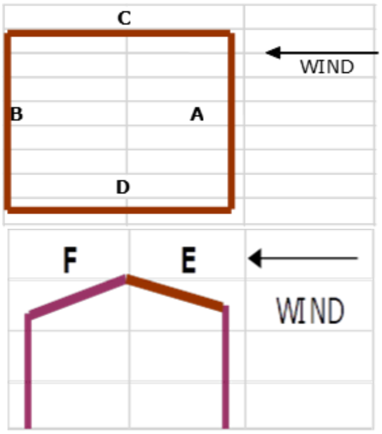

Figure. 4.1 – Wind load

Table. 4.1– Wind load Coefficient

Wind	Side wall Coefficients				Roof Coefficient	
	A	B	C	D	E	F
0^0	0.70	-0.25	-0.60	-0.60	-0.943	-0.4
90^0	-0.50	-0.50	0.70	-0.10	-0.80	-0.42

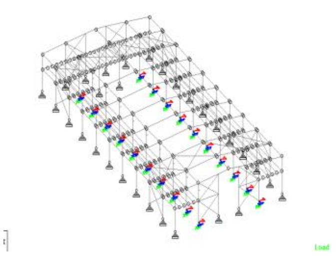

Figure. 4.2 – Industrial Shed Model

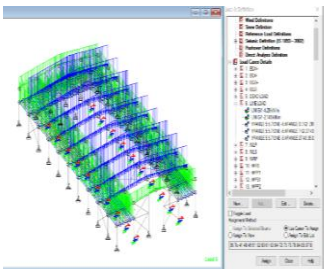

Figure. 4.3 – Load on Member

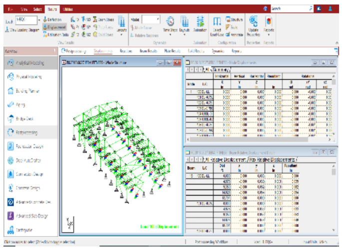

Figure. 4.4 – Displacement

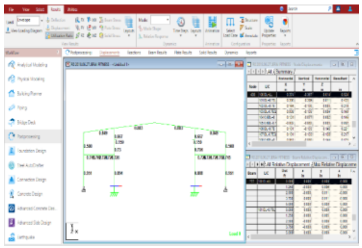

Figure. 4.5 – Utilization Ratio

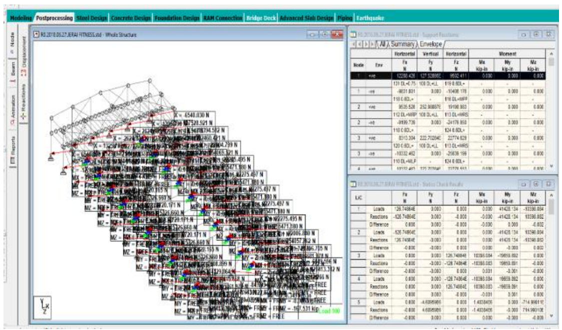

Figure. 4.6 – Support Reaction

5. RESULT AND DICUSSION

5.1. Results

we have analyzed structures for three different codal positions as mentioned in design methodology. We have followed static non-linear analysis method for structural analysis to check results. STAAD.pro is finite element analyses software which is globally used in construction industry for structural analysis and design.

- Maximum Deflection of Building in
X direction = 0.754 mm, Y direction = 2.736 mm, Z direction = 11.156 mm.
- Allowable Maximum Deflection of Buildings as per code is H/400 = 24000/400 = 60 mm
- Maximum Deflection of Building < Allowable Maximum Deflection.

R0.2018.06.27.JERAI FITNESS.std - Node Displacements:

All Summary

	Node	L/C	Horizontal X in	Vertical Y in	Horizontal Z in	Resultant in	Rota rX rad
Max X	335	118 0.6DL+W	0.754	-0.002	-0.020	0.755	0.000
Min X	344	120 0.6DL+W	-0.754	-0.002	-0.020	0.755	0.000
Max Y	118	119 0.6DL+W	0.343	2.736	0.016	2.758	0.001
Min Y	131	100 DL+LL	-0.000	-2.580	0.202	2.588	0.002
Max Z	145	111 DL+WLS	-0.002	0.008	8.688	8.688	0.010
Min Z	145	122 0.6DL+W	-0.006	0.000	-11.156	11.156	-0.014
Max rX	144	114 DL+WPP	-0.006	-0.001	-1.926	1.926	0.838
Min rX	144	119 0.6DL+W	-0.003	0.033	0.215	0.218	-0.767
Max rY	146	122 0.6DL+W	-0.006	-0.003	-1.441	1.441	0.008
Min rY	147	122 0.6DL+W	-0.006	-0.004	-1.440	1.440	0.008
Max rZ	134	100 DL+LL	0.251	-0.052	0.106	0.278	0.000
Min rZ	133	100 DL+LL	-0.251	-0.052	0.106	0.278	0.000
Max Rs	145	122 0.6DL+W	-0.006	0.000	-11.156	11.156	-0.014

Table 5.1 – Deflection Check

5.2. Discussion

1. The weight consumption for structure as per IS code, by AISC with uniform flanges and by AISC with different flanges are 1870.83 KN, 1070.60 KN and 986 KN respectively.

2. From the table we state that the weight consumption ratio for first design case to second case reduced by, 42.77%.

3. Also, weight consumption ratio for first case to third case is reduced by 47.28%. 4. Weight consumption ratio of second case to third case is reduced by 7.87%.

MEMBER DESCRIPTION	WEIGHT		
	BY IS CODE METHOD	BY AISC METHOD (UNIFORM FLANGES)	BY AISC METHOD (DIFFERENT FLANGES)
Member 18	177.60	137.78	126.76
Member 19	272.59	140.42	124.97
Member 24	210.91	61.86	56.91
Member 25	50.75	23.95	23.23
Member 32	22.31	19.57	18.98
Member 49	232.78	87.73	79.83
Member 150	50.17	38.32	36.78
ST 200ZS60X2	0.42	0.42	0.42
Member 207	690.30	430.35	395.92
Member 287	157.94	126.10	118.53
Member 618	5.07	4.11	4.03
Total Weight (in KN)	**1870.83**	**1070.60**	**986.37**
Weight Comparison	**42.77 %**		
	47.28%		
		7.87%	

4. Also in general practice of industry, uniform size flanges are used which are not necessary because if different size flanges are used, it will cause reduction in the weight and will bring down cost of the project.

6. CONCLUSION

1. From study, It has been found that by IS code, we need to provide more material weight than the American code (AISC).

2. The major reason for weight reduction is due to different section classification clause in code.

3. By using AISC code we can use more thinner section as compared to IS code, as AISC code allows thinner section by their section classification for primary members.

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