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Parametric Study on Design of Pre-Engineeredbuilding Using Is 800–2007 and Aisc 360-10 13th Edition

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Abstract- *: Pre-engineered buildings have become quite popular in the last few years. The main advantages of P.E.B are speed of construction and good control over quality .The pre-engineered building has a great advantage to the single storey buildings, practical and efficient alternative to conventional buildings. In this review, a brief comparison of Pre-engineered building and conventional beam is done. Also comparison is made between IS800:2007 & AISC 360-10. This comparison is done by studying the entire range of pre-engineered buildings . A warehouse frame is designed using IS 800:2007 & AISC 360-10 by keeping the loading parameters similar, all the loads are applied in accordance with Indian codes. An attempt is made to study the variation in tonnage as per IS 800:2007 and AISC 360-10 & possible reasons for variation in respective results. Analysis and design of these building frames was carried out using STAAD-PRO software. As per market study it observed that more than 70 % pre-engineered buildings are designed according to AISC360-10.*

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I. Introduction

1.1. GENERAL

The concept of Pre-engineered buildings were being introduced to the Indian market in the late 1990s with the opening up of the economy; and a number of multi–nationals setting up their projects. Over a period it gained widespread acceptance among the end users and is steadily making in roads in the construction, and infrastructure projects across the country. As largely based on the fact that PEB based construction technique is offering the foremost innovative, high-tech and faster methods of construction which are ensuring efficient, cost-effectiveness, and speedy completion of projects. Steel industry is growing rapidly in almost all the parts of the world. The use of steel structures is economical as well as Eco-friendly. Here, the word "economical" is used stating the time and cost involved. As time is a most important aspect, steel structures (Prefabricated) are built in less period, and one such example is Pre Engineered Buildings (PEB). Pre-engineered buildings are nothing but steel buildings where excess steel is avoided by tapering the sections as per the requirement of bending moment.

1.2. PRE-ENGINEERED BUILDING

Pre-Engineered Steel Buildings are produced in the plants itself. The manufacturing of structural members is done as per the customer's requirements. By using steel efficiently, pre-engineered buildings can be made about 30% lighter than conventional steel structures. In primary framing tapered built up sections are provided with the smaller depth in areas of lower stress and larger depth in areas of higher stress. In secondary members "Z" or "C" shaped sections are provided which are lightweight cold formed. At the time of erection possibly no modification can be made at the site such as welding and cutting. There is no manufacturing process taking place at the customer site.

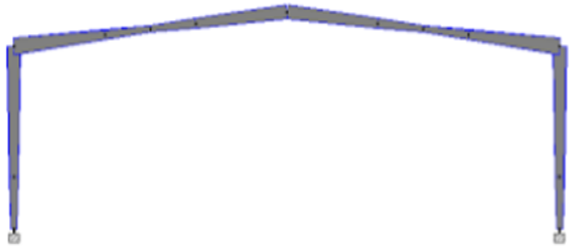


FIG.1 P.E.B Frame

1.3 CONVENTIONAL STEEL BUILDING

Steel structures are low rise with the truss system of roofing with roof coverings are termed as conventional steel buildings.For these kind of structures can be utilization of various types of the roof trusses.Type of roof system is used according to pitch of truss. The steel structures also termed as metal structures. In this construction process producing the shapes of structures also termed as metal structures. In this construction process producing the shapes of structural steel material used is steel. The shape of steel structure is unique,built with a specific cross section and also including certain chemical composition.

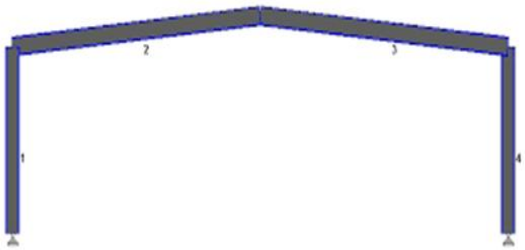


FIG. 2. C.S.B FRAME

1.4 ADVANTAGES OF P.E.B

After carrying out studies it is seen that the use of P.E.B will decrease the duration of construction of the project by at least less than time required by conventional steel structures. Due to this system, there is saving in design, production of members and on site erection costs.Steel structures are completely manufactured in factories in the presence of controlled conditions hence the quality control is assured. The applications of P.E.B are ability to span long distance, Faster occupancy, Cost efficient, Low.

1.5 APPLICATION OF P.E.B

Pre-engineered building system is new concept in structural engineering field, found itself in a construction and the erection various building structures, this concept have widely used for WareHouse, workshops, Gas Station, Parking for vehicle Sheds, Showrooms, Aircraft Hangers, Roofs of indoor Stadium, Canopies for Outdoor Stadium, Bridges, Railway platform, Sheltes, and Industrial roofs

Objective

- Comparison between PEB and CSB
- Compairing codal povision
- Comparing design result of IS800-2007 with AISC 360-10 13th Edition
- Significant Behavior of wind on the structure and how does it affect the structure Comparison of different parameters like loads, load combinations,design methodology and section sizes of the structure
- Comparing percentage variation in effective weight (MT) of structure.
- Suggest most efficient method & design code for industry.

II. Literature Review

2.1 C. M. Meera (June 2013) – She studied that Pre-engineered building is a versatile solution to all the single storey industrial building as along with providing a high-quality pre-design structure it is also economical and light weight construction technique. P.E.B has many advantages over conventional steel structures such as providing a standard fabricated section according to the optimum requirement. In this paper author administered a comparative study of PEB and CSB on the idea of design and analysis of a typical frame. Design of conventional steel frame include selection of an appropriate roof truss built up from standard hot rolled sections. Analysis for both the steel frame using different concept shows that there's about 30% reduction in steel consumption in Pre-engineered building as compared to standard steel frame, hence PEB are lighter than CSB. In this way PEB proves to be more advantageous from CSB in because it is more economical, internal control , speed in construction, longer span, durability, standard designs, ease in expansion and erection designs, ease in expansion and erection

2.2 G. Sai Kiran, **A. Kailasa Rao**, **R**. **Pradeep Kumar** (Aug 2014) - Observes that, In recent years, the introduction of Pre Engineered Building (PEB) concept within the design of structures has helped in optimizing design. There are many advantages like economy and easier fabrication by the adaptability of PEB in the place of conventional steel buildings (C.E.B) design concepts. An industrial structure (Ware House) under this study is analyzed and designed consistent with the Indian standards, IS 800- 1984, IS 800-2007 and also by referring MBMA-96 and AISC-89. The structure with length 187m, width 40m, clear height 8m and having R Slope 1:10

, is considered to be taken out for analysis & design for 2D frames (End frame, frame without crane and frame with 3 module cranes) in this study. Between Indian codes (IS800-1984, IS800-2007) & American code (MBMA- 96), & between Indian codes (IS800-1984, IS800-2007), the Economy of the structure got discussed in terms of its weight comparison.

2.3 Apurv Rajendra Thorat, Santosh k.Patil (9june 2017) - They studied that In the present study Pre-engineered Buildings are designed and studied in accordance with KirbyTechnical Specification which is based on ASCE-07.Two examples are taken for the study. Comparison of Pre Engineered Buildings (PEB) with bracings and Pre Engineered Buildings (PEB) without bracings is completed in two examples. Later Pre Engineered Buildings (PEB) is analyzed for Dynamic loads using El-centro specified ground motion.

2.4 B K Raghu Prasad, Sunil kumar, Amarnath K (September 2014) - They studied that Pre-engineered buildings have become quite popular in the last few years. The main advantages are speed of construction and good control over quality. However there is not much information on its economy. There are several parameters like the inclination of the gable, spans, bay spacing, which control the cost of the structure. The above parameters are varied systematically in the present paper and in each case the gable frame designed for the common loads DL, LL, EQ , and WL. In each case the quantity is obtained and finally the structure which regulates the lowest quantity of steel is recommended.

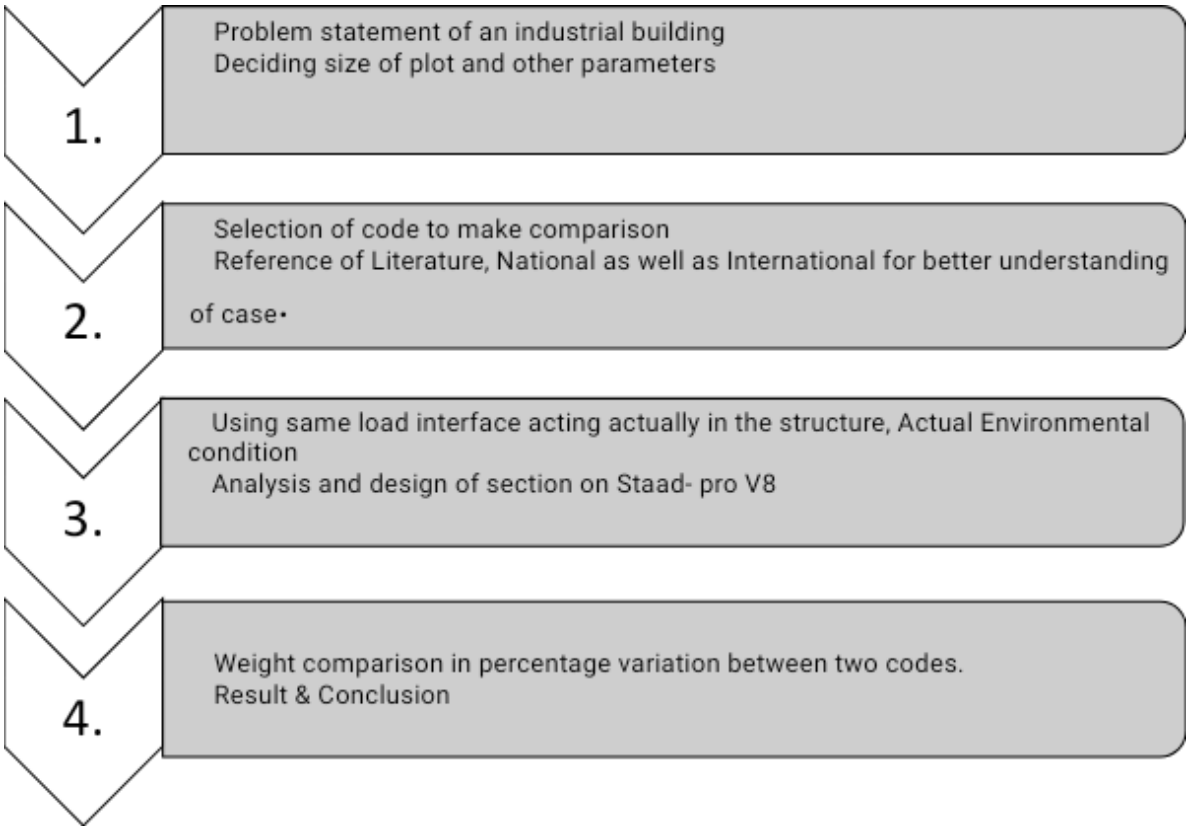
2.5 Pradeep V, Papa Rao G (march 2014) - This paper effectively conveys that PEB structures can be easily designed by simple design procedures in accordance with country standards. Higher resistance is offered by low weight flexible frames to earthquake loads. PEB roof structure is nearly 26% lighter than Conventional Steel Building. Light weight "Z" purlins are used for PEB structure, in Secondary members whereas heavier hot-rolled sections are used for CSB. In case of PEB , the support reactions are lesser than CSB as per analysis. Light weight foundation are often adopted for PEB which results in simplicity in design and reduction in cost of construction of foundation. Heavy foundation will be required for CSB structure. PEB building cost is 30% lesser than the value of CSB structure. Low cost, strength, durability, design flexibility, adaptability and recyclability is offered by PEB . As far as long span structures are concerned where large column free areas are needed. PEB construction gives end-users the more economical and better solution and therefore it got concluded

2.6 Neha R.Kolate, Shipa Kewate (july 2015) - A comparative study between pre-engineered building and conventional steel building are made by them and observes that PEB has many advantages over conventional Steel building such as superior strength and zero maintenance and it's corrosion resistance and showing a beautiful appearance and it's high level technology innovation and better product over conventional material. PEB system has protection against non-uniform weathering. In this paper, they studied that the majority of the steel structures are made during a conventional way using conventional sections and this results in uneconomical and heavy structure and this pushes forward technology to urge a far better replacement which is Pre-engineered building having better properties than conventional steel frames.

2.7 Shrunkhal V Bhagatkar, Farman Iqbal Shaikh, Bhanu Prakash Gupta, Deepak Kharta (March 2015) – They studied that Steel industry is growing rapidly in almost all the parts of the world. The use of steel structures isn't only economical but also eco friendly at the time when there's a threat of worldwide warming. Prefabricated steel structures is made in very short period and one such example is Pre Engineered Buildings (PEB) , time being the evidence of this as an important aspect . Results of experimental and analytical studies done on Pre Engineered Building got checked and presented from the past experiences. Results are the proof and shows that these structures are economic, reduces construction cost and time, energy efficient and adaptability of expansion.

III. Methodology

In recent years, the introduction of Pre Engineered Building (PEB) concept in the design of structures has helped in optimizing design. The adoptability of PEB in the place of Conventional Steel Building (C.S.B) design concept resulted in many advantages, including economy and easier fabrication & faster construction. In this project work, an industrial structure (Pre-engineered Building) with loading as per Indian Standard codes will be analyzed and will be designed according to the various standards, i.e. IS 800-2007 (LSM), IS 800-2007 (ASD), AISC-360 LRFD, design results will be compared in terms of steel consumption. Here an attempt will be made to highlight the essential contents of IS: 800-2007 while following Limit State Method, the corresponding stipulations as adopted by other International codes. The project work will be carried out as,



31. Structure Configuration

- The present study is included in the design of an Industrial structure located at Chakan Pune. The structure is a factory sheds of Warale in Chakan Pune.
- The actual structure is proposed as a Pre-Engineered Building
- The building configuration are

Parameter	
Length	99 m
Width	49.5m
Clear Hieght	11 m
Bay spacing	7 m
NO. of Bay	17
Height of brick wall	3
Sloping angle	5.7
Design life of structure	50 years
Location	Chakan, Pune
Length of sag rod	1.7
Dia. Of sag rod	12
No. of brace tiers for roof	3
No. of brace tiers for column	2
No. of brace rod	4
Dia. Of brace rod	20
Brace angle	For alternate purlin
No.of canopy	4
Wieght of each canopy	350
Unit weight for sheeting	4.25
Unit weight for flashing	4.25

TABLE.1 : SPECIFICATION OF STRUCTURE

3.3 LOADS ACTING ON PEB

Dead load (DL) – Dead comprises weight of sheeting, Purlins, self weight of section including stiffners and fastners. If clients ask for any different requirement collateral load like fan, cable tray and Turbo ventilators weight are considered.

- From the calculation total weight for all exclusive of collateral is around $0.1kN/m^2$

Live Load (LL) – Live load is considered for maintenance work. Considering a person weight who will be doing maintenance at a specific time.

- In India – 75 kg/ m^2
- In America – 57 kg/ m^2

Wind Load (WL) – Generally wind force is omni-directional

- Wind forces are exerted upon that portion of the structure that is exposed and will contribute toward force. Generally sheeting will obstruct the flow of air and hence it will experience the major force, which is then delivered to column and Secondary structure.
- Wind is most important in case of Pre Engineered building as it create maximum moment and try to make structure unstable. Gravity loads are stabilizing force in case of PEB. While calculating for wind force we have assigned certain direction along with pressure and suction activity which is based on Coefficient on internal wind pressure

3.4 LOAD COMBINATION

DL	1.5(DL+WLP)
LL	1.5(DL+WLS)
WLP	1.5(DL+WPP)
WLS	1.5(DL+WPS)
WPP	1.5(DL+WRP)
WPS	1.5(DL+WRS)
WRP	$1.5(DL+LL)+1.05CL_1$
WRS	$1.5(DL+LL)+1.05CL_2$
DL+LL	DL+LL
DL+LL+WL	DL+WLP
CL_1	DL+WLS
CL_2	DL+WPP
CSW	DL+WPS
1.5(DL+LL)	DL+WRP
1.2(DL+LL+WLP+CSW)	DL+WRS
1.2(DL+CSW+LL+WLS)	DL+0.8(LL+WLP)
1.2(DL+CSW+LL+WPP)	DL+0.8(LL+WLS)
1.2(DL+CSW+LL+WRP)	DL+0.8(LL+WPP)
1.2(DL+CSW+LL+WRS)	DL+0.8(LL+WPS)
1.2(DL+CSW+LL+WPS)	DL+0.8(LL+WRP)
	DL+0.8(LL+WRS)

TABLE .2: Load combination according to IS code : -

DL	DL+0.75(LL+WLP)+CSW
LL	DL+0.75(LL+WLS)+CSW
WLP	DL+0.75(LL+WPP)+CSW
WLS	DL+0.75(LL+WPS)+CSW
WPP	DL+0.75(LL+WRP)+CSW
WPS	DL+0.75(LL+WRS)+CSW
WRP	$DL+LL+CW_1$
WRS	$DL+LL+CW_2$
CW_1	$DL+LL+CW_3$
CW_2	$DL+LL+CW_4$
CW_3	1.0(DL+LL)
CW_4	1.0(DL+WLP)
CSW	1.0(DL+WLS)
DL+LL	1.0(DL+WPP)
DL+WLP	1.0(DL+WPS)
DL+WLS	1.0(DL)+0.8(LL+WLP)
DL+WPP	1.0(DL)+0.8(LL+WLS)
DL+WPS	1.0(DL)+0.8(LL+WPP)
DL+WRP	1.0(DL)+0.8(LL+WPS)
DL+WRS	1.0(DL)+0.8(LL+WLP+CSW)
DL+0.75(LL+WLP)	1.0(DL)+0.8(LL+WLS+CSW)
DL+0.75(LL+WLS)	1.0(DL)+0.8(LL+WPP+CSW)
DL+0.75(LL+WPP)	1.0(DL)+0.8(LL+WPS+CSW)

DL+0.75(LL+WPS)	DL+LL+CW_1
DL+0.75(LL+WRP)	DL+LL+CW_2
DL+0.75(LL+WRS)	DL+LL+CW_3
0.6DL+WLP	DL+LL+CW_4
0.6DL+WLS	1.0(DL+WRP)
0.6DL+WPP	1.0(DL+WRS)
0.6DL+WPS	1.0(DL)+0.8(LL+WRP)
0.6DL+WRP	1.0(DL)+0.8(LL+WRS)
0.6DL+WRS	1.0(DL)+0.8(LL+WRP+CSW)
	1.0(DL)+0.8(LL+WRS+CSW)

TABLE.3: Load combination according to AISC :-

IV. Modelling & Analysis

- After calculating all force a 2D model was framed keeping all input in place.
- Width = 49.5 meters
- Length = 99 meters
- Clear height = 8 meters
- Location = Chakan, Pune
- After modelling all the loads which are explained above are incorporated in the model as shown in figure.
- Providing section on random basis and analysis is run to check the Bending moment on the whole 2-D frame.
- After getting BMD. Sections are divided where the BM is getting zero. This is the method used in industry for calculating section length as in India section length should not exceed 12-14 meters because of transportation& erection issue.
- As earlier mentioned section sizes are determined using BMD. Also BMD is helps to understand why tapered sections are need to be used in the PEB.
- Location where BMD is maximum, web height is kept maximum there and less web size where BMD is less, it will help in reduction in material and cost for the client also saving of steel.
- After this the 2 D structure is translated and changed into 3 D for calculation of actual effect of wind. In many case incorporating C and D direction loading of wing stabilize the structure and help designers to optimize the structure more efficiently.
- Translation is done keeping bay length constant. If bay length changes all loading properties will be changed.
- After incorporating all loading and codal properties in design section Utility ratio is checked and try to maintain UR at 90%. Percentage describe that this much section is getting utilised by the action of force.
- Utility ratio is ratio describing the load and moment acting on the section to the Moment / Force capacity of section.

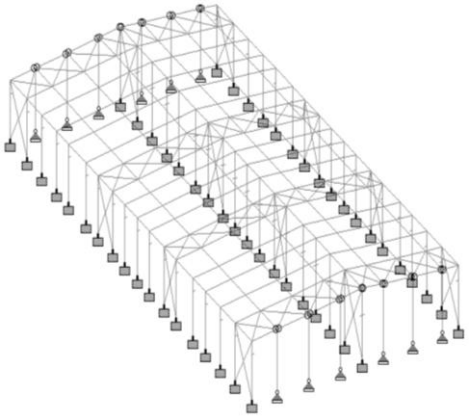


FIG.4 : STRUCTURE AFTER MODELLING

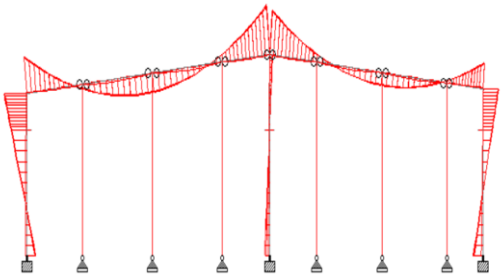
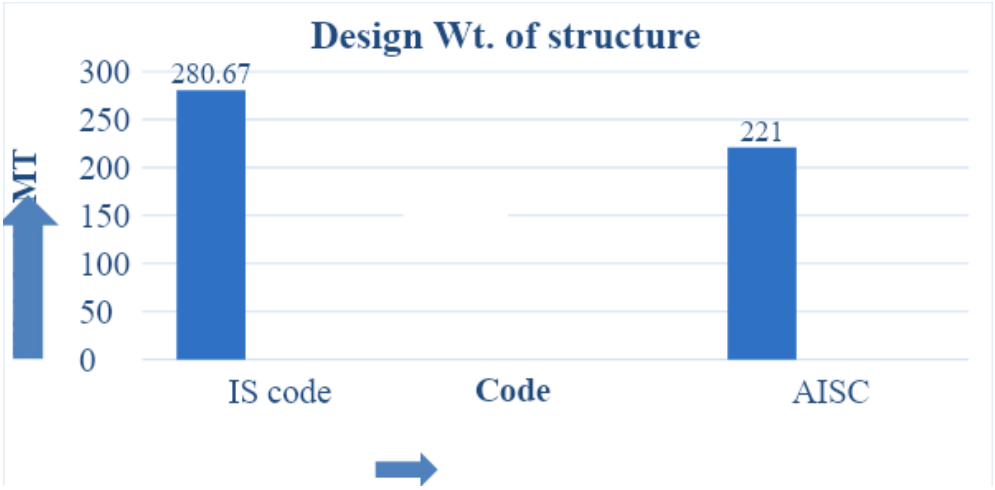
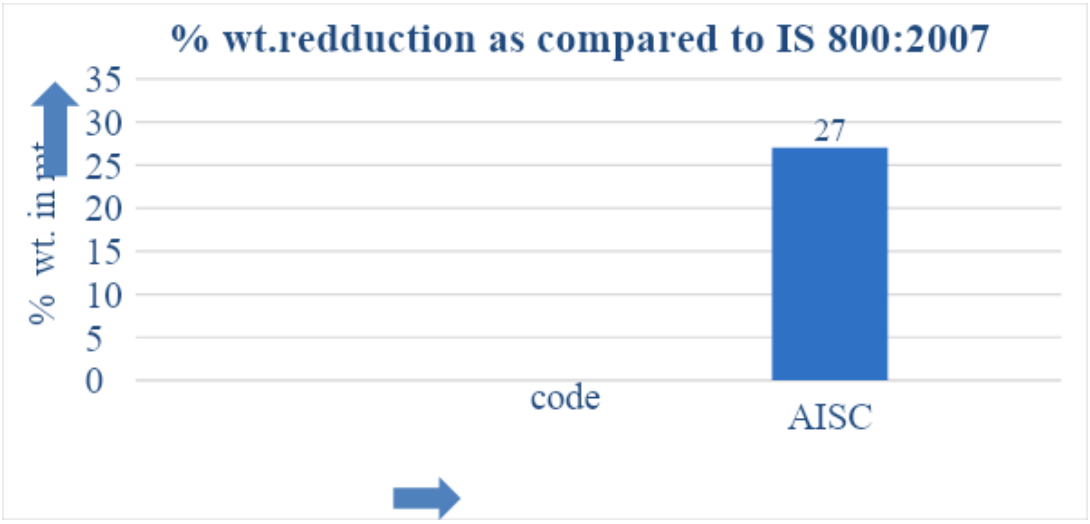


FIG.4 BMD

V. Result





VI. Conclusion

- As it is seen in the present work, the weight of steel can be reduced to 27% as per AISC compare to IS for industrial building , providing same load
- It is also observed that the weight of PEB depends on the Bay Spacing, with the increase in Bay Spacing up to certain spacing, the weight reduces and further more increase makes the weight heavier.
- One of the main reason to increase in weight in IS 800:2007 compared to IS AISC is "Serviceability Criteria". Deflection limits by IS code are higher than deflection limits by AISC.
- Reason for higher wt. in IS 800-2007 compared to AISC is limiting ratios of the sections (Table 2 of IS800-2007).

- Live load is 0.75 KN/m2 in IS code & whereas it is 0.57 KN/m2 in AISC. Thus, concluded that loading as per Indian codes is greater than AISC code.
- The main difference between the Indian Code (IS800:2007) to the other equivalent American Codes is seen in the classification of the cross-section of the steel member. According to the Indian code, the classes of section considered for design are Plastic, Compact and Semi- compact, slender cross-section. As it is familiar that most of the 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 used doesn't satisfy the codal provisions of IS 800: 2007.
- It was observed in industries most of the projects done with AISC. Reasons to preferring AISC Code are IS 800:2007 has not considered slender sections which are often encountered in cold formed thin sections, because there is another code IS 801 for this. Hence people using cold formed sections cannot use IS 800.May be that is the reason people are using AISC code &the main reason to use the AISC code for PEB structures is due to the fact that it leads to an economical structural solution as compared to the Indian Code.
- It is found by observations that the crane Impact load allowance is similar in case of vertical loads although in case of horizontal loads (surge, barking loads) the impact allowance is greater in AISC compared to IS codes.
- To Summarise "Pre-Engineered Building Construction" carried out as per AISC code gives the end users a much more economical, efficient and a much better solutions for long span structures where large column free areas are needed

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