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Comparison of Steel Frame using Rolled and PEB Sections for Comparison of Weight, Cost and Time

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***Abstract*: This paper presents a comparison of steel frame using rolled and PEB sections for comparison of weight, cost and time.**

***Keywords*: Steel frame, PEB section**

1. Introduction

Building and house are oldest construction practice of humans. The construction technology has advanced. Since the beginning from primitive to the present concept of modern home building. The present construction methodology of structures calls for the best aesthetic look, good quality & faster construction, cost-effective & innovative solution. A recent survey by the Metal Building Associations (MBMA) reveals that about 60% of non-residential low rises buildings in USA are pre-engineered buildings. Even though PEB systems are largely used in industrial and many other non-residential construction world-wide, it is comparatively a new concept in India. These concepts were introduced to the Indian markets lately in the late 1990's with the rise of the economy and a number of multinational setting up their projects. The market potential of PEB's is 1.2 million tons per annum. The industry is growing at the compound rate of 25 to 30 %.

Pre-fabricated building came into existence in 1960. It had ceiling, floor, frame etc. These parts together make the complete building. This made construction very faster & easier. Steel buildings are used in various applications and their demand is increasing extensively. There are mainly two categories in steel buildings-

1) Conventional Steel Building [CSB]
2) Pre-Engineered Building [PEB]

Conventional Steel Building [CSB]: In today's world, steel is bringing elegance, artistry and is functioning in endless ways contributing to new solutions for the construction of formidable structures, which were once not thinkable. Steel offers speedy construction right from the start. Due to its important characteristics like ductility, flexibility etc., steel has been widely used in the construction industry. It bends under the application of heavy loads rather than undergoing crushing and crumbling. Due to its strength, low rate, stability, flexibility including recyclability, it makes a very great choice to use steel in construction. It has been notified that steel has some reserve strength in its characteristics. The conventional steel buildings are stable. Mainly hot-rolled structural members are used in CS buildings. Here the members are fabricated in factories or workshops and then transported to the erection site. The changes are possible during the erection by welding and cutting process. Normally trusses are used in this system. Pre-Engineered Building [PEB]: These are produced in the plant itself. Here, according to the requirements of customer the manufacturing of the members is carried out. The components are made in completely fabricated condition for transportation. These are then transported to the site and then the erection process starts. The manufacturing process doesn't take place at the site. The pre-engineered buildings are constructed for office, shop fronts, ware houses etc. The extra amount of steel is avoided because the sections are fabricated, tapered according to the bending moment diagram.

Components of PEBs The pre-engineered-building is made up of the following components,

- Primary Components
- Secondary Components
- Accessories

A. Primary Components

- *Main Frame:* It generally includes the main components of the building. It includes tapered columns and rafters (also known as built-up I sections). These tapered sections are manufactured where the webs are fillet welded to flanges. Then the splice plates are connected to the ends of tapered members. The PEB frame is then raised by connecting the members by the use of bolts. The columns can be either tapered or of uniform depth. The webs are connected to the flanges by continuous fillet welding. The base plates, splices, stiffeners etc. are welded at factory on the structural members.
- *Columns:* Their main function is transferring the vertical loads to the foundation. Some part of lateral load is transferred by the columns. Usually columns are made up of 'I' sections which are found less costly

than other section. Its depth goes on increasing from bottom to the top end of column. The prefabricated column is made of 'I-section' consisting of flanges and web connected to each other by welding.

- *Rafters:* These are the series of inclined members-(beams) which stretch from ridge to wall plate, eave and are generally designed to support the roof and to take the loads.
- Secondary Components: Girts and purlins form the secondary components which are used as a support system for walls and panels of roofs. The purlins are used on roofs and girts are used on walls. The main function of the secondary members is that it acts as struts which help in counter acting the part of loads which act on the building like wind and seismic loads and they provide lateral-bracings to the flanges in compression of the members of the main frame thereby increasing the capacity of the frame. The secondary components are pre galvanized or painted at factory with minimum of 35 microns of corrosion protection primer.

Accessories:

- Anchor Bolts
- Turbo Ventilator
- Walking Doors
- Aluminium Windows
- Sheeting

2. Literature review

Neha R. Kolate, Shipa Kewate (july 2015) made a comparative study between pre-engineered building and conventional steel building and observes that PEB has many advantages over CSB such as no maintenance and very superior strength, it is corrosion resistant and features a very attractive appearance and it is next high level technology innovation and better product over conventional material. PEB system is protected against non-uniform weathering. In this paper, author studied that many of the steel buildings are made in a traditional way by using conventional sections and this leads to be uneconomical and heavy structure and creates an opportunity for developing technology to get a better replacement and that is Pre-engineered building having better properties over conventional steel frames.

S.D. Charkha and Latesh S. Sanklecha (June 2014) found that constantly increase in cost of steel giving rise to an uneconomical construction practice which needs to be reduced using new innovative technology. There are reasons to choose PEB over CSB such as quality design, manufacturing, erection, low maintenance due to pre-painted sections, building can be dismantled and re-erected easily and future extension without much hassle is possible due to flexible bolted connection. Along with this PEB proves to be a better system because of its ability to span long distance as many other gable structures are limited to a span of about 100 ft. in cost effective manner. Mainly trusses are provided for larger span but significant design fabrication time is required. Based on above parameters author concluded that choosing PEB over CSB will reduce steel quantity which further reduces dead load and hence size of foundation is also reduced.

B K Raghu Prasad, Sunil Kumar, Amarnath K (September 2014): observes the reason behind PEB being so high in demand is due to speed of construction and good control over the quality and when talking about the cost, there are several parameters responsible for this such as span, bay spacing, gable inclination. In this paper, these` Variety of model have been analyzed by varying roof angles, span and bay spacing and keeping the load common for each model i.e. DL, EL, LL, and WL. Pre-engineered buildings are completely factory fabricated and assembled at site using bolted connection not like welding in conventional steel building. PEB uses hot rolled plated tapered sections for primary framing as required by the internal stresses hence using the steel in optimum quantity. and eliminating wastage of steel which further reduce self-weight of structure.

Jinsha M S, Linda Ann Mathew (July 2016) found that now a day's structures without column are desirable mainly for industries and Pre-engineered buildings fulfils this requirement. In this study, an attempt is made to achieve the economy in steel quantity in pre-engineered buildings by varying the bay spacing. Observation is done by considering models with different bay spacing designed for wind loads. Analysis and design is performed using the software STAAD Pro V8i. Concept of pre-engineered building is to reduce the quantity of excessive steel as per the internal stress distribution or say bending moment diagram of the frame. Weight of Pre-engineered building depends upon the bay spacing and in this analysis most suitable bay spacing in terms of cost is found by performing the above analysis. As a conclusion of whole study made author aims to achieve a most economical framing system.

C. M. Meera (June2013) 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. PEB has many advantage over conventional steel structures such as providing a standard fabricated section according to the optimum requirement. In this paper author carried out a comparative study of PEB and CSB on the basis of design and analysis of a typical frame. Design of conventional steel frame include selection of a suitable roof truss built up from standard hot rolled sections. Analysis for both the steel frame using different concept shows that there is about 30% reduction in steel consumption in Pre-engineered building as compared to conventional steel frame, hence PEB are lighter than CSB. In this way PEB proves to be more advantageous from CSB in as it is more economical, quality control, speed in construction, longer span, durability, standard designs, ease in expansion and erection

3. Modeling

The models of the Conventional Steel Building (CSB) and Pre-Engineered Building (PEB) are analysed and designed using StaadPro software. One model each for CSB and PEB was prepared.

Parameter:

- Total length - 36 m
- Total width - 30 m
- Clear height - 15 m
- Slope of roof - 11.80
- Single bay length - 6 m

4. Structural analysis and design

The loads taken for the analysis and design of the buildings are as follows-

- Dead Load (DL)
- Live Load (LL)
- Wind load 90^0 (pressure)
- Wind load 90^0 (suction)

Following are the load combinations used in the present study.

- (DL+LL)
- DL+ Wind load 90^0 (pressure)
- DL+ Wind load 90^0 (suction)

All the loads were worked out according to the IS codes and applied on the models and the analysis was carried out.

5. Results and discussion

Each of the two models was modelled and analysed using StaadPro 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,

- Self-weight of the Structure
- Cost of Construction
- Time of Construction

Each of these three parameters was worked out for both the models which are presented below in Table-1, Table-2 and Table-3 respectively. The weight of the connections was assumed as 12.5% of total weight for CSB model and 7.5% of total weight for PEB model. Steel Girts are designed for the wind speed of 150 km/hr. and the corresponding members were designed. Steel Girts are designed as cold formed sections versus hot rolled sections. The result are tabulated in table 1. Similarly comparing for the shed portal by using hot rolled and PEB design of sections the comparison are shown in the tables.

Total steel tonnage = 76500 kg. Total cost of structure including erection = 2983500+1026140+1147500 = Rs. 51,57,140/-

Total steel tonnage = 67310 kg. Total cost of structure including erection = 2625090+992650+1009650 = Rs. 4627390/-

Table 4
Time Comparison

S. No.	Structure	Procurement Time (Weeks)	Fabrication Time (Weeks)	Erection Time (Weeks)	Total Time (Weeks)
1	Rolled Sections	4	5	26	35
2	PEB	2	9	35	46

Table 5
Statistical Comparison

S. No.	Structure	Weight (kg)	Procurement Cost (Rs.)	Fabrication Cost (Rs.)	Erection Cost (Rs.)
1	Rolled Sections	76500	2983500	1026140	1147500
2	PEB	67310	2625090	992650	1009650

Table 1
Cost details

Sr. No.	Sections Size	Weight	Procurement Cost	Fabrication Cost
1	ISMC200	50,041 Kg	39x50041=Rs. 19,51,600	Rs. 13/kg, 50041x13=6,50,533
2	Z200x2.4	15,708 Kg	59x15708=Rs. 9,26,800	Rs. 13/Kg 15708x13=2,04,204

Table 2
Cost details

Sr. No.	Sections Size	Weight (kg)	Procurement Cost (Rs.)	Fabrication Cost (Rs.)	Erection Cost (Rs)
1	ISMB600	52180	52180x39=2035020	52180x13=678340	52180x15=782700
2	ISA75X75X6	3430	3430x39=133770	3430x13=44590	3430x15=51450
3	ISA90X90X6	5070	5070x39=197730	5070x13=65910	5070x15=76050
4	Plate 8 &10thk	15820	15820x39=616980	15820x15=237300	15820x15=237300
	TOTAL	76500	2983500	1026140	1147500

Table 3
Cost details

Sr. No.	Sections Size	Weight (kg)	Procurement Cost (Rs)	Fabrication Cost (Rs)	Erection Cost (Rs)
1	Plate 25 Thk	10560	10560x39=411840	10560x15=158400	10560x15=158400
2	Plate 20 Thk	9140	9140x39=356460	9140x15=137100	9140x15=137100
3	Plate 12 Thk	20610	20610x39=803790	20610x15=309150	20610x15=309150
4	Plate 10 Thk	18500	18500x39=721500	18500x15=277500	18500x15=277500
5	ISA75X75X6	3430	3430x39=133770	3430x13=44590	3430x15=51450
6	ISA90X90X6	5070	5070x39=197730	5070x13=65910	5070x15=76050
	TOTAL	67310	2625090	992650	1009650

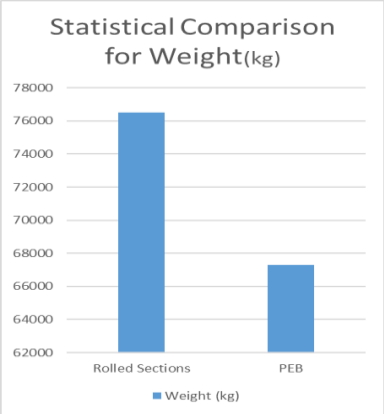

Fig. 1. Statistical comparison for weight

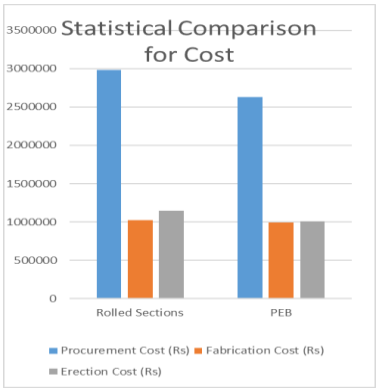

Fig. 2. Statistical comparison for cost

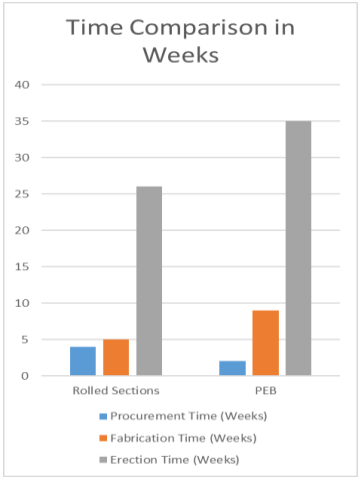

Fig. 3. Time comparison in weeks

6. Conclusion

Following conclusions can be drawn from the present study,

- The study of Self-Weight of the models showed that the Self-Weight for PEB was lower than CSB for the same geometry. With reduction in Self-Weight, the loads and hence the forces on the PEB will be relatively lesser, which decreases the effective sizes of the structural members.
- The study of Cost of Construction of the models showed that PEB structures are economical since the effective sizes of the structural members in PEB structures are lesser than CSB structures. Hence, the quantity of steel required for PEB structures will be lower than the CSB structures. It was seen that there was about 11% saving in cost for PEB compared to CSB.
- The study of Time of Construction of the models showed that CSB structures can be constructed in a lesser time compared to the PEB structures for the same geometry. On an average, the CSB structures can be constructed in about 25% lesser time duration than PEB structures.
- It is also seen 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 increase makes the weight heavier.
- Pre-engineered building concept forms a unique position in the construction industry in view of their being ideally suited to the needs of modern Engineering Industry. It would be the only solution for large industrial enclosures having thermal and acoustical features. The major advantage of PE building is the high speed of design and construction for buildings of various categories.

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