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Advantages of Pre-Engineered Building over Conventional Building

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Abstract: ***In these days, the cost and time of construction is in more priority for the client with the large working area for various uses. For the economically and minimum loss of material, pre-engineered building system (PEBs) has many advantage, because it gives more column free space at low cost. Pre-engineered metal buildings are more reliable for various uses like complex industrial facilities, warehouses and distributioncenters, stock-house, shopping malls, resort, motor court, office, cabin, service complex, aircraft-hanger, athletics and fun stadium, study places, temples, hospitals, and any types of industrial structures. In the pre-engineered metal building system, the rigid frame consists of slab, wall are connected with primary member (beam and column). This frame can spanlarge spacing without any intermediate columns. The frameswidths are spaced at spacing between 15 m to 60 m and span can increase with column-free up to 300 m in proposed building structures. Therefore in this paper, an attempt has been made to analyze a pre-engineered metal building with a span of 40 m with the help of finite element based software ETABS (2013). For the comparison, for the same span of 40 m length a conventional steel building is analyzed in same software. The results were found from both analysis indicated the pre-engineered steel building is economic with the conventional steel building as well as stablealso.***

Keywords: ***Pre-engineered metal building, Conventional building, ETAB***

I. INTRODUCTION

The efficient and economic construction over conventional method of building construction Pre-engineered building (PEB) system were induced. the concept of pre-engineered steel metal building systemmade over all structural component like, beam, column, purlin, rafter as well as roof wall sheeting, primary members, secondary members, connected with each other and different structural components [Ref.8 and 9]. Thistechnology is a built, structure with precast and prefabricated members which are erected at site. Pre-engineered steel buildings are mainly low height buildings which are useful for residential building, show-rooms, shopping malls etc.[Ref.2].The PEBs system are very economical and faster to application for the low height buildings, with this system the construction time is reduced about half than conventional Steel building.

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Although pre- engineered steel building are widely used for any industrial purpose building or non-residential building construction globalized, In India, it is now new structural concept.[Ref.3and4].Now a days, large spaced area is the uttermost requirement for any type of industry and with the approach of computer software's it is now easily possible.

With the improvement in technology, computer software's have contributed immensely to the enhancement of quality of life through new researches. Pre-engineered building (PEB) is one of such revolution. "Pre-engineered buildings" are fully fabricated in the factory in the robotic manner after designing, then transported to the site directly in completely knocked down (CKD) condition and all components are assembled and erected with connection like, nut-bolts, hence it reducing the time of completion[Ref.1 and 7].

With increased significance on the green buildings ensuring sustainable construction, the PEB structures are designed with a high proportion of recycled content making them lighter in weight by about 30% to 40% than the conventional steel buildings (CSB). Since the PEB system based construction technique is contributing the ultimate modernization with high-technology and faster methods of construction ensuring efficient, cost effectiveness and speedy completion of projects [Ref.3, 4 and 6]. As a result today the PEB system is the most favored choice among the consultant, architects, builders, developers, and industrialists.

A. PEBs Structural Members Concept

Pre-engineered buildings use a prearranged supply of raw materials in lighter weight that has verified over time to satisfy a broad range of structural and unique esthetic design requirements. This flexibility allows PEBs to fulfill and almost unlimited range of building configurations, custom design, requirements and applications. The pre-engineered steel building is a building shell utilizing three distinct product categories as:

Built-up "I" shaped primary structural framing members(columns and rafters) Refer fig. 1 Cold-formed "Z" and "C" shaped secondary structural members (roof purlin, eave struts and wall grits) Refer fig. 2Roll formed profiled sheeting (roof and wall panels) Refer fig 3

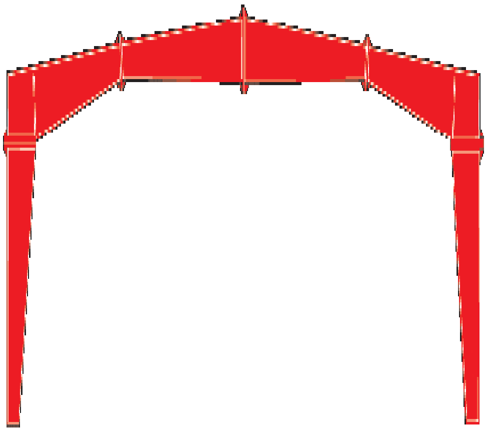

Fig.1 Built-up "I" shaped primary structural framing members.

Fig.2 cold-formed "Z" and "C"

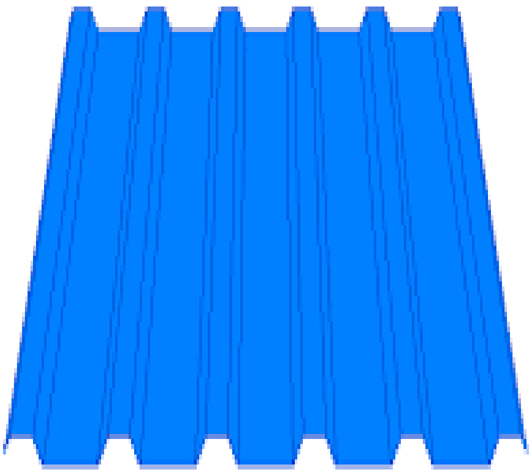

Fig.3 Roll-formed profiled sheeting Shaped secondary member

B. Comparison Between Pre-Engineered Building System And Conventional Building System (Table 1 and fig.4)

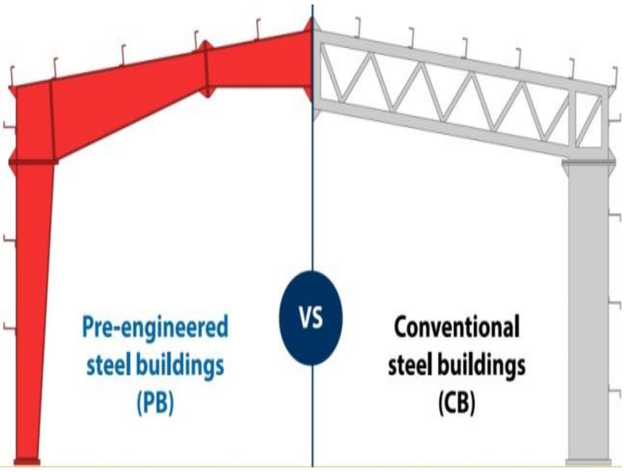

Fig.4 Difference between PEBs and Conventional steel building

Table 1: Comparison between PEBs and Conventional steel building

Function Type	**Pre-engineered Building system(PEBs)**	**Conventionalbuilding system (CSBs)**
1.Construction cost and time	Cost and time of construction are calculated based upon extensive experience with similar building. 30% cost is reduced in overall.	They are 20% more expensive than PEBs. Building construction cost and time are not estimated accurately in advance.
2.Building weight	In PEBs, Primary framing member are tapered, so the system is about 30 to 40% advantages for the main rigid frame than conventional hot rolled section as primary member	Section and members have constant cross-section, are selected from standard hot rolled I-section as the Primary steel members so they are heavier than what is actually required
3.Delivery to site	Approx.42 to 56 days	Approx. 140 to 182 days.
4.Foundation	designis Simple and easily constructed with light weight foundation	Extensive, foundation required is heavy in weight

5.Eartquake resistance	The less-weight flexible frames produced higher resistance seismic forces.	Do not perform well in seismic zones because of heavy in weight and rigid
6.Architectural appearance	Aesthetic architectural design and appearancecan be achieved at low cost.	Architectural design required for each project in the consideration of esthetic appearance.
7.Source of material and component	Building is supplied complete with cladding and all accessories, from one single source	Many source of supply is required to co-ordinates suppliers and contractors.
8.Quality control	Designed and fabricated at single in-house unit with strict quality control	It is not possible to control the quality because there are many sources and many manufactures.

II. PROCESS OF MODELLING

In the present attempted a three dimensional single storey industrial frame havingsymmetry along X and Y direction and rectangle (110m X 40m) in shape is considered (Table 2: Description of building**)**. Steel frame having tapered "I" section is used in pre-engineered frame model

(Table 3:Pre-engineered building members)and standard hot rolled "I section" constant cross section are used in conventional steel frame model (Table 4: Conventional steel building members).For the bracings (X-type) 25mm diameter of steel rod is used in both of the model. The structure having fixed support and all joints designed asperfectly rigid.IS: 875-1987 (Parts – I to V),IS: 1893-2002, andIS: 800-2007 are used in the process of calculating forces and load (national codes).

Table 2:Description of building

Location	Ujjain
Length	110m
Width	40
Eave height	9
Seismic zone	II
Wind speed	39m/s
Wind terrain category	2
Wind class	C
Life span	50years
Slope of roof	1 in 10
Soil type	Medium
Importance factor	1.5
Response reduction factor	5

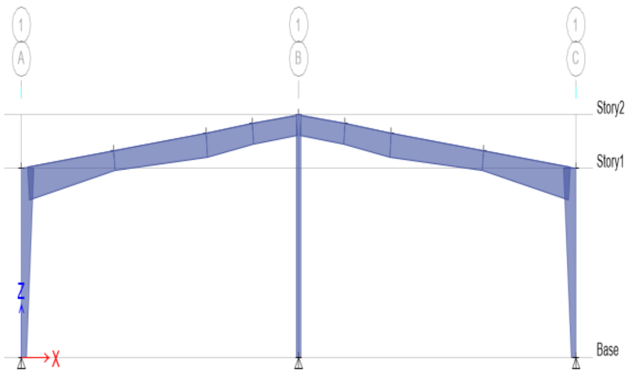

Fig.5 Pre-engineered building with tapered member

Table3:Pre-engineered building members

S.no	Structural steel member	Section properties
1	Frame rafter 1(prismatic1200_750mm)	Tapered I section
2	Frame rafter2(prismatic750_900mm)	Tapered I section
3	Frame rafter3(prismatic900_750mm)	Tapered I section
4	Frame rafter4	I section 750mm
5	Frame purlin and gable end purlin	ISMC_350
6	End column(prismatic350_900mm)	Tapered I section
7	Centre column	ISMB350
8	Bracings (X-Type)	25mm dia of steel rod

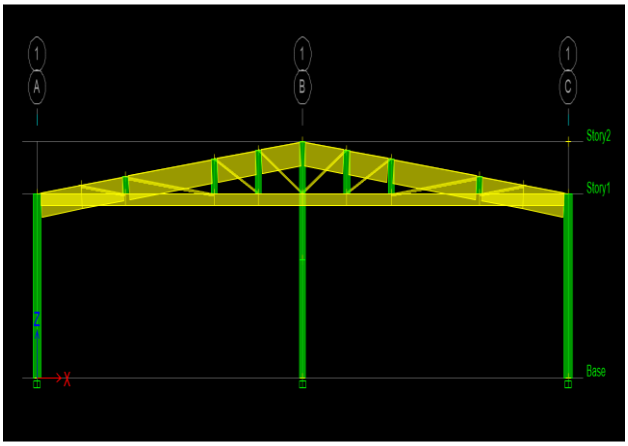

Fig.6 conventional steel building

Table 4: Conventional steel building members

S.no	Structural steel member	Section properties
1	Frame rafter	ISLB900
2	Purlin	ISLB500
3	End column	$ISWB600_2$
4	Centre column	ISWB450
5	Bracings (X-Type)	25x200mm Rec. steel Plate

LOAD COMBINATIONS

In the limit state design of steel structure, load combination istaken as per clause no. 6.3.1.1of IS 1893(Part I):2002 and IS800:2007.

(DL+LL)
(DL+WL/EL)
(DL+0.8LL+0.8WL/EL)
1.5(DL+LL)
1.5(DL+WL/EL)
(0.9DL+1.5WL/EL)
1.2(DL+LL)+0.6WL/EL
1.2(DL+LL+WL/EL)
(1.2DL+0.5LL+2.5EL)
(0.9DL+2.5EL)
1.7 (DL+LL)
1.3 (DL+LL +EL_X)
1.3 (DL+ LL –EL_X)
1.3 (DL+ LL +EL_Y)
1.3 (DL+ LL –EL_Y)
1.7 (DL+EL_X)
1.7 (DL–EL_X)
1.7 (DL+EL_Y)
1.7 (DL–EL_Y)
(DL denotes (Dead Load) and EL_X/EL_Y denotes Earthquake load in X-direction and Y-direction

WL, wind load respectively

III. RESULTS AND DISCUSSION

Table5 and table6 shows the design weight of structure and total steel take off and reduction of steel in pre-engineered building(**Table 6:Pre-engineered building steel take off)**comparison with conventional steel building(Table 5: Conventional building steel take off).

Table 5:Conventional building steel take off

Structure Member	Cross Section Area (cm^2)	Weight Of Single Member (kg)	Number Of Member	Cumulative Weight (kg)
Frame Rafter1	335.5	1764.084	44	77619.726
Frame Rafter2	335.5	882.174	44	38815.656
Frame purlin	95.5	749.58	90	67462.55
Outer frame column	184.9	1015.902	26	26413.452
Center frame column	101.2	714.891	13	9293.583
Gable end column1	101.2	579.856	4	2319.424
Gable end column2	101.2	659.288	4	2637.154
Gable end purlin1	95.5	374.791	6	2248.751
Gable end purlin2	95.5	378.142	4	1512.570
Gable end purlin3	95.5	375.631	4	1502.526
Gable end rafter 1	95.5	451.991	4	1807.966
Gable end rafter 2	95.5	527.324	8	4218.598
Bracings	50	-	-	27022.68
Truss	83.1+21.1	1831.691	22	40297.20
Total weight (kg)		311879.68		

Table 6:Pre-engineered building steel take off

Structure Member	Cross Section Area (cm^2)	Weight Of Single Member (kg)	Number Of Member	Cumulative Weight (Kg)
Tapered rafter 1	295.25	1552.447	22	34153.836
Tapered rafter 2	275.75	1449.914	22	31898.121
Tapered rafter 3	275.75	725.065	22	15951.441
Tapered rafter 4	266	699.428	22	15387.428

Frame purlin	53.7	421.49	90	37934.444
Tapered outer column	151.14	830.413	26	21590.750

Center column	89.4	631.534	13	8209.946
Gable end rafter1	266	1258.950	4	5035.802
Gable end rafter	266	1468.779	8	11750.233
Gable end coulmn1	89.4	512.24	4	2048.97
Gable end coulmn2	89.4	582.414	4	2329.659
Gable end purlin1	53.7	210.746	6	1264.481
Gable end purlin2	53.7	212.630	4	850.523
Gable end purlin3	53.7	211.218	4	844.875
Bracings	4.9	-	-	2647.901
Total weight (kg)				191898.41

The structural design and comparative analysis of a industrial steel frame has been done with very effective and user friendly software ETAB. A typical steel frame is analysed with both the concept (PEBs and CSB) in all structural and loading criteria and the results were obtained as following in table7.

Table 7: ETAB Software analysis results comparison

Sl. No.	Structural description	PEBs	CSBs
1	Total steel take off (kg)	191898.41	311879.68
2	Maximum deflection (mm)	5.2	9.4
3	Maximum shear force (kN)	463.23	546.41
4	Maximum moment (kN-m)	160.45	204.71
5	Axial force (kN)	387.78	542.43
6	Maximum storey force (kN)	13445.72	16762.54
7	Maximum column force (kN)	342.94	573.88

IV. CONCLUSION

Basically in pre- engineered building the sections used are built up sections and built-up member are specified by the designer when the desired properties or configuration cannot be obtained in a single hot-rolled section. In this pre-engineered steel building 38.47% steel weight is reduced. Built-up section can be bolted or Welded, in general it is less expensive because much less handling is required in the shop and because of more efficient utilization ofmaterial. The clean lines of welded members also produce a better appearance.

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