

Comparison of Structural Elements of a Pre-Engineered Building in Two Different Wind Zone Area

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Abstract - Steel industry is growing rapidly in almost all the parts of the world. The use of steel structure is not only economical but also eco friendly. The Pre-Engineered steel building system construction has great advantages to the single storey buildings, practical and efficient alternative to conventional buildings. Pre-Engineered Building (PEB) creates and maintains in real time multi-dimensional data rich views through a project support which is implemented by STAAD.Pro software packages for design and engineering. This paper involves the comparison of dimensions of the structural elements of a PEB built up in two different wind zone area (Hyderabad and Bangalore). Analysis is done as per codal provisions and plan is drafted using AutoCAD.

Key Words: Pre-Engineered Building, STAAD.Pro, AutoCAD

1. INTRODUCTION

Pre-Engineered Buildings (PEB) are the buildings which are engineered at a factory and assembled at site. Usually PEBs are steel structures. Built-up sections are fabricated at the factory to exact size, transported to site and assembled at site with bolted connections. This type of structural concept is generally used to build industrial buildings, metro stations, warehouses, etc. The adoptability of PEB in the place of conventional steel building design concept resulted in many advantages, including economy and easier fabrication. These type of building structure can be finished internally to serve any functions that is actually help in low rise building design. Steel structures also have much better strength to weight ratios than RCC and they can also be reused after dismantling. PEB can be shifted and/or expanded as per the requirements in future. With the improvement in technology, computer software's have contributed immensely to the enhancement of quality of life through new researches. PEB is one such revolution.

1.1 Components of PEB

Pre-Engineered Buildings consists of different steel structural member which are as follows:

- Primary frame – Primary framing of a PEB is an assembly of built-up I shaped steel members and that framing consist trusses or castellated beams

- Secondary structural elements – It is actually cold formed members, which can be in different shapes like 'Z', 'C', etc in general known as purlins
- Roof & wall panels – Tin shades and curtain wall made of glass & roll-formed steel sheets usually comes in this category
- Sandwich panels – Sandwich panel is made of three layers, in which a non-aluminum core is inserted between two aluminum sheet
- Other accessories – Mezzanine floors, bolts, insulation, etc

1.2 Advantages of PEB

There are many advantages of Pre-Engineered Buildings which are as follows:

- Quality control is the main advantage as all the structural member are engineered beforehand, standards of different codes also taken into consideration and these components are made in factory under the supervision of quality control Engineer
- Lower cost due to the saving in design, manufacturing and on site erection cost
- Minimizing time of construction due to the use of software for design of the structural components
- Low maintenance due to use of standard quality of paints over steel members, which increases the ability to withstand and finally the maintenance cost will be low as compare to conventional building
- Quick erection, as all the members are pre manufactured and skilled labor is used for connections of different components
- Warranty on PEB, mostly warranty period of 20 years given by manufactures for PEB

1.3 Disadvantages of PEB

Although PEB have many advantages in the field of industrial structure but still there are some demerits of Pre-Engineered Buildings, which are as follows:

- Rusting / corrosion sensitive, as if the quality of steel used or paint used for coating of steel members is not of good quality, that it can damage the structure and thus reduces the life of structure

- Insulation cost as insulating the building to an agreeable benchmark will furthermore add to the construction costs
- Appearance, steel sections can be unattractive when left exposed

1.4 PEB by STAAD.Pro

STAAD.Pro software has been used in order to analyze and design Pre-Engineered Building structures. STAAD.Pro is the most popular structural engineering software product for 3D model generation, analysis and multi-material design. It has an intuitive, user friendly and design software products. It is utilized for analyzing and designing practically for the PEB. It implements the Bending Moment, Axial Forces, Shear Forces, Torsion and Beam Stresses.

2. LITERATURE REVIEW

2.1 C.M.Meera (June 2013)

C.M.Meera (June 2013) observes that, Pre-Engineered Building (PEB) concept is a new conception of single storey industrial building construction. This methodology is versatile not only due to its quality pre-designing and prefabrication, but also due to its light weight and economical construction. The concept includes the technique of providing the best possible section according to the optimum requirement. This concept has many advantages over the Conventional Steel Building (CSB) concept of buildings with roof truss. This paper is a comparative study of PEB Concept and CSB concept.

Pre-Engineered Building concept have wide applications including warehouses, factories, offices, workshops, gas stations, showrooms, vehicle parking sheds, aircraft hangars, metro stations, schools, recreational buildings, indoor stadium roofs, outdoor stadium canopies, railway platform shelters, bridges, auditoriums, etc, explicitly as in. PEB structures can also be designed as relocatable structures. Steel is a material which has high strength per unit mass. Hence it is used in construction of structures with large column-free space.

An industrial warehouse is a storage building and is usually characterized as single storey steel structures with or without mezzanine floors. The enclosures of these structures may be brick masonry, concrete walls or GI sheet coverings. The walls are generally non bearing but sufficiently strong enough to withstand lateral forces caused by wind or earthquake.

The designing of industrial warehouse includes designing of the structural elements including principal rafter or roof truss, column and column base, purlins, sag rods, tie-rods, gantry girder, bracings, etc. A combination of standard hot-rolled sections, cold-formed sections, profiled

sheets, steel rods, etc. are used for the construction of industrial steel structures.

Industrial Buildings can be categorized as Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB), according to the design concepts. The paper starts with the discussion of methods adopted in the study. Introduction to PEB systems and CSB systems are then described followed by the details of case study. Loads and the load combinations adopted for carrying out the analysis of the structure is well defined in the further portions. A section depicting the importance of the software used and the software procedure followed is included. Final portion explains the results obtained from the software analysis of the case study and the inferences from the literature studies. The paper aims at developing a perception of the design concepts of PEB structures and its advantages over CSB structures.

2.2 JATIN D.THAKRA R, Prof. P.G.PATEL (SEP 2013)

Jatin D.Thakra R, Prof. P.G.Patel (Sep 2013) observes that, Pre-engineered building are steel building wherein the framing members and other components are fully fabricated in the factory after designing and brought to the site for assembly, mainly by nut-bolts, thereby resulting into a steel structure of high quality and precision. In conventional steel construction, we have site welding involved, which is not the case in PEB using nut-bolt mechanism. These structures use hot rolled tapered sections for primary framing and cold rolled sections (generally Z and C sections) for secondary framing as per the internal stress requirements, thus reducing wastage of steel and the self-weight of the structure and hence lighter foundations.

International codes are referred in their design as per the MBMA (Metal Building Manufacturers Association) standards which are more flexible allowing the use of built-up sections of minimum 3.5 mm thickness against 6 mm as minimum criteria in conventional steel sections. There is use of steel of high strength which prominently speaks about greater strength with judicious use of steel as a result of tapered profile. The tapered section concept was first adopted in U.S.A keeping in mind the bending diagram. At locations of high bending moment values, greater depth is used while less moment encourages the use of lesser depths. Further unlike the conventional steel sections, where moment of inertia (I) remains constant, it is not as in case of PEB due to varying depths.

2.3 G.SAI KIRAN, A.KAILASA RAO, R.PRADEEP KUMAR (AUG 2014)

G.Sai Kiran, A.Kailasa Rao, R.Pradeep Kumar (Aug 2014) observes that, 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 (CSB) design concept resulted in many advantages, including economy and easier fabrication. In this study, an industrial structure (warehouse) is analyzed and designed according to the Indian standards, IS 800 : 1984, IS 800 : 2007 and also by referring MBMA-96 and AISC-89. In this study, a structure with length 187 m, width 40 m, with clear height 8 m and having R-slope 1:10, is considered to carry out analysis and design for 2D frames. The economy of the structure is discussed in terms of its weight comparison, between Indian codes (IS 800 : 1987, IS 800 : 2007) & American code (MBMA-96) & between Indian codes (IS 800 : 1987, IS 800 : 2007).

2.4 S.D.CHARKHA, LATESH S (JUNE 2014)

S.D.Charkha, Latesh S (June 2014) observes that, using of PEB instead of CSB may be reducing the steel quantity. Reduction in the steel quantity definitely reducing the dead load. Reduction in the dead load reducing the size of foundation. Using of PEB increase the aesthetic view of structure.

2.5 U.D.DABHADEL, N.A.HEDAHO, DR.L.M.GUPTA, DR.G.N (2009)

U.D.Dabhadel, N.A.Hedao, Dr.L.M.Gupta, Dr.G.N (2009) observes that, the time savings of 55.3% is achieved due to use of steel framed composite floor construction rather than precast framed with precast concrete floor and 14.3% time than that of steel framed with precast concrete slab.

The construction of steel framed composite floor building saves time, which leads to an overall savings in net cost. The direct cost required for steel framed with composite floor is 23.10%, higher than precast frame with precast concrete floor and only 0.52% higher than steel framed with precast concrete floor.

Considering time related savings, the net cost required for steel framed with composite floor is 12.99%, more than precast frame with precast concrete floor and 2.32% less than steel frame with precast floor. The steel framed with precast concrete floor saves 35.83% construction time than precast frame with precast concrete floor, which required extra 22.7% of direct cost and 14.96% of net cost. However, study is restricted to structural frame only. If other items are also considered in the study like excavation work, finishing items, services, cladding, etc.

3. PLANNING OF STRUCTURE

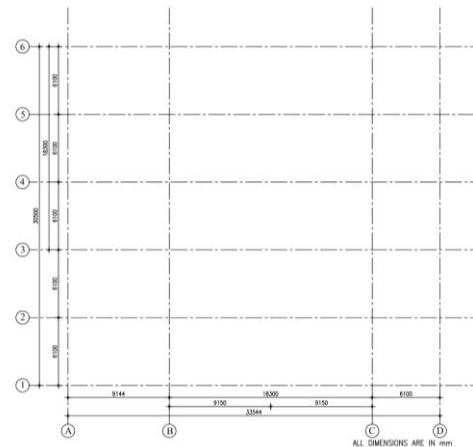


Fig - 1 Centre line drawing

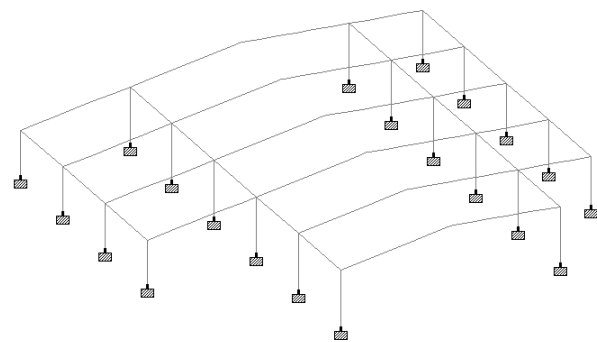


Fig - 2 Frame STAAD Modeling

4. DIMENSIONAL COMPARISON

4.1 PITCHED ROOF

4.1.1 Columns

	Hyderabad	Bangalore
Depth of section at top node, $D_t(H)$	= 450 mm	450 mm
Depth of section at bottom node, $D_b(H)$	= 350 mm	250 mm
Thickness of web, t_w	= 8 mm	8 mm
Width of flange, b_f	= 210 mm	160 mm
Thickness of flange, t_f	= 12 mm	12 mm

4.1.2 Back Columns

Hyderabad	Bangalore
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Depth of section at top node, $D_t(H)$	=	450 mm	450 mm	Width of flange, b_f	=	150 mm	150 mm
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Depth of section at bottom node, $D_b(H)$	=	350 mm	300 mm	Thickness of flange, t_f	=	8 mm	8 mm
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Thickness of web, t_w	=	8 mm	8 mm
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4.1.6 Rafter 04 to 07

Hyderabad Bangalore

Width of flange, b_f	=	220 mm	200 mm
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Depth of section at top node, $D_t(H)$	=	290 mm	290 mm
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Thickness of flange, t_f	=	13 mm	12 mm
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Depth of section at bottom node, $D_b(H)$	=	290 mm	290 mm
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4.1.3 Rafter 01

Hyderabad Bangalore

Thickness of web, t_w	=	6 mm	6 mm
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Depth of section at top node, $D_t(H)$	=	410 mm	350 mm
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Width of flange, b_f	=	150 mm	150 mm
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Depth of section at bottom node, $D_b(H)$	=	370 mm	330 mm
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Thickness of flange, t_f	=	6 mm	6 mm
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Thickness of web, t_w	=	6 mm	6 mm
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4.2 LEFT MONOSLOPE ROOF

4.2.1 Columns

Hyderabad Bangalore

Width of flange, b_f	=	150 mm	160 mm
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Depth of section at top node, $D_t(H)$	=	250 mm	225 mm
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Thickness of flange, t_f	=	8 mm	8 mm
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4.1.4 Rafter 02

Hyderabad Bangalore

Depth of section at bottom node, $D_b(H)$	=	200 mm	225 mm
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Depth of section at top node, $D_t(H)$	=	370 mm	330 mm
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Thickness of web, t_w	=	6 mm	6 mm
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Depth of section at bottom node, $D_b(H)$	=	330 mm	310 mm
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Width of flange, b_f	=	130 mm	125 mm
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Thickness of web, t_w	=	6 mm	6 mm
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Thickness of flange, t_f	=	8 mm	8 mm
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4.2.2 Rafter 01

Hyderabad Bangalore

Width of flange, b_f	=	150 mm	150 mm
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Depth of section at top node, $D_t(H)$	=	390 mm	330 mm
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Thickness of flange, t_f	=	8 mm	8 mm
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4.1.5 Rafter 03

Hyderabad Bangalore

Depth of section at bottom node, $D_b(H)$	=	410 mm	350 mm
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Depth of section at top node, $D_t(H)$	=	330 mm	310 mm
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Thickness of web, t_w	=	6 mm	6 mm
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Depth of section at bottom node, $D_b(H)$	=	290 mm	290 mm
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Width of flange, b_f	=	150 mm	150 mm
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Thickness of web, t_w	=	6 mm	6 mm
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Thickness of flange, t_f	=	8 mm	8 mm
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4.2.3 Rafter 02

			Depth of section at top node, $D_t(H)$	=	310 mm	250 mm	
	Hyderabad	Bangalore	Depth of section at bottom node, $D_b(H)$	=	330 mm	270 mm	
Depth of section at top node, $D_t(H)$	=	370 mm	310 mm	Thickness of web, t_w	=	6 mm	6 mm
Depth of section at bottom node, $D_b(H)$	=	390 mm	330 mm	Width of flange, b_f	=	150 mm	150 mm
Thickness of web, t_w	=	6 mm	6 mm	Thickness of flange, t_f	=	6 mm	6 mm
Width of flange, b_f	=	150 mm	150 mm				

4.2.4 Rafter 03

	Hyderabad	Bangalore					
Depth of section at top node, $D_t(H)$	=	350 mm	290 mm	Depth of section at top node, $D_t(H)$	=	290 mm	230 mm
Depth of section at bottom node, $D_b(H)$	=	370 mm	310 mm	Depth of section at bottom node, $D_b(H)$	=	310 mm	250 mm
Thickness of web, t_w	=	6 mm	6 mm	Thickness of web, t_w	=	6 mm	6 mm
Width of flange, b_f	=	150 mm	150 mm	Width of flange, b_f	=	150 mm	150 mm
Thickness of flange, t_f	=	8 mm	8 mm	Thickness of flange, t_f	=	6 mm	6 mm

4.2.5 Rafter 04

	Hyderabad	Bangalore					
Depth of section at top node, $D_t(H)$	=	330 mm	270 mm	Depth of section at top node, $D_t(H)$	=	270 mm	210 mm
Depth of section at bottom node, $D_b(H)$	=	350 mm	290 mm	Depth of section at bottom node, $D_b(H)$	=	290 mm	230 mm
Thickness of web, t_w	=	6 mm	6 mm	Thickness of web, t_w	=	6 mm	6 mm
Width of flange, b_f	=	150 mm	150 mm	Width of flange, b_f	=	150 mm	150 mm
Thickness of flange, t_f	=	6 mm	6 mm	Thickness of flange, t_f	=	6 mm	6 mm

4.2.6 Rafter 05

	Hyderabad	Bangalore				
			Depth of section at top node, $D_t(H)$	=	250 mm	225 mm
			Depth of section at bottom node, $D_b(H)$	=	200 mm	225 mm

4.2.7 Rafter 06

	Hyderabad	Bangalore				
			Depth of section at top node, $D_t(H)$	=	290 mm	230 mm
			Depth of section at bottom node, $D_b(H)$	=	310 mm	250 mm
			Thickness of web, t_w	=	6 mm	6 mm
			Width of flange, b_f	=	150 mm	150 mm
			Thickness of flange, t_f	=	6 mm	6 mm

4.2.8 Rafter 07

	Hyderabad	Bangalore				
			Depth of section at top node, $D_t(H)$	=	270 mm	210 mm
			Depth of section at bottom node, $D_b(H)$	=	290 mm	230 mm
			Thickness of web, t_w	=	6 mm	6 mm
			Width of flange, b_f	=	150 mm	150 mm
			Thickness of flange, t_f	=	6 mm	6 mm

4.3 RIGHT MONOSLOPE ROOF

4.3.1 Columns

	Hyderabad	Bangalore				
			Depth of section at top node, $D_t(H)$	=	250 mm	225 mm
			Depth of section at bottom node, $D_b(H)$	=	200 mm	225 mm

Thickness of web, t_w = 6 mm 6 mm

Width of flange, b_f = 130 mm 125 mm

Thickness of flange, t_f = 8 mm 8 mm

4.3.2 Rafter 01

Hyderabad Bangalore

Depth of section at top node, $D_t(H)$ = 410 mm 350 mm

Depth of section at bottom node, $D_b(H)$ = 390 mm 310 mm

Thickness of web, t_w = 6 mm 6 mm

Width of flange, b_f = 150 mm 150 mm

Thickness of flange, t_f = 8 mm 8 mm

4.3.3 Rafter 02

Hyderabad Bangalore

Depth of section at top node, $D_t(H)$ = 390 mm 310 mm

Depth of section at bottom node, $D_b(H)$ = 370 mm 270 mm

Thickness of web, t_w = 6 mm 6 mm

Width of flange, b_f = 150 mm 150 mm

Thickness of flange, t_f = 8 mm 8 mm

4.3.4 Rafter 03

Hyderabad Bangalore

Depth of section at top node, $D_t(H)$ = 370 mm 270 mm

Depth of section at bottom node, $D_b(H)$ = 350 mm 230 mm

Thickness of web, t_w = 6 mm 6 mm

Width of flange, b_f = 150 mm 150 mm

Thickness of flange, t_f = 8 mm 8 mm

4.3.5 Rafter 04

Hyderabad Bangalore

Depth of section at top node, $D_t(H)$ = 350 mm 230 mm

Depth of section at bottom node, $D_b(H)$ = 330 mm 190 mm

Thickness of web, t_w = 6 mm 6 mm

Width of flange, b_f = 150 mm 150 mm

Thickness of flange, t_f = 6 mm 6 mm

5. AUTOCAD DRAWINGS

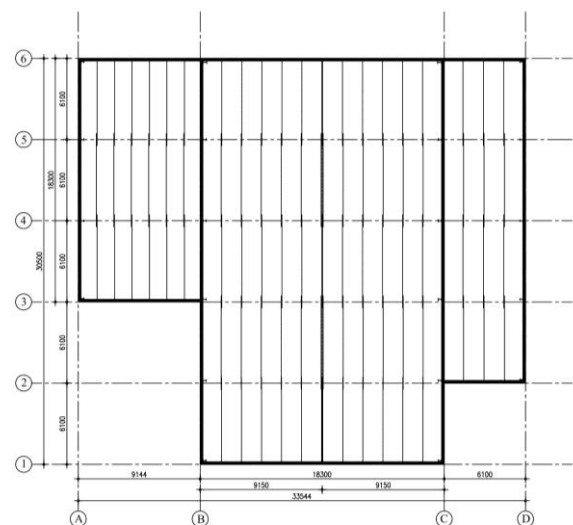


Fig - 3 Roof frame plan

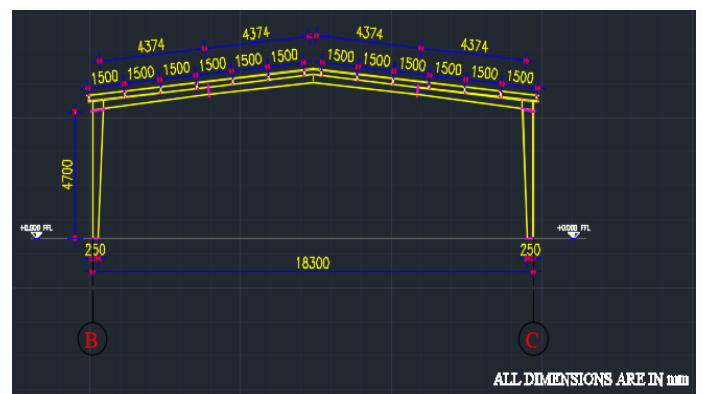


Fig - 4 Frame 1

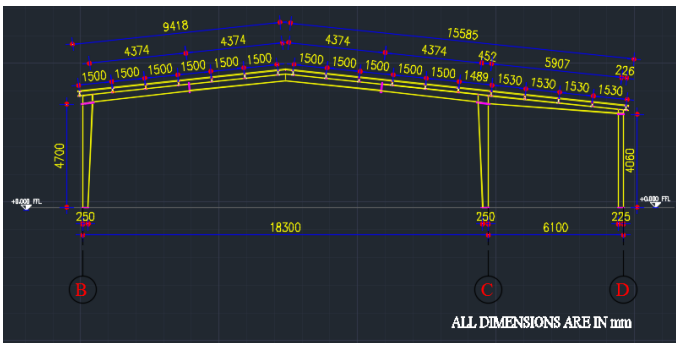


Fig - 5 Frame 2

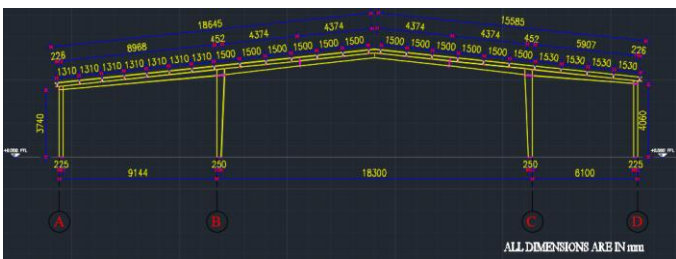


Fig - 6 Frame 3



Fig - 7 Frame 6

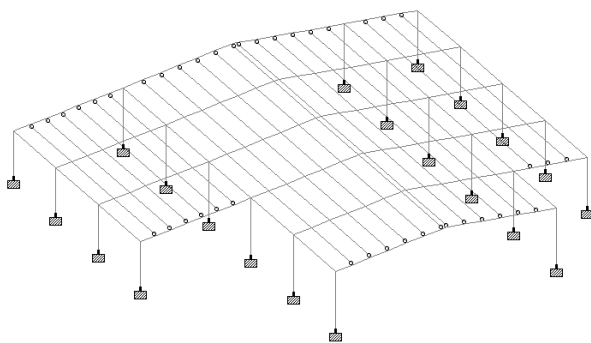


Fig - 8 STAAD Modeling

6. CONCLUSION

Steel is the basic material used for Pre-Engineered Building (PEB). By choosing steel to design a Pre-Engineered Building, it offers low cost, strength, durability, design flexibility, adaptability and recyclability. PEB is the best solution for longer span structures without interior column in between. In this thesis, dimensional comparison of structural elements of a PEB in two different wind zone area (Hyderabad and Bangalore) is done. To conclude, "Pre-Engineered Building construction gives the end users a much

more economical and better solution for long span structures where large column free areas are needed".

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