Comparative Study of Warehouse Structure in Pre Engineered Building with Conventional Steel Building

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Abstract— In present years, the concept of Pre-Engineered Building in creation format of structures has helped into optimizing a design. Steel industry sector is developing more hastily in almost throughout elements of the world. In a hazard of global warming the usage of steel structures is not only efficient but also sustainable at the time. In Pre-Engineered Buildings (PEB) steel structures (Pre-fabricated) time is being the maximum significant aspect is built in very short duration period. In any type of Industrial structures and Pre-Engineered Buildings (PEB) Maximum Span, Column free suitable structures are the most vital in fulfills this requirement at the aspect of decreased time and price in comparison to conventional structures. Here this is study is achieved by planning 3D frame of an Industrial Warehouse constructing the use of the thoughts and studying the frames using appropriate assessment and design software after due validation. In this research, an industrial structure warehouse is analyzed and designed according to the Indian standards (IS 800-2007) and additionally through referring American Standard (AISC LRFD). The various loads like dead, live, wind, seismic and snow loads according as per IS codes are considered for the present work for relative study of Pre-Engineered Buildings (PEB) and Conventional Steel Building (CSB). To compare the consequences of the numerous parametric study to perform the variations in terms of shear force, support reaction, weight correlation and cost evaluation.

Keywords— *Pre-Engineered Building, Conventional Steel Building, Ware House, Tapered Section, STAAD Pro V8i*

I. INTRODUCTION

Buildings & companies are one of the primeval creation activities of people. The present modern concept of house buildings the technology of creation has progressive since the established order from simple construction. India has emerged as one of the key worldwide markets for pre-engineered buildings steel structures. A plenty of growth has been given to do with the way how recognition towards steel buildings had been changing to developed a country. Today's the scene is such that PEB's are expected to about 25% to 30% of marketplace share within the creation industry sector. The most recent improving technology was continuously increasing the maximum clear-span competencies of steel structures. In India the industry has fast development of steel building makes for exciting analyzing and it can have commenced all with the on location fabrication model. With the opening up of the economy during the 1990s but, such things started to change. In the might of the PEB enterprise this became the cause for predominantly "manufacturing plant constructed" structures and to achieve economy growth. In PEB technology steel is one of the world's most reused material and toward the finish of any steel product's life, practically 100% of it tends to be reused without losing its engineering properties, preferred and ecological construction methods. The tropical nation like in India to give great protection impact and would be highly suitable for a PEB structures. PEBs is an ideal construction sector for in remote & hilly areas. A recently survey through the Metal Building Associations (MBMA) shows that nearby 50% to 60% of the non-residential near to the ground rises constructing in USA are pre-engineered buildings. This flexibility would seem to with ease provide itself to optimization of member cross-section shapes. In Industrial building systems, the partitions can be formed of steel columns with cladding which may be of profiled or plain sheets, Galvanized Iron sheets, roofing, precast concrete, or masonry work. The wall must be effectively in strong to resist the lateral pressure because of wind or seismic activity resistance. As the PEBs offers fastest technique to construct the warehouses structures as compared to conventional methods and its demand for a broad range activities of construction will growth over the afterward four years. A growing range of distinguished International contractors and designers, who formerly certain conventional steel structural buildings entirely, have recently converted to the PEB approach.

II. FRAMING SYSYTEM

A. Concept of Conventional Steel Building

Conventional steel buildings (CSB) are small rise steel buildings with roofing structures of truss with roof coverings. The criterion selection process of roof truss also includes the gradient of the roof, pitch of the roof, fabrication and transport techniques, aesthetics, climatic conditions, etc. In a Conventional steel building design uses selected hot rolled "T" type steel sections that are regular in period but need to be reduce, punched, and bolted on site. The necessity of materials is delivered or produced in the plant and are placed to the site. The need for further economy of creation region and the design of the conventional industrial buildings is governed through beneficial necessities. The Structural members are very hot rolled and are utilized in conventional buildings. Steel roof trusses are normally used for industrial buildings, work shop buildings, packaging areas, warehouses and even for residential buildings, faculty buildings, places of work whereas the construction work is to be completed in a short length of time. In high winds the structural performance of these buildings is well agreed and for the maximum part, suitable code provisions are presently in area to that that make certain excellent behavior. In a roof truss the entire section of every member is subjected to uniform stress and consequently the strength of every member is wholly utilized. A roof truss is essentially frame structure formed through connecting various members at their ends to form a system of triangle, organized in pre-determined pattern depending upon the distance, type of loading and functional requirements.

B. Concept of Pre-Engineered Building

Pre-Engineered steel structures are fabricated or created necessity in the plant itself. The production of structural members is done on customer requirements. The buildings were pre-engineered due to the fact they actually depend on general engineering designs for the limited amount of configurations. A pre-engineered building (PEB) is designed by the producer to be fabricated using a pre-determined inventory of raw materials and production techniques that may be efficiently satisfy a wide variety of a structural and aesthetic view of design requirements within a few geographic manufacturing sectors these buildings are also called as Pre-Engineered Steel Buildings. Generally, a PEB is an inflexible jointed plane frame from hot-rolled or cold-rolled sections, helping the roofing and side cladding through hot-rolled or cold-formed sections purlins and sheeting rails. Z and C-shaped cold formed steel members may be used as secondary structural elements to fasten and support to the outside cladding. Steel building system usually a variety of wall materials, the unique creations and still the maximum popular being steel siding, supported by means of`sidewall or end wall girts. In order to perfectly layout a pre-engineered building, engineers consider the clear span among the bearing factors, bay spacing, roof slope, dead loads, superimposed loads, collateral loads, wind uplift, deflection criteria, internal crane system and maximum realistic size and weight of the fabricated members. The use of an optimum least section leads to the equipped savings in steel and price reduction.

Fig. 1: Pre-Engineered Warehouse Structure

III. METHODOLOGY

In the research work, by using STAAD Pro V8i structural software three dissimilar types of 3D steel buildings are designed for static and vibrant forces. In this work, an industrial warehouse structure of length 60m with bay spacing at 6m along the length, 24m width and 8.402m eave height in which 2.1 m from ground level is used for brick work and remaining 6.3 m is used for cladding. The slope of roof is taken as 9.91° for both Pre-Engineered Steel Building and Conventional steel buildings and roofs are protected with GI sheet. The spacing of the purlins is maintained as 1.5m and girts is maintained as 2.1m. Pinned type of support condition can be used. The building layout plan of the proposed industrial warehouse structure considered for the study is as shown below in figure:

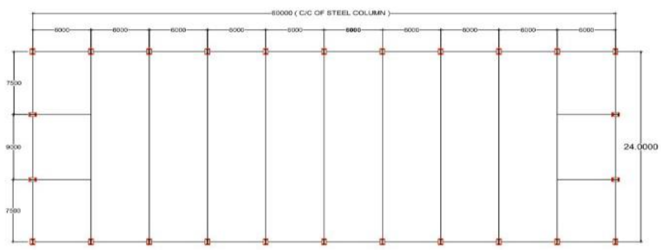

Fig 2. Plan Layout of Warehouse Structure

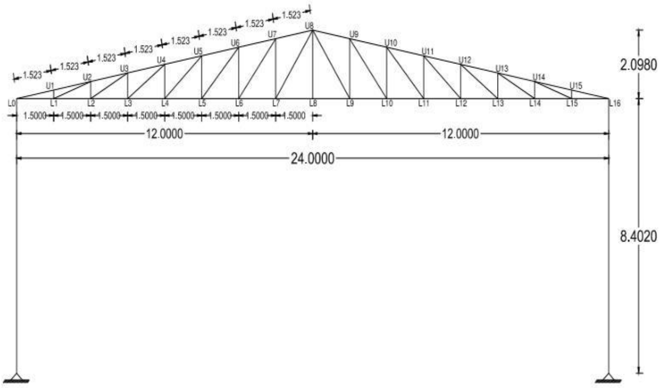

Fig. 3: Elevation of Warehouse Structure

IV. LOADING CALCULATIONS

A. Dead Load

Dead load calculation (IS 875-1987 Part-I):

Total load on purlin:

Weight of sheet = 0.058 kN/m^2

Weight of fixing = 0.025 kN/m^2

Weight of services = 0.1 kN/m^2

Spacing of Purlin = 1.523 m

Total weight on Purlin = 0.183 kN/m^2

Total weight on Purlin = weight (kN/m^2) × spacing of Purlin

= 0.183 × 1.523

= 0.278 kN/m Assume weight of purlin= 0.10 kN/m Weight of truss = (Span/3+5) × 10

= (24/3+5) × 10

= 0.130 kN/m^2

= 0.103 × plan length

= 0.103 × 1.5

= 0.154 kN/m

Total dead load = 0.532 kN/m

B. Live Load

= 750 – 20(9.91 – 10)

= 0.751 kN/m^2

= 0.751 × 1.523

= 1.143 kN/m

= 2/3 × 1.143

= 0.762 kN/m

C. Wind Load

Wind load calculation (IS 875-1987 Part-III):

Basic wind speed = Vb = 39 m/s

Design wind speed = Vz = K_1 K_2 K_3 V_b

Design wind pressure = Pz = 0.6 Vz^2

Wind pressure on roof = (C_{pe} - C_{pi})

Where,

C_{pe} = Coefficient of external wind pressure

C_{pi} = Coefficient of internal wind pressure

K_1 = Risk coefficient

K_2 = Terrain height and structure size factor

K_3 = Topography factor

For all general building and structure,

Mean probable design life = 50 years

Risk coefficient K_1 = 1.0

Terrain category = 3 ……..… (As height of building 10 m)

Class B ……..…… (As horizontal or vertical dimension in between 20 to 50 m)

K2 = 0.99
K3 = topography factor
K3=1

= 1.0 × 0.99 × 1.0 × 39
= 38.61 m/s
Design wind pressure = Pz = 0.6 × Vz2

$= 0.6 \times 38.61^2$
$= 894\ N/m^2$

D. Load Combinations

Table 1: Load Combinations as per Design Codes

AISC-89/MBMA-86	IS 800-2007
Limit state of serviceability	Limit state of serviceability
(DL+LL)	(DL+LL)
(DL+WL/EL)	(DL+WL/EL)
(DL+CL)	(DL+LL+CL)
(DL+.05WL/EL+CL)	(DL+0.8LL+0.8WL/EL+0.8CL)
Limit state of strength	Limit state of strength
(DL+LL)	1.5(DL+LL)
(DL+CL)	1.5(DL+WL/EL)
0.75(DL+WL/EL)	(0.9DL+1.5WL/EL)
0.75(DL+WLRL-P)	(1.5DL+1.5LL+1.05CL)
0.75(DL+0.58WL/EL+CL)	(1.5DL+1.05LL+1.5CL)
	(1.2DL+1.2LL+0.6WL/EL+1.05CL)
	(1.2DL+1.2LL+0.6WL/EL+1.2CL)
	(1.2DL+1.2LL+1.2WL/EL+0.53CL)
	(1.2DL+1.2LL+1.2WL/EL+0.53CL)

V. STAAD PRO PROCESS

In the modern study, STAAD Pro V8i programming has been utilized in order to analyses and design PEB and CSB. The industrial warehouse structures we are designing is of Pre-Engineered structure. The sizable majority of the channel sections and angle sections are available in the steel tables of STAAD Pro V8i are the C or else I sections. In any case, for the design of PEB, there is likewise one command known as tapered sections. Optimum Tapered sections are one in which we can assemble the web, flange, their thicknesses, and so on. STAAD Pro is the structural engineering professional's decision for steel, concrete, timber, aluminum, and cold-formed steel design of practically any structure including of culverts, petrochemical plants, tunnels, bridges, piles, and substantially more through its adaptable demonstrating condition, propelled highlights. For making plans or breaking down any shape on STAAD Pro V8i, we first of all need to create a model of it. For demonstrating in STAAD Pro V8i various types of section properties, members, steel tables, materials are presented. Not just this, there are the plan codes of different countries feed. In the beams and columns act as line component and slabs, walls and shear walls, and so forth go about as plate component.

Optimum Tapered sections are for the most part accommodated for rafters & columns. The modelling of warehouse structure using software and how the tapered sections are collected and placed as below:

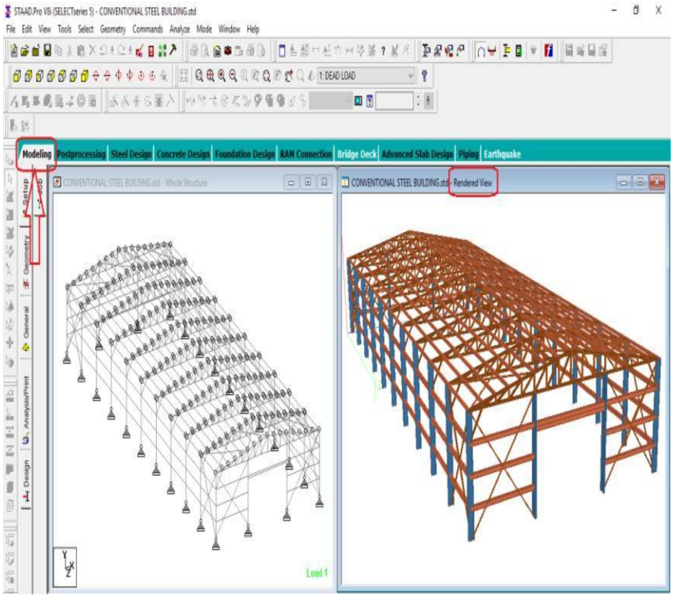

Fig. 4: Modelling and Rendered View of CSB Structure

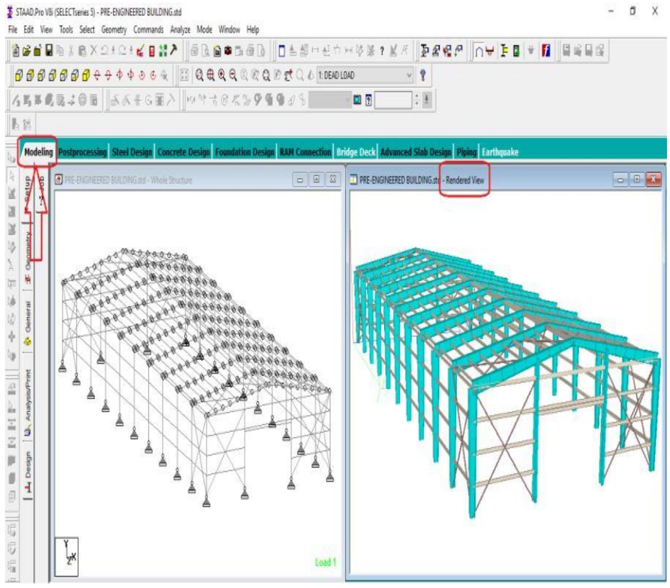

Fig. 5: Modelling and 3D View of PEB Structure

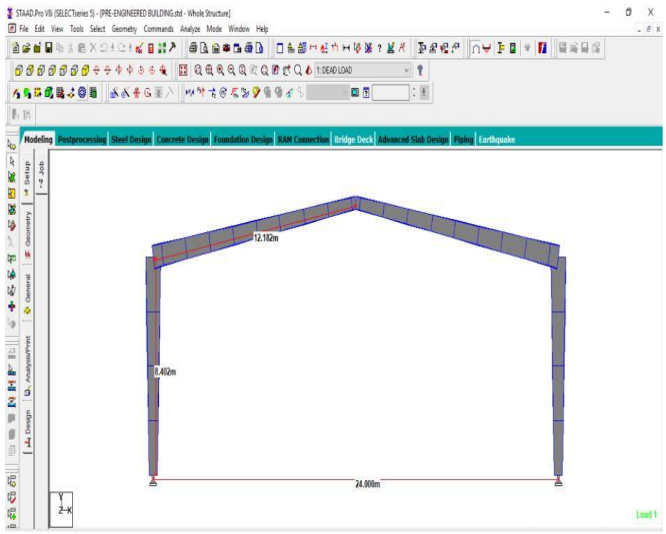

Fig. 6: Assembled Tapered Section

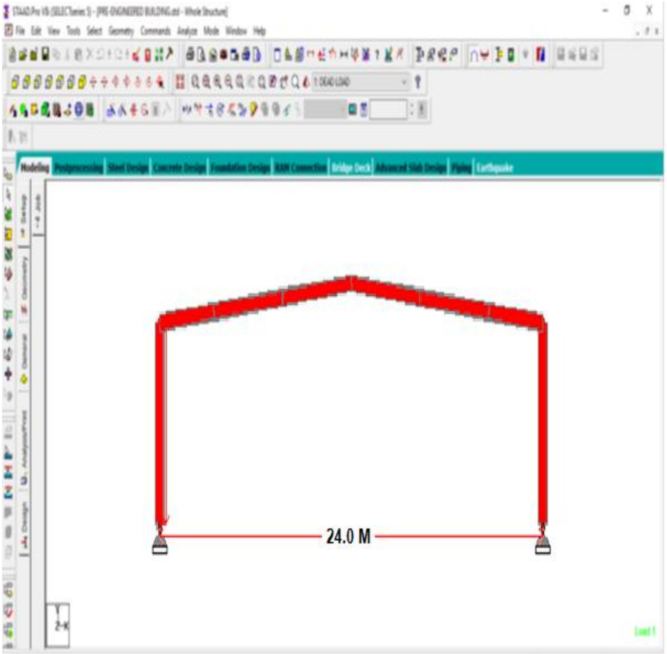

Fig. 7: Assembled I-Section OF CSB Section

VI. RESULTS AND PERFORMED ANALYSIS

The structural analysis and design of the structural constructing taken into consideration changed into executed using the Staad Pro software database which may be very user pleasant and powerful. Graphical representation shows results obtained from software as below:

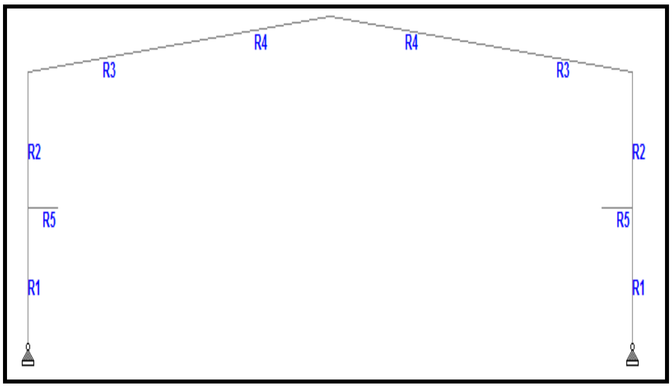

Fig. 8: Typical Section of PEB-IS 800:2007 Frame

Table 2: Sectional Details of PEB-IS 800:2007 Frame

Profile	Length (m)	Weight (t)
Tapered Member No: 1	12	5.006
Tapered Member No: 2	37.68	26.925
Tapered Member No: 3	37.68	23.763
Tapered Member No: 4	12	6.616
ST ISMB300	7.5	3.243
ISA 75X75X6	502.65	8.150604
ISA 50X50X6	501.143	22.04178
ST 200Z60X2	3680	20.16215
	Total =	115.9015

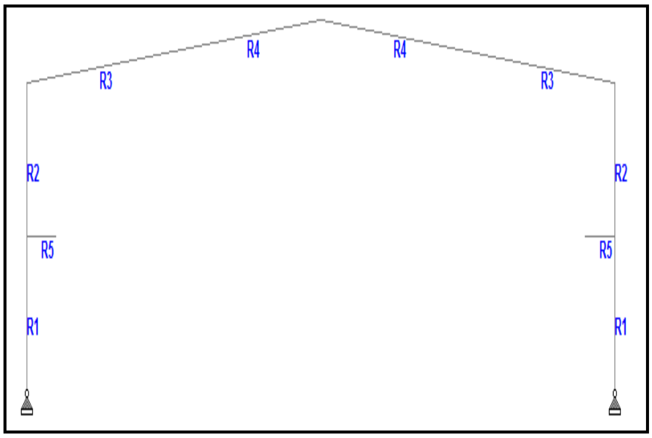

Fig. 9: Typical Section OF PEB- AISC/LRFD Frame

Table 3 : Sectional Details of PEB-IS 800:2007 Frame

Profile	Length (m)	Weight (t)
Tapered Member No: 1	12	5.006
Tapered Member No: 2	28.68	20.49387
Tapered Member No: 3	28.68	18.08712
Tapered Member No: 4	12	6.616
ST ISMB300	7.5	3.243
ISA 75X75X6	506.851	8.218725
ISA 50X50X6	506.843	22.29248
ST 200Z60X2	3680	20.16215
	Total =	104.3854

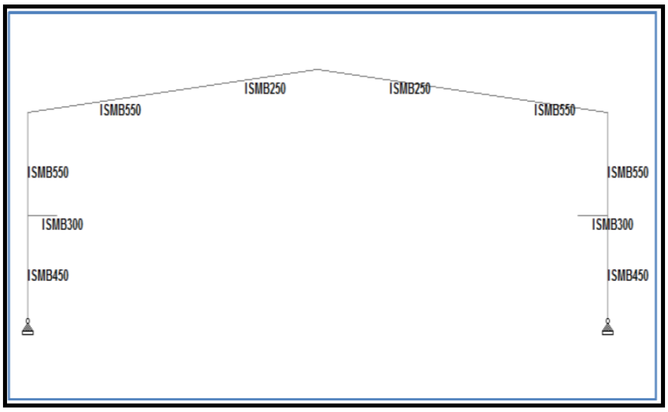

Fig. 10 : Typical Section of CSB-IS 800:2007 Frame

Table 4 : Sectional Details of CSB-IS 800:2007 Frame

Profile	Length (m)	Weight (t)
ST ISMB250	48.1	17.554968
ST ISMB300	10	4.324
ST ISMB450	24	17.016
ST ISMB550	74.02	75.124717
ISA 75X75X6	583.03	38.78454
ISA 50X50X6	587.02	25.67551
ST 200Z60X2	6140	33.640115
	Total =	**212.1185**

Table 5 : Comparison Of Weight Between Csb & Peb Frame

TYPE OF FRAME	WEIGHT IN KN
CSB FRAME IS 800:2007	1394.289
PEB FRAME IS 800:2007	935.619
PEB FRAME AISC LRFD	879.151

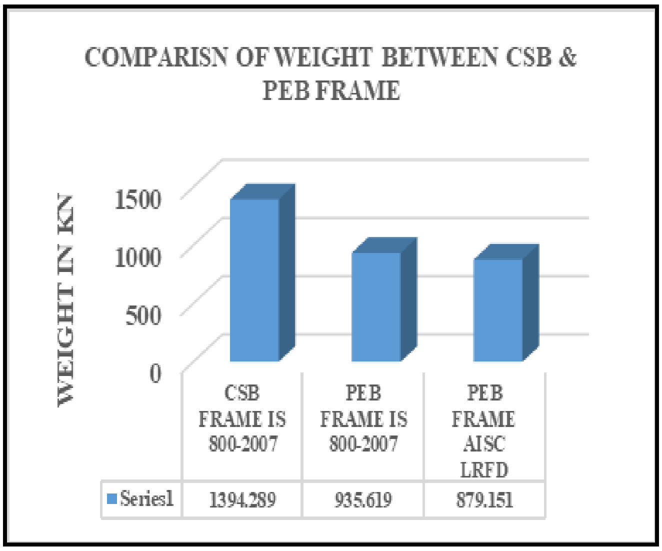

Fig. 11: Weight Correlation

As consistent with the design outcomes acquired for the duration of this dissertation work it is noted that the weight of PEB as consistent with Indian code structure by 33% and weight of PEB as consistent with American code structure with the aid of 37% as compared to lesser than the weight of CSB structure.

Table 6: Steel Quantity For Purlin

Types Of Frame	Weight in KN
CSB FRAME (Hot Rolled Steel Section) IS 800:2007	333.796
PEB FRAME (Cold Formed Steel Section) IS 800:2007	144.19
PEB FRAME (Cold Formed Steel Section) AISC LRFD	105.09

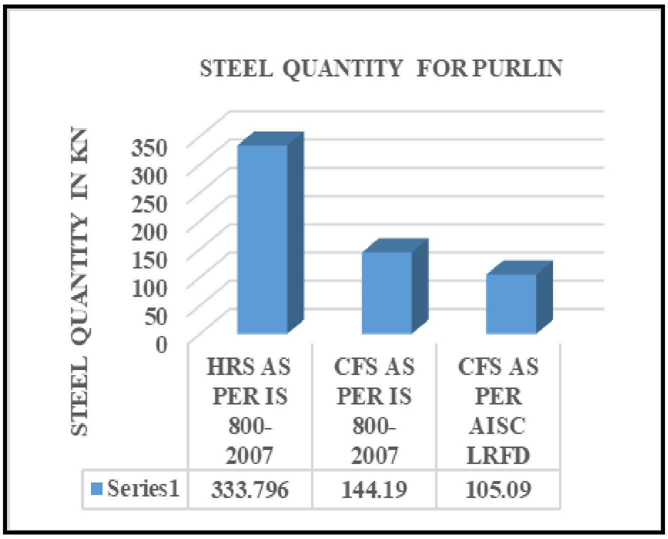

Fig. 12: Steel Quantity required for Hot Rolled Section and Cold Formed Steel section used for Purlin members

As consistent with the design outcomes acquired for the duration of this dissertation work it is noted that the Purlin weight of PEB as consistent with Indian code structure by 56.80% and Purlin weight of PEB as consistent with American code structure with the aid of 68.51% as compared to lesser than the weight of CSB structure.

Table 7: Steel Quantity for Grit Members

Types Of Frame	Weight IN KN
CSB FRAME (Hot Rolled Steel Section) IS 800:2007	352.118
PEB FRAME (Cold Formed Steel Section) IS 800:2007	56.807
PEB FRAME (Cold Formed Steel Section) AISC LRFD	39.439

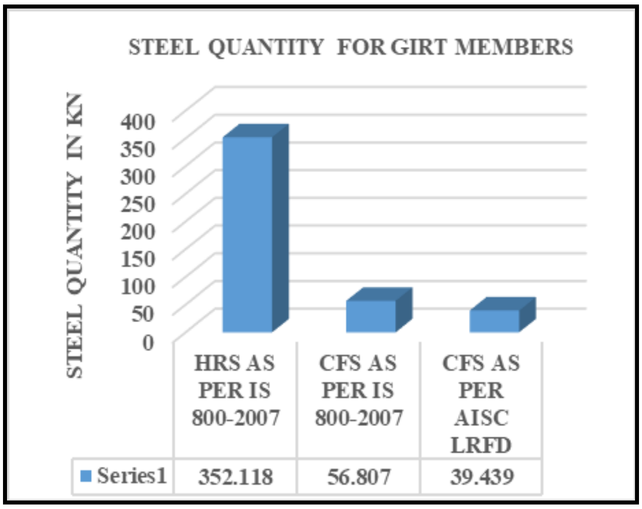

Fig. 13: Quantity of steel required for Hot Rolled Section and Cold Formed Steel used for Girt members

In this dissertation work it is noted that the Grit Member weight of PEB as consistent with Indian code structure by 83.86 % and Grit Member weight of PEB as consistent with American code structure with the aid of 88.79% as compared to lesser than the Grit Member weight of CSB structure.

Table 8: MAXIMUM SHEAR FORCE IN KN

TYPES OF FRAME	SHEAR FORCE IN KN
CSB FRAME IS 800:2007	403.064
PEB FRAME IS 800:2007	204.744
PEB FRAME AISC LRFD	151.018

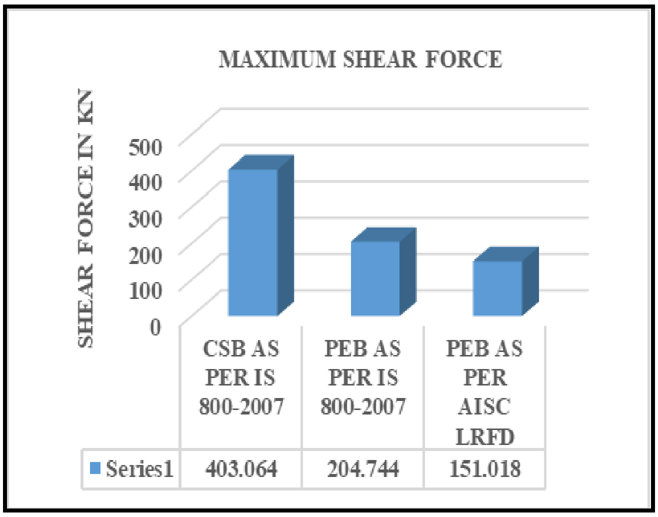

Fig. 14: Maximum Shear Force

In this dissertation work it is noted that the Maximum Shear Force of PEB as consistent with Indian code structure by 49.27% and Maximum Shear Force of PEB as consistent with

American code structure with the aid of 62.53% as compared to lesser than the Maximum Shear Force of CSB structure.

Table 9: Maximum Support Reaction in KN

Types of Frame	Support Reactions in KN
CSB FRAME IS 800:2007	193.067
PEB FRAME IS 800:2007	159.603
PEB FRAME AISC LRFD	121.266

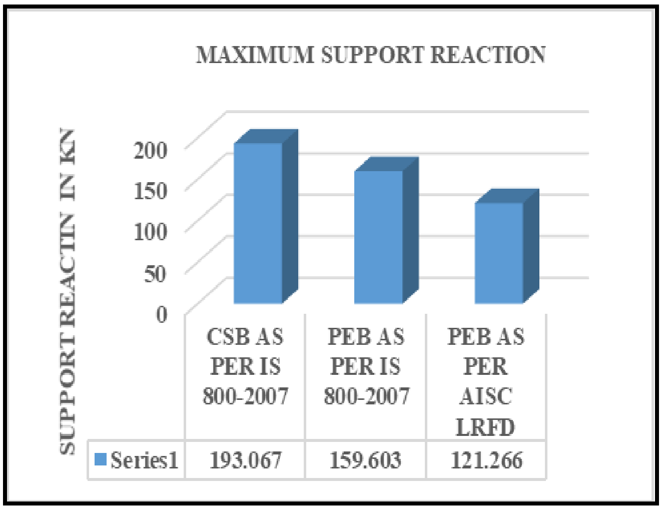

Fig. 15: Maximum Support Reaction

In this dissertation work it is noted that the Maximum Support Reaction of PEB as consistent with Indian code structure by 17.33% and Maximum Support Reaction of PEB as consistent with American code structure with the aid of 37.18 % as compared to lesser than the Maximum Support Reaction of CSB structure.

Table 10 : Cost Analysis Between PEB AND CSB

types of frame	weight of frame in kn	purlin weight in kn	grit member weight in kn	total weight in kn	total weight in kg	rate of steel in kg	total cost
CSB FRAME IS 800:2007	1394.289	333.796	352.118	2080.2	2,12,118.30	55.00	**1,16,66,506**
PEB FRAME IS 800:2007	935.619	144.19	56.807	1136.62	1,15,900.73	55.00	**63,74,540.3**
PEB FRAME AISC LRFD	879.151	105.09	39.439	1023.68	1,04,384.65	55.00	**57,41,155.7**

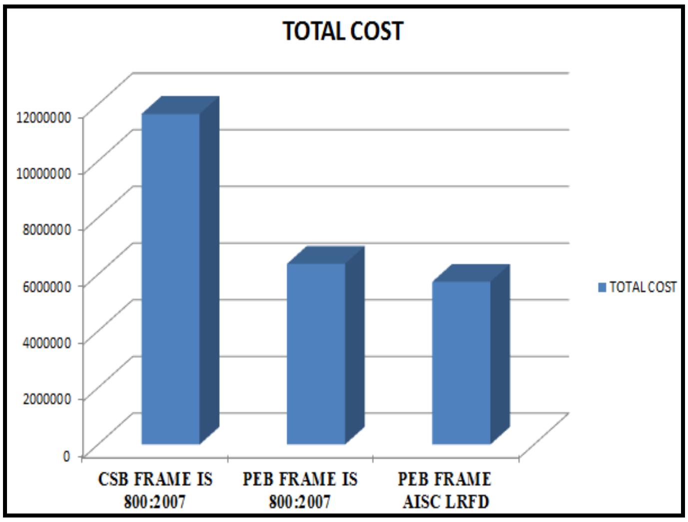

Fig. 16: Cost Analysis

In this dissertation work it is noted that the Cost Analysis of PEB as consistent with Indian code structure by 45.36% and Cost Analysis of PEB as consistent with American code structure with the aid of 50.78% as compared to lesser than the Cost Analysis of CSB structure.

CONCLUSIONS

In our everyday existence steel is versatile material that each object we see used in steel immediately or circuitously. In Pre-engineered steel structures building offers low cost, strength, durability, design flexibility, adaptability and recyclability. Steel is the basic material that is used in the materials that are used for Pre-engineered steel building. It negates from regional sources. Infinitely recyclable, steel is the material that reflects the imperatives of sustainable development. Based on the analytical and design results thereon of conventional and pre-engineered steel buildings, the following conclusions are drawn. In our everyday existence steel is versatile material that each object we see used in steel immediately or circuitously. In the observe of self-weight of the models indicated that the self-weight for PEB is much less than that of CSB in the equivalent geometry.

1. As consistent with the design outcomes acquired for the duration of this dissertation work it is noted that the weight of PEB as consistent with Indian code structure by 33% and weight of PEB as consistent with American code structure with the aid of 37% as compared to lesser than the weight of CSB structure.
2. In this dissertation work it is noted that the Purlin weight of PEB as consistent with Indian code structure by 56.80% and Purlin weight of PEB as consistent with American code structure with the aid of 68.51% as compared to lesser than the weight of CSB structure.
3. In this dissertation work it is noted that the Grit Member weight of PEB as consistent with Indian code structure by 83.86 % and Grit Member weight of PEB as consistent with American code structure with the aid of 88.79% as compared to lesser than the Grit Member weight of CSB structure.
4. In this dissertation work it is noted that the Maximum Shear Force of PEB as consistent with Indian code structure by 49.27% and Maximum Shear Force of PEB as consistent with American code structure with the aid of 62.53% as compared to lesser than the Maximum Shear Force of CSB structure.
5. In this dissertation work it is noted that the Maximum Support Reaction of PEB as consistent with Indian code structure by 17.33% and Maximum Support Reaction of PEB as consistent with American code structure with the aid of 37.18 % as compared to lesser than the Maximum Support Reaction of CSB structure.
6. In this dissertation work it is noted that the Cost Analysis of PEB as consistent with Indian code structure by 45.36% and Cost Analysis of PEB as consistent with American code structure with the aid of 50.78% as compared to lesser than the Cost Analysis of CSB structure.

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