IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

STUDY & ANALYSIS OF PRE-ENGINEERED BUILDING [PEB] WITH RESPECT TO CONVENTIONAL STEEL BUILDING

Mr. Chetan Tagade[1], Prof .A.D.Shende[2], Dr.B.S.Ruprai[3], Mr. Jigar Shah[4]

[1]Post Graduate (PG) Student, KDK College of Engineering,
Nagpur-09, MH, India.
[2]Assistant Professor of KDK College of Engineering,
Nagpur-09, MH, India. Civil Engineering Dept.
[3]Assistant Professor of KDK College of Engineering,
Nagpur-09, MH, India. Civil Engineering Dept.
[4]Structural Consultant and Architects ISO 9001: 2015,
Certified Company Nagpur-09, MH, India.

Abstract: This work is primarily concerned with the concepts of PEB and CSB. In steel construction, pre-engineered building (PEB) systems are state-of-the-art for creating cost-effective, ecologically friendly, and long-lasting buildings. The Prefabricated Building (PEB) concept is a new one-story industrial building concept. Because of its lightweight and cost-effective design, this technology can be employed in a variety of ways. For buildings with roof trusses, this idea has several advantages over the traditional steel structure (CSB) concept. The work is a 60 m long, 15 m wide & 60m long, 20m wide industrial building with an assumed roof truss slope of 5.71 degrees and Bay spacing is 6m. The eave height is 6m. These structures were STAAD pro v8i is used for analysis and design to compare PEB and conventional steel trusses. PEB design is based on US code AISC 360:10 and CSB design is based on Indian code IS800:2007. According to IS800:2007 and AISC, the loads considered in the analysis are dead loads, traffic loads, and wind loads, as well as various combinations. Dead weight per IS: 875 (Part 1)-1987. Payload is obtained based on IS: 875(Part-2)-1987. Wind loads per IS: 875 (Part 3)-2015.

Keywords: Structure analysis and design, wind load, tapered sections, Pre-engineered Buildings (PEB), Conventional Steel Buildings (CSB), and STAAD PRO V8i.

I. INTRODUCTION

India is the world's second fastest expanding economy, owing largely to the construction industry, which ranks second only to agriculture in terms of economic contribution to the country. The construction business has constantly discovered, invented, and produced new technologies, techniques, and products. One of these is the pre-engineered building (PEB) concept. In contrast to on-site manufacture, PEB is supplied to your location as a fully finished product from a single provider. It is made up of a basic steel structural frame with factory finished cladding and roof. The structure was built on site by bolting several buildings together according to specifications. This approach is not only suitable for pre-planning and prefabrication, but also for its speed and low weight. The Pre-Engineered Building concept includes technology to provide the best section possible according to optimal requirements. This approach provides a number of advantages over traditional steel structures (CSB). In this research, Staad Pro's analysis and design of prefabricated mainframes with widths 12 meters, 14 meters, 16 meters, 18 meters, and 20 meters and an eave height of 6 m were done to comprehend the behavior of PEB. The design is based on "Indian Standard Recommended Practice for Weight of Structures and Structures," IS 875:1987 (the parts 1, 2 and 3) and IS 800:2007, "Code of Practice for General Construction in Steel Structures." Dead, live, and wind loads in various combinations as described in IS are among the load scenarios taken into account in the modelling. PEB construction is popular these days due to its superiority over traditional concrete and steel construction. Concrete structures are bulkier and flex less with increased but steel has a seismic weight structures increase structural flex as well as ductility helps resist seismic forces. The outstanding qualities of concrete and steel are combined in PEB construction, low cost, rapid construction, high quality control, long-term viability, and so on. As a result, the purpose of this study is to contrast the G+ two-story Frame RCC with the PEB- frame. Both frames are intended to support identical load combinations. Steel or RCC sections are used. Used for the beams and column sections. Analyze and design using STAAD PRO software, then compare the outcomes. Material costs for both building frames are used to calculate the economics. The steel take-off and standard a steel structure and a pre-engineered structure will be compared as project objectives. To compare pre-engineered structures to typical steel buildings and to analyses buildings that contain critical design components. To compare the benefits of constructed buildings compared to conventional steel structures.

1.1 [CSB] CONVENTIONAL STEEL STRUCTURES

The modern steel, world offers beauty, artistry, as well as practicality in numerous ways, contributing to create fresh approaches to the construction of impressive structures that were previously unimaginable. Give a solid framework. Steel is utilized extensively in the building sector because of its valuable qualities, including ductility and elasticity. Instead of being crushed or crumbling, it bends under heavy loads. Its power, low speed, stability, flexibility, and recyclability are all advantages. Make this suitable for use in structural steel. We can also see that steel has a certain reserve power. The traditional steel structure is stable. These buildings typically use hot-rolled parts. Components are made in factories close by after that delivered to construction site. Over assembly, modifications welding and cutting procedures can be used to complete the task. Trusses are commonly used in this design

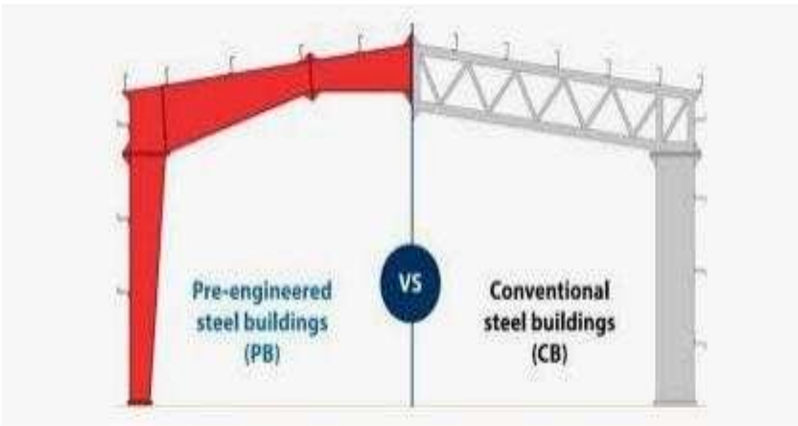


Fig - 1: PEB vs CSB

1.2 PRE-ENGINEERED BUILDING [PEB]

The Pre-engineering building Links are manufactured here according to customer requirements. Components are manufactured in a fully transportable condition. This is followed by delivered to construction place, when the assembly procedure begins. Manufacturing procedure is not carried out on-site. Prefabricated structures are typically used for offices, retail, and warehouses. Prefabricated buildings are primarily low-rise constructions suitable for use as offices, flats, showrooms, shops, and other similar applications. Applying the principle of prefabricated construction to low-rise structures is particularly important cost-effective with time-efficient. Buildings can be built in a fraction the majority of the time that is ordinarily necessary. PEB systems are used commonly global in commercial and non-residential buildings.

1.3 COMPONENTS OF PEB

- Main Element - The primary load-bearing component of a PEB, which typically consists of a rigid main frame, is its major component. Columns refer to vertical members, and rafters to horizontal members. These composite parts are frequently constructed from hot rolled plate.
- Secondary Elements - Purlins, wall flanges, eaves braces, and other cold formed pieces are secondary elements During the PEB procedure. These are referred to as cold formed. Elements since they do not require any cutting, welding, or polishing operations. Cold formed elements are made with presses, and MS steel coils are machine pressed into the desired shape.
- Bracing In order to stabilize a structure against wind, seismic, or other stresses as well as longitudinal cross bracing is used to provide lateral support. The brace's function is to transfer the frame's horizontal load to the base. Types of bracing: 01. Cross brace. 02. Brace Angle.
  03. Pipe brace. 04. Portal Brace.
  Rod bracing is often utilized for buildings with minimal axial loads, and as the building's intricacy grows with cranes otherwise mezzanines, angular brace and tubes are used.

Fig - 2: Component of PEB

II. METHODOLOGY

- The Structure with 10 bays, walls bay spacing of 6 meters, and a building height of 6 meters, the framework is clear-span framed and is 60 meters long by 15 meters wide and 20 meters wide by 60 meters long. The design and analysis carried out in this study work on the 3D PEB structure with a 15-meter and 20-meter widths is done utilizing the Limit State Method (LSM), which adopts The most important load for a building is wind load.
- In addition, the CSB structure 3D frame with the same dimensions is an analysis and design using an affordable roof truss and Indian standard code. All three of the structures mentioned above are designs that are then compared to assess economic production. The hot-rolled section used in CSB and the cold-formed purlins used in PEB are also compared. The designs are created utilizing Indian and American standards, as well as STADD-Pro.

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

III. BUILDING PARAMETER

- The STADD-pro programmer was used to compare Pre-Engineered Structures (PEB) with Conventional Steel Buildings.
- Analyze and design the structure using I.S 800:2007 (LSM) is a standard code in India. Reduce consumption of steel and compare the outcomes for different creation procedures.
- Determine the more effective design process.

1	Type of structure	Clear-Span industrial structure PEB & CSB	
2	Location	Nagpur	Nagpur
3	Area	960 m2	1200 M^2
4	Length	60 m o/o	60 M C/C
5	Width	15 m o/o	15 M C/C
7	Height	6 m o/o	6 M O/O
8	Bay Spacing	10 @ 6.0 m c/c	10@6.0 M C/C
9	Slope of the PEB Roof	5.71 degrees on the roof	5.71 degree
10	Slope of the CSB Roof	5.71 degrees on the roof	5.71 degree
11	Column Support	Fixed	Fixed
12	Wind Pressure	44 m/s	44 M/SEC
13	Seismic Zone	II	II

Table - 1: Building Parameter

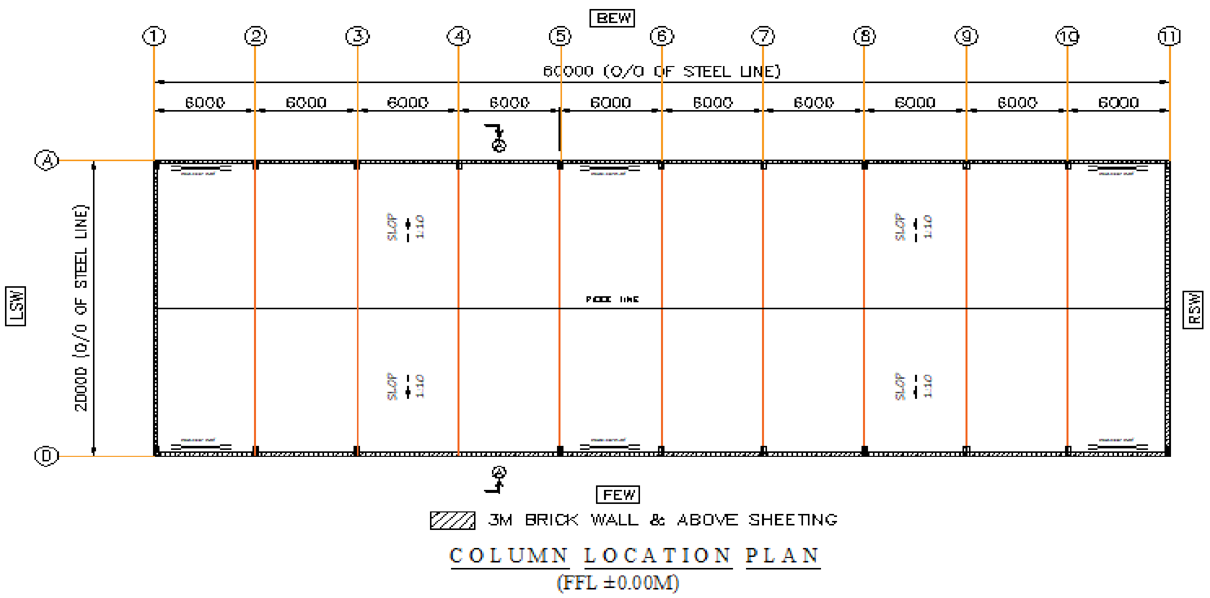


Fig -3: Industrial Warehouse Ground Floor Plan

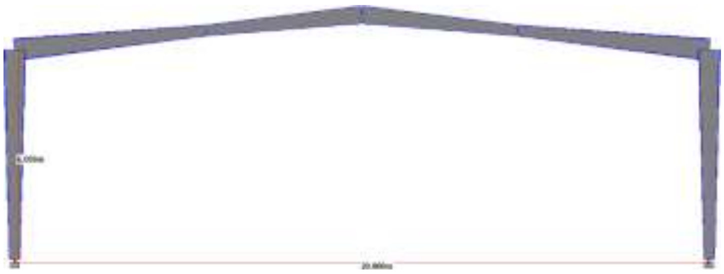


Fig -4: Section of Pre-Engineered Building

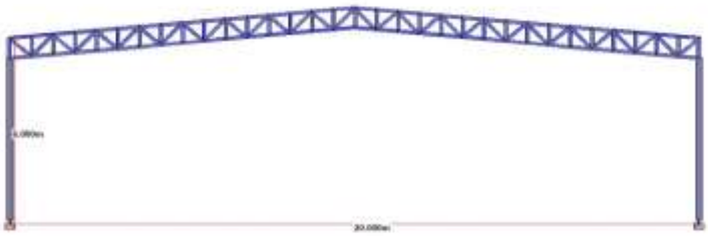


Fig -5: Section of Conventional steel Building

IV. LOAD CALCULATION

- The load acting over the course of a structure's full life is crucial in the design of any structure. It must make certain that the frame is properly undersigned; otherwise, the structure would failed. 875-1987, according to IS, the load exerted on a structure can be computed. The wind load is recognized as a storage facility structure's frame requires a critical load.

1) DEAD LOAD

- The deceased is identified utilizing the While functioning under the Indian Act (IS 875-1987 Parts 1) a 2D and 3D frame of the PEB. Self-weight and structural elements, such as insulation, bracing, sag rods, and G.I. roof sheets, among others, act as Roofs with dead loads. If a dead load operates on a roof, 1.5 kn/m of self-weight is found ignored, is required. In PEB, the weight is distributed uniformly along each meter of rafter length. Additionally, Indian code IS 800:2007 (LSM) is used to construct both 3D and 2D PEB frames. In the case of, a dead load is transmitted to the truss a 3D CSB frame.as and 1.5 KN equivalent point load at a middle panel location and 0.75 KN at an end panel position.

2) LIVE LOAD

- The live load applied to the inaccessible the term roof originates in the Indian standard rule IS 875 (in Part 2) - 1987. It is anticipated 0.75 KN/m2 for the structure, with a 0.02 KN/m2 drop for each degree rise in rooftop slope above 10 degrees. A rafter's total equally dispersed load per running meter on the PEB 3D framework is 4.5 KN/m., according to Indian code. The live load is considered 7.57 KN in middle panel locations, with half of that 4.5 KN on ends equalling 4.5 KN/m on a CSB 3D structure.

Sr.No.	Load	PEB Structure	CSB Structure
		Load on Rafter	Load on Rafter
		As per IS 875:1987	As per IS 875:1987
1	**Dead Load**	0.9 kN/m	0.75 kN/m
2	**Live Load**	4.5 kN/m	3.75 kN/m

Table - 2: Load calculation

3) WIND LOAD

- Wind load is estimated in accordance with IS: 875 (Part3) -2015. The building is in Nagpur, as well as the baseline this location's wind velocity is 44 m/s., according to the regulation. Wind load is applied to a PEB rafter and sidewall as U.D.L. Each point is subjected to the point load. Case of CSB, but it is applied as U.D.L. to the sidewall. Tables 3 and 4 show six different wind combinations affecting the rafter and sidewall.

Sr. No.	Case	Column (kN/m)		PEB Roof panel (kN/m)	
		Left	Right	Wind-ward Intermediate	Lee-ward Intermediate
1	WL1	1.87	-1.68	-4.11	-2.21
2	WL2	-1.68	1.87	-2.44	-4.11
3	WL3	3.37	-0.19	-2.62	-0.75
4	WL4	-0.19	3.37	-0.75	-2.62
5	WL5	-2.99	-2.62	-3.74	-2.24
6	WL6	-2.62	-2.99	-2.24	-3.74
7	WL7	-1.5	-1.12	-2.24	-0.75
8	WL8	-1.12	-1.5	-0.75	-2.24

Table - 3: Wind calculation for PEB

Sr.No.	Case	Column (kN/m)		PEB Roof panel (kN/m)	
		Left	Right	Wind-ward Intermediate	Lee-ward Intermediate
1	WL1	1.56	-1.4	-3.43	-1.87
2	WL2	-1.4	1.56	-1.87	-3.43
3	WL3	2.8	-0.16	-2.18	-0.62
4	WL4	-0.16	2.8	-0.62	-2.18
5	WL5	-2.49	2.18	-3.12	-1.87
6	WL6	-2.18	-2.49	-1.87	-3.12
7	WL7	-1.25	-0.93	-1.87	-0.62
8	WL8	-0.93	-1.25	-0.62	-1.87

Table - 4: Wind calculation for CSB

V. LOAD COMBINATION

- Load combinations are permitted in accordance with IS: 800-2007 (LSM). The thirteen combinations of loads are taken into consideration for both system assessments.

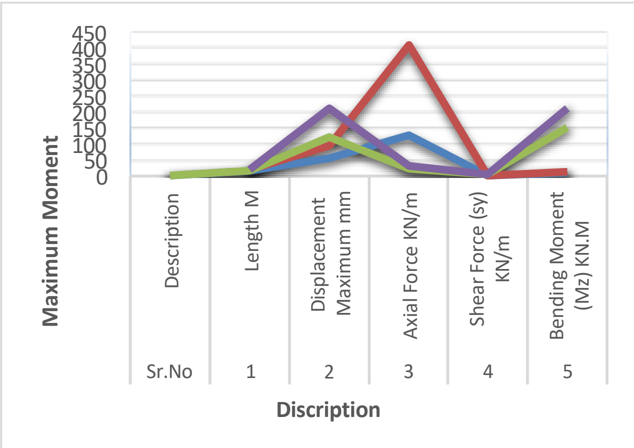
VI. STAAD PRO PROCEDURE

- STADD Pro software is used for structure design, analysis, and modelling. This programmer supports a variety of national standards, including Indian norms. This software is used to model the structure, characteristics, specifications for loads and loading combinations, applied analysis, and design. The STADD Pro study's utilization percentage shows that the component's code is adequate. The component is overstressed if the value exceeds one; if it is less than one, it is under stressed. It is under stress and is suitable for design.

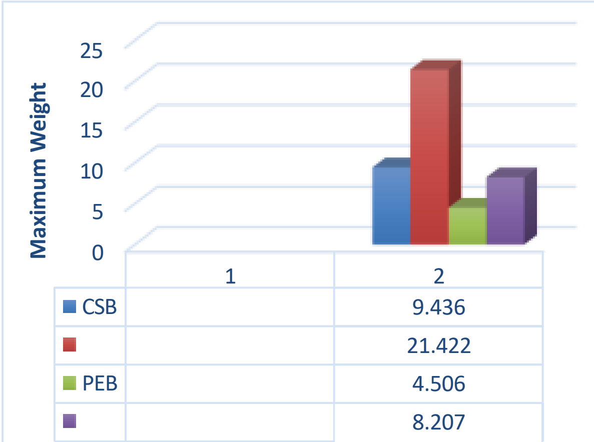
VII. RESULT

Sr.No	Particular	(IS 800:2007) CSB		(IS 800:2007) PEB	
1	Length (M)	15	20	15	20
2	Displacement Maximum mm	55.011	94.568	121.2	212.2
3	Axial Force KN/m	126.107	409.657	21.8	32.702
4	Shear Force (sy) KN/m	1.256	1.356	3.556	5.448
5	Bending Moment (Mz) KN/m	9.223	13.009	150.049	211.759
6	Steel Quantity KN	9.436	21.422	4.506	8.207

Table - 5: Calculation for Rafter



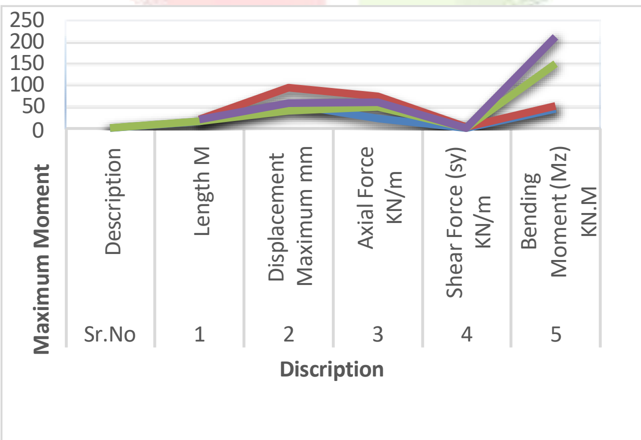
Graph - 1: Rafter



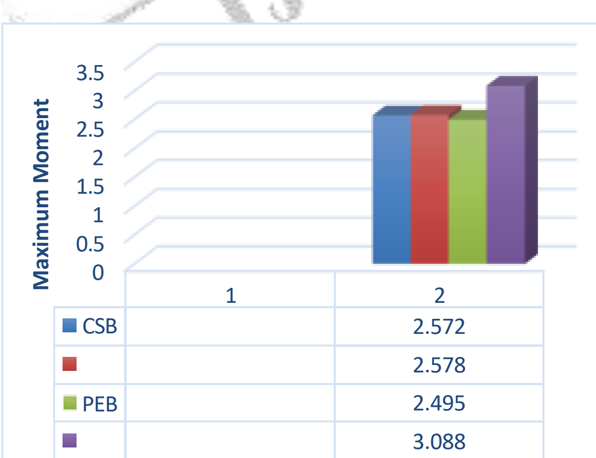
Graph - 2: Rafter Weight

Sr.No	Particular	(IS 800:2007) CSB		(IS 800:2007) PEB	
1	Length (M)	15	20	15	20
2	Displacement Maximum mm	55.011	94.568	40.42	58.158
3	Axial Force KN/m	21.823	74.137	48.374	59.86
4	Shear Force (sy) KN/m	1.232	2.365	1.225	1.356
5	Bending Moment (Mz) KN/m	43.918	52.174	150.049	211.75
6	Steel Quantity KN	2.548	2.578	2.489	3.088

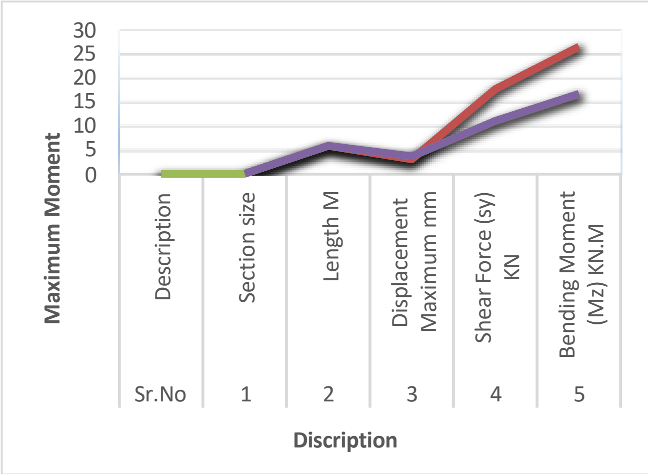
Table - 6: Column calculation



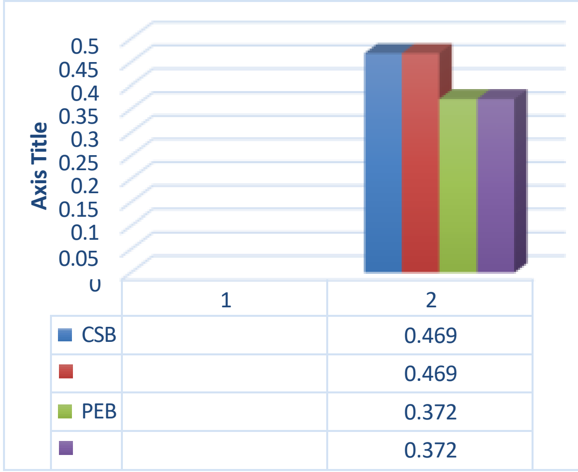
Graph - 3: Column



Graph - 4: Column Weight



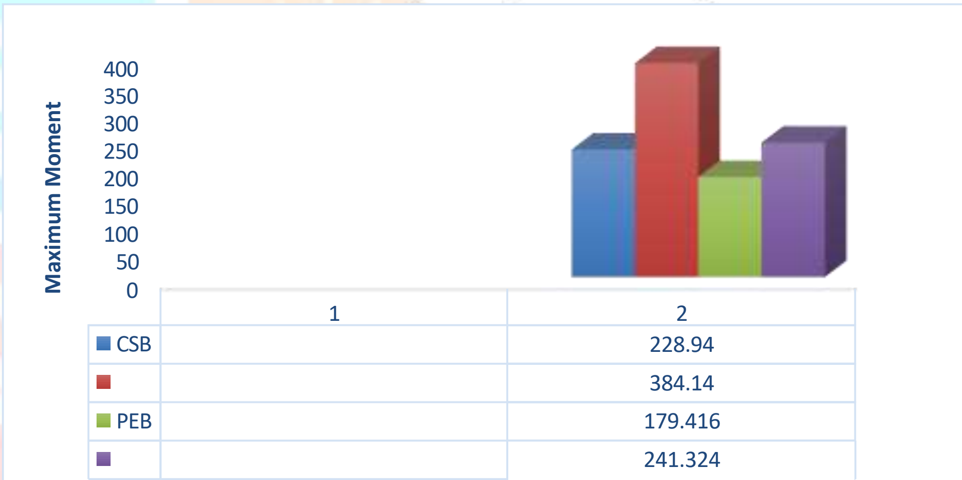
Graph - 5: Purlin



Graph - 6: Purlin Weight

Sr.No	Particular	(IS 800:2007) CSB		(IS 800:2007) PEB	
1	Length (M)	15	20	15	20
2	Steel Quantity KN	228.94	384.14	179.416	241.324

Table - 7: Total Weight of Steel Building



Graph - 6: Total Weight of Steel Building

VIII. DISCUSSION

The findings of structure software analysis and literature investigations indicate showing The PEB construction is less expensive and more advantageous compared to the CSB structure.

Sr.No	Particular	(IS 800:2007) CSB		(IS 800:2007) PEB	
1	Section Size	ISMC100	ISMC100	Z200X60X2.0	Z200X60X2.0
2	Displacement Maximum mm	6	6	6	6
3	Axial Force KN/m	4.125	4.125	4.256	4.256
4	Shear Force (sy) KN/m	16.25	16.25	12.635	12.635
5	Bending Moment (Mz) KN/m	25.625	25.625	17.648	17.648
6	Steel Quantity KN	0.469	0.469	0.372	0.372

IX. CONCLUSION

The displacement of the PEB structure model produced by IS 800:2007 is greater than that of the CSB structure. Because the structure is lighter than a CSB structure, the support reaction is reduced. PEB has a 15% lower maximal support reaction than CSB. When compared to a CSB structure, it has reduced axial, shear force, and bending moment. PEB has a lower maximum axial force than CSB. The building is lighter than a CSB building. Compared to CSB constructions, PEB structures are 26% lighter. Wind resistance is higher than in a CSB construction. Cold-formed purlin is 26% lighter than hot-rolled purlin. Steel can be used to design pre-engineered steel structure buildings since it is a low-cost material that also offers strength, durability, design flexibility, adaptability, and recyclability.

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