P.E.B. Framed Structure Design and Analysis Using STAAD Pro

Abhinav

Department of Civil Engineering Roorkee Institute of Technology, Roorkee

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Abstract:

In the construction business, pre-engineered buildings, or P.E.B.s, have become increasingly popular because of their efficiency, affordability, and quick assembly. An overview of the key elements involved in the design and analysis of P.E.B. framed structures using STAAD.Pro software is given in this abstract.P.E.B. buildings are designed systems in which the building Androoftrusses and beams are produced off-site and assembled on-site. The concepts and benefits of P.E.B. technology are examined in this project, including its cost-effectiveness, shortened construction time, and flexible design.

To guarantee P.E.B. framed constructions' performance and safety under varied load scenarios, structural analysis and design are essential. A key tool in this process is the widely used structural analysis and design program STAAD.Pro. The practical use of STAAD.Pro for modeling, analyzing, and constructing P.E.B. buildings is explored in this work.It includes modeling different structural parts, evaluating structural reactions, and assigning loads (wind, earthquake, and other pressures).

The project also highlights how crucial it is to follow international design codes and standards, such AICC, IS800, and MBMA, in order to guarantee compliance and safety in P.E.B. construction.

In summary, STAAD is used in the design and analysis of P.E.B.-framed structures.represent a substantial development in contemporary building techniques. This abstract provides as a foundation for comprehending the essential components required to establish secure, effective, and ecologically consciousPEB structures will change as a result of research and innovation in PEB technology.

Keywords *- pre-engineered buildings STAAD.Pro.*

INTRODUCTION

Pre-Engineered Buildings (PEBs) are a contemporary building technique that finds extensive usage in commercial, industrial, and even residential sectors. This kind of construction system consists of structural elements that are assembled on-site from a factory. Because of its reputation for efficiency, affordability, and adaptability, PEB buildings are a common option for a range of building projects.

A pre-engineered building, or PEB, is a structural structure made up of pre-fabricated and pre-designed parts.These are produced at a factory and delivered to the building site where they are assembled. Primary frame components like columns, beams, and rafters, as well as secondary components like roof and wall panels, can be found in PEB constructions.

Design: PEB buildings are developed and constructed to fulfill project-specific needs, accounting for local building rules and elements such as location. When developing PEB structures, computer-aided design (CAD) and engineering software are essential for accurate specifications and effective material utilization.

Components: A PEB structure's essential parts are as follows:

o Primary Framing: This consists of the rafters and columns that make up the building's fundamental structural structure. These parts are often produced of extremely strong steel.

o Secondary Framing: Purlins and girts are examples of secondary framing elements that provide the structure more solidity and support. They are involved in the process of connecting roof and wall panels.

o Wall and Roof Panels: PEB buildings usually include wall cladding and roofing panels that are strong and lightweight. For increased energy efficiency, these panels can be constructed from materials like steel, aluminum, or insulated sandwich panels.

o Accessories: Depending on the purpose and architectural specifications of the building, a variety of accessories, including doors, windows, ventilation systems, and insulation, can be included into the PEB structure.

Benefits

o Cost-Effective: Due to expedited construction timelines and reduced material waste, pre-engineered buildings (PEB) usually provide a more affordable option than traditional construction methods.

o Speed of Construction: PEB buildings are a popular option for projects with constrained timetables since the use of pre-fabricated components drastically cuts down on construction time.

o Customization: PEB structures provide architectural designers flexibility by allowing them to be tailored to specific functional and design needs.

o Durability: PEB buildings are renowned for their strength and resilience, which makes them appropriate for a variety of settings, such as factories, airplane hangars, warehouses, and gymnasiums.

OBJECTIVE AND RESEARCH PROPOSAL

The purpose of this study is to assess the design skills of two software designs by comparing their output. The members used in the design are essentially the same, and the structure is designed as a steel link.

1. MATERIAL AND METHODS - We assumed a lot about the building, its function, its environment, and the forces it would encounter before beginning construction. Since the project is in seismic zone IV, we utilized the LSM technique with Indian standard criteria to design the members. The structure is partially open and framed in PEB.

2. LIMIT STATE METHOD: Carefully designed and constructed structures have the lowest chance of collapsing. The structure is constructed utilizing typical values of its material strengths and applied loads to account for differences in material qualities and the load to be sustained. Partial safety factor application yields design value.

Detailed Engineering Design Calculations

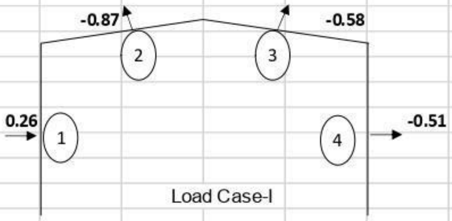
WIND LOAD (WL) MBMA-2012- END FRAME

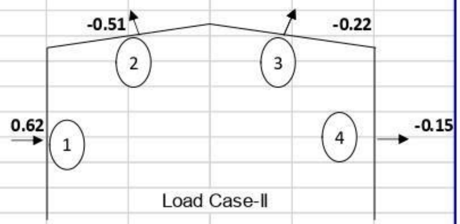
LOAD WIDTH (BAY SPACING)		3.81	M		
Basic Wind Speed (3-sec gu:	V =	50	m/s	=	111.9 mph
		50.00	m/s	=	111.9 mph
Mean Height of roof	h =	10.70	m	=	35.1 ft
Velocity Pressure q	q =	0.00256 Kz Kzt Kd V²			(ASCE 7-10 Eq. 28.3-1 or 30.3-1)
Where,	Kz =	2.01(h/1200)2/7		=	FOR EXPASURE-B
	Kz =	0.733			
	Kzt =	1.00			Kzt = Topographic factor
	Kd =	0.850			Kd = Directionality factor
Velocity Pressure q	q =	0.00256 Kz Kzt Kd V²			(ASCE 7-10 Eq. 28.3-1 or 30.3-1)
Therefore design wind pressure = q	=	0.96	Kn/m²	=	19.95 psf

Main Framing Coefficient (GCp) for Transverse Direction

Interior Zone Coefficients

Opening Condition: ENCLOSED   0° < θ < 10°





Load on Interior Main Frame (Load Case-I)

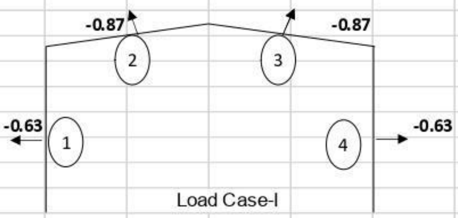
		Load = (GCp x lw x q x Bay Spacing)			
Left wall (Zone 1)	=	0.26xx0.9557x3.81	=	0.95	Kn/m
Left Roof (Zone 2)	=	-0.87xx0.9557x3.81	=	-3.17	Kn/m
Right Roof (Zone 3	=	-0.58xx0.9557x3.81	=	-2.11	Kn/m
Right wall (Zone 4)	=	-0.51xx0.9557x3.81	=	-1.86	Kn/m

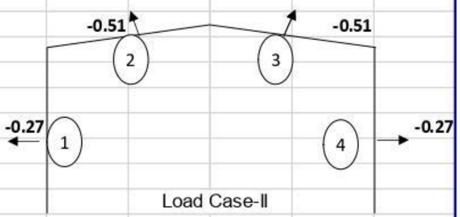
Load on Interior Main Frame (Load Case-II)

		Load = (GCp x lw x q x Bay Spacing)			
Left wall (Zone 1)	=	0.62xx0.9557x3.81	=	2.26	Kn/m
Left Roof (Zone 2)	=	-0.51xx0.9557x3.81	=	-1.86	Kn/m
Right Roof (Zone 3	=	-0.22xx0.9557x3.81	=	-0.80	Kn/m
Right wall (Zone 4)	=	-0.15xx0.9557x3.81	=	-0.55	Kn/m

Main Framing Coefficient (GCp) for Longitudinal Direction

Interior Zone Coefficients





Load on Interior Main Frame (Load Case-I)

		Load = (GCp x lw x q x Bay Spacing)			
Left wall (Zone 1)	=	-0.63xx0.9557x3.81	=	-2.29	Kn/m
Left Roof (Zone 2)	=	-0.87xx0.9557x3.81	=	-3.17	Kn/m
Right Roof (Zone 3	=	-0.87xx0.9557x3.81	=	-3.17	Kn/m
Right wall (Zone 4)	=	-0.63xx0.9557x3.81	=	-2.29	Kn/m

Load on Interior Main Frame (Load Case-II)

		Load = (GCp x lw x q x Bay Spacing)			
Left wall (Zone 1)	=	-0.27xx0.9557x3.81	=	-0.98	Kn/m
Left Roof (Zone 2)	=	-0.51xx0.9557x3.81	=	-1.86	Kn/m
Right Roof (Zone 3	=	-0.51xx0.9557x3.81	=	-1.86	Kn/m
Right wall (Zone 4)	=	-0.27xx0.9557x3.81	=	-0.98	Kn/m

METHODOLOGY

• Design Process: PEB Structures use a collaborative design approach in which architects and engineers collaborate to produce a unique building design. Detailed blueprints are frequently created using computer-aided design (CAD) software.

• Manufacturing: Structures such as columns, beams, purlins, and panels are produced in a factory setting under strict supervision. Because these parts are engineered to exact specifications, consistency and quality are guaranteed.

• Transportation: After fabrication, the parts are packed and brought to the building site. Because they are pre-engineered, they can be transported efficiently and have less logistical obstacles.

• Assembly: Using bolts or welding, the prefabricated components are connected during on-site assembly. This technology often reduces building time and associated expenses since it is faster than traditional construction methods.

• Cost-Effective: Because PEB constructions need less work, take less time to construct, and waste less material than traditional buildings, they are frequently more affordable. There may be total project savings as a result of the expedited building process.

• Construction Speed: PEB structures are renowned for their quick construction. Most building components arrive at the construction site prepared for assembly, reducing construction delays and saving time.

• Versatility in Design: PEB constructions provide versatility in terms of building size, arrangement, and architectural features. Creative customization is possible due to the ability to support a variety of building shapes and designs.

• Energy Efficiency: Insulation, natural lighting, and ventilation systems are examples of energy-efficient elements that PEB buildings can be constructed to include, which can reduce operating expenses.

• Sturdiness and Durability: PEB components are designed to support particular loads, encompassing seismic, wind, and snow forces. This guarantees the building's durability and structural integrity.

• Versatility: PEB buildings may be used in a variety of settings, such as factories, warehouses, offices, sports facilities, and commercial areas.

• Quality Control: Compared to on-site construction, a better level of quality control is ensured in the regulated factory environment where PEB components are created.

• Environmental Impact: When compared to traditional building methods, the efficiency of PEB construction can result in less construction waste and a reduced environmental impact.

LOADS CALCULATION

Dead load: Indian code 875 part 1 is used to compute the dead load. Dead load of members The segment consists of the following two frames: 1) Gabble end frame

2) The center span frame or main frame

3.1 KN/m is the dead load on the members in the main frame, which range in size from rod section to nonpragmatic members. 1.4 KN/m is the dead load on the gabble ends of the end frame. 40.0 kg/m^2 is the total load on the various sections, including sheets, purlins, HVAC fittings, solar panels, etc.

These loads are either determined using IS 875 part 1 and then allocated to the members, or codes can be chosen during the structure's design process, and the self-weight option can be used to assign weight.

Live load: Indian code 875 part 2 may be used to compute live loads. The area that is affected by live loads on members is 2600 square meters.

Unit area / live load = 75.00 kg/m^

5.5 KN/m is the dead load center span.

Gable end span dead load = 3 KN/m

Wind load: We used IS 875 part 3Vb = 33 m/s to calculate the wind load.

is provided by (= 0.9 7.2.1 = 0.80 7.2.2 Clause = 0.90 7.3.3.13 clause = 0.648 > 0.7 = 0.457 KN/m2

The following data are used to get pressure coefficients from IS 875 part 3.9.65% is the opening's percentage area (between 5% and 20%).

RENDERING –

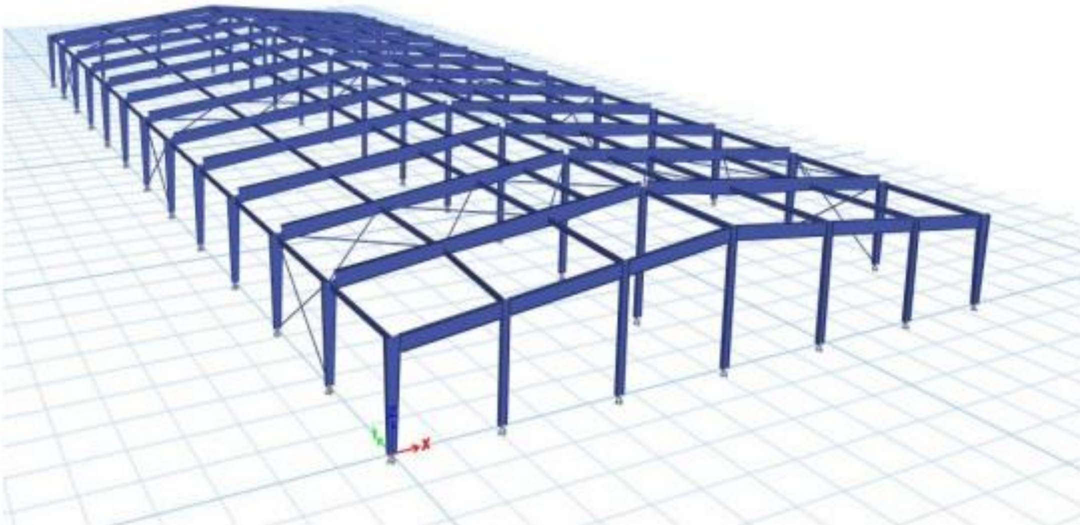


Fig 5– Render result of PEB structure using ETABS

Moment diagram –

Fig 6- Render result of PEB structure using Staad Pro

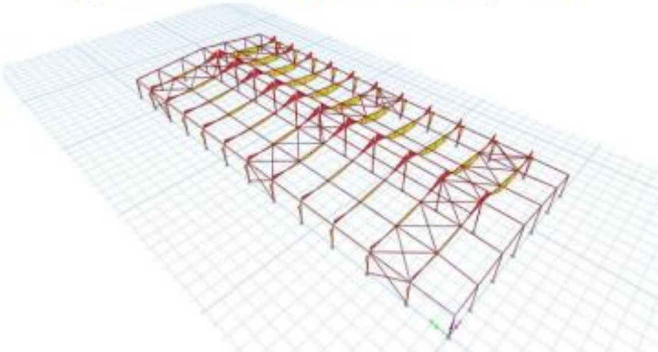


Fig 7– Bending Moment diagram using Etabs

1. Compressive Strength Test:

This test is performed to determine the brick's compressive strength. It is also known as brick's crushing strength. Three brick samples are typically brought to a laboratory for testing and examined one by one. In this test, a brick specimen is placed on a compressive strength testing machine and subjected to steady pressure until it breaks. Consideration is given to the maximum pressure at which a brick is crushed. Each of the three brick specimens is tested individually, and the average result is used to determine the compressive/crushing strength of the bricks. The formula used to determine the brick's compressive strength is (maximum load sustained before failure/area of the brick surface) N/mm2.

2. Water Absorption Test:

In this, the bricks are weighed initially in a dry state before being submerged in water for 24 hours. After that, they are removed from the water and cleaned with a cloth. After that, the percentage difference between the dry and wet bricks is computed. The weight of the three plastic bricks has been measured, and the average brick weight has been computed.

Table 1 - Structure specification

01	The span of the PEB	40 m
02	Spacing of the PEB frame	7.6 m
03	Height of column	5 m
04	Length of building	91 m
05	Rise of the PEB	7 m
06	Slope of the roof (ϴ)	10 degree
07	Length along the sloping roof	20. m
08	Length of each panel (c/c spacing of purlin)	7.6 m
09	Spacing of gable from PEB frame	7.4 m

II. MATERIAL REQUIRED

Table 2 -Material List by frame Section Property

TABLE: Frame Section Property Definitions - Steel I/Wide Flange								
Name	File Name	Sectionin File	Total Depth	Top Flange Width	Top Flange Thickness	Web Thickness	Bottom Flange Width	Bottom Flange Thickness
			Mm	Mm	mm	mm	mm	mm
col_400			400	300	16	8	300	16
col_750_depth			750	350	16	8	350	16
ISLB600	Indian	ISLB600	600	210	15.5	10.5	210	15.5
ISWB550	Indian	ISWB550	550	250	17.6	10.5	250	17.6

RESULT AND DISCUSSIONS

An optimal industrial building must have large, clear spans, which can be easily created with the aid of pre-engineered buildings. When building long span constructions, the structure's balance should be taken into account.

Pre-engineered structures are best suited for high strength steel plates, which increase the structure's capacity to support loads. Furthermore, galvalumed profile sheets and cold form purlins, which are stronger but lighter in weight, are also often used in the construction of pre-engineered buildings. These materials give the construction increased tensile strength, reduced weight, and a pleasing appearance.

In order to get the most cost-effective value for our 80-meter span, we compare several bay spacings. The weights that were determined for each bay spacing are displayed in the Table BELOW.

Column 1 of this chart displays the bay spacing over an 88-meter length. Column 3 displays the weight for each plane frame at its appropriate spacing, whereas Column 2 displays the number of frames. The weight per frame multiplied by the number of frames yields the overall weight. Column 4 displays the overall weight of the estimated portions.

Table -3

Section	Object Type	No of Pieces	Length	Weight
			m	kN
member_700mm	Beam	34	154.098	166.0928
mem_1_prismatic_800mm_to_700mm	Beam	22	147.3982	173.1145
member_2_prismat_700mm_to_900mm	Beam	22	147.3981	227.7299
Column 400mm	Column	21	138.6	133.8249
Column middle	Column	26	130	124.8399
member_3_900_to_700	Beam	22	73.6992	113.8653
ISMC	Beam	104	791.54	273.43
ROD50	Beam	36	366.54	16.72
ROD50	Brace	12	109.83	5.08

CONCLUSION

1. The results provided by both software programs are not exact, but they are comparable within a ±5% range.
2. Although the ETABS software has a superior graphical user interface, it lacks the ability to construct connections and must rely on other programs to do so.
3. The Staad Pro is capable of creating connections by using RAM Connection link to create generic connections inside the software.
4. Both programs have the ability to transmit data between them.

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BIOGRAPHIES

ER. ABHINAV
DEPARTMENT OF CIVIL ENGINEERING,
ROORKEE INSTITUTE OF TECHNOLOGY, ROORKEE