Comparative Study of Different Configuration of Roof Truss for an Industrial Shed

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ABSTRACT

High rise steel buildings account for a very small percentage of the total number of structures that are built around the world. The majority of steel structures being built are low rise buildings, which are generally of one storey only. Industrial buildings, a subset of low rise buildings are normally used for steel plants, automobiles industries, utility and process industries, thermal power stations, warehouses, assembly plants, storage, garages, small scale industries, etc. These buildings require large column free areas. Hence interior columns, walls, and partitions are often eliminated or kept minimum. Most of these buildings may require adequate head room for the use of an over travelling crane. In present study Different configuration of trusses and Pre Engineered buildings (PEB) structures were analyzed and designed as per relevant Indian codes using Staad pro software. The quantity of structural steel required for each quantity was compared to establish the economy of each structure.

Key words: High rise buildings, Pre Engineering Buildings (PEB), Roof Trusses.

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INTRODUCTION

Most building roofs can be framed with engineered light-gauge steel trusses which are manufactured from C shaped metal studs. Prefabricated steel trusses offer a high-strength, light-weight roof system that can be installed headed quickly. Roofs on more than 20% of all new commercial structures in the US are built with light gage steel roof systems are gaining ground in markets where additional strength is needed, or where greater free spans are required. A standard truss is a series of triangles- a stable geometric shape that is difficult to distort under load. Regardless of its overall size and shape, all the chords and webs of a truss form triangles. These triangles combine to distribute the load across each of the other members, resulting in a light structure that is stronger than the sum of the strength of its individual components.

PRE ENGINEERED BUILDINGS (PEB)

Technological improvement over the year has contributed immensely the enhancement of quality of life through various products and services. Once such revolution was the pre engineered buildings.

Though its origin can be traced back to 1960's, its potential has been felt only during the recent years. This was mainly due to the development in technology, which helped in computerizing the design.

A recent survey by the metal building associations (MBMA) shows that about 60% of the non residential low rise buildings in USA are PEB's. Although PEB systems are extensively used in industrial and many other non residential constructions worldwide, it is relatively a new concept in India. The market potential of PEB's is 1.2 million tonnes per annum.

Pre engineered steel buildings can be fitted with different structural accessories including mezzanine floors, canopies, fascias, interior partitions etc. & the building is made waterproof by use special mastic beads, filler strips and trims. This is very versatile building system and can be finished internally to serve any functions and accessorized externally to achieve attractive and unique designing styles. It is very advantageous over the conventional buildings and is really help full in the low rise building design.

PEB's are generally low rise buildings however the maximum height can go up to 25-30m. Low rise buildings are ideal for offices, houses, showrooms, shop fronts, etc. The application of PEB concept to low rise buildings is very economical and speedy. Buildings can be constructed in less than half the normal time especially when complemented with the other engineered sub systems.

The most common and economical type of low raise buildings, is a building with ground floor and two intermediate floor plus roof .The roof of low rise buildings may be flat or sloped. Intermediate floors of low rise building are made of mezzanine systems. Single storeyed houses for living take minimum time for construction and can be built in any type of geographical location like extreme cold hilly areas, high rain prone areas, plain land obviously and extreme hot climatic zones as well.

OBJECTIVES

- To adopt different configuration of trusses and PEB for an industrial shed under consideration.
- To analyze the truss with different configurations and PEB for gravity and wind load as per relevant Indian codes and to proportion the sizes of members to keep the internal forces and deformation within the limits.
- To compare the internal forces and deflection in different configuration of trusses and PEB for the loads under consideration.
- To compare the quantity of steel required for different configuration of trusses and PEB to compare the efficiency and economy of various configurations.

METHODOLOGY

- Industrial shed of medium span (about 12m) has been considered for present study.
- Different types of trusses such as Pratt, Howe, Parallel chord, Fan, Arch type and PEB Have been considered for present study.
- DL, LL and WL resulted on panel points have been calculated based on Indian code provisions. The required member sizes are found out.
- This truss have been analyzed and designed for calculated loads using Staad pro software.
- Internal forces such as axial force and deflection in each of the configuration have been compared.

- The quantity of steel required for each configuration is found out and compared to assess the economy of each configuration.

PRESENT WORK

The plan considered for the present study is as shown in the figure below

Fig 1: Plan Details of present Study

Plan details

- Location - Community hall near Mandya district, Karnataka, India.
 - Area – 255.4m²
 - No. of trusses – 2
 - No. of columns – 10
 - Roof sheet – Galvanized iron sheets
- Purlins details
- Section - ISMC 200
 - Length – 19.78 m
 - Spacing – 1.3 m

SELECTION OF CONFIGURATION

The calculation of various parameters involved with the configuration of the truss is as follows.

Effective Span of Truss	L	12.56	m
Rise of truss	$H=L/8$	1.65	m
Length of Sloping Side		6.50	m
Number of Panel Points		6	no's
Spacing of Purlins	$\frac{\text{length of sloping side}}{(\text{no. of p. points} - 1)}$	1.33	m
Spacing of truss		6.98	m
Angle of inclination	$\tan^{-1}(H/(0.5*L))$	14.7	Degrees
Height to the Eve of Truss=		4	m

Table1: Calculation of Various parameters

LOAD CALCULATION

Load Calculations for a typical truss is as shown below.

Dead Load					
Weight of Sheeting		0.131	kN/sqm	asperIS875 part1	
Weight of Fixtures and Others=		0.11	kN/sqm		
Total=		0.241	kN/sqm		
Weight of Purlin=		0.218	kN/m		
Total dead Load on Panel Point=		3.72	KN		
Live Load					
Live Load=		0.75	kN/sq m	asper IS875 part2	
Reaction due to inclination=		0.66	kN/sq m	asperIS875 part2	
Total live Load on Panel Point=		6.00	KN		
Wind Load					
Basic Wind Speed=	V_b	33	m/s		

k1		1			
k2		1.03			
k3		1			
Design Wind Speed	$V_z = V_b * k1 * k2 * k3$	33.99	m/s		
Design Wind Pressure=	$P_d = 0.6 V_z^2$	0.69	kN/sqm		
h/w=		0.32			
External Pressure Coefficient=	C_{pe}	0.9			
Internal Pressure Coefficient=	c_{pi}	0.5			
area under consideration=	A	9.2834			
wind Load on Panel Point=	$(C_{pe} - C_{pi}) A p_d$	8.8	kN		
Total load on each panel point=	DL+LL+WL	18.52	kN		

ANALYSIS AND OUTPUT

- Axial force diagram for Truss

Fig 2: Axial force diagram for Pratt Type Truss

Fig 3: Axial force diagram for Howe Type Truss

Fig 4: Axial force diagram for Fan Type Truss

Fig 5: Axial force diagram for Parallel Chord Type Truss

Fig 6: Axial force diagram for Arch Type Truss

BMD for PEB Structure

Fig 7: Bending Moment for PEB Structure

RESULTS AND DISCUSSIONS

The maximum internal forces, deflections and the quantity of steel required for different configurations of steel are as shown below in the Table

Truss	Type	Max Tension in kN	Max comp in kN	Deflection in mm	Steel Qty. in tonnes
1	Pratt	377	399	37.66	0.5207
2	Howe	161	393	41.75	0.5029
3	Fan	380	419	43.14	0.695
4	Parallel chord	106	251	13.79	0.3704
5	Arch	78.1	182	14.26	0.268
6	PEB			53.52	0.428

Table 2: Maximum internals,dedlection and quantity of steel

The maximum tension, compressive forces, quantity of steel, deflection in the different configuration of trusses are compared in the following graph

Fig 8: Maximum tensile force vs Configuration

Fig 9: Maximum compressive force vs Configuration

Fig 10: Steel quantity vs Configuration

Fig 11: Deflection vs Configuration

From the above graph it can be seen that parallel chord and arch type truss undergo least deflection and requires least amount of quantity of steel.

1	2	3	4	5	6
Pratt	Howe	Fan	Parallel chord	Arch	PEB

Numbering Convention for Truss Configurations

CONCLUSION

Different configuration of trusses and PEB structures were analyzed and designed as per relevant Indian codes using Staad pro software. The quantity of structural steel required for each quantity was compared to establish the economy of each structure.

Following are the observations made:

- Among the conventional Pratt and Howe trusses, the major difference in the analytical behavior lies in the fact that the diagonal members are tension for gravity loads in Pratt configuration, while they are in compression in Howe configuration. The nature of forces are reversed in the case of uplift pressure.
- The comparison of total quantity of steel required for trusses reveals that the Arch type requires least amount of steel in comparison to the other configuration. Both Parallel chord and Arch type truss are very efficient in terms of economy.
- Comparison of total vertical deflection shows that Arch type of truss has the least deflection because of its advantageous shape.
- PEB are efficient in comparison to conventional Pratt, Howe and Fan trusses. Even though it proves slightly uneconomical in comparison to arch and parallel chord trusses. It has added advantages such as ease and speed of construction, better utilization of cross sections, aesthetics, etc.

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