Comparison of Various Types of Roofs in PEB

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***Abstract*— Pre Engineered Building systems have become a great alternative to conventional steel buildings due to its advantages like faster construction, easy fabrication and economy. In this contest more researches on pre engineering buildings (PEB) are being done to make it more efficient. In this paper Pre Engineered Buildings (PEB) with different roof shapes such as Curved, Pitched & Mono slope have been compared. The study involves an industrial building of length 77.5m and width 25m, with different shapes of roof system. Analysis and design are done using STAAD PRO V8i and results are compared, to understand the behaviour of different roof shapes of Pre Engineered Building.**

***Keywords*— Pre Engineered Building, STAAD Pro V8i, Curved roof, Pitched roof, Mono slope roof.**

I. INTRODUCTION

Pre-engineered metal building concept forms a unique position in the construction industry in view of their ideal suitability to the needs of modern engineering industry. Indian industries are growing very fast due to globalisation, discoveries, inventions and development in technologies. For this rapid development more space is required at faster rate and Pre Engineered Buildings (PEBs) are the only solution.PEBs have lot of scope in India, which can actually fill up the critical shortage of housing, educational and health care institutions, airports, railway stations, industrial buildings like steel plants, automobile industries, light, 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 to a minimum. Most of these buildings may require adequate headroom for use of an overhead travelling crane.

A building system which is predesigned and prefabricated is called as Pre-Engineered Building (PEB). As the name indicates, this concept involves pre-engineering of structural elements like column and rafter using a predetermined registry of buildings. The concept of PEB is evolved in motivation of reducing the cost of construction and to make an aesthetically pleasing structure. A PEB frame is designed such that locus of bending moment value at a section considered is within the rafter depth.

Main framing basically includes the rigid steel frames of the building. The PEB rigid frame comprises of tapered columns and tapered rafters (the fabricated tapered sections are referred to as built-up members). The tapered sections are fabricated using the state of art technology wherein the flanges are welded to the web. The selection of particular roof depends on the following

A. Aesthetics –Roofs determines the Architectural elevation of the structure .
B. Economy - Different shape of roofs also determines the cost of the structure. Tonnage of steel differs for different type of roofs.
C. Ease in fabrication and erection - The roof should be easily made, if not, more man power is required which increase the cost of the frame.
D. Ventilation - Different roofs provides different amount of ventilation inside the building, that depends upon purpose of the building.

These PEBs are designed in various shapes such as curved roof, pitched roof and mono slope roof. A curved roof is like shed roof, but the planes are curved. It is very modern and provides a unique, creative roof design as shown in Fig:1. The amount of curve can vary from slightly curved up to an arch shape. A gabled roof is a common roof type that is characterized by a roof with same-angled slopes. From a pointed tip, the gables angle down to create a roof that looks like a triangle. Technically, "gable" refers to the triangular portion of the wall that sits under the sloped roof. Gabled roofs are usually built with a 5 to 25 degree angle gradation. It is shown in Fig : 2. A mono-sloped roof as shown in Fig:3 is a single-sloping roof surface, often not attached to another roof surface. Mono-sloped roofs are sometimes called a shed roof, lean-to roof or skillion roof.

Fig: 1 Curved Roof

Fig: 2 Pitched Roof

Fig: 3 Mono slope Roof

II. METHODOLOGY

The main objective of this paper is to compare various parameters of a Pre Engineered Building with different shapes of roof. This study includes the design of an Industrial building located at Chennai. The structure is proposed as a Pre Engineered Building with 77.5 meter length and 25 meter width with an eave height of 6 meter. The designs are done in accordance with the Indian Standards. The structure is analysed and designed using Staad.pro V8i. Wind load is consider to be the critical load in the design.

The Pre-Engineered Building described in this paper is designed as per the following codes.

- IS 875 - 1987 Code of Practice for design loads (Other than EQ) for building and structures.
- IS 1893 (Part 4): 2005 Criteria for earthquake resistant design of structures.
- IS 800 - 2007 : Code of Practice for General Construction in Steel.

A. Design consideration

- The main frame rafters and exterior columns are rigidly connected to each other (moment type connections).
- Column bases are considered to be pinned.
- The lateral stability of the building is provided through the frame action of the main frames.
- The building is designed for fully enclosed condition.
- The longitudinal stability of the building is provided through the truss action in the cross braced bays of the building.
- The roof purlins are designed as continuous beams supported at rigid frame locations and they span the bay spacing of the building.

B. Building Parameters

The table below shows the parameter involved in this study.

Table : 1

Length	77.5 m
Width	25m
Eave Height	6m
Roof Slope	1:10
Bay Spacing	7.75m
Purlin Spacing	1.5m
Wall Girt spacing	1.5m
Side wall height	3m
Roof sheet	0.5mm tk GI sheet
Purlin	Cold form 'Z' purlin

III. LOAD CALCULATIONS

A. Dead Load

Dead load as per IS: 875(Part 1)
Weight of G.I sheet & purlin = 0.1 kN/m^2

B. Live Load

Live load is calculated as per IS: 875(Part 2)
Live load on roof = 0.75 kN/m^2

C. Earthquake Load

Earthquake loads are calculated as per IS: 1893

Seismic zone	Z	= II
Response reduction factor	R	= 3 (OMRF)
Importance Factor	I	= 1.0

Total load

Dead load	DL	= 0.1 kN/m^2
Live load	LL	= 0.5625 kN/m^2
(25% of reduction as per is 1893)		
Total load		= 0.6625 kN/m^2

D. Wind Load

Wind load is calculated as per IS: 875(Part 3)
Basic Wind speed

Vb = 50 m/sec
K1 = 1
K2 = 0.82 (Category: 3; class - C)
K3 = 1

Design Wind Speed

$$V_z = V_b K_1 K_2 K_3 = 41$$

Design Wind Pressure

$$P = 0.6\ V_z^2 = 1.009\ \text{kN/m}^2$$

The Internal Coefficients are taken as +0.2 and -0.2.

Wind Load on individual members are then calculated by

$$F = (C_{pe} - C_{pi}) \times A \times P$$

Where,

Cpe - External Coefficient
Cpi - Internal Coefficient
A - Surface Area (m^2)
P - Design Wind Pressure (kN/m^2)

External Pressure co – efficient for different types of roof are taken as below from IS: 875 (part-3)

Curved roof	-	Table: 15
Pitched roof	-	Table: 5
Monoslope roof	-	Table: 6

E. Load Combinations

For Strength (As per IS 800: 2007)

1.5 DEAD + 1.5 LIVE
1.2 DEAD + 1.2 LIVE + 0.6 WIND
1.2 DEAD + 1.2 LIVE + 0.6 SEIS
1.2 DEAD + 1.2 LIVE
1.2 DEAD + 1.2 LIVE + 1.2 WIND
1.2 DEAD + 1.2 LIVE + 1.2 SEIS
1.5 DEAD + 1.5 WIND
1.5 DEAD + 1.5 SEIS
1.0 DEAD + 0.35 LIVE

For Deflection (As per IS 800 - 2007)

1.0 DEAD + 1.00 LIVE
1.0 DEAD + 0.8 LIVE + 0.8 WIND
1.0 DEAD + 0.8 LIVE + 0.8 SEIS
1.0 DEAD + 0.8 LIVE
1.0 DEAD + 1.0 WIND

Above loads are applied in 2D frame in STAAD Pro

IV. ANALYSIS RESULTS

The Bending moment diagram for the three types of roof are given Fig :4, Fig : 5, Fig:6.

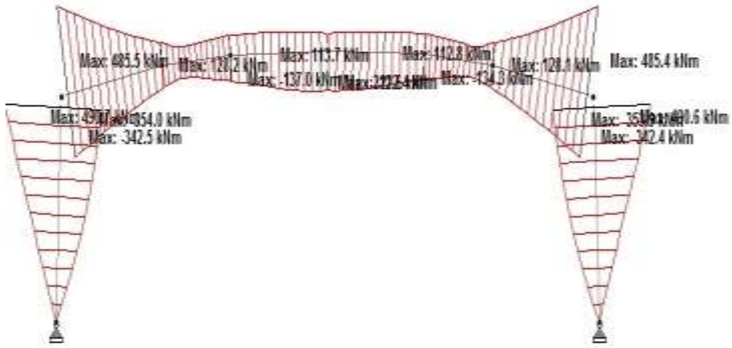

Fig: 4 BMD for Curved roof frame

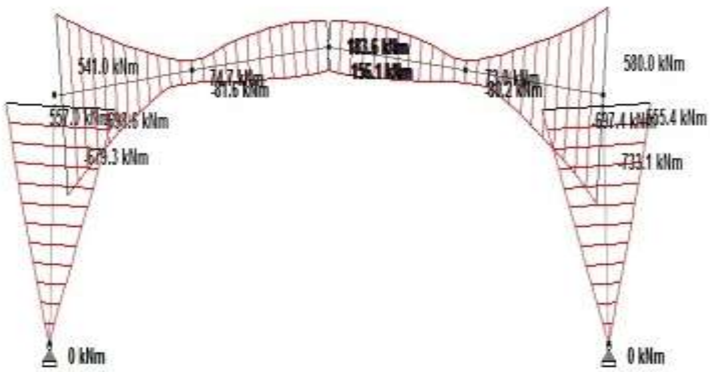

Fig: 5 BMD for Pitched roof frame

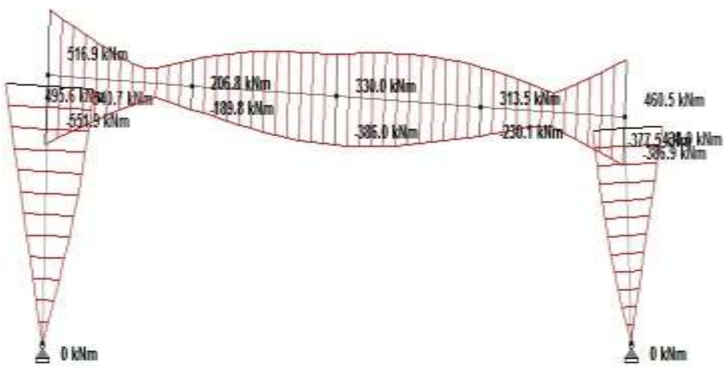

Fig: 6 BMD for MonoSlope roof frame

From the STADD Pro analysis results, Bending moment values, Shear force, Axial force, Deflection and Steel take off are obtained. From the results various charts are prepared as shown in the following figures. Fig: 7 & 8 Shows the comparative chart for BM in columns and rafters. Shear force values obtained for various types of roof frame are compared in Fig:9. Deflection and axial force of each frame are compared in Fig:10 & Fig:11.

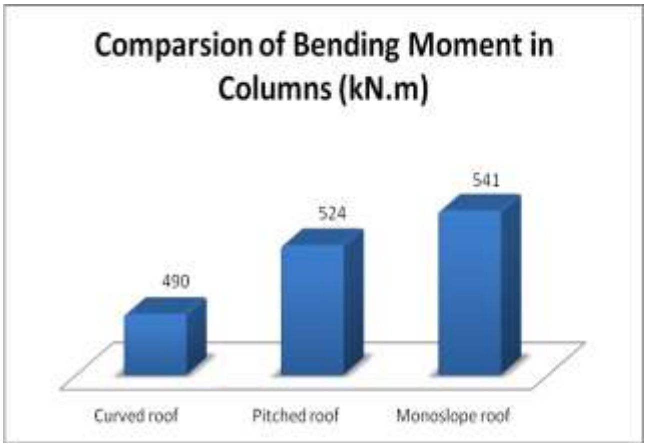

Fig: 7 BM in Columns of various roofs

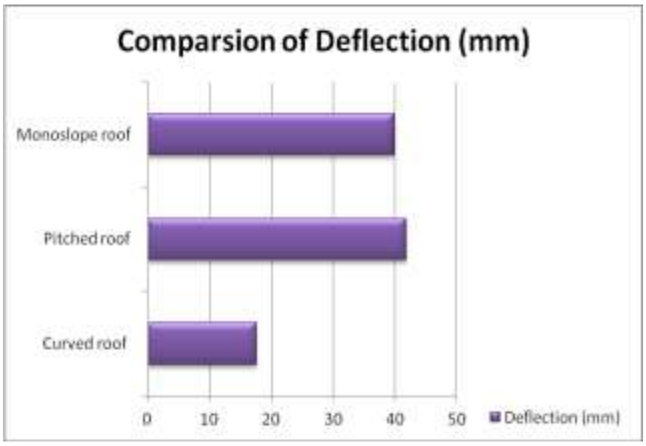

Fig: 10 Deflection of various roofs

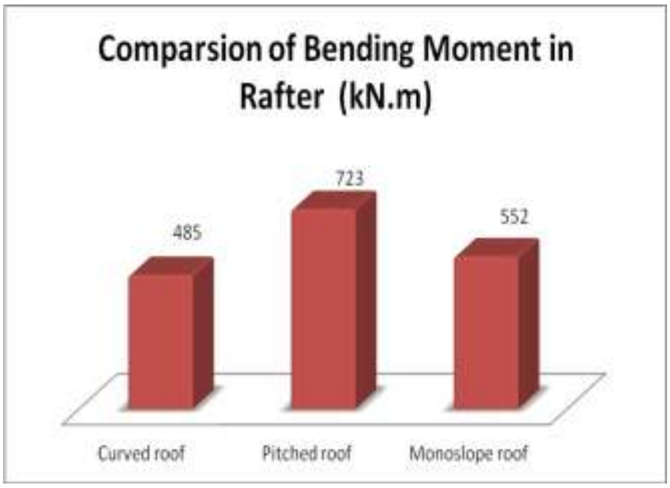

Fig: 8 BM in Rafters of various roofs

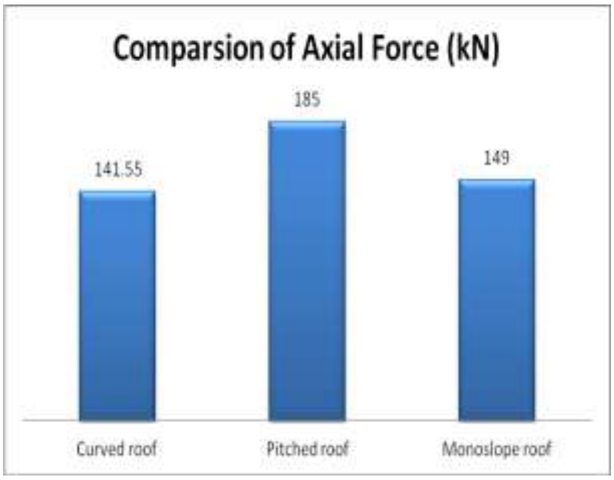

Fig: 11 axial forces in various roofs

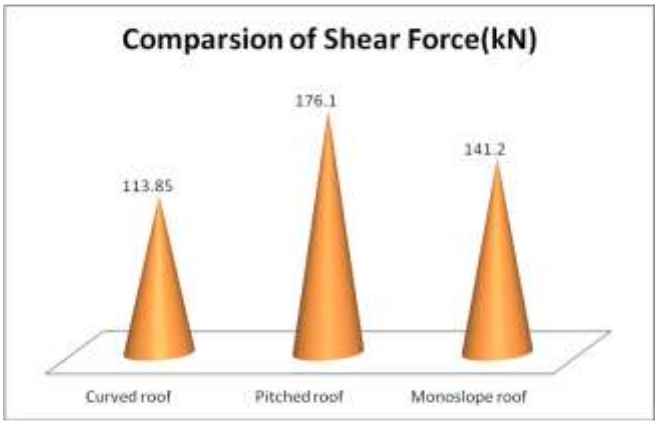

Fig:9 Shear force in various roof

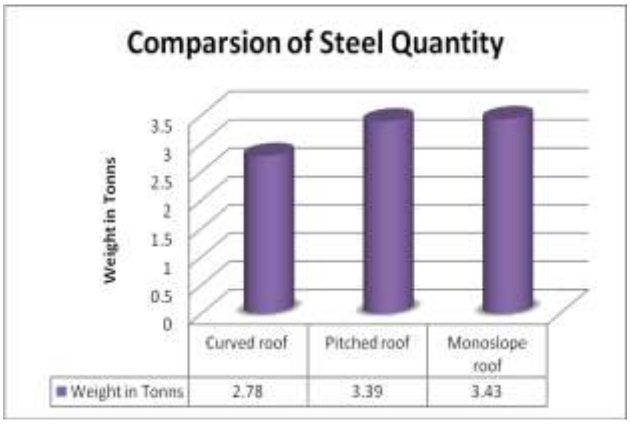

Fig : 12 Quantity of steel for various roofs

The quantity of steel for curved, Monosloped and Pitched roof are shown in above figure Fig:12. Note: steel quantity is calculated for single frame, not for entire building

V. DISCUSSION

- From Fig: 7 The Bending moment in columns is maximum for Mono sloped roof, Since it is sloping towards one end column, it will have max BM.
- From Fig: 8 The Bending moment in rafter is maximum for Pitched roof compared to other two roofs.
- The Shear force is maximum in pitched roof when compared to mono sloped roof and curved roof from Fig: 9.
- The maximum central deflection is produced in pitched roof 41.84mm, which is under permissible deflection as per IS:800 – 2007,referring Fig : 10.
- From Fig: 11 The Axial force in frame is maximum for Pitched roof when compared to other two roofs.
- It can be seen that curved roof frame consumes less steel compared to other two roofs. It consumes almost 19% of steel lesser than other two frames.

VI. CONCLUSION

In this study three types of roof PEB frames were analysed and designed as per IS codes. The various inferences made from the study are as follows.

- Curved roofs are aesthetically pleasing for design purposes to add architectural interest.
- Curved roof consumes less steel than the other frames which means that it is economical.
- Curved roof produced lesser deflection than other two frames, since it is in arch shape which is good in compression, it can take more load with less deflection.
- Pitched roof is easy to fabricate and erect than curved roof frames.
- Also Curved roof frame produces less support reactions, compared to other frames. Hence smaller size foundation is sufficient for the curved frame.
- Pitched roof are commonly used roofs for industrial buildings, as it is easy to fabricate and erect.
- Mono slope roofs are used for particular industry like north roofing truss building.

VII. REFERENCE

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