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Comparative Study of Pre Engineered and Conventional Steel Building

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***Abstract*— Pre Engineered Steel Buildings (PEB) fulfils the requirements of industrial steel structures along with reduced time and cost as compared to Conventional Steel Buildings (CSB). This methodology is versatile not only due to its quality predesigning and prefabrication, but also due to its light weight and economical construction. In the present work, Pre Engineered Steel Buildings (PEB) and Conventional Steel Buildings is designed for static and dynamic forces, which include wind forces and seismic forces. In this work, an industrial building of 60m length, 30m width and 10m eave height is located at Vijayawada and with different roof slopes like 5.71° & 7.125° as Pre-Engineered Steel Building and Conventional steel Buildings with 5.71° slope of roof is analysed and designed by using STAAD Pro V8i. Dead load is taken according to IS: 875 (Part 1)-1987. Live load is taken according to IS: 875(Part 2)-1987.Wind analysis has been done as per IS 875 (Part 3) -1987, seismic analysis has been carried out as per IS 1893 (2002) and cold formed sections are designed as per IS 801-1975.**

***Index Terms*— Conventional steel Buildings, Pre Engineered Steel Buildings, Seismic forces, Staad Pro V8i**

I. INTRODUCTION

Steel industry is growing rapidly in almost all the parts of the world. The use of steel structures is not only economical but also eco-friendly at the time when there is a threat of global warming. Here, "economical" word is stated considering time and cost. Time being the most important aspect, steel structures (Pre-fabricated) is built in very short period and one such example is Pre Engineered Buildings (PEB). The concept of Pre-engineered Building originated from United States of America in the 1960s. Although PEB systems are extensively used in industrial and many other non-residential constructions worldwide, it is relatively a new concept in India since 1990s.

Pre-engineered buildings are nothing but steel buildings in which excess steel is avoided by tapering the sections as per the bending moment's requirement. One may think about its possibility, but it's a fact many people are not aware about Pre Engineered Buildings. If we go for regular conventional steel structures, time frame will be more, and also cost will be more, and both together i.e. time and cost, makes it uneconomical. In pre-engineered buildings, the total design is done in the factory and as per the design members are pre-fabricated and then transported to the site where they are erected in a time less than 6 to 8 weeks. Pre-Engineered Buildings have bolted connections and hence can also be reused after dismantling. Thus, pre-engineered buildings can be shifted and/or expanded as per the requirements in future.

In this paper we will discuss the various advantages of pre-engineered buildings with different roof slopes and also, with the help of 3D model examples, a comparison will be made between pre-engineered buildings and conventional steel structures

II. FRAMING SYSTEM

A. Conventional Steel Buildings

Conventional steel buildings (CSB) are low rise steel structures with roofing systems of truss with roof coverings. Various types of roof trusses can be used for these structures depending upon the pitch of the truss. For large pitch, Fink type truss can be used; for medium pitch, Pratt type truss can be used and for small pitch, Howe type truss can be used. Skylight can be provided for day lighting and for more day lighting, quadrangular type truss can be used. The selection criterion of roof truss also includes the slope of the roof, fabrication and transportation methods, aesthetics, climatic conditions, etc. Several compound and combination type of economical roof trusses can also be selected depending upon the utility. Standard hot-rolled sections are usually used for the truss elements along with gusset plates. In this study, a 3D structure of Conventional Steel Buildings is considered, shown in Fig.1and also cross section of CSB is shown in Fig.2

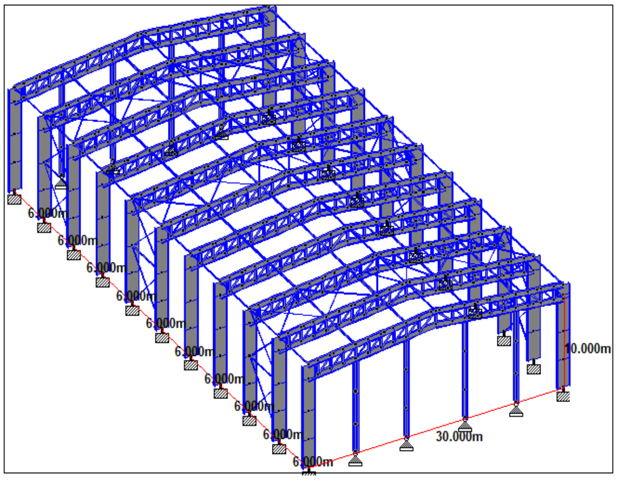

Fig.1 3D Structure of Conventional Steel Buildings

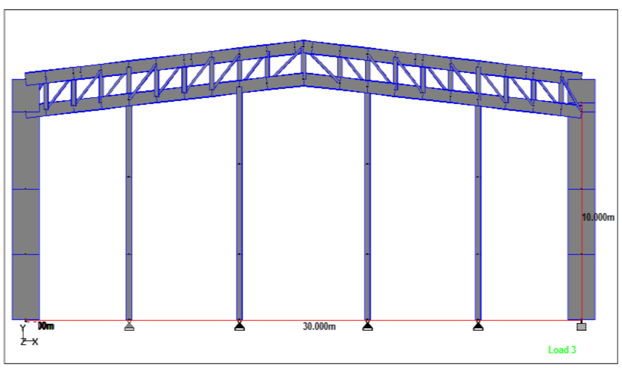

Fig.2 Cross section of Conventional Steel Buildings

B. Pre Engineered steel Buildings

Pre-Engineered steel Building (PEB) concept involves the steel building systems which are predesigned and prefabricated. As the name indicates, this concept involves pre-engineering of structural elements using a predetermined registry of building materials and manufacturing techniques that can be proficiently complied with a wide range of structural and aesthetic design requirements. The basis of the PEB concept lies in providing the section at a location only according to the requirement at that spot. The sections can be varying throughout the length according to the bending moment diagram. This leads to the utilization of non-prismatic rigid frames with slender elements. Tapered I sections made with built-up thin plates are used to achieve this configuration. Standard hot-rolled sections, cold-formed sections [13], profiled roofing sheets, etc. is also used along with the tapered sections. The use of optimal least section leads to effective saving of steel and cost reduction. In this study, a 3D structure of Pre-Engineered Steel Buildings is considered, shown in Fig.3 and also cross section of PEB is shown in Fig.4

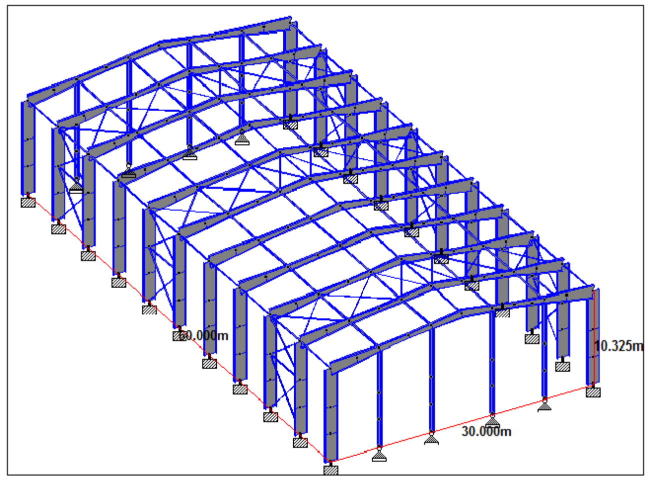

Fig.3 3D Structure of Conventional Steel Buildings

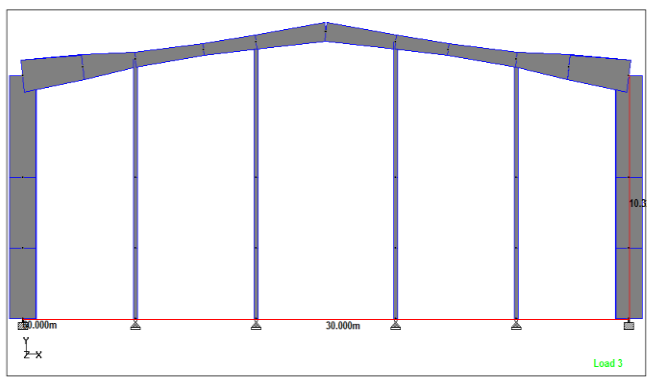

Fig.4 Cross section of Conventional Steel Buildings

Following are some of the advantages PEB

a) Construction Time: Buildings are generally constructed in just 6 to 8 weeks after approval of drawings. PEB will thus reduce total construction time of the project by at least 40%. This allows faster occupancy and earlier realization of revenue.

This is one of the main advantages of using Pre-engineered building.

b) Lower Cost: Because of systems approach, considerable saving is achieved in design, manufacturing and erection cost.

c) Flexibility of Expansion: As discussed earlier, these can be easily expanded in length by adding additional bays. Also expansion in width and height is possible by pre designing for future expansion.

d) Large Clear Spans: Buildings can be supplied to around 90m clear spans. This is one of the most important advantages of PEB giving column free space.

e) Quality Control: Buildings are manufactured completely in the factory under controlled conditions, and hence the quality can be assured.

f) Low Maintenance: PEB Buildings have high quality paint systems for cladding and steel to suit ambient conditions at the site, which in turn gives long durability and low maintenance coats.

g) Energy Efficient Roofing: Buildings are supplied with polyurethane insulated panels or fiberglass blankets insulation to achieve required "U" values

h) Erection: As PEB sections are lighter in weight, the small members can be very easily assembled.

The most common applications of pre-engineered buildings are:

a) Industrial: Factories, Workshops, Warehouses, Cold stores, Car parking sheds, Slaughter houses, Bulk product storage.

b) Commercial: Showrooms, Distribution centres, Supermarkets, Fast food restaurants, Offices, Labour camps, Service station, Shopping centres.

c) Institutional: Schools, Exhibition halls, Hospitals, Theatres/auditoriums, Sports halls.

d) Recreational: Gymnasiums, swimming pool enclosures, Indoor tennis courts.

e) Aviation & Military: Aircraft hangars, Administration buildings, Residential barracks.

f) Agricultural: Poultry buildings, Dairy farms, Greenhouses, Grain storage, Animal confinement.

III. METHODOLOGY

In the present work, by using STAAD Pro V8i software three different types of 3D steel buildings are designed for static and dynamic forces. In this work, an industrial building of length 60m with bay spacing at 6m along the length, 30m width and10m eave height in which 3 m from ground level is used for brick work and remaining 7 m is used for cladding is located at Vijayawada. The slope of roof is taken as 5.71° for both Pre-Engineered steel Building and Conventional steel buildings, and also another Pre-Engineered steel Building is designed for roof slope 7.125° and roofs are covered with GI sheet. The spacing of the purlins and girts are maintained as 1.5m.

Table 1: Structure Parameters

Type of building	Industrial building
Location	Vijayawada
Area of building	1800 m^2
Eave height	10 m
Span width	30 m
Total length	60 m
Support condition	Fixed and pinned
PEB roof slope	5.71˚and 7.125 ˚
CSB roof slope	5.71˚

IV. LOAD CALCULATIONS

A. Dead load:

Dead load is calculated According to IS: 875 (Part 1) -1987[9].

Weight of the G.I sheet = 0.131 KN/m^2

(Class 1 G.I sheeting, thickness 1.60 mm)

Weight of fixings = 0.025 KN/m^2

Total weight = 0.156 KN/m^2

Spacing of the purlin = 1.5 m

Total weight on purlins = 0.156 × 1.5 = 0.234 KN/m

B. Live Load:

The Live load is calculated according to IS: 875 (Part 2) -1987 [10].

Live load on the sloping roof is = 750 – 20(α -10) in N/m2, Where α = 5.71°

Live load on purlins = 0.750 KN/m^2

Live load on purlins =0.75 × 1.5 = 1.125 KN/m.

C. Earthquake Load

Earthquake loads are calculated as per IS: 1893-2002[12]

Dead load = 0.156 KN/m^2

Live load = 0.1875 KN/m^2 (25٪ of reduction as per is 1893-2002)

Total load = 0.3435 KN/m^2

Bay width of the building is 6 m

Therefore earthquake load on rafter

= 0.3435 × 6 = 2.061 kN/m.

D. Wind Load

Wind load is calculated as per IS: 875 (Part 3) – 1987[11]
Basic Wind speed V_b = 50 m/sec for Vijayawada
Risk coefficient factor (k_1) = 1(50 years design life of structure for all general buildings)
Terrain and height factor (k_2) = 0.954 (category 2, class C and height 10 m)
Topography factor (k_3) = 1 (upwind slope of the site is less than 3˚)
Design wind speed $V_z = V_b \times k_1 \times k_2 \times k_3$
Design wind speed $V_z = 50 \times 1 \times 0.954 \times 1 = 47.7$ m/s
The Internal Coefficients are taken as +0.5 and -0.5.
Wind Load on individual members are then calculated by
Wind Load F = (Cpe – Cpi) x A x P in KN
Where, Cpe – External Coefficient
Cpi – Internal Coefficient
A – Surface Area in m2
P – Design Wind Pressure in kN/m2

V. STAAD PRO PROCEDURE

In the present study, STAAD Pro V8i software has been used in order to analyse and design PEB and CSB. It gives the Bending moment, Shear Forces, Axial Forces of a Steel structure so that the design can be done using Tapered Sections and check for safety in Pre Engineered Buildings.

VI. RESULTS

Table 3: Quantity of steel utilized

Type of Structure	Quantity of steel (Tonnes)
CSB with roof slope 5.71°	129.82
PEB with roof slope 5.71°	80.421
PEB with roof slope 7.125°	77.05

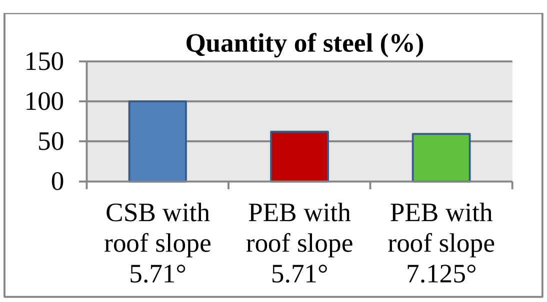

Fig.5 Quantity of steel utilised

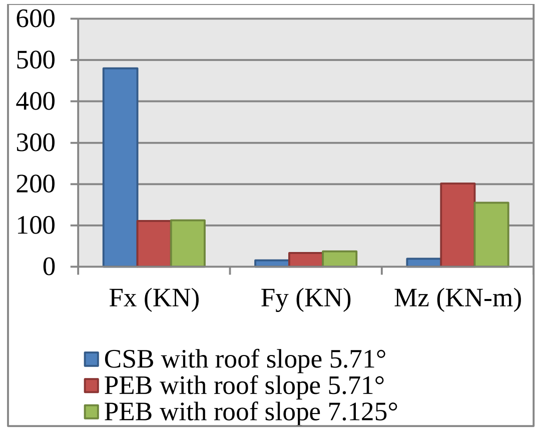

Fig.6 Bending moments and reactions at ridge portion of middle frames

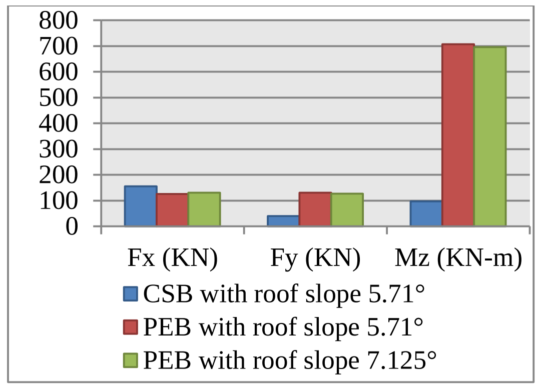

Fig.7 Bending moments and reactions at haunch portion of middle frames

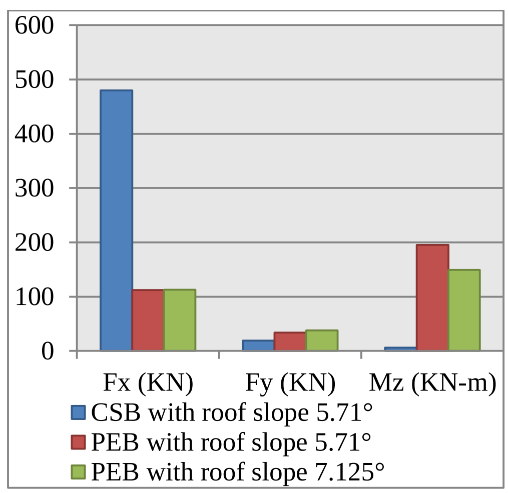

Fig.8 Bending moments and reactions at ridge Portion of end frames

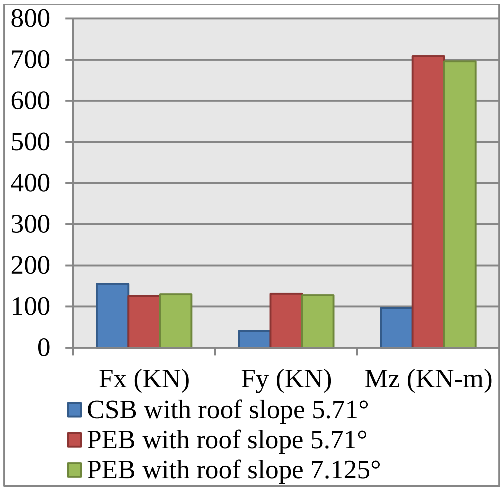

Fig.9 Bending moments and reactions at haunch portion of end frames

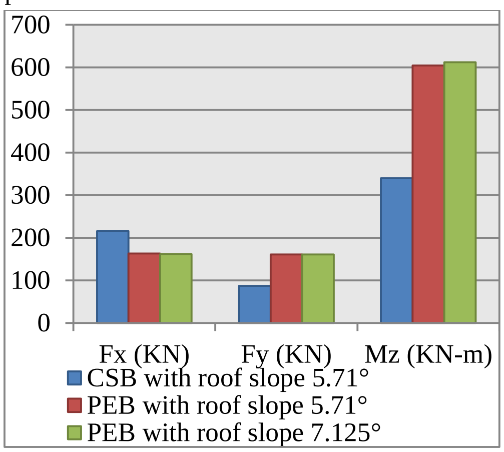

Fig.10 Bending moments and reactions at Supports

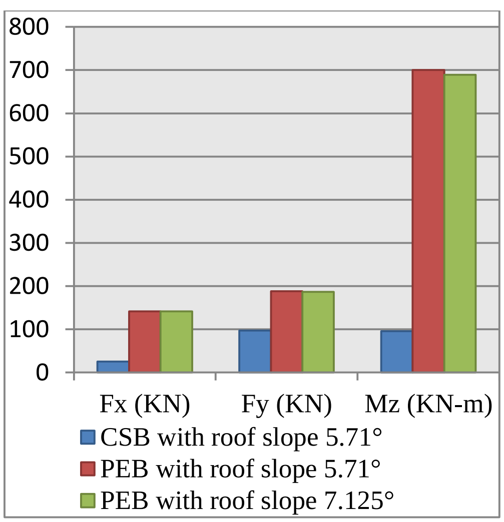

Fig.11 Bending moments and reactions in Columns

VII. CONCLUSION

This paper effectively conveys that Pre-Engineered steel Buildings can be easily designed by simple design procedures in accordance Low weight flexible frames of Pre-Engineered steel Building offer higher resistance to earthquake loads. After analysing, the following are the conclusions of Pre-Engineered steel Building when compared with Conventional Steel Buildings

1. The total steel take-off for PEB with slope 5.71˚ is 62% of the conventional steel building, shown in Fig.5.
2. The total steel take-off for PEB with slope 7.125˚ is 59.35% of the conventional steel building in Fig.5.
3. Steel take-off is more for PEB with flat roof compared to PEB with steep roof. The total steel take-off for PEB with slope 5.71˚ is more than the total steel take-off for PEB with slope 7.125˚
4. The axial forces for both haunch and ridge portions are less in PEB with slope 5.71˚ when compared to CSB with slope 5.71˚ & PEB with slope 7.125˚ at both end and middle frames.
5. The shear forces for both haunch and ridge portion are more in PEB with slope 5.71˚ when compared to CSB with slope 5.71˚ at both end and middle frames.
6. The moments for both haunch and ridge portion are more in PEB with slope 5.71˚ when compared to CSB with slope 5.71˚ at both end and middle frames.
7. The moments for both haunch and ridge portion are more in PEB with slope 5.71˚ when compared to PEB with slope 7.125˚ at both end and middle frames.
8. The axial forces at supports are less in PEB with slope 5.71˚ when compared to CSB with slope 5.71˚ & PEB with slope 7.125˚ at both end and middle frames.
9. The moments at supports are more in PEB with slope 5.71˚ when compared to CSB with slope 5.71˚ & PEB with slope 7.125˚ at both end and middle frames.
10. The axial forces in columns are less in PEB with slope 5.71˚ when compared to CSB

with slope 5.71˚ & PEB with slope 7.125˚ at both end and middle frames.

REFERENCES

[1] Bhavikatti S.S, "*Design of steel structures by limit state method as per IS 800-2007*", I.K.International publishing house Pvt.Ltd., New Delhi, (2010).

[3] Darshana P.Zoad, "Evaluation of Pre-Engineering Structure Design by IS-800 as against Pre-Engineering Structure Design by AISC", *International Journal of Engineering Research and technology* (IJERT), Volume-1, issue 5, July 2012

[4] Duggal S.K, "*Limit State Design of steel Structural*" Tata McGraw Hill education

[5] Subramanian N, "*Design of steel structures*", Oxford higher education, Chennai (2008).

[6] Subramanian. N, "*Pre- Engineered buildings selection of framing system, roofing and wall materials*" The Master builder, July,2008, pp 48-62

[7] Zamil steel, "Technical Manual" January 1999.

[8] IS 800, "*General construct in steel – code of practice*" Bureau of Indian standards, New Delhi, (2007).

[9] IS 875 (part 1) "*Code of practice for design loads (other than earthquake) for building and structures*", dead loads, New Delhi,1987.

[10] IS 875 (part 2) "*Code of practice for design loads (other than earthquake) for building and structures*", Imposed loads, New Delhi, 1987.

[11] IS 875 (part 3) "*Code of practice for design loads (other than earthquake) for building and structures*", wind loads, New Delhi,1987.

[12] IS 1893-2002 "*Code of practice for Seismic loads"*

[13] IS 801- 1975 "*Code of Practice for Use of Cold-Formed Light Weight Gauge*"