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Comparative Study of Pre-Engineered and Conventional Steel Frames for Different Wind Zones

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Abstract:- In this paper, the conventional steel frames having triangular Pratt truss as a roofing system of 60 m length, span 30m and varying bay spacing 4m, 5m and 6m respectively having eaves level for all the portals is at 10m and the EOT crane is supported at the height of 8m from ground level and pre-engineered steel frames of same dimensions are analyzed and designed for wind zones (wind zone 2, wind zone 3, wind zone 4 and wind zone 5) by using STAAD Pro V8i. The study deals with the comparative study of both conventional and pre-engineered with respect to the amount of structural steel required, reduction in dead load of the structure.

Keywords: - Pre-engineered steel frame, STAAD Pro V8i, Tapered section.

I. INTRODUCTION

1.1 General

Most of the steel structures are builted – up with conventional sections of steels which are designed and constructed by conventional methods. This leads to heavy or uneconomical structures. The structural members are hot rolled and are used in conventional steel frames. Now a day's pre-engineered steel frames are the best replacement to the conventional ones with their useful and comparatively better properties. The scientific – sounding term pre-engineered frame came into being in the 1960s. The frames were "pre-engineered" because, like their ancestors, they relied upon standard engineering designs for a limited number of off-the-shelf configurations.[1]

II. METHODOLOGY

In the present study, conventional steel frames and pre-engineered frames are considered for the analysis and design using Staad. Pro V8i. Conventional steel frame of length 60m and span 30m. Bay spacing varies from 4m, 5m and 6m. Eaves level for all portals is at 10m from the ground level. The EOT crane is supported at the height of 8m from ground level. The selected conventional steel frame is a built up column comprising of Indian standard channel section laced together and triangular Pratt truss as a roofing system. The basic frame for a pre-engineered building portal is a Single span rigid frame with pinned base comprising of tapered column and rafter welded together. The length of the building, span, bay spacing, Eaves level and the level of the EOT carne are all similar to that of conventional steel building but the angle of the pitch roof is maintained at 6° with the horizontal. Analysis and design of members in conventional steel frame (lacing column, rafter, column supporting truss, bottom chord, internal members) and in pre-engineered steel frame (tapered column and tapered rafter) for wind zones (wind zone 2, wind zone 3, wind zone 4 and wind zone 5) are by using Staad Pro V8i. Analysis and design of secondary member (purlin) of conventional and pre-engineered steel frame is by using Excel sheet.

III. ADVANTAGES OF PRE-ENGINEERED FRAME STRCUCTURE

1. PEB system is zero maintenance and superior in strength
2. It is corrosion resistance & feature an attractive appearance
3. Steel arriving at the site is dry with no residual oil on the surface
4. PEB system is excellent resistant in transit to corrosion and storage strain
5.This system reduces energy loads on buildings due to long term bright surface that helps to retain heat reflectivity
6. It is a higher level technology & innovation & better product over conventional materialEB system has protection against non uniform weathering

IV. LOAD CALCULATIONS

3.1 Model of conventional steel frame on Staad. Pro V8i

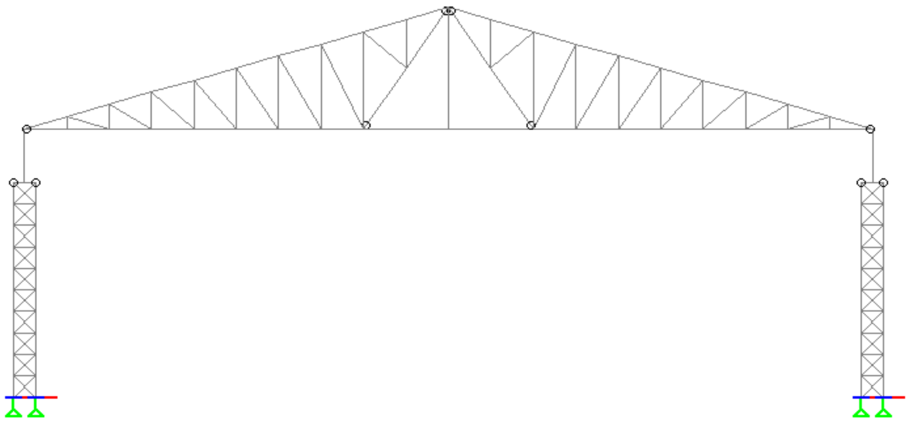


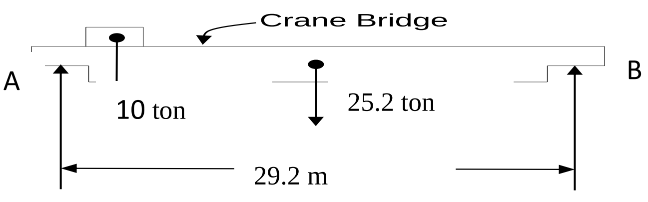
Fig 1 : Model of conventional steel frame on Staad. Pro V8i

3.1.1 Dead load on conventional steel frame

Dead load is calculated according to IS:875 (Part 1).
a) Purlin load
Assumed Channel Section ISMC 125
Wt = 12.7 kg/m
Spacing of purlin = 1.57m
Load per square meter = 12.7/1.57
= 8.09 kg/m^2
= say 0.0809 kN/m^2
Bay spacing is 5m c/c
Intensity of load on rafter = 5 × 0.0809 = 0.4045 kN/m
Hence purlin load = 0.4045 kN/m
b) Sheeting load
Galvanized sheeting (1.6mm thk) = 0.131 kN/m^2 (from IS 875 – 1987 Part 1)
Intensity of load on rafter = 5 × 0.131 = 0.655 kN/m

3.1.2 Crane load calculation for conventional steel frame

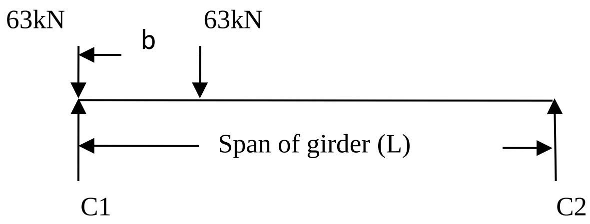
Crane capacity	=	100 kN
Weight of crane excluding crab	=	252 kN
Span of crane between rails (B)	=	29.2m
Minimum hook approach (a)	=	0.85m
Wheel base (b)	=	4m
Span of gantry girder (L)	=	5m



a) Crane dead load calculation

Max reaction at A = 252/2 = 126 kN
Since there are two wheels at A = 126/2 = 63 kN
Total load on column C1 = 63+ (63 x (5 – 4) / 5) = 75.6 kN

b) Crane live load calculation
Crane dead load calculation



Max reaction at A = ((29.2 – 0.85) × 100) / 29.2 = 97.08 kN
Min reaction at B = 100 – 97.08 = 2.92 kN
Since there are two wheels at A = 97.08 / 2 = 48.54 kN
Since there are two wheels at B = 2.92 / 2 = 1.46 kN
Since it's an EOT crane taking 25% impact allowance
Total load for A = 48.54 × 1.25 = 60.68 kN
Total load for B = 1.46 ×1.25 = 1.825 kN
Total load on column C1 = 60.68 + (60.68 × (5 – 4)) / 5 = 72.82 kN
Total load on column C2 = 1.825 + (1.825 × (5 – 4)) / 5 = 2.19 kN
Horizontal thrust
10% wt of trolley + lifted load = 10 kN
This load is transferred to the crane girder through two wheels of craneLoad on wheels = 10/2 = 5 kN
Load on column = 5 + (5 × 1) /(5) = 6 kN

Summary of crane load:

Dead load on column A and B	=	75.6 kN
Live load on column A	=	72.82 kN
Live load on column B	=	2.19 kN
Horizontal thrust	=	6 kN

3.1.3 Live load on conventional steel frame
Live load is calculated according to IS:875 (Part 2).
The slope of the roof is 16.7° the live load for non accessible roof of 0.75 kN/m^2 is reduce to 0.62 kN/m^2 by 0.02 kN/m^2 for every degree increase in slope over 10°.
Intensity of load on rafter = 0.62 × 5 = 3.1 kN/m

3.1.4 Wind load on conventional steel frame
Wind load is calculated according to IS:875 (Part 3).
Location: Bombay
Terrain: Category 1 Class: B
Risk coefficient (k_1): 1
Structure size factor (k_2): 1.04
Topography factor (k_3): 1
Basic wind speed (V_b): 44 m/s
Design wind velocity (V_z): 44 x 1 x 1.04 x 1 = 45.8 m/s
Design wind pressure (P_z): 0.6 x 45.8^2 = 1.25 kN/m^2
The internal pressure coefficients are taken as +0.2 and -0.2.
Building height ratio (h/w): 0.34 and Building plan ratio (L/w): 1.34
External pressure coefficients (C_{pe}) for walls of rectangular clad building are taken as +0.7 and -0.25
External pressure coefficients (C_{pe}) for pitch roof of rectangular clad building are taken as -0.64 and -0.4
Roof angle – 16.7^0
Wind load on individual members are then calculated by
$F = (C_{pe} – C_{pi}) \times A \times P_z$

3.2 Model of pre-engineered steel frame on Staad. Pro V8i

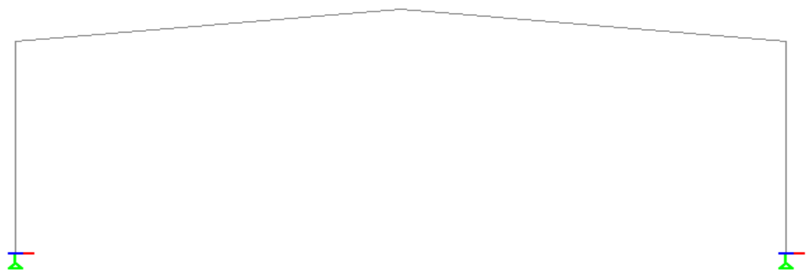


Fig 2 : Model of pre-engineered steel frame on Staad. Pro V8i

3.2.1 Dead load on pre-engineered steel frame

a) Purlin load
Assumed Z - section with clips 200×60×20×3.15
Wt = 8.23 kg/m
Spacing of purlin = 1.51m
Load per square meter = 8.23/1.51
= 5.45 kg/m^2
= say 0.0545 kN/m^2
Bay spacing is 5m c/c
Intensity of load on rafter = 5 × 0.0545 = 0.29 kN/m
Hence purlin load = 0.2725 kN/m
b) Sheeting load
Galvanized sheeting (0.63mm thk) = 0.056 kN/m^2 (from IS 875 – 1987 Part 1)
Intensity of load on rafter = 5 × 0.056 = 0.28 kN/m
3.2.2 Crane load calculation for pre-engineered steel frame
Crane load calculations are same as that for conventional portal hence refer (3.1.2 load calculation for carne load)
Summary of crane load:

Dead load on column A and B	=	75.6 kN
Live load on column A	=	72.82 kN
Live load on column B	=	2.19 kN
Horizontal thrust	=	6 kN

3.2.3 Live load on pre-engineered steel frame
The slope of the roof is 6° the live load for non accessible roof of 0.75 kN/m^2 is adopted.With the Bay spacing of 5m.
Intensity of load on the rafter = 5 × 0.75 = 3.75 kN/m

3.2.4 Wind load on conventional steel frame

Location: Bombay
Terrain: Category 1 Class: B
Risk coefficient (k_1): 1
Structure size factor (k_2): 1.04
Topography factor (k_3): 1
Basic wind speed (V_b): 44 m/s
Design wind velocity (V_z): 44 x 1 x 1.04 x 1 = 45.8 m/s
Design wind pressure (P_z): 0.6 x 45.8^2 = 1.25 kN/m^2
The internal coefficients are taken as +0.2 and -0.2.
Building height ratio (h/w): 0.34 and Building plan ratio (L/w): 1.34
External pressure coefficients (C_{pe}) for walls of rectangular clad building are taken as +0.7 and -0.25
External pressure coefficients (C_{pe}) for pitch roof of rectangular clad building are taken as -0.96 and -0.4
Roof angle - 6^0
Wind load on individual members are then calculated by
$F = (C_{pe} – C_{pi}) \times A \times P_z$

V. RESULTS

5.1 Graphical representation of result comparison of structure for span 30 m and bay spacing 4 m

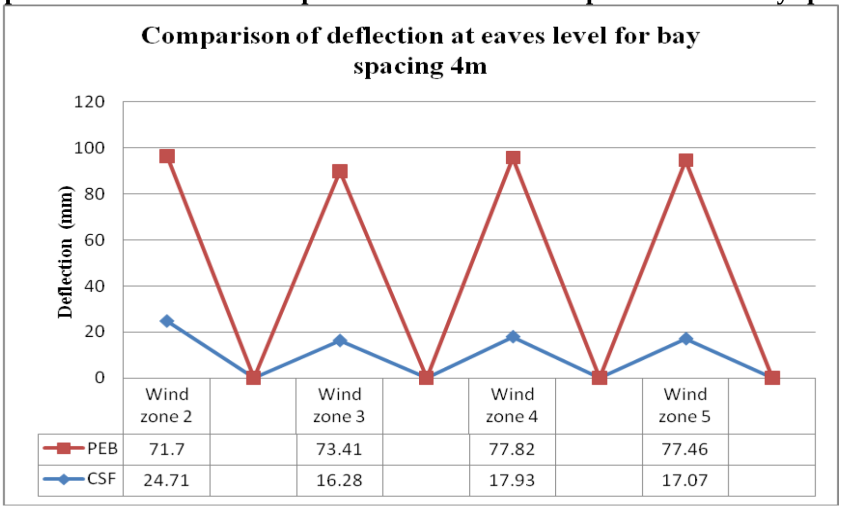


Fig 3 : Graphical representation of comparison of deflection at eaves level for bay spacing 4m

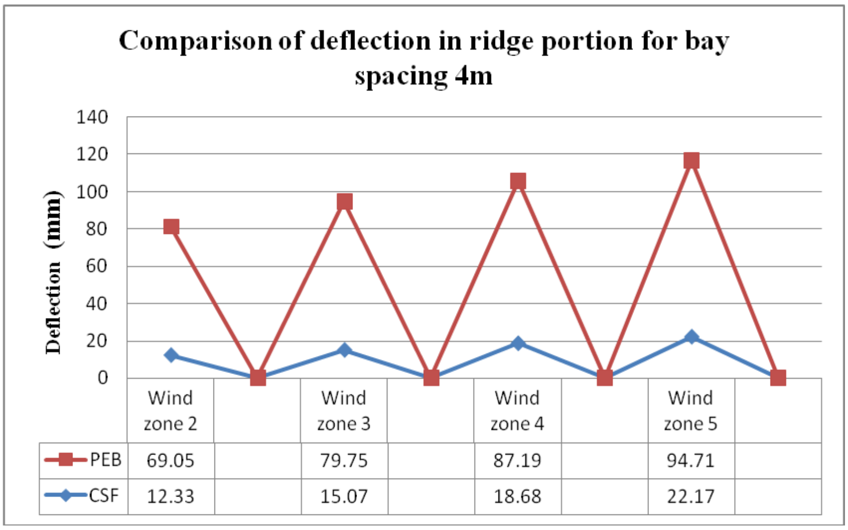


Fig 4 : Graphical representation of comparison of deflection in ridge portion for bay spacing 4m

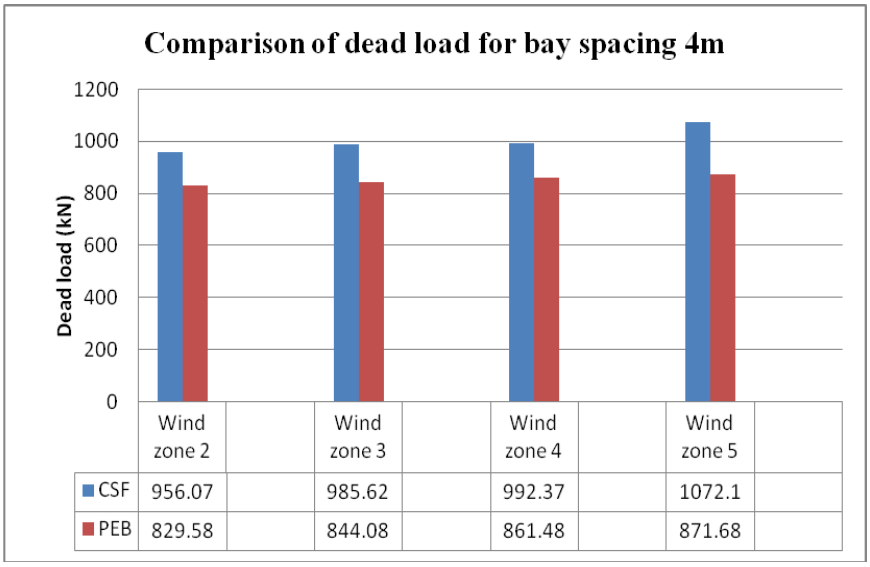


Fig 5 : Graphical representation of comparison of dead load for bay spacing 4m

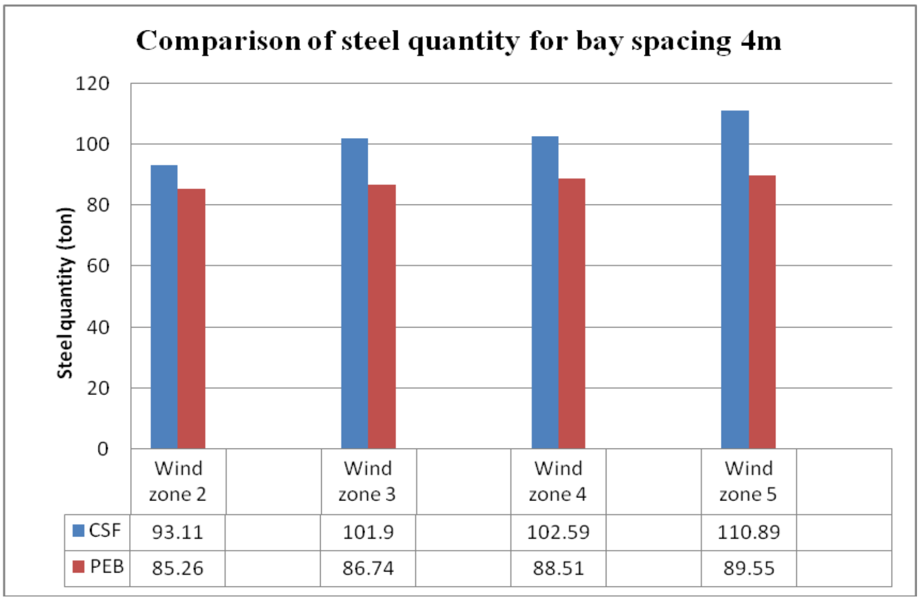


Fig 6 : Graphical representation of comparison of steel quantity for bay spacing 4m

5.2 Graphical representation of result comparison of structure for span 30 m and bay spacing 5 m

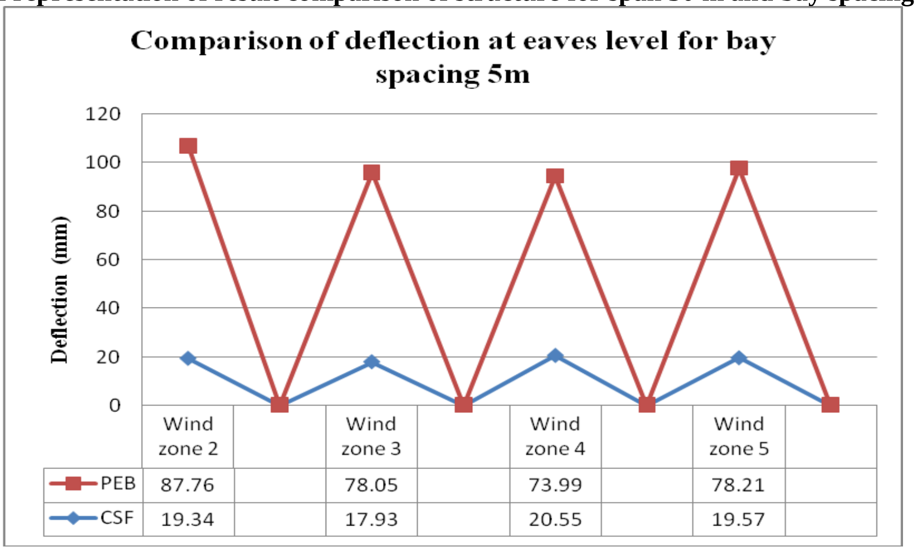


Fig 7 : Graphical representation of comparison of deflection at eaves level for bay spacing 5m

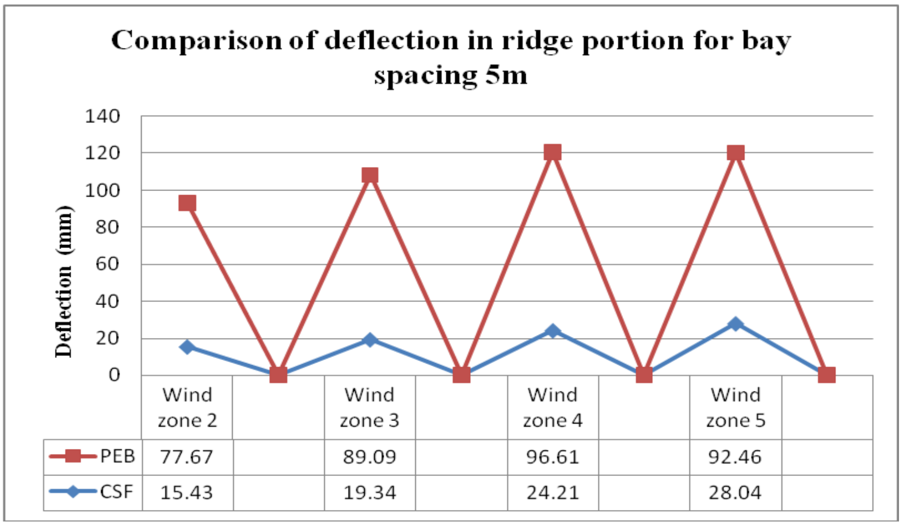


Fig 8 : Graphical representation of comparison of deflection in ridge portion for bay spacing 5m

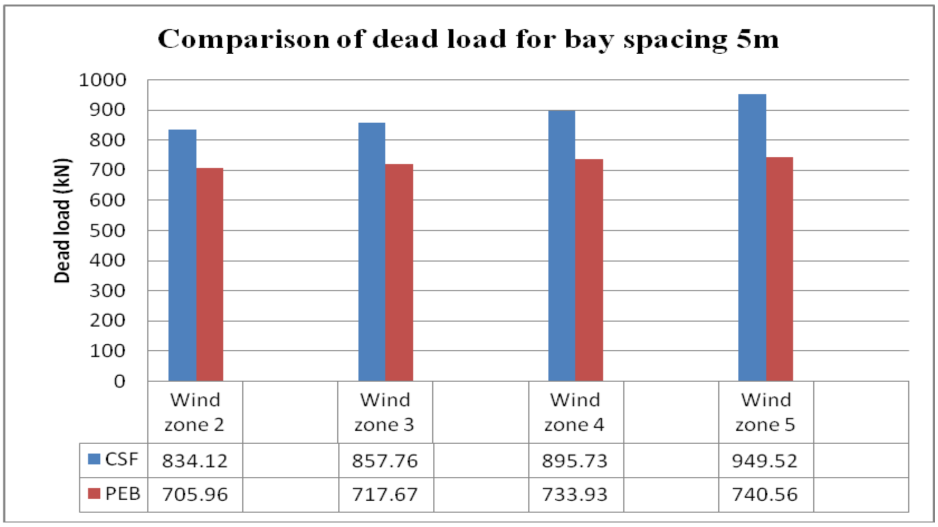


Fig 9 : Graphical representation of comparison of dead load for bay spacing 5m

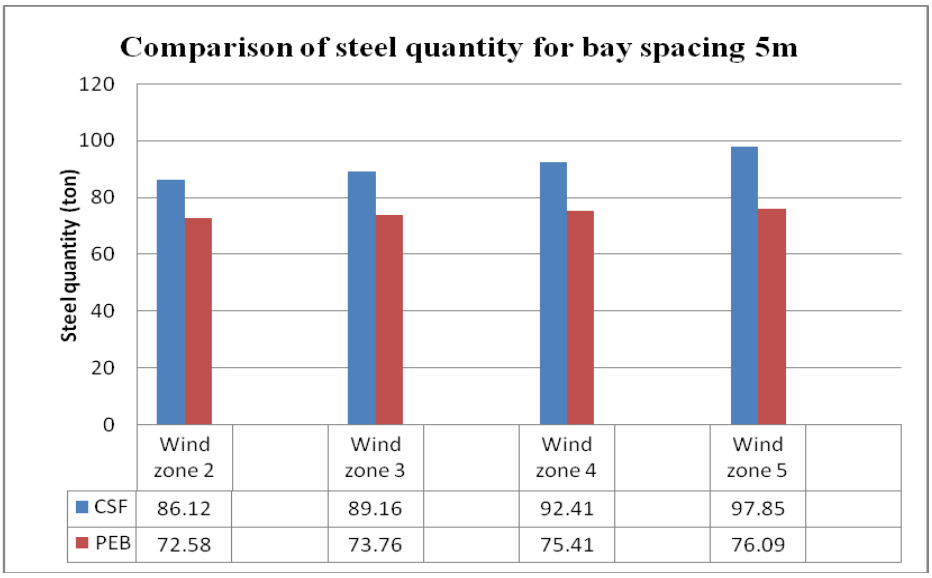


Fig 10 : Graphical representation of comparison of sreel quantity for bay spacing 5m

5.2 Graphical representation of result comparison of structure for span 30 m and bay spacing 6 m

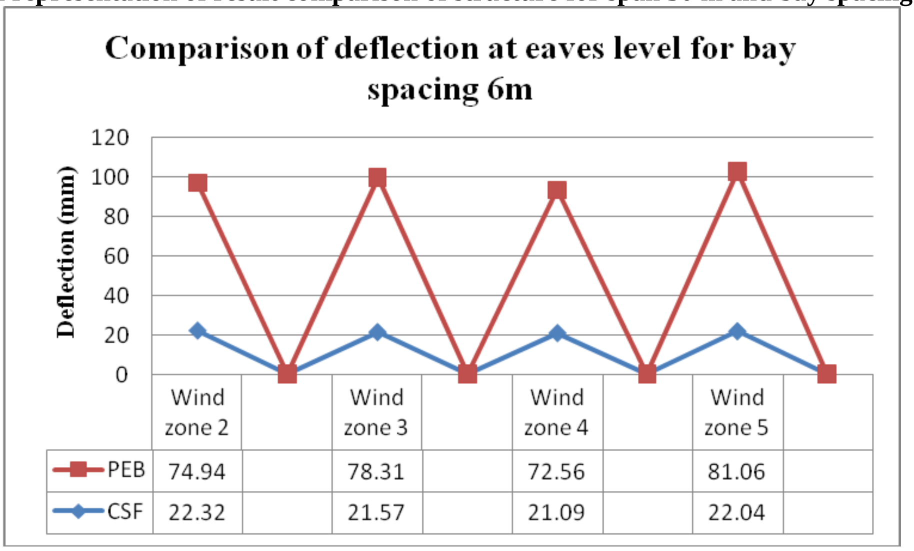


Fig 11 : Graphical representation of comparison of deflection at eaves level for bay spacing 6m

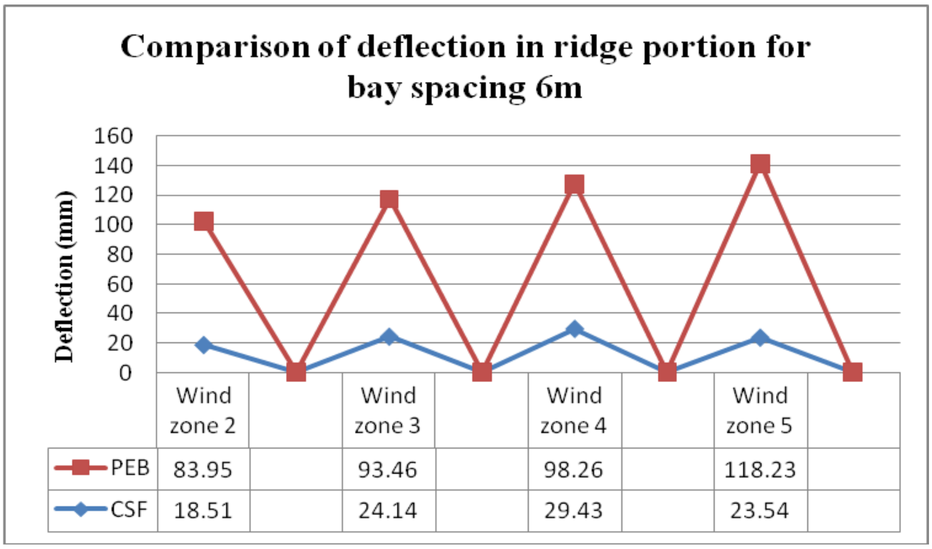


Fig 12 : Graphical representation of comparison of deflection in ridge portion for bay spacing 6m

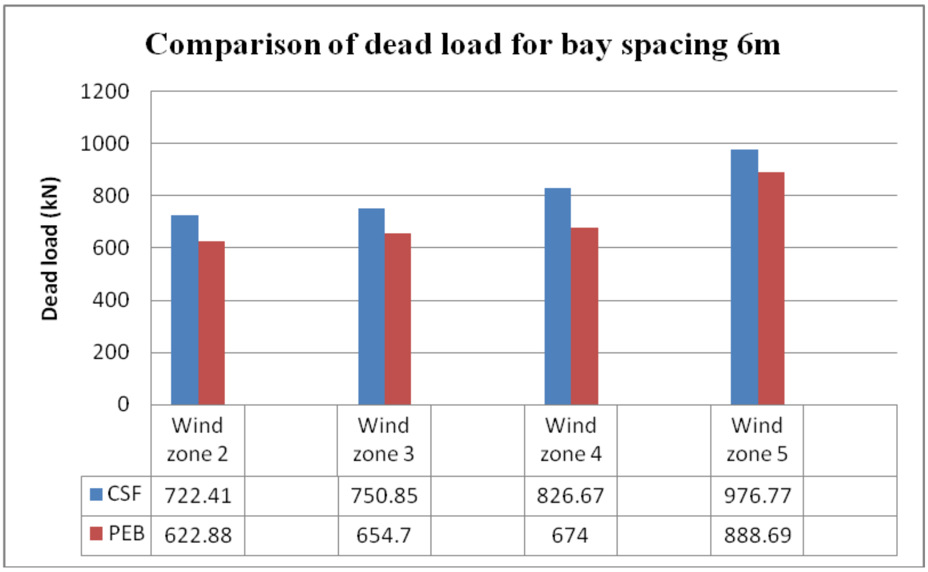


Fig 13 : Graphical representation of comparison of dead load for bay spacing 6 m

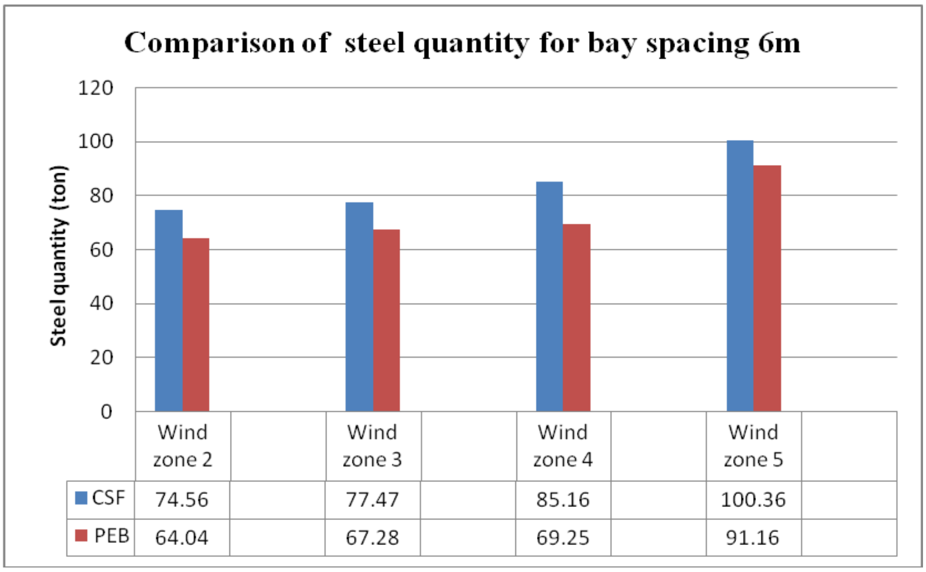


Fig 14 : Graphical representation of comparison of steel quantity for bay spacing 6m

VI. DISCUSSIONS

Deflection in ridge portion and eaves level in pre-engineered steel frames always more due to light weight structure when compared to that deflection in conventional steel frames.

From the graphs, it is seen that result on an average of consumption of steel for considered wind zones(wind zone 2, wind zone 3, wind zone 4, wind zone 5) is about 14%, 18% & 14% more in case of conventional steel frames of bay spacing 4m, 5m and 6m respectively, as compared to pre-engineered steel frames.

From the graphs, it is seen that result on an average of dead load of the structure for considered wind zones(wind zone 2, wind zone 3, wind zone 4, wind zone 5) is reduced about 19%, 23% & 18% in pre-engineered steel frames as compared to conventional steel frames.

A remarkable reduction in dead load is due to use of tapered sections with large depths instead of hot rolled steel sections. The use of light weight cold form purlin Z - section also plays a significant role in reducing the dead load.

VII. CONCLUSION

The comparative study of pre-engineered and conventional steel frames shows that pre-engineered steel frames are beneficial for ware houses equipped with cranes. Pre engineered structure is more economical than conventional steel structure because of less steel required. Apart from main parameters steel quantity, reduction in dead load, concrete quantity and cost, transportation cost, time for completing the project, speed and quality of work are also the advantages of pre-engineered steel frames. And in this way, all the advantages of pre engineered Steel structures can be claimed.

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