OPTIMIZATION OF WAREHOUSE DESIGN WITH PEB SYSTEM RESTING ON DIFFERENT SOIL STRATA

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***Abstract*: This paper describes the displacement and weight comparison of pre-engineered warehouse structure with respect to changes in foundation strata such as fixed and pinned base.The concept of PEB is the frame geometry which matches the shape of the internal stress (bending moment) diagram thus optimizing material usage and reducing the total weight of the structure.**

Keywords: Pre-engineered building; Tapered I section; fixed and pinned support; STAAD-PRO.

I. INTRODUCTION

Pre-Engineered Building concept involves the steel building systems which are predesigned and prefabricated. 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. The use of optimal least section leads to effective saving of steel and cost reduction. The concept of PEB is the frame geometry which matches the shape of the internal stress (bending moment) diagram thus optimizing material usage and reducing the total weight of the structure.

Presently, large column free area is the utmost requirement for any type of industry and with the advent of computer software's it is now easily possible. With the improvement in technology, computer software's have contributed immensely to the enhancement of quality of life through new researches. pre-engineered building is one of such revolution are fully fabricated in the factory after designing, then transported to the site and all components are assembled and erected with nut-bolts, thereby reducing the time of completion.Pre-Engineered Buildings have bolted connections and hence can also be reused after dismantling.

This flexibility would seem to readily lenditself to optimization of member cross-section shapes. India has the second fastest growing economy in the world and a lot of it, is attributed to its construction industry which figures just next to agriculture in its economic contribution to the nation. In its steadfast development, the construction industry has discovered, invented and developed a number of technologies, systems and products, one of them being the concept of Pre-engineered Buildings. Steel is a material which has high strength per unit mass. Hence it is used in construction of structures with large column-free space. The scientific-sounding term pre-engineered buildings came into being in the 1960s. The buildings were pre-engineered because they rely upon standard engineering designs for limited number configurations. These buildings are mostly custom designed metal building to fill the particular needs of customer.

II. METHODOLOGY

The 24 Pre-engineered building warehouse structure were developed. As per the Soft, Medium, Hard Strata with Varying foundation supports Based on displacement and weight ratio optimized structure were found.

III. DESIGN OF WAREHOUSE WITH PEB

A. Problem Statement:

Warehouse PEB structure of span 20m and 40 m is modelled with following properties. Warehouse structure Span 20 plan Dimension: 20m x 80m. Height of Column: 8 m. Centre to Centre column spacing: 4 m. Slope of roof: 1/10. Warehouse structure Span 40 m. Plan Dimension: 40m x 80m. Height of Column: 8 m. Centre to Centre column spacing: 4 m Slope of roof: 1/10. Material Input and Site Data. Structural Steel grade – FE345.Wind speed, Vb = 39 m/sec. Terrain category= 2. Structure class= C. Risk coefficient K1= 1. Topography k3= 1. Terrain factor k2= 0.93. Seismic Zone – III (Z- 0.16)Response reduction factor- 5. Damping factor- 2%. Importance factor-1.

B. Load combinations as per AISC:

**Strength Combinations*

1). DL+LL
2) DL+EQX
3) DL+EQZ
4) DL+0.75(LL+EQX)
5) DL+0.75(LL+EQZ)
6) DL+WLP
7) DL+WLS
8) DL+WPP
9) DL+WPS
10) DL+0.75(LL+WLP)
11) DL+0.75(LL+WLS)
12) DL+0.75(LL+WPP)
13) DL+0.75(LL+WPS)

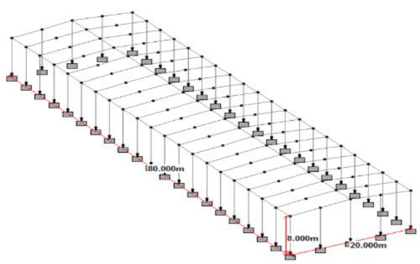
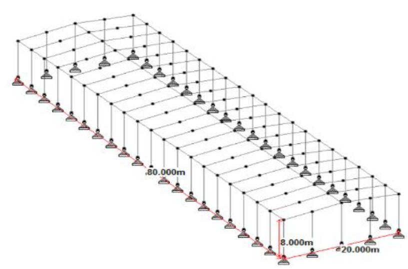
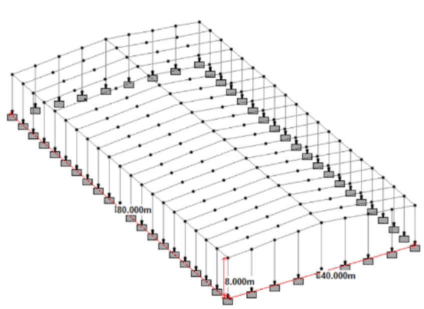
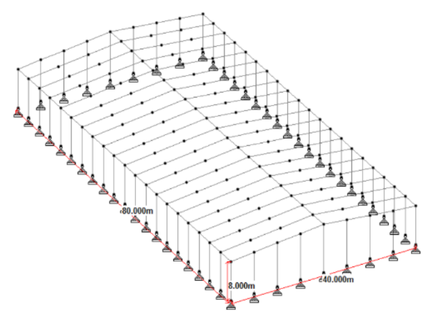
**Serviceability Combinations*

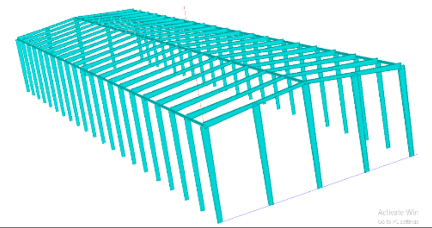
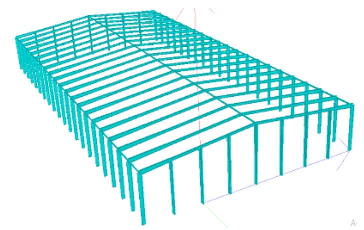
1) 1.0(DL)+0.8(LL+EQX)
2)1.0(DL)+0.8(LL+EQZ)
3) 1.0(DL)+0.8(LL+WLP)
4) 1.0(DL)+0.8(LL+WLS)

* Loadings

Dead Load- It includes self-weight of structure and weight of GI sheets etc. Dead weight of galvanized sheet 0.45 bmt = 4.56 kg/sqm = 0.0456 kn/sqm. dead weight of purlins + fixtures and fasteners = 0.06kn/sqm. hence total dead load = 0.0456+0.06 = 0.11kn/sqm. for 4 m tributary = 0.11*4 = 0.44 kn/m. *Live Load* – It includes weight moving elements like access of human being or sameRoof live load: 57 kg/sqm. roof slope: 1:10 (5.71 degrees approx.) total loading on frame (per running meter). Roof LL = 0.57 x 4 m (bay spacing) = 2.28 kn/m.

Wind Load **-** Basic design wind speed = 39 m/sec design wind speed vz = vb x k1 x k2 x k3. Vz = 39 x 1 x 0.93 x 1 =36.27 m/s. Design pressure. pz = 0.6 x (vz)sq. Pz = 0.6 x 36.27 x 36.27 = 0.79.kn/sqm.

	
20M Span with fixed support	20M Span with Pinned support
	
40M Span with Fixed support	40M Span with Pinned support

20M Span 3D Elevation	40M Span 3D Elevation

Fig. 1. Section geometries of Pre-engineered building warehouse. (All dimensions are in m)

B.Closure:

As per previous literature study most of research is carried out on conventional Pre-engineered building structure by considering parameter such as length to area ratio of conventional sections. Few research is carried out on innovative Pre-engineered building column section. It is need to be developing innovative Pre-engineered building column section to enhance its strength and durability. Paper includes the optimized design of Pre-engineered building structure.

Table 1.
Following below are the Results.

Models With Fixed Supports		**Lateral Deflection along Length**	**Lateral Deflection along Width**	**Vertical Deflection**	**Total Tonnage**
		(mm)	**(mm)**	**(mm)**	**(Ton)**
Warehouse PEB structure with 20 m Span	Hard	90.50	18.32	91.42	51.2
	Mediu m	93.77	17.65	88.83	52.7
	Soft	89.91	17.11	87.28	53.6
Warehouse PEB structure with 40 m Span	Hard	44.53	20.09	206.15	106.3
	Mediu m	53.62	24.59	251.56	115.2
	Soft	51.68	24.03	240.83	115.8
Warehouse PEB structure with 60 m Span	Hard	38.09	25.13	271.68	222.9
	Mediu m	47.20	24.05	259.36	235.3
	Soft	48.86	23.93	257.42	241.9
Warehouse PEB structure with 80 m Span	Hard	56.88	20.19	256.49	522.7
	Mediu m	82.12	21.06	258.00	555.9
	Soft	82.30	21.41	263.20	593.4

Models With Pinned Supports		**Lateral Deflection along Length (mm)**	**Lateral Deflection along Width (mm)**	**Vertical Deflection (mm)**	**Total Tonnage (Ton)**
Warehouse PEB structure with 20 m Span	Hard	5.32	50.69	88.95	73.4
	Mediu m	5.09	47.85	86.74	75.2
	Soft	4.86	50.69	90.74	79.5
Warehouse PEB structure with 40 m	Hard	18.25	28.26	245.39	175.1
	Mediu	21.17	28.41	226.17	177.5

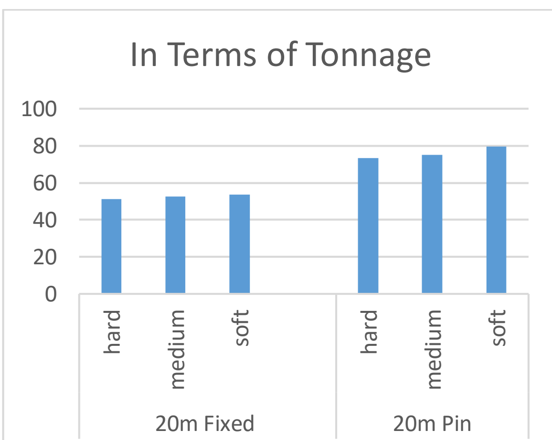
Span	m				
	Soft	21.29	27.13	215.55	178.3
Warehouse PEB structure with 60 m Span	Hard	30.06	45.43	369.62	327.2
	Mediu m	35.86	43.05	342.13	336.9
	Soft	33.99	41.71	327.83	342.4
Warehouse PEB structure with 80 m Span	Hard	57.47	39.31	402.76	765.1
	Mediu m	78.93	42.09	411.83	799.2
	Soft	79.29	42.50	414.20	813.0

The following are the main objectives of this project:

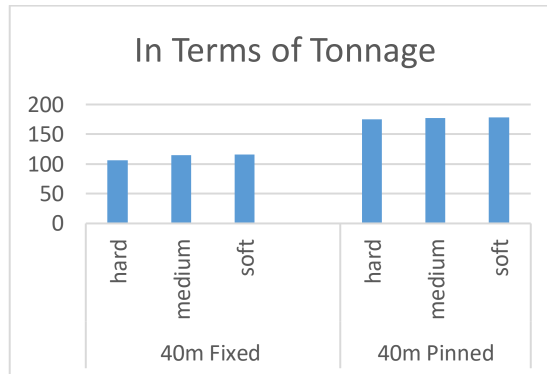
1. Design of Warehouse with PEB System having fixed support and pinned support with moment and shear connection which is resting on different soil strata such as Hard, Medium and Soft soil.
2. Investigate behaviour of PEB structure for various span such as 20 m, 40 m, 60 m, 80 m and soil strata such as Hard, Medium and Soft soil.
3. Establish the optimized design of Warehouse with PEB System.
4. To develop nomograph / design guidelines for PEB system.

Following below are the Results in Graphical Form.

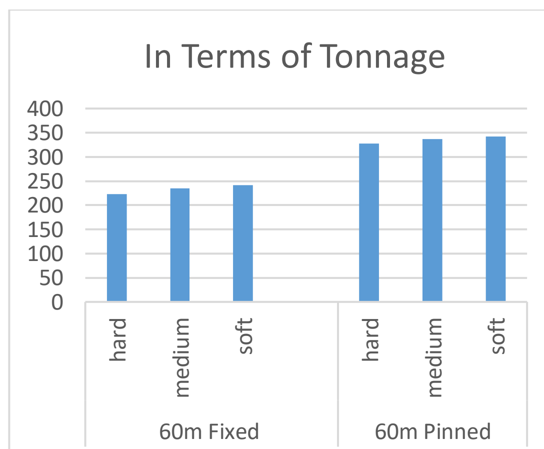
1. For 20M Span of PEB Structure.



2. For 40M Span of PEB Structure.



3. For 60M Span of PEB Structure.



In previous studies, research is carried out only on conventional and PEB steel structures. Also all studies are carried on the comparison of both types. But there is lack of research on different type of support and soil strata effect on the tapered sections. Also in general for construction and design of pre-engineered building a maximum cost is required, but there was no any optimum design or types are available to reduce the cost. Hence there will be optimization of ware house structure as per different soil strata.

Fig 2. Site Construction work of PEB structure.

IV. CONCLUSION

1. Based on ultimate strength to weight ratio, Column 4 was found to be most efficient.
2. Local as well as global buckling were observed in innovative cold formed steel column sections, but for most of long column, global buckling governs the failure mode.
3. It was found that for most of innovative columns maximum deflection were observed at the mid length of the column.
4. Among nine different innovative cold formed steel column sections, it is observed that buckling mode depends on sectional geometry, stiffeners, centroid and column length.

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