Planning Analysis and Design of Industrial Building Using STAAD PRO

K. PRABIN KUMAR¹, D.SUNNY PRAKSH²
U.G. scholar, department of civil engineering, Saveetha School of engineering, Saveetha University, India ¹
kprabin2393@gmail.com
Associate professor, department of civil engineering, Saveetha School of engineering, Saveetha University, India ².

ABSTRACT:
Structural Steel is a common building material used throughout the construction industry. Its primary purpose is to form a skeleton for the structure, essentially the part of the structure that holds everything up and together. Steel is one of the friendliest environmental materials which is 100% recyclable. Structural design has evolved, mostly due to the necessity caused by earthquakes. By using the available ISMB steel sections the desired design requirements cannot be met, especially for the highly loaded structures, as the moment of inertia and cross sectional play major role. Reinforced concrete sections also carry the ultimate load but when the assembly is subjected to great height of about 50-60 meters it is unsuitable for the use of concreting processes, thus by using the fabricated structure it is easy to fabricate durable structure. However, like all innovations, technology breeds its own set of new problems. So by the use of STAAD-Pro, seismic analysis is easily carried out with adequacy.

Keywords: STAAD PRO, Code book.

1. Introduction:
The concept of Pre Engineered buildings (PEB’S) originated in the USA during the times of the two world wars. The need for portable shelters that can be set up on a very short time and can be dismantled and re-used at different locations rose very much especially for the armed forces who were always on the move. What began as small shelters was later developed as separate types of buildings which were referred to as Pre-Engineered buildings.

Now a days many industrial buildings are Pre-Engineered Buildings(P.E.B). These buildings are easy to erect and have proved to be efficient in terms of durability and strength. Thus, it is no surprise that many industrial buildings that once relied on conventional methods of construction have begun to chance their buildings to PEB structures.

These buildings can be categorized as Pre-Engineered Buildings (PEB) and Conventional Steel Buildings (CSB) according to the design concepts. PEB’s are nothing but steel buildings in which excess steel is avoided by tapering the sections as per the bending moment’s requirement. If we go for regular steel structures, time required and cost will be more which together makes it uneconomical. Thus these buildings are fabricated fully in the factory after designing and then brought to the site. All the components are erected at the site with nut and bolts system which in total reduces the time needed for the completion of the structure.

2. DESIGN OF PRE-ENGINEERING BUILDING:
In this section the design of various component of PEB has been considered.

**The component include:-**
- i. Purlins
- ii. Girt Rods
- iii. Main frame
- iv. Bracings

### 2.1 PURLIN DESIGN:

Purlin is designed with one sag rod at width span

- Maximum spacing of purlin = 1.4m
- Weight of sheeting = 2.38N/m
- Self weight of purlin = 1.8N/m
- Total dead load = 4.18N/m
- Total live load = 8.138N/m
- Wind load uplift force= 11.2N/m
- Net uplift force = 7.23N/m

Considering the unsymmetrical/bending of the channel section,

\[ M_{xx} = 52.59N/m \]

Considering the sag rod at mid span,

\[ Myy = 4.38N/m \]

Checking the section ISMC125,

\[ F_{bc} = 112.40 \times 165N/cm^2 \]

Under uplift condition,

\[ M_{xx} = 32.54N/m, \quad Myy = 1.499N/m, \quad F_{bc} = 60.3 \times 219.5N/cm \]

Assume the size = ISRO 12mm diameter

Number of purlins = 8

Total load on sag rod = 116.8N

Required net area of sag rod = 0.78cm²

Thus use 12mm dia rod.

### 2.2 SIZE OF DIAGONAL SAG ROD:

Diagonal sag rod are used at least every eight panel of purlin from bottom and at the top most panel of purlins.

- Maximum force in the sag rod = 116.9N
- Maximum force in diagonal sag rod= 138.2N
- Required net area diagonal sag rod =0.92cm²
- Minimum outside diameter of pipe= (1/40) = 150mm
- Section modulus required = 33.5cm², Use 150 lights for purlins.

### 2.3 GIRT DESIGN:

The girt design is done for the roof. It is given to support the sheeting and any other amenities necessary in the building.

- Span of girt
  - For vertical bending = 3.0m, For horizontal bending = 6.0m
  - Maximum spacing of girt = 1.7m, Channel girt with sag rod at the center
  - The sag rod is given to prevent any buckling of the structure due to self-weight or due to impossible loads.

Vertical bending

- AC sheet weight = 2.98n/m, Girt self-weight = 1.5n/m
- Total DL = 4.39n/m, Vertical BM =Myy = 4.94Nm

Horizontal bending

- Wind load = 8.93N/m, Horizontal BM = 40.19N/m

Thus, we try using ISMC 125 at 1.27n/m, Fbc= 98.0N/m<165N/cm²

Tension in central straight sag rod/purlin = 16.46N
Maximum number of panels supported = 4
Maximum tension sag rods = 65.8 N
Required net area of sag rod = 0.44 cm²
Thus, use 12ø rods
Number of girts supported by diagonal sag rods = 5
Actual spacing of girts = 1.5m, Tension in diagonal sag rod = 92.0 N
Net area of rod required = 0.61 cm²
Thus, use 12ø rods
Using tabular girt
Vertical BM = 19.8 Nm
Horizontal BM = 44.8 Nm, Resultant BM = 44.8 Nm
Trying 100 L-Tube, Fb = 131.7 N/cm²
Thus, 100 L-tube can be used.

2.4. FRAME MEMBER DESIGN:
The frame design involves the use of steel as PEB structures for the beams and columns. The column forces are calculated and accordingly the beams are redesigned.

Column forces are:
Axial force = 444.2 N, Moment = 965.3 N
Maximum sway deflection x I = 0.774 x 10x10x10x10x10 cm⁴cm²
Trying ISMB 500/86.69
(I/r)xx = 89.06, (I/r)yy = 127.84
Allowable compressive stress = 61.3 N/cm²
Effective length for lateral buckling = 6.00 m
Torsion constant k = 82.5 cm, Effective depth = 0.48 m

Critical buckling stress = 194.9 N/cm², Fbc = 106.3 N/cm²
Checking column for simultaneous action of axial compression and moment,
On solving we get, 0.567 < 1.0
Checking for deflection,
From above calculations, we know, I = Deflection for ISMB 500, DELTA = 1.65 cm
Allowable deflection = 1.84 cm
Thus, 1.65 < 1.84,

3. COLUMN BASE PLATE FOR INDUSTRIAL BUILDING TYPE OF SUPPORT:
The column base is designed as building. This shall reduce the formation of any moments at the base of the structure. Thus, lighter sections can be used in the design and it will also be economical.

Column size ISMB 500/86.69
We first try with 550*300*18 cm plate
The force on foundation is as follows,
Dead load (DL) = 233.9 N downwards
Live load (LL) = 261.8 N downwards
Wind load (WL) for 10 N/m² = 243 N upwards
DL+LL = 495.7 N
0.75(DL+LL) = 7 N upwards
Since the load intensity is governed by 1 in 5 slope, the total downward force is slightly larger than the value obtained from the analysis.

As the DL+WL forces are not governing the design, design the base plate for DL+LL forces.
Add forces due to the self weight of column and side claddings:
Self weight of column = 52.5 N
Dead load of AC sheeting and girts = 108N
Total axial force in column = 656N

Thickness of base plate (t) = \( \left( \frac{3W}{P_{bct}} \right) \times \left( \frac{A^2 - B^2}{4} \right) \)

Where,
- \( W \) = pressure on the underside of the base plate
- \( A \) = greater projection of the plate beyond column = 0.06 m
- \( B \) = lesser projection of plate beyond the column = 0.025 m
- \( P_{bct} \) = permissible blending stress in base plate = 189.0 N/cm²

Therefore,
\[ t = 0.5 \text{cm} < 1.8 \text{cm provided} \]

4. FOOTING DESIGN:
The footing is done based on the loads that are transferred by the column to the base. The maximum load from various combinations is due to the wind load, and the wind acting perpendicular to the structure.

Cross section of the column: 400*400
Load acting on the footing = 3.75 KN/m²
Soil bearing capacity = 150 KN/m²
Grade of the concrete: 20
Adopt FE 415 steel bars.
10% increase for dead load of footing.
\( P = 3.75 \text{KN/m²} \)
\( 10\% = 0.375 \text{KN/m²}, \) Total load = 4.125 KN/m²,
\( \text{Area} = 4.125/150 = 0.023 \text{m}² \)

Since columns is on square shape adopt square shape for footing.
Area=\( L^2, \) L=0.152

\[ Qu = \left( \frac{3.75 \times 1.5}{(0.1522 	imes 0.152)} \right) = 250 \text{KNm}^2 = 0.2 \text{N/mm}² \]

The critical section is at the section d from the face column.

5. STAAD.PRO. RESULTS AND DISCUSSION:
The below figure represents the isometric line diagram of the hanger. The support hanger provided are hinged.

Since columns is on square shape adopt square shape for footing.
Area=\( L^2, \) L=0.152

\[ Qu = \left( \frac{3.75 \times 1.5}{(0.1522 	imes 0.152)} \right) = 250 \text{KNm}^2 = 0.2 \text{N/mm}² \]

The critical section is at the section d from the face column.
Figure 3 Displacement for Dead Load

The above figure represents the displacement diagram for the dead load and the imposed load into the structure. The displacement produced due to this load combination is very little.

Figure 4 Bending moment towards Z direction due to minimum Load

Figure 5 Axial force due to D.L and L.L combination

6. CONCLUSION:

In this project work, hangar was designed using PEB sections to achieve a ductile and most stiffened hangar. This was achieved using bracing in the hangar at intervals. The hangar has seven bays. The first and last bay have a spacing of 7.5 meter. The other 5 bays have spacing of 7.0 m. The length of the hangar is 50m and width is 15m. The height of the hangar is 10m. A slope of 10deg is provided at the roof. The calculation of various loads acting on to the structure was done using codal provisions. Then, load combinations are developed in the foundation design was done based on the loads acting the base of the structure. The design of Hagar was done and analysis of structure was carried out using staad pro software. The result show similarities in the design of the hangar. The deflection values both methods were found to be less than the calculated allowable deflection. Thus, the structure is safe against deflection.
7. REFERENCES:

- C. M. Meera (IJERT) June 2013 PEB design of an industrial warehouse.
- Sagar D Science (IRJES) Volume 3, Issue 6 (June 2014), PP.13-29 Design & Comparison of Various Types of Industrial Buildings
- of Multistorey Steel Building.
- Miss. Kavita K. Ghogare (IJRASET) Volume 2 Issue XI, November 2014 ISSN: 2321-9653 Seismic Analysis & Design