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Analysis and design of Lacing, Slab base, and Concrete Pedestal for Industrial Steel Structure by Using Software Package STAAD PRO.V8i.

Rohan S. Mutnal

rohansmutnal88@gmail.com

KLS Gogte Institute of Technology, Belgaum, Karnataka

ABSTRACT

The conception of project evaluation as well as developing of steel structures is the very up-to-date version in the civil engineering area. It is needed to model a steel structure but if it is also examined through its sculpting then there will not be any prospects of malfunction. The firmness constituent consists of two main elements laced and tied should, where feasible, have a radius of gyration about the axis perpendicular to the plane of lacing not less than the radius of gyration at right angles to that axis. The base plates are intended to withstand the axial load, horizontal shear or external moments transmitted through the column and must be able to securely transfer the same to the groundwork. Pedestals are generally substantially oversized since the rise in materials is more than compensated by reduced project time and the value of the accumulated safety aspect. In this project work, a general building data is adopted for the study and is well analyzed and designed. The project was undertaken at Belagavi location. The assessment and planning were done corresponding to the standard design to the potential extend. The assessment of structure was done using the software package STAAD PRO.V8i. All the structural components were designed manually.

Keywords: Analysis, Design, Lacing, Slab base

1. INTRODUCTION

Any building arrangement used by the industry to store raw materials or for industrial goods of the industry is recognized as an industrial building. High increase steel buildings account for a very small proportion of total no of structures that are built all around the world. Most steel structures have been constructed are low rise buildings and are normally use for steel plants, automobile industries, utility n process industries, thermal power stations, etc. These buildings involve large column free areas. Hence interior columns, walls and partitions are often eliminated or kept to minimum. Most of these buildings involve sufficient head room for the use of an upstairs moving crane. To get such column free area one of the frequently employed roofing systems is to offer a set of steel roof trusses, interconnected with purlins. The structural engineer must contemplate the subsequent points through the development and enterprise of industrial buildings; selection of roof, material, bay width, structural framing systems, roof trusses, Purlins, girts, sag rods, Bracing system, Gantry girders, columns, base plate and foundation. Steel frame construction offers many advantages over traditional reinforced concrete with lower costs, sustainability and flexibility being amongst the many benefits of choosing steel framed buildings over the alternatives.

The firmness member consists of two main elements laced and tied should, where workable, have a radius of gyration about the axis perpendicular to the plane of lacing not less than the radius of gyration at right angles to that axis. The lacing system ought not be different all over the length of the strut as concerns practical. Cross should not be supplied along the length of the column with lacing system, if not all forces stemming from distortion of column members are analyzed and offered for in the lacing and its fastening. The single-laced systems on parallel sides of the main elements should if possible be in the same route so that one system is the shade of the other. Laced firmness members should be supplied with tie plates at the ends of the lacing system and at points where the lacing system are disrupted.

A slab base plate is supplied when the column is to stand on an unbiased concrete organization. The carrying end is machined to give full interaction with the base plate so that-the column load is transferred to the base plate by bearing. To avoid any possible dislocation of the column at the stage of erection, sometimes secondary joint is also provided connecting the column (web) and the base plate. Under the action of the downward load exerted by the column on the base plate, and the upward reaction exerted by the concrete foundation. Slab base which is usually a reinforced concrete slab. The steel column is linked to a flat steel base plate which is laid down on that horizontal surface of the RC slab. The base plate is attached to the slab by the method of appropriate hold fast bolts. The base plates are intended to resist the axial load, horizontal shear or external moments transmitted through the column

and must be able to safely transfer the same to the foundation. The pressure supply of reaction from concrete on the underneath of the baseplate is thought to be consistent even though hypothetically and major design factors are the size of the base plate.

A pedestal is utilized to incorporate the loads from metal columns across the floor and soil to the footing when the footing is at some depth in the ground. The objective is to avert feasible corrosion of the metal from the soil. Careful backfill over the footing and around the pedestal will be required to avoid subsidence and floor cracks. If the pedestal is very long, a delicately compressed backfill will give enough lateral assistance to control buckling. Pedestals are generally noticeably oversized, as the rise in materials is more than compensated by reduced project time and the use of the added safety factor and normally be constructed as short columns since of the lateral support of the adjoining soil.

2. METHODOLGOY

2.1. Essence of the Present study

The main objective of the present study is to plan, analyze and design an industrial steel structure. For this purpose, STAAD.Pro software package v.8i has been made use of. The general features of the structure are given in Tables 1 and 2. The various views of the structure given by the STAAD.Pro software are depicted in Figures.

Table 1: General Building Data adopted for the study

Feature	Description
Location	Belagavi
Type of Structure	Industrial Steel Structure
Functionality	Godown
Total Site Area	165.6 Sq. m
Size of the Structure	16.35m * 10.13m
Total Height of Frame	8m
Height of the Truss	2m
Height of Truss Column	6m
Span of the Truss	10.13m
No. of Trusses	05
Spacing of Trusses	4.09m
Spacing of Purlins	1.36m

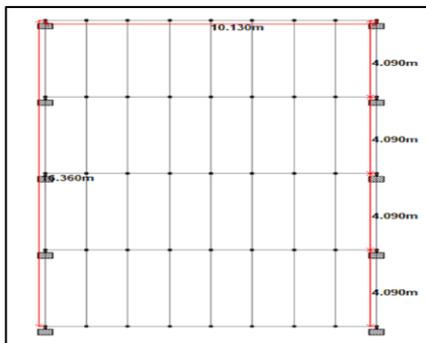


Fig. 1: Plan of the Whole Structure

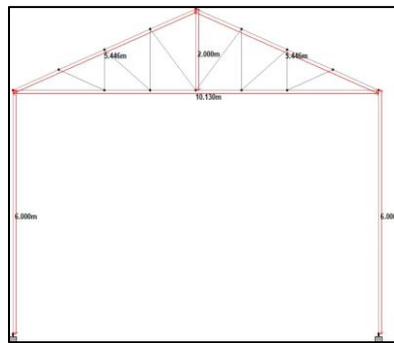


Fig. 2: Front Elevation of the Whole Structure

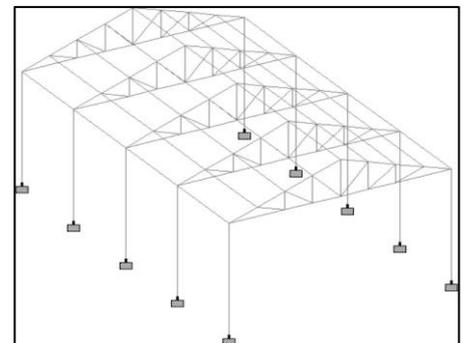


Fig. 3: Isometric view of the Whole Structure

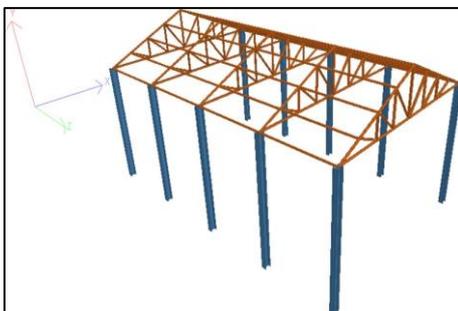


Fig. 4: STAAD 3D-Rendered View of the Structure

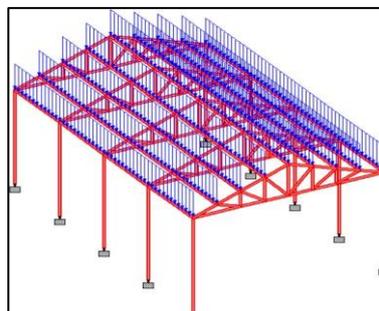


Fig. 5: Whole structure with [Dead Load (DL) + Live Load (LL)]

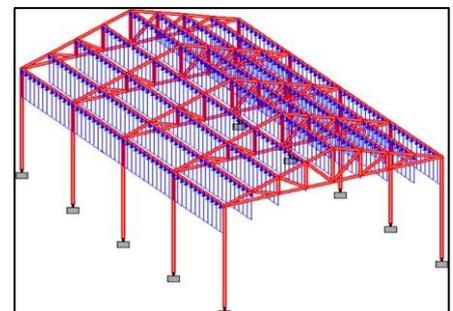


Fig. 6: Whole Structure with Wind Load (WL) - Suction

Table 2: Design data for Roof truss design

DESIGN DATA:				
*	Truss span (l)	=	10.13	m

*	Height of column	=	6	m
*	Type of roofing = AC/GI Sheets (1.6mm thick)			
*	Roof angle	=	21.54	degree
*	Spacing between the bay= 18x30=540cm(L)	=	4.09	m
*	Spacing between the purlins	=	1.36	m
*	Size of GI sheet	=	2.2x0.9	m
*	Weight of sheet	=	156	N/mm ²
*	Assuming Rise of truss (h) (Central span)	=	2	m
	$\sqrt{(h^2 + (L/2)^2)}$			
*	Inclined length =	=	5.45	m
*	Roof angle = $\tan\theta = \frac{\text{Central span} \times (\text{Span}/2)}{\text{Inclined}}$	=	0.395	
		$\theta =$	21.54	
			0.31939525	Radians
*	Spacing of purlins= (Inclined)	=	1.361	m
*	Therefore number of purlins	=	5	no
*	Yeild stress of materials(f_y)	=	250	N/mm ²
*	Ultimate stress of materials(f_u)	=	400	N/mm ³

2.2. Calculations of Loads

2.2.1 Wind Load

As per IS - 875-1987 (Part-3)

Basic wind speed from the topography lies in ZONE-A

Therefore

$$V_b = 33 \text{ m/sec}$$

Design wind Speed(V_z)

$$V_z = V_b \times k_1 \times k_2 \times k_3 \times k_4$$

V_b = Basic wind speed

k_1 = Probability factor (Risk coefficient from 5.3.1) k_2 = Terrain, Height and structure size facore 5.3.2 k_3 = Topography factor 5.3.3

k_4 = Importance factor for cyclonic region 5.3.4.

* Calculation of k_1

From Table - 1

For $V_b = 33 \text{ m/sec}$

$$k_1 = 1$$

Calculation of k_2

Total height of structure = Column + Gantry Girdar + Central rise

$$H = 6 + 2 + 2$$

$$H = 10 \text{ m}$$

From table - 2 , clause 5.3.2 , Category-3 , Class - A

H	k_2
10	1
By interpolating	

k ₂ value for h	101
* Calculation of k ₃	

From 5.3.3.1, For flat area and wind slope less than 30°
k₃ = 1

Calculation of k₄

From clause 5.5 for cyclonic storms
k₄ = 1

Therefore,

Design wind speed (V_z)

$$V_z = 33 \times 1.00 \times 1 \times 1 \times 1$$

$$V_z = \mathbf{33.00 \text{ m/sec}}$$

Design of wind pressure:

From clause 5.4

$$p_z = 0.6 \times V_z^2 \quad p_z = 0.6 \times 33^2$$

$$p_z = 653.400 \text{ N/m}^2$$

$$p_z = \mathbf{0.653 \text{ kN/m}^2}$$

Wind pressure on roof:

From clause 6.2.1

$$F = [C_{pe} - C_{pi}] \times A \times p_z$$

C_{pe} = External pressure coefficient. C_{pi} = Internal pressure coefficient.
 A = Surface area of structural element. (Per meter area)
 p_z = Design wind pressure.

From table- 5,
 Building height ratio ,

$$(1/2) < (h/w) < (3/2)$$

h= height till gantry girder w= span

$$(0.5) < (8/10.13) < (1.5)$$

$$(0.5) < (0.78) < (1.5)$$

Calculation of C_{pe}:

For wind angle - 0°

$$C_{pe} = 0.7 \text{ AB}$$

$$C_{pe} = \mathbf{-0.7 \text{ CD}}$$

For wind angle - 90°

$$C_{pe} = \mathbf{0.7 \text{ BC}}$$

$$C_{pe} = -0.5 \text{ AD}$$

Calculation of C_{pi}:

From clause 6.2.3.1

$$C_{pi} = \pm 0.5$$

Adopt

$$C_{pi} = \pm \mathbf{0.2}$$

Therefore,

$$F = (-0.7 - 0.2) \times 5.562 \times 0.653$$

$$F = -3.270 \text{ kN}$$

Now,

The maximum wind load / purlin / meter

$$= 1.36 \times \cos \theta \times F$$

$$= 1.36 \times \cos (21.54) \times -3.27$$

$$= -4.002 \text{ kN/m}$$

2.2.2 Dead Load

Weight of GI sheet = 0.131 kN/m² (1.6mm thickness of sheet)

Weight of services = 0.1 kN/m² Weight of fixings = 0.025 kN/m² Total weight = 0.256 kN/m² Spacing of purlins = 1.36m

$$\text{Total Dead Load (W}_d) = 348 \text{ N/m}^2$$

$$= 0.348 \text{ kN/m}^2$$

2.2.3 Live Load

$$\text{Live load for slope } 10^\circ = 750 \text{ N/m}^2 = 0.75 \text{ kN/m}^2$$

$$\text{Live load for slope } 10^\circ - 20^\circ = 0.01 \text{ KN/m}^2/\text{Degree}$$

$$\text{Live load for slope } >20^\circ = 0.02 \text{ KN/m}^2/\text{Degree}$$

$$\text{Therefore live load on truss} = 0.75 - 0.02 \times (\theta - 10^\circ)$$

$$= 0.5192 \text{ kN/m}^2$$

$$\text{Live load/purlin/meter span} = 0.519 \times 1.36$$

$$0.706 \text{ kN/m}$$

$$\text{Total load on purlin (W)} = \text{DL} + \text{LL}$$

$$W = 1.054 \text{ kN/m}$$

2.3. Design of Lacing

For ISHB-400@ 77.9kg/m, Properties from Steel Table are:

$$A = 9866 \text{ mm}^2 \quad I_{xx} = 280835000 \text{ mm}^4 \quad I_{yy} = 27283000 \text{ mm}^4$$

Design:

Let clear distance be 'd',

For 2-ISHB-400

$$I_{xx} = 2 \times 280835000$$

$$I_{xx} = 561670000$$

$$2I_{yy} = 2 \times [I_{yy}(\text{self}) + (A \times d^2/2)]$$

According to condition ,

$$I_{xx} = I_{yy}$$

$$561670000$$

$$280835000$$

$$253552000$$

160.3108677

$$=2x[27283000+(9866 \times d^2/2)]$$

$$=[27283000+(9866 \times d^2/2)]$$

$$=(9866 \times d^2/2)$$

$$=(d/2)$$

d=320.622 mm

Therefore Adopt,

Horizontal spacing d= 300 mm

Provide lacings at an angle of 45° ,

$$\text{Spacing between 2 lacings} = 2x(300+125+125) \times \text{COS}(45)$$

$$= 777.74 \text{ mm}$$

Therefore,

Vertical spacing ≈ 780 mm

Therefore, use 65 x 14 mm lacing bar and 100 x 14 mm End tie plate. Provided at 780mm Spacing.

Use, 6mm weld size to join the lacing flats and I-SECTION .

2.4. Slab Base

The slab base as shown in Figure consists of cleat angles and base plate. The column end is faced for bearing over the whole area. The gussets (gusset plates and gusset angles) are not provided with the column with the slab bases. The sufficient fastenings are used to retain the parts securely in plate and to resist all moments and forces, other than the direct compression. The forces and moments arising during transit, unloading and erection are also considered.

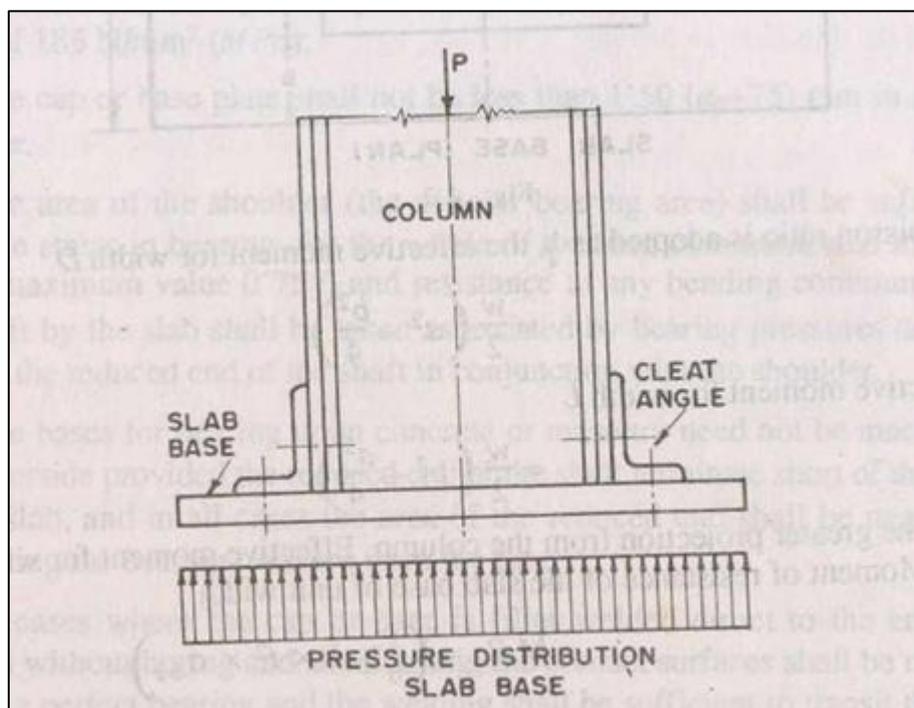


Fig. 5: Slab Base

There are three types of column bases-

1. Slab Base
2. Gusseted base
3. Grillage Foundation

2.4.1 Design of Slab Base

Load on the Column Base.

$$\text{Load on Truss}=72 \text{ kN}$$

$$\text{Load on gantry}=300 \text{ kN}$$

$$\text{Total Factored load}=372 \text{ kN Service load on base plate}=248.000 \text{ kN}$$

Adopt,

$$f_{ck}=20 \text{ N/mm}^2$$

Permissible bearing stress

$$q_p=0.45f_{ck}$$

$$q_p=9 \text{ N/mm}^2$$

$$P_u/A \leq q_p$$

Therefore,

$$A=P_u/q_p$$

$$= 372 \text{ 1000}/9$$

$$A_{req}=41333.333 \text{ mm}^2$$

Designing for 2-ISHB-400

Let the side projections be 50mm both sides, so,

$$a=b=50 \text{ mm}$$

Therefore, Provide 900 x 500mm size base plate

$$L=900 \text{ mm}$$

$$B=500 \text{ mm}$$

Therefore,

$$\text{Area provided}(A)=900 \times 500$$

$$A=450000 \text{ mm}^2$$

$$\text{Actual bearing pressure}(w)= P_u/A$$

$$w = 372 \times 1000 / 450000$$

$$w = 0.827 \text{ N/mm}^2$$

From IS:800-2007, as per clause 7.4.3.1,

$$t = \sqrt{\left((2.5 \times w \times (L^2 - (0.3 \times b)^2)) \times Y_{mo} \right) / f_y}$$

t=

$$\sqrt{\left((2.5 \times 0.827 \times (900^2 - (0.3 \times 500)^2)) \times 1.1 \right) / 250}$$

But, Therefore,

$$t=3.989 \text{ mm } t \text{ Should be } > t_r$$

$$\text{Adopt } t=16 \text{ mm}$$

Thus, Overall size of base plate is (500x900x16) mm

* Design for welding:

For 2-ISHB-400

Length of weld provided

$$L_e = 2 \times [(4 \times 250) + (2 \times 400) - (2 \times 10.6) - (4 \times 12.7)] = 4056 \text{ mm}$$

$$L_e = 4056 \text{ mm}$$

Strength of the weld =

$$\begin{aligned} & f_u / (\sqrt{3} \gamma_{mw}) \\ & = 410 / (\sqrt{3} \times 1.25) \\ & = 189.371 \text{ N/mm}^2 \end{aligned}$$

Let "t" be the size of weld,

The effective area of weld = $0.7 \times t \times L_e$ where 'Le' is the effective length

Therefore,

Adopt,

Therefore,

But,

Design condition is,

$$372 \times 10^3 = 0.7 \times \text{Strength of weld} \times t \times L_e \quad 372 \times 10^3 = 0.7 \times 189.371 \times t \times L_e$$

$$t \times L_e = 2806.284409$$

$$t = 6 \text{ mm}$$

$$L_e = 467.7140682 \text{ mm}$$

$$\text{Available effective length} = 3500.27 \text{ mm} > 467.714 \text{ mm}$$

Hence 6mm weld is adequate.

2.5 Design of Concrete Pedestal

Axial load on column	=	72	kN
Self-weight of foundation (@ 10%)	=	7.2	kN
Total load on soil	=	79.2	kN
Therefore, area of concrete base	=	(79.2/150)	
	=	0.528	m ²
Side length	=	$\sqrt{0.528}$	
	=	0.726	m

Adopt 1.25m x 1.25m square concrete block.

Assuming 45° load dispersion,

Depth of concrete block	=	0.5(1250-500)	
=	375		mm
=	500		mm

Adopt 1.25m x 1.25m x 0.5m for the foundation.

3. CONCLUSIONS

- On completion of the design the proposed industrial structure including all the structural elements detailed understanding of interpreted design of structure is achieved. Depend on the essentials, industrial sheds can be both small or huge and they be able to be utilized for various purposes inclusive of method, design, keep or distribute substances. Concocting such metal structures involves expertise in steel production to construct structural steel sheds of the appropriate features and various abilities as in stage with the essentials.
- All the structural components were designed manually and detailed using Saidpur software package v.8i. The analysis and design were done according to standard specifications to the possible extend and which proved to be premium software of great potential in analysis and design sections of construction industry.
- A detailed understanding of the loading and load combination provisions of IS-800:2007 for the design of Lacing, Slab base and Concrete Pedestal are understood.

- Use of MS-EXCEL for design is understood.
- Use of AutoCAD for drawings is understood.

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