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Steel Project Report
Design of Industrial Buildings

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Design Objectives

Design an Industrial structure in steel construction in steel located in Jaipur for the details given below. Consider all possible loads and load combinations including wind.

- Live Load = 0.75 kN/m2
- Dead Load = Self weight + 20% Extra
- Crane Capacity = 100 kN
- Safe Bearing Capacity (SBC) = 20 kN/m2
- Span Length (L) = 15 m
- Bay Length (10 nos.) = 5 m
- Height (H1) = 7 m
- Height (H2) = 6 m

- Note: These are the details provided by the contractor for the structure

Approach

- Analysis of the climatic topography of the region.
- Selection of Roofing Material
  - Specification of GI Sheets
- Selection of Truss
- Calculation of Dead, Live and Wind load.
- Load calculation for Gantry Girder
- Design of Purlins(Open Web Joist)
- Analysis and Design of Truss members with connection detailing.
- Design of Gantry Girder
- Design of Wind Girt
- Desing of Column
- Design of base plate and foundation.

Jaipur Climatic Topography

- Jaipur has a hot semi-arid climate receiving over 650 millimeters (26 in) of rainfall annually.
- Temperatures remain relatively high throughout the year, with the summer months of April to early July having average daily temperatures of around 30 °C (86 °F).
- The winter months of November to February are mild and pleasant, with average temperatures ranging from15–18 °C (59–64 °F) and with little or no humidity.
- Where are however occasional cold waves that lead to temperatures near freezing.
- **From the above climatic conditions and topography we come to conclusion that**
  - **Jaipur is a warm place,**
  - **with flat terrain and**
  - **has an occasional cold waves and normal wind speed.**
- Note: The climatic and topography results were taken from Wikipedia.

Selection of Roofing material

- We have three options for roofing material
  - Steel or Aluminum Decking Sheets
    - Since Jaipur experiences vary higher temperature so, the aluminum would expand much larger than the steel. (Note. - Aluminum expand approximately twice as much steel and are easily damaged in hailstorms.). Thus, the aluminum sheets cannot be used.
  - Corrugated Asbestos (AC) Sheets
    - Asbestos sheets are now obsolete these days and also have health concerns associated with the fibers it's made of.
    - Also, because of change in temperature from high in day time to low in night, the AC sheets may experience cracking.
- Corrugated Galvanized Iron (GI) Sheets

Specification of GI sheets

- 8 corrugations (75 mm wide and 19 mm deep) per sheet
- Size of the sheet o Length = 1.8m
  - Width = .75m
  - Thickness = .63mm
- Assumed weight of the sheets =85 N/m2 (50-156 N/m2) For roof
  - Side overlap = 112 corrugations
  - End Overlap = 150 mm
- For side cladding o Side Overlap = 1 corrugations
  - End Overlap = 100 mm

Selection Of truss

- Most Economical and appropriate truss = Fink Truss
  - Spacing of truss o Bay length = 5m
  - Spacing of truss = 1/5 to 1/3 of span(15m) = 3m to 5m
    - Therefor Spacing is 5m
  - Depth of Truss o Range for Fink Truss= L/6 to L/5 = 2.5m to 3m
    - Assumed Depth of Truss within the limits= 2.8 m
  - Spacing of Purlins o The spacing of the purlins should be between 1.5m to 1.75m
    - Assumed spacing of the purlins = 1.6m

Calculation of Dead Loads

- GI sheeting = 0.085
- Fixings = 0.025
- Services = 0.100
- Total Load = 0.210 kN/m2
- For 5 m bays,
  - Roof Dead Load = 0.21 x 5 x 15 = 15.75 kN
  - Weight of the purlin (assuming 70 N/m2) = 0.07 x 5 x 15 = 5.25 kN
  - For welded sheet roof trusses , the self-weight is approximately given by
    - W = 53.7 + 0.53A = 53.7 + 0.53 x 5 x 15 = 93.45 N/m2
    - Self-weight of one truss = 0.09345 x 5 x 15 = 7.00 kN
- Total Dead Load = 15.75 + 5.25 + 7 = 28 kN

Calculation of Wind Load

- As per IS 875 (Part 3) - 1987
- Basic Wind speed in Jaipur Vb = 47 m/sec
- Design Wind Speed (Vz) = Vb K1 K2 K3 K4 = 56.7525 m/sec
- Design Wind Pressure (Pd)= Kd (1) x Ka (1)x Kc x 1.932 kN/m2 =1.932 kN/m2
- Wind Pressure on Roofs
  - Cpe
    - h/w ratio = 7/15 = 0.4667 < ½
    - Truss Slope = 20° approxx
  - Cpi = +5 /-5

Calculation of Wind Load

Wind Angle	Pressure Coefficient			C_{pe} (+/-) C_{pi}		A x P_d (kN)	Wind Load , F (kN)	
	C_{pe}		C_{pi}					
	Windward	Leeward		Windward	Leeward		Windward	Leeward
0^0	-0.4	-0.4	-0.5	-0.9	-0.9	15.456	-13.9104	-13.9104
			0.5	0.1	0.1	15.456	1.5456	1.5456
90^0	-0.7	-0.6	-0.5	-1.2	-1.1	15.456	-18.5472	-17.0016
			0.5	-0.2	-0.1	15.456	-3.0912	-1.5456

Therefore, Design Wind Pressure = -18.5472/8 = 2.3 kN/m2

Calculation Of live Load

- Live Load = 0.75 kN/m2
- Reduction due to Slope =0.75 - 0.02 x (20-10) =0.55 kN/m2

Final Load Conditions

- Dead Load = 0.37 kN/m^2
- Live Load = 0.46 kN/m^2
- Wind Load = 2.3 kN/m^2

Loads From Gantry Girder

- Loads Calculation
  - Vertical load
    - Maximum static wheel load =64.4 kN
    - Maximum static factored wheel load with impact = 214.5 kN
  - Surge Load (Horizontal Load)
    - Lateral Factored Load per wheel = 9kN
  - Longitudinal (horizontal) braking load
    - Factored Horizontal Load Pg. = 1.5 x 7.15 = 10.725 kN

Loads From Gantry Girder

- Moment Calculation
  - Vertical moment
    - Bending Moment due to dead load = 8.9 kNm
    - Bending Moment due to vertical load =226.566 kNm
  - Horizontal Moment
    - Moment due to surge Load (My) = 9.5 kNm
  - Bending Moment due to drag
    - Bending Moment = 1.5685 kNm

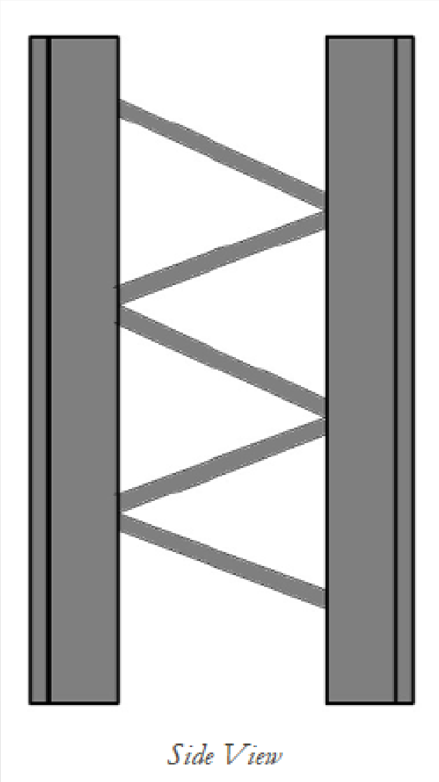
Loads From Gantry Girder

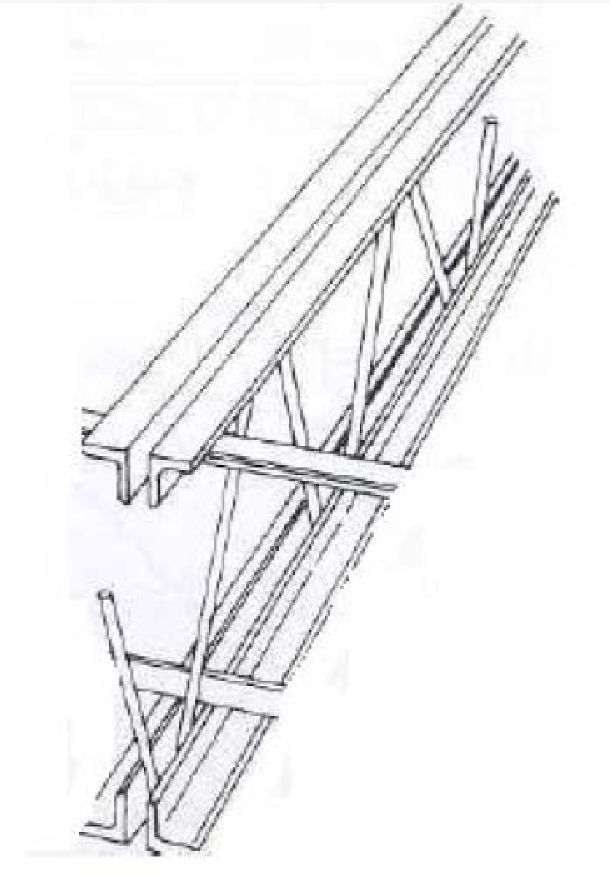
- Shear Calculation
  - Vertical moment
    - Shear due to dead load = 7.125 kN
    - Shear due to vertical load =278.85 kN
  - Lateral Shear
    - Shear due to surge Load (My) = 11.7 kN
  - Shear due to drag
    - Shear = 0.965 kN

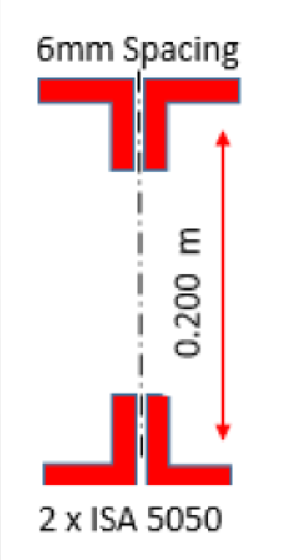
Design Of Purlin

- We choose to deign purlin as open web joist because
  - The bay length is large and thus the design is mostly governed by
    - Bending
    - Deflection
  - Thus we need to minimize the web section to make the structure economically feasible.
- We have considered open web joist wit the following details
  - 2 x (2 ISA 5050 back –to- back)
  - Spacing : 200 mm center to center
  - Distance Between ISA (back-to-back) = 6 mm

Design Of purlins







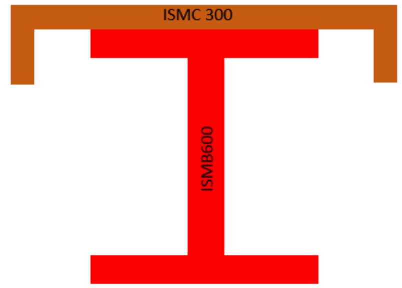
Analysis of Truss

- Final Load Combinations used:
  - DL+LL
  - DL+WL at 0 degrees
  - DL+WL at 90 degrees
- Based on relevant load combinations applied on the STAAD Drawing of the truss, we noted
  - Forces experienced by each member
  - Displacement of the nodes
  - End reactions at node 1 and 8

Design of Truss

- For the purpose of Design the Truss was divided into 4 types of members based on the maximum forces observed.
  - Principal Rafter
  - Horizontal Tie members
  - Other web members I and II
- The design was governed by larger forces in compression and was checked for failure in tension. The base element used was ISA 75x75x5 either just one or two back to back with an 8mm gusset plate.
- Connections were made by welding with differential lengths L1 and L2 as shown in dig.

Design of Gantry Girder



- **Various design Vertical , Horizontal and Moments are taken from the above section respectively**
- **Preliminary Section of the girder decided based on deflection governance**
- Elastic Modulus and Plastic modulus of combined section calculated to check for plasticity
- Check for moment capacity, shear capacity ,buckling resistance done

Design of Wind Girt

- Basic assumptions and Load calculations:
  - Critical wind pressure (as calculated for column) = 1.94 kN/m2
  - Assuming 3 wind-girds @ 2m distance:
  - Uniform load acting on gird =3.88 kN/m ≈ 4.0 kN/m
  - Maximum shear force = w x l/2 = 4.0 x 5/2 kN = 10.0 kN
  - Maximum bending moment = wl2/8 = 4 x 52/8 kN-m = 12.8 kN-m
- Based on moment analysis ISLB200 was used and checked for:
  - shear failure
  - Web Buckling
  - Web crippling
  - Serviceability

Design of Column

- Given Data:
  - Overall height of the column = 7 m
  - Height of crane rail = 6.4 m
  - Crane rail eccentricity = 0.5 m
  - Cladding eccentricity = 0.25 m
- Load Calculations: are mentioned in detail in the load matrix with the critical cases:
  - 1.2 Wd + 1.2 Wl + 1.05Wcv + 0.6 Ww + 1.05 Wch .... Case (i)
  - 1.5 Wd + 1.5 Wl + 1.05Wcv + 1.05 Wch .... Case (ii)
  - 1.2 Wd + 1.2 Wl + 0.53Wcv + 1.2 Ww + 0.53 Wch .... Case (iii)
- Along with the relevant coefficients for the lever arm we can calculate F, M1,2,3 at 3 locations on the column for an approximate bending moment dig.

Design of Column

- Hence, final design of built up column includes:
  - 2 x ISHB 150 (w= 346 N/m) Lacings: ISA6060 (65 x 65 x 6)
  - Tie plates (800 x 850 x 16), 16mm bolts
  - Weight of column (excluding lacings and tie plates) =5.328 tones
  - Weight of column (including lacings and tie plates) = 6.394 tones

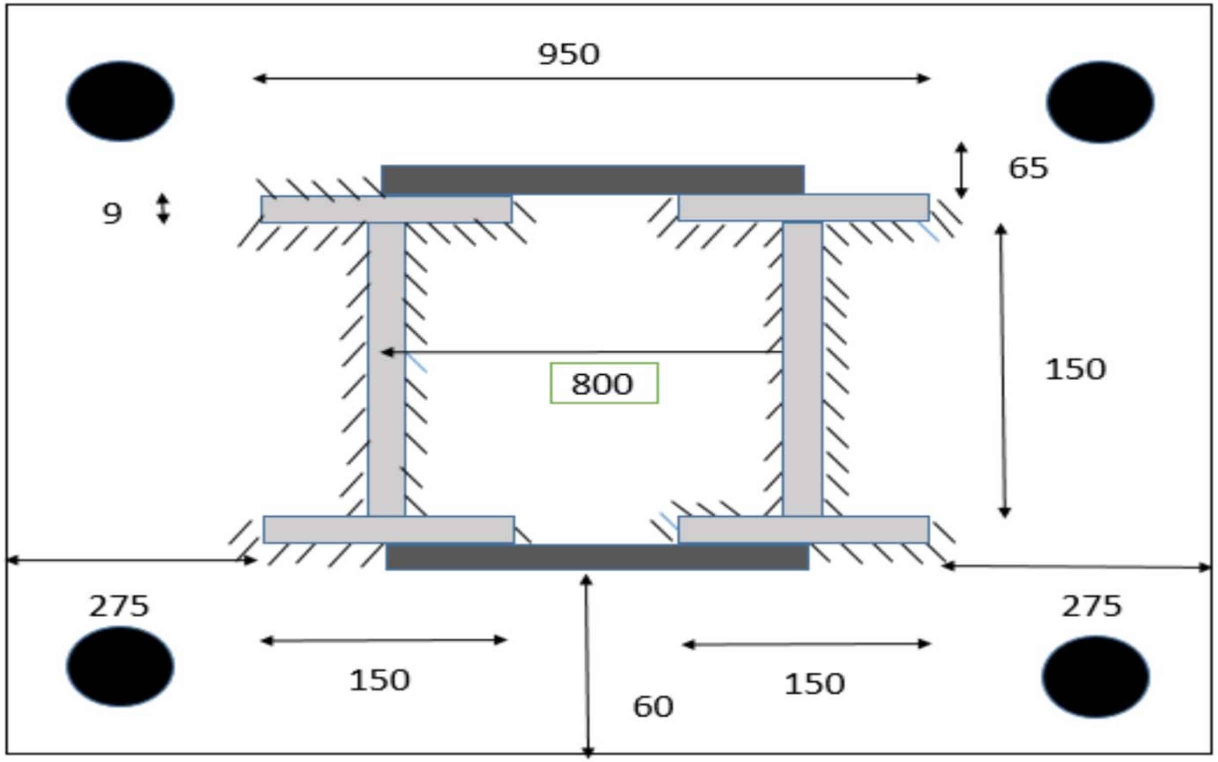
Design of Base Plate

- Assumed a base plate of size 520x520mm with four anchor bolts of grade 4.6
- Plate Details

  Area = 400 x 1500 = 600 x 103 mm2

  Thickness of the base plate is 50 mm
- Weld Connecting beam-column to base plate.. the weld is designed to carry the maximum moment, ignoring the effect of the vertical load.
  - Size : 1500 x 400 x 50
  - 6 mm fillet weld all around the built-up column and over the cross section.

Base plate



Base Plate design (All Dimensions are in mm)

Design of Foundation

- Area of foundation calculated corresponding to total load on the foundation
- Foundation chosen is ISOLATED FOOTING

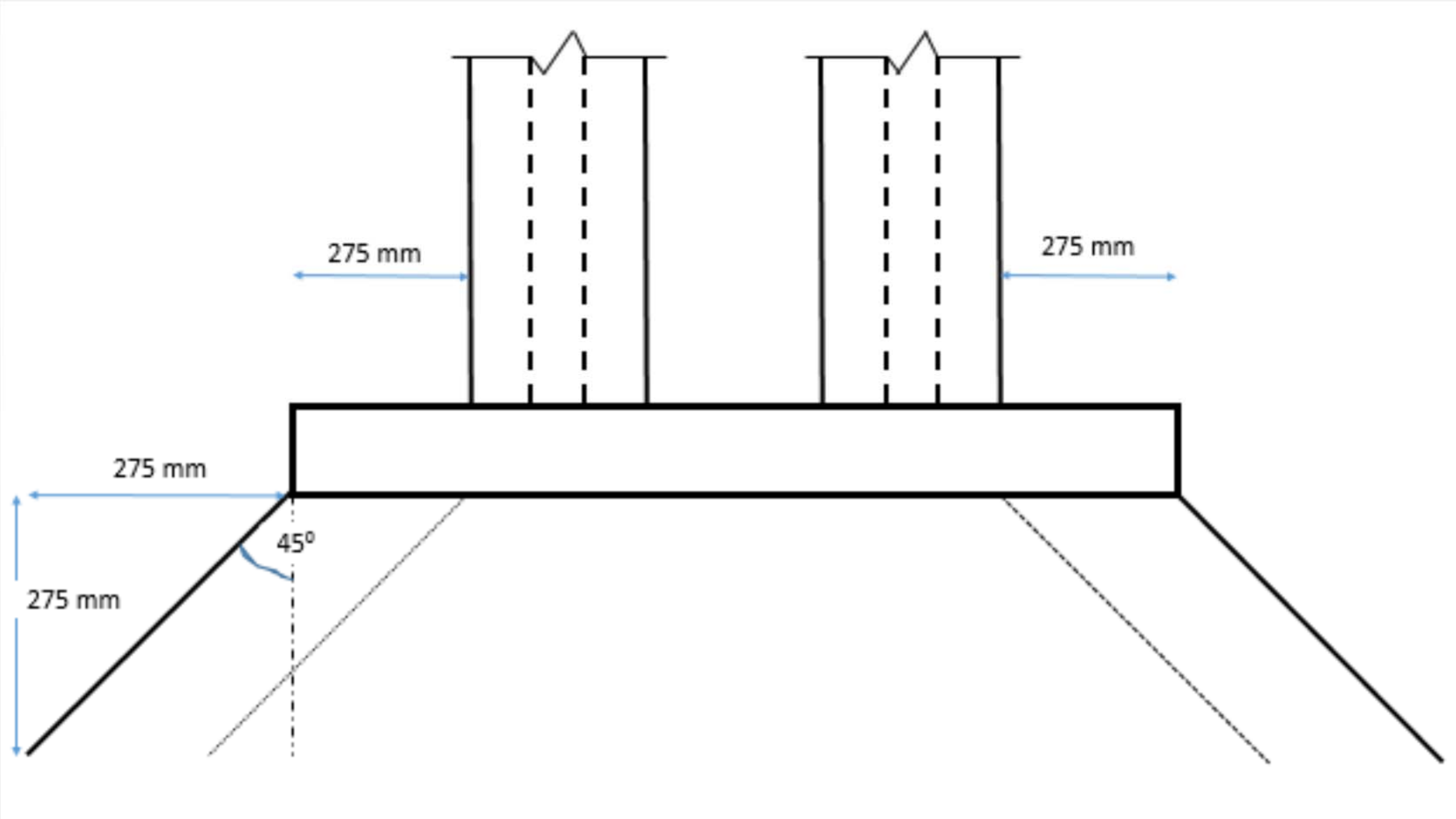
M25 concrete

300 mm thickness

2 m width

7.5 m length

Foundation



Weight Analysis of the Structure

- Design of purlins: Total weight= 7.2 tones
- Design of Column:
  - Weight of column (excluding lacings and tie plates) =5.328 tones
  - Weight of column (including lacings and tie plates) = 6.394 tones
- Design of Truss Members:
  - Weight of members (combined) =1.068 tones
  - Total weight of truss (including connections) =1.175 tones (Assuming 10% extra)

Weight Analysis of Structure

- Gantry Girder : Total weight= 7.24 tones
- Wind Girt: Total weight= 2.97 tones
- Base Plate: Total weight =0.234 tones

- •Total weight of steel used in the structure = 25.213 tones
- •Assuming miscellaneous uses= 26.43765 tones (5 % increase)

References

- IS: 800- 2007
- IS: 875 part 1
- IS: 875 part 2
- IS: 875 part 3
- IS: 875 part 4
- IS: 875 part 5
- "Design of Steel structures", N. Subramanian
- IBR