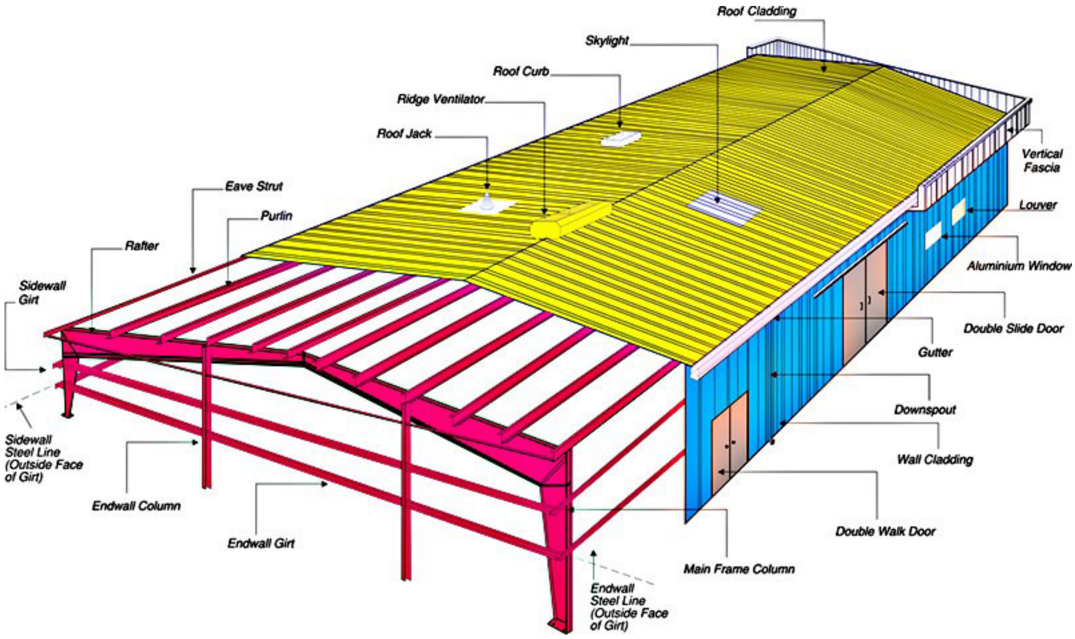
CE332 - Course Project
Structural Design Report

Design of Pre-Engineered Building
Group 2



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List of Contents

Abstract

Our project was to make a pre-engineered building which was located in the industrial areas in non-cyclonic region in Mumbai. Basic dimensions and related information is mentioned in the upcoming section. We have made some assumptions while making our structure:

- Material is uniform in nature, i.e. there is no geometric non-linearity.
- Wind load is static in nature.

Approach:
Firstly, we took uniform I sections to start with our structure, then we applied various load combination and identified the utility ratio of each of the member. According to it, we modified the depth of I section such that the utility ratio of each of the member is less than 1 and it is perfectly stable.
Softwares used:
We have used STAAD Pro for designing the members and analyzing our entire structure and used OSDAG for connection design.
Challenges faced:
After 1st iteration, we are getting infinite displacement of one of the members which was leading to stable structure. On proper analysis, we found that one of the member was wrongly placed and then finally we got our stable structure. At the end, we got a completely stable structure.

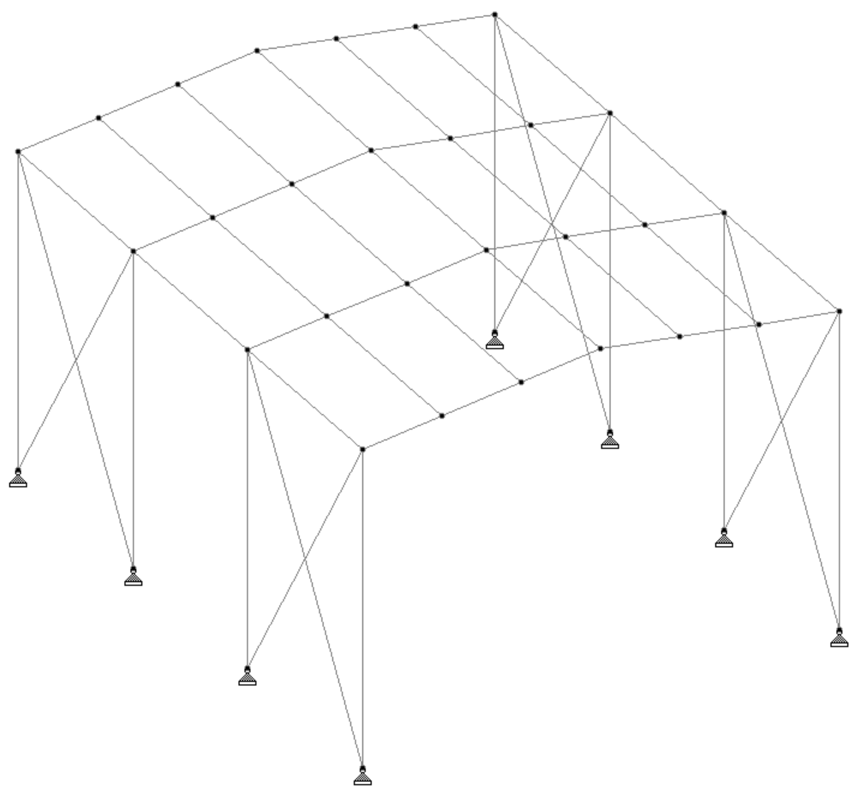
1 Problem Statement

We have won a contract from a client to design and detail a pre-engineered building. The terms of the contract include:

- Preparation of a General Arrangement (GA) of the structure. The team needs to decide and arrange the frame of varying depth columns and beams as per requirement due to bending moment developed.
- The basic components of the structure are beams, columns, purlins and bracings.
- Design as per the requirements provided in the relevant IS codes.
- Satisfy the required deliverables provided in the relevant IS codes.

Following things are expected from us in the final stage:

- Final geometric layout
- Design of all members
- Plan drawings, side elevations with the structural member chosen
- Front view, side view and plan of desired column base plate
- Bill of quantities



2 Design Preamble

2.1 General Information

- The plan dimension of the PEB: 12m (width) X 15m (length)
- Eaves height of the structure: 8m
- Slope of roof: 1 in 7.5
- Support at base: Hinged
- Longitudinal Bracing between frames along one span
- Side sheeting along the length (18m span) and roof should be considered during loading
- Site is at location in industrial areas.
- The topography of the site is such that the upwind slope is less than 3 deg.
- Site is at non cyclonic region in Mumbai.
- References to various IS/design codes: **Design Codes & standards**
  1. **Design:**
     - Steel Design: As per IS: 800-2007
     - Dead load: As per IS: 875 Part1-1987
     - Live load: As per IS: 875 Part2-1987
     - Wind load: As per IS: 875 Part3-2015
  2. **Sections/Materials:**
     - Angle Sections: As per IS: 5624-1993
     - Pipe: As per IS: 1161-1998
  3. **Fasteners:**
     - High strength Structural Bolts: As per IS: 3757-1985 & IS:4000-1992
     - Foundation bolts: As per IS: 5624-1993

2.2 Structural Steel

Since, we have to make a tapered section so there's not any specific dimensions of our steel members as per IS codes. In fact, we have to make few iterations on the depth of our beams and columns to get a stable structure.

2.3 Bolts and Nuts

We have used 20mm diameter bolts with 12.9 property class for base plate design and 8mm diameter bolts with 12.9 property class.

2.4 Other materials

We have used pipe (PIP889H) section in our structure and ISA 55*55*6 RA for bracings.

3 Loads and forces

3.1 Dead Load

- Self-weight of the structure as per IS 875 (Part-1) for density of different materials.
- Weight of roof and side sheeting (consider sheeting weight: 5 kg/m 2)

3.2 Live Load

- Roof live load as per IS 875 (Part-2).
- Uniformly distributed imposed load measured on plan area as per Table 2 of IS 875 (Part-2).

3.3 Wind Load

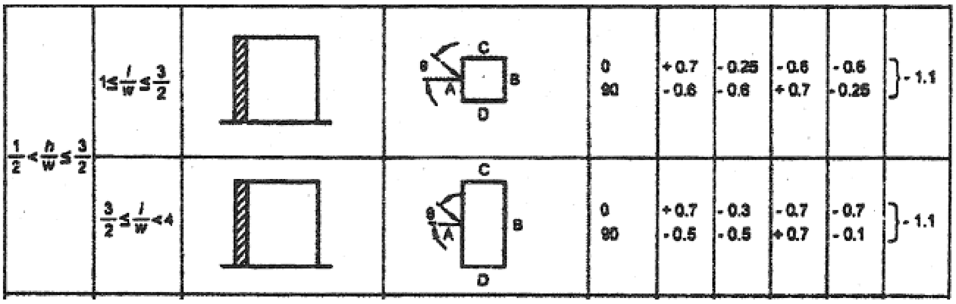
- Side and roof wind load are calculated as per IS 875 (Part-3)
  Force acting at a panel F = (Cpe - Cpi)*A*pd using Cl 7.3.1 of IS 875 (Part-3)
  where,
  Cpe = external pressure coefficient,
  Cpi = internal pressure- coefficient,
  A = surface area of structural or cladding unit,
  pd = design wind pressure.

Wind Load calculations:

- **Basic wind speed (Vb)**: Basic wind speed is based on peak gust velocity averaged over a short time interval of about 3 s and corresponds to mean heights above ground level in an open terrain. The value of basic wind speed for Mumbai region is 44 m/s.[Fig1., IS 875 part 3]
- **Design wind speed (Vz)**:V z at any height z, for the chosen structure shall be obtained by modifying the following effects:
  a) Risk level,
  b) Terrain roughness and height of structure,
  c) Local topography,and
  d) Importance factor for the cyclonic region.
  Mathematically, it can be written as follows:
  Vz = Vb * k1*k2*k3*k4
  where,
  Vb = design wind speed at height z, in m/s;
  k1 = probability factor (risk coefficient) (clause 6.3.1);
  k2 = terrain roughness and height factor (clause 6.3.2);
  k3 = topography factor (clause 6.3.3); and
  k4 = importance factor for the cyclonic region (clause 6.3.4).
  Thus, we have:
  k1 = 1.0(general buildings and structure),
  k2 = 0.91(terrain category 3),

k3 = 1.0(less than 3') and
k4 = 1.15(industrial area)

- Hence, **Vz** = 44*1.0*0.91*1.0*1.15 = **46.046 m/s**
- **Pressure due to wind velocity**: The wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind speed:
  pz = 0.6*V_z^2
  where,
  Pz = wind pressure at height z, in N/m^2; and
  Vz = design wind speed at height z, in m/s.
  Therefore, pressure due to wind velocity = 1.272 kN/m^2.
- **Design wind pressure**: The design wind pressure P d can be obtained as,
  Pd = Kd*Ka*Kc* pz
  where,
  Kd = wind directionality factor,
  Ka = area averaging factor, and
  Kc; = combination factor (clause 7.3.3.13).
  Note: The value of Pd, however shall not be taken as less than 0.70 Pz.
  Thus, we have:
  Kd = 0.9(prismatic building)
  Ka = 0.8(tributary area greater than 100 m^2.
  Kc = 1.0 (given)
  Therefore, design wind pressure = 0.9*0.8*1.0*1.272 = 0.91584 kN/m^2.
- **Wind load on individual members**: When calculating the wind load on individual structural elements such as roofs and walls, and individual cladding units and their fittings, it is essential to take account of the pressure difference between opposite faces of such elements or units. For clad structures, it is, therefore, necessary to know the internal pressure as well as the external pressure.
  Then the wind load, F, acting in a direction normal to the individual structural element or cladding unit is:
  F = (C_{pe}- C_{pi}) * A *pd
  where,
  C_{pe} = external pressure coefficient,
  C_{pi} = internal pressure coefficient,
  A = surface area of structural element or cladding unit, and
  pd = design wind pressure.
- Now, let's compute the pressure coefficients C_{pe}, external pressure coefficient & C_{pi}, internal pressure coefficient.
  C_{pi} = ± 0.7 (building with large opening) (clause 7.3.2.2)
  Now, slope of the roof, $\alpha = tan^{-1}\frac{1}{7.5} = 7.59^o$.
  (i) C_{pe} for the walls(clause 7.3.3.1):
  $\theta = 0^o$ as C and D are open faces.
  $\frac{l}{w}$ = 1.25 and $\frac{h}{w}$ = 0.67.



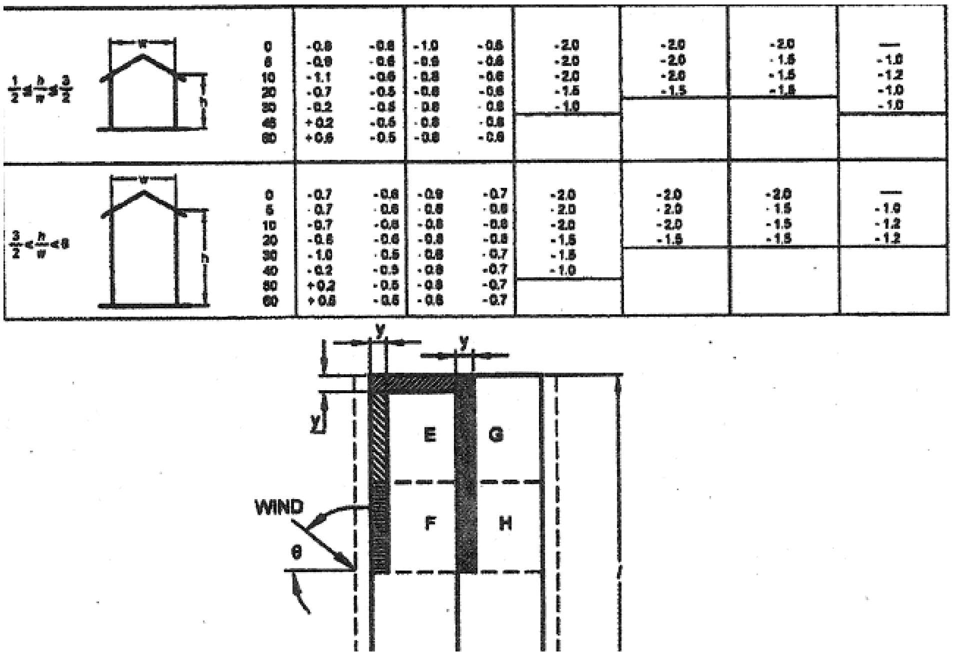
$\frac{1}{2} < \frac{h}{w} \le \frac{3}{2}$	$1 \le \frac{l}{w} \le \frac{3}{2}$	0 90	+0.7 -0.6	-0.25 -0.6	-0.6 +0.7	-0.6 -0.25	-1.1
	$\frac{3}{2} \le \frac{l}{w} < 4$	0 90	+0.7 -0.5	-0.3 -0.5	-0.7 +0.7	-0.7 -0.1	-1.1

Figure2: External Pressure Coefficients (Cpe) for Walls of Rectangular Clad Buildings

Therefore,

Cpe	0'	180'
A	+0.7	-0.25
B	-0.25	+0.7

Again, slope of the roof, $\alpha = tan^{-1}\frac{1}{7.5} = 7.59^o$.
(i) C_{pe} for the roofs(clause 7.3.3.2):
$\frac{h}{w} = 0.67$.
angle of wind incident$=\theta = 0^o$



$\frac{1}{2} \le \frac{h}{w} \le \frac{3}{2}$	0 5 10 20 30 45 60	-0.8 -0.9 -1.1 -0.7 -0.2 +0.2 +0.6	-0.6 -0.6 -0.6 -0.5 -0.5 -0.5 -0.5	-1.0 -0.9 -0.8 -0.8 -0.8 -0.8 -0.8	-0.6 -0.6 -0.6 -0.6 -0.8 -0.8 -0.8	-2.0 -2.0 -2.0 -1.5 -1.0	-2.0 -2.0 -2.0 -1.5	-2.0 -1.5 -1.5 -1.5	— -1.0 -1.2 -1.0 -1.0
$\frac{3}{2} < \frac{h}{w} < 6$	0 5 10 20 30 40 50 60	-0.7 -0.7 -0.7 -0.8 -1.0 -0.2 +0.2 +0.5	-0.6 -0.6 -0.6 -0.6 -0.5 -0.5 -0.5 -0.5	-0.9 -0.8 -0.8 -0.8 -0.8 -0.8 -0.8 -0.8	-0.7 -0.8 -0.8 -0.8 -0.7 -0.7 -0.7 -0.7	-2.0 -2.0 -2.0 -1.5 -1.5 -1.0	-2.0 -2.0 -2.0 -1.5	-2.0 -1.5 -1.5 -1.5	— -1.0 -1.2 -1.2

Figure3: External Pressure Coefficients (Cpe) for Pitched Roofs of Rectangular Clad Buildings

Therefore,
for EF face,
Cpe $= \frac{(-1.1+0.9)}{5}$*(7.59-5)-0.9 = -1.0036
for GH face,
Cpe $= \frac{(-0.6+0.6)}{5}$*(7.59-5)-0.6 = -0.6

- $C_{p_{net}}$ for the walls:
  Cpnet = Cpe-Cpi=(0.7)-(-0.7) = 1.4 (pressure zone)
  Cpnet = -0.25-(0.7) = -0.95 (suction zone)

- $C_{p_{net}}$ for the roof:
  Cpnet = -1.0036-0.7=-1.7036 (windward side)
  Cpnet = -0.6-0.7 = -1.3 (leeward side)

- Design pressure for the walls:
  Pressure = Cpnet * Pd
  For windward side: 1.4*0.91584 = 1.28 kN/m^2 (pressure)
  For leeward side: -0.95 * 0.91584 = -0.87 kN/m^2 (suction)

- Design pressure for the roof:
  Pressure = Cpnet * Pd
  For windward side: -1.7036*0.91584 = -1.56 kN/m^2 (suction)
  For leeward side: -1.3 * 0.91584 = -1.194 kN/m^2 (suction)

- Summarizing the wind load conditions for walls:

Cases	θ	W.W.(Cpe)	L.W.(Cpe)	Cpi	W.W.(Cpnet)	L.W.(Cpnet)	W.W.	L.W.
1a	0'	0.7	-0.25	-0.7	1.4	0.45	1.28	0.412
1b	0'	0.7	-0.25	+0.7	0	-0.95	0	-0.87
2a	180'	-0.25	0.7	-0.7	0.45	1.4	0.412	1.28
2b	180'	-0.25	0.7	+0.7	-0.95	0	-0.87	0

- Summarizing the wind load conditions for roof:

Cases	θ	W.W.(Cpe)	L.W.(Cpe)	Cpi	W.W.(Cpnet)	L.W.(Cpnet)	W.W.	L.W.
1a	0'	-1.036	-0.6	-0.7	0.303	0.1	-0.28	0.092
1b	0'	-1.036	-0.6	+0.7	-1.703	-1.3	-1.56	-1.19
2a	180'	-0.6	-1.036	-0.7	0.1	-0.303	0.092	-0.28
2b	180'	-0.6	-1.0036	+0.7	-1.3	-1.703	-1.19	-1.56

The last 2 columns of the above tables indicates the final wind load forces. These values are areal loads, so we will convert them into linear loads. Just for an illustration for side walls case(1a), we 1.28kN/m^2 *5 = 6.4 kN/m and 1.28 kN/m^2 *2.5=3.2 kN/m.

3.4 Load Combinations

- The combined effect of various loads should be done as follows:
  Limit State of Strength:
  1.2DL + 1.2 LL + 1.2 WL

- Load combinations for 4 different WL cases are to be considered separately.

4 Analysis and design

4.1 Analysis

For the analysis of our pre-engineered building, we used the structural designing software STAAD Pro. We have chosen limit state of strength as our criterion for analyzing our structure as prescribed in the code. Majorly our task involved:

- Assigning the members for the structure as per IS 800 LSD (Limit state of design)
- Checking the IS codes for the stability of our structure
- Iterating the depth of the tapered section to make a perfectly stable structure and maintaining the utility ratio which is defined as the actual load on the member to its capacity

The main purpose of the analysis check is to see whether the section sizes of the different structural members are sufficient in handling the various load combinations.

4.2 Design

We have used STAAD Pro for designing our beams, columns and other sections. We have also used Osdag for designing the connection design. Majorly our task involved:

- Choosing an optimal tapered section maintaining design all the design philosophies.
- Designing the connection members based on the reaction forces at the base joints.
- Autocad drawings of the final structure

Steel Design in Staad pro as per IS 800 - 2007 LSD. For steel design, STAAD Pro compares the actual design forces with the capacities as defined by the Indian Standard Code. The IS 800: 2007 Code is used as the basis of this design. We have designed our structure as per the limit state of design. A Limit state is a state of impending failure beyond which a structure ceases to perform its intended function satisfactorily. Characteristic values derived from the probabilistic approach are used in the limit state method. We have maintained the utility ratio is the ratio of Actual Load on member to the capacity of member. If it exceeds more than 1 then load on member will be greater than its capacity and the member gets collapsed. Utility is also an important parameter to know if the structure is economical.

5 Modelling

5.1 Software Model: Details

- All the columns are pin-jointed to the ground
- Bracings are attached to the side walls which doesn't carry any moment as expected.

5.2 Software Model: Images

5.2.1 Line model of structure

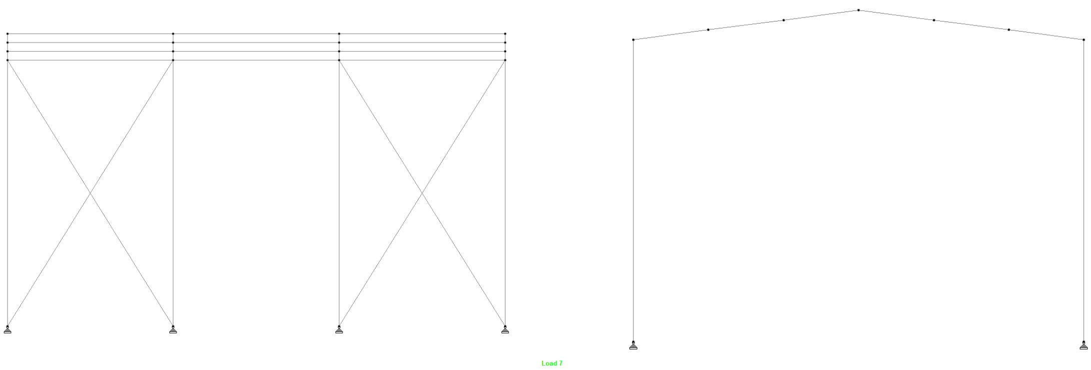


Figure4: Side view and Front view

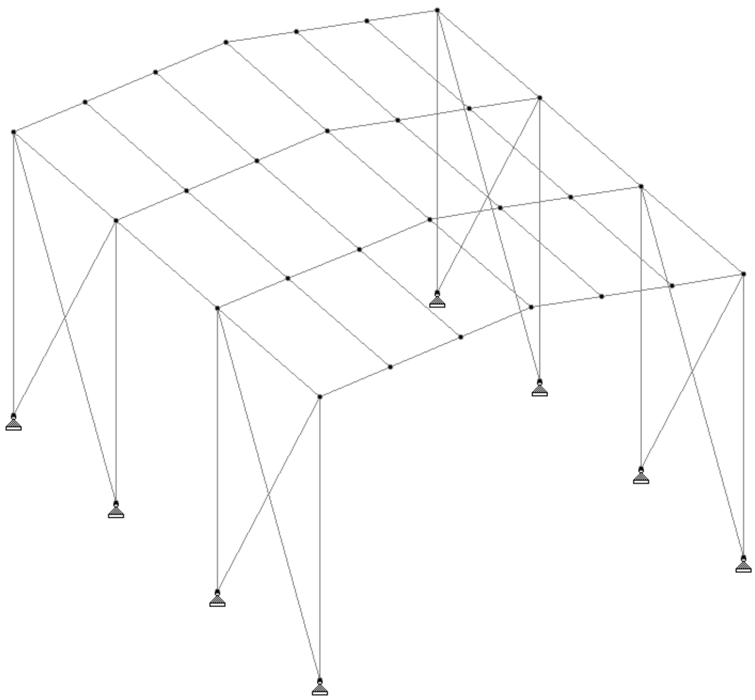


Figure5: Isometric view

5.2.2 3D rendered view of the model

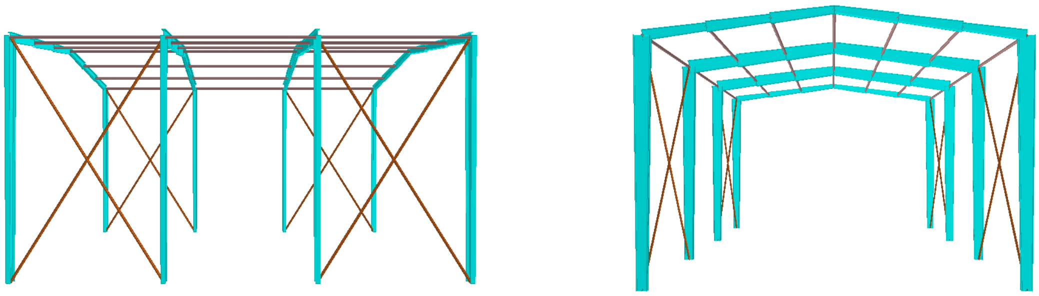


Figure6: Side view and Front view

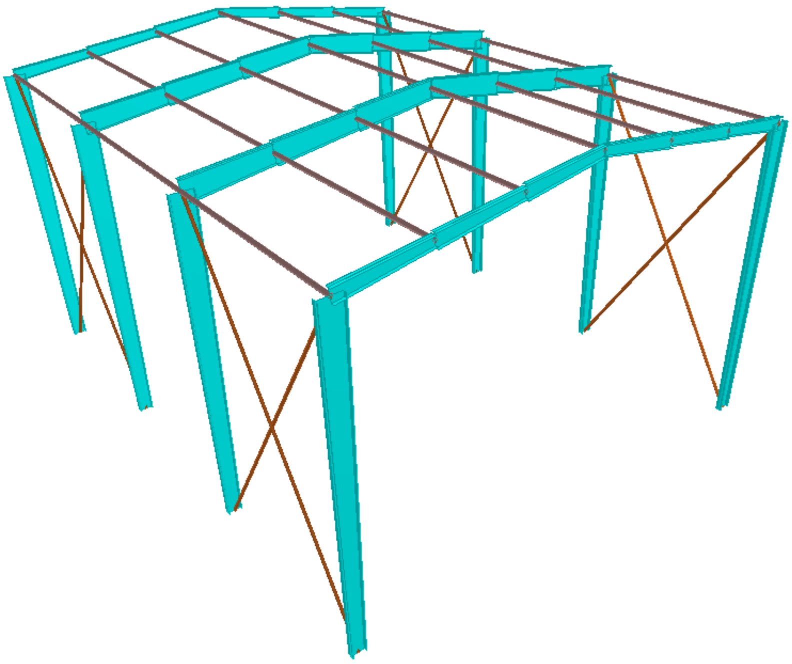


Figure7: Isometric view

6 Structural Design

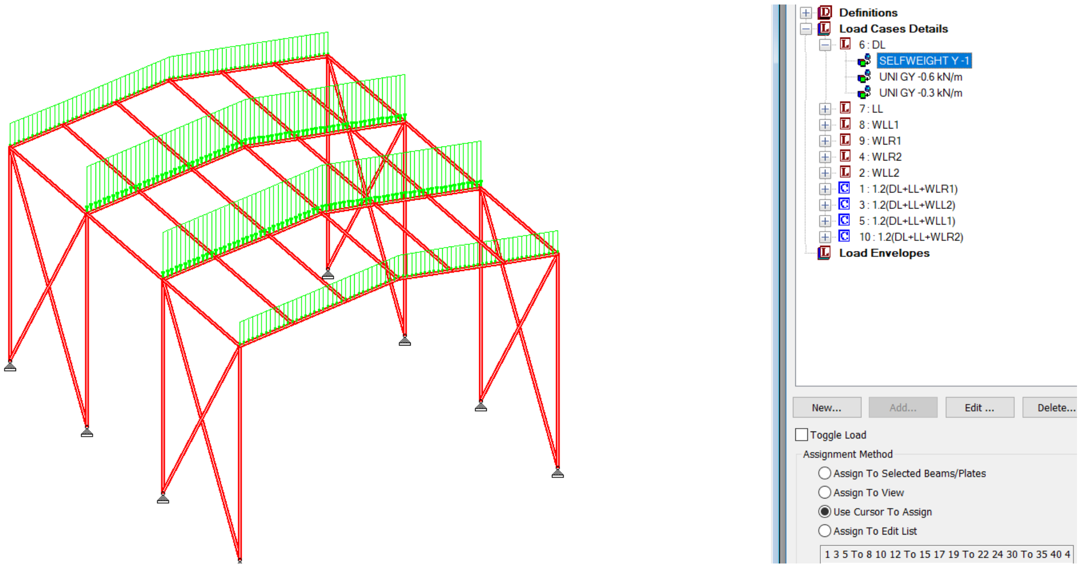


Figure8: Dead load application (IS 875 Part-I)

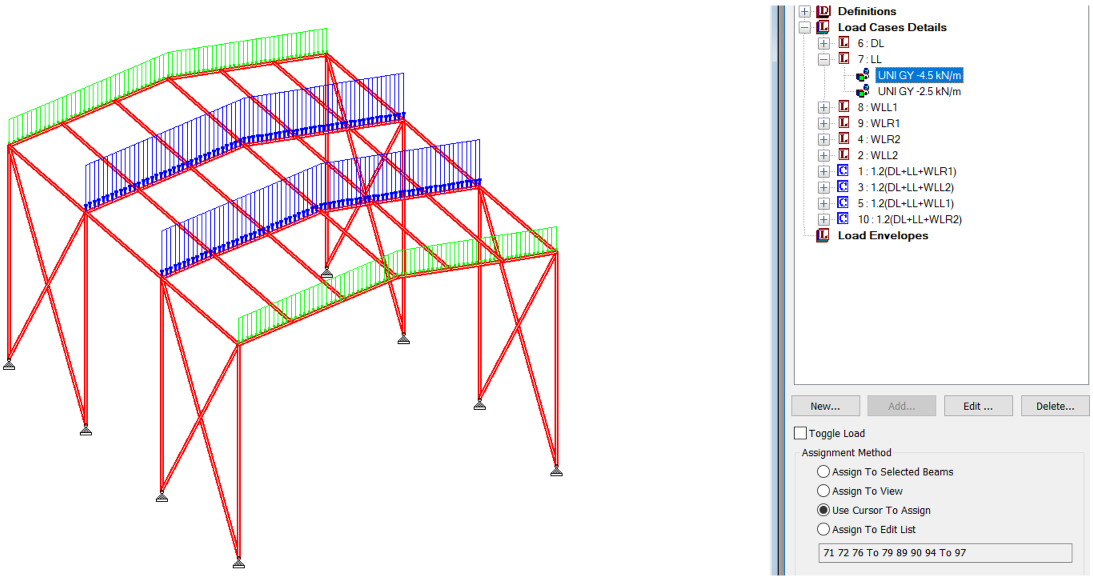


Figure9: Live load application (IS 875 Part-II)

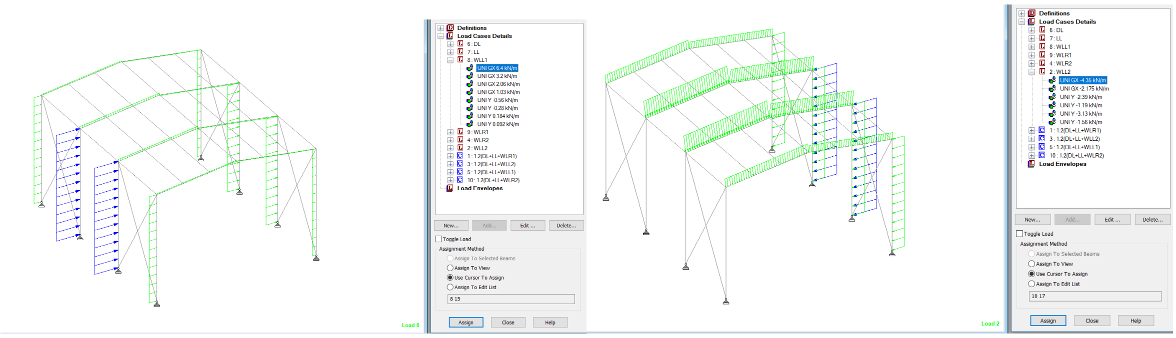


Figure10: Wind load application in +x direction

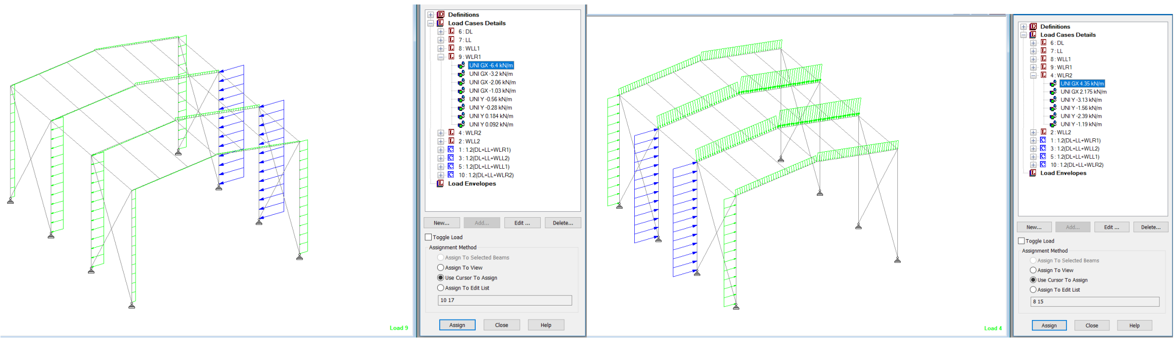


Figure11: Wind load application in -x direction

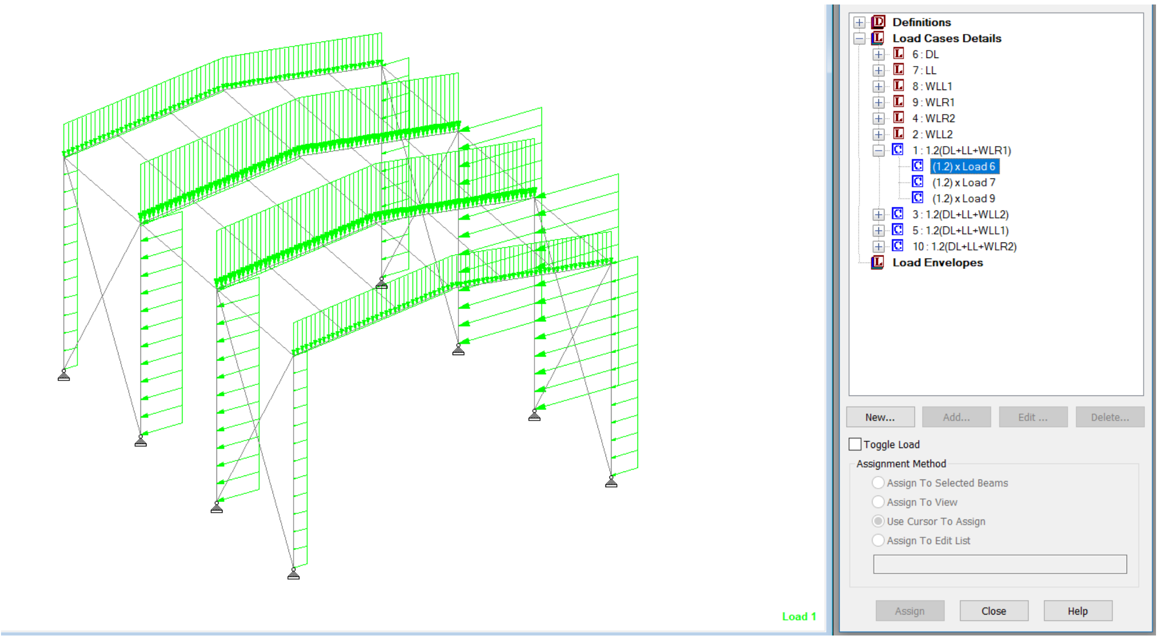


Figure12: Load combination sample case

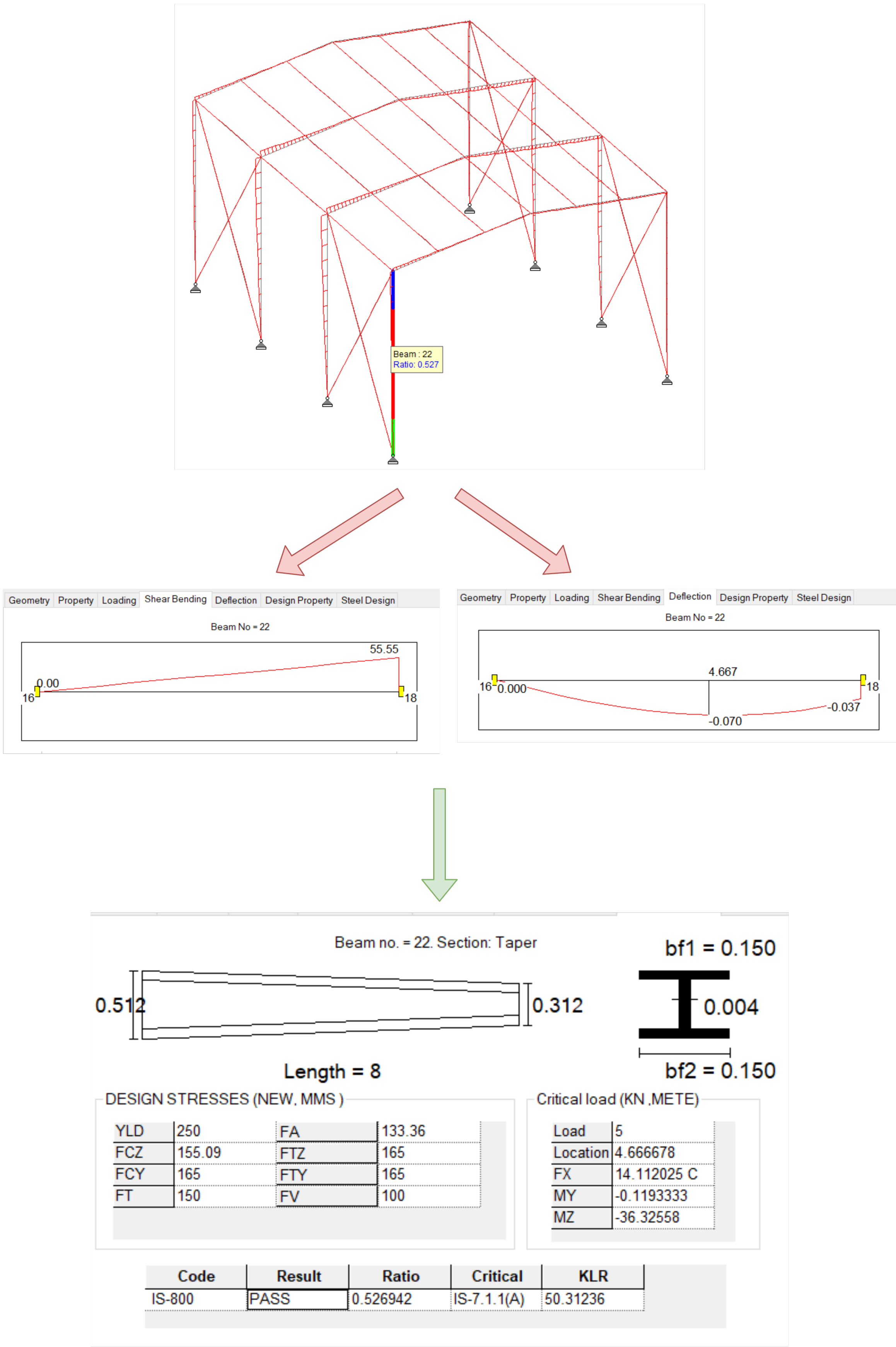


Figure13: Stability check for column

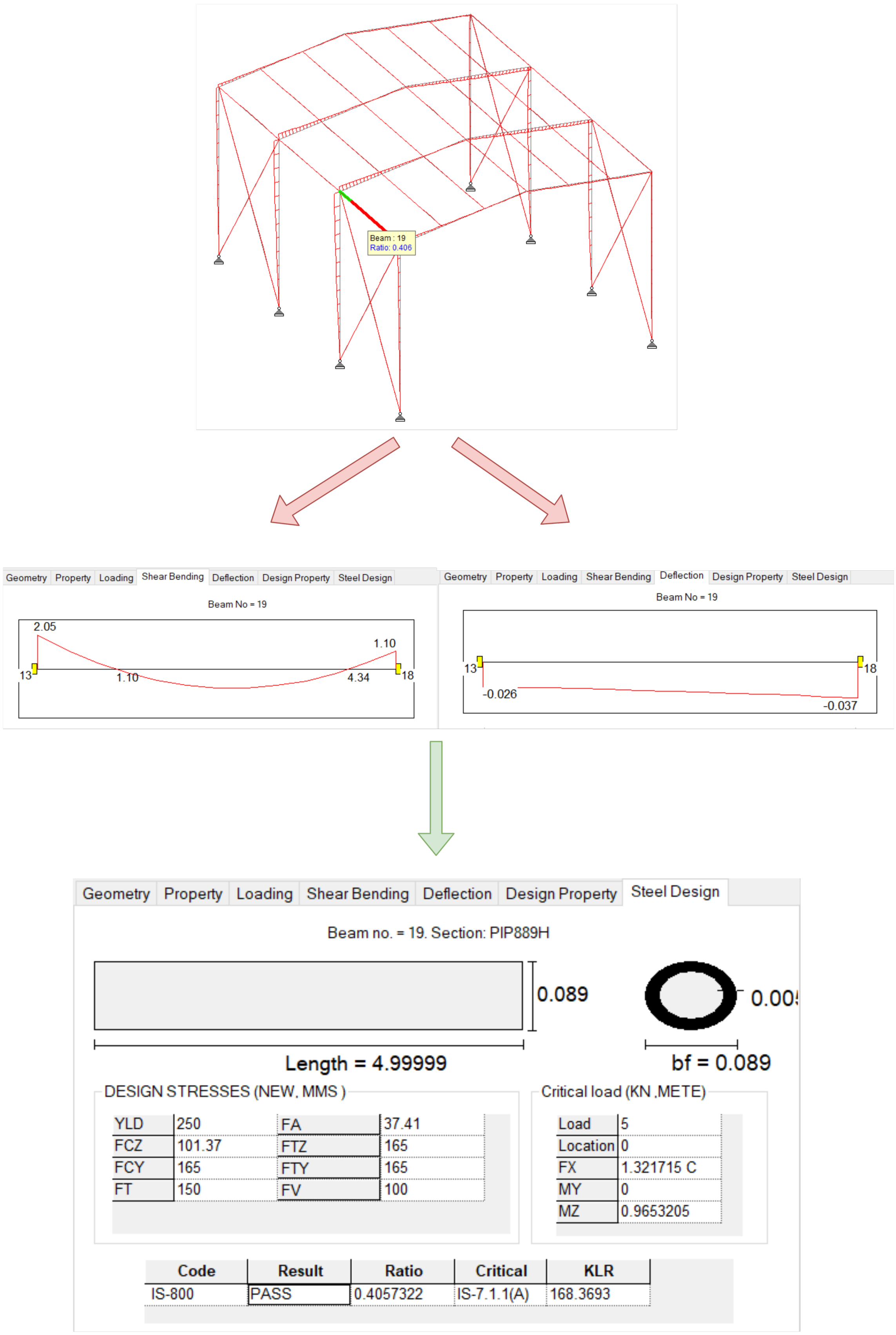


Figure14: Stability check for pipe beam

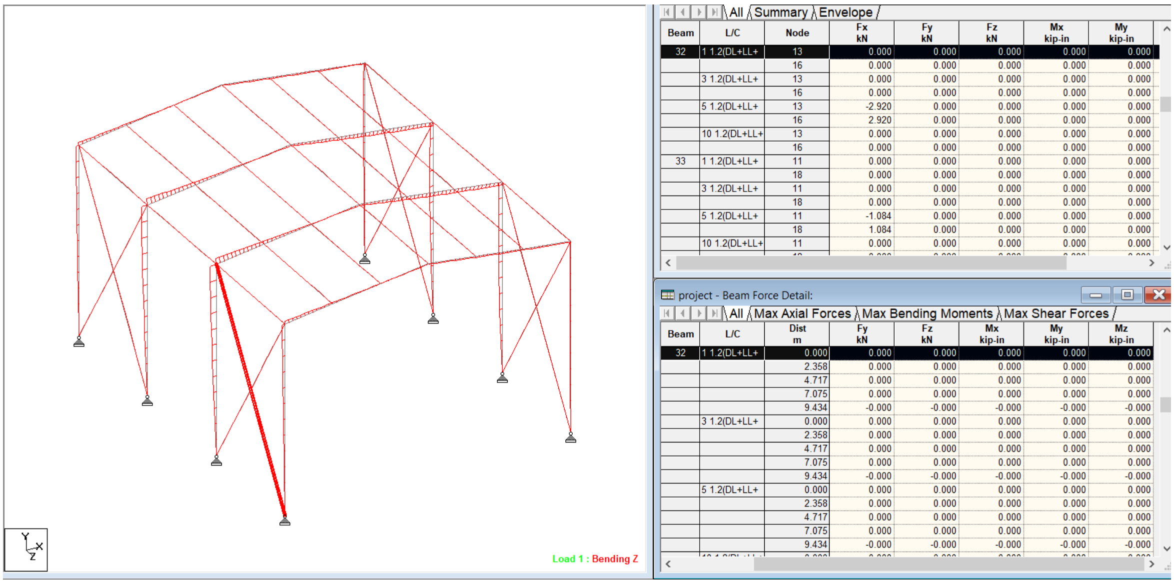


Figure15: Moment check for bracing.

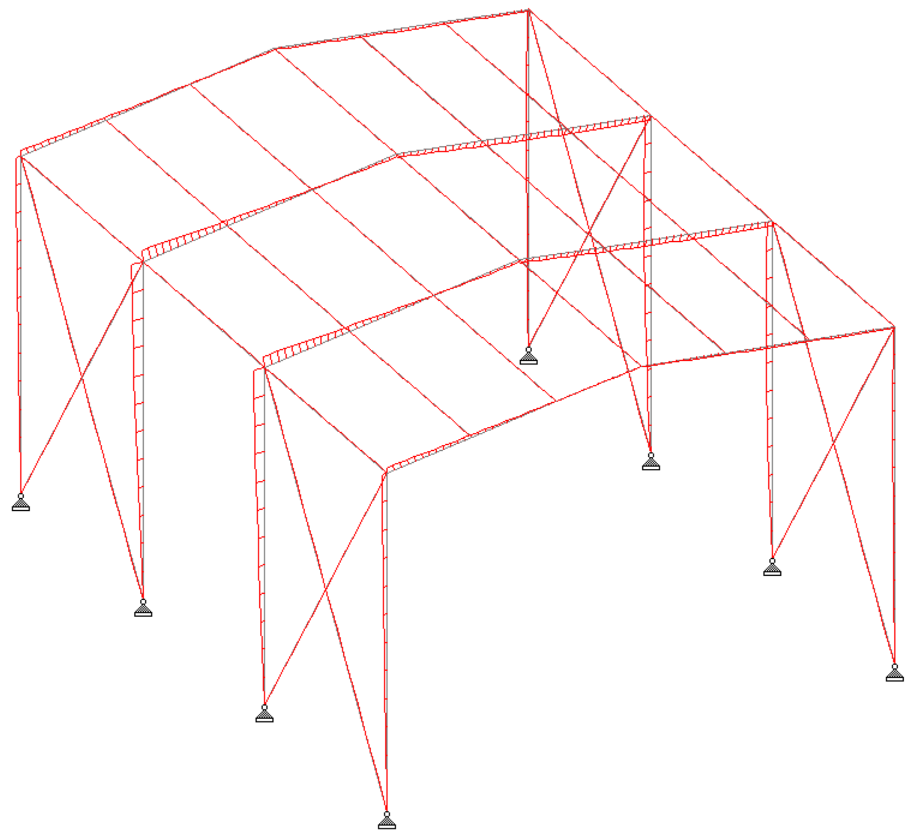


Figure16: Moment along z-direction

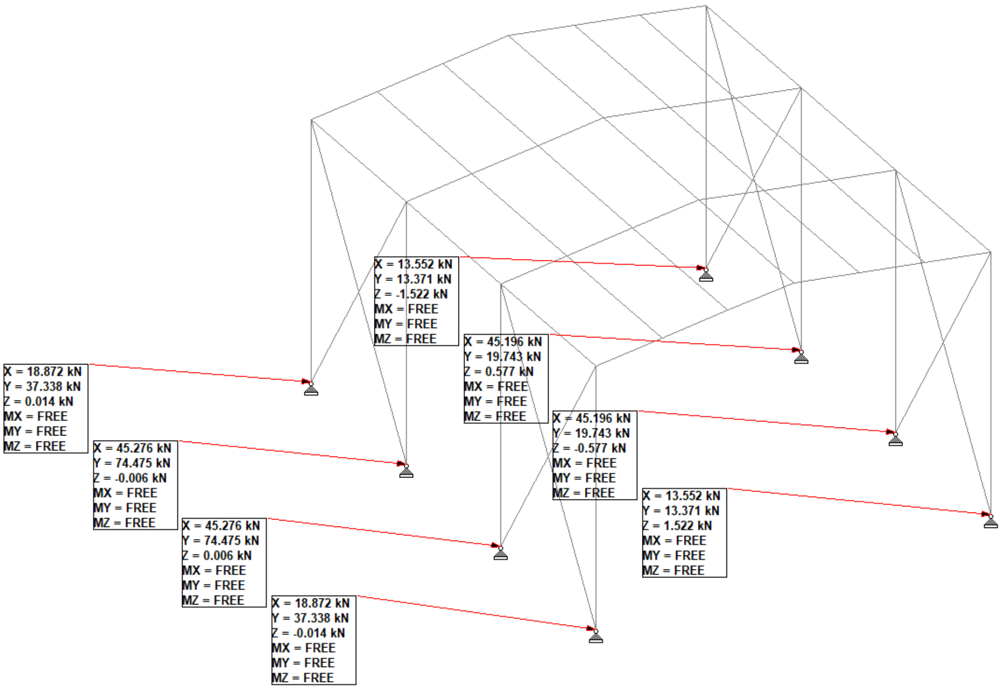


Figure17: Base reactions

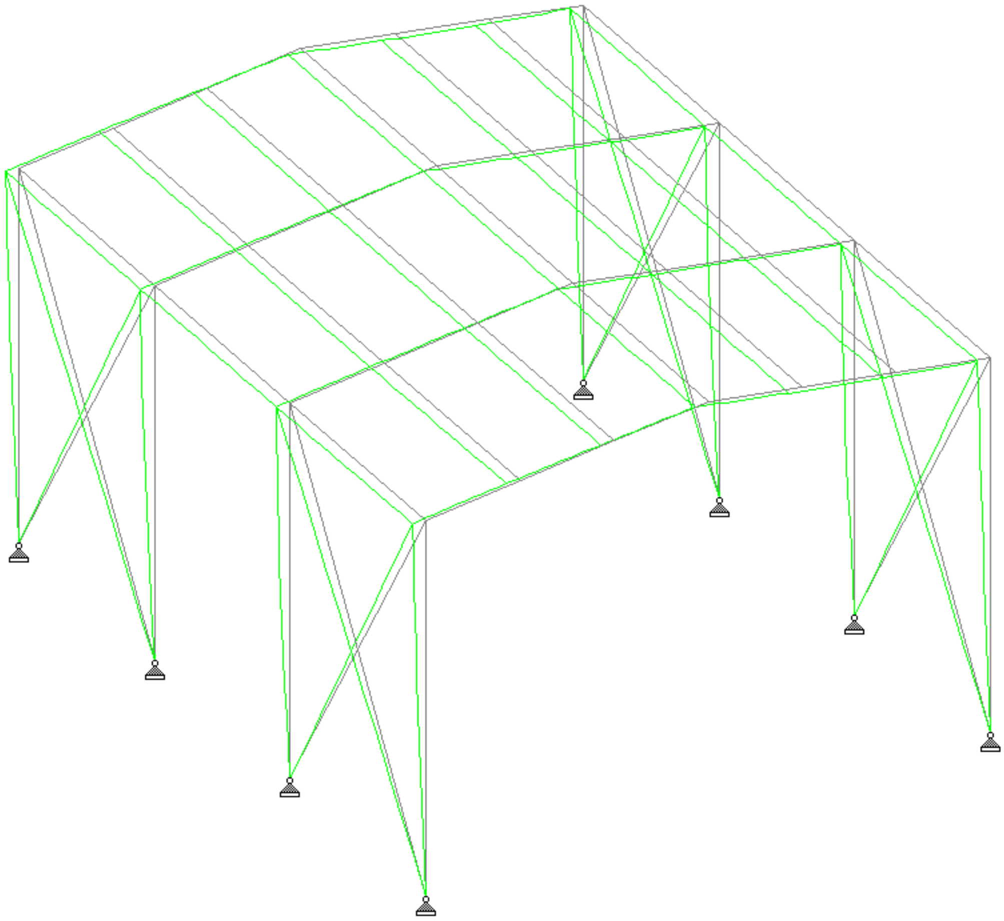


Figure18: Deflections and deformed shapes

Final design of the PEB:

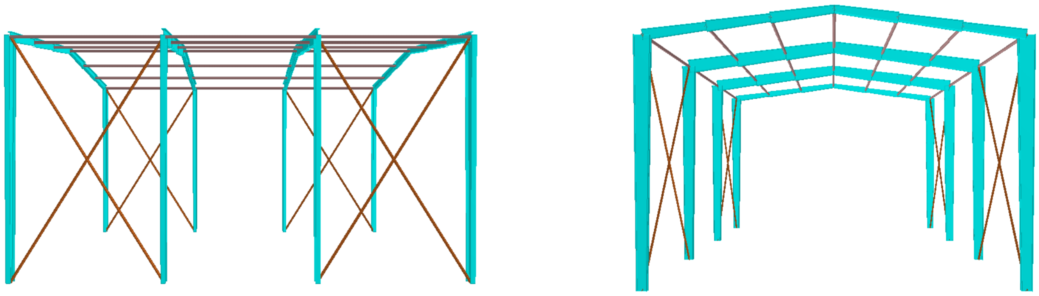


Figure19: Side view and Front view

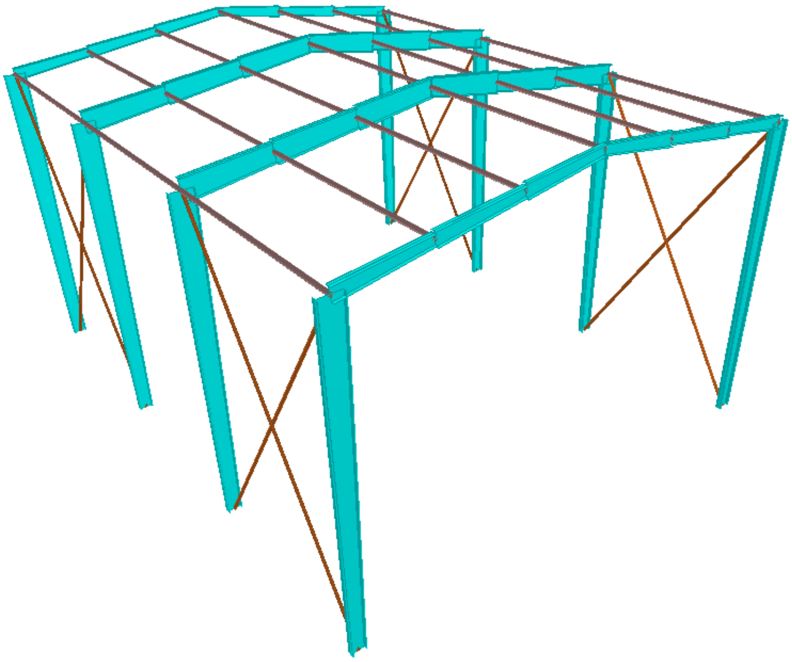
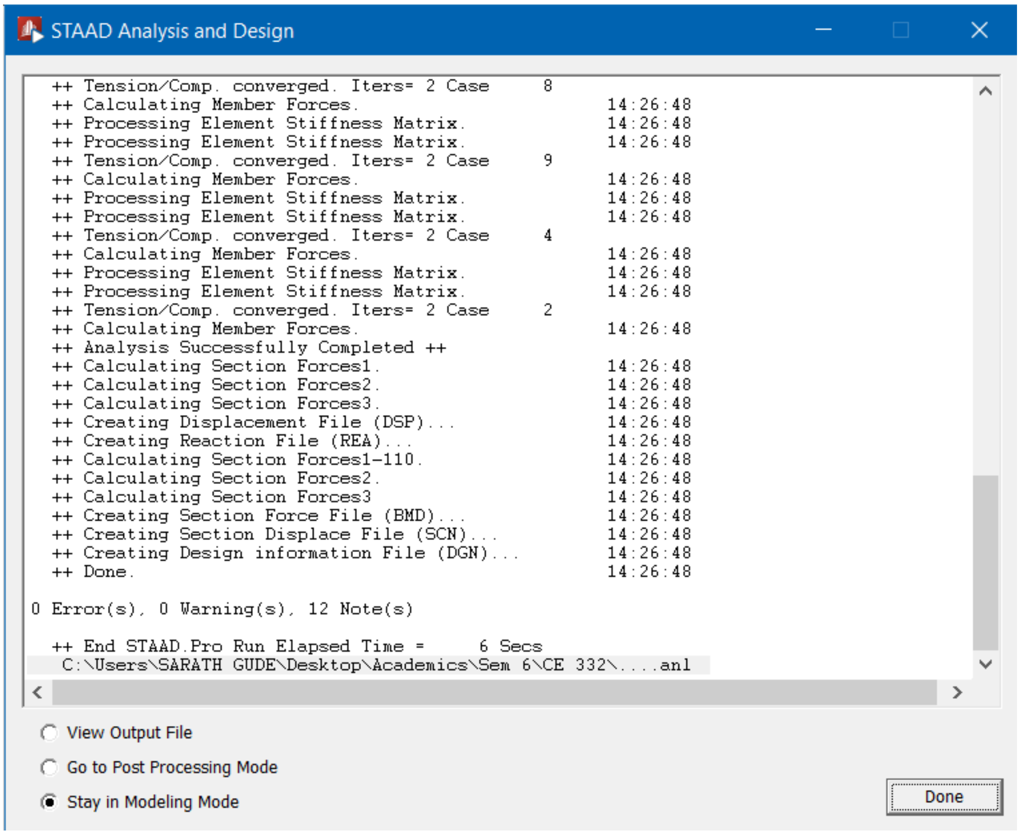


Figure20: Isometric view of final structure

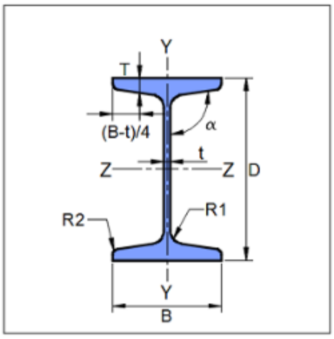

STAAD Analysis and Design
++ Tension/Comp. converged. Iters= 2 Case 8
++ Calculating Member Forces. 14:26:48
++ Processing Element Stiffness Matrix. 14:26:48
++ Processing Element Stiffness Matrix. 14:26:48
++ Tension/Comp. converged. Iters= 2 Case 9
++ Calculating Member Forces. 14:26:48
++ Processing Element Stiffness Matrix. 14:26:48
++ Processing Element Stiffness Matrix. 14:26:48
++ Tension/Comp. converged. Iters= 2 Case 4
++ Calculating Member Forces. 14:26:48
++ Processing Element Stiffness Matrix. 14:26:48
++ Processing Element Stiffness Matrix. 14:26:48
++ Tension/Comp. converged. Iters= 2 Case 2
++ Calculating Member Forces. 14:26:48
++ Analysis Successfully Completed ++
++ Calculating Section Forces1. 14:26:48
++ Calculating Section Forces2. 14:26:48
++ Calculating Section Forces3. 14:26:48
++ Creating Displacement File (DSP)... 14:26:48
++ Creating Reaction File (REA)... 14:26:48
++ Calculating Section Forces1-110. 14:26:48
++ Calculating Section Forces2. 14:26:48
++ Calculating Section Forces3 14:26:48
++ Creating Section Force File (BMD)... 14:26:48
++ Creating Section Displace File (SCN)... 14:26:48
++ Creating Design information File (DGN)... 14:26:48
++ Done. 14:26:48
0 Error(s), 0 Warning(s), 12 Note(s)
++ End STAAD.Pro Run Elapsed Time = 6 Secs
C:\Users\SARATH GUDE\Desktop\Academics\Sem 6\CE 332\....anl
View Output File
Go to Post Processing Mode
Stay in Modeling Mode
Done

7 Connection Design

7.1 Base plate design

Main Module	Moment Connection
Module	Base Plate Connection
Connectivity	Welded Column Base
End Condition	Pinned
Axial Compression (kN)	45.28
Axial Tension/Uplift (kN)	0.0
Shear Force (kN)	
- Along major axis (z-z)	13.37
- Along minor axis (y-y)	85.43
Bending Moment (kNm)	
- Major axis (M_{z-z})	0.0
- Minor axis (M_{y-y})	0.0

Column Section - Mechanical Properties



Column Section		HB 350	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410.0	
Yield Strength, F_y (MPa)		250.0	
Mass, m (kg/m)	67.42	I_z (cm^4)	19100.0
Area, A (cm^2)	85.9	I_y(cm^4)	2450.0
None	None	r_z (cm)	14.9
D (mm)	350.0	r_y (cm)	5.34
B (mm)	250.0	Z_z (cm^3)	1090.0
T (mm)	11.6	Z_y (cm^3)	196.0
t (mm)	8.3	Z_{pz} (cm^3)	1210.0
Flange Slope	94	Z_{py} (cm^3)	324.0
R_1 (mm)	12.0		
R_2 (mm)	6.0		

Base Plate - Design Preference

Material	E 250 (Fe 410 W)A
Ultimate Strength, F_u (MPa)	410
Yield Strength, F_y (MPa)	250

Stiffener/Shear Key - Design Preference	
Material	E 250 (Fe 410 W)A
Anchor Bolt Outside Column Flange - Input and Design Preference	
Diameter (mm)	['M20', 'M24', 'M30', 'M36', 'M42', 'M48', 'M56', 'M64', 'M72']
Property Class	['3.6', '4.6', '4.8', '5.6', '5.8', '6.8', '8.8', '9.8', '10.9', '12.9']
Anchor Bolt Type	End Plate Type
Anchor Bolt Galvanized?	Yes
Designation	M20X346.5 IS5624 GALV
Hole Type	Over-sized
Total Length (mm)	346.5
Material Grade, F_u (MPa)	1220.0
Anchor Bolt Inside Column Flange - Input and Design Prefereself.anchor_grade_list_outnce	
Diameter (mm)	N/A
Property Class	N/A
Anchor Bolt Type	N/A
Anchor Bolt Galvanized?	N/A
Designation	N/A
Hole Type	N/A
Total Length (mm)	N/A
Material Grade, F_u (MPa)	N/A
Friction Coefficient (between concrete and anchor bolt)	0.3
Weld - Design Preference	
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, F_u (MPa)	410.0

2.4 Anchor Bolt Summary - Outside Column Flange

Check	Required	Provided	Remarks
Diameter (mm)		20	Pass
Number of Bolts		$n_{\mathrm{out}} = 4$	Pass
Property Class		12.9	Pass

2.7 Base Plate Dimension (L X W)

Check	Required	Provided	Remarks
Length (mm)	$L = D + 2\,(e + e)$ $= 350.0 + 2 \times (55 + 55)$ $= 570.0$ [Ref. based on detailing requirement]	570.0	Pass
Width (mm)	$W = (0.85B) + 2\,(e' + e')$ $= (0.85 \times 250.0) + 2 \times (55 + 55)$ $= 432.5$ [Ref. based on detailing requirement]	470.0	Pass

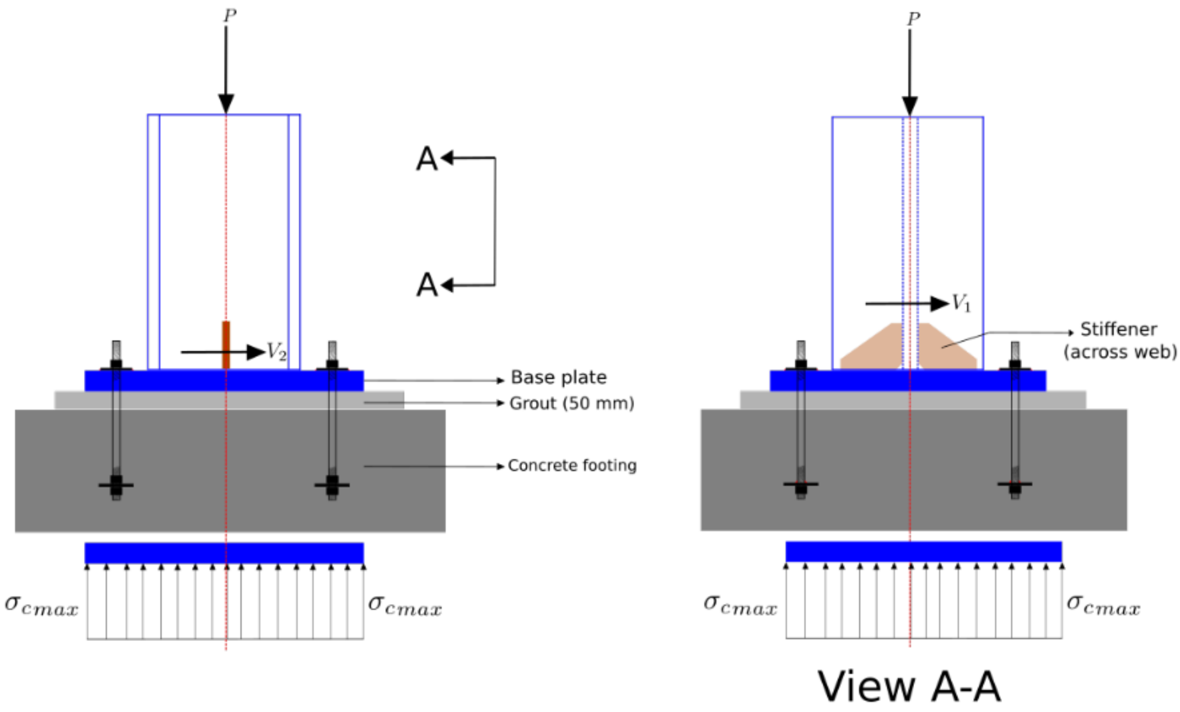


Figure 1: Typical Base Plate Details

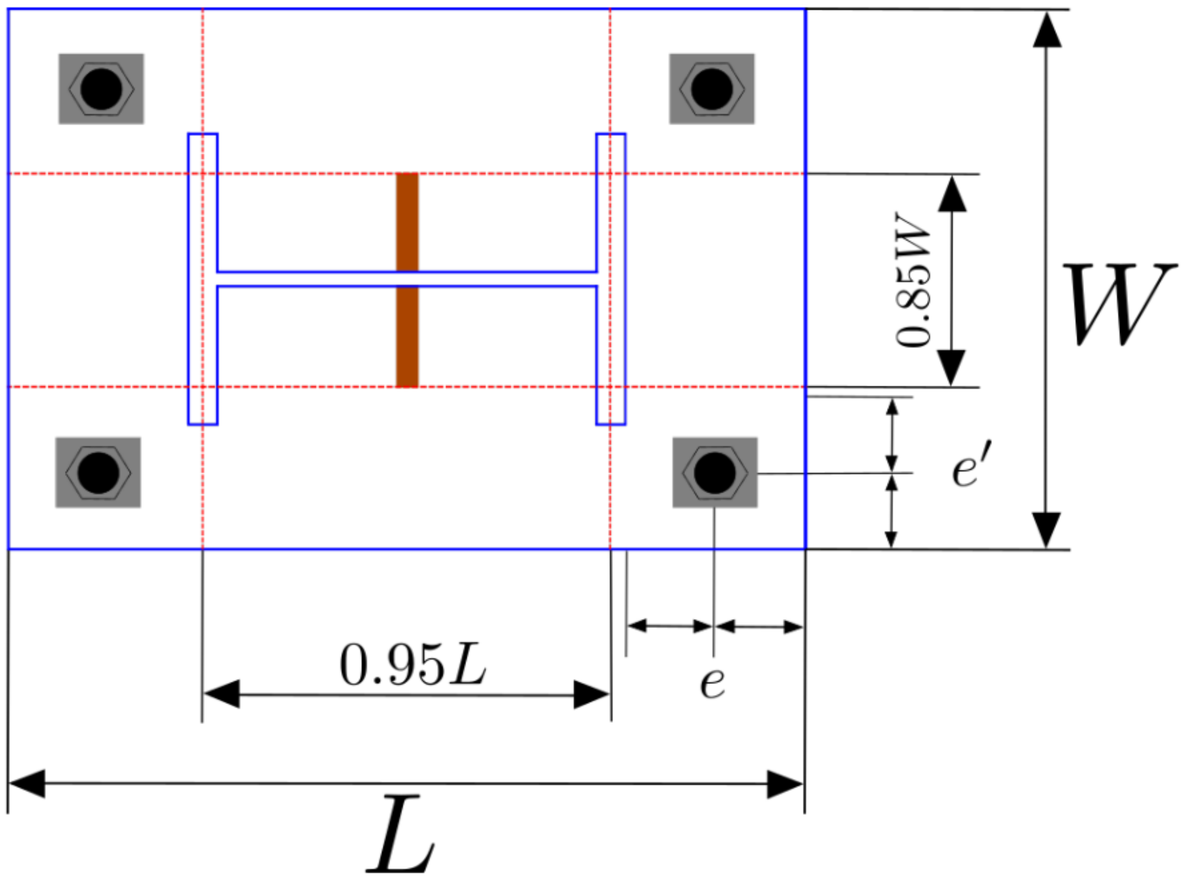


Figure 2: Typical Base Plate Detailing

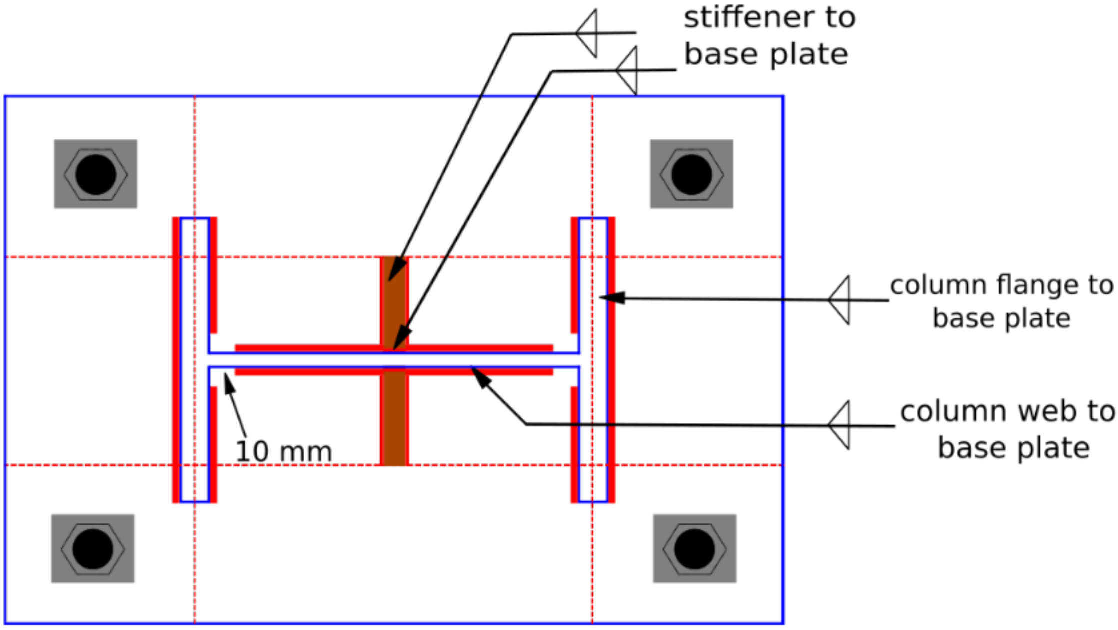
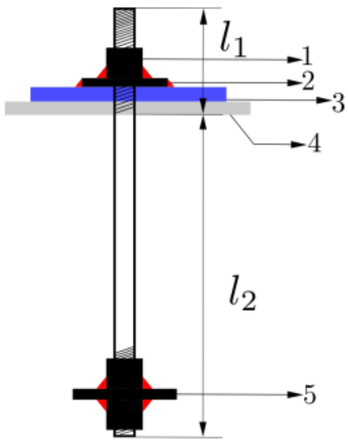
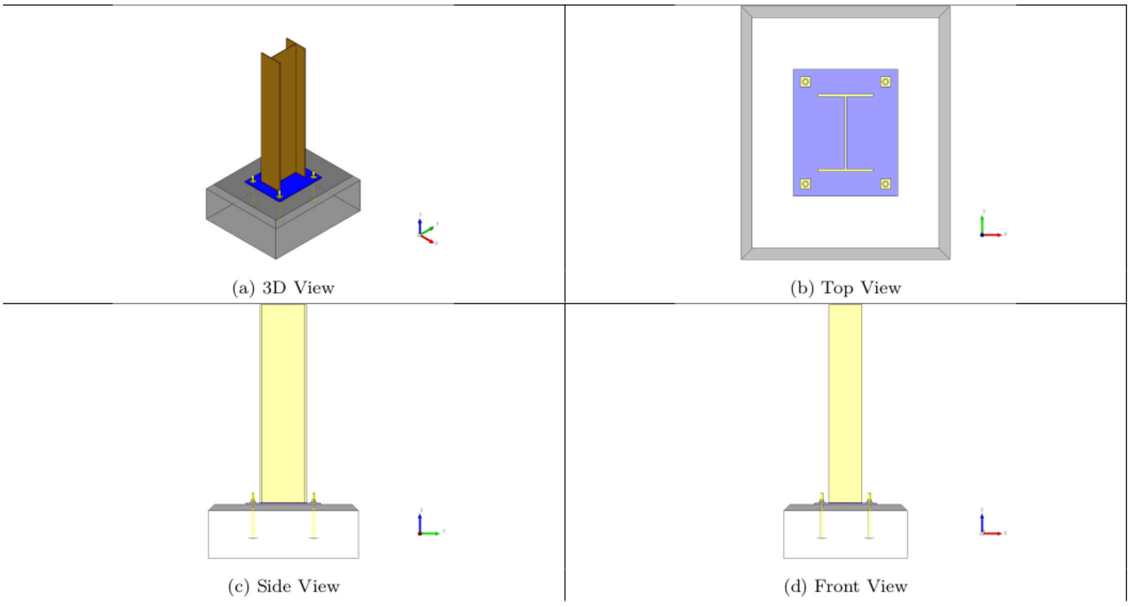


Figure 3: Typical Weld Details

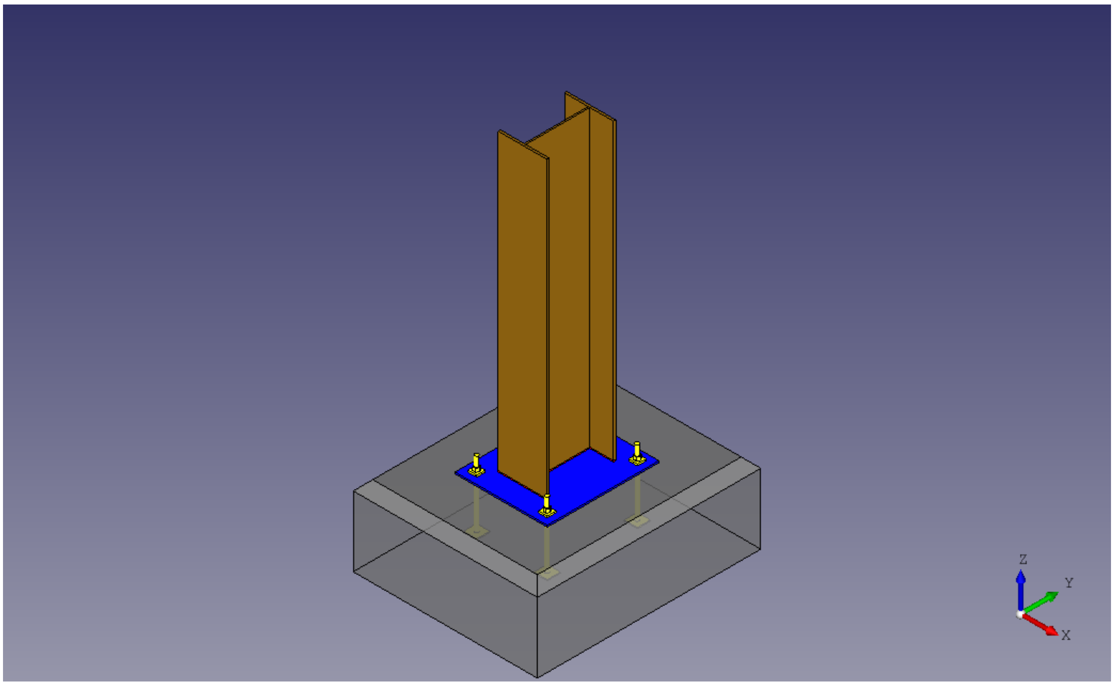


$l_1 =$ length above footing
$l_2 =$ length below footing
$1 = t_{\text{n}}$, nut thickness
$2 = t_{\text{w}}$, washer thickness
$3 = t_{\text{p}}$, plate thickness
$4 = t_{\text{g}}$, grout thickness
$5 =$ end plate thickness

Figure 4: Typical Anchor Bolt Details

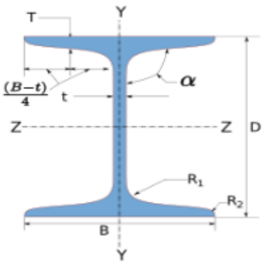


(a) 3D View (b) Top View (c) Side View (d) Front View



7.2 Ridge Plate design

Main Module	Moment Connection
Module	Beam-to-Beam End Plate Connection
Connectivity	Coplanar Tension-Compression Flange
End Plate Type	Flushed - Reversible Moment
Bending Moment (kNm)	126.09
Shear Force (kN)	3.04
Axial Force (kN)	15.406
Beam Section - Mechanical Properties	



Beam Section		LB 450	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	65.22	I_z (cm^4)	27500.0
Area, A (cm^2)	8310.0	I_y(cm^4)	853.0
D (mm)	450.0	r_z (cm)	18.2
B (mm)	170.0	r_y (cm)	3.2
t (mm)	8.6	Z_z (cm^3)	1220.0
T (mm)	13.4	Z_y (cm^3)	100.0
Flange Slope	98	Z_{pz} (cm^3)	1400.0
R_1 (mm)	16.0	Z_{py} (cm^3)	174.0
R_2 (mm)	8.0		

Plate Details - Input and Design Preference	
Thickness (mm)	[8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 75, 80, 90, 100, 110, 120]
Material	E 250 (Fe 410 W)A
Ultimate Strength, F_u (MPa)	410
Yield Strength, F_y (MPa)	250
Bolt Details - Input and Design Preference	
Diameter (mm)	[8, 10, 12, 14, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 42, 45, 48, 52, 56, 60, 64]
Property Class	[3.6, 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8, 10.9, 12.9]
Type	Bearing Bolt
Bolt Tension	Non pre-tensioned
Hole Type	Standard
Slip Factor, (μ_f)	0.3
Weld Details - Input and Design Preference	
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, F_u (MPa)	410.0
Beam Flange to End Plate	Groove Weld
Beam Web to End Plate	Fillet Weld
Stiffener	Fillet Weld
Detailing - Design Preference	
Edge Preparation Method	Sheared or hand flame cut
Gap Between Beams (mm)	0.0
Are the Members Exposed to Corrosive Influences?	False

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Diameter Optimization	$d = 8$	Pass
Property Class	Bolt Property Class Optimization	12.9	Pass
Hole Diameter (mm)		$d_0 = 8$	OK
No. of Bolt Columns		$n_c = 4$	Pass
No. of Bolt Rows		$n_r = 8$	Pass
Total No. of Bolts		$n = n_r X n_c = 32$	Pass

Check	Required	Provided	Remarks
Weld Strength (N/mm2)	$f_{u_w} = \min(f_w,\ f_u)$ $= \min(410.0,\ 410)$ [Ref. IS 800:2007, Cl.10.5.7.1.1]	$f_{u_w} = 410.0$	Pass
Total Weld Length (mm)		$L_w = 2 \times \left[D - (2 \times T) - (2 \times R1) - 20\right]$ $= 2 \times \left[450.0 - (2 \times 13.4) - (2 \times 16.0) - 20\right]$ $= 742$ Note: Weld is provided on both sides of the web	
Weld Size (mm)	$t_w = \frac{V_u}{f_{u_w} k L_w} \times \sqrt{3}\ \gamma_{mw}$ $= \frac{40 \times 10^3}{410.0 \times 0.7 \times 742} \times \sqrt{3} \times 1.25$ $= 0.41$ [Ref. IS 800:2007, Cl.10.5.7]	6	Pass

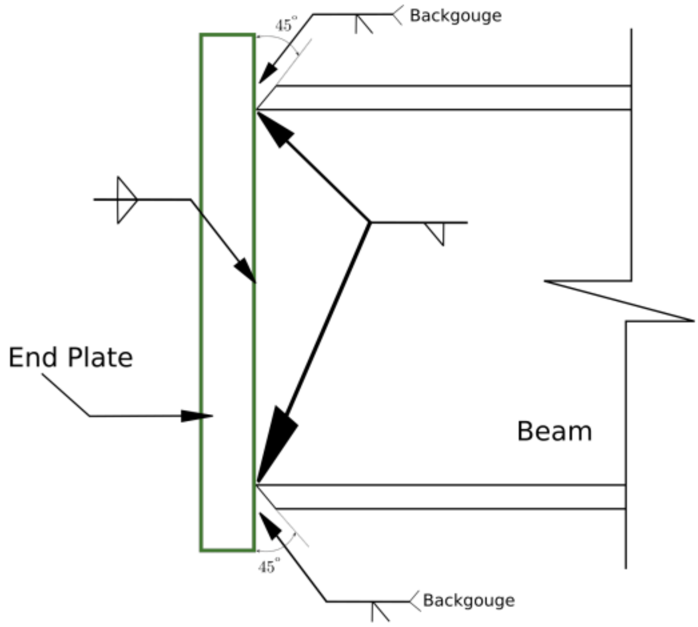


Figure 1: Typical Weld Details – Beam to End Plate Connection

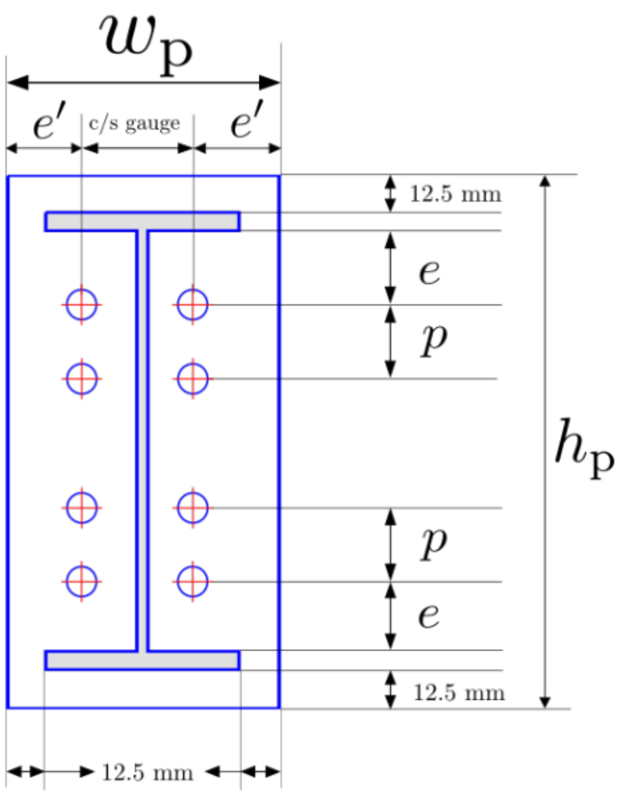


Figure 2: Typical Detailing

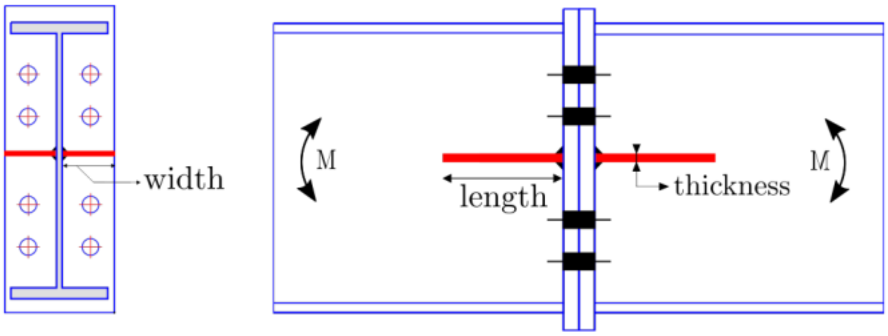
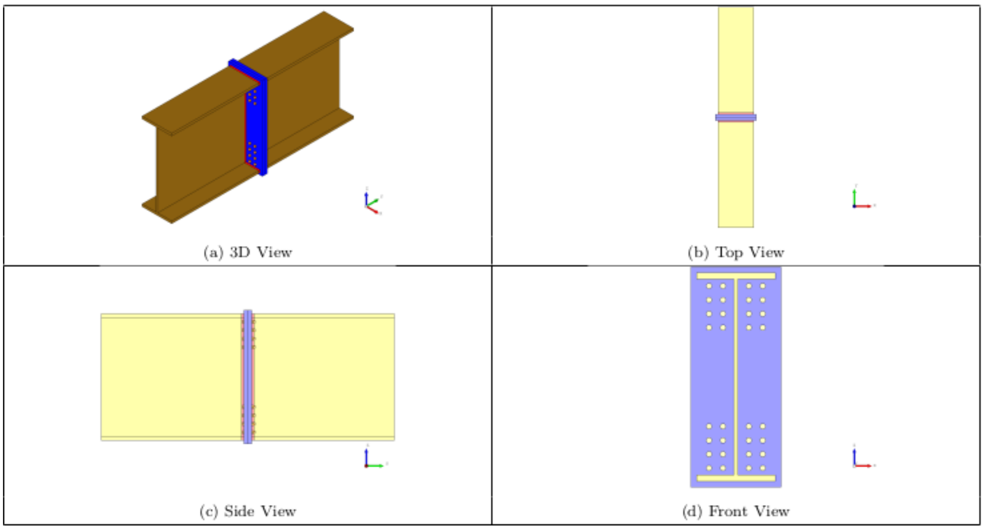


Figure 3: Typical Stiffener Details

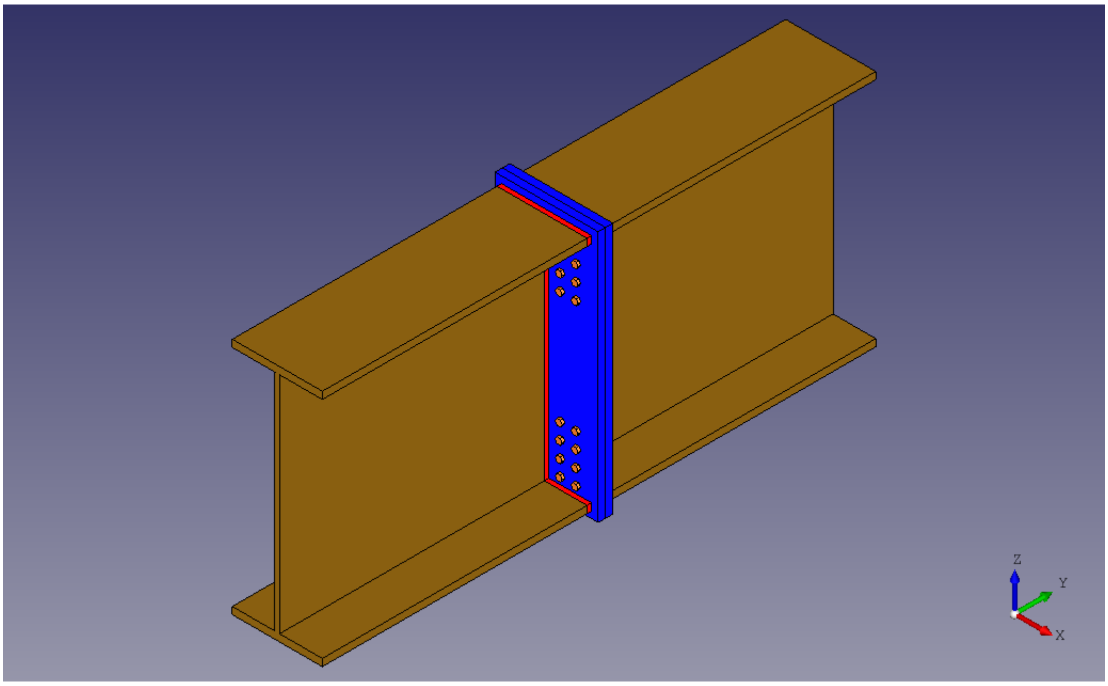


(a) 3D View

(b) Top View

(c) Side View

(d) Front View



8 Bill of quantity

Raw cost:

Total weight of the structure = 6648 Kg and Steel 202 has a cost of Rs.127/Kg.

Thus, total cost = Rs. 6648*127 = Rs. 844296

Connections = 10% * 844296 = Rs. 84429.6

Labour = 30% * 844296 = Rs. 253288.8

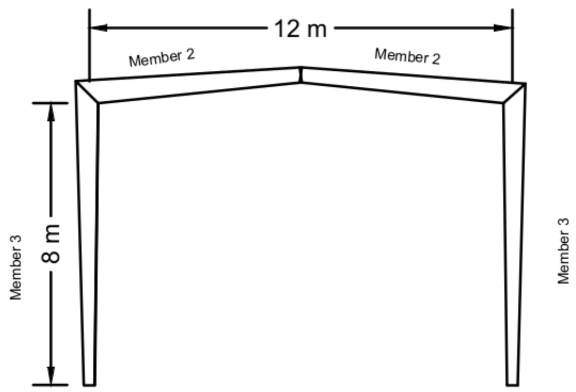
Contingencies = 10% * 844296 = Rs. 84429.6

Foundation = 3% * 844296 = Rs. 25328.88

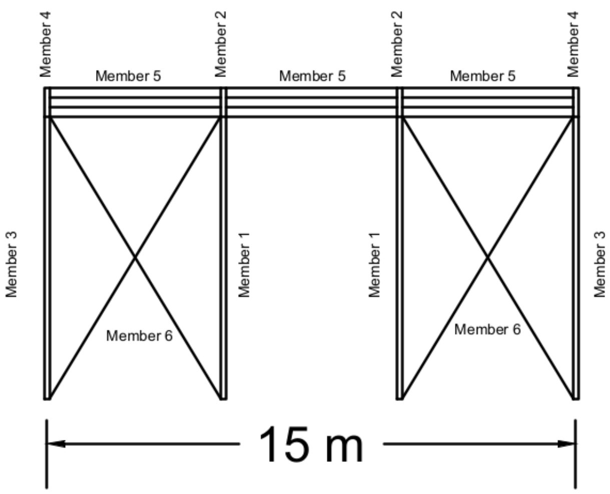
Therefore, total cost = 844296+84429.6+253288.8+84429.6+25328.88 = Rs. 12,91,772.88

9 Appendix

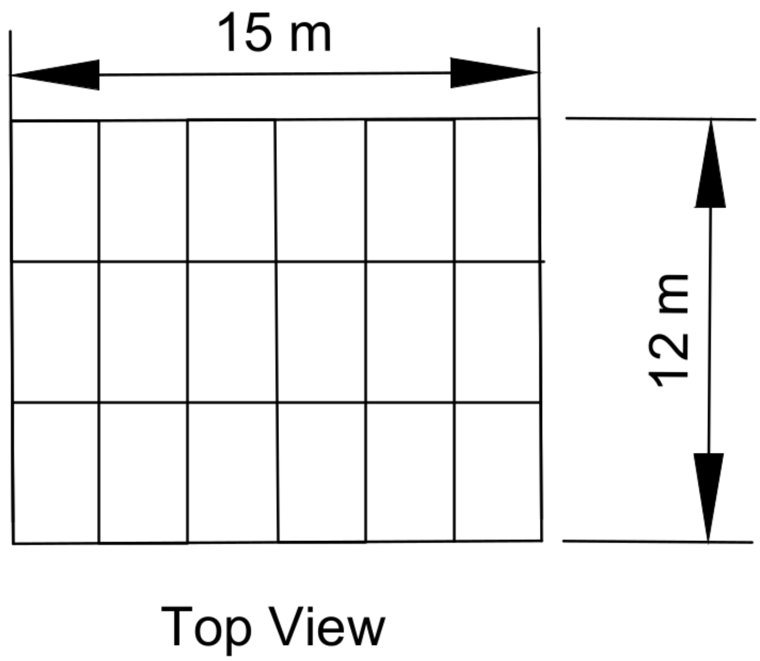
9.1 Structural Drawings



Front View



Side View



9.2 Connection Drawings

Attached above in the connection design section itself.

10 Contributions

This section includes the brief contributions of each of the team member.

10.1 Analysis team

- Dikshant: Done the entire wind load calculation. Tested various load combinations and found all the issues in the preliminary structure. Helped in the iterations for the depth of tapered section. Made the entire report solely on latex. Made ppt for all three phases and coordinated with design analysis team for deliverables to get the task done on time.
- Dhananjay: Read relevant design codes and helped in wind load calculations. Contributed in making presentations for all the phases .Helped in bill of quantities.
- Shruthi: Assigned dead load, live load and wind load to the model defined the combination of loads. Helped in making presentation for phase 2.
- Harshil: Helped in wind load calculations
- Mohan: Checked the possible load combinations

10.2 Design team

- Sarath: Contributed in iterating the depth of the tapered section in the initial staad model. Helped in solving the issues of preliminary model. Made the autocad drawings of the structure. Helped in making presentations

- Karan: Made the preliminary model and depth iterations . Applied wind loads to the modified structure. Helped in making presentations. Did the connection design using osdag and provided the content.
- Aishwarya: Read Relevant Design Codes, Structural analysis for a load case. Contributed in discussions and coordinated with each member to ensure task completion. Collected entire content and made the presentation for phase 3.
- Faisal: Base plate design
- Aravind: Found relevant codes
- Aadarsh: Bracing members design