CE 332 - Course Project
Structural Design Report

Design of Truss Road Bridge

Group Number: 4

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Problem Statement

The team has just won a contract from XYZ client to design a steel truss road bridge over a particular span. The terms of the contract include:

• **Prepare a General Arrangement (GA) of the structure. Decide and arrange the truss type, main girders and cross girders.**
- The span of the bridge: 40 m
- Width of the bridge: 10 m
- Height of truss: 5 m

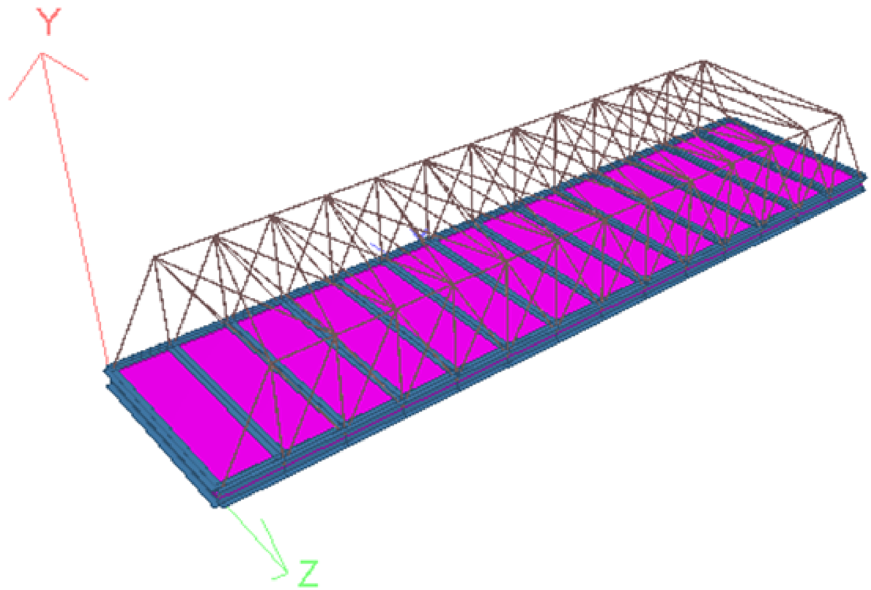
• **The basic components are the truss type, main girders and cross girders.**

• **Design as per the requirements of the design standards.**
- Design as per IS 800:2007.
- Density of different materials as per IS 875 (Part-1).
- Track and wind Load as per IRC:6-2016
- Use structural steel confirming to IS2062 (Grade A) [Table 1. of IS 800:2007]

• **Satisfy the required Deliverables given below.**
- ❖ General Arrangement (GA) of the structure as per the requirements.
- ❖ Design of all members which includes:
    - Truss members
    - Main girders
    - Cross girders
- ❖ Connection Design using Osdag
  One design for each of the following:
    - Connection detail between cross beam and main girder (Shear connection).
    - Connection detail of splicing of main girder (Beam to beam)
- ❖ Detailed Project Report
- ❖ Fabrication/Erection Drawings
  – Structural drawings:
  Plan view of the deck, elevation of the truss, and front view of bridge with representative sections of the members.
  – Connection drawings:
  Representative connection details for the designed connections have to be shown.

• **Bill of Quantities**

It is assumed that the soil can take the full load of the bridge and has very high strength and bearing capacity.



3D Image of Bridge

Design Preamble

General information

1. The assumptions while designing the bridge are:

- Members are perfectly straight
- Loads are applied at the joints
- Joints are pinned and frictionless
- Members are subjected to axial force only

2. The loads under consideration are:

Dead Load
- Self-weight of the structure
- Weight of RCC slab

Live Load
- Pedestrian live load.
- Vehicular load

Wind Load
- Basic wind Speed, V_b (m/s) = 33.00

• Transverse force on the truss members and main girders.
• Longitudinal force on the truss
• Upward and downward wind pressure on the deck slab

Load Combination of various loads based on Limit state of Strength and Limit state of Serviceability

3. The methodology used for designing the members and connections is **limit state method**

4. DESIGN CODES AND STANDARDS (REFERENCES)

1. DESIGN

- ❖ Steel design as per IS 800:2007
- ❖ Track and wind Load as per IRC:6-2016
- ❖ Dead Load as per IS 875 (Part-1)
- ❖ Live Load as per IRC:6-2016, Clause 206.1 and IRC:6-2016, Clause 204.1

2. SECTION/MATERIALS

- ❖ Density of different materials as per IS 875 (Part-1).
- ❖ Use structural steel confirming to IS2062 (Grade A) [Table 1. of IS 800:2007]

3. FASTENERS

- ❖ High strength structural bolts as per IS 4000 (1992).

4. WELDING

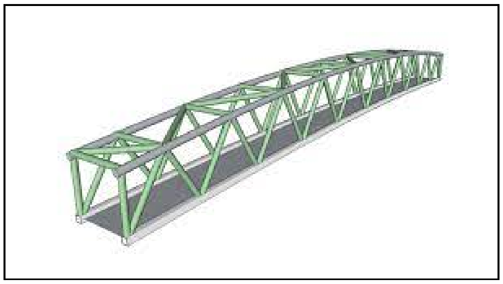
- ❖ Symbols for welding shall be according to IS: 813-1986
- ❖ Weld strength as per IS 800:2007, Cl.10.5.7.1.1

Structural Steel

The type of structural steel section used are:

1. I-Sections
2. Circular hollow sections

The material grade of steel used is E 250 (Fe 410 W)A



Bolts and Nuts

1. Bolts used for fin plate connection between girder and cross girder
   - 20 mm diameter bolts
   - Property class – 12.9
   - Friction grip type of bolts
   - Pre-tensioned
   - Edge preparation methods used are sheared or hand flame cut

2. Bolts used for splice connection along the main girder

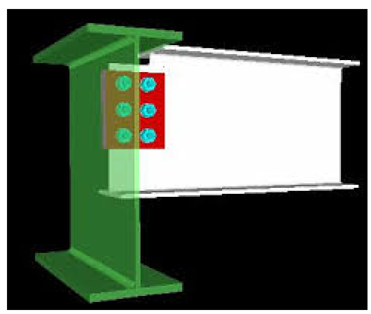
Flange Bolts and Web Bolts
   - 42mm diameter
   - Property class 8.8
   - Edge preparation method is sheared or hand flame cut

   - Bearing bolts

Welding and Consumables

Fin plate weld

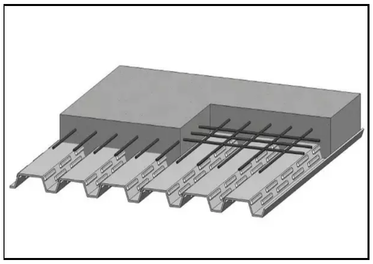
- ❖ Weld type – fillet weld
- ❖ Shop weld fabrication
- ❖ Weld size – 5mm
- ❖ Some good welding procedures include Arc welding, Metal insert gas welding, etc for shop fabrication.



Other Materials

Other materials used in the bridge construction are:

1. RCC slab of thickness 200mm
2. Railings on both sides of road
3. RCC foundation
4. Paint for road markings

Loads and Forces

3.1 Gravity Loads

3.1.1 Dead Load

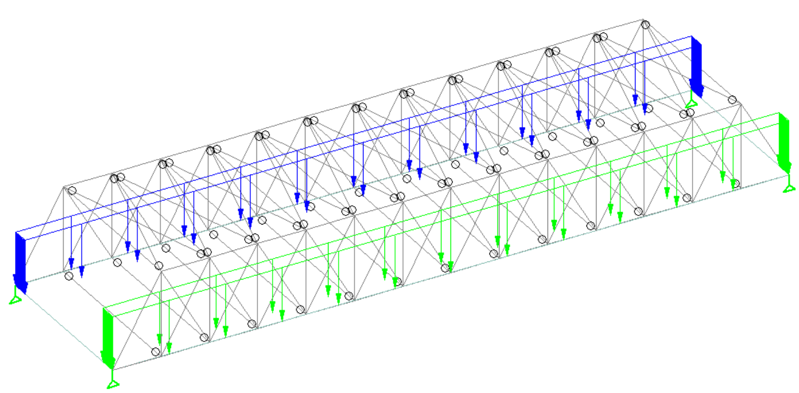
Self weight of the **RCC slab** of thickness 200mm on the deck of the bridge is calculated after taking the density to be **25kN/m^3** and is due to the weight of the slab.

UDL = Density x Thickness
= 25 x 0.2
= 5 kN/m^2

Self weight of steel **structure** is calculated from density of steel as per design & will act as a UDL on every member accordingly.

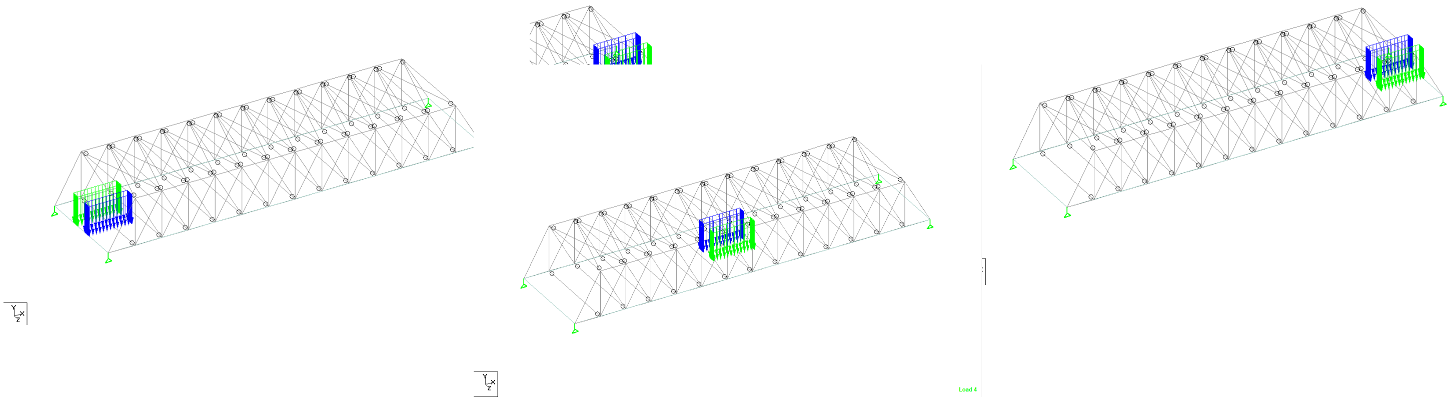
3.1.2 Live Load

Pedestrian Live Load as per IRC:6-2016, Clause 206.1 is 400 kg/m^2 & UDL will act on 40m x 1m; both sides of the bridge
Resultant Load(each side) = Density x length x breadth
= 400 x 40x1 = 156.96 kN



Vehicular Live Load as per IRC:6-2016, Clause 204.1: Consider one "**tracked 70R vehicle**" on the bridge deck
Contact Length = 4.57m
Weight of each tract = 350 kN

Centre-to-centre distance b/w wheels in axle = 2.06 m
The Vehicular Load of 70R tracked vehicle is discretized into 12 discrete loadings (350/12 KN) and a load train is generated for analysis and 3 cases are considered



3.2 Wind/Lateral Load

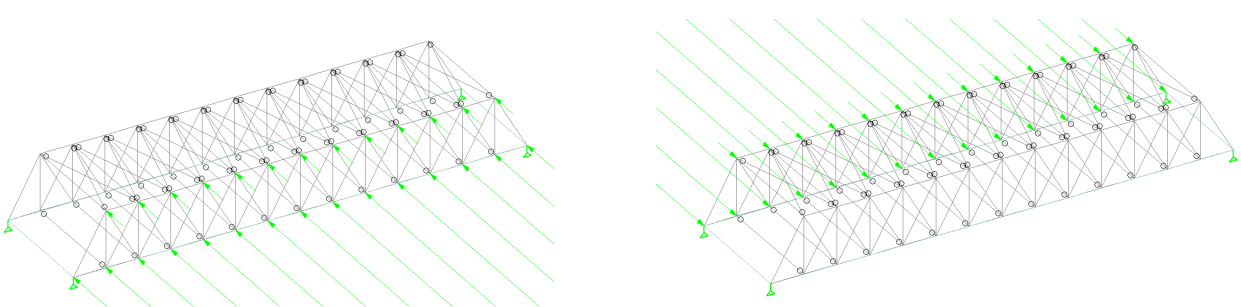
Transverse Wind Load

209.3.3 The transverse wind force F_T (in N) shall be taken as acting at the centroids of the appropriate areas and horizontally and shall be estimated from:

$$F_T = P_Z \times A_1 \times G \times C_D$$

where, P_Z is the hourly mean wind pressure in N/m^2 (see **Table 12**), A_1 is the solid area in m^2 (see Clause **209.3.2**), G is the gust factor and C_D is the drag coefficient depending on the geometric shape of bridge deck.

Solidity ratio (ϕ)	Drag Coefficient C_D for		
	Built-up Sections	Rounded Members of Diameter (d)	
		Subcritical flow ($dV_z < 6m^2/s$)	Supercritical flow ($dV_z \geq 6m^2/s$)
0.1	1.9	1.2	0.7
0.2	1.8	1.2	0.8
0.3	1.7	1.2	0.8
0.4	1.7	1.1	0.8
0.5	1.6	1.1	0.8



I-Section

Solidity ratio (Φ) = $\frac{Net\ Area\ of\ Member}{Total\ Area\ of\ Truss}$ = $\frac{2.354}{32.958}$ = 0.071

C_D = 1.9 P_z = 463.7 N/m^2 (Table 12) G = 2

A_1 = Area of one section = 2.354 m^2

F_T = C_D x P_z x G x A_1 = 1.9 x 463.7 x 2 x 2.354

= 4148.18 N

= 4.14 kN

Slant Members

C_D = 1.2 P_z = 463.7 N/m^2 G = 2 A_1 = 0.120 m^2

F_T = 1.2 x 463.7 x 2 x 0.120 = 134.567 N

Horizontal Members

C_D = 1.2 P_z = 463.7 N/m^2 G = 2 A_1 = 0.059 m^2

F_T = 1.2 x 463.7 x 2 x 0.059 = 66.769 N

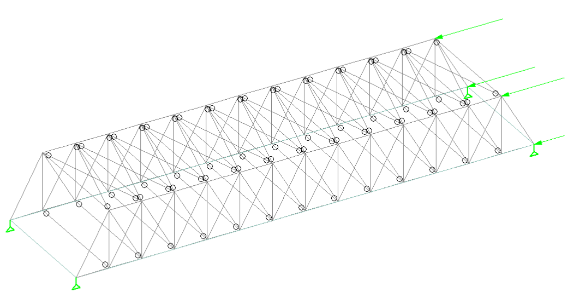
Vertical Members

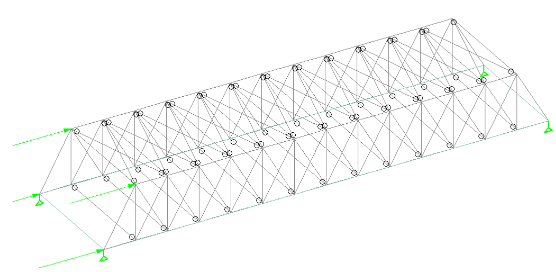
C_D = 1.2 P_z = 463.7 N/m^2 G = 2 A_1 = 0.104 m^2

F_T = 1.2 x 463.7 x 2 x 0.104 = 116.852 N

Longitudinal Wind Load

209.3.4 The longitudinal force on bridge superstructure F_L (in N) shall be taken as 25 percent and 50 percent of the transverse wind load as calculated as per Clause **209.3.3** for beam/ box/plate girder bridges and truss girder bridges respectively.





I – Sections

F_L = $\frac{F_T}{2}$ = 2074.092 N

Slant Members

$F_L = \frac{F_T}{2} = 67.283$ N

Horizontal Members

$F_L = \frac{F_T}{2} = 33.384$ N

Vertical Members

$F_L = \frac{F_T}{2} = 58.426$ N

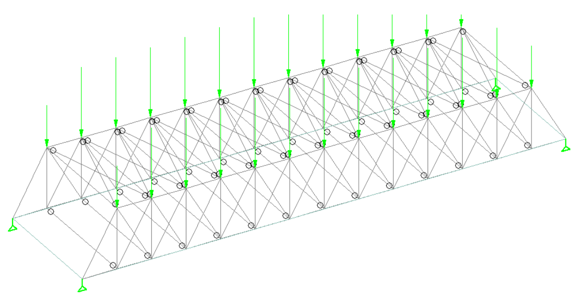
Upward and Downward Vertical Wind Load

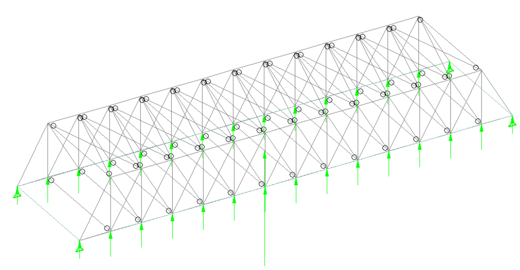
209.3.5 An upward or downward vertical wind load F_V (in N) acting at the centroid of the appropriate area, for all superstructures shall be derived from:

$$F_V = P_Z \times A_3 \times G \times C_L$$

Where,

P_z	=	Hourly mean wind speed in N/m^2 at height H
A_3	=	Area in plain in m^2
C_L	=	Lift coefficient which shall be taken as 0.75 for normal type of slab, box, I-girder and plate girder bridges. For other type of deck cross-sections C_L shall be ascertained either from wind tunnel tests or, if available, for similar type of structure. Specialist literature shall be referred to.





Girder

C_L = 0.75 P_z = 463.7 N/m^2 G = 2 A_3 = 8.239 m^2

F_V = 0.75 x 463.7 x 2 x 8.239 = 5731.32 N

Cross Girder

C_L = 0.75 P_z = 463.7 N/m^2 G = 2 A_3 = 8.239 m^2

F_V = 0.75 x 463.7 x 2 x 8.239 = 10433.25 N

Cement

C_L = 0.75 P_z = 463.7 N/m^2 G = 2 A_3 = 18.113 m^2

F_V = 0.75 x 463.7 x 2 x 18.113 = 12598.79 N

<u>Slant Members</u>

C_L = 0.75 P_z = 463.7 N/m^2 G = 2 A_3 = 0.218 m^2

F_V = 0.75 x 463.7 x 2 x 0.218 = 151.90 N

<u>Horizontal Members</u>

C_L = 0.75 P_z = 463.7 N/m^2 G = 2 A_3 = 0.059 m^2

F_V = 0.75 x 463.7 x 2 x 0.059 = 125.83 N

<u>Vertical Members</u>

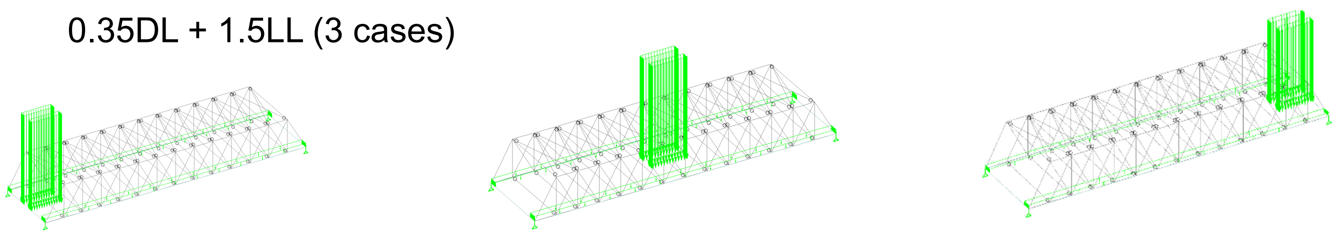
C_L = 0.75 P_z = 463.7 N/m^2 G = 2 A_3 = 0.209 m^2

F_V = 0.75 x 463.7 x 2 x 0.209 = 146.06 N

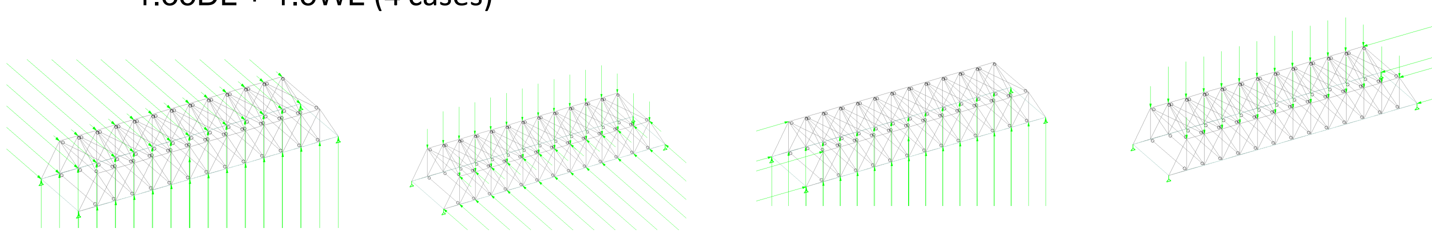
3.3 Load Combination

Limit State of Strength

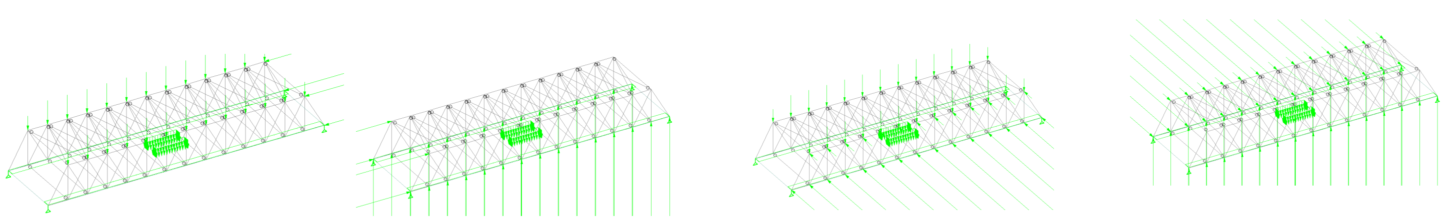
0.35DL + 1.5LL (3 cases)

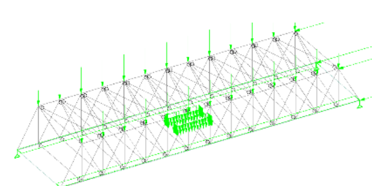


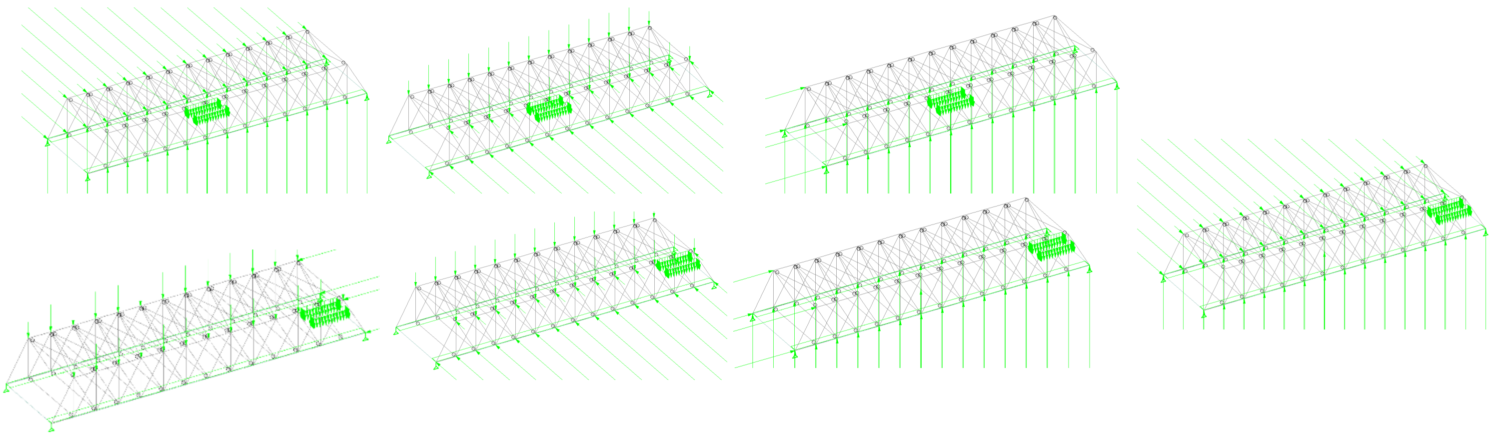
1.35DL + 1.5WL (4 cases)



1.35DL + 1.15LL + 0.9WL (12 cases)

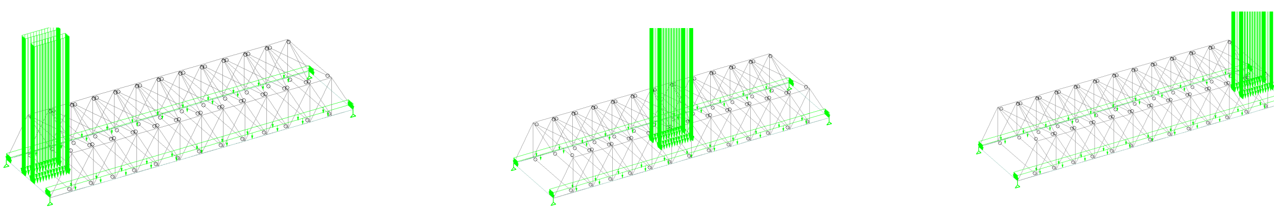




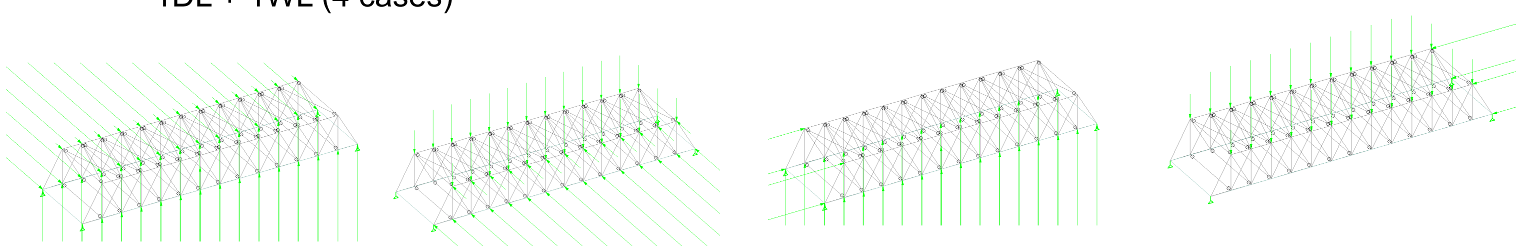


LIMIT STATE OF SERVICEABILITY

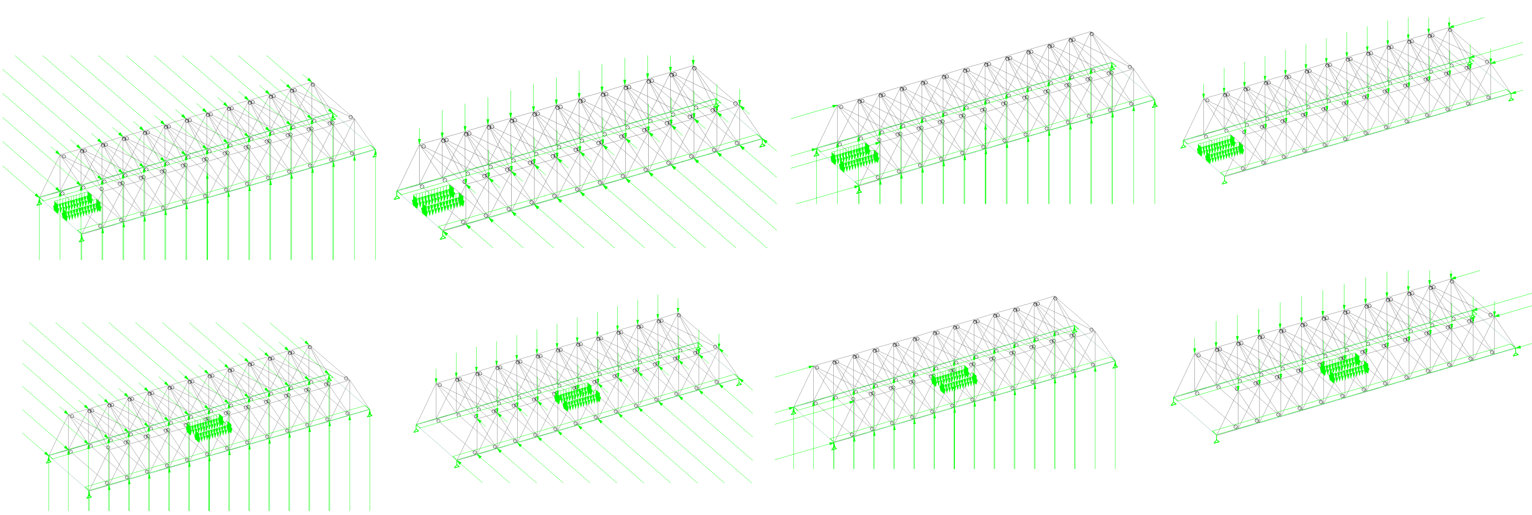
1DL + 1LL (3 cases)

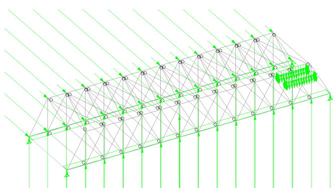
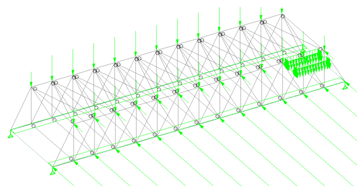
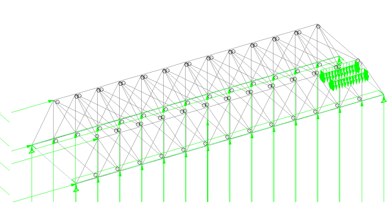
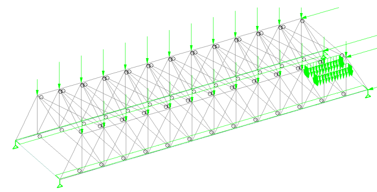


1DL + 1WL (4 cases)



1DL + 0.8LL + 0.8WL (12 cases)



4.2

Analysis:

For the analysis of the truss bridge the structural designing software used is SAAD Pro. we analysed with the limit state of design method (LSD) as per IS 800(2007).

Modelling

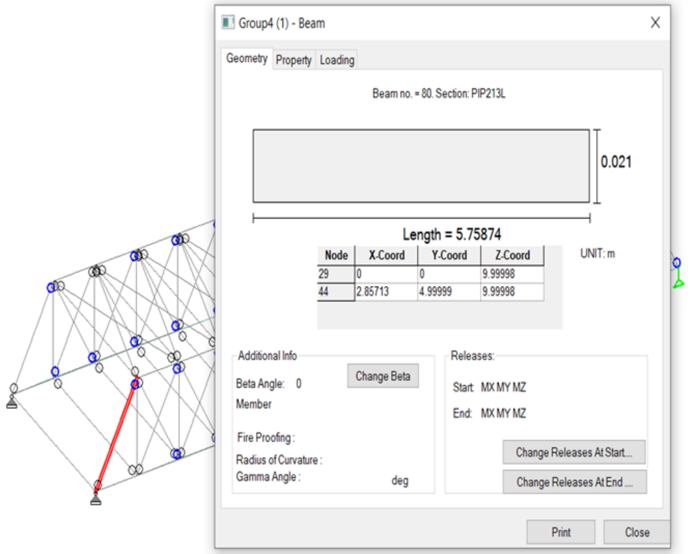
5.1 software model: details

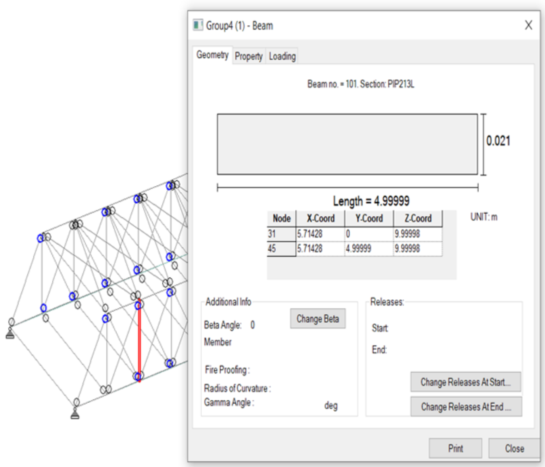
{a}boundary conditions::

1. two supports are pinned joined and other two supports are rollers.
2. moment is released in Y and Z direction for the bracings and girders.
3. Also moment is released in X,Y and Z direction for the joints.

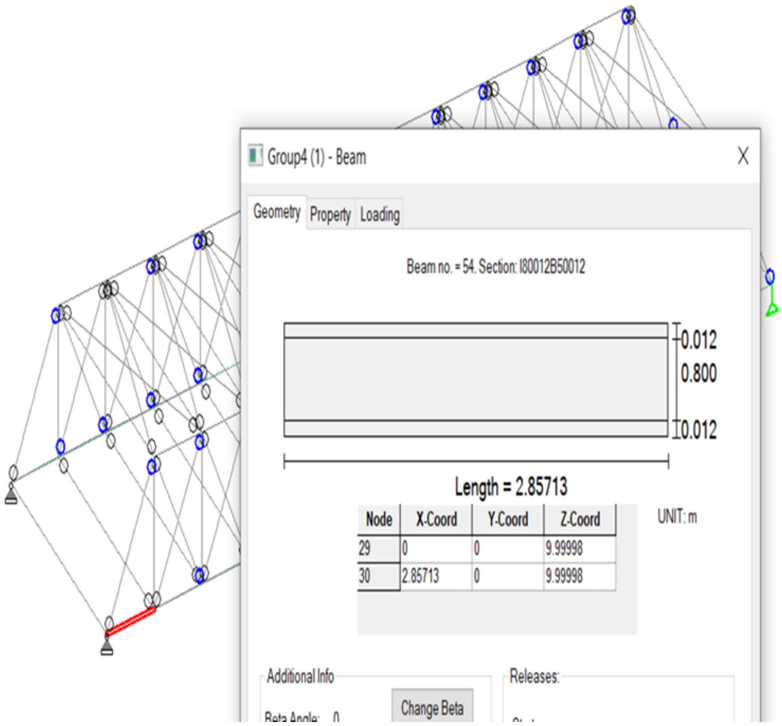
{b} type of connections

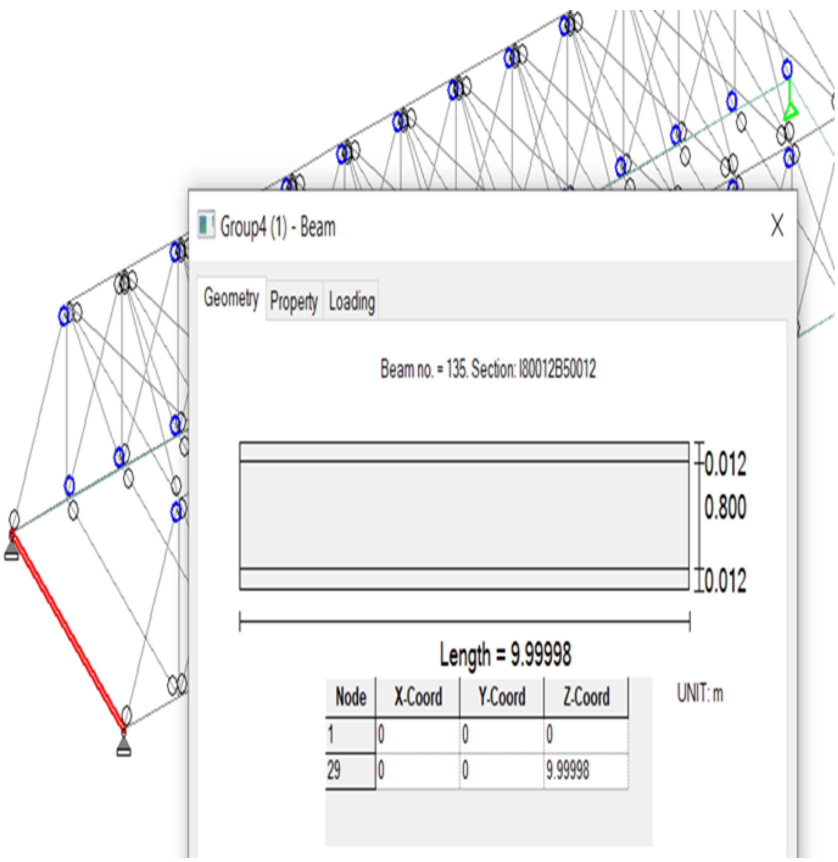
Hollow pipes (side)



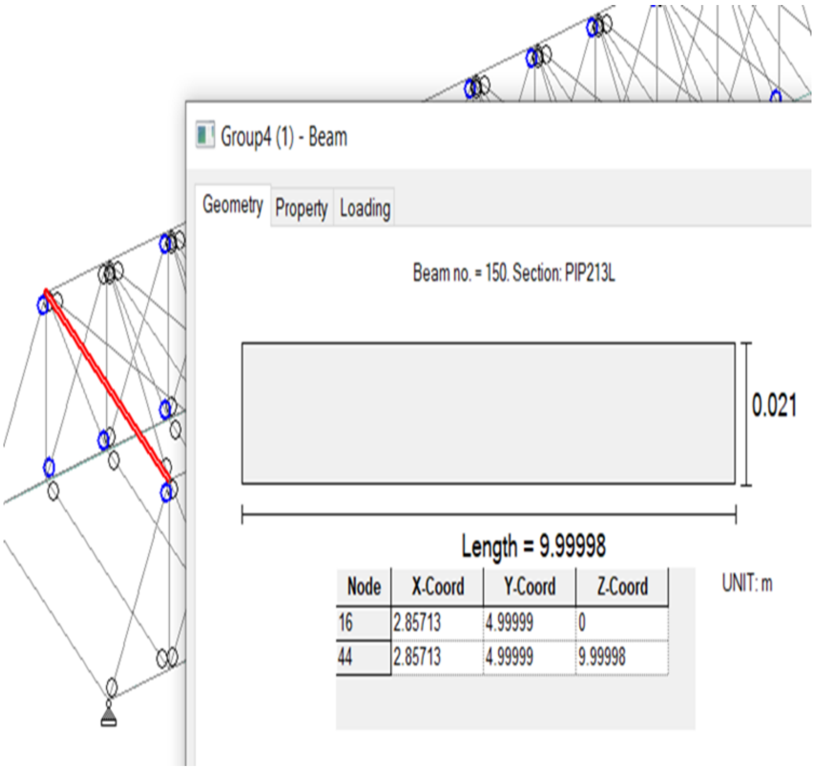


I sections (bottom part)

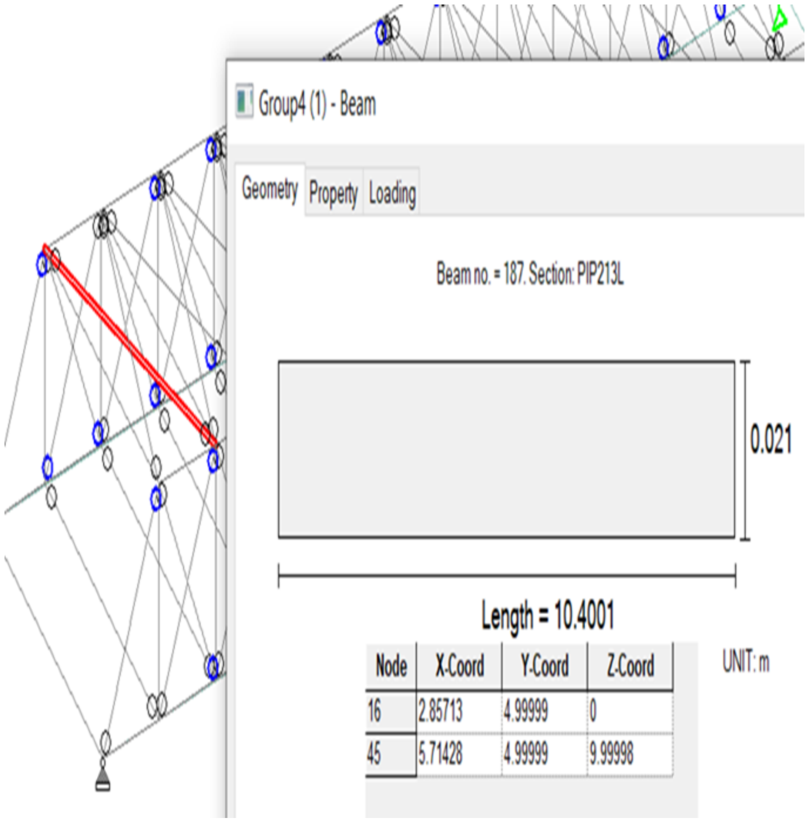

Group4 (1) - Beam
X
Geometry
Property
Loading
Beam no. = 54. Section: I80012B50012
0.012
0.800
0.012
Length = 2.85713
UNIT: m
Node | X-Coord | Y-Coord | Z-Coord
29 | 0 | 0 | 9.99998
30 | 2.85713 | 0 | 9.99998
Additional Info
Change Beta
Releases:


Group4 (1) - Beam
X
Geometry
Property
Loading
Beam no. = 135. Section: I80012B50012
0.012
0.800
0.012
Length = 9.99998
UNIT: m
Node | X-Coord | Y-Coord | Z-Coord
1 | 0 | 0 | 0
29 | 0 | 0 | 9.99998

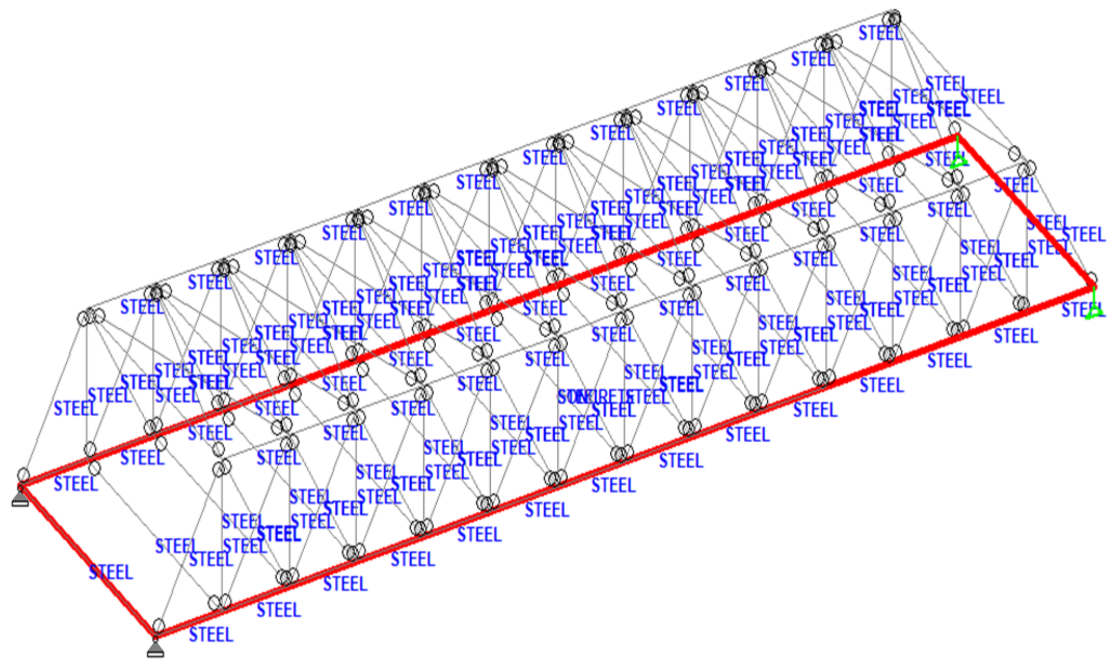
Hollow pipes (top part)

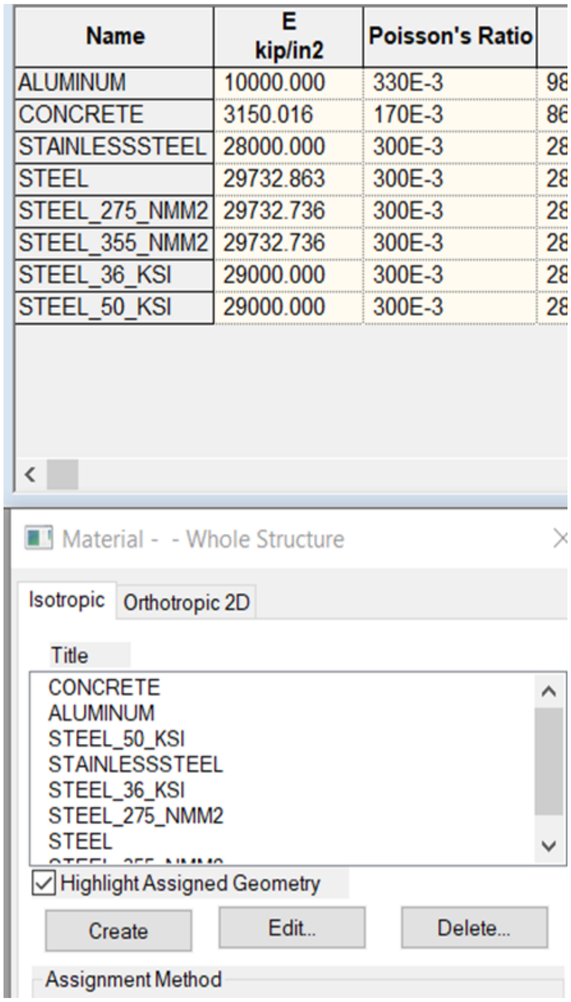


Node	X-Coord	Y-Coord	Z-Coord
16	2.85713	4.99999	0
44	2.85713	4.99999	9.99998



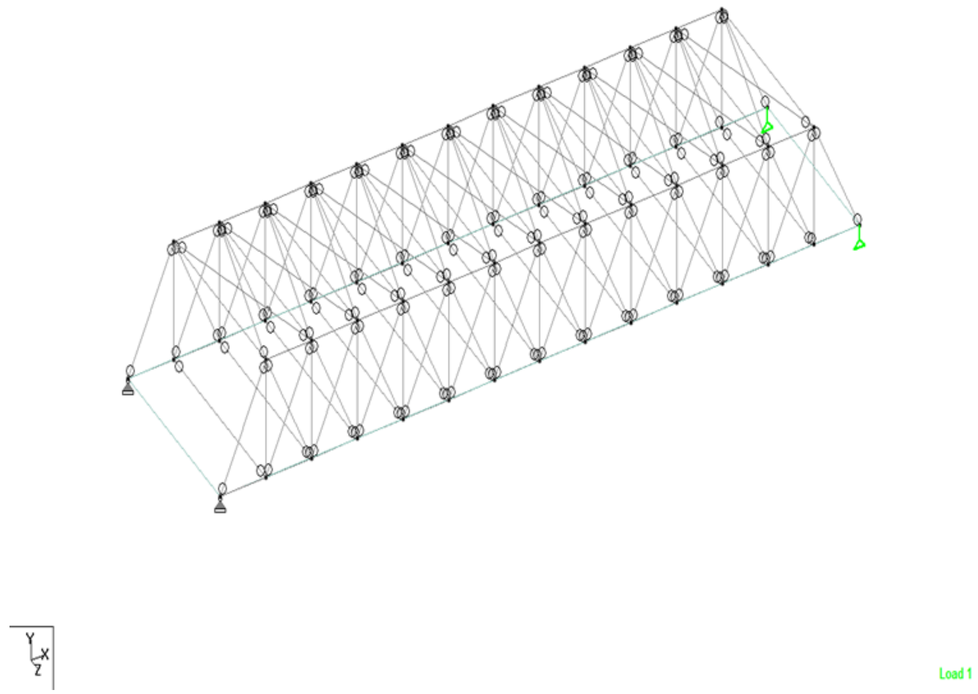
1. Cement slab
2. I sections (bottom)

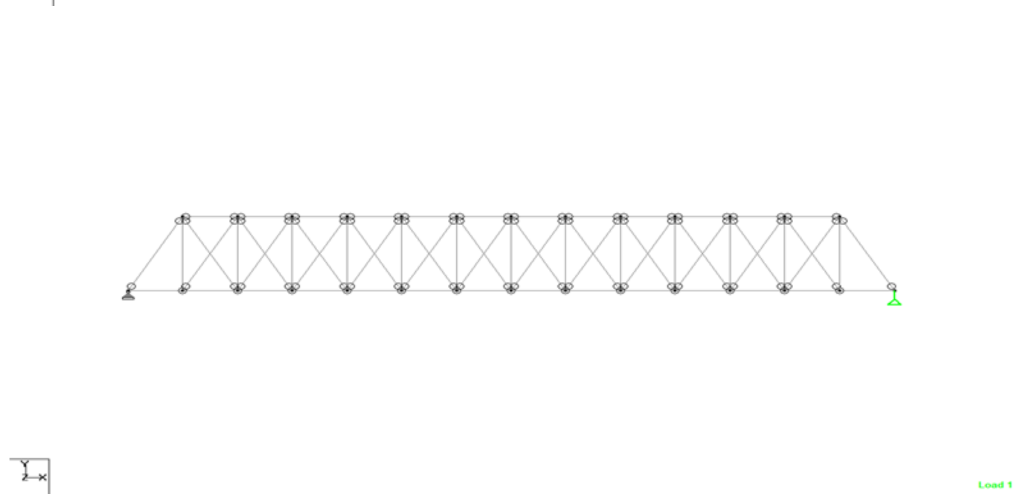

STEEL

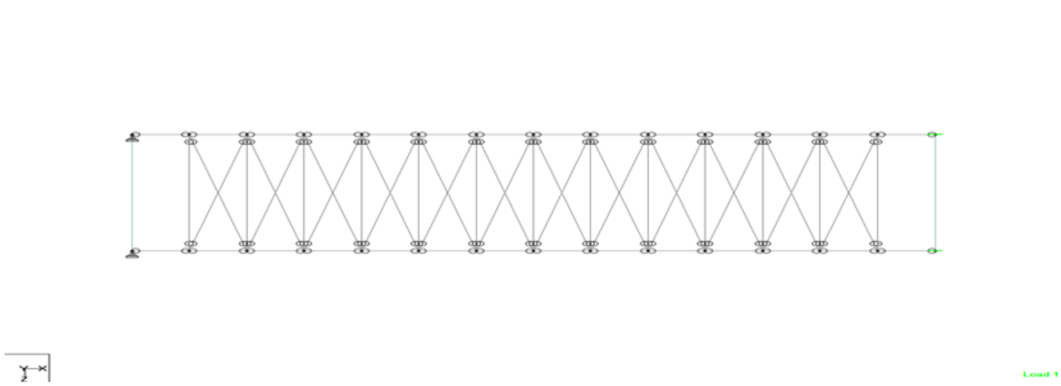


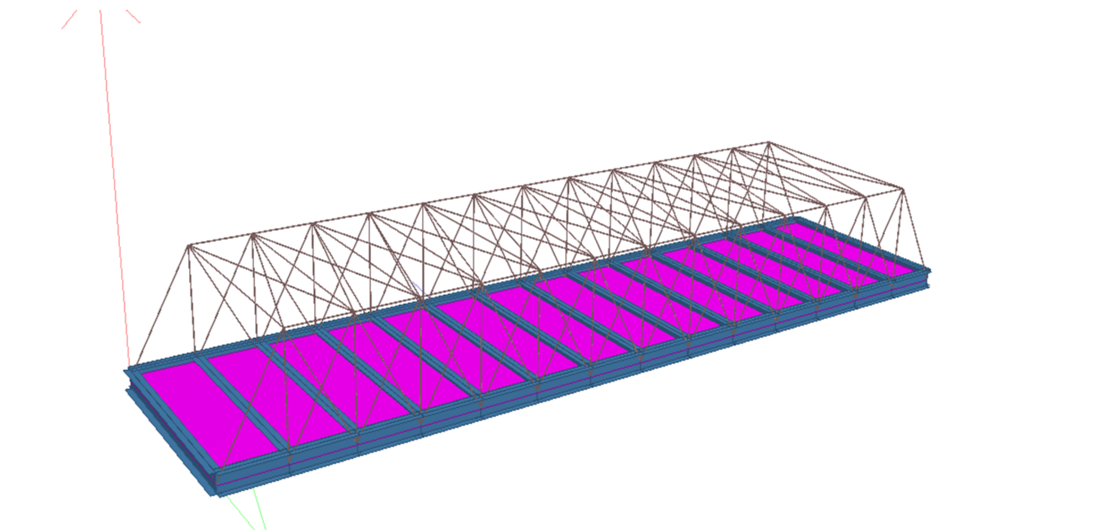
Name	E kip/in2	Poisson's Ratio	
ALUMINUM	10000.000	330E-3	98
CONCRETE	3150.016	170E-3	86
STAINLESSSTEEL	28000.000	300E-3	28
STEEL	29732.863	300E-3	28
STEEL_275_NMM2	29732.736	300E-3	28
STEEL_355_NMM2	29732.736	300E-3	28
STEEL_36_KSI	29000.000	300E-3	28
STEEL_50_KSI	29000.000	300E-3	28

5.2 software model: images


Y
X
Z
Load 1


Load 1





Design

We have adopted Limit State Design Philosophy for the design which focuses on state of impending failure and beyond this structure is not going to perform well.

In this design philosophy we are balancing Supply and Demand taking safety factors by reducing supply and increasing demand.

There are two limit states-

- Limit State of Strength
- Limit State of Serviceability

LRFD format

$$\frac{S_u}{\gamma_m} = S_d \geq Q_d = \sum_k \gamma_{f_k} Q_{c_k}$$

S_d = Design strength
Q_d = Design load (action)
S_u = Ultimate strength
γ_m = Partial safety factor for material
γ_f = Partial safety factor for load
Q_c = Characteristic load (action)

Limit State of Serviceability is accounted by considering the following load combinations-

$$1.0DL + 1.0LL$$
$$1.0DL + 1.0WL$$
$$1.0DL + 0.8LL + 0.8WL$$

- The combination with wind load makes sure that there is no lateral or longitudinal deformation which defies serviceability criteria
- The combinations with Dead Load and Live Load, make sure that the serviceability checks due to structure self-weight and people/vehicle on the bridge does not breach the serviceability criteria.

Structural Design

- Structural Design inputs for staad pro are the member properties like their dimension, type of member, weight, section properties, axial, shear and bending moments as per the load cases given both for strength and serviceability checks, grade of steel which was IS 2062 Grade A in our case.

- Output of the design was the properties of newly designed member, utilization ratio of the member, respective section of IS 800:2007 which talks about the critical condition on which the member was designed, the result whether the member passed or failed the test and the KLR value

Main Girder

Code	Result	Ratio	Critical	KLR
IS800-07	PASS	0.4305614	Sec. 9.3.1.3	28.22788

Cross Girder

Code	Result	Ratio	Critical	KLR
IS800-07	PASS	0.2469942	Slenderness	98.79768

Truss Members

Side truss Bracings

Code	Result	Ratio	Critical	KLR
IS800-07	PASS	0.9242547	Slenderness	166.3658

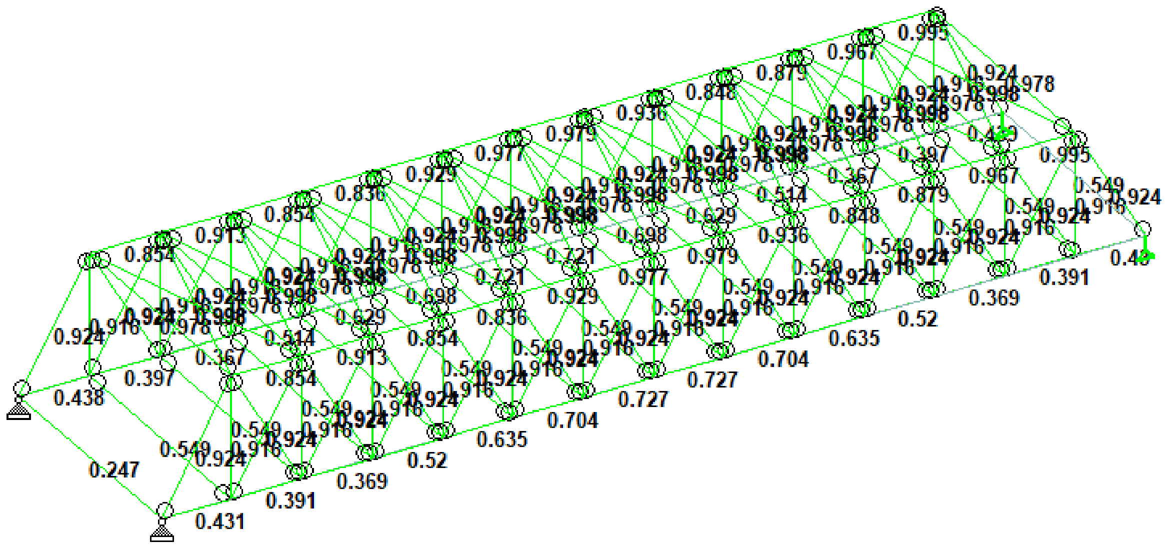
Code	Result	Ratio	Critical	KLR
IS800-07	PASS	0.9164072	Slenderness	164.9533

Side truss Vertical

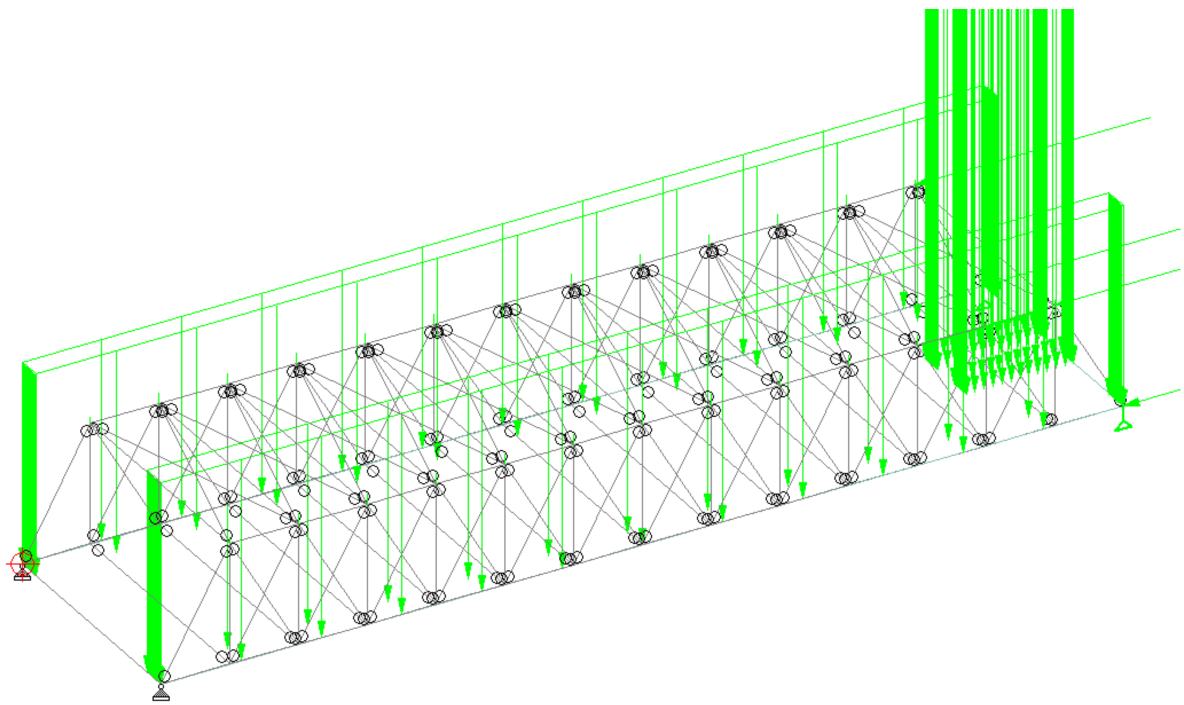
Top Bracings

Code	Result	Ratio	Critical	KLR
IS800-07	PASS	0.9983916	Slenderness	179.7105

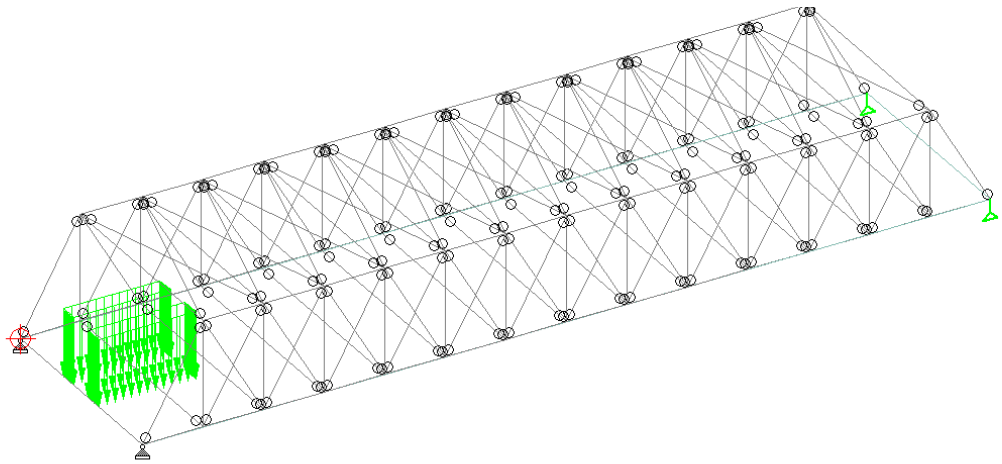
Utilization Ratio for the Model



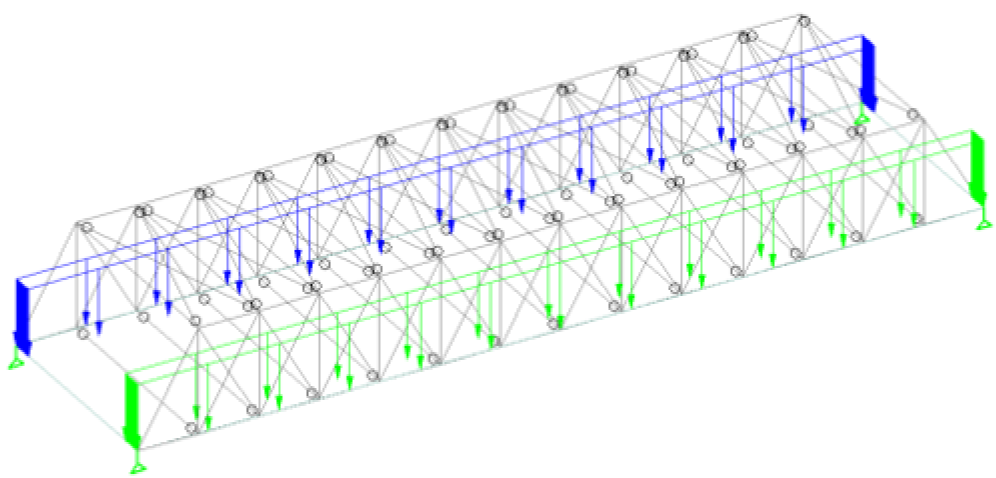
Model with load combination



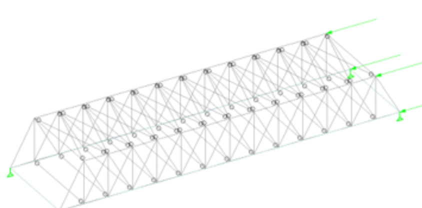
Model with Vehicular load

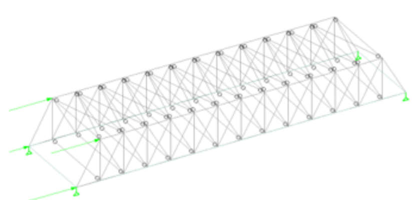


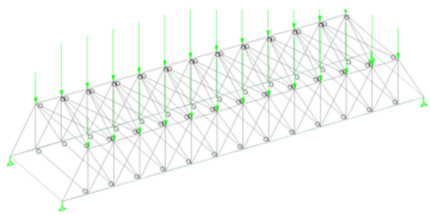
Model with Pedestrian Load

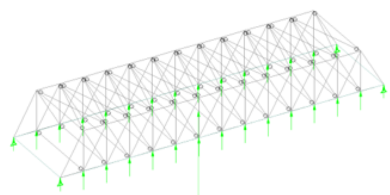


Model with wind loads

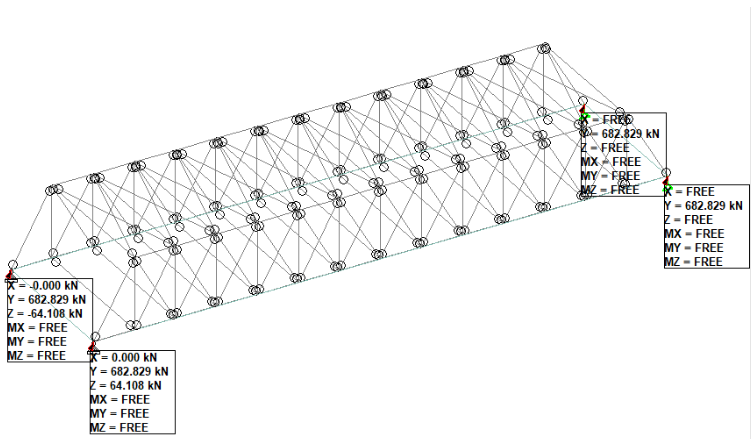




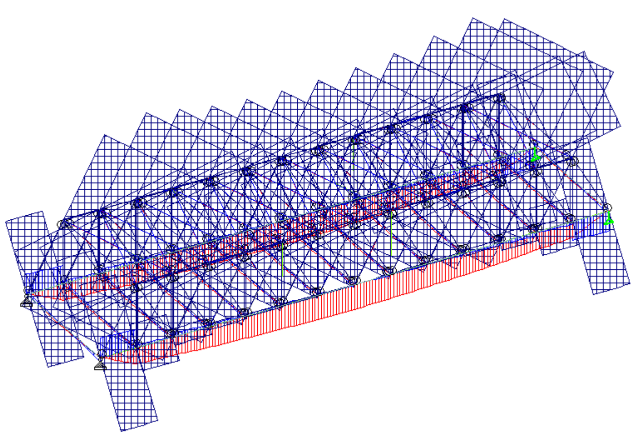




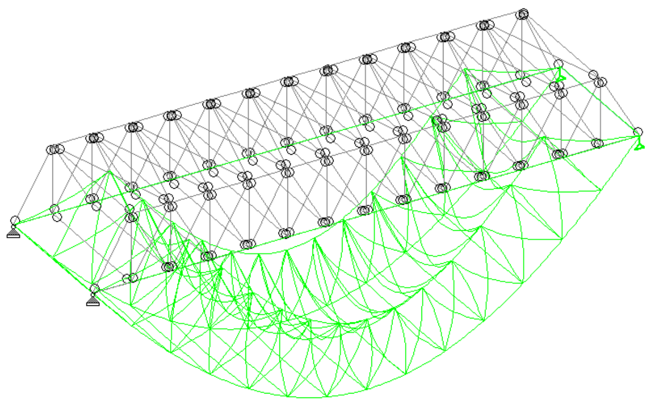
Model with Reactions



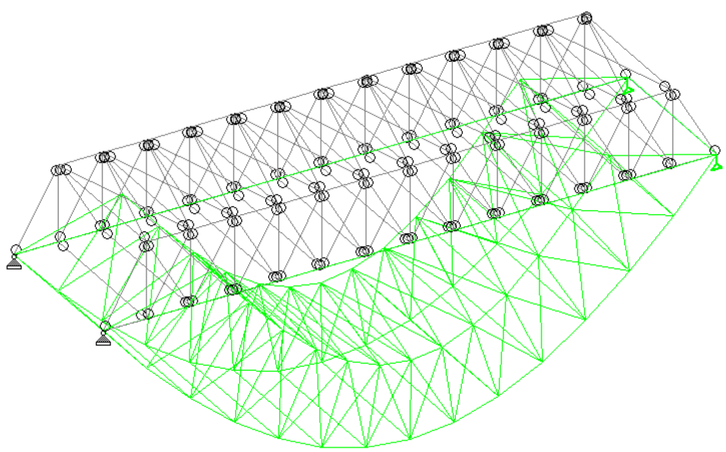
Shear Force and Bending Moments



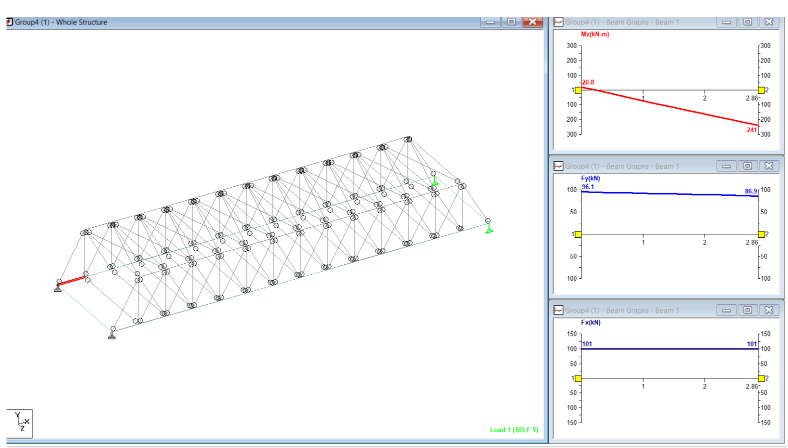
Model with displacements highlighted



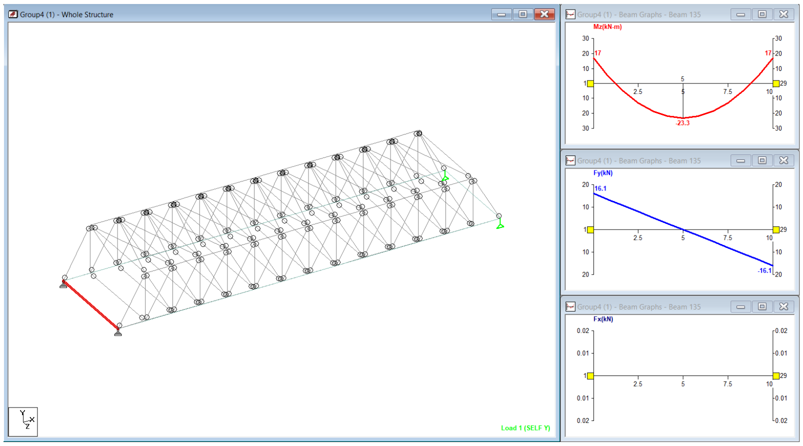
Models with deflection highlighted



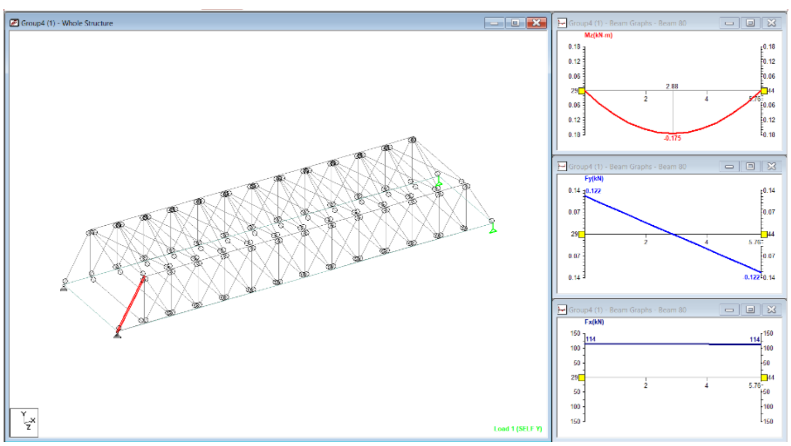
BMD, AFD and SFD for a main girder beam



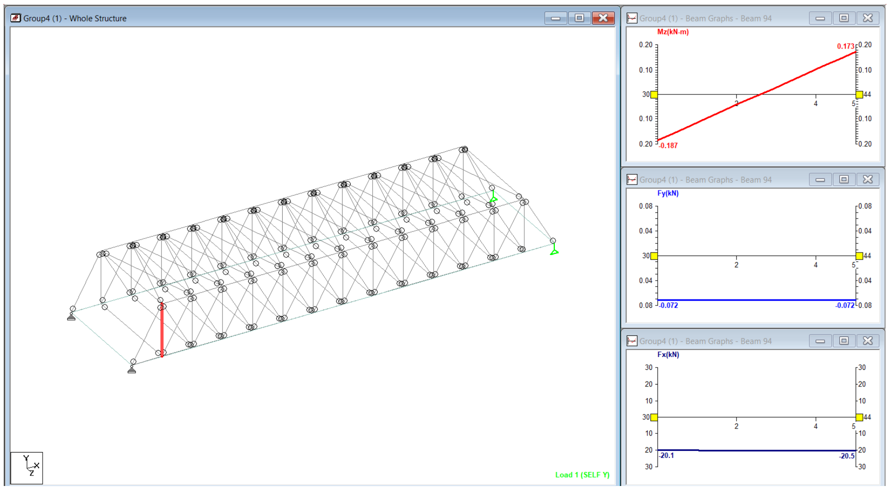
BMD, AFD and SFD for a cross girder beam



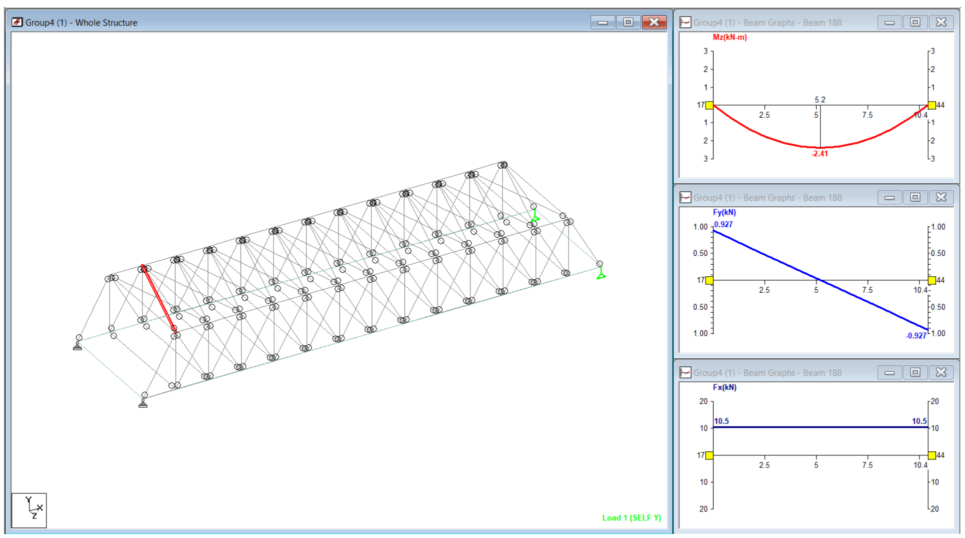
BMD, AFD and SFD for side truss bracings



BMD, AFD and SFD for side truss vertical members



BMD, AFD and SFD for top truss bracings



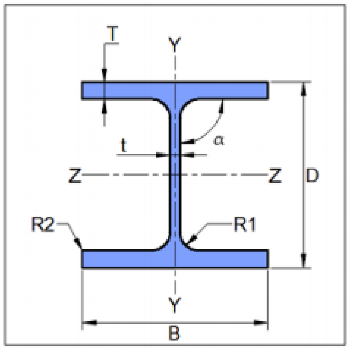
CONNECTION DESIGN

DESIGN OF A FIN PLATE (SHEAR DESIGN):

THESE ARE THE INPUT PARAMETERS WHICH WE HAVE USED FOR THE DESIGN:

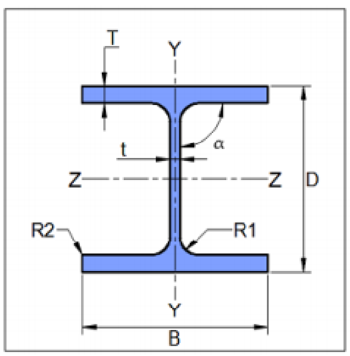
Main Module	Shear Connection
Module	Fin Plate Connection
Connectivity	Beam-Beam
Shear Force (kN)	131.628
Axial Force (kN)	147.368

Supporting Section - Mechanical Properties



Supporting Section		GROUP4	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	328.22	I_z (cm^4)	511521.0
Area, A (cm^2)	419.0	I_y(cm^4)	42926.0
D (mm)	824.0	r_z (cm)	34.9
B (mm)	500.0	r_y (cm)	10.12
t (mm)	12.0	Z_z (cm^3)	13034.0
T (mm)	16.0	Z_y (cm^3)	2071.0
Flange Slope	90	Z_{pz} (cm^3)	7374.9
R_1 (mm)	20.0	Z_{py} (cm^3)	15512.0
R_2 (mm)	10.0		

Supported Section - Mechanical Properties



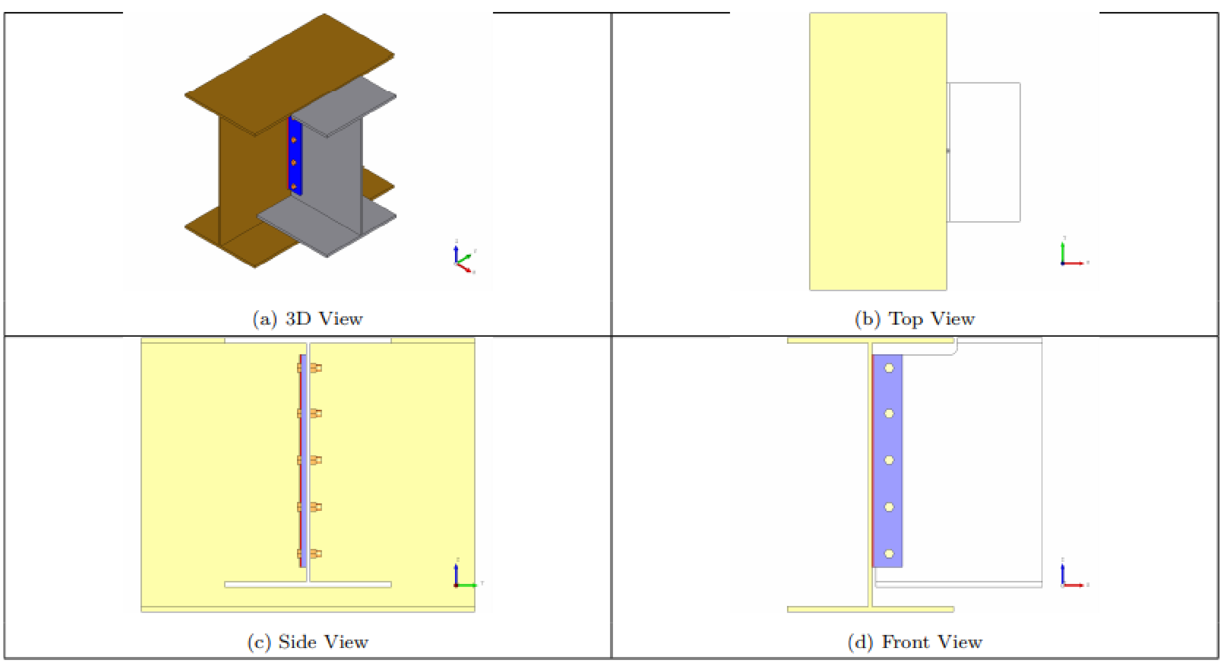
Supported Section		GROUP4-S1-	
Material		E 250 (Fe 410 W)A	
Ultimate Strength, F_u (MPa)		410	
Yield Strength, F_y (MPa)		250	
Mass, m (kg/m)	324.0	I_z (cm^4)	511521.0
Area, A (cm^2)	419.0	I_y(cm^4)	42926.0
D (mm)	750.0	r_z (cm)	34.9
B (mm)	500.0	r_y (cm)	10.12
t (mm)	12.0	Z_z (cm^3)	13034.0
T (mm)	16.0	Z_y (cm^3)	2071.0
Flange Slope	90	Z_{pz} (cm^3)	6483.59
R_1 (mm)	20.0	Z_{py} (cm^3)	15464.64
R_2 (mm)	10.0		

OTHER DESIGN PREFERENCES:

Bolt Details - Input and Design Preference	
Diameter (mm)	[12, 14, 16, 18, 20]
Property Class	[3.6, 4.6, 4.8, 5.6, 5.8, 6.8, 8.8, 9.8, 10.9, 12.9]
Type	Friction Grip Bolt
Hole Type	Standard
Bolt Tension	Pre-tensioned
Slip Factor, (μ_f)	0.3
Detailing - Design Preference	
Edge Preparation Method	Sheared or hand flame cut
Gap Between Members (mm)	10.0
Are the Members Exposed to Corrosive Influences?	False
Plate Details - Input and Design Preference	
Thickness (mm)	[14, 16, 18, 20]
Material	E 250 (Fe 410 W)A
Ultimate Strength, Fu (MPa)	410
Yield Strength, Fy (MPa)	250
Weld Details - Input and Design Preference	
Weld Type	Fillet
Type of Weld Fabrication	Shop Weld
Material Grade Overwrite, Fu (MPa)	410.0

FINAL DESIGN WHICH WE GOT:

3 3D Views



(a) 3D View

(b) Top View

(c) Side View

(d) Front View

BOLT DESIGN:

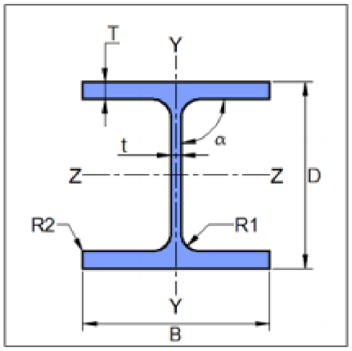
DETAILS ON NUMBER OF BOLTS, DIMENSIONS LIKE PITCH, END AND EDGE LENGTHS.

Check	Required	Provided
Diameter (mm)		20.0
Property Class		12.9
Plate Thickness (mm)	$t_w = 12.0$	14.0
No. of Bolt Columns		1
No. of Bolt Rows		5
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	140
Max. Pitch Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 12.0,\ 300)$ $= \min(384.0,\ 300)$ $= 300$ Where, $t = \min(14.0, 12.0)$ [Ref. IS 800:2007, Cl.10.2.3]	140

Check	Required	Provided
Min. Gauge Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 20.0$ $= 50.0$ [Ref. IS 800:2007, Cl.10.2.2]	0.0
Max. Gauge Distance (mm)	$p/g_{\max} = \min(32t,\ 300)$ $= \min(32 \times 12.0,\ 300)$ $= \min(384.0,\ 300)$ $= 300$ Where, $t = \min(14.0, 12.0)$ [Ref. IS 800:2007, Cl.10.2.3]	0.0
Min. End Distance (mm)	$e_{\min} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40
Max. End Distance (mm)	$e_{\max} = 12t\varepsilon;\ \varepsilon = \sqrt{\frac{250}{f_y}}$ $e_1 = 12 \times 14.0 \times \sqrt{\frac{250}{250}} = 168.0$ $e_2 = 12 \times 12.0 \times \sqrt{\frac{250}{250}} = 144.0$ $e_{\max} = \min(e_1,\ e_2) = 144.0$ [Ref. IS 800:2007, Cl.10.2.4.3]	40
Min. Edge Distance (mm)	$e'_{\min} = 1.7d_0$ $= 1.7 \times 22.0$ $= 37.4$ [Ref. IS 800:2007, Cl.10.2.4.2]	40

SPLICE DESIGN:

INPUT PARAMETERS:

<table>
<tr><td colspan="3">Module</td><td colspan="2">Beam-to-Beam Cover Plate Bolted Connection</td></tr>
<tr><td colspan="3">Main Module</td><td colspan="2">Moment Connection</td></tr>
<tr><td colspan="3">Bending Moment (kNm)</td><td colspan="2">12.167</td></tr>
<tr><td colspan="3">Shear Force (kN)</td><td colspan="2">131.628</td></tr>
<tr><td colspan="3">Axial Force (kN)</td><td colspan="2">147.368</td></tr>
<tr><td colspan="5">Beam Section - Mechanical Properties</td></tr>
<tr><td rowspan="13">
</td><td colspan="2">Beam Section</td><td colspan="2">GROUP4-S-+</td></tr>
<tr><td colspan="2">Material</td><td colspan="2">E 250 (Fe 410 W)A</td></tr>
<tr><td colspan="2">Ultimate Strength, F_u (MPa)</td><td colspan="2">410</td></tr>
<tr><td colspan="2">Yield Strength, F_y (MPa)</td><td colspan="2">240</td></tr>
<tr><td>Mass, m (kg/m)</td><td>328.22</td><td>I_z (cm^4)</td><td>51152.0</td></tr>
<tr><td>Area, A (cm^2)</td><td>41900.0</td><td>I_y(cm^4)</td><td>42926.0</td></tr>
<tr><td>D (mm)</td><td>824.0</td><td>r_z (cm)</td><td>34.9</td></tr>
<tr><td>B (mm)</td><td>500.0</td><td>r_y (cm)</td><td>10.12</td></tr>
<tr><td>t (mm)</td><td>12.0</td><td>Z_z (cm^3)</td><td>13034.0</td></tr>
<tr><td>T (mm)</td><td>20.0</td><td>Z_y (cm^3)</td><td>2071.0</td></tr>
<tr><td>Flange Slope</td><td>90</td><td>Z_{pz} (cm^3)</td><td>7374.9</td></tr>
<tr><td>R_1 (mm)</td><td>20.0</td><td>Z_{py} (cm^3)</td><td>15512.0</td></tr>
<tr><td>R_2 (mm)</td><td>10.0</td><td></td><td></td></tr>
<tr><td colspan="5">Bolt Details - Input and Design Preference</td></tr>
<tr><td colspan="3">Diameter (mm)</td><td colspan="2">[8, 10, 12, 14, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 42, 45]</td></tr>
<tr><td colspan="3">Property Class</td><td colspan="2">[8.8, 9.8, 10.9, 12.9]</td></tr>
<tr><td colspan="3">Type</td><td colspan="2">Bearing Bolt</td></tr>
<tr><td colspan="3">Hole Type</td><td colspan="2">Standard</td></tr>
<tr><td colspan="3">Slip Factor, (μ_f)</td><td colspan="2">0.3</td></tr>
<tr><td colspan="3">Edge Preparation Method</td><td colspan="2">Sheared or hand flame cut</td></tr>
<tr><td colspan="3">Gap Between Beams (mm)</td><td colspan="2">3.0</td></tr>
<tr><td colspan="3">Are the Members Exposed to Corrosive Influences?</td><td colspan="2">False</td></tr>
<tr><td colspan="5">Plate Details - Input and Design Preference</td></tr>
<tr><td colspan="3">Preference</td><td colspan="2">Outside + Inside</td></tr>
<tr><td colspan="3">Ultimate Strength, F_u (MPa)</td><td colspan="2">410</td></tr>
</table>

DESIGN RESULT:

1. **FOR BOLTS:**

Check	Required	Provided	Remarks
Diameter (mm)	Bolt Quantity Optimization	$d = 42.0$	
Property Class	Bolt Grade Optimization	8.8	
Bolt Ultimate Strength (N/mm2)		$f_{ub} = 830.0$	
Bolt Yield Strength (N/mm2)		$f_{yb} = 660.0$	
Nominal Stress Area (mm2)		$A_{nb} = 1080 \ (Ref\ IS\ 1367-3\ (2002))$	
Hole Diameter (mm)		$d_0 = 45.0$	
Min. Flange Plate Thickness (mm)	$T/2 = 10.0$	$t_{ifp} = 12.0$	Pass
No. of Bolt Columns		$n_c = 6$	
No. of Bolt Rows		$n_r = 2$	

Check	Required	Provided
Diameter (mm)	Bolt Quantity Optimization	$d = 42.0$
Property Class	Bolt Grade Optimization	8.8
Min. Web Plate Thickness (mm)	$t/2 = 6.0$	$t_{wp} = 12.0$
No. of Bolt Columns		$n_c = 4$
No. of Bolt Rows		$n_r = 6$
Min. Pitch Distance (mm)	$p_{\min} = 2.5d$ $= 2.5 \times 42.0$ $= 105.0$ [Ref. IS 800:2007, Cl.10.2.2]	105

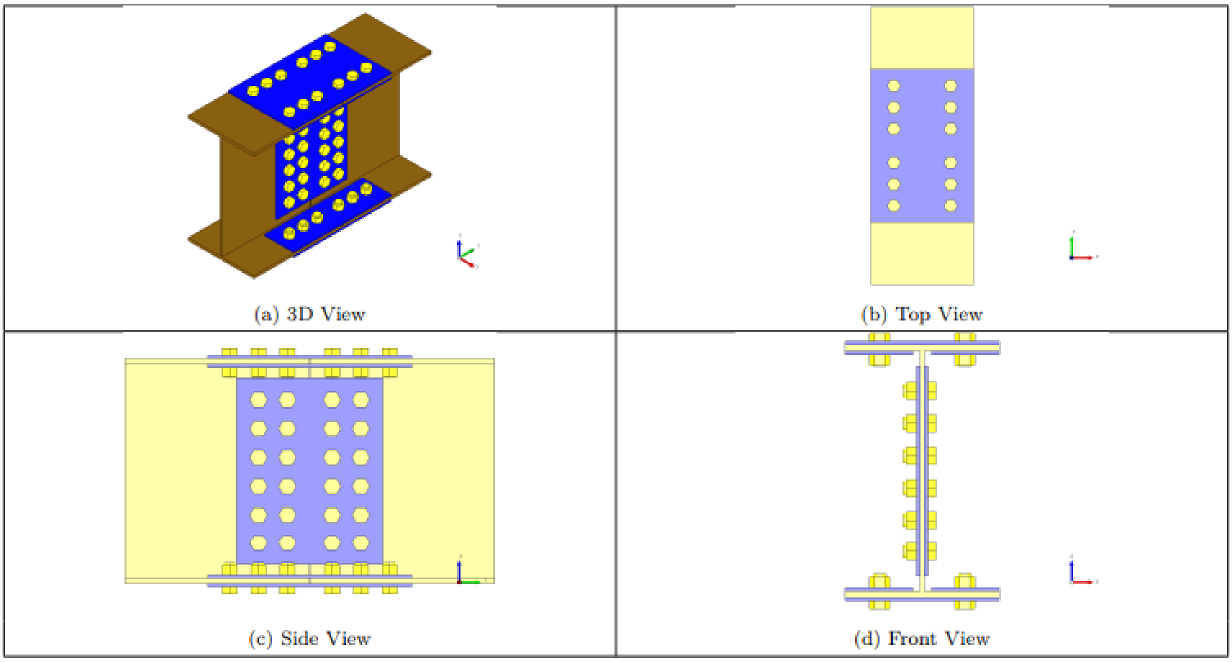
2. FOR FLANGE PLATE:

Check	Required	Provided
Min. Flange Plate Width (mm)	min. flange plate height = beam width $= 500.0$	500.0
Min. Flange Plate Length (mm)	$2 \times [2e_{min} + (\frac{n_c}{2} - 1) \times p_{min})]$ $+ \frac{gap}{2}]$ $= 2 \times [(2 \times 76.5 + (\frac{6}{2} - 1) \times 105.0$ $= + \frac{3.0}{2}]$ $= 729.0$	743.0
Min. Inner Plate Width (mm)	>=50	220
Max. Inner Plate Width (mm)	$= \frac{B - t - (2R1)}{2}$ $= \frac{500.0 - 12.0 - 2 \times 20.0}{2}$ $= 224$	220
Min. Inner Plate Length (mm)	$2 \times [2e_{min} + (\frac{n_c}{2} - 1) \times p_{min})]$ $+ \frac{gap}{2}]$ $= 2 \times [(2 \times 76.5 + (\frac{6}{2} - 1) \times 105.0$ $= + \frac{3.0}{2}]$ $= 729.0$	743.0
Min. Flange Plate Thickness (mm)	$T/2 = 10.0$	$t_{ifp} = 12.0$
Plate Area Check (mm2)	plate area >= 1.05 X connected member area $= 10500.0$ [Ref: Cl.8.6.3.2, IS 800:2007]	plate area $= (B_{fp} + (2 \times B_{ifp})) \times t_{ifp}$ $= (500.0 + (2 \times 220)) \times 12.0$ $= 11280.0$

3. WEB FLANGE DESIGN:

Check	Required	Provided
Min. Web Plate Height (mm)	$0.6 \times (d_b - 2 \times t_f - 2 \times r_r)$ $= 0.6 \times (824.0 - 2 \times 20.0 - 2 \times 20.0)$ $= 446.4$ [Ref. INSDAG, Ch.5, sec.5.2.3]	685
Min. Web Plate Width (mm)	$2 \times [2e_{min} + (\frac{n_c}{2} - 1) \times p_{min})]$ $+ \frac{gap}{2}]$ $= 2 \times [(2 \times 76.5 + (\frac{4}{2} - 1) \times 105.0$ $= + \frac{3.0}{2}]$ $= 519.0$	533.0
Min. Web Plate Thickness (mm)	$t/2 = 6.0$	$t_{wp} = 12.0$
Plate Area Check (mm2)	plate area >= 1.05 X connected member area $= 9878.4$ [Ref: Cl.8.6.3.2, IS 800:2007]	plate area $= 2 \times W_{wp} \times t_{wp}$ $= 2 \times 685 \times 12.0$ $= 16440.0$

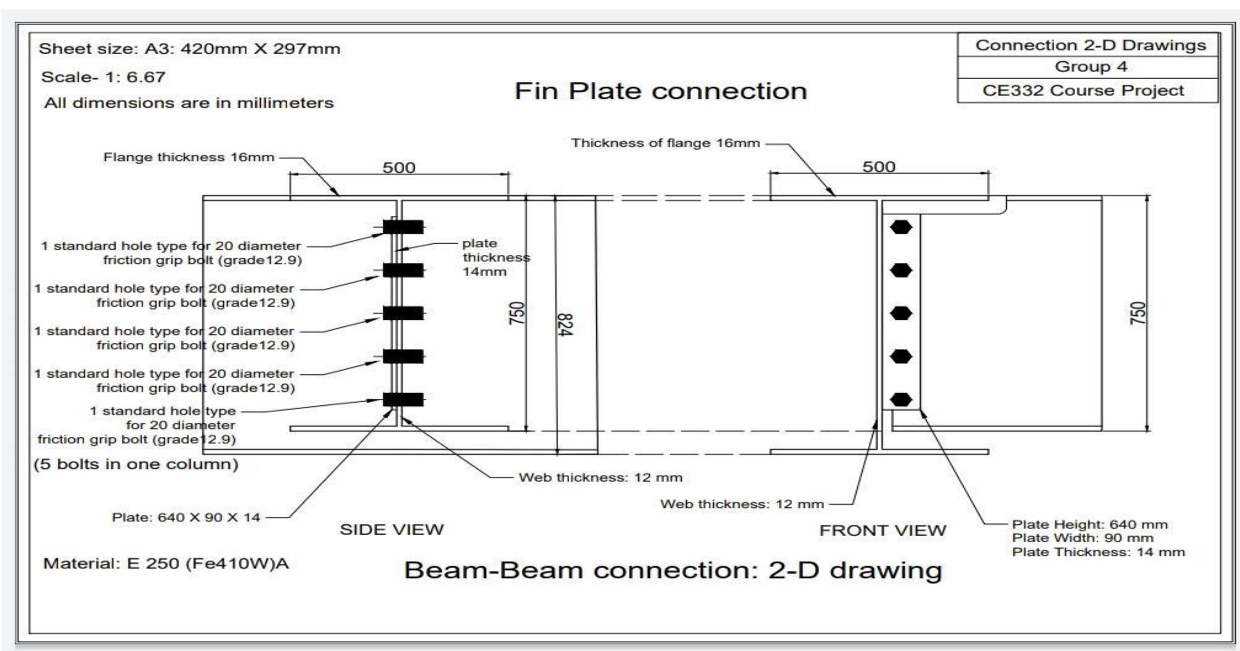
FINAL DESIGN STRUCTURE:



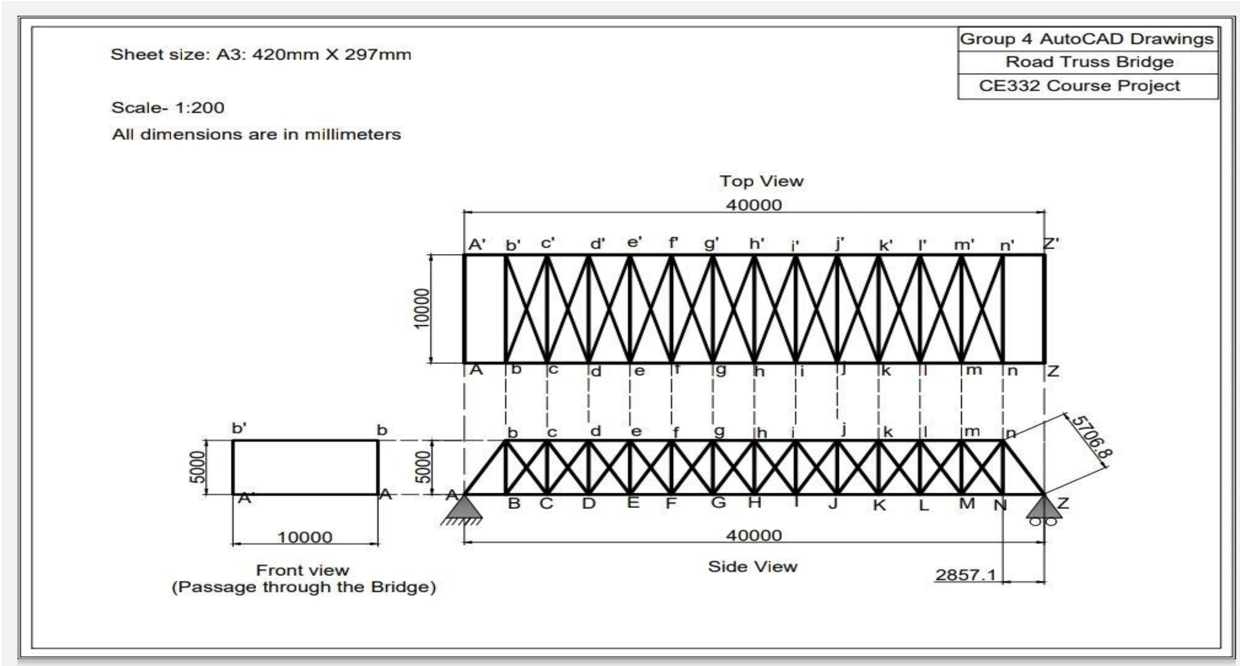
(a) 3D View
(b) Top View
(c) Side View
(d) Front View

DRAWINGS:

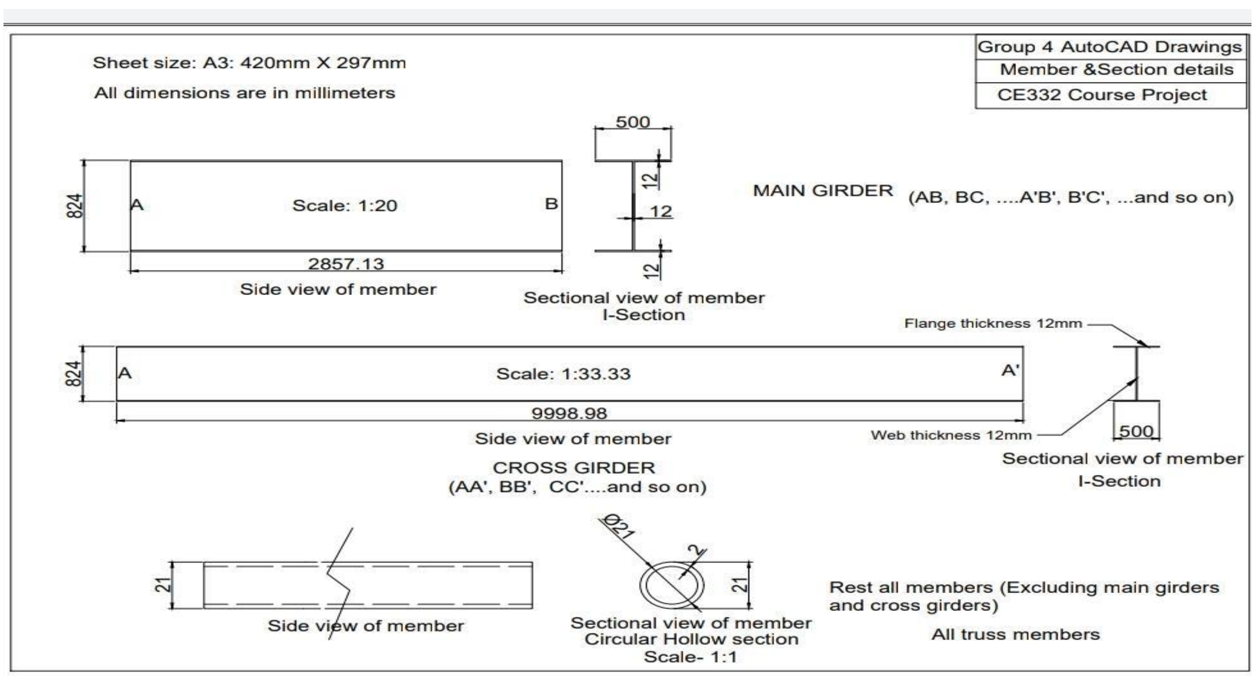
AUTOCAD DRAWINGS- FIN PLATE CONNECTION



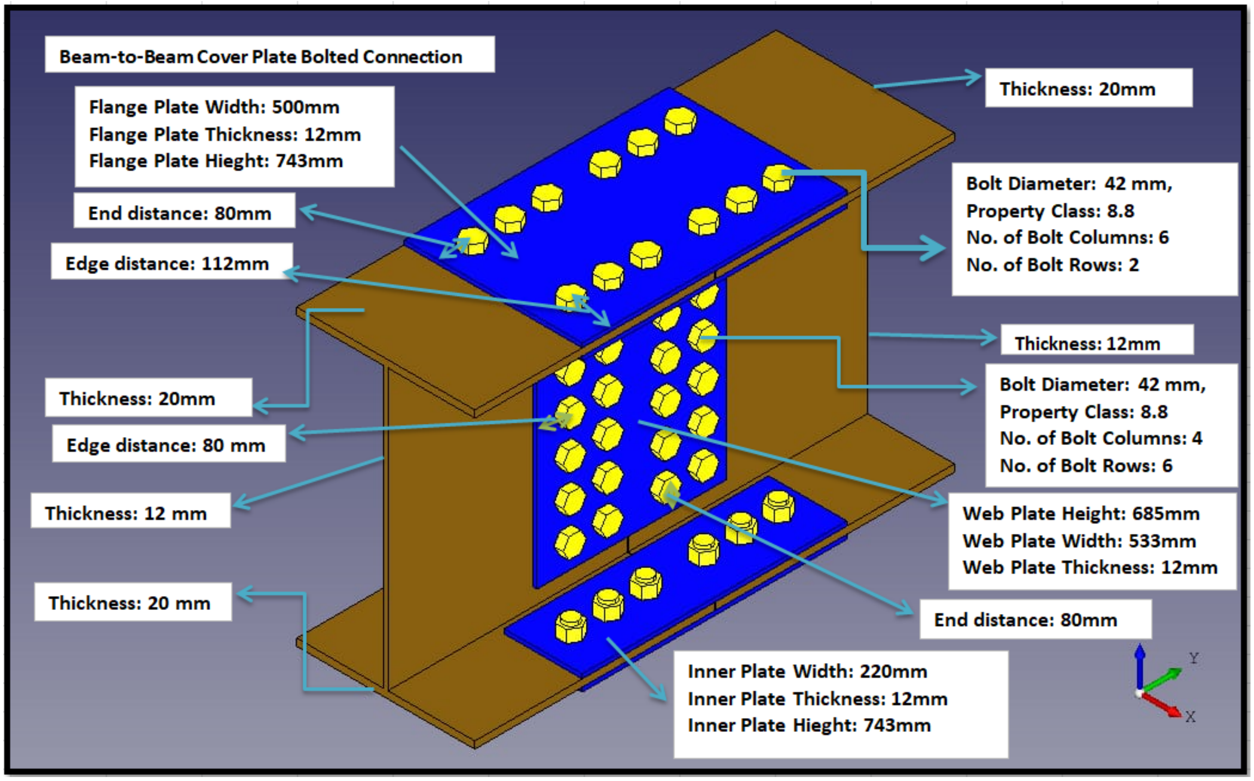
AUTOCAD DRAWINGS- TRUSS BRIDGE



AUTOCAD DRAWINGS- MEMBER AND SECTION DESIGN



AUTOCAD DRAWINGS (FROM OSDAG)- SPLICE DESIGN



BILL OF QUANTITIES:

PROFILE	LENGTH(M)	WEIGHT(kN)	VOLUME(M^3)	Rate of sections per Kg as per the market	Cost
I80016B50012	230	740.31		₹ 51.00	₹ 38,48,706.42
PIP603M	11.43	0.563		₹ 43.00	₹ 2,467.79
PIP761L	11.43	0.644		₹ 43.00	₹ 2,822.83
PIP889L	141.43	9.365		₹ 43.00	₹ 41,049.44
PIP889M	34.29	2.818		₹ 43.00	₹ 12,352.09
PIP1016L	299.46	25.534		₹ 43.00	₹ 1,11,922.73
PIP1651L	130	22.669		₹ 43.00	₹ 99,364.63
PIP1683L	249.6	44.485		₹ 43.00	₹ 1,94,990.32
				TOTAL	₹ 43,13,676.25
RCC			80	20000	₹ 16,00,000.00
				NET TOTAL	₹ 59,13,676.25
				LABOUR + FOUNDATION + CONNECTION(40%)	₹ 23,65,470.50
				TOTAL COST	₹ 82,79,146.75

ESSAY:

JAHANVI AKANKSHA

- I have participated in deciding the preliminary geometry of the road bridge by doing some research over the internet.
- I have worked on the clauses, which are related to the structural steel design inside the Staad pro and made a report out of it.
- I was involved in the presentation making, report making and compiling in all three stages of presentation, with that I have also presented the part of the design which we have done in the second stage.
- I have researched the connections type from the lecture notes and the internet to find out the relevant connection type for our project.
- I was involved in the design of connections that are:
    a. Design of fin plate between main girder and cross girder using osdag software.
    b. Design of Splice between the two main girders using osdag software.
    c. For the above two designs, I was involved in collecting all the relevant input information from the structural design report of the Staad pro.
- I was involved in deciding the bill of quantities for the structural design of the bridge.
- I worked on the AutoCAD drawing of one of the connections and labelling the relevant stuff on it.

Hemant

1. Decided the preliminary geometry and layout of the road bridge. In the initial phase, researched varieties of truss bridges, their components, and connection types; helped in deciding which one to use in our project.
2. Made the summary of the design codes, for performing the design process, by reading the relevant clauses and codes of practice in steel design. (Mainly it was various design state methods for tension and compression)
3. Made the 2-D drawings of the connections with complete bolt-detailing and dimensioning in AutoCAD.
4. As a part of the design team, worked on evaluating the bill of quantities
5. Drew the CAD drawings of the structure showing plan-drawings, side elevations and also drawn the drawings of each structural member chosen for the structure with detailing and sectional views (various I sections and circular hollow sections)
6. Worked on presentation and in report making for all 3 stages of the project work.

Muhammed Ali V P

I helped in coming up with the preliminary structure of the steel bridge. I also contributed making the slides for wind load with Guru Charan for the Stage 1 presentation. For this I did research on different type of wind load with the help of information given by the instructor and the TAs. In the 2nd stage I learned Staad Pro and helped my team members in coming up with temporary steel bridge structure. With a team effort and a little help from our Tas we were able to find the boundary conditions and release the moments. With the help of the analysis members we found out manually the load calculation for wind load, pedestrian load, vehicular load and self load. I made the slides for the manual calculations of various loads stated above. For 3rd stage I collected all the inputs from my team members and compiled into slides with the help of Dilyachana. I will be representing my team to present for the Stage 3 evaluation.

Mohammed KM

I learnt STAAD Pro and contributed towards application of various boundary conditions i.e support conditions and moment release for the structure in STAAD. I was involved extensively in the wind load and live load calculation for all cases and in the application of dead load, live load and wind load in STAAD along with Ali, Ankit Yadav and Chaitanya. In stage 1, I prepared the introductory part of the presentation along with Ankit Ratre. In stage 2, I prepared the presentation for the structural analysis part pertaining to preliminary dimensions, materials used and boundary conditions. I was responsible presentation of the analysis part in stage 2 of the project. For stage 3, I prepared the report for Loads and Forces section.

Guru Charan

I helped in making the preliminary structure of our truss bridge with the analysis team and Chaitanya. I made the presentation slides of wind load on our truss bridge for stage 1. I studied the Staad.Pro code for slenderness ratio and section classification and made a short passage for my team when they are designing. I studied the different types of connections that we as a design team used in our model. I read and gathered information about fin plate connection for shear design, bolted gusset connection for tension, etc., Then I made slides and explained the connection design procedures for the presentation and the report. I made slides regarding the slenderness ratio and section classification for our design in our presentation and report. Then I presented and talked about these things in our stage 2 presentation. For stage 3, I helped in finalizing our connection designs like splice plate connection for the beam to beam and fin plate connection for shear. Then we as a design team worked on the bill of quantities. We searched on the internet for rates of different steel members we used in our structural design and also the percentage of the total cost for other costs like labour cost, foundation cost, connection cost, etc., I was given the role to prepare the report on the bill of quantities. I am also presenting from the design team for our stage 3 presentation

ANKIT RATRE

My overall contribution to the project work is as follows:

1. Design of fin plate connection between main girder and cross girder using osdag
2. Design of splice connection between two members of the main girder using osdag
3. The I-sections in the bridge used are larger than any other sections given in code. Therefore, used the staad pro member properties to create entirely new member sections by manually entering mass, cross sectional area, radius of gyration, moment of inertia etc. And used them as primary and secondary beams for connection design in osdag.
4. Using staad pro to find the maximum axial force, shear force and bending moment from load envelopes for all members for connection design
5. Worked on evaluating the bill of quantities by searching for Rs/kg rate of hollow circular section members
6. Searched about various types of truss bridges, their components, and connection types and helped in deciding which one to use in our project.
7. Worked on learning combined interaction check and minimum web thickness based on IS code which are used for designing process in staad pro
8. Worked on presentation and report making for all 3 stages of the project work

AKMAL NAZER:

- contributed to make the preliminary structure of our truss bridge
- Made the presentation slides of different load combinations on the truss bridge for stage 1
- Helped in live load calculation from the respective code
- Helped in Vehicular Load Calculation

CHAITANYA KEDIA:

Contributed towards deciding the preliminary structure with the whole team.

- Assisted in monitoring the critical location of Vehicular load using point load.
- Assisted in application of Live Load and manual wind load on the structure.
- Worked on incorporation of the load combinations in staad pro for the structure
- Worked on Structural Design of the structure.

DILYACHANA:

Responsible for the timeline of the project for stage 1

- Involved in the connection design with design team in fin plate connection (shear design) and Tension design using osdag.Reading the clauses on Member property specification and Design parameters.

- Design of splice connection between two members of the main girder using osdag worked on evaluating bill of quantities and worked on overall presentation.

CONCLUSION:

We have completed our design and Analysis.

References:

- Bentley Documentation
- IS800:2007
- IRC 6 -2016
- http://www.steelconstruction.info/
- http://www.youtube.com
- http://www.google.com