Structural Design Report
for Continuous Deep Beam Template

Table of Contents

1. Design Conditions

1) General Characteristics
   (1) Project Name
   (2) Design Code
   (3) Unit
   (4) Strength Reduction Factors
   (5) Scope of Report
2) Materials
   (1) Concrete
   (2) Steel
3) Geometrical Shape
4) Loads and Load Combinations
   (1) Loads
   (2) Load Combinations
5) Reference
   (1) Designer
   (2) Date
   (3) Note

2. Strut-Tie Model Design (Load Combination-1)

1) Construction of Strut-Tie Model
   (1) ESO (Evolutionary Structural Optimization)
   (2) Compressive Principal Stress Flow
   (3) Constructed Strut-Tie Model
2) Analysis of Strut-Tie Model
   (1) Loading Conditions
   (2) Strut and Tie Types
   (3) Strut and Tie Forces
3) Strength Verification and Required Rebars
   (1) Strength under Bearing/Loading Plates
   (2) Required Area of Rebars
   (3) Available Widths of Struts and Nodal Zones
   (4) Strength of Struts
   (5) Strength of Nodal Zones
4) Detailed design
   (1) Calculate the minimum reinforcement for crack control

3. Summary

1) Dimensioned Shape
2) Required and Used Areas of Rebars
3) Placement of Rebars

1. Design Conditions

1) General Characteristics

(1) Project Name : Continuous Deep Beam Template
(2) Design Code : ASSHTO LRFD
(3) Unit : Kips.in
(4) Strength Reduction Factors
Strut : 0.70
Tie : 0.90
Node : 0.70
(5) Scope of Report

The purpose of this report is to design structural concrete member using strut-tie model. The design is performed according to the ASSHTO LRFD strut-tie model provisions.

This report provides results of calculation for:

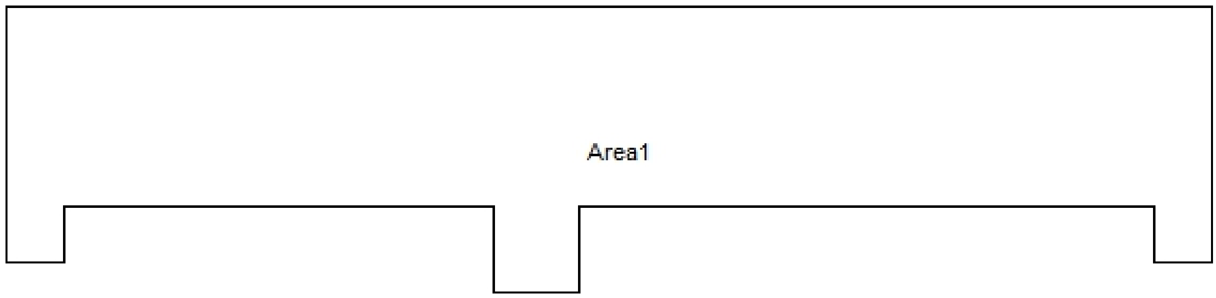
- check capacity of bearing plates
- design tie reinforcement
- check capacity of struts
- check capacity of nodal zones

2) Materials

(1) Concrete
- Mass : 147 lb/ft^3
- Weight : 149.6 lb/ft^3
- Poisson's ratio : 0.15
- Compressive Strength of Concrete, fck : 3480.9 lb/in^2
- Tensile Strength of Concrete, fct : 348.1 lb/in^2
- Elastic modulus of concrete, Ec : 4,039,177 lb/in^2

(2) Steel1
- Mass : 490 lb/ft^3
- Weight : 499.7 lb/ft^3
- Poisson's ratio : 0.15
- Yield strength of steel, fy : 58015.4 lb/in^2
- Elastic modulus of steel, Es : 29,007,699 lb/in^2

3) Geometrical Shape

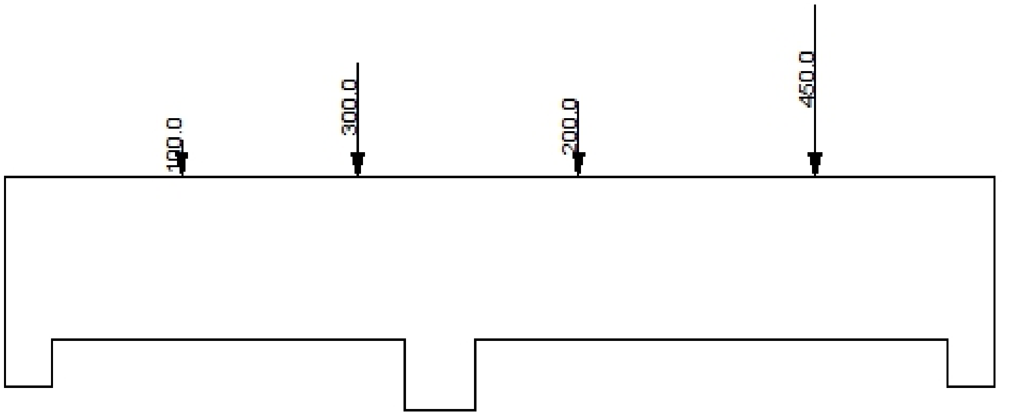


- Thickness : 20.00 in

4) Loads and Load Combinations

(1) Loads

D (Load)



(2) Load Combinations

1) LC01 : 1.00D

5) Reference

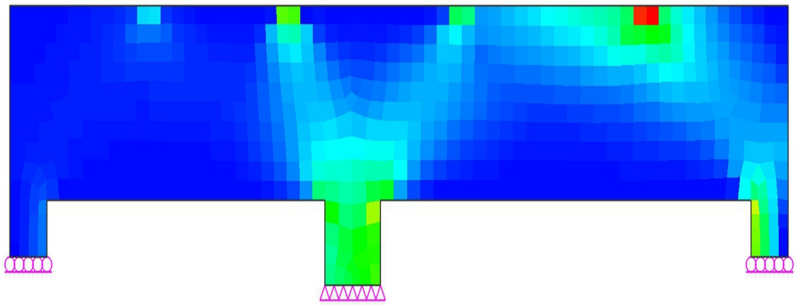
(1) Designer : Hangil IT
(2) Date : 2017-07-15
(3) Note : Design of Continuous Deep Beam using Template (AASHTO LRFD)

2. Strut-Tie Model Design (Load Combination-1)

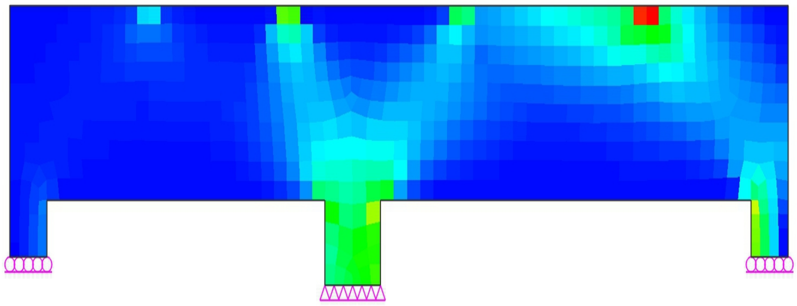
1) Construction of Strut-Tie Model

(1) ESO (Evolutionary Structural Optimization)

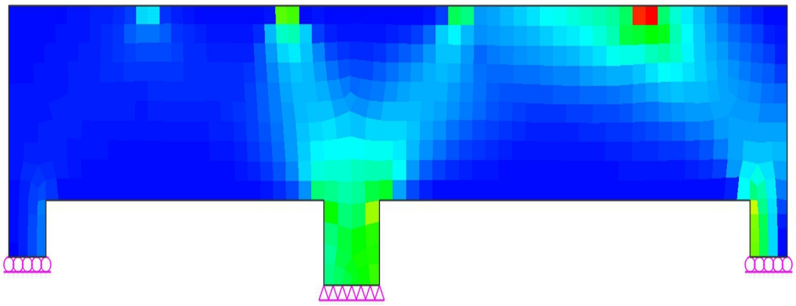
1. STAGE-01 (Initial shape)



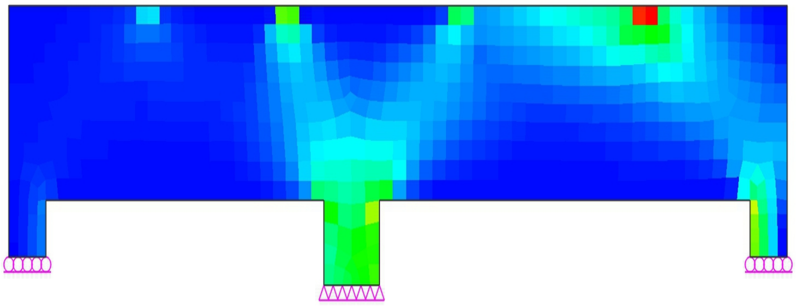
2. STAGE-01 (Initial shape)



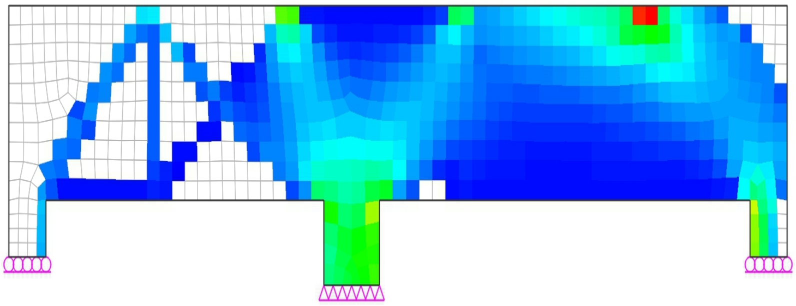
3. STAGE-01 (Initial shape)



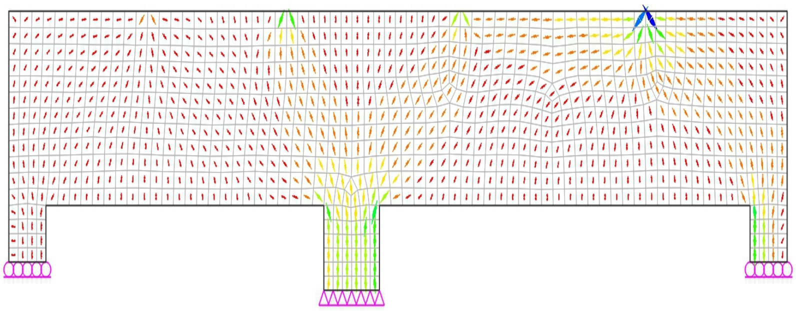
4. STAGE-01 (Initial shape)



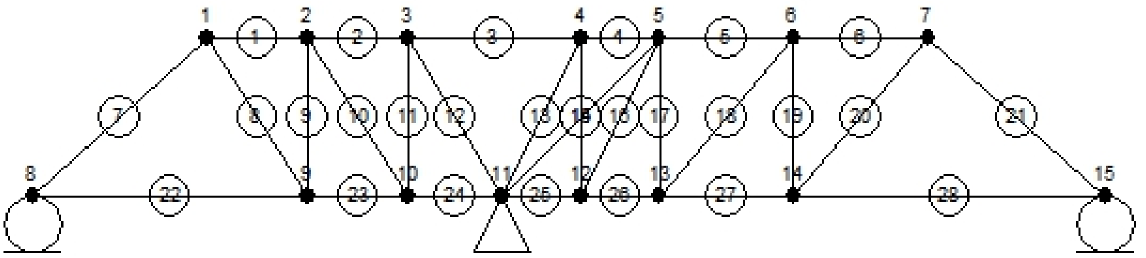
5. STAGE-04 (Elimination ratio = 26%)



(2) Compressive Principal Stress Flow



(3) Constructed Strut-Tie Model



(A) Nodal Coordinates

Node No.	X coordi.	Z coordi.	Node No.	X coordi.	Z coordi.
1	60.000	67.000	2	90.000	67.000
3	120.000	67.000	4	171.500	67.000
5	195.000	67.000	6	235.000	67.000
7	275.000	67.000	8	8.000	20.000
9	90.000	20.000	10	120.000	20.000
11	148.000	20.000	12	171.500	20.000
13	195.000	20.000	14	235.000	20.000
15	328.000	20.000			

(B) Element Connectivity

Element No.	Start Node	End Node	Element No.	Start Node	End Node
1	1	2	2	2	3
3	3	4	4	4	5
5	5	6	6	6	7
7	8	1	8	1	9
9	9	2	10	2	10
11	3	10	12	11	3
13	11	4	14	4	12
15	11	5	16	5	12
17	5	13	18	6	13
19	14	6	20	7	14
21	15	7	22	8	9
23	9	10	24	10	11
25	12	11	26	12	13
27	13	14	28	14	15

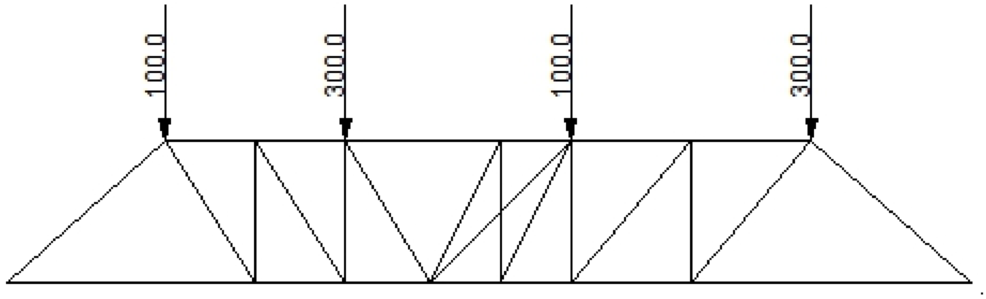
(C) Restraints

Node	Ux	Uy	Uz	Rx	Ry	Rz
8	-	-	O	-	-	-
11	O	O	O	O	-	O
15	-	-	O	-	-	-

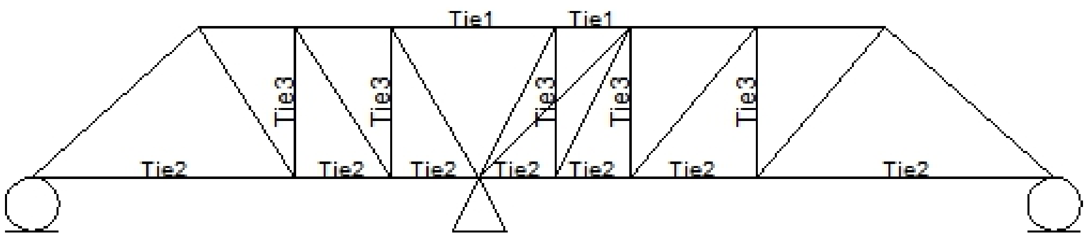
2) Analysis of Strut-Tie Model

(1) Loading Conditions

(1) (D)

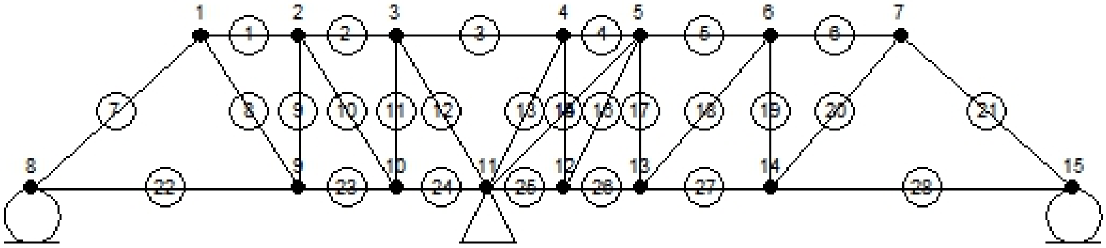


(2) Strut and Tie Types



- Tie1 : Tie for top rebars
- Tie2 : Tie for bottom rebars
- Tie3 : Tie for intermediate vertical/horizontal rebars

(3) Strut and Tie Forces



Elem. No.	Force (kip)	Elem. No.	Force (kip)	Elem. No.	Force (kip)	Elem. No.	Force (kip)
1	-34.3	2	-6.4	3	198.4	4	187.9
5	-15.6	6	-112.7	7	-83.9	8	-51.9
9	43.7	10	-51.9	11	43.7	12	-400.1
13	-23.5	14	21.0	15	-272.9	16	-23.5
17	114.0	18	-149.7	19	114.0	20	-149.7
21	-280.3	22	62.2	23	34.3	24	6.4
25	5.1	26	15.6	27	112.7	28	209.7

3) Strength Verification and Required Rebars

(1) Strength under Bearing/Loading Plates

phi fce = phi·0.65·fck > Fu / A
A = Area of bearing plates (= BxW)

Node	phi	fce(lb/in²)	Fu (kip)	B (in)	W (in)	Fu/A (lb/in²)	Note
8	0.70	1583.81	56.3	14.0	16.0	251.165	O.K
11	0.70	1583.81	557.8	14.0	24.0	1659.997	N.G
15	0.70	1583.81	186.0	14.0	16.0	830.272	O.K
1	0.70	1583.81	100.0	14.0	16.0	446.429	O.K
3	0.70	1583.81	300.0	14.0	16.0	1339.286	O.K
5	0.70	1583.81	100.0	14.0	16.0	446.429	O.K
7	0.70	1583.81	300.0	14.0	16.0	1339.286	O.K

(2) Required Area of Rebars

1) Main Rebars

(A) Horizontal Rebars

As.req = Fu / phi·fy·cos theta < As.used
where,
Fu = member force of steel tie
phi = strength reduction factor of steel tie : 0.90
fy = yield strength of steel : 58015.4 lb/in²
theta = angle of steel tie measured from positive horizontal axis
(+: counterclockwise)

Tie No.	Types	Fu (kip)	theta (deg.)	Rebars	As.req (in²)	As.used (in²)	Note
3	Top	44.60	0.0	8-#9	4	8	O.K
4	Top	42.23	0.0	8-#9	4	8	O.K
22	Bottom	13.99	0.0	8-#9	1	8	O.K
23	Bottom	7.72	0.0	8-#9	1	8	O.K
24	Bottom	1.44	0.0	8-#9	0	8	O.K
25	Bottom	1.15	0.0	8-#9	0	8	O.K
26	Bottom	3.52	0.0	8-#9	0	8	O.K
27	Bottom	25.33	0.0	8-#9	2	8	O.K
28	Bottom	47.15	0.0	8-#9	4	8	O.K

2) Transverse Rebars

(A) Horizontal-Vertical Rebars

Tie No.	Fu (kip)	theta (deg.)	Rebars	Weff,tie (in)	Sprov (in)	phi Fn (kip)	Note
9	9.83	90.0	4-#6 4-#6	1.2 1.2	0.4 0.4	62.2	O.K
11	9.83	90.0	4-#6 4-#6	0.6 1.1	0.4 0.4	60.2	O.K
14	4.73	90.0	4-#6 4-#6	0.9 0.9	0.4 0.4	48.7	O.K
17	25.63	90.0	4-#6 4-#6	0.6 1.3	0.4 0.4	65.9	O.K
19	25.63	90.0	4-#6 4-#6	1.6 1.6	0.4 0.4	83.0	O.K

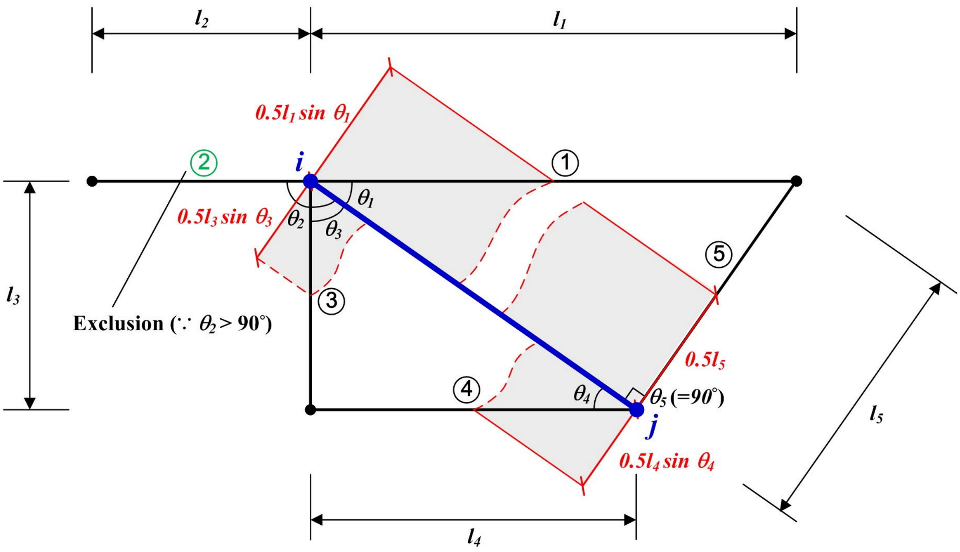
phi·Fn = (phi·Avh·fy·Weff,tie·cos theta / Sh) + (phi·Av·fy·Weff,tie·sin theta / Sv) > Fu
where,
Fu = member force of steel tie
phi = strength reduction factor of steel tie : 0.90
fy = yield strength of steel : 58015.4 lb/in^2
theta = angle of steel tie measured from positive horizontal axis (+: counterclockwise)
Sprov = spacing of vertical and horizontal rebars
Weff,tie = effective width of tie

(3) Available Widths of Struts and Nodal Zones

1) Node without bearing plate
The available widths of a strut at both ends and nodal zone faces are determined by taking the minimum ones from the values calculated below for case 1 and case 2.

2) Node with bearing plate
The available widths of a strut at both ends and nodal zone faces are determined by taking the values calculated below for case 3.

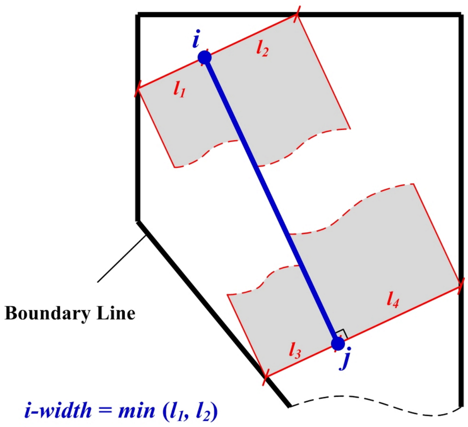
[CASE 1]



i-width = *min* ($l_1 \sin\ \theta_1$, $l_3 \sin\ \theta_3$)

j-width = *min* ($l_4 \sin\ \theta_4$, l_5)

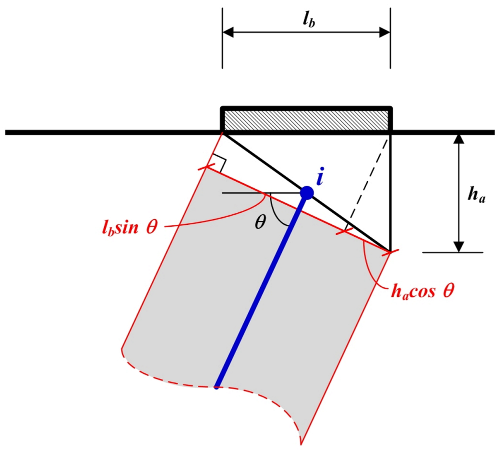
[CASE 2]



i-width = *min* (l_1, l_2)

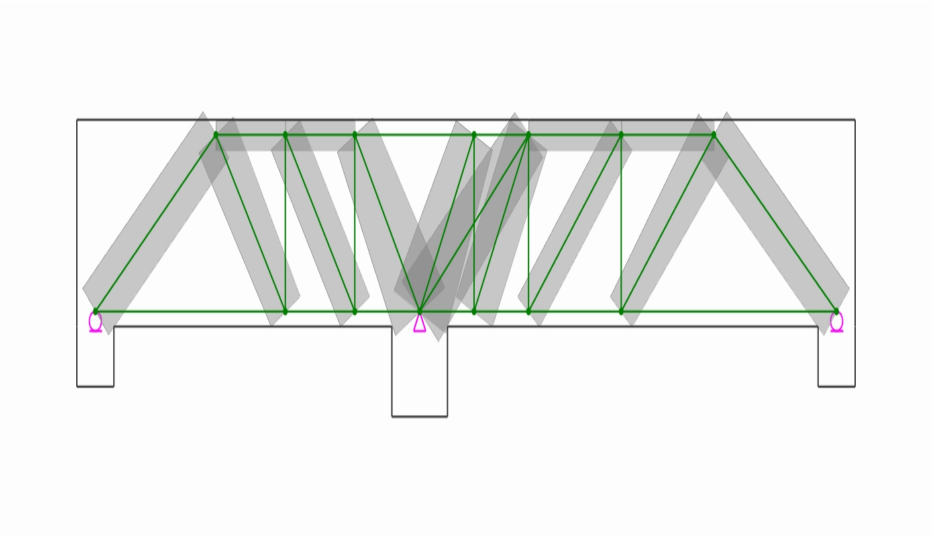
j-width = *min* (l_3, l_4)

[CASE 3]



i-width = $l_b \sin\ \theta + h_a \cos\ \theta$

The available widths of struts and ties determined by the methods introduced above are shown below



Elem. No.	i-width	j-width	Available Width	Elem. No.	i-width	j-width	Available Width
1	8.0	8.0	8.0	2	8.0	8.0	8.0
5	8.0	8.0	8.0	6	8.0	8.0	8.0
7	16.6	16.6	16.6	8	17.7	14.8	14.8
10	14.8	14.8	14.8	12	24.7	17.8	17.8
13	25.0	17.5	17.5	15	22.6	16.9	16.9
16	17.8	17.5	17.5	18	12.3	12.3	12.3
20	17.3	12.3	12.3	21	16.6	16.6	16.6

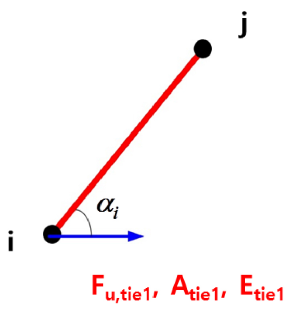
(4) Strength of Struts

The verification of the strut strength should be done through comparing the available strut area with that required. In this report, because the thickness of the structural concrete is consistent, the verification will be done by comparing the available strut width, Wprov, with that required, Wreq.

Wreq = Fu / phi·fcu·b < Wprov (See AASHTO LRFD Article 5.6.3.3)
fcu = fck / 0.8 + 170epsilon_l < 0.85
epsilon_l = epsilon_s + (epsilon_s + 0.002)cot2 alpha
alpha = The smallest angle between the compressive strut and adjoining tension ties
epsilon_s = The tensile strain in the concrete in the direction of the tension tie

The principal tensile strain is determined by taking the maximum ones from the values calculated below for six cases.

- Case 1



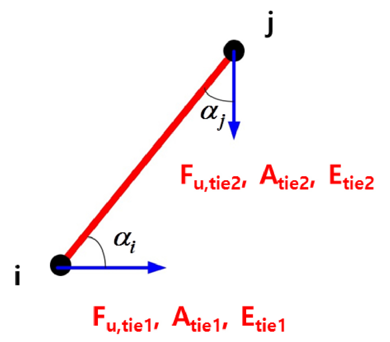
$$\varepsilon_{s,inode} = F_{u,tie1} \Big/ A_{tie1} E_{tie1}$$

$$\varepsilon_{s,inode,adjust} = \frac{1}{2} \varepsilon_{s,inode}$$

$$\varepsilon_{1,inode} = \varepsilon_{s,inode,adjust} + (\varepsilon_{s,inode,adjust} + 0.002)\cot^2 a_i$$

$$\varepsilon_1 = \varepsilon_{1,inode}$$

- Case 2



$$\varepsilon_{s,inode} = F_{u,tie1} \Big/ A_{tie1} E_{tie1}$$

$$\varepsilon_{s,jnode} = F_{u,tie2} \Big/ A_{tie2} E_{tie2}$$

$$\varepsilon_{s,inode,adjust} = \frac{1}{2} \varepsilon_{s,inode}$$

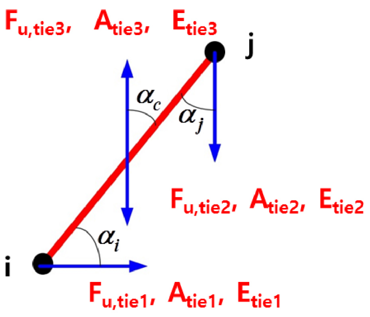
$$\varepsilon_{s,jnode,adjust} = \frac{1}{2} \varepsilon_{s,jnode}$$

$$\varepsilon_{1,inode} = \varepsilon_{s,inode,adjust} + (\varepsilon_{s,inode,adjust} + 0.002)\cot^2 a_i$$

$$\varepsilon_{1,jnode} = \varepsilon_{s,jnode,adjust} + (\varepsilon_{s,jnode,adjust} + 0.002)\cot^2 a_j$$

$$\varepsilon_1 = \max.\left[\varepsilon_{1,inode},\ \ \varepsilon_{1,jnode}\right]$$

- Case 3



$$\varepsilon_{s,inode} = \frac{F_{u,tie1}}{A_{tie1}E_{tie1}} \qquad \varepsilon_{s,jnode} = \frac{F_{u,tie2}}{A_{tie2}E_{tie2}} \qquad \varepsilon_{s,center} = \frac{F_{u,tie3}}{A_{tie3}E_{tie3}}$$

$$\varepsilon_{s,inode,adjust} = \frac{1}{2}\varepsilon_{s,inode} \qquad \varepsilon_{s,jnode,adjust} = \frac{1}{2}\varepsilon_{s,jnode}$$

$$\varepsilon_{s,center,adjust} = \varepsilon_{s,cener}$$

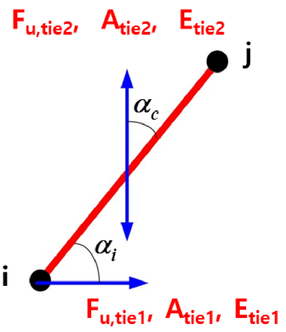
$$\varepsilon_{1,inode} = \varepsilon_{s,inode,adjust} + (\varepsilon_{s,inode,adjust} + 0.002)\cot^2 \boldsymbol{a}_i$$

$$\varepsilon_{1,jnode} = \varepsilon_{s,jnode,adjust} + (\varepsilon_{s,jnode,adjust} + 0.002)\cot^2 \boldsymbol{a}_j$$

$$\varepsilon_{1,center} = \varepsilon_{s,center,adjust} + (\varepsilon_{s,center,adjust} + 0.002)\cot^2 \boldsymbol{a}_c$$

$$\varepsilon_1 = \max.\left[\varepsilon_{1,inode},\ \ \varepsilon_{1,jnode},\ \ \varepsilon_{1,center}\right]$$

- Case 4



$$\varepsilon_{s,inode} = \frac{F_{u,tie1}}{A_{tie1}E_{tie1}} \qquad \varepsilon_{s,center} = \frac{F_{u,tie2}}{A_{tie2}E_{tie2}}$$

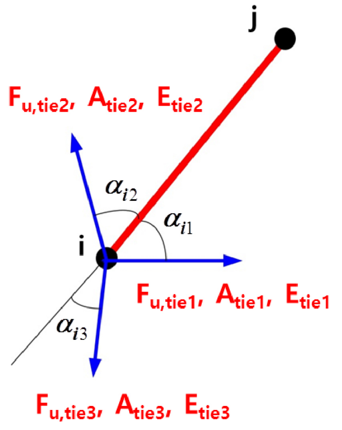
$$\varepsilon_{s,inode,adjust} = \frac{1}{2}\varepsilon_{s,inode} \qquad \varepsilon_{s,center,adjust} = \varepsilon_{s,cener}$$

$$\varepsilon_{1,inode} = \varepsilon_{s,inode,adjust} + (\varepsilon_{s,inode,adjust} + 0.002)\cot^2 \boldsymbol{a}_i$$

$$\varepsilon_{1,center} = \varepsilon_{s,center,adjust} + (\varepsilon_{s,center,adjust} + 0.002)\cot^2 \boldsymbol{a}_c$$

$$\varepsilon_1 = \max.\left[\varepsilon_{1,inode},\ \ \varepsilon_{1,center}\right]$$

- Case 5



$$\varepsilon_{s,inode,tie1} = \frac{F_{u,tie1}}{A_{tie1}E_{tie1}} \quad \varepsilon_{s,inode,tie2} = \frac{F_{u,tie2}}{A_{tie2}E_{tie2}} \quad \varepsilon_{s,inode,tie3} = \frac{F_{u,tie3}}{A_{tie2}E_{tie3}}$$

$$\varepsilon_{s,inode,tie1,adjust} = \frac{1}{2}\varepsilon_{s,inode,tie1} \quad \varepsilon_{s,inode,tie2,adjust} = \frac{1}{2}\varepsilon_{s,inode,tie2}$$

$$\varepsilon_{s,inode,tie3,adjust} = \frac{1}{2}\varepsilon_{s,inode,tie3}$$

$$\varepsilon_{1,inode,tie1} = \varepsilon_{s,inode,tie1,adjust} + (\varepsilon_{s,inode,tie1,adjust} + 0.002)\cot^2 \boldsymbol{a}_{i1}$$

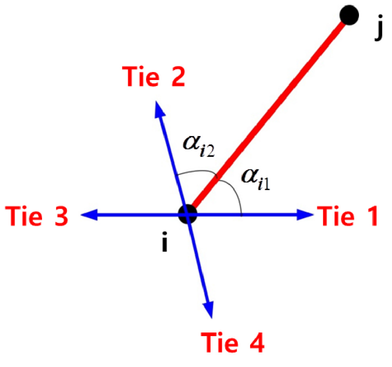
$$\varepsilon_{1,inode,tie2} = \varepsilon_{s,inode,tie2,adjust} + (\varepsilon_{s,inode,tie2,adjust} + 0.002)\cot^2 \boldsymbol{a}_{i2}$$

$$\varepsilon_{1,inode,tie3} = \varepsilon_{s,inode,tie3,adjust} + (\varepsilon_{s,inode,tie3,adjust} + 0.002)\cot^2 \boldsymbol{a}_{i3}$$

$$\varepsilon_{1,inode} = \max.\left[\varepsilon_{1,inode,tie1},\ \varepsilon_{1,inode,tie2},\ \varepsilon_{1,inode,tie3}\right]$$

$$\varepsilon_1 = \varepsilon_{1,inode}$$

- Case 6



$$\varepsilon_{s,inode,tie1} = \frac{F_{u,tie1}}{A_{tie1}E_{tie1}} \quad \varepsilon_{s,inode,tie2} = \frac{F_{u,tie2}}{A_{tie2}E_{tie2}}$$

$$\varepsilon_{s,inode,tie3} = \frac{F_{u,tie3}}{A_{tie2}E_{tie3}} \quad \varepsilon_{s,inode,tie4} = \frac{F_{u,tie4}}{A_{tie4}E_{tie4}}$$

$$\varepsilon_{s,inode,tie1,adjust} = \frac{1}{2}\varepsilon_{s,inode,tie1} \quad \varepsilon_{s,inode,tie2,adjust} = \frac{1}{2}\varepsilon_{s,inode,tie2}$$

$$\varepsilon_{s,inode,tie3,adjust} = \frac{1}{2}\varepsilon_{s,inode,tie3} \quad \varepsilon_{s,inode,tie4,adjust} = \frac{1}{2}\varepsilon_{s,inode,tie4}$$

$$\varepsilon_{s,inode,tie1\&3} = \varepsilon_{s,inode,tie1,adjust} + \varepsilon_{s,inode,tie3,adjust}$$

$$\varepsilon_{s,inode,tie2\&4} = \varepsilon_{s,inode,tie2,adjust} + \varepsilon_{s,inode,tie4,adjust}$$

$$\varepsilon_{1,inode,tie1\&3} = \varepsilon_{s,inode,tie1\&3} + (\varepsilon_{s,inode,tie1\&3} + 0.002)\cot^2 a_{i1}$$

$$\varepsilon_{1,inode,tie2\&4} = \varepsilon_{s,inode,tie2\&4} + (\varepsilon_{s,inode,tie2\&4} + 0.002)\cot^2 a_{i2}$$

$$\varepsilon_{1,inode} = \max.\left[\varepsilon_{1,inode,tie1\&3},\ \varepsilon_{1,inode,tie2\&4}\right]$$

$$\varepsilon_1 = \varepsilon_{1,inode}$$

- Effective strength of concrete struts

Strut No.	Tie No.	Tie Force (kip)	epsilon_s	alpha (deg.)	epsilon_l	epsilon_l,max	nu (=fcu/fck)
1	9	43.74	0.00001	90.0	0.00000	0.00000	0.85000
2	9	43.74	0.00001	90.0	0.00000	79700000000.00000	0.40000
	3	198.40	0.00086	0.0	79700000000.00000		
	11	43.74	0.00053	90.0	0.00027		
5	4	187.80	0.00081	0.0	78950000000.00000	78950000000.00000	0.40000
	17	114.00	0.00002	90.0	0.00001		
	19	114.00	0.00001	90.0	0.00001		
6	19	114.00	0.00001	90.0	0.00001	0.00001	0.85000
7	22	62.25	0.00027	42.1	0.00275	0.00275	0.78900
8	9	43.74	0.00001	32.5	0.00492	0.00492	0.61100
	22	62.25	0.00027	57.5	0.00111		
	23	34.33	0.00015	57.5	0.00111		
10	9	43.74	0.00001	32.5	0.00492	0.00583	0.55800
	11	43.74	0.00053	32.5	0.00583		
	23	34.33	0.00015	57.5	0.00094		
	24	6.41	0.00003	57.5	0.00094		
12	24	6.41	0.00003	59.2	0.00074	0.00665	0.51800
	25	5.12	0.00002	59.2	0.00074		
	3	198.40	0.00086	59.2	0.00129		
	11	43.74	0.00053	30.8	0.00665		
13	24	6.41	0.00003	63.4	0.00053	0.00844	0.44800
	25	5.12	0.00002	63.4	0.00053		
	3	198.40	0.00086	63.4	0.00154		
	4	187.80	0.00081	63.4	0.00154		
	14	21.05	0.00017	26.6	0.00844		
15	24	6.41	0.00003	45.0	0.00205	0.00281	0.78300
	25	5.12	0.00002	45.0	0.00205		
	4	187.80	0.00081	45.0	0.00281		
	17	114.00	0.00002	45.0	0.00202		
	14	21.05	0.00017	45.0	0.00235		
16	4	187.80	0.00081	63.4	0.00101	0.00844	0.44800
	17	114.00	0.00002	26.6	0.00806		
	14	21.05	0.00017	26.6	0.00844		
	25	5.12	0.00002	63.4	0.00056		

16	26	15.65	0.00007	63.4	0.00056	0.00844	0.44800
18	19	114.00	0.00001	40.4	0.00278	0.00279	0.78500
	17	114.00	0.00002	40.4	0.00279		
	26	15.65	0.00007	49.6	0.00193		
	27	112.70	0.00049	49.6	0.00193		
20	19	114.00	0.00001	40.4	0.00278	0.00278	0.78600
	27	112.70	0.00049	49.6	0.00265		
	28	209.70	0.00090	49.6	0.00265		
21	28	209.70	0.00090	41.6	0.00357	0.00357	0.71100

- Check strength of concrete struts

Strut No.	nu	theta	Fu (kip)	phi	Wreq (in)	Wprov (in)	Note
1	0.85	0.0	34.3	0.70	0.8	8.0	O.K
2	0.40	0.0	6.4	0.70	0.3	8.0	O.K
5	0.40	0.0	15.6	0.70	0.8	8.0	O.K
6	0.85	0.0	112.7	0.70	2.7	8.0	O.K
7	0.79	42.1	83.9	0.70	2.2	16.7	O.K
8	0.61	57.4	51.9	0.70	1.7	14.9	O.K
10	0.56	57.4	51.9	0.70	1.9	14.9	O.K
12	0.52	59.2	400.1	0.70	15.9	17.8	O.K
13	0.45	63.4	23.5	0.70	1.1	17.5	O.K
15	0.78	45.0	272.9	0.70	7.2	17.0	O.K
16	0.45	63.4	23.5	0.70	1.1	17.5	O.K
18	0.79	49.6	149.7	0.70	3.9	12.3	O.K
20	0.79	49.6	149.7	0.70	3.9	12.3	O.K
21	0.71	41.6	280.3	0.70	8.1	16.6	O.K

(5) Strength of Nodal Zones

The verification of the nodal zone strength should be done through comparing the available nodal zone area with that required. In this report, if the thickness of the structural concrete is consistent, the verification will be done by comparing the available nodal zone width, Wprov, with that required, Wreq

Wreq = Fu / phi·nu·fck·b < Wprov (See AASHTO LRFD Article 5.6.3.5)
nu = 0.85 (for node regions bounded by compressive struts and bearing areas)
0.75 (for node regions anchoring a one-direction tension tie)
0.65 (for node regions anchoring tension ties in more than one direction)

Node No.	nu	Type	Element	Fu (kip)	Wreq (in)	Wprov (in)	Note

1	0.85	CCC	V	22.5	0.5	16.0	O.K
			C-1	34.3	0.8	8.0	O.K
			C-7	83.9	2.0	16.7	O.K
			C-8	51.9	1.3	17.8	O.K
2	0.75	CCT	C-1	34.3	0.9	8.0	O.K
			C-2	6.4	0.2	8.0	O.K
			T-9	43.7	1.2	30.0	O.K
			C-10	51.9	1.4	14.9	O.K
3	0.65	CTT	V	67.4	2.1	16.0	O.K
			C-2	6.4	0.2	8.0	O.K
			T-3	198.4	6.3	8.0	O.K
			T-11	43.7	1.4	16.0	O.K
			C-12	400.1	12.6	17.8	O.K
4	0.65	CTT	T-3	10.5	0.3	8.0	O.K
			T-4	-	-	-	-
			C-13	23.5	0.7	17.5	O.K
			T-14	21.0	0.7	23.5	O.K
5	0.65	CTT	V	22.5	0.7	16.0	O.K
			T-4	187.9	5.9	8.0	O.K
			C-5	15.6	0.5	8.0	O.K
			C-15	272.9	8.6	17.0	O.K
			C-16	23.5	0.7	17.9	O.K
			T-17	114.0	3.6	16.0	O.K
6	0.75	CCT	C-5	15.6	0.4	8.0	O.K
			C-6	112.7	3.1	8.0	O.K
			C-18	149.7	4.1	12.3	O.K
			T-19	114.0	3.1	40.0	O.K
7	0.85	CCC	V	67.4	1.6	16.0	O.K
			C-6	112.7	2.7	8.0	O.K
			C-20	149.7	3.6	17.4	O.K
			C-21	280.3	6.8	16.6	O.K
8	0.75	CCT	R	56.3	1.5	16.0	O.K
			C-7	83.9	2.3	16.7	O.K
			T-22	62.2	1.7	8.0	O.K
9	0.65	CTT	C-8	51.9	1.6	14.9	O.K
			T-9	43.7	1.4	30.0	O.K
			T-22	27.9	0.9	8.0	O.K
			T-23	-	-	-	-

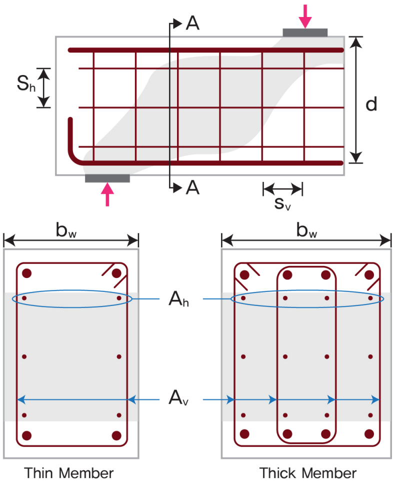
10	0.65	CTT	C-10	51.9	1.6	14.9	O.K
			T-11	43.7	1.4	28.0	O.K
			T-23	27.9	0.9	8.0	O.K
			T-24	-	-	-	-
11	0.65	CTT	R	557.8	17.6	24.0	O.K
			C-12	400.1	12.6	24.7	O.K
			C-13	23.5	0.7	25.0	O.K
			C-15	272.9	8.6	22.6	O.K
			T-24	1.3	0.0	8.0	O.K
			T-25	-	-	-	-
12	0.65	CTT	T-14	21.0	0.7	23.5	O.K
			C-16	23.5	0.7	17.5	O.K
			T-25	-	-	-	-
			T-26	10.5	0.3	8.0	O.K
13	0.65	CTT	T-17	114.0	3.6	23.5	O.K
			C-18	149.7	4.7	12.3	O.K
			T-26	-	-	-	-
			T-27	97.0	3.1	8.0	O.K
14	0.65	CTT	T-19	114.0	3.6	40.0	O.K
			C-20	149.7	4.7	12.3	O.K
			T-27	-	-	-	-
			T-28	97.0	3.1	8.0	O.K
15	0.75	CCT	R	186.0	5.1	16.0	O.K
			C-21	280.3	7.7	16.6	O.K
			T-28	209.7	5.7	8.0	O.K

C: compression; T: tension; V: vertical force; H: horizontal force

4) Detailed design

(1) Calculate the minimum reinforcement for crack control

Structures and components or regions thereof, except for slabs and footings, which have been designed in accordance with the provisions of Article 5.6.3, shall contain orthogonal grids of reinforcing bars. The spacing of the bars in these grid shall not exceed the smaller of d/4 and 300 mm.
The reinforcement in the vertical and horizontal direction shall satisfy the following:



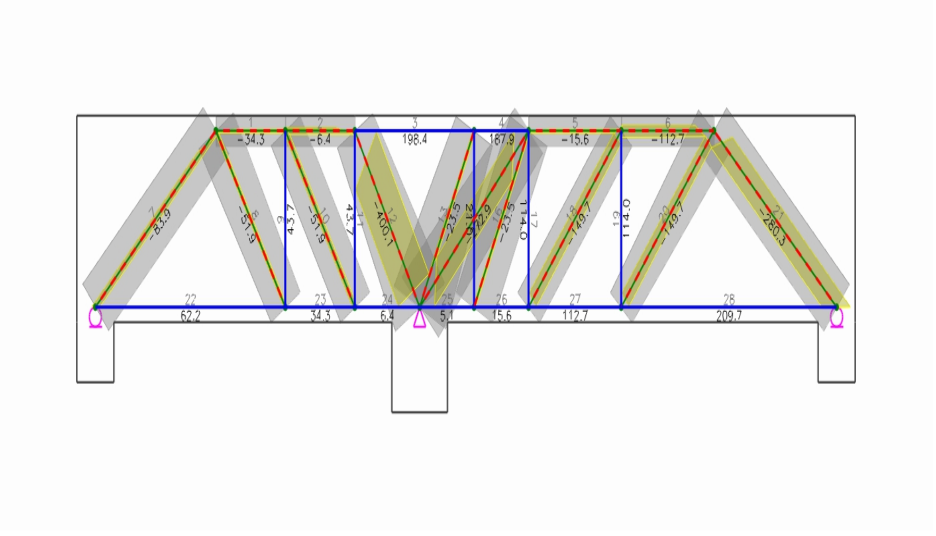
(Av / bwSv) > 0.003
(Ah / bwSh) > 0.003

Elem. No.	Av (in²)	Sv (in)	Ah (in²)	Sh (in)	Av/(bw·Sv)	Ah/(bw·Sh)	Note
7	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
8	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
10	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
12	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
13	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
15	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
16	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
18	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
20	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K
21	1.8	10.0	1.8	10.0	0.0088	0.0088	O.K

3. Summary

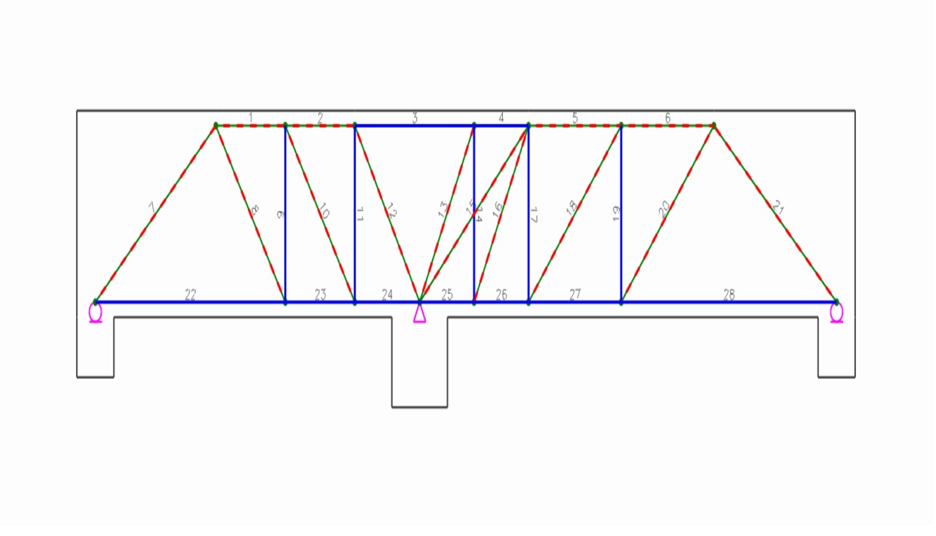
1) Dimensioned Shape

1) Load Combination - 1



2) Required and Used Areas of Rebars

1) Load Combination - 1



(A) Main Rebars

Tie No.	Types	Fu (kip)	theta (deg.)	Rebars	As.req (in²)	As.used (in²)	Note
3	Top	44.60	0.0	8-#9	4	8	O.K

4	Top	42.23	0.0	8-#9	4	8	O.K
22	Bottom	13.99	0.0	8-#9	1	8	O.K
23	Bottom	7.72	0.0	8-#9	1	8	O.K
24	Bottom	1.44	0.0	8-#9	0	8	O.K
25	Bottom	1.15	0.0	8-#9	0	8	O.K
26	Bottom	3.52	0.0	8-#9	0	8	O.K
27	Bottom	25.33	0.0	8-#9	2	8	O.K
28	Bottom	47.15	0.0	8-#9	4	8	O.K

(B) Transverse Rebars

- Horizontal-Vertical Rebars

Tie No.	Fu (kip)	theta (deg.)	Rebars	Weff,tie (in)	Sprov (in)	phi Fn (kip)	Note
9	9.83	90.0	4-#6 4-#6	1.2 1.2	0.4 0.4	62.2	O.K
11	9.83	90.0	4-#6 4-#6	0.6 1.1	0.4 0.4	60.2	O.K
14	4.73	90.0	4-#6 4-#6	0.9 0.9	0.4 0.4	48.7	O.K
17	25.63	90.0	4-#6 4-#6	0.6 1.3	0.4 0.4	65.9	O.K
19	25.63	90.0	4-#6 4-#6	1.6 1.6	0.4 0.4	83.0	O.K