

Appendix I

**San Lorenzo Supplemental Repair Report
and
Load Ratings**



CHARLESTON WV | EDWARDSVILLE IL | MECHANICSBURG PA | MOORESTOWN NJ | NEW ORLEANS LA
PHILADELPHIA PA | POUGHKEEPSIE NY | ST LOUIS MO | WASHINGTON DC

8/23/2012

Mr. Dan L. Davis
J.L. Patterson & Associates
725 Town & Country Road, Suite 300
Orange, CA 92868

RE: PN 3165
Santa Cruz County Regional Transportation Commission
San Lorenzo River Bridge – Load Capacity Evaluation

Dear Mr. Davis:

Modjeski and Masters, Inc. (MMI) performed a normal load capacity evaluation (rating) for the San Lorenzo River Bridge of the two through truss spans based on the existing condition of the structure. Member section properties were provided by J.L. Patterson & Associates, Inc. based on their findings during their inspection of the structure. The section properties were used by MMI to develop the existing condition ratings. Per the Scope of Work, only the main truss members were rated; fatigue, floorsystem, and gusset plates were not evaluated as part of this work. The existing condition rating was performed in order to determine the actual load carrying capacity of the truss.

The rating evaluation and analysis were performed in accordance with AREMA Chapter 15, Part 7 and standard practice. Ratings are calculated for the purpose of determining the live load carrying capacity of the bridge within allowable service stresses. The live loading criteria per the AREMA Manual is a Cooper E-80 Loading. The Cooper E-80 loading consists of two locomotives, each having main drive wheels of 80,000 pounds per axle, followed by a trailing uniform load of 8,000 pounds per lineal foot. The load ratings are expressed as a Cooper E series of axle live loadings, for example a rating of E55 would indicate that the bridge component can support two locomotives having drive wheels of 55,000 pounds per axle with a trailing uniform load of 5,500 pounds per lineal foot.

Most rail lines are usually rated for the actual configuration of locomotives and maximum car weight that can operate without restrictions on the line. Typical load configurations are for six axle locomotives with trailing cars having a specific loaded weight limit. The typical interchange weight limit on most lines is currently a 286,000 pound car. The previous limit was typically a 263,000 pound car. Cooper E loadings provide a comparable reference point and the actual live loading requirements for a given configuration of loadings on a bridge can usually be equated to the Cooper E loadings without much difficulty, through the use of equivalent loading graphs.

Other assumptions or modifications of the AREMA Manual are as follows:

- Steel was assumed to be Open Hearth with yield strength of 30,000 psi.
- Impact loading was reduced for a speed of 30 miles per hour.
- Only normal rating capacities were evaluated, as the criteria for rehabilitation of the bridge is to function at normal operational live loadings.



- 2 -

Attached for your reference are the existing condition rating calculations. As shown in the attached calculations, the truss members in their existing condition were all found to have capacities sufficient to carry a Cooper E80 live loading, except for the hangers (L0-U1, L3-U3, L5-U5) with an E65 controlling, and the lower chord of the two end bays (L4-L5, L5-L6 for case shown) with an E75. The low ratings on the lower chord are contributed to the longitudinal force, which may be in either direction. However, the longitudinal loading applied is considered a worst case scenario and therefore the lower chords are not considered insufficient for a Cooper E80 live loading.

Based on equivalent loading graphs, MMI concludes that the bridges have sufficient capacity to carry 263,000 and 286,000 pound railcars with two - six axle locomotives.

The rating calculations have been attached for your reference.

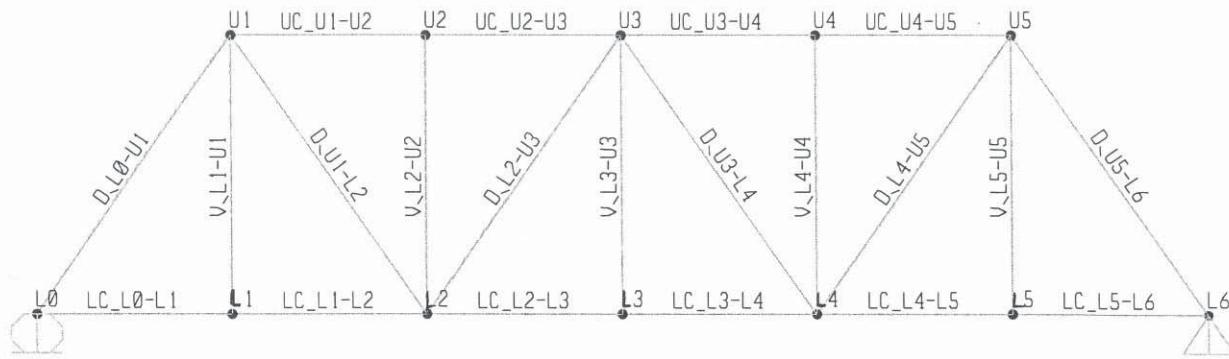
Very truly yours,

A handwritten signature in blue ink that appears to read "Jen Schade".

Jason E. Schade
Associate

encl.





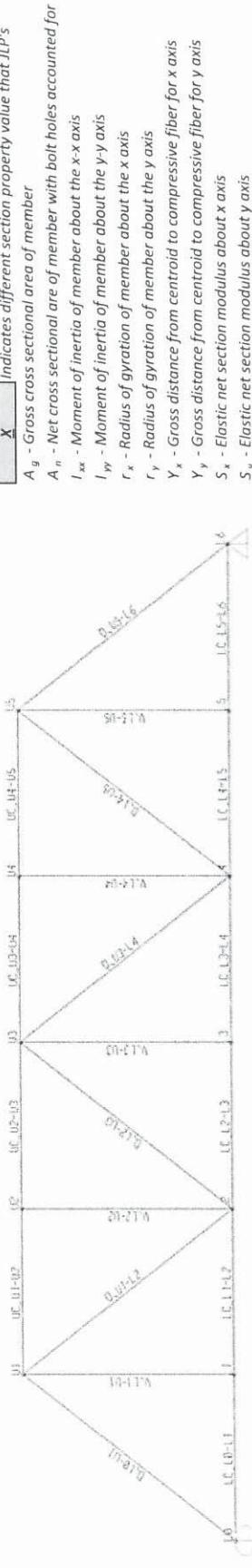


Experience great bridges.

Project: San Lorenzo
Subject: Truss Section Properties

Designed By: JBN
Checked By: MRB

Date: 8/16/2012
Date: 8/22/2012



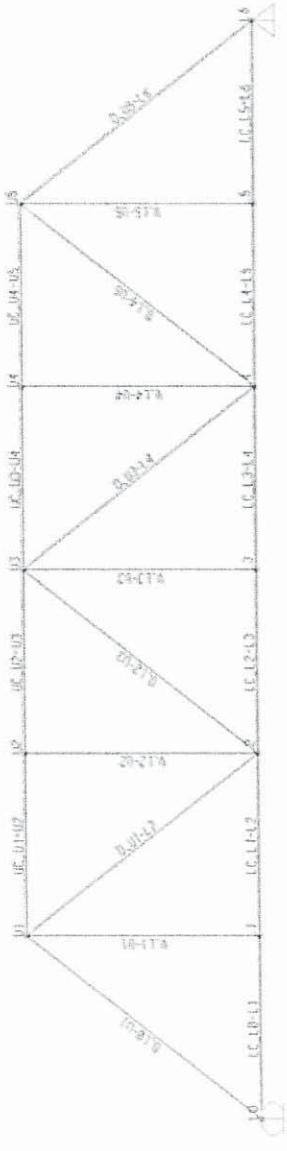
SPAN 1 LEFT TRUSS CURRENT SECTION PROPERTIES

MEMBER	A_g (in ²)	A_n (in ²)	I_{xx} (in ⁴)	I_{yy} (in ⁴)	r_x (in)	r_y (in)	Section Loss Notes	Y_x (in)	Y_y (in)	S_x (in ³)	S_y (in ³)
1 L0L1	20.12	15.90	188.00	295.00	3.06	3.83	-	-	-	-	-
2 L1L2	20.12	15.90	188.00	295.00	3.06	3.83	-	-	-	-	-
3 L2L3	35.15	30.58	291.00	436.00	2.88	3.52	-	-	-	-	-
4 L3L4	35.15	30.58	291.00	436.00	2.88	3.52	-	-	-	-	-
5 L4L5	20.12	15.90	188.00	295.00	3.06	3.83	-	-	-	-	-
6 L5L6	20.12	15.90	188.00	295.00	3.06	3.83	-	-	-	-	-
7 U1U2	31.40	25.46	1050.00	1155.00	5.78	6.07	-	-	-	-	-
8 U2U3	31.40	25.46	1050.00	1155.00	5.78	6.07	-	-	-	-	-
9 U3U4	31.40	25.46	1050.00	1155.00	5.78	6.07	-	-	-	-	-
10 U4U5	31.40	25.46	1050.00	1155.00	5.78	6.07	-	-	-	-	-
11 L0U1	40.24	32.08	1245.00	1432.00	5.56	5.97	-	-	-	-	-
12 U1L2	23.84	18.80	164.00	293.00	2.62	3.51	-	-	-	-	-
13 L2U3	26.70	19.58	601.00	1002.00	4.74	6.13	-	-	-	-	-
14 U3L4	26.70	19.58	601.00	1002.00	4.74	6.13	-	-	-	-	-
15 L4U5	23.84	18.80	164.00	293.00	2.62	3.51	-	-	-	-	-
16 U5L6	40.24	32.08	1245.00	1432.00	5.56	5.97	-	-	-	-	-
17 L1U1	14.17	10.42	39.00	171.00	1.66	3.48	-	-	-	-	-
18 L2U2	14.17	10.20	38.00	167.00	1.64	3.43	5% SL on inside angle legs	4.25	4.50	8.94	37.11
19 L3U3	14.17	10.20	38.00	167.00	1.64	3.43	5% SL on inside angle legs	4.25	4.50	8.94	37.11
20 L4U4	14.17	9.97	37.00	163.00	1.62	3.39	10% SL on inside angle legs	4.25	4.50	8.71	36.22
21 L5U5	14.17	9.97	37.00	163.00	1.62	3.39	10% SL on inside angle legs	4.25	4.50	8.71	36.22

Project: San Lorenzo
Subject: Truss Section Properties

Designed By: JBN
Checked By: MRB

Date: 8/16/2012
Date: 8/22/2012



X Indicates different section property value that JLP's

A_g - Gross cross sectional area of member
A_n - Net cross sectional area of member with bolt holes accounted for
I_{xx} - Moment of inertia of member about the x-x axis
I_{yy} - Moment of inertia of member about the y-y axis
r_x - Radius of gyration of member about the x axis
r_y - Radius of gyration of member about the y axis
Y_x - Gross distance from centroid to compressive fiber for x axis
Y_y - Gross distance from centroid to compressive fiber for y axis
S_x - Elastic net section modulus about x axis
S_y - Elastic net section modulus about y axis

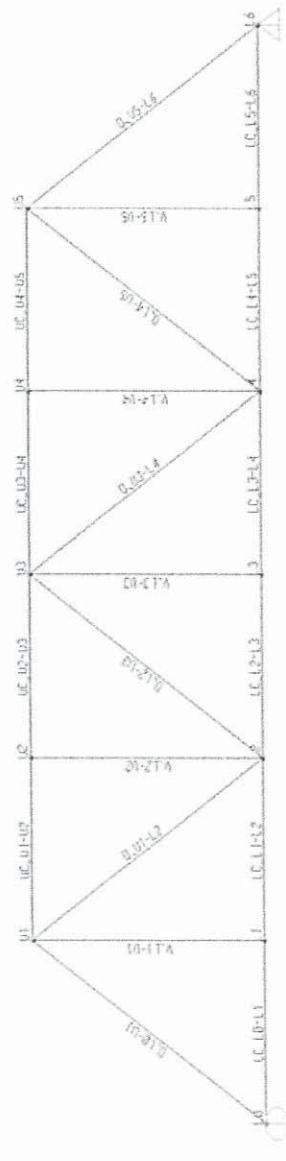
SPAN 1 RIGHT TRUSS CURRENT SECTION PROPERTIES

MEMBER	A _g (in ²)	A _n (in ²)	I _{xx} (in ⁴)	I _{yy} (in ⁴)	r _x (in)	r _y (in)	Section Loss Notes	Y _x (in)	Y _y (in)	S _x (in ³)	S _y (in ³)
1 L01	20.12	14.55	169.00	270.00	2.90	3.67	20% SL on top angle legs				
2 L1L2	20.12	13.88	160.00	258.00	2.82	3.58	30% SL on top angle legs				
3 L2L3	35.15	26.83	237.00	370.00	2.59	3.25	Top legs of top angles reduced to 1/2"				
4 L3L4	35.15	28.63	263.00	402.00	2.73	3.38	20% SL on top angle legs				
5 L4L5	20.12	15.90	188.00	295.00	3.06	3.83	-				
6 L5L6	20.12	15.90	188.00	295.00	3.06	3.83	-				
7 U1U2	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
8 U2U3	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
9 U3U4	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
10 U4U5	40.24	32.08	1245.00	1432.00	5.56	5.97	-				
11 U5U6	23.84	18.80	164.00	293.00	2.62	3.51	-				
12 U12	26.70	18.04	541.00	929.00	4.50	5.90	50% SL to top of plates				
13 U2U3	26.70	18.04	541.00	929.00	4.50	5.90	50% SL to top of plates				
14 U3L4	23.84	17.90	146.70	260.70	2.48	3.31	30% SL on top angle legs				
15 U4U5	40.24	32.08	1245.00	1432.00	5.56	5.97	-				
16 U5U6	14.17	9.52	36.00	154.00	1.59	3.30	20% SL on inside angle legs	4.25	4.50	8.47	34.22
17 L1U1	14.17	9.75	37.00	158.00	1.61	3.34	15% SL on inside angle legs	4.25	4.50	8.71	35.11
18 L2U2	14.17	9.07	34.00	146.00	1.55	3.21	30% SL on inside angle legs	4.25	4.50	8.00	32.44
19 L3U3	14.17	9.52	36.00	154.00	1.59	3.30	20% SL on inside angle legs	4.25	4.50	8.47	34.22
20 L4U4	14.17	9.97	37.00	163.00	1.62	3.39	10% SL on inside angle legs	4.25	4.50	8.71	36.22
21 L5U5											

Project: San Lorenzo
Subject: Truss Section Properties

Designed By: JBN
Checked By: MRB

Date: 8/16/2012
Date: 8/22/2012



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A_g - Gross cross sectional area of member
 A_n - Net cross sectional area of member with bolt holes accounted for
 I_{xx} - Moment of inertia of member about the x-x axis
 I_{yy} - Moment of inertia of member about the y-y axis
 r_x - Radius of gyration of member about the x axis
 r_y - Radius of gyration of member about the y axis
 Y_x - Gross distance from centroid to compressive fiber for x axis
 Y_y - Gross distance from centroid to compressive fiber for y axis
 S_x - Elastic net section modulus about x axis
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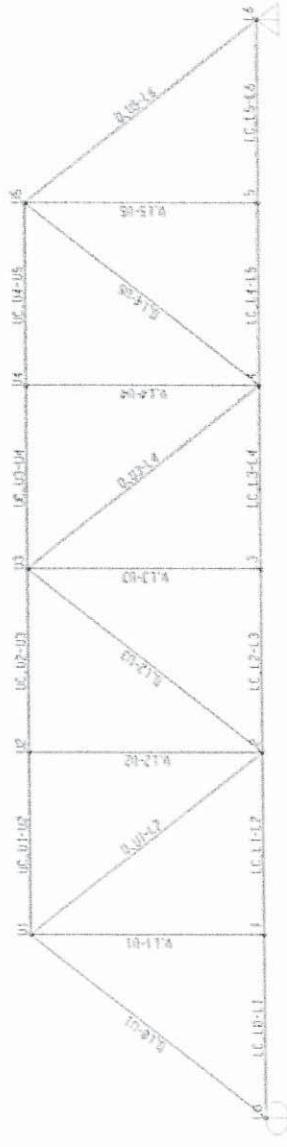
SPAN 2 LEFT TRUSS CURRENT SECTION PROPERTIES

MEMBER	A_g (in ²)	A_n (in ²)	I_{xx} (in ⁴)	I_{yy} (in ⁴)	r_x (in)	r_y (in)	Section Loss Notes	Y_x (in)	Y_y (in)	S_x (in ³)	S_y (in ³)
1 L0L1	20.12	15.90	188.00	295.00	3.06	3.83	-				
2 L1L2	20.12	15.90	188.00	295.00	3.06	3.83	-				
3 L2L3	35.15	30.58	291.00	436.00	2.88	3.52	-				
4 L3L4	35.15	30.58	291.00	436.00	2.88	3.52	-				
5 L4L5	20.12	15.90	188.00	295.00	3.06	3.83	-				
6 L5L6	20.12	15.90	188.00	295.00	3.06	3.83	-				
7 U1U2	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
8 U2U3	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
9 U3U4	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
10 U4U5	40.24	32.08	1245.00	1432.00	5.56	5.97	-				
11 U1L2	23.84	18.80	164.00	293.00	2.62	3.51	-				
12 L2U3	26.70	19.58	601.00	1002.00	4.74	6.13	-				
13 U3L4	26.70	19.58	601.00	1002.00	4.74	6.13	-				
14 L4U5	23.84	18.80	164.00	293.00	2.62	3.51	-				
15 U5L6	40.24	32.08	1245.00	1432.00	5.56	5.97	-				
16 L1U1	14.17	10.20	38.00	167.00	1.64	3.43	5% SL on inside angle legs	4.25	4.50	8.94	37.11
17 L2U2	14.17	9.75	37.00	158.00	1.61	3.34	15% SL on inside angle legs	4.25	4.50	8.71	35.11
18 L3U3	14.17	9.52	36.00	154.00	1.59	3.30	20% SL on inside angle legs	4.25	4.50	8.47	34.22
19 L4U4	14.17	9.97	37.00	163.00	1.62	3.39	10% SL on inside angle legs	4.25	4.50	8.71	36.22
20 L5U5	14.17	9.75	37.00	158.00	1.61	3.34	15% SL on inside angle legs	4.25	4.50	8.71	35.11

Project: San Lorenzo
Subject: Truss Section Properties

Designed By: JBN
Checked By: MRB

Date: 8/16/2012
Date: 8/22/2012



X Indicates different section property value than JLP's

A_g - Gross cross sectional area of member
 A_n - Net cross sectional area of member with bolt holes accounted for
 I_{xx} - Moment of inertia of member about the x-x axis
 I_{yy} - Moment of inertia of member about the y-y axis
 r_x - Radius of gyration of member about the x axis
 r_y - Radius of gyration of member about the y axis
 Y_x - Gross distance from centroid to compressive fiber for x axis
 Y_y - Gross distance from centroid to compressive fiber for y axis
 S_x - Elastic net section modulus about x axis
 S_y - Elastic net section modulus about y axis

SPAN 2 RIGHT TRUSS CURRENT SECTION PROPERTIES

MEMBER	A_g (in ²)	A_n (in ²)	I_{xx} (in ⁴)	I_{yy} (in ⁴)	r_x (in)	r_y (in)	Section Loss Notes	Y_x (in)	Y_y (in)	S_x (in ³)	S_y (in ³)
1 L0L1	20.12	14.55	169.00	270.00	2.90	3.67	20% SL on top angle legs				
2 L1L2	20.12	15.90	188.00	295.00	3.06	3.83	-				
3 L2L3	35.15	28.63	263.00	492.00	2.73	3.38	20% SL to top angle legs				
4 L3L4	35.15	30.58	291.00	436.00	2.88	3.52	-				
5 L4L5	20.12	15.90	188.00	295.00	3.06	3.83	-				
6 L5L6	20.12	15.90	188.00	295.00	3.06	3.83	-				
7 U1U2	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
8 U2U3	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
9 U3U4	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
10 U4U5	31.40	25.46	1050.00	1155.00	5.78	6.07	-				
11 L0U1	40.24	32.08	1245.00	1432.00	5.56	5.97	-				
12 U1L2	23.84	18.80	164.00	293.00	2.62	3.51	-				
13 L2U3	26.70	19.58	601.00	1002.00	4.74	6.13	-				
14 U3L4	26.70	19.58	601.00	1002.00	4.74	6.13	-				
15 L4U5	23.84	18.80	164.00	293.00	2.62	3.51	-				
16 U5L6	40.24	32.08	1245.00	1432.00	5.56	5.97	-				
17 L1U1	14.17	9.97	37.00	163.00	1.62	3.39	10% SL on inside angle legs	4.25	4.50	8.71	36.22
18 L2U2	14.17	9.75	37.00	158.00	1.61	3.34	15% SL on inside angle legs	4.25	4.50	8.71	35.11
19 L3U3	14.17	9.52	36.00	154.00	1.59	3.30	20% SL on inside angle legs	4.25	4.50	8.47	34.22
20 L4U4	14.17	9.07	34.00	146.00	1.55	3.21	30% SL on inside angle legs	4.25	4.50	8.00	32.44
21 L5U5	14.17	9.97	37.00	163.00	1.62	3.39	10% SL on inside angle legs	4.25	4.50	8.71	36.22



Project 3165 San Lorenzo
Subject Existing Truss Capacities

Designed By: MRB
Checked By: LCJF
Date: 08/22/12
Date: 8/22/12

Span 1 Capacities

Member	Includes Wind ^a			Does Not Include Wind ^b		
	Axial Tension Capacity ^c - Gross (kips)	Axial Tension Capacity ^c - Net (kips)	Axial Tension Capacity ^c - Gross (in ³)	Axial Tension Capacity ^c - Net (kips)	Axial Tension Capacity ^c - Gross (in ³)	Axial Tension Capacity ^c - Net (kips)
I.C_10_11_15S	20.42	15.90	17.1	15.9	415.0	560.5
I.C_11_12_15S	20.12	15.90	17.1	15.9	415.0	560.5
I.C_12_13_15S	35.15	30.58	29.9	29.9	725.0	1053.2
I.C_13_14_15S	35.15	30.58	29.9	29.9	725.0	1053.2
I.C_14_15_15S	20.12	15.90	17.1	15.9	415.0	560.5
I.C_15_16_15S	20.12	15.90	17.1	15.9	415.0	560.5
I.C_16_17_15S	31.40	25.46	26.7	25.5	647.6	897.5
I.C_17_18_15S	31.40	25.46	26.7	25.5	647.6	897.5
I.C_18_19_15S	31.40	25.46	26.7	25.5	647.6	897.5
D_10_11_15S	30.24	32.03	34.2	32.1	830.0	1130.8
D_11_12_15S	23.84	18.80	20.3	18.8	491.7	662.7
D_12_13_15S	26.70	19.58	22.7	19.6	550.7	690.2
D_13_14_15S	26.70	19.58	22.7	19.6	550.7	690.2
D_14_15_15S	23.84	18.80	20.3	18.8	491.7	662.7
D_15_16_15S	40.24	32.08	34.2	32.1	830.0	1130.8
V_01_12_15S	14.17	10.42	12.0	10.4	212.6	390.8
V_02_12_15S	14.17	10.42	12.0	10.4	212.6	390.8
V_03_13_15S	14.17	10.20	12.0	10.2	292.3	359.6
V_04_14_15S	14.17	10.20	12.0	10.2	212.6	382.5
V_05_15_15S	14.17	9.97	12.0	10.0	292.3	351.4
I.C_10_11_15S	20.12	14.55	17.1	14.6	415.0	512.9
I.C_11_12_15S	20.12	13.88	17.1	13.9	415.0	489.3
I.C_12_13_15S	35.15	26.83	29.9	28.6	725.0	945.8
I.C_13_14_15S	35.15	28.63	29.9	28.6	725.0	1009.2
I.C_14_15_15S	20.12	15.90	17.1	15.9	415.0	560.5
I.C_15_16_15S	20.12	15.90	17.1	15.9	415.0	560.5
I.C_16_17_15S	31.40	25.46	26.7	25.5	647.6	897.5
I.C_17_18_15S	31.40	25.46	26.7	25.5	647.6	897.5
I.C_18_19_15S	31.40	25.46	26.7	25.5	647.6	897.5
I.C_19_20_15S	40.24	32.08	34.2	32.1	830.0	1130.8
V_11_12_15S	14.17	9.52	12.0	9.5	491.7	662.7
V_12_13_15S	14.17	9.75	12.0	9.8	343.7	292.3
V_13_14_15S	26.70	18.04	22.7	18.0	550.7	635.9
V_14_15_15S	14.17	9.07	12.0	9.1	212.6	340.1
V_15_15_15S	14.17	9.52	12.0	9.5	292.3	335.6
V_16_15_15S	14.17	9.97	12.0	10.0	3273.9	212.6

^a Capacities are increased by 25% of 9.7.3.1.1b where wind is applied

^b Capacities are based on equation equation below without wind applied (i.e. no 25% increase)

General Notes

Allowable Stress Equations Used - Table 15-1-11 AREMA 2011

Axial Tension (Gross) - 0.55Fy

Axial Tension (Net) - 0.47Fy

Axial Compression - when k/r <= 6.29*(Fy/E)^{1/2}, then 0.55*Fy if 0.629*(Fy/E)^{1/2} < k/r < 5.034*(Fy/E)^{1/2}; then 0.60*Fy if k/r >= 5.034/(Fy/E)^{1/2}

Axial Tension (Gross) for floorbeam hangers, including bending, using rivets in end connections - 0.40Fy

Axial Tension (Net) for floorbeam hangers, including bending, using rivets in end connections - 0.50Fy

2\Project Files\3165 SCCRRC Bridges\Calculations\Structural\San Lorenzo\Capacities Tab Capacities



Project: San Lorenzo
 Subject: Dead Load Calcs
 Designed By: JBN
 Checked By: KJP
 Date: 8/17/2012
 Date: 8/22/2012

PRIMARY TRUSS MEMBERS

Unit Weight = **490**pcf

Member	Gross Area (in ²)	Adjusting Coef	Adjusted Area (in ²)	w (klf)	Length (ft)	Self Weight (kip)
L0L1	20.12	1.05	21.13	0.072	20.00	1.44
L1L2	20.12	1.05	21.13	0.072	20.00	1.44
L2L3	35.15	1.00	35.15	0.120	20.00	2.39
L3L4	35.15	1.00	35.15	0.120	20.00	2.39
L4L5	20.12	1.05	21.13	0.072	20.00	1.44
L5L6	20.12	1.05	21.13	0.072	20.00	1.44
U1U2	31.40	1.05	32.97	0.112	20.00	2.24
U2U3	31.40	1.05	32.97	0.112	20.00	2.24
U3U4	31.40	1.05	32.97	0.112	20.00	2.24
U4U5	31.40	1.05	32.97	0.112	20.00	2.24
L0U1	40.24	1.05	42.25	0.144	34.61	4.98
U1L2	23.84	1.00	23.84	0.081	34.61	2.81
L2U3	26.70	1.10	29.37	0.100	34.61	3.46
U3L4	26.70	1.10	29.37	0.100	34.61	3.46
L4U5	23.84	1.00	23.84	0.081	34.61	2.81
U5L6	40.24	1.05	42.25	0.144	34.61	4.98
L1U1	14.17	1.00	14.17	0.048	28.25	1.36
L2U2	14.17	1.00	14.17	0.048	28.25	1.36
L3U3	14.17	1.00	14.17	0.048	28.25	1.36
L4U4	14.17	1.00	14.17	0.048	28.25	1.36
L5U5	14.17	1.00	14.17	0.048	28.25	1.36

Members with lacing have an adjusted coefficient of 5% per side of lacing to account for additional weight

SECONDARY TRUSS MEMBERS

Unit Weight = **490**pcf

Member	Gross Area (in ²)	Adjusting Coef	Adjusted Area (in ²)	w (klf)	Length (ft)	Self Weight (kip)	Notes
T1	5.00	1.10	5.50	0.019	24.63	0.46	
T2	5.00	1.10	5.50	0.019	12.31	0.23	
T3	5.00	1.10	5.50	0.019	12.31	0.23	
T4	5.00	1.10	5.50	0.019	24.63	0.46	
T5	5.00	1.10	5.50	0.019	12.31	0.23	
T6	5.00	1.10	5.50	0.019	12.31	0.23	
KB	2.50	1.15	2.88	0.010	6.48	0.06	Adj coef used to account for plates
PB	2.50	1.15	2.88	0.010	10.17	0.10	Adj coef used to account for plates
P	6.48	1.10	7.13	0.024	14.92	0.36	
TS	7.68	1.10	8.45	0.029	14.92	0.43	
L1	2.86	1.00	2.86	0.010	24.63	0.24	
L2	2.86	1.00	2.86	0.010	24.63	0.24	
L3	2.86	1.00	2.86	0.010	24.63	0.24	
L4	2.86	1.00	2.86	0.010	24.63	0.24	

Members with lacing have an arbitrary adjusted coefficient to account for additional weight



Project: San Lorenzo
 Subject: Dead Load Calcs
 Designed By: JBN
 Checked By: KJP
 Date: 8/17/2012
 Date: 8/22/2012

GUSSET PLATE DEAD LOADS

Unit Weight = **490** pcf

Joint	VP Volume (in ³)	HP Volume (in ³)	Gross Volume (in ³)	Adjusting Coef	Adjusted Volume (in ³)	Self Weight (kip)
L0	2098.00	324.00	2422.00	0.90	2179.80	0.62
L1	328.00	324.00	652.00	0.95	619.40	0.18
L2	2008.00	324.00	2332.00	0.95	2215.40	0.63
L3	328.00	324.00	652.00	0.95	619.40	0.18
L4	2008.00	324.00	2332.00	0.95	2215.40	0.63
L5	328.00	324.00	652.00	0.95	619.40	0.18
L6	2098.00	324.00	2422.00	0.90	2179.80	0.62
U1	1802.00	260.00	2062.00	1.00	2062.00	0.58
U2	0.00	108.00	108.00	1.00	108.00	0.03
U3	1472.00	108.00	1580.00	1.00	1580.00	0.45
U4	0.00	108.00	108.00	1.00	108.00	0.03
U5	1802.00	260.00	2062.00	1.00	2062.00	0.58

Adjustment coef used to account to cuts in base gusset plate dimensions or gusset plate stiffeners

FLOOR SYSTEM DEAD LOADS

Joint	Description	Weight (kip)	Adjust Coef	Adjusted Weight (kip)	Notes
L0 - L6	Floorbeam (JLP)	2.59	1.05	2.72	Adj coef used for stiffeners
	2x Int Stringers (JLP)	5.41	1.05	5.68	Adj coef used for stiffeners
	Sidewall & Track (JLP)	40.00	1.00	40.00	
	2x End Stringers	5.72	1.05	6.01	Adj coef used for stiffeners
	Cross Frames & Bracing	0.52	1.00	0.52	Assume 0.2xFB as rough estimate

Descriptions with (JLP) indicate calculations were done by others

SUMMARY OF LOADS

Dead-loads will be split evenly between the left and right trusses.

Where applicable, dead-loads will be split evenly between the upper and lower chords of an individual truss

All dead-loads were calculated for the right side truss

Joint	Primary Member	No.	Secondary Member	No.	Gusset Plates	No.	Floor System	No.	Axial Load (kip)
L0	LOL1	0.50							0.72
	LOU1	0.50							2.49
			L2	0.50					0.12
					LO	1.00			0.62
							FB	0.00	0.00
							STR	0.25	1.50
							S&T	0.25	10.00
							XFRAME	0.50	0.26
									$\Sigma = 15.71$
L1	LOL1	0.50							0.72
	L1U1	0.50							0.68
	L1L2	0.50							0.72
			L1	0.50					0.12
			L4	0.50					0.12
					L1	1.00			0.18
							FB	0.50	1.36
							STR	0.50	2.92
							S&T	0.50	20.00
							XFRAME	0.00	0.00
									$\Sigma = 26.82$



Project: San Lorenzo
 Subject: Dead Load Calcs
 Designed By: JBN
 Checked By: KJP
 Date: 8/17/2012
 Date: 8/22/2012

Joint	Primary Member	No.	Secondary Member	No.	Gusset Plates	No.	Floor System	No.	Axial Load (kip)
L2	L1L2	0.50							0.72
	U1L2	0.50							1.40
	L2U2	0.50							0.68
	L2U3	0.50							1.73
	L2L3	0.50							1.20
			L3	0.50					0.12
				L4	0.50				0.12
						L2	1.00		0.63
							FB	0.50	1.36
							STR	0.50	2.84
							S&T	0.50	20.00
							XFRAME	0.00	0.00
								$\Sigma =$	30.80
L3	L2L3	0.50							1.20
	L3U3	0.50							0.68
	L3L4	0.50							1.20
			L3	0.50					0.12
				L4	0.50				0.12
						L3	1.00		0.18
							FB	0.50	1.36
							STR	0.50	2.84
							S&T	0.50	20.00
							XFRAME	0.00	0.00
								$\Sigma =$	27.69
L4	L3L4	0.50							1.20
	U3L4	0.50							1.73
	L4U4	0.50							0.68
	L4U5	0.50							1.40
	L4L5	0.50							0.72
			L3	0.50					0.12
				L4	0.50				0.12
						L4	1.00		0.63
							FB	0.50	1.36
							STR	0.50	2.84
							S&T	0.50	20.00
							XFRAME	0.00	0.00
								$\Sigma =$	30.80
L5	L4L5	0.50							0.72
	L5U5	0.50							0.68
	L5L6	0.50							0.72
			L1	0.50					0.12
				L4	0.50				0.12
						L5	1.00		0.18
							FB	0.50	1.36
							STR	0.50	2.92
							S&T	0.50	20.00
							XFRAME	0.00	0.00
								$\Sigma =$	26.82
L6	L5L6	0.50							0.72
	U5L6	0.50							2.49
			L2	0.50					0.12
						L6	1.00		0.62
							FB	0.00	0.00
							STR	0.25	1.50
							S&T	0.25	10.00
							XFRAME	0.50	0.26
								$\Sigma =$	15.71



Project: San Lorenzo
 Subject: Dead Load Calcs
 Designed By: JBN
 Checked By: KJP
 Date: 8/17/2012
 Date: 8/22/2012

Joint	Primary Member	No.	Secondary Member	No.	Gusset Plates	No.	Floor System	No.	Axial Load (kip)
U1	L0U1	0.50							2.49
	L1U1	0.50							0.68
	U1L2	0.50							1.40
	U1U2	0.50							1.12
		P	0.50						0.18
		PB	1.00						0.10
		T1	0.50						0.23
				U1	1.00				0.58
								$\Sigma =$	6.79
U2	U1U2	0.50							1.12
	L2U2	0.50							0.68
	U2U3	0.50							1.12
		TS	0.50						0.21
		T2	1.00						0.23
		T4	0.50						0.23
				U2	1.00				0.03
								$\Sigma =$	3.63
U3	U2U3	0.50							1.12
	L2U3	0.50							1.73
	L3U3	0.50							0.68
	U3L4	0.50							1.73
	U3U4	0.50							1.12
		TS	0.50						0.21
		T4	0.50						0.23
		T6	1.00						0.23
				U3	1.00				0.45
								$\Sigma =$	7.51
U4	U3U4	0.50							1.12
	L4U4	0.50							0.68
	U4U5	0.50							1.12
		TS	0.50						0.21
		T2	1.00						0.23
		T4	0.50						0.23
				U4	1.00				0.03
								$\Sigma =$	3.63
U5	U4U5	0.50							1.12
	L4U5	0.50							1.40
	L5U5	0.50							0.68
	U5L6	0.50							2.49
		P	0.50						0.18
		PB	1.00						0.10
		T1	0.50						0.23
				U5	1.00				0.58
								$\Sigma =$	6.79

DEAD LOADS FOR EXISTING TRUSS RATING

(Input for SAP model: San Lorenzo, DEAD1)

Joint	Truss DL (per truss) (k)	Total Applied DL (per truss) (k)
L0	15.71	15.71
L1	16.82	26.82
L2	19.38	30.80
L3	16.27	27.69
L4	19.38	30.80
L5	16.82	26.82
L6	15.71	15.71
U1	6.79	6.79
U2	3.63	3.63
U3	7.51	7.51
U4	3.63	3.63
U5	6.79	6.79
Total =		202.70



1 DATE= 8/15/2012
TIME=16:22:43

MODJESKI AND MASTERS, ENGINEERS
HARRISBURG, PENNSYLVANIA 17105

SAN LORENZO RIVER BRIDGE - TRUSS MEMBERS
DESIGN LOAD 1 RAIL (1/2 TRACK/AXLE LOADS)
COMPUTER FILENAME: SL E80.IN

INFL3 v1.1 - LOAD TRAIN ON INFLUENCE LINE PAGE 1

LOAD TRAIN-AXLE LOADS

D .0000 8.0000 13.0000 18.0000 23.0000 32.0000

P 20.0000 40.0000 40.0000 40.0000 40.0000 26.0000

D 37.0000 43.0000 48.0000 56.0000 64.0000 69.0000

P 26.0000 26.0000 26.0000 20.0000 40.0000 40.0000

D 74.0000 79.0000 88.0000 93.0000 99.0000 104.0000

P 40.0000 40.0000 26.0000 26.0000 26.0000 26.0000

LOAD TRAIN-UNIFORM LOADS

D 109.0000 500.0000

W .0000 4.0000

OINFLUENCE LINE FOR LC_L0-L1

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

V .00000 .59000 .47000 .35000 .24000 .12000

D 120.0000

V .00000

MAX VALUE= 190.5920,NOSE OF LOAD AT 113.0000 R

MIN VALUE= .0000,NOSE OF LOAD AT .0000

OINFLUENCE LINE FOR LC_L1-L2

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

V .00000 .59000 .47000 .35000 .24000 .12000

D 120.0000

V .00000

MAX VALUE= 190.5920,NOSE OF LOAD AT 113.0000 R

MIN VALUE= .0000,NOSE OF LOAD AT .0000



Project: SCCRTC - San Lorenzo

Subject: Ratings

INFL3 E-80 Live Load

Designed by: KJP 8/22/12

Checked by: KJP 8/23/12

1 DATE= 8/15/2012

MODJESKI AND MASTERS, ENGINEERS

TIME=16:22:43

HARRISBURG, PENNSYLVANIA 17105

SAN LORENZO RIVER BRIDGE - TRUSS MEMBERS

DESIGN LOAD 1 RAIL (1/2 TRACK/AXLE LOADS)

COMPUTER FILENAME: SL E80.IN

INFL3 v1.1 - LOAD TRAIN ON INFLUENCE LINE PAGE 2

OINFLUENCE LINE FOR LC_L2-L3

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

V .00000 .35000 .71000 1.06000 .71000 .35000

D 120.0000

V .00000

MAX VALUE= 324.7510,NOSE OF LOAD AT 124.0000 F

MIN VALUE= .0000,NOSE OF LOAD AT .0000

OINFLUENCE LINE FOR LC_L3-L4

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

V .00000 .35000 .71000 1.06000 .71000 .35000

D 120.0000

V .00000

MAX VALUE= 324.7510,NOSE OF LOAD AT 124.0000 F

MIN VALUE= .0000,NOSE OF LOAD AT .0000

OINFLUENCE LINE FOR LC_L4-L5

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

V .00000 .12000 .24000 .35000 .47000 .59000

D 120.0000



V .00000

MAX VALUE= 190.5920,NOSE OF LOAD AT 113.0000 F

MIN VALUE= .0000,NOSE OF LOAD AT .0000

1DATE= 8/15/2012 MODJESKI AND MASTERS, ENGINEERS
TIME=16:22:43 HARRISBURG, PENNSYLVANIA 17105

SAN LORENZO RIVER BRIDGE - TRUSS MEMBERS

DESIGN LOAD 1 RAIL (1/2 TRACK/AXLE LOADS)

COMPUTER FILENAME: SL E80.IN

INFL3 v1.1 - LOAD TRAIN ON INFLUENCE LINE PAGE 3

OINFLUENCE LINE FOR LC_L5-L6

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

V .00000 .12000 .24000 .35000 .47000 .59000

D 120.0000

V .00000

MAX VALUE= 190.5920,NOSE OF LOAD AT 113.0000 F

MIN VALUE= .0000,NOSE OF LOAD AT .0000

OINFLUENCE LINE FOR UC_U1-U2

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

V .00000 -.47000 -.94000 -.71000 -.47000 -.24000

D 120.0000

V .00000

MAX VALUE= .0000,NOSE OF LOAD AT 113.0000 F

MIN VALUE= -297.4810,NOSE OF LOAD AT 114.0000 F

OINFLUENCE LINE FOR UC_U2-U3

INFLUENCE LINE

D .0000 20.0000 40.0000 60.0000 80.0000 100.0000

Reference: AREMA, Ch. 15

IMPACT

$$I = (\text{Vertical Effect} * \text{Reduction Factor}) + \text{Rocking Effect}$$

(Art. 1.3.5)

Vertical Effect with No hammer blow:

If $L < 80'$, then $40 - ((3L^2)/1600)$

If $L > 80'$, then $16 + (600/(L-30))$

Rocking Effect

$$RE = (100/S)\%$$

(Art. 9.1.3.5)

Reductions

For $S < 60$ mph and no hammer blow:

$$1 - (0.8/2500) * (60 - S)^2 \geq 0.2$$

(Art. 7.3.2.3)

Member	Length, L (ft)	VE (%)	Spacing, S (ft)	RE (%)	Speed, S (mph)	Reduction Factor	Impact (%)
Stringer	20	39.25	---	---	30	0.712	---
Int. Floorbeam	20	39.25	---	---	30	0.712	---
End Floorbeam	20	39.25	---	---	30	0.712	---
Truss	120	22.67	16.5	6.06	30	0.712	22.20
Hanger	28.25	38.50	16.5	6.06	30	0.712	33.48



Project: SCCRTC - San Lorenzo
Subject: Ratings - Stringer, Floorbeams
Cooper E-80 Live Loading

Designed by: KJP 8/22/12
Checked by: *[Signature]* 8/23/12

Reference: AREMA, Ch. 15

Cooper E-80 Live Load

Stringer

Stringer Length = 20.0 ft.

Max Shear = 100.00 kips
Max Moment = 412.50 ft-kips

(Table 15-1-15)
(Table 15-1-15)

Floorbeam

Interior Floorbeam

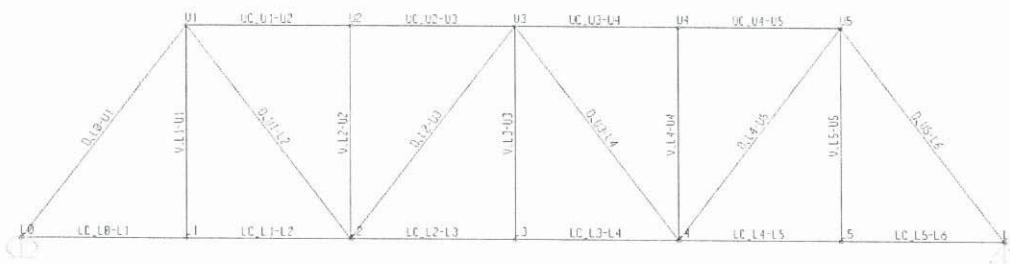
Max Shear = 131.10 kips
Max Moment = 622.73 ft-kips

(Table 15-1-15)
(131.1k*4.75')

End Floorbeam

Max Shear = 100.00 kips
Max Moment = 475.00 ft-kips

(Table 15-1-15)
(100k*4.75')



Reference: AREMA, Ch. 15

Wind Force

Wind force on train = 200 plf applied 8 ft above top of rail

(Art. 7.3.2.5)

Distance from Base of Rail to CL bottom chord = 4.88 ft

Distance from Top of Rail to CL bottom chord = 5.48 ft

Wind force on the bridge = 20 psf

Stringer

Height = 3.71 ft

When including wind in rating calculations, capacity may be increased 25% per Art. 1.3.14.3 for applicable members.

TRUSS MEMBER AREAS

Frame	Member	Member Length (ft)	Member Width (in)	Member Area (ft ²)
1	LC_L0-L1	20.0	12.375	20.63
2	LC_L1-L2	20.0	12.375	20.63
3	LC_L2-L3	20.0	12.8125	21.35
4	LC_L3-L4	20.0	12.8125	21.35
5	LC_L4-L5	20.0	12.375	20.63
6	LC_L5-L6	20.0	12.375	20.63
7	UC_U1-U2	20.0	15.4375	25.73
8	UC_U2-U3	20.0	15.4375	25.73
9	UC_U3-U4	20.0	15.4375	25.73
10	UC_U4-U5	20.0	15.4375	25.73
11	V_L1-U1	28.3	9.0	21.19
12	V_L2-U2	28.3	9.0	21.19
13	V_L3-U3	28.3	9.0	21.19
14	V_L4-U4	28.3	9.0	21.19
15	V_L5-U5	28.3	9.0	21.19
16	D_L0-U1	34.6	15.4375	44.53
17	D_U1-L2	34.6	12.6875	36.60
18	D_L2-U3	34.6	13.75	39.66
19	D_U3-L4	34.6	13.75	39.66
20	D_L4-U5	34.6	12.6875	36.60
21	D_U5-L6	34.6	15.4375	44.53

FORCE DUE TO 20 PSF WIND

Joint	Member	Windward Force on Stringer (k)	Windward Force on Truss (k)	Leeward Force on Truss (k)	Total Windward Force (k)	Total Force (k)
1	L0	0.74	0.65	0.45	1.39	1.84
2	L1	1.48	0.62	0.21	2.11	2.32
3	L2	1.48	1.39	0.97	2.88	3.85
4	L3	1.48	0.64	0.21	2.12	2.33
5	L4	1.48	1.39	0.97	2.88	3.85
6	L5	1.48	0.62	0.21	2.11	2.32
7	L6	0.74	0.65	0.45	1.39	1.84
8	U1	0.00	1.28	1.28	1.28	2.56
9	U2	0.00	0.73	0.73	0.73	1.45
10	U3	0.00	1.52	1.52	1.52	3.04
11	U4	0.00	0.73	0.73	0.73	1.45
12	U5	0.00	1.28	1.28	1.28	2.56

FORCE DUE TO WIND ON TRAIN

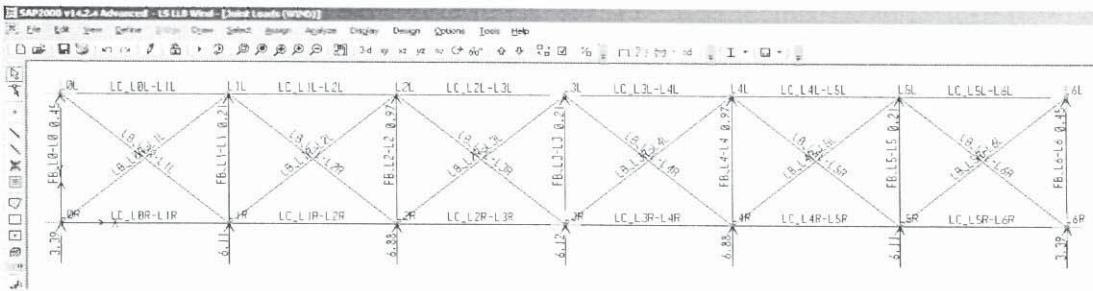
Joint	Member	(couple)	
		Lateral Force from Wind (k)	Force on LL (k)
1	L0	2.00	1.63
2	L1	4.00	3.27
3	L2	4.00	3.27
4	L3	4.00	3.27
5	L4	4.00	3.27
6	L5	4.00	3.27
7	L6	2.00	1.63

FOR LATERALS, SAP MODEL: LS ULB Wind
FOR LATERALS, SAP MODEL: LS LLB Wind

Joint	Member	Wind Force on Laterals (WW) (k)	Wind Force on Laterals (LW) (k)
L0R/L0L	L0	3.39	0.45
L1R/L1L	L1	6.11	0.21
L2R/L2L	L2	6.88	0.97
L3R/L3L	L3	6.12	0.21
L4R/L4L	L4	6.88	0.97
L5R/L5L	L5	6.11	0.21
L6R/L6L	L6	3.39	0.45
U1R/U1L	U1	1.28	1.28
U2R/U2L	U2	0.73	0.73
U3R/U3L	U3	1.52	1.52
U4R/U4L	U4	0.73	0.73
U5R/U5L	U5	1.28	1.28

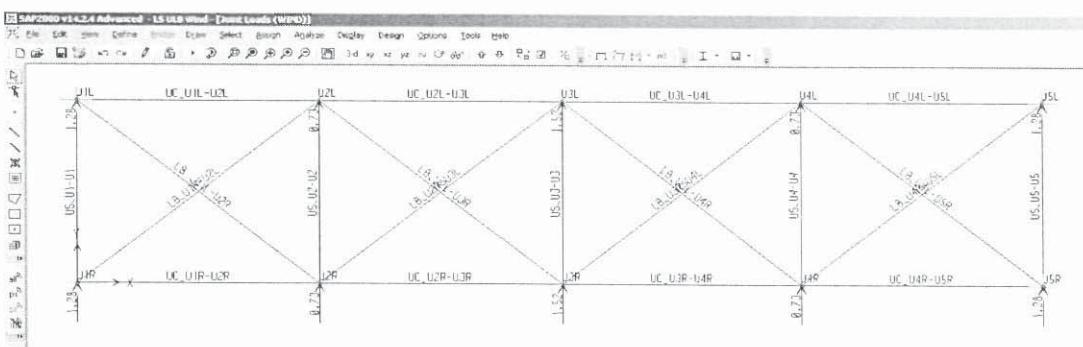
SAP OUTPUT FROM FILE: SL LLB Wind
WIND LATERAL FORCES

Frame	Station	Member	Force (k) WIND	Compression Members	Capacity
1	0	LC_L0R-L1R	-10.26	-10.26	
2	0	LC_L1R-L2R	-27.20	-27.20	
3	0	LC_L2R-L3R	-35.82	-35.82	
4	0	LC_L3R-L4R	-35.82	-35.82	
5	0	LC_L4R-L5R	-27.20	-27.20	
6	0	LC_L5R-L6R	-10.26	-10.26	
22	0	LC_L0L-L1L	10.76		
23	0	LC_L1L-L2L	28.17		
24	0	LC_L2L-L3L	36.75		
25	0	LC_L3L-L4L	36.75		
26	0	LC_L4L-L5L	28.17		
27	0	LC_L5L-L6L	10.76		
28	0	LB_L0R-L1L	13.30		
29	0	LB_L1R-L2L	8.03		
30	0	LB_L2R-L3L	1.88		
31	0	LB_L3R-L4L	-3.09	-3.09	
32	0	LB_L4R-L5L	-9.28	-9.28	
33	0	LB_L5R-L6L	-13.95	-13.95	
34	0	LB_L0L-L1R	-13.95	-13.95	
35	0	LB_L1L-L2R	-9.28	-9.28	
36	0	LB_L2L-L3R	-3.09	-3.09	
37	0	LB_L3L-L4R	1.88		
38	0	LB_L4L-L5R	8.03		
39	0	LB_L5L-L6R	13.30		
40	0	FB_L0-L0	0.00		
41	0	FB_L1-L1	-2.34	-2.34	
42	0	FB_L2-L2	-2.17	-2.17	
43	0	FB_L3-L3	-2.19	-2.19	
44	0	FB_L4-L4	-2.17	-2.17	
45	0	FB_L5-L5	-2.34	-2.34	
46	0	FB_L6-L6	0.00		



SAP OUTPUT FROM FILE: SL ULB Wind
WIND LATERAL FORCES

Frame	Station	Member	Force (k) WIND	Compression Members	Capacity
7	0	UC_U1R-U2R	-1.81	-1.81	
8	0	UC_U2R-U3R	-4.53	-4.53	
9	0	UC_U3R-U4R	-4.53	-4.53	
10	0	UC_U4R-U5R	-1.81	-1.81	
47	0	UC_U1L-U2L	1.81		
48	0	UC_U2L-U3L	4.53		
49	0	UC_U3L-U4L	4.53		
50	0	UC_U4L-U5L	1.81		
51	0	LB_U1R-U2L	2.34		
52	0	LB_U2R-U3L	1.19		
53	0	LB_U3R-U4L	-1.19	-1.19	
54	0	LB_U4R-U5L	-2.34	-2.34	
55	0	LB_U1L-U2R	-2.34	-2.34	
56	0	LB_U2L-U3R	-1.19	-1.19	
57	0	LB_U3L-U4R	1.19		
58	0	LB_U4L-U5R	2.34		
59	0	US_U1-U1	0.00		
60	0	US_U2-U2	0.00		
61	0	US_U3-U3	0.00	0.00	
62	0	US_U4-U4	0.00	0.00	
63	0	US_U5-U5	0.00		



Lateral Forces from Equipment

Lateral forces from equipment shall be as specified by Part 1, Design, Article 1.3.9.

(Art. 7.3.2.6)

Apply single moving concentrated lateral force equal to 1/4 of heaviest axle weight of LL (w/out Impact) at base of rail in addition to other lateral forces specified.

(Art. 1.3.9)

Live Load = E-80

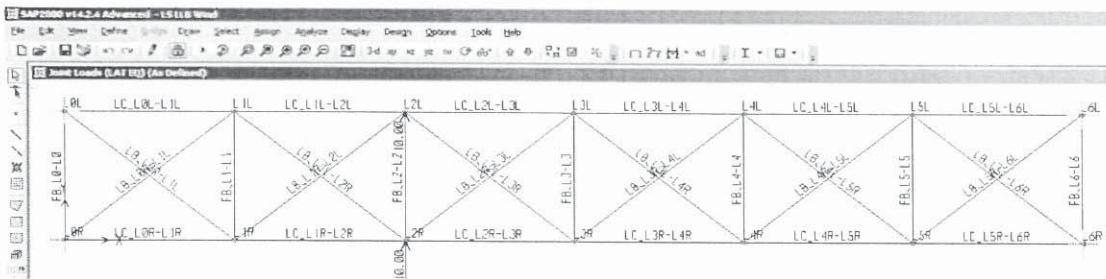
Lateral Force to be applied = 80 kips /
 20 kips/axle

Apply at joint where largest wind forces are applied for controlling case.

SAP OUTPUT FROM FILE: SL LLB Wind

Forces applied at L2 (Joints L2R & L2L)

Frame	Station	Member	(Jt. L2) LAT EQ
1	0	LC_L0R-L1R	-8.08
2	0	LC_L1R-L2R	-24.24
3	0	LC_L2R-L3R	-28.28
4	0	LC_L3R-L4R	-20.20
5	0	LC_L4R-L5R	-12.12
6	0	LC_L5R-L6R	-4.04
22	0	LC_L0L-L1L	8.08
23	0	LC_L1L-L2L	24.24
24	0	LC_L2L-L3L	28.28
25	0	LC_L3L-L4L	20.20
26	0	LC_L4L-L5L	12.12
27	0	LC_L5L-L6L	4.04
28	0	LB_L0R-L1L	10.48
29	0	LB_L1R-L2L	10.48
30	0	LB_L2R-L3L	-5.24
31	0	LB_L3R-L4L	-5.24
32	0	LB_L4R-L5L	-5.24
33	0	LB_L5R-L6L	-5.24
34	0	LB_L0L-L1R	-10.48
35	0	LB_L1L-L2R	-10.48
36	0	LB_L2L-L3R	5.24
37	0	LB_L3L-L4R	5.24
38	0	LB_L4L-L5R	5.24
39	0	LB_L5L-L6R	5.24
40	0	FB_L0-L0	0.00
41	0	FB_L1-L1	0.00
42	0	FB_L2-L2	0.00
43	0	FB_L3-L3	0.00
44	0	FB_L4-L4	0.00
45	0	FB_L5-L5	0.00
46	0	FB_L6-L6	0.00



Reference: AREMA, Ch. 15

LONGITUDINAL FORCES

(Art. 7.3.2.8)

Longitudinal forces shall be as specified by Part 1, Design, Article 1.3.12.

When including longitudinal forces in rating calculations, capacity may be increased 50% per Art. 7.3.2.8.f.

Longitudinal force for E-80 loading shall be taken as the larger of: (Art. 1.3.12)

Longitudinal braking force = $45 + 1.2L$, acting 8 ft above top of rail. (track)

Longitudinal braking force = 94.50 kips (per rail)

Couple produced = 10.62 kips CONTROLS FOR COUPLE

Longitudinal traction force = $25(L)^{0.5}$, acting 3 feet above top of rail. (track)

Longitudinal traction force = 136.93 kips (per rail) CONTROLS FOR FORCE

Couple produced = 9.68 kips

$L = \boxed{120}$ ft (Cases 3&4)

Distance from Base of Rail to CL bottom chord = $\boxed{4.88}$ ft

Distance from Top of Rail to CL bottom chord = $\boxed{5.48}$ ft

Distribute controlling force evenly across joints.

$$LF = 136.93$$

FORCE DUE TO LONGITUDINAL FORCES

Joint	Member	Longit Force (k)	Force on LL (k) (couple)
1	L0	34.23	10.62
2	L1	34.23	10.62
3	L2	34.23	10.62
4	L3	34.23	10.62
5	L4	34.23	10.62
6	L5	34.23	10.62
7	L6	34.23	10.62

SPAN 2: LEFT TRUSS													
Frame / Member	Impact (%)	Live Load - E80 (kips)				Wind Loads (kips)				Nosing (Lateral Equip) (kips)			
		Existing Dead Loads (kips)	COMP	TENS	COMP	COMP	TENS	COMP	Longitudinal Forces (kips)	CAPACITIES (kN-kips)	Rating Factors (No Wind, with Longit.)		
1 L/C L0-L1	22.20	61	0	191	0	10.76	10.26	5.79	8.08	34.23	342.3		
2 L/C L1-L2	22.20	61	0	191	0	28.17	27.20	5.79	24.24	68.46	332.0		
3 L/C L2-L3	22.20	110	0	325	0	36.75	35.82	10.42	28.38	28.28	102.69		
4 L/C L3-L4	22.20	110	0	325	0	36.75	35.82	10.42	28.38	136.92	580.463		
5 L/C L4-L5	22.20	61	0	191	0	28.17	27.20	5.79	24.24	171.15	1.22		
6 L/C L5-L6	22.20	61	0	191	0	10.76	10.26	5.79	8.08	205.38	332.0		
7 U/C U1-U2	22.20	0	97	0	297	1.81	1.81	9.26	9.26	0.00	0.00		
8 U/C U2-U3	22.20	0	97	0	297	4.53	4.53	9.26	9.26	0.00	0.00		
9 U/C U3-U4	22.20	0	97	0	297	1.81	1.81	9.26	9.26	0.00	0.00		
10 U/C U4-U5	22.20	0	97	0	297	1.81	1.81	9.26	9.26	0.00	0.00		
11 V L1-U1	33.48	27	0	131	0	3.00	0.00	3.27	0.00	0.00	0.00		
12 V L2-U2	22.20	0	4	0	0	0.00	0.00	0.00	0.00	0.00	0.00		
13 V L3-U3	22.20	0	28	0	131	0	0.00	0.00	0.00	0.00	0.00		
14 V L4-U4	22.20	0	4	0	0	0.00	0.00	0.00	0.00	0.00	0.00		
15 U L5-U5	33.48	27	0	131	0	0.00	0.00	3.27	0.00	0.00	0.00		
16 D L0-U1	22.20	0	105	0	329	0.00	0.00	10.02	0.00	64.51	0.00		
17 D L1-U2	22.20	64	0	218	16	0.00	0.00	6.01	0.00	393.21	19.63		
18 D L2-U3	22.20	0	222	61	124	0.00	0.00	2.00	0.00	441.345	9.10		
19 D L3-U4	22.20	0	222	61	124	0.00	0.00	2.00	0.00	345.9	3.28		
20 D L4-U5	22.20	64	0	218	16	0.00	0.00	6.01	0.00	61.24	2.14		
21 D U5-L6	22.20	0	105	0	329	0.00	0.00	10.02	0.00	64.51	0.00		

Values used as though from either direction.

SPAN 2: RIGHT TRUSS													
Frame / Member	Impact (%)	Live Load - E80 (kips)				Wind Loads (kips)				Nosing (Lateral Equip) (kips)			
		Existing Dead Loads (kips)	COMP	TENS	COMP	COMP	TENS	COMP	Longitudinal Forces (kips)	CAPACITIES (kN-kips)	Rating Factors (No Wind, with Longit.)		
1 L/C L0-L1	22.20	61	0	191	0	10.76	10.26	5.79	8.08	34.23	32.3		
2 L/C L1-L2	22.20	61	0	191	0	28.17	27.20	5.79	24.24	68.46	332.0		
3 L/C L2-L3	22.20	110	0	325	0	36.75	35.82	10.42	28.38	102.69	580.463		
4 L/C L3-L4	22.20	110	0	325	0	36.75	35.82	10.42	28.38	136.92	580.463		
5 L/C L4-L5	22.20	61	0	191	0	28.17	27.20	5.79	24.24	171.15	1.22		
6 L/C L5-L6	22.20	61	0	191	0	10.76	10.26	5.79	8.08	205.38	332.0		
7 U/C U1-U2	22.20	0	97	0	297	1.81	1.81	9.26	9.26	0.00	0.00		
8 U/C U2-U3	22.20	0	97	0	297	4.53	4.53	9.26	9.26	0.00	0.00		
9 U/C U3-U4	22.20	0	97	0	297	1.81	1.81	9.26	9.26	0.00	0.00		
10 U/C U4-U5	22.20	0	97	0	297	1.81	1.81	9.26	9.26	0.00	0.00		
11 V L1-U1	33.48	27	0	131	0	3.00	0.00	3.27	0.00	0.00	0.00		
12 V L2-U2	22.20	0	4	0	0	0.00	0.00	0.00	0.00	0.00	0.00		
13 V L3-U3	33.48	28	0	131	0	0.00	0.00	3.27	0.00	0.00	0.00		
14 V L4-U4	22.20	0	4	0	0	0.00	0.00	0.00	0.00	0.00	0.00		
15 V L5-U5	33.48	27	0	131	0	0.00	0.00	3.27	0.00	0.00	0.00		
16 D L0-U1	22.20	0	105	0	329	0.00	0.00	10.02	0.00	64.51	0.00		
17 D L1-U2	22.20	64	0	218	16	0.00	0.00	6.01	0.00	393.21	19.63		
18 D L2-U3	22.20	64	0	218	16	0.00	0.00	6.01	0.00	441.345	9.10		
19 D L3-U4	22.20	0	105	0	329	0.00	0.00	10.02	0.00	64.51	0.00		

Values used as though from either direction.

Hangers
 Member L1-U1
 Member L3-U3

Loc	Member	Area (in ²)	S (in ³)	Impact (%)	Capacity (ksi)	P Forces (k)						Moments (ft-k) - from SAP model							
						Existing Dead Load	Modified Dead Load	Rating Dead Load	Live Load E-80	286	Rating Live Load	Impact	Wind Load	Existing Dead Load	Modified Dead Load	Rating Dead Load	E-80 Live Load	286	
S1, L	V_L1-U1	14.17	9.18	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.72	-	0.24	0.02
	V_L3-U3	14.17	8.94	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.04	0.04	0.68	-	0.23	0.02
	V_L5-U5	14.17	8.71	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.74	-	0.25	0.02
S1, R	V_L1-U1	14.17	8.47	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.77	-	0.26	0.02
	V_L3-U3	14.17	8.00	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.75	-	0.25	0.02
	V_L5-U5	14.17	8.71	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.74	-	0.25	0.02
S2, L	V_L1-U1	14.17	8.94	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.74	-	0.25	0.02
	V_L3-U3	14.17	8.47	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.72	-	0.24	0.02
	V_L5-U5	14.17	8.71	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.74	-	0.25	0.02
S2, R	V_L1-U1	14.17	8.71	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.76	-	0.25	0.02
	V_L3-U3	14.17	8.47	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.72	-	0.24	0.02
	V_L5-U5	14.17	8.71	33.48	12.0	8.6	-	9	131	-	131	43.9	3.27	0.05	0.05	0.73	-	0.25	0.02

Existing Condition
E-80 Live Load

Member	P/A	Dead Load (ksi)		Live Load (ksi)		Impact (ksi)		Wind (ksi)		Rating Factors		E-80 Rating	Controlling Case
		M/S	P/A	M/S	P/A	M/S	P/A	No Wind	Incl. Wind				
S1, L	V_L1-U1	0.61	0.06	9.25	0.95	3.10	0.32	0.23	0.02	0.83	1.03	E 67	No Wind
	V_L3-U3	0.61	0.05	9.25	0.91	3.10	0.31	0.23	0.03	0.84	1.04	E 67	No Wind
	V_L5-U5	0.61	0.07	9.25	1.02	3.10	0.34	0.23	0.03	0.83	1.03	E 66	No Wind
S1, R	V_L1-U1	0.61	0.07	9.25	1.09	3.10	0.37	0.23	0.03	0.82	1.02	E 66	No Wind
	V_L3-U3	0.61	0.08	9.25	1.13	3.10	0.38	0.23	0.03	0.82	1.01	E 65	No Wind
	V_L5-U5	0.61	0.07	9.25	1.02	3.10	0.34	0.23	0.03	0.83	1.03	E 66	No Wind
S2, L	V_L1-U1	0.61	0.07	9.25	0.99	3.10	0.33	0.23	0.03	0.83	1.03	E 66	No Wind
	V_L3-U3	0.61	0.07	9.25	1.02	3.10	0.34	0.23	0.03	0.83	1.03	E 66	No Wind
	V_L5-U5	0.61	0.07	9.25	1.02	3.10	0.34	0.23	0.03	0.83	1.03	E 66	No Wind
S2, R	V_L1-U1	0.61	0.07	9.25	1.04	3.10	0.35	0.23	0.03	0.82	1.02	E 66	No Wind
	V_L3-U3	0.61	0.07	9.25	1.02	3.10	0.34	0.23	0.03	0.83	1.03	E 66	No Wind
	V_L5-U5	0.61	0.07	9.25	1.01	3.10	0.34	0.23	0.03	0.83	1.03	E 66	No Wind

Controlling Rating Factor	E-80 Live Load			Controlling Case
	Existing Condition		E-80 Rating	
0.83	E 67	E 67	E 67	No Wind

Rating Summary
Normal Ratings for Strength

Existing Condition

E-80 Live Load

SPAN 1, LEFT TRUSS

Member	Controlling Rating Factor	E-80 Rating	Case
LC_L0-L1	1.13	E 90	No Wind or Longitudinal Forces
LC_L1-L2	1.06	E 84	No Wind or Longitudinal Forces
LC_L2-L3	1.11	E 88	No Wind or Longitudinal Forces
LC_L3-L4	1.11	E 88	No Wind or Longitudinal Forces
LC_L4-L5	0.94	E 75	Including Wind & Longitudinal Forces
LC_L5-L6	0.94	E 75	Including Wind & Longitudinal Forces
UC_U1-U2	1.08	E 86	No Wind or Longitudinal Forces
UC_U2-U3	1.08	E 86	No Wind or Longitudinal Forces
UC_U3-U4	1.08	E 86	No Wind or Longitudinal Forces
UC_U4-U5	1.08	E 86	No Wind or Longitudinal Forces
V_L1-U1	0.82	E 65	No Wind or Longitudinal Forces
V_L2-U2	-	-	-
V_L3-U3	0.81	E 65	No Wind or Longitudinal Forces
V_L4-U4	-	-	-
V_L5-U5	0.82	E 65	No Wind or Longitudinal Forces
D_L0-U1	1.11	E 89	No Wind or Longitudinal Forces
D_U1-L2	1.24	E 99	No Wind or Longitudinal Forces
D_L2-U3	2.14	E 171	No Wind or Longitudinal Forces
D_U3-L4	2.14	-	No Wind or Longitudinal Forces
D_L4-U5	1.24	E 99	No Wind or Longitudinal Forces
D_U5-L6	1.11	E 89	No Wind or Longitudinal Forces
Hangers			
V_L1-U1	0.83	E 67	No Wind
V_L3-U3	0.84	E 67	No Wind
V_L5-U5	0.83	E 66	No Wind

SPAN 1, RIGHT TRUSS

Member	Controlling Rating Factor	E-80 Rating	Case
LC_L0-L1	1.13	E 90	No Wind or Longitudinal Forces
LC_L1-L2	1.06	E 84	No Wind or Longitudinal Forces
LC_L2-L3	1.11	E 88	No Wind or Longitudinal Forces
LC_L3-L4	1.11	E 88	No Wind or Longitudinal Forces
LC_L4-L5	0.94	E 75	Including Wind & Longitudinal Forces
LC_L5-L6	0.94	E 75	Including Wind & Longitudinal Forces
UC_U1-U2	1.08	E 86	No Wind or Longitudinal Forces
UC_U2-U3	1.08	E 86	No Wind or Longitudinal Forces
UC_U3-U4	1.08	E 86	No Wind or Longitudinal Forces
UC_U4-U5	1.08	E 86	No Wind or Longitudinal Forces
V_L1-U1	0.82	E 65	No Wind or Longitudinal Forces
V_L2-U2	-	-	-
V_L3-U3	0.81	E 65	No Wind or Longitudinal Forces
V_L4-U4	-	-	-
V_L5-U5	0.82	E 65	No Wind or Longitudinal Forces
D_L0-U1	1.11	E 89	No Wind or Longitudinal Forces
D_U1-L2	1.24	E 99	No Wind or Longitudinal Forces
D_L2-U3	2.09	E 167	No Wind or Longitudinal Forces
D_U3-L4	2.09	E 167	No Wind or Longitudinal Forces
D_L4-U5	1.24	E 99	No Wind or Longitudinal Forces
D_U5-L6	1.11	E 89	No Wind or Longitudinal Forces
Hangers			
V_L1-U1	0.82	E 66	No Wind
V_L3-U3	0.82	E 65	No Wind
V_L5-U5	0.83	E 66	No Wind

SPAN 2, LEFT TRUSS

Member	Controlling Rating Factor	E-80 Rating	Case
LC_L0-L1	1.13	E 90	No Wind or Longitudinal Forces
LC_L1-L2	1.06	E 84	No Wind or Longitudinal Forces
LC_L2-L3	1.11	E 88	No Wind or Longitudinal Forces
LC_L3-L4	1.11	E 88	No Wind or Longitudinal Forces
LC_L4-L5	0.94	E 75	Including Wind & Longitudinal Forces
LC_L5-L6	0.94	E 75	Including Wind & Longitudinal Forces
UC_U1-U2	1.08	E 86	No Wind or Longitudinal Forces
UC_U2-U3	1.08	E 86	No Wind or Longitudinal Forces
UC_U3-U4	1.08	E 86	No Wind or Longitudinal Forces
UC_U4-U5	1.08	E 86	No Wind or Longitudinal Forces
V_L1-U1	0.82	E 65	No Wind or Longitudinal Forces
V_L2-U2	-	-	-
V_L3-U3	0.81	E 65	No Wind or Longitudinal Forces
V_L4-U4	-	-	-
V_L5-U5	0.82	E 65	No Wind or Longitudinal Forces
D_L0-U1	1.11	E 89	No Wind or Longitudinal Forces
D_U1-L2	1.24	E 99	No Wind or Longitudinal Forces
D_L2-U3	2.14	E 171	No Wind or Longitudinal Forces
D_U3-L4	2.14	E 171	No Wind or Longitudinal Forces
D_L4-U5	1.24	E 99	No Wind or Longitudinal Forces
D_U5-L6	1.11	E 89	No Wind or Longitudinal Forces
Hangers			
V_L1-U1	0.83	E 66	No Wind
V_L3-U3	0.83	E 66	No Wind
V_L5-U5	0.83	E 66	No Wind

SPAN 2, RIGHT TRUSS

Member	Controlling Rating Factor	E-80 Rating	Case
LC_L0-L1	1.13	E 90	No Wind or Longitudinal Forces
LC_L1-L2	1.06	E 84	No Wind or Longitudinal Forces
LC_L2-L3	1.11	E 88	No Wind or Longitudinal Forces
LC_L3-L4	1.11	E 88	No Wind or Longitudinal Forces
LC_L4-L5	0.94	E 75	Including Wind & Longitudinal Forces
LC_L5-L6	0.94	E 75	Including Wind & Longitudinal Forces
UC_U1-U2	1.08	E 86	No Wind or Longitudinal Forces
UC_U2-U3	1.08	E 86	No Wind or Longitudinal Forces
UC_U3-U4	1.08	E 86	No Wind or Longitudinal Forces
UC_U4-U5	1.08	E 86	No Wind or Longitudinal Forces
V_L1-U1	0.82	E 65	No Wind or Longitudinal Forces
V_L2-U2	-	-	-
V_L3-U3	0.81	E 65	No Wind or Longitudinal Forces
V_L4-U4	-	-	-
V_L5-U5	0.82	E 65	No Wind or Longitudinal Forces
D_L0-U1	1.11	E 89	No Wind or Longitudinal Forces
D_U1-L2	1.24	E 99	No Wind or Longitudinal Forces
D_L2-U3	2.14	E 171	No Wind or Longitudinal Forces
D_U3-L4	2.14	E 171	No Wind or Longitudinal Forces
D_L4-U5	1.24	E 99	No Wind or Longitudinal Forces
D_U5-L6	1.11	E 89	No Wind or Longitudinal Forces
Hangers			
V_L1-U1	0.82	E 66	No Wind
V_L3-U3	0.83	E 66	No Wind
V_L5-U5	0.83	E 66	No Wind

Bridge Inspection and Rating

San Lorenzo River Bridge Truss Spans

MP 19.43a

BACKGROUND

The San Lorenzo River Bridge, MP 19.43, is located in the south of the city of Santa Cruz, California between Davenport to the north and the town of Watsonville to the south on the Santa Cruz Branch Line. It is comprised of 3 spans. The southern and middle span is 120'-0" through riveted Warren trusses. The northern span is a 60'-3" Steel Deck Girder span. These rating calculations are for the trusses.

The bridge was estimated to be built in 1904. Material strengths of steel shown on the shop drawings indicated steel with an ultimate tensile strength between 60 ksi and 68 ksi. Yielding stress was estimated at 35 ksi based on the Historical Record, History of ASTM Structural Steel Specification Stresses, listing A7 steel, dated 1900, with tensile strengths between 60,000 psi and 70,000 psi having a minimum yield stress of 35,000 psi.

BRIDGE MEMBER DESCRIPTION

The Deck girders consist of built-up members.

Truss members are built-up riveted members.

Posts are built of 4 L's-4 x 3 x 3/8 riveted to a 7/16" plate that is 8½" wide.

Diagonals are built of either 4 L's-6 x 3½ x ½ with a 11/16" plate that is 8½" wide or 2 12" deep channels with flanges augmented with 4 7/16" plates that are 3½" wide.

Bottom chord members are built of either 4 L's-6 x 3½ x 9/16 or 4 L's-6 x 3½ x 13/16 with a 13/16 plate that is 8½" wide.

End posts are comprised of 2 15" deep channels with a 7/16" cover plate that is 18" wide.

Top chord members are built with 2 15" deep channels with a 7/16" cover plate that is 18" wide.

Floor beams are I-sections built up from 4 L's-6 x 4 x ¾ and a 3/8" web plate that is 56" deep.

Stringers are I-sections built up from 4 L's-6 x 4 x 5/8" and a 3/8" web plate that is 44" deep.

SUMMARY OF INSPECTIONS

120'-0" Through Truss Span

An inspection of the San Lorenzo River Bridge truss spans was performed on July 18-20, 2012 by J.L. Patterson & Associates, Inc. The inspection of the bridge was mostly visual with some measurements of section loss on bridge components. No subsurface or under water investigation was performed. The inspection was performed on both the Southern and Northern truss.

Specific Truss Members of Concern

Member L1-U1 Hanger- 20% section loss in member.

Member L3-U3 Hanger- 30% section loss in the member.
Member L5-U5 Hanger- 15% section loss in the member.
Member L4-L5 Lower Chord- 30% section loss in the member.
Member L5-L6 Lower Chord- 20% section loss in the member.

Truss Floor System

Floor Beams-

The floor beams showed significant loss at connections to the trusses and at stringer connections. Some also showed general section loss in both flanges and webs.

Stringers-

Stringers had significant section loss on bottom flanges.

Bottom Lateral Bracing-

Many lateral braces had complete section loss.

RATING

Truss Rating

The 120'-0" trusses were rated by Modjeski and Masters, Inc. (MMI). The rating calculations are attached. Those findings conclude that the truss has sufficient capacity to carry 263,000 and 286,000 pound railcars with two – six axle locomotives.

Normal Rating: E65

Controlling Member: Hanger L3-U3

Floor System Rating-120' Truss Spans

The floor system was rated taking into account the section losses presented in the inspection report. The live loading criteria is Cooper E-80 per AREMA Manual. Rating is expressed as a Cooper E series. The controlling members are listed below along with the tabulated ratings for the whole floor system.

Floor beam FB5, Span 1:

Normal Rating: E83

Stringer S4, Span 1:

Normal Rating: E76

Ratings		Normal	Maximum	263-kip Unit Train	286-kip Unit Train	315-kip Unit Train
Stringers	Flexure	E-76	E-111	E-55	E-61	E-67
	Shear	E-88	E-152	E-54	E-54	E-63
Floor Beams	Flexure	E-100	E-147	E-54	E-54	E-63
	Shear	E-83	E-146	E-54	E-54	E-63

REQUIRED REPAIR

Truss Spans

Lattice that has 50% or greater section loss anywhere along its length and/or around the rivet holes shall be removed, replaced and attached using bolts.

Rivets that display section loss of 30% or more, or are missing, shall be replaced with bolts.

2 stringers shall have $\frac{1}{2}$ " steel plates bolted to the bottom flanges to remedy section loss. See repair plans for details.

Holes in the webs of stringers and floor beams shall be repaired by cleaning the hole, cutting the web beyond the rust to weldable material, patched by welding a $\frac{1}{2}$ " steel plate over it and spray-galvanized. See plans for details.

Bottom lateral bracing members that display 50% or more section loss shall be replaced, per original as-built drawings, and bolted to connecting gusset plates. If the gusset plates, or a portion thereof, display 50% or more section loss they shall be replaced. If only a portion of a gusset plate is deteriorated, that portion shall be cut and replaced by welding the replacement to the remaining plate, per original as-built drawings.

Bearings

All anchor bolts shall be replaced for the 3 spans.

For seismic concerns, bearings at Piers 2 and 3 shall be replaced with seismic isolation bearings.

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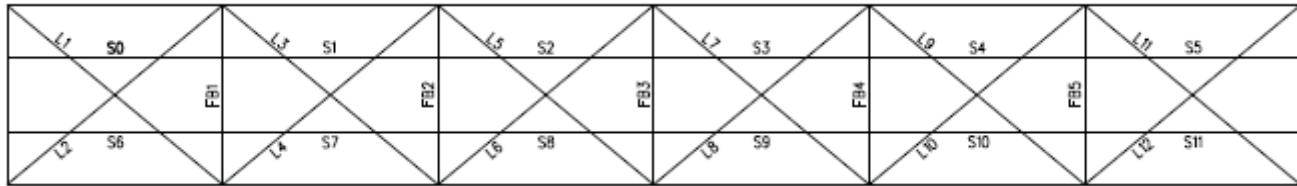


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SCCRTC-San Lorenzo River-Spans 1 & 2

Floor System- Rating Calculations DRAFT

By M. Ponce



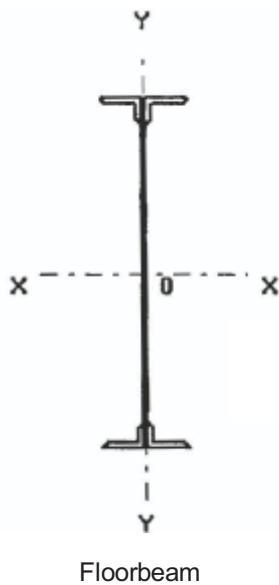
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Floor System

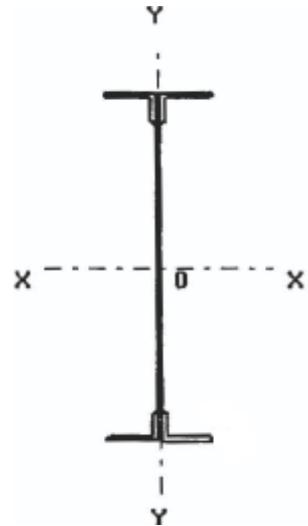
Watsonville----->

Note:

Bridge member numbering convention is the opposite of the actual plans. This is to keep consistent with previous rating calculations. Repair plans will address the correct members that need to be repaired.



Floorbeam



Stringer

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FLOORBEAMS

(Plans Sheet 4)

Gross Section: 4 angles- L6x4x3/4
1 plate 56"x3/8"

Area of Plate: $A_{plate.FB} := 56\text{in} \cdot \left(\frac{3}{8}\text{in}\right) = 21\cdot\text{in}^2$

Area of Angles: $A_{angle.FB} := 6.90\text{in}^2$

Gross area of Section: $A_{g.FB} := A_{plate.FB} + 4A_{angle.FB} = 48.6\cdot\text{in}^2$

X-axis c.g. of angle: $y_{angle.FB} := 2.08\text{in}$ (to be used in determining I_y due to 90 deg orientation)

Y-axis c.g. of angle: $x_{angle.FB} := 1.08\text{in}$ (to be used in determining I_x due to 90 deg orientation)

Inertia of angle about x-axis: $I_{x.angle.FB} := 24.4\text{in}^4$ (to be used in determining I_y due to 90 deg orientation)

Inertia of angle about y-axis: $I_{y.angle.FB} := 8.63\text{in}^4$ (to be used in determining I_x due to 90 deg orientation)

X-axis inertia of section: $I_{x.FB} := \frac{1}{12} \left[\frac{3}{8}\text{in} \cdot (56\text{in})^3 \right] + 4 \cdot I_{y.angle.FB} \dots = 25897.09 \cdot \text{in}^4$
 $+ 4A_{angle.FB} \cdot \left(\frac{56.5\text{in}}{2} - x_{angle.FB} \right)^2$

Y-axis inertia of section: $I_{y.FB} := \frac{1}{12} \left[\left(\frac{3}{8}\text{in} \right)^3 \cdot 56\text{in} \right] + 4 \cdot I_{x.angle.FB} \dots = 239.75 \cdot \text{in}^4$
 $+ 4A_{angle.FB} \cdot \left(\frac{3}{16}\text{in} + y_{angle.FB} \right)^2$

X-axis section modulus: $S_{x.FB} := \frac{I_{x.FB}}{\left(\frac{56.5\text{in}}{2} \right)} = 916.71 \cdot \text{in}^3$

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X radius of gyration:	$r_{x,FB} := \sqrt{\frac{I_{x,FB}}{A_{g,FB}}} = 23.08 \cdot \text{in}$
Y radius of gyration:	$r_{y,FB} := \sqrt{\frac{I_{y,FB}}{A_{g,FB}}} = 2.22 \cdot \text{in}$
Bolt hole:	$\text{hole} := \frac{15}{16} \cdot \text{in}$
Angle rivet holes:	$\text{holes}_{\text{angle},FB} := 1 \cdot 4 \cdot \text{hole} \cdot \frac{3}{4} \cdot \text{in} = 2.81 \cdot \text{in}^2$
Plate rivet holes:	$\text{holes}_{\text{plate},FB} := 14 \cdot \text{hole} \cdot \frac{3}{8} \cdot \text{in} = 4.92 \cdot \text{in}^2$
Gross area of section:	$A_{g,FB} = 48.6 \cdot \text{in}^2$
Net area of section:	$A_{n,FB} := A_{g,FB} - \text{holes}_{\text{angle},FB} - \text{holes}_{\text{plate},FB} = 40.87 \cdot \text{in}^2$

FLOORBEAMS Properties for Any Section Loss

Span 1

FB1, Span 1: No section loss.

$$\text{Gross Area: } A_{g,FB1,S1} := A_{g,FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,FB1,S1} := A_{n,FB} = 40.87 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{\text{plate},FB1,S1} := A_{\text{plate},FB} = 21 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,FB1,S1} := I_{x,FB} = 25897 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,FB1,S1} := S_{x,FB} = 917 \cdot \text{in}^3$$

FB2, Span 1: 12"-long x3"-high hole in web at top of stringer connection.

$$\text{Gross Area: } A_{g,FB2,S1} := A_{g,FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,FB2,S1} := A_{n,FB} - 3 \cdot \text{in} \cdot \left(\frac{3}{8} \cdot \text{in} \right) = 39.74 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{\text{plate},FB2,S1} := A_{\text{plate},FB} - (3 \cdot \text{in} + 5.5 \cdot \text{in}) \cdot \left(\frac{3}{8} \cdot \text{in} \right) = 17.81 \cdot \text{in}^2$$

Web area not interacted above web hole, 5.5in.

$$\text{X-axis Inertia: } I_{x,FB2,S1} := I_{x,FB} - \left[\frac{1}{12} \cdot \frac{3}{8} \cdot \text{in} \cdot (3 \cdot \text{in})^3 \dots + \left(\frac{3}{8} \cdot \text{in} \cdot 3 \cdot \text{in} \right) \cdot \left(\frac{56.5 \cdot \text{in}}{2} - 7 \cdot \text{in} \right)^2 \right] = 25388 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,FB2,S1} := \frac{I_{x,FB2,S1}}{\left(\frac{56.5 \cdot \text{in}}{2} \right)} = 899 \cdot \text{in}^3$$

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FB3, Span 1: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.

$$\text{Gross Area: } A_{g.FB3.S1} := A_{g.FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.FB3.S1} := A_{n.FB2.S1} = 39.74 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate.FB3.S1} := A_{plate.FB2.S1} = 17.81 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x.FB3.S1} := I_{x.FB2.S1} = 25388 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x.FB3.S1} := S_{x.FB2.S1} = 899 \cdot \text{in}^3$$

FB4, Span 1: 12"-long x4"-high hole in web at top of stringer connection. Pitting in top flange.

$$\text{Gross Area: } A_{g.FB4.S1} := A_{g.FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.FB4.S1} := A_{n.FB} - 4\text{in} \cdot \left(\frac{3}{8}\text{in}\right) = 39.37 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate.FB4.S1} := A_{plate.FB} - (4\text{in} + 5.5\text{in}) \cdot \left(\frac{3}{8}\text{in}\right) = 17.44 \cdot \text{in}^2$$

Web area not interacted above web hole, 5.5in.

X-axis Inertia for hole in web:

$$I_{x.FB4hole.S1} := I_{x.FB} - \left[\frac{1}{12} \cdot \frac{3}{8} \text{in} \cdot (4\text{in})^3 \dots + \left(\frac{3}{8} \text{in} \cdot 4\text{in} \right) \cdot \left(\frac{56.5\text{in}}{2} - 7.5\text{in} \right)^2 \right] = 25249 \cdot \text{in}^4$$

Section Modulus for hole in web:

$$S_{x.FB4hole.S1} := \frac{I_{x.FB4hole.S1}}{\left(\frac{56.5\text{in}}{2}\right)} = 894 \cdot \text{in}^3 \text{ controls for flexure.}$$

X-axis Inertia for pitting flange:

$$I_{x.FB4pit.S1} := I_{x.FB} - \left[\frac{1}{12} \cdot 1.5\text{in} \cdot \left(\frac{3}{8}\text{in}\right)^3 \dots + \left(1.5\text{in} \cdot \frac{3}{8}\text{in} \right) \cdot \left(\frac{56.5\text{in}}{2} - \frac{3}{16}\text{in} \right)^2 \right] = 25454 \cdot \text{in}^4$$

Section Modulus for pitting in flange:

$$S_{x.FB4pit.S1} := \frac{I_{x.FB4pit.S1}}{\left(\frac{56.5\text{in}}{2}\right)} = 901 \cdot \text{in}^3$$

$$\text{Section Mod.: } S_{x.FB4.S1} := \min(S_{x.FB4hole.S1}, S_{x.FB4pit.S1}) = 894 \cdot \text{in}^3$$

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FB5, Span 1: 12"-long x4"-high hole in web at top of stringer connection. Pitting in top flange.

$$\text{Gross Area: } A_{g,FB5,S1} := A_{g,FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,FB5,S1} := A_{n,FB} - 4\text{in} \cdot \left(\frac{3}{8} \text{in} \right) = 39.37 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,FB5,S1} := A_{plate,FB} - (4\text{in} + 5.5\text{in}) \cdot \left(\frac{3}{8} \text{in} \right) = 17.44 \cdot \text{in}^2$$

Web area not interacted above web hole, 5.5in.

X-axis Inertia for hole in web, same as FB4, Span1:

$$I_{x,FB5hole,S1} := I_{x,FB4hole,S1} = 25249 \cdot \text{in}^4$$

Section Modulus for hole in web, same as FB4, Span 1:

$$S_{x,FB5hole,S1} := S_{x,FB4hole,S1} = 894 \cdot \text{in}^3$$

X-axis Inertia for 30% section loss due to pitting in the flanges:

$$I_{x,FB5pit,S1} := I_{x,FB} - \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{3}{4} \text{in} \right)^3 \cdot 0.30 \dots + \left(12\text{in} \cdot \frac{3}{4} \text{in} \right) \cdot 0.3 \cdot \left(\frac{56.5\text{in}}{2} - \frac{3}{8} \text{in} \right)^2 \right] = 23799 \cdot \text{in}^4$$

Section Modulus for pitting in flange:

$$S_{x,FB5pit,S1} := \frac{I_{x,FB5pit,S1}}{\left(\frac{56.5\text{in}}{2} \right)} = 842 \cdot \text{in}^3 \quad \text{controls for flexure.}$$

$$\text{Section Mod.: } S_{x,FB5,S1} := \min(S_{x,FB5hole,S1}, S_{x,FB5pit,S1}) = 842 \cdot \text{in}^3$$

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Span 2

FB1, Span 2: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.

$$\text{Gross Area: } A_{g.FB1.S2} := A_{g.FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.FB1.S2} := A_{n.FB2.S1} = 39.74 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate.FB1.S2} := A_{plate.FB2.S1} = 17.81 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x.FB1.S2} := I_{x.FB2.S1} = 25388 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x.FB1.S2} := S_{x.FB2.S1} = 899 \cdot \text{in}^3$$

FB2, Span 2: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.

$$\text{Gross Area: } A_{g.FB2.S2} := A_{g.FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.FB2.S2} := A_{n.FB2.S1} = 39.74 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate.FB2.S2} := A_{plate.FB2.S1} = 17.81 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x.FB2.S2} := I_{x.FB2.S1} = 25388 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x.FB2.S2} := S_{x.FB2.S1} = 899 \cdot \text{in}^3$$

FB3, Span 2: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.

$$\text{Gross Area: } A_{g.FB3.S2} := A_{g.FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.FB3.S2} := A_{n.FB2.S1} = 39.74 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate.FB3.S2} := A_{plate.FB2.S1} = 17.81 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x.FB3.S2} := I_{x.FB2.S1} = 25388 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x.FB3.S2} := S_{x.FB2.S1} = 899 \cdot \text{in}^3$$

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FB4, Span 2: 12"-long x2"-high area of 80% section loss in web at top of stringer connection.
 1" hole in web above bottom flanges.

$$\text{Gross Area: } A_{g.FB4.S2} := A_{g.FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.FB4.S2} := A_{n.FB} - 2\text{in} \cdot \left(\frac{3}{8} \text{in}\right) \cdot 0.8 = 40.27 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate.FB4.S2} := A_{plate.FB} - (2\text{in} + 5.5\text{in}) \cdot \left(\frac{3}{8} \text{in}\right) \cdot 0.8 = 18.75 \cdot \text{in}^2$$

Web area not interacted above web hole, 5.5in.

X-axis Inertia for 80% section loss in web:

$$I_{x.FB4web.S2} := I_{x.FB} - \left[\frac{1}{12} \cdot \frac{3}{8} \text{in} \cdot 0.8 \cdot (2\text{in})^3 \dots + \left(\frac{3}{8} \text{in} \cdot 2\text{in} \right) \cdot 0.8 \cdot \left(\frac{56.5\text{in}}{2} - 6.5\text{in} \right)^2 \right] = 25613 \cdot \text{in}^4$$

Section Modulus for section loss in web:

$$S_{x.FB4web.S2} := \frac{I_{x.FB4web.S2}}{\left(\frac{56.5\text{in}}{2}\right)} = 907 \cdot \text{in}^3 \text{ controls for flexure.}$$

X-axis Inertia for hole in web above bottom flanges.

$$I_{x.FB4hole.S2} := I_{x.FB} - \left[\frac{1}{12} \cdot \frac{3}{8} \text{in} \cdot (1\text{in})^3 \dots + \left(\frac{3}{8} \text{in} \cdot 1\text{in} \right) \cdot \left(\frac{56.5\text{in}}{2} - 4.5\text{in} \right)^2 \right] = 25686 \cdot \text{in}^4$$

Section Modulus for hole in web:

$$S_{x.FB4hole.S2} := \frac{I_{x.FB4hole.S2}}{\left(\frac{56.5\text{in}}{2}\right)} = 909 \cdot \text{in}^3$$

$$\text{Section Mod.: } S_{x.FB4.S2} := \min(S_{x.FB4web.S2}, S_{x.FB4hole.S2}) = 907 \cdot \text{in}^3$$

FB5, Span 2: 11"-long x3"-high hole in web at top of stringer connection.

$$\text{Gross Area: } A_{g.FB5.S2} := A_{g.FB} = 48.6 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.FB5.S2} := A_{n.FB} - 3\text{in} \cdot \left(\frac{3}{8} \text{in}\right) = 39.74 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate.FB5.S2} := A_{plate.FB} - (3\text{in} + 5.5\text{in}) \cdot \left(\frac{3}{8} \text{in}\right) = 17.81 \cdot \text{in}^2$$

Web area not interacted above web hole, 5.5in.

$$\text{X-axis Inertia: } I_{x.FB5.S2} := I_{x.FB} - \left[\frac{1}{12} \cdot \frac{3}{8} \text{in} \cdot (3\text{in})^3 \dots + \left(\frac{3}{8} \text{in} \cdot 3\text{in} \right) \cdot \left(\frac{56.5\text{in}}{2} - 7\text{in} \right)^2 \right] = 25388 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x.FB5.S2} := \frac{I_{x.FB5.S2}}{\left(\frac{56.5\text{in}}{2}\right)} = 899 \cdot \text{in}^3$$

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STRINGERS (Plans Sheet 4)

Gross Section:	4 angles- L6x4x5/8 1 plate 44"x3/8"
Area of Plate:	$A_{plate,S} := 44\text{in} \cdot \left(\frac{3}{8}\text{ in}\right) = 16.5 \cdot \text{in}^2$
Area of Angles:	$A_{angle,S} := 5.83\text{in}^2$
Gross area of Section:	$A_{g,S} := A_{plate,S} + 4A_{angle,S} = 39.82 \cdot \text{in}^2$
X-axis c.g. of angle:	$y_{angle,S} := 2.03\text{in}$ (to be used in determining Iy due to 90 deg orientation)
Y-axis c.g. of angle: orientation)	$x_{angle,S} := 1.03\text{in}$ (to be used in determining Ix due to 90 deg orientation)
Inertia of angle about x-axis:	$I_{x,angle,S} := 21\text{in}^4$ (to be used in determining Iy due to 90 deg orientation)
Inertia of angle about y-axis:	$I_{y,angle,S} := 7.47\text{in}^4$ (to be used in determining Ix due to 90 deg orientation)
X-axis inertia of section:	$I_{x,S} := \frac{1}{12} \left[\frac{3}{8} \text{in} \cdot (44\text{in})^3 \right] + 4 \cdot I_{y,angle,S} \dots = 13193 \cdot \text{in}^4$ $+ 4A_{angle,S} \left(\frac{44.5\text{in}}{2} - x_{angle,S} \right)^2$
Y-axis inertia of section:	$I_{y,S} := \frac{1}{12} \left[\left(\frac{3}{8} \text{in} \right)^3 \cdot 44\text{in} \right] + 4 \cdot I_{x,angle,S} \dots = 199 \cdot \text{in}^4$ $+ 4A_{angle,S} \left(\frac{3}{16} \text{in} + y_{angle,S} \right)^2$
X-axis section modulus:	$S_{x,S} := \frac{I_{x,S}}{\left(\frac{44.5\text{in}}{2} \right)} = 593 \cdot \text{in}^3$
X radius of gyration:	$r_{x,S} := \sqrt{\frac{I_{x,S}}{A_{g,S}}} = 18.2 \cdot \text{in}$
Y radius of gyration:	$r_{y,S} := \sqrt{\frac{I_{y,S}}{A_{g,S}}} = 2.23 \cdot \text{in}$
Angle rivet holes:	$\text{holes}_{angle,S} := 1 \cdot 4 \cdot \text{hole} \cdot \frac{5}{8} \text{in} = 2.34 \cdot \text{in}^2$
Plate rivet holes:	$\text{holes}_{plate,S} := 9 \cdot \text{hole} \cdot \frac{3}{8} \text{in} = 3.16 \cdot \text{in}^2$
Gross area of section:	$A_{g,S} = 39.82 \cdot \text{in}^2$
Net area of section:	$A_{n,S} := A_{g,S} - \text{holes}_{angle,S} - \text{holes}_{plate,S} = 34.31 \cdot \text{in}^2$

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STRINGERS Properties for Any Section Loss

Span 1

S0, Span 1: 20% section loss in bottom flange.

$$\text{Gross Area: } A_{g,S0,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S0,S1} := A_{n,S} - 12\text{in} \cdot \left(\frac{5}{8} \text{in} \right) \cdot 0.2 = 32.81 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S0,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S0,S1} := I_{x,S} - \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8} \text{in} \cdot 0.2 \right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8} \text{in} \right) \cdot 0.2 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16} \text{in} \right)^2 \right] = 12471 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S0,S1} := \frac{I_{x,S0,S1}}{\left(\frac{44.5\text{in}}{2} \right)} = 560 \cdot \text{in}^3$$

S1, Span 1: 5% section loss in top flange.

$$\text{Gross Area: } A_{g,S1,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S1,S1} := A_{n,S} - 12\text{in} \cdot \left(\frac{5}{8} \text{in} \right) \cdot 0.05 = 33.94 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S1,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S1,S1} := I_{x,S} - \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8} \text{in} \cdot 0.05 \right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8} \text{in} \right) \cdot 0.05 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16} \text{in} \right)^2 \right] = 13012 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S1,S1} := \frac{I_{x,S1,S1}}{\left(\frac{44.5\text{in}}{2} \right)} = 585 \cdot \text{in}^3$$

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S2, Span 1: 20% section loss in top flange.

$$\text{Gross Area: } A_{g,S2,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S2,S1} := A_{n,S} - 12\text{in} \cdot \left(\frac{5}{8}\text{in}\right) \cdot 0.2 = 32.81 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S2,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S2,S1} := I_{x,S} - \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8}\text{in} \cdot 0.2\right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8}\text{in}\right) \cdot 0.2 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16}\text{in}\right)^2 \right] = 12471 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S2,S1} := \frac{I_{x,S2,S1}}{\left(\frac{44.5\text{in}}{2}\right)} = 560 \cdot \text{in}^3$$

S3, Span 1: 1"-wide x1/2"-high hole in the web above bottom flanges.

$$\text{Gross Area: } A_{g,S3,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S3,S1} := A_{n,S} - \left(\frac{1}{2}\text{in}\right) \cdot \left(\frac{3}{8}\text{in}\right) = 34.12 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S3,S1} := A_{plate,S} - \left(\frac{1}{2}\text{in}\right) \cdot \left(\frac{3}{8}\text{in}\right) = 16.31 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S3,S1} := I_{x,S} - \left[\frac{1}{12} \cdot \frac{3}{8}\text{in} \cdot \left(\frac{1}{2}\text{in}\right)^3 \dots + \left(\frac{3}{8}\text{in} \cdot \frac{1}{2}\text{in}\right) \cdot \left(\frac{44.5\text{in}}{2} - 4.5\text{in}\right)^2 \right] = 13134 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S3,S1} := \frac{I_{x,S3,S1}}{\left(\frac{44.5\text{in}}{2}\right)} = 590 \cdot \text{in}^3$$

S4, Span 1: 50% section loss in top and bottom flanges.

$$\text{Gross Area: } A_{g,S4,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S4,S1} := A_{n,S} - 2 \cdot 12\text{in} \cdot \left(\frac{5}{8}\text{in}\right) \cdot 0.5 = 26.81 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S4,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S4,S1} := I_{x,S} - 2 \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8}\text{in} \cdot 0.5\right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8}\text{in}\right) \cdot 0.5 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16}\text{in}\right)^2 \right] = 9583 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S4,S1} := \frac{I_{x,S4,S1}}{\left(\frac{44.5\text{in}}{2}\right)} = 431 \cdot \text{in}^3$$

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S5, Span 1: 10% section loss in top flange.

$$\text{Gross Area: } A_{g,S5,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S5,S1} := A_{n,S} - 12\text{in} \cdot \left(\frac{5}{8}\text{in}\right) \cdot 0.1 = 33.56 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S5,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S5,S1} := I_{x,S} - \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8}\text{in} \cdot 0.1\right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8}\text{in}\right) \cdot 0.1 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16}\text{in}\right)^2 \right] = 12832 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S5,S1} := \frac{I_{x,S5,S1}}{\left(\frac{44.5\text{in}}{2}\right)} = 577 \cdot \text{in}^3$$

S6, Span 1: No section loss.

$$\text{Gross Area: } A_{g,S6,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S6,S1} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S6,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S6,S1} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S6,S1} := S_{x,S} = 593 \cdot \text{in}^3$$

S7, Span 1: 25% section loss in bottom flange.

$$\text{Gross Area: } A_{g,S7,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S7,S1} := A_{n,S} - 12\text{in} \cdot \left(\frac{5}{8}\text{in}\right) \cdot 0.25 = 32.44 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S7,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S7,S1} := I_{x,S} - \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8}\text{in} \cdot 0.25\right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8}\text{in}\right) \cdot 0.25 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16}\text{in}\right)^2 \right] = 12290 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S7,S1} := \frac{I_{x,S7,S1}}{\left(\frac{44.5\text{in}}{2}\right)} = 552 \cdot \text{in}^3$$

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S8, Span 1: 20% section loss in top and bottom flanges.

$$\text{Gross Area: } A_{g,S8,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S8,S1} := A_{n,S} - 2 \cdot 12\text{in} \cdot \left(\frac{5}{8} \text{in} \right) \cdot 0.2 = 31.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S8,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S8,S1} := I_{x,S} - 2 \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8} \text{in} \cdot 0.2 \right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8} \text{in} \right) \cdot 0.2 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16} \text{in} \right)^2 \right] = 11749 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S8,S1} := \frac{I_{x,S8,S1}}{\left(\frac{44.5\text{in}}{2} \right)} = 528 \cdot \text{in}^3$$

S9, Span 1: 10% section loss in top and bottom flanges.

$$\text{Gross Area: } A_{g,S9,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S9,S1} := A_{n,S} - 2 \cdot 12\text{in} \cdot \left(\frac{5}{8} \text{in} \right) \cdot 0.1 = 32.81 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S9,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S9,S1} := I_{x,S} - 2 \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8} \text{in} \cdot 0.1 \right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8} \text{in} \right) \cdot 0.1 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16} \text{in} \right)^2 \right] = 12471 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S9,S1} := \frac{I_{x,S9,S1}}{\left(\frac{44.5\text{in}}{2} \right)} = 560 \cdot \text{in}^3$$

S10, Span 1: No section loss.

$$\text{Gross Area: } A_{g,S10,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S10,S1} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S10,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S10,S1} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S10,S1} := S_{x,S} = 593 \cdot \text{in}^3$$

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S11, Span 1: 50% section loss in top flange. Complete loss of one bottom flange at abutment, not affecting flexural capacity.

$$\text{Gross Area: } A_{g,S11,S1} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S11,S1} := A_{n,S} - 12\text{in} \cdot \left(\frac{5}{8}\text{in}\right) \cdot 0.5 = 30.56 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S11,S1} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S11,S1} := I_{x,S} - \left[\frac{1}{12} \cdot 12\text{in} \cdot \left(\frac{5}{8}\text{in} \cdot 0.5\right)^3 \dots + \left(12\text{in} \cdot \frac{5}{8}\text{in}\right) \cdot 0.5 \cdot \left(\frac{44.5\text{in}}{2} - \frac{5}{16}\text{in}\right)^2 \right] = 11388 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S11,S1} := \frac{I_{x,S11,S1}}{\left(\frac{44.5\text{in}}{2}\right)} = 512 \cdot \text{in}^3$$

Span 2

S0, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S0,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S0,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S0,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S0,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S0,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S1, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S1,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S1,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S1,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S1,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S1,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

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S2, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S2,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S2,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S2,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S2,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S2,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S3, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S3,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S3,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S3,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S3,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S3,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S4, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S4,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S4,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S4,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S4,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S4,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S5, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S5,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S5,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S5,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S5,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S5,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

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S6, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S6,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S6,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S6,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S6,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S6,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S7, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S7,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S7,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S7,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S7,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S7,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S8, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S8,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S8,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S8,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S8,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S8,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S9, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S9,S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S9,S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S9,S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S9,S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S9,S2} := S_{x,S} = 593 \cdot \text{in}^3$$

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S10, Span 2: No section loss.

$$\text{Gross Area: } A_{g,S10.S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S10.S2} := A_{n,S} = 34.31 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S10.S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S10.S2} := I_{x,S} = 13193 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S10.S2} := S_{x,S} = 593 \cdot \text{in}^3$$

S11, Span 2: 50% section loss in vertical legs of bottom angles.

$$\text{Gross Area: } A_{g,S11.S2} := A_{g,S} = 39.82 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,S11.S2} := A_{n,S} - 2 \cdot 4\text{in} \cdot \left(\frac{5}{8} \cdot \text{in} \right) \cdot 0.5 = 31.81 \cdot \text{in}^2$$

$$\text{Plate Area: } A_{plate,S11.S2} := A_{plate,S} = 16.5 \cdot \text{in}^2$$

$$\text{X-axis Inertia: } I_{x,S11.S2} := I_{x,S} - 2 \left[\frac{1}{12} \cdot \left(\frac{5}{8} \cdot \text{in} \cdot 0.5 \right) \cdot (4\text{in})^3 \dots + \left(\frac{5}{8} \cdot \text{in} \cdot 4\text{in} \right) \cdot 0.5 \cdot \left(\frac{44.5\text{in}}{2} - 2\text{in} \right)^2 \right] = 12164 \cdot \text{in}^4$$

$$\text{Section Mod.: } S_{x,S11.S2} := \frac{I_{x,S11.S2}}{\left(\frac{44.5\text{in}}{2} \right)} = 547 \cdot \text{in}^3$$

Impact Factor for Main Members

Impact:

$$\text{Vertical effect: } VE := 16 + \frac{600}{120 - 30} = 22.67 \quad \text{AREMA (15-1.3.5)}$$

$$\text{Rocking effect: } RE := \frac{20 \cdot 5\text{ft}}{15\text{ft} + 8\text{in}} = 6.38 \quad \text{AREMA (15-1.3.5d)}$$

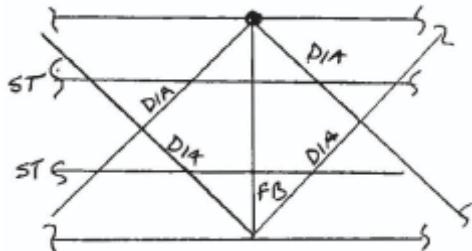
$$\text{Reduce for low speed: } \text{Reduction} := 1 - \frac{0.8}{2500} \cdot \left(\frac{60\text{mph} - 30\text{mph}}{\text{mph}} \right)^2 = 0.71$$

$$\text{Impact: } I := \frac{VE \cdot \text{Reduction} + RE}{100} = 0.23$$

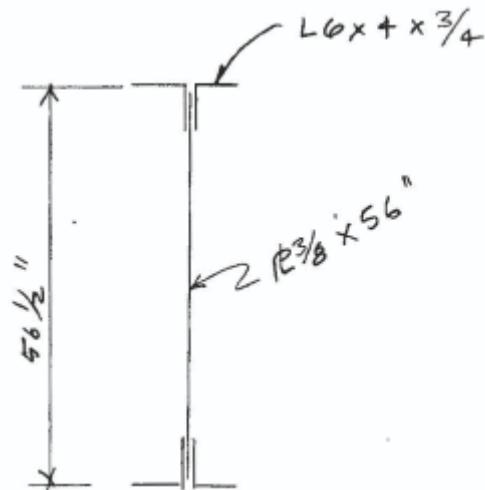
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Lower Panel Point Loading



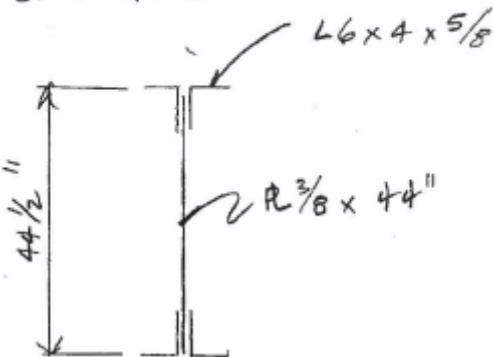
Lower Panel Point Loading (for TRAP Input)

Bracing Dead Load
Floor System

Floor beams

$$\begin{aligned} \text{Area: } A_{g,FB} &= 48.6 \cdot \text{in}^2 \\ \text{Weight/ft: } w_{FB} &:= 490 \text{pcf} \cdot A_{g,FB} = 165.38 \cdot \text{plf} \\ \text{Length: } L_{FB} &:= 15\text{ft} + 8\text{in} = 15.67 \text{ ft} \end{aligned}$$

STRINGERS



Intermediate Stringers

$$\begin{aligned} \text{Area: } A_{g,S} &= 39.82 \cdot \text{in}^2 \\ \text{Weight: } w_S &:= 490 \text{pcf} \cdot A_{g,S} = 135.5 \cdot \text{plf} \\ \text{Length: } L_S &:= 19\text{ft} + \left(11 + \frac{5}{8}\right) \text{in} = 19.97 \text{ ft} \end{aligned}$$

Diagonals

$$\begin{aligned} \text{Area: } A_{g,botDiag} &:= 2.86 \text{in}^2 \\ \text{Weight: } w_{botDiag} &:= 9.72 \text{plf} \\ \text{Length: } L_{botDiag} &:= 23\text{ft} + \left(11 + \frac{5}{8}\right) \text{in} = 23.97 \text{ ft} \end{aligned}$$

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Interior Panel Point Bracing Dead Load

Load at point: $P_{lowerPt} := w_{FB} \cdot \frac{L_{FB}}{2} + w_S \cdot L_S + w_{botDiag} \cdot L_{botDiag} = 4.23 \cdot \text{kip}$

Inc. 30% for connections $P_{DLlowerPoint} := 1.30 \cdot P_{lowerPt} = 5.5 \cdot \text{kip}$

Additional Dead Load

Wire rope/Sidewalk Estimate

Use estimates from prior rating calcs

$$P_{sidewalk} := 11 \cdot \text{kip}$$

Track and Timber Track $w_{track} := 200 \cdot \text{plf}$

Timber timber := 60pcf

Open timber deck on steel girder uses:

$$V_{timber} := 10\text{in} \cdot 12\text{in} \cdot 10\text{ft} = 8.33 \cdot \text{ft}^3 @ 1'-0" \text{ on-center}$$

Wt. of 1 timber: $W_{timber} := V_{timber} \cdot \text{timber} = 0.5 \cdot \text{kip}$

Timber point load: $P_{timber} := \frac{20 \cdot W_{timber}}{2} = 5 \cdot \text{kip}$

Track point load: $P_{track} := \frac{200 \cdot \text{plf} \cdot (20\text{ft}) \cdot 2}{2} = 4 \cdot \text{kip}$

Total Add. Dead Load: $P_{ADLlowerPt} := P_{sidewalk} + P_{timber} + P_{track} = 20 \cdot \text{kip}$

Top Panel Point Loading

(for TRAP Input)

Portal Bracing

Load of Top Struts: $P_{TS} := \frac{(14\text{ft} + 11\text{in})}{2} \cdot 4 \cdot (6.6 \cdot \text{plf}) = 0.2 \cdot \text{kip}$

Load of Top Laterals: $P_{TL} := \frac{(23\text{ft} + 11.5\text{in})}{2} \cdot 2 \cdot (6.6 \cdot \text{plf}) = 0.32 \cdot \text{kip}$

Load at Point: $P_{TS} + P_{TL} = 0.51 \cdot \text{kip}$

Add 30% for connections and lattice

$$1.30 \cdot (P_{TS} + P_{TL}) = 0.67 \cdot \text{kip}$$

Use: $P_{DLupperIntPoint} := 1.0 \cdot \text{kip} @ \text{interior points}$

$$P_{DLupperEndPoint} := 2.0 \cdot \text{kip} @ \text{end points}$$

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Stringer Load Rating

Section Properties

Area: $A_{g,S} = 39.82 \cdot \text{in}^2$

X-axis inertia: $I_{x,S} = 13192.61 \cdot \text{in}^4$

Live Load

Length of stringer span: $L_{S,\text{span}} := 20\text{ft}$

Maximum moment: $M_{S,LL} := 475 \cdot \text{kip}\cdot\text{ft}$ Alt. LL, AREMA Table 15-1-15

Max shear: $V_{S,LL} := 120 \cdot \text{kip}$ Alt. LL, AREMA Table 15-1-15

Maximum pier reaction: $R_{S,LL} := 131.10 \cdot \text{kip}$ E-80, AREMA Table 15-1-15

Dead Load

Self weight: $w_S = 135.5 \cdot \text{plf}$

Inc. 30% for connections: $w_{S,conn} := w_S \cdot 1.30 = 176.15 \cdot \text{plf}$

Track: $w_{S,track} := 100 \cdot \text{plf}$

Timber: $w_{S,timber} := \frac{W_{t,timber}}{1\text{ft}} = 500 \cdot \text{plf}$

Total: $w_{S,DL} := w_S + w_{S,track} + \frac{w_{S,timber}}{2} = 0.53 \cdot \frac{\text{kip}}{\text{ft}}$

Max Moment: $M_{S,DL} := \frac{w_{S,DL} \cdot L_{S,\text{span}}}{8}^2 = 26.31 \cdot \text{kip}\cdot\text{ft}$

Max Shear: $V_{S,DL} := \frac{w_{S,DL} \cdot L_{S,\text{span}}}{2} = 5.26 \cdot \text{kip}$

Normal allowable flexure: $F_{\text{allow},b} := 0.55 \cdot 35 \cdot \text{ksi} = 19.25 \cdot \text{ksi}$ AREMA (15-1.4.1)

Max. allowable flexure: $F_{\text{max},b} := 0.80 \cdot 35 \cdot \text{ksi} = 28 \cdot \text{ksi}$ AREMA (15-7.3.4.3)

Normal allowable shear: $F_{\text{allow},v} := 0.35 \cdot 35 \cdot \text{ksi} = 12.25 \cdot \text{ksi}$ AREMA (15-1.4.1)

Max. allowable shear: $F_{\text{max},v} := 0.75 \cdot (0.8 \cdot 35 \cdot \text{ksi}) = 21 \cdot \text{ksi}$ AREMA (15-7.3.4.3)

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Impact for Stringer

Vertical Effect: $VE_S := 40 - \frac{3(L_{S.span})^2}{1600 \cdot ft^2} = 39.25\% \quad AREMA (15-1.3.5)$

Rocking Effect: $RE_S := 20\% \quad AREMA (15-1.3.5d)$

Reduce for low speed: Reduction = 0.71

Impact: $I_S := \frac{VE_S \cdot \text{Reduction} + RE_S}{100} = 0.48$

Normal Rating of Stringer Dead Load Stresses

Flexure: $\sigma_{S.DL} := \frac{M_{S.DL}}{S_{x,S}} = 0.53 \cdot \text{ksi}$

Shear: $\tau_{S.DL} := \frac{V_{S.DL}}{A_{plate,S}} = 0.32 \cdot \text{ksi}$

Live Load Stresses

Flexure: $\sigma_{S.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x,S}} = 14.22 \cdot \text{ksi}$

Shear: $\tau_{S.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate,S}} = 10.76 \cdot \text{ksi}$

E-80 Normal Load Rating Without Section Loss

Flexure: $R_{S,\sigma} := \frac{F_{allow,b} - \sigma_{S.DL}}{\sigma_{S.LL}} \cdot 80 = 105$

Shear: $R_{S,\tau} := \frac{F_{allow,v} - \tau_{S.DL}}{\tau_{S.LL}} \cdot 80 = 89$

Maximum Rating of Stringer Without Section Loss

E-80 Maximum Load Rating

Flexure: $MaxR_{S,\sigma} := \frac{F_{max,b} - \sigma_{S.DL}}{\sigma_{S.LL}} \cdot 80 = 155$

Shear: $MaxR_{S,\tau} := \frac{F_{max,v} - \tau_{S.DL}}{\tau_{S.LL}} \cdot 80 = 154$

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Rating for Each Stringers in Span 1

S0, Span 1: 20% section loss in bottom flange.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S0.S1.DL} := \frac{M_{S.DL}}{S_x.S0.S1} = 0.56 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S0.S1.DL} := \frac{V_{S.DL}}{A_{plate.S0.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S0.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S0.S1} = 15.05 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S0.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S0.S1}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S0.S1.\sigma} := \frac{F_{allow.b} - \sigma_{S0.S1.DL}}{\sigma_{S0.S1.LL}} \cdot 80 = 99$$

$$\text{Shear: } R_{S0.S1.\tau} := \frac{F_{allow.v} - \tau_{S0.S1.DL}}{\tau_{S0.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S0.S1.\sigma} := \frac{F_{max.b} - \sigma_{S0.S1.DL}}{\sigma_{S0.S1.LL}} \cdot 80 = 146$$

$$\text{Shear: } MaxR_{S0.S1.\tau} := \frac{F_{max.v} - \tau_{S0.S1.DL}}{\tau_{S0.S1.LL}} \cdot 80 = 154$$

S1, Span 1: 5% section loss in top flange.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S1.S1.DL} := \frac{M_{S.DL}}{S_x.S1.S1} = 0.54 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S1.S1.DL} := \frac{V_{S.DL}}{A_{plate.S1.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S1.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S1.S1} = 14.42 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S1.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S1.S1}} = 10.76 \cdot \text{ksi}$$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{S1.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{S1.S1.DL}}{\sigma_{S1.S1.LL}} \cdot 80 = 104$$

$$\text{Shear: } R_{S1.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{S1.S1.DL}}{\tau_{S1.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{Max}R_{S1.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{S1.S1.DL}}{\sigma_{S1.S1.LL}} \cdot 80 = 152$$

$$\text{Shear: } \text{Max}R_{S1.S1.\tau} := \frac{F_{\text{max},v} - \tau_{S1.S1.DL}}{\tau_{S1.S1.LL}} \cdot 80 = 154$$

S2, Span 1: 20% section loss in top flange.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S2.S1.DL} := \frac{M_{S.DL}}{S_{x,S2.S1}} = 0.56 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S2.S1.DL} := \frac{V_{S.DL}}{A_{\text{plate},S2.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S2.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x,S2.S1}} = 15.05 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S2.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate},S2.S1}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S2.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{S2.S1.DL}}{\sigma_{S2.S1.LL}} \cdot 80 = 99$$

$$\text{Shear: } R_{S2.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{S2.S1.DL}}{\tau_{S2.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{Max}R_{S2.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{S2.S1.DL}}{\sigma_{S2.S1.LL}} \cdot 80 = 146$$

$$\text{Shear: } \text{Max}R_{S2.S1.\tau} := \frac{F_{\text{max},v} - \tau_{S2.S1.DL}}{\tau_{S2.S1.LL}} \cdot 80 = 154$$

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S3, Span 1: 1"-wide x 1/2"-high hole in the web above bottom flanges.

Dead Load Stresses

Flexure: $\sigma_{S3.S1.DL} := \frac{M_{S.DL}}{S_{x.S3.S1}} = 0.53\text{-ksi}$

Shear: $\tau_{S3.S1.DL} := \frac{V_{S.DL}}{A_{plate.S3.S1}} = 0.32\text{-ksi}$

Live Load Stresses

Flexure: $\sigma_{S3.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x.S3.S1}} = 14.29\text{-ksi}$

Shear: $\tau_{S3.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S3.S1}} = 10.88\text{-ksi}$

E-80 Normal Load Rating

Flexure: $R_{S3.S1.\sigma} := \frac{F_{allow.b} - \sigma_{S3.S1.DL}}{\sigma_{S3.S1.LL}} \cdot 80 = 105$

Shear: $R_{S3.S1.\tau} := \frac{F_{allow.v} - \tau_{S3.S1.DL}}{\tau_{S3.S1.LL}} \cdot 80 = 88$

E-80 Maximum Load Rating

Flexure: $MaxR_{S3.S1.\sigma} := \frac{F_{max.b} - \sigma_{S3.S1.DL}}{\sigma_{S3.S1.LL}} \cdot 80 = 154$

Shear: $MaxR_{S3.S1.\tau} := \frac{F_{max.v} - \tau_{S3.S1.DL}}{\tau_{S3.S1.LL}} \cdot 80 = 152$

S4, Span 1: 50% section loss in top and bottom flanges.

Dead Load Stresses

Flexure: $\sigma_{S4.S1.DL} := \frac{M_{S.DL}}{S_{x.S4.S1}} = 0.73\text{-ksi}$

Shear: $\tau_{S4.S1.DL} := \frac{V_{S.DL}}{A_{plate.S4.S1}} = 0.32\text{-ksi}$

Live Load Stresses

Flexure: $\sigma_{S4.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x.S4.S1}} = 19.58\text{-ksi}$

Shear: $\tau_{S4.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S4.S1}} = 10.76\text{-ksi}$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{S4.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{S4.S1.DL}}{\sigma_{S4.S1.LL}} \cdot 80 = 76$$

$$\text{Shear: } R_{S4.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{S4.S1.DL}}{\tau_{S4.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{S4.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{S4.S1.DL}}{\sigma_{S4.S1.LL}} \cdot 80 = 111$$

$$\text{Shear: } \text{MaxR}_{S4.S1.\tau} := \frac{F_{\text{max},v} - \tau_{S4.S1.DL}}{\tau_{S4.S1.LL}} \cdot 80 = 154$$

S5, Span 1: 10% section loss in top flange.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S5.S1.DL} := \frac{M_{S.DL}}{S_{x,S5.S1}} = 0.55 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S5.S1.DL} := \frac{V_{S.DL}}{A_{\text{plate},S5.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S5.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x,S5.S1}} = 14.62 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S5.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate},S5.S1}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S5.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{S5.S1.DL}}{\sigma_{S5.S1.LL}} \cdot 80 = 102$$

$$\text{Shear: } R_{S5.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{S5.S1.DL}}{\tau_{S5.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{S5.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{S5.S1.DL}}{\sigma_{S5.S1.LL}} \cdot 80 = 150$$

$$\text{Shear: } \text{MaxR}_{S5.S1.\tau} := \frac{F_{\text{max},v} - \tau_{S5.S1.DL}}{\tau_{S5.S1.LL}} \cdot 80 = 154$$

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S6, Span 1: No section loss.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S6.S1.DL} := \frac{M_{S.DL}}{S_x.S6.S1} = 0.53 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S6.S1.DL} := \frac{V_{S.DL}}{A_{\text{plate}.S6.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S6.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S6.S1} = 14.22 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S6.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate}.S6.S1}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S6.S1.\sigma} := \frac{F_{\text{allow}.b} - \sigma_{S6.S1.DL}}{\sigma_{S6.S1.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S6.S1.\tau} := \frac{F_{\text{allow}.v} - \tau_{S6.S1.DL}}{\tau_{S6.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{S6.S1.\sigma} := \frac{F_{\text{max}.b} - \sigma_{S6.S1.DL}}{\sigma_{S6.S1.LL}} \cdot 80 = 155$$

$$\text{Shear: } \text{MaxR}_{S6.S1.\tau} := \frac{F_{\text{max}.v} - \tau_{S6.S1.DL}}{\tau_{S6.S1.LL}} \cdot 80 = 154$$

S7, Span 1: 25% section loss in bottom flange.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S7.S1.DL} := \frac{M_{S.DL}}{S_x.S7.S1} = 0.57 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S7.S1.DL} := \frac{V_{S.DL}}{A_{\text{plate}.S7.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S7.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S7.S1} = 15.27 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S7.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate}.S7.S1}} = 10.76 \cdot \text{ksi}$$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{S7.S1.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S7.S1.DL}}{\sigma_{S7.S1.LL}} \cdot 80 = 98$$

$$\text{Shear: } R_{S7.S1.\tau} := \frac{F_{\text{allow.v}} - \tau_{S7.S1.DL}}{\tau_{S7.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S7.S1.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S7.S1.DL}}{\sigma_{S7.S1.LL}} \cdot 80 = 144$$

$$\text{Shear: } MaxR_{S7.S1.\tau} := \frac{F_{\text{max.v}} - \tau_{S7.S1.DL}}{\tau_{S7.S1.LL}} \cdot 80 = 154$$

S8, Span 1: 20% section loss in top and bottom flanges.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S8.S1.DL} := \frac{M_{S.DL}}{S_{x,S8.S1}} = 0.6 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S8.S1.DL} := \frac{V_{S.DL}}{A_{\text{plate},S8.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S8.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x,S8.S1}} = 15.97 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S8.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate},S8.S1}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S8.S1.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S8.S1.DL}}{\sigma_{S8.S1.LL}} \cdot 80 = 93$$

$$\text{Shear: } R_{S8.S1.\tau} := \frac{F_{\text{allow.v}} - \tau_{S8.S1.DL}}{\tau_{S8.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S8.S1.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S8.S1.DL}}{\sigma_{S8.S1.LL}} \cdot 80 = 137$$

$$\text{Shear: } MaxR_{S8.S1.\tau} := \frac{F_{\text{max.v}} - \tau_{S8.S1.DL}}{\tau_{S8.S1.LL}} \cdot 80 = 154$$

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S9, Span 1: 10% section loss in top and bottom flanges.

Dead Load Stresses

Flexure: $\sigma_{S9.S1.DL} := \frac{M_{S.DL}}{S_x.S9.S1} = 0.56 \text{ ksi}$

Shear: $\tau_{S9.S1.DL} := \frac{V_{S.DL}}{A_{plate.S9.S1}} = 0.32 \text{ ksi}$

Live Load Stresses

Flexure: $\sigma_{S9.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S9.S1} = 15.05 \text{ ksi}$

Shear: $\tau_{S9.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S9.S1}} = 10.76 \text{ ksi}$

E-80 Normal Load Rating

Flexure: $R_{S9.S1.\sigma} := \frac{F_{allow.b} - \sigma_{S9.S1.DL}}{\sigma_{S9.S1.LL}} \cdot 80 = 99$

Shear: $R_{S9.S1.\tau} := \frac{F_{allow.v} - \tau_{S9.S1.DL}}{\tau_{S9.S1.LL}} \cdot 80 = 89$

E-80 Maximum Load Rating

Flexure: $MaxR_{S9.S1.\sigma} := \frac{F_{max.b} - \sigma_{S9.S1.DL}}{\sigma_{S9.S1.LL}} \cdot 80 = 146$

Shear: $MaxR_{S9.S1.\tau} := \frac{F_{max.v} - \tau_{S9.S1.DL}}{\tau_{S9.S1.LL}} \cdot 80 = 154$

S10, Span 1: No section loss.

Dead Load Stresses

Flexure: $\sigma_{S10.S1.DL} := \frac{M_{S.DL}}{S_x.S10.S1} = 0.53 \text{ ksi}$

Shear: $\tau_{S10.S1.DL} := \frac{V_{S.DL}}{A_{plate.S10.S1}} = 0.32 \text{ ksi}$

Live Load Stresses

Flexure: $\sigma_{S10.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S10.S1} = 14.22 \text{ ksi}$

Shear: $\tau_{S10.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S10.S1}} = 10.76 \text{ ksi}$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{S10.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{S10.S1.DL}}{\sigma_{S10.S1.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S10.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{S10.S1.DL}}{\tau_{S10.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S10.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{S10.S1.DL}}{\sigma_{S10.S1.LL}} \cdot 80 = 155$$

$$\text{Shear: } MaxR_{S10.S1.\tau} := \frac{F_{\text{max},v} - \tau_{S10.S1.DL}}{\tau_{S10.S1.LL}} \cdot 80 = 154$$

S11, Span 1: 50% section loss in top flange. Complete loss of one bottom flange at abutment, not affecting flexural capacity.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S11.S1.DL} := \frac{M_{S.DL}}{S_{x,S11.S1}} = 0.62 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S11.S1.DL} := \frac{V_{S.DL}}{A_{\text{plate},S11.S1}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S11.S1.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x,S11.S1}} = 16.48 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S11.S1.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate},S11.S1}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S11.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{S11.S1.DL}}{\sigma_{S11.S1.LL}} \cdot 80 = 90$$

$$\text{Shear: } R_{S11.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{S11.S1.DL}}{\tau_{S11.S1.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S11.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{S11.S1.DL}}{\sigma_{S11.S1.LL}} \cdot 80 = 133$$

$$\text{Shear: } MaxR_{S11.S1.\tau} := \frac{F_{\text{max},v} - \tau_{S11.S1.DL}}{\tau_{S11.S1.LL}} \cdot 80 = 154$$

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Rating for Each Stringers in Span 2

S0, Span 2: No section loss.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S0.S2.DL} := \frac{M_{S.DL}}{S_x.S0.S2} = 0.53 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S0.S2.DL} := \frac{V_{S.DL}}{A_{plate.S0.S2}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S0.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S0.S2} = 14.22 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S0.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S0.S2}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S0.S2.\sigma} := \frac{F_{allow.b} - \sigma_{S0.S2.DL}}{\sigma_{S0.S2.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S0.S2.\tau} := \frac{F_{allow.v} - \tau_{S0.S2.DL}}{\tau_{S0.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S0.S2.\sigma} := \frac{F_{max.b} - \sigma_{S0.S2.DL}}{\sigma_{S0.S2.LL}} \cdot 80 = 155$$

$$\text{Shear: } MaxR_{S0.S2.\tau} := \frac{F_{max.v} - \tau_{S0.S2.DL}}{\tau_{S0.S2.LL}} \cdot 80 = 154$$

S1, Span 2: No section loss.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S1.S2.DL} := \frac{M_{S.DL}}{S_x.S1.S2} = 0.53 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S1.S2.DL} := \frac{V_{S.DL}}{A_{plate.S1.S2}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S1.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S1.S2} = 14.22 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S1.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S1.S2}} = 10.76 \cdot \text{ksi}$$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{S1.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S1.S2.DL}}{\sigma_{S1.S2.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S1.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S1.S2.DL}}{\tau_{S1.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{S1.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S1.S2.DL}}{\sigma_{S1.S2.LL}} \cdot 80 = 155$$

$$\text{Shear: } \text{MaxR}_{S1.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S1.S2.DL}}{\tau_{S1.S2.LL}} \cdot 80 = 154$$

S2, Span 2: No section loss.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S2.S2.DL} := \frac{M_{S.DL}}{S_{x,S2.S2}} = 0.53 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S2.S2.DL} := \frac{V_{S.DL}}{A_{\text{plate},S2.S2}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S2.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x,S2.S2}} = 14.22 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S2.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate},S2.S2}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S2.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S2.S2.DL}}{\sigma_{S2.S2.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S2.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S2.S2.DL}}{\tau_{S2.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{S2.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S2.S2.DL}}{\sigma_{S2.S2.LL}} \cdot 80 = 155$$

$$\text{Shear: } \text{MaxR}_{S2.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S2.S2.DL}}{\tau_{S2.S2.LL}} \cdot 80 = 154$$

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S3, Span 2: No section loss.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S3.S2.DL} := \frac{M_{S.DL}}{S_x.S3.S2} = 0.53 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S3.S2.DL} := \frac{V_{S.DL}}{A_{\text{plate}.S3.S2}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S3.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S3.S2} = 14.22 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S3.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate}.S3.S2}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S3.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S3.S2.DL}}{\sigma_{S3.S2.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S3.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S3.S2.DL}}{\tau_{S3.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{S3.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S3.S2.DL}}{\sigma_{S3.S2.LL}} \cdot 80 = 155$$

$$\text{Shear: } \text{MaxR}_{S3.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S3.S2.DL}}{\tau_{S3.S2.LL}} \cdot 80 = 154$$

S4, Span 2: No section loss.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S4.S2.DL} := \frac{M_{S.DL}}{S_x.S4.S2} = 0.53 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S4.S2.DL} := \frac{V_{S.DL}}{A_{\text{plate}.S4.S2}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S4.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S4.S2} = 14.22 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S4.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate}.S4.S2}} = 10.76 \cdot \text{ksi}$$

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E-80 Normal Load Rating

Flexure: $R_{S4.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S4.S2.DL}}{\sigma_{S4.S2.LL}} \cdot 80 = 105$

Shear: $R_{S4.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S4.S2.DL}}{\tau_{S4.S2.LL}} \cdot 80 = 89$

E-80 Maximum Load Rating

Flexure: $\text{MaxR}_{S4.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S4.S2.DL}}{\sigma_{S4.S2.LL}} \cdot 80 = 155$

Shear: $\text{MaxR}_{S4.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S4.S2.DL}}{\tau_{S4.S2.LL}} \cdot 80 = 154$

S5, Span 2: No section loss.

Dead Load Stresses

Flexure: $\sigma_{S5.S2.DL} := \frac{M_{S.DL}}{S_x.S5.S2} = 0.53 \cdot \text{ksi}$

Shear: $\tau_{S5.S2.DL} := \frac{V_{S.DL}}{A_{\text{plate}}.S5.S2} = 0.32 \cdot \text{ksi}$

Live Load Stresses

Flexure: $\sigma_{S5.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S5.S2} = 14.22 \cdot \text{ksi}$

Shear: $\tau_{S5.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate}}.S5.S2} = 10.76 \cdot \text{ksi}$

E-80 Normal Load Rating

Flexure: $R_{S5.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S5.S2.DL}}{\sigma_{S5.S2.LL}} \cdot 80 = 105$

Shear: $R_{S5.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S5.S2.DL}}{\tau_{S5.S2.LL}} \cdot 80 = 89$

E-80 Maximum Load Rating

Flexure: $\text{MaxR}_{S5.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S5.S2.DL}}{\sigma_{S5.S2.LL}} \cdot 80 = 155$

Shear: $\text{MaxR}_{S5.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S5.S2.DL}}{\tau_{S5.S2.LL}} \cdot 80 = 154$

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S6, Span 2: No section loss.

Dead Load Stresses

Flexure: $\sigma_{S6.S2.DL} := \frac{M_{S.DL}}{S_x.S6.S2} = 0.53\text{-ksi}$

Shear: $\tau_{S6.S2.DL} := \frac{V_{S.DL}}{A_{plate.S6.S2}} = 0.32\text{-ksi}$

Live Load Stresses

Flexure: $\sigma_{S6.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S6.S2} = 14.22\text{-ksi}$

Shear: $\tau_{S6.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S6.S2}} = 10.76\text{-ksi}$

E-80 Normal Load Rating

Flexure: $R_{S6.S2.\sigma} := \frac{F_{allow.b} - \sigma_{S6.S2.DL}}{\sigma_{S6.S2.LL}} \cdot 80 = 105$

Shear: $R_{S6.S2.\tau} := \frac{F_{allow.v} - \tau_{S6.S2.DL}}{\tau_{S6.S2.LL}} \cdot 80 = 89$

E-80 Maximum Load Rating

Flexure: $MaxR_{S6.S2.\sigma} := \frac{F_{max.b} - \sigma_{S6.S2.DL}}{\sigma_{S6.S2.LL}} \cdot 80 = 155$

Shear: $MaxR_{S6.S2.\tau} := \frac{F_{max.v} - \tau_{S6.S2.DL}}{\tau_{S6.S2.LL}} \cdot 80 = 154$

S7, Span 2: No section loss.

Dead Load Stresses

Flexure: $\sigma_{S7.S2.DL} := \frac{M_{S.DL}}{S_x.S7.S2} = 0.53\text{-ksi}$

Shear: $\tau_{S7.S2.DL} := \frac{V_{S.DL}}{A_{plate.S7.S2}} = 0.32\text{-ksi}$

Live Load Stresses

Flexure: $\sigma_{S7.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S7.S2} = 14.22\text{-ksi}$

Shear: $\tau_{S7.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S7.S2}} = 10.76\text{-ksi}$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{S7.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S7.S2.DL}}{\sigma_{S7.S2.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S7.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S7.S2.DL}}{\tau_{S7.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S7.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S7.S2.DL}}{\sigma_{S7.S2.LL}} \cdot 80 = 155$$

$$\text{Shear: } MaxR_{S7.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S7.S2.DL}}{\tau_{S7.S2.LL}} \cdot 80 = 154$$

S8, Span 2: No section loss.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S8.S2.DL} := \frac{M_{S.DL}}{S_x.S8.S2} = 0.53 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S8.S2.DL} := \frac{V_{S.DL}}{A_{\text{plate}}.S8.S2} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S8.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S8.S2} = 14.22 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S8.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate}}.S8.S2} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S8.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S8.S2.DL}}{\sigma_{S8.S2.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S8.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S8.S2.DL}}{\tau_{S8.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S8.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S8.S2.DL}}{\sigma_{S8.S2.LL}} \cdot 80 = 155$$

$$\text{Shear: } MaxR_{S8.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S8.S2.DL}}{\tau_{S8.S2.LL}} \cdot 80 = 154$$

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S9, Span 2: No section loss.
Dead Load Stresses

Flexure: $\sigma_{S9.S2.DL} := \frac{M_{S.DL}}{S_x.S9.S2} = 0.53\text{-ksi}$

Shear: $\tau_{S9.S2.DL} := \frac{V_{S.DL}}{A_{plate.S9.S2}} = 0.32\text{-ksi}$

Live Load Stresses

Flexure: $\sigma_{S9.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S9.S2} = 14.22\text{-ksi}$

Shear: $\tau_{S9.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S9.S2}} = 10.76\text{-ksi}$

E-80 Normal Load Rating

Flexure: $R_{S9.S2.\sigma} := \frac{F_{allow.b} - \sigma_{S9.S2.DL}}{\sigma_{S9.S2.LL}} \cdot 80 = 105$

Shear: $R_{S9.S2.\tau} := \frac{F_{allow.v} - \tau_{S9.S2.DL}}{\tau_{S9.S2.LL}} \cdot 80 = 89$

E-80 Maximum Load Rating

Flexure: $MaxR_{S9.S2.\sigma} := \frac{F_{max.b} - \sigma_{S9.S2.DL}}{\sigma_{S9.S2.LL}} \cdot 80 = 155$

Shear: $MaxR_{S9.S2.\tau} := \frac{F_{max.v} - \tau_{S9.S2.DL}}{\tau_{S9.S2.LL}} \cdot 80 = 154$

S10, Span 2: No section loss.
Dead Load Stresses

Flexure: $\sigma_{S10.S2.DL} := \frac{M_{S.DL}}{S_x.S10.S2} = 0.53\text{-ksi}$

Shear: $\tau_{S10.S2.DL} := \frac{V_{S.DL}}{A_{plate.S10.S2}} = 0.32\text{-ksi}$

Live Load Stresses

Flexure: $\sigma_{S10.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_x.S10.S2} = 14.22\text{-ksi}$

Shear: $\tau_{S10.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{plate.S10.S2}} = 10.76\text{-ksi}$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{S10.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S10.S2.DL}}{\sigma_{S10.S2.LL}} \cdot 80 = 105$$

$$\text{Shear: } R_{S10.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S10.S2.DL}}{\tau_{S10.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S10.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S10.S2.DL}}{\sigma_{S10.S2.LL}} \cdot 80 = 155$$

$$\text{Shear: } MaxR_{S10.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S10.S2.DL}}{\tau_{S10.S2.LL}} \cdot 80 = 154$$

S11, Span 2: 50% section loss in vertical legs of bottom angles.

Dead Load Stresses

$$\text{Flexure: } \sigma_{S11.S2.DL} := \frac{M_{S.DL}}{S_{x.S11.S2}} = 0.58 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S11.S2.DL} := \frac{V_{S.DL}}{A_{\text{plate.S11.S2}}} = 0.32 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{S11.S2.LL} := \frac{(1 + I_S) \cdot M_{S.LL}}{S_{x.S11.S2}} = 15.43 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{S11.S2.LL} := \frac{(1 + I_S) \cdot V_{S.LL}}{A_{\text{plate.S11.S2}}} = 10.76 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{S11.S2.\sigma} := \frac{F_{\text{allow.b}} - \sigma_{S11.S2.DL}}{\sigma_{S11.S2.LL}} \cdot 80 = 97$$

$$\text{Shear: } R_{S11.S2.\tau} := \frac{F_{\text{allow.v}} - \tau_{S11.S2.DL}}{\tau_{S11.S2.LL}} \cdot 80 = 89$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{S11.S2.\sigma} := \frac{F_{\text{max.b}} - \sigma_{S11.S2.DL}}{\sigma_{S11.S2.LL}} \cdot 80 = 142$$

$$\text{Shear: } MaxR_{S11.S2.\tau} := \frac{F_{\text{max.v}} - \tau_{S11.S2.DL}}{\tau_{S11.S2.LL}} \cdot 80 = 154$$

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Floor Beam Load Rating

Section Properties

Length: $L_{FB} = 15.67 \text{ ft}$

Area: $A_{g,FB} = 48.6 \cdot \text{in}^2$

X-axis inertia: $I_{x,FB} = 25897.09 \cdot \text{in}^4$

Stringer Reactions at Floor Beam Connection

Point DL from stringer: $P_{S,DL} := V_{S,DL} \cdot 2 = 10.52 \cdot \text{kip}$

Point LL from stringer: $P_{S,LL} := R_{S,LL} = 131.1 \cdot \text{kip}$

Load lever arm from end: $a := \frac{L_{FB} - 5\text{ft}}{2} = 5.33 \text{ ft}$

Dead load moment: $M_{FB,dl} := a \cdot P_{S,DL} = 56.12 \cdot \text{kip} \cdot \text{ft}$

Live load moment: $M_{FB,LL} := a \cdot P_{S,LL} = 699.2 \cdot \text{kip} \cdot \text{ft}$

Self Weight: $w_{FB} = 165.38 \cdot \text{plf}$

Increase by 30% for connections.

Total dead load moment: $M_{FB,DL} := M_{FB,dl} + \frac{1.3w_{FB} \cdot L_{FB}^2}{8} = 62.72 \cdot \text{kip} \cdot \text{ft}$

Total dead load shear: $V_{FB,DL} := P_{S,DL} + \frac{1.3 \cdot w_{FB} \cdot L_{FB}}{2} = 12.21 \cdot \text{kip}$

Total live load shear: $V_{FB,LL} := P_{S,LL} = 131.1 \cdot \text{kip}$

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Impact for Floor Beam

Vertical Effect: $VE_{FB} := 40 - \frac{3(L_{FB})^2}{1600 \cdot ft^2} = 39.54\%$

Rocking Effect: $RE_{FB} := 20\%$

Reduce for low speed: Reduction = 0.71

Impact: $I_{FB} := \frac{VE_{FB} \cdot \text{Reduction} + RE_{FB}}{100} = 0.48$

Normal Rating of Floor Beam Dead Load Stresses

Flexure: $\sigma_{FB.DL} := \frac{M_{FB.DL}}{S_{x.FB}} = 0.82 \cdot ksi$

Shear: $\tau_{FB.DL} := \frac{V_{FB.DL}}{A_{plate.FB}} = 0.58 \cdot ksi$

Live Load Stresses

Flexure: $\sigma_{FB.LL} := \frac{(1 + I_{FB}) \cdot M_{FB.LL}}{S_{x.FB}} = 13.56 \cdot ksi$

Shear: $\tau_{FB.LL} := \frac{(1 + I_{FB}) \cdot V_{FB.LL}}{A_{plate.FB}} = 9.25 \cdot ksi$

E-80 Normal Load Rating Without Section Loss

Flexure: $R_{FB.\sigma} := \frac{F_{allow.b} - \sigma_{FB.DL}}{\sigma_{FB.LL}} \cdot 80 = 109$

Shear: $R_{FB.\tau} := \frac{F_{allow.v} - \tau_{FB.DL}}{\tau_{FB.LL}} \cdot 80 = 101$

Maximum Rating of Stringer Without Section Loss

E-80 Maximum Load Rating

Flexure: $MaxR_{FB.\sigma} := \frac{F_{max.b} - \sigma_{FB.DL}}{\sigma_{FB.LL}} \cdot 80 = 160$

Shear: $MaxR_{FB.\tau} := \frac{F_{max.v} - \tau_{FB.DL}}{\tau_{FB.LL}} \cdot 80 = 177$

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Rating for Each Floor Beam in Span 1

FB1, Span 1: No section loss.

Dead Load Stresses

Flexure: $\sigma_{FB1.S1.DL} := \frac{M_{FB.DL}}{S_{x.FB1.S1}} = 0.82 \text{ ksi}$

Shear: $\tau_{FB1.S1.DL} := \frac{V_{FB.DL}}{A_{plate.FB1.S1}} = 0.58 \text{ ksi}$

Live Load Stresses

Flexure: $\sigma_{FB1.S1.LL} := \frac{(1 + I_{FB}) \cdot M_{FB.LL}}{S_{x.FB1.S1}} = 13.56 \text{ ksi}$

Shear: $\tau_{FB1.S1.LL} := \frac{(1 + I_{FB}) \cdot V_{FB.LL}}{A_{plate.FB1.S1}} = 9.25 \text{ ksi}$

E-80 Normal Load Rating

Flexure: $R_{FB1.S1.\sigma} := \frac{F_{allow.b} - \sigma_{FB1.S1.DL}}{\sigma_{FB1.S1.LL}} \cdot 80 = 109$

Shear: $R_{FB1.S1.\tau} := \frac{F_{allow.v} - \tau_{FB1.S1.DL}}{\tau_{FB1.S1.LL}} \cdot 80 = 101$

E-80 Maximum Load Rating

Flexure: $MaxR_{FB1.S1.\sigma} := \frac{F_{max.b} - \sigma_{FB1.S1.DL}}{\sigma_{FB1.S1.LL}} \cdot 80 = 160$

Shear: $MaxR_{FB1.S1.\tau} := \frac{F_{max.v} - \tau_{FB1.S1.DL}}{\tau_{FB1.S1.LL}} \cdot 80 = 177$

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FB2, Span 1: 12"-long x3"-high hole in web at top of stringer connection.
 Dead Load Stresses

Flexure: $\sigma_{FB2.S1.DL} := \frac{M_{FB.DL}}{S_x.FB2.S1} = 0.84 \text{ ksi}$

Shear: $\tau_{FB2.S1.DL} := \frac{V_{FB.DL}}{A_{plate.FB2.S1}} = 0.69 \text{ ksi}$

Live Load Stresses

Flexure: $\sigma_{FB2.S1.LL} := \frac{(1 + I_{FB}) \cdot M_{FB.LL}}{S_x.FB2.S1} = 13.83 \text{ ksi}$

Shear: $\tau_{FB2.S1.LL} := \frac{(1 + I_{FB}) \cdot V_{FB.LL}}{A_{plate.FB2.S1}} = 10.9 \text{ ksi}$

E-80 Normal Load Rating

Flexure: $R_{FB2.S1.\sigma} := \frac{F_{allow.b} - \sigma_{FB2.S1.DL}}{\sigma_{FB2.S1.LL}} \cdot 80 = 106$

Shear: $R_{FB2.S1.\tau} := \frac{F_{allow.v} - \tau_{FB2.S1.DL}}{\tau_{FB2.S1.LL}} \cdot 80 = 85$

E-80 Maximum Load Rating

Flexure: $MaxR_{FB2.S1.\sigma} := \frac{F_{max.b} - \sigma_{FB2.S1.DL}}{\sigma_{FB2.S1.LL}} \cdot 80 = 157$

Shear: $MaxR_{FB2.S1.\tau} := \frac{F_{max.v} - \tau_{FB2.S1.DL}}{\tau_{FB2.S1.LL}} \cdot 80 = 149$

FB3, Span 1: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.
 Dead Load Stresses

Flexure: $\sigma_{FB3.S1.DL} := \frac{M_{FB.DL}}{S_x.FB3.S1} = 0.84 \text{ ksi}$

Shear: $\tau_{FB3.S1.DL} := \frac{V_{FB.DL}}{A_{plate.FB3.S1}} = 0.69 \text{ ksi}$

Live Load Stresses

Flexure: $\sigma_{FB3.S1.LL} := \frac{(1 + I_{FB}) \cdot M_{FB.LL}}{S_x.FB3.S1} = 13.83 \text{ ksi}$

Shear: $\tau_{FB3.S1.LL} := \frac{(1 + I_{FB}) \cdot V_{FB.LL}}{A_{plate.FB3.S1}} = 10.9 \text{ ksi}$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{FB3.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{FB3.S1.DL}}{\sigma_{FB3.S1.LL}} \cdot 80 = 106$$

$$\text{Shear: } R_{FB3.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{FB3.S1.DL}}{\tau_{FB3.S1.LL}} \cdot 80 = 85$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{FB3.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{FB3.S1.DL}}{\sigma_{FB3.S1.LL}} \cdot 80 = 157$$

$$\text{Shear: } MaxR_{FB3.S1.\tau} := \frac{F_{\text{max},v} - \tau_{FB3.S1.DL}}{\tau_{FB3.S1.LL}} \cdot 80 = 149$$

FB4, Span 1: 12"-long x4"-high hole in web at top of stringer connection. Pitting in top flange.

Dead Load Stresses

$$\text{Flexure: } \sigma_{FB4.S1.DL} := \frac{M_{FB.DL}}{S_{x.FB4.S1}} = 0.84 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{FB4.S1.DL} := \frac{V_{FB.DL}}{A_{\text{plate.FB4.S1}}} = 0.7 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{FB4.S1.LL} := \frac{(1 + I_{FB}) \cdot M_{FB.LL}}{S_{x.FB4.S1}} = 13.91 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{FB4.S1.LL} := \frac{(1 + I_{FB}) \cdot V_{FB.LL}}{A_{\text{plate.FB4.S1}}} = 11.14 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{FB4.S1.\sigma} := \frac{F_{\text{allow},b} - \sigma_{FB4.S1.DL}}{\sigma_{FB4.S1.LL}} \cdot 80 = 106$$

$$\text{Shear: } R_{FB4.S1.\tau} := \frac{F_{\text{allow},v} - \tau_{FB4.S1.DL}}{\tau_{FB4.S1.LL}} \cdot 80 = 83$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{FB4.S1.\sigma} := \frac{F_{\text{max},b} - \sigma_{FB4.S1.DL}}{\sigma_{FB4.S1.LL}} \cdot 80 = 156$$

$$\text{Shear: } MaxR_{FB4.S1.\tau} := \frac{F_{\text{max},v} - \tau_{FB4.S1.DL}}{\tau_{FB4.S1.LL}} \cdot 80 = 146$$

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FB5, Span 1: 12"-long x4"-high hole in web at top of stringer connection. Pitting in top flange.
 Dead Load Stresses

$$\text{Flexure: } \sigma_{\text{FB5.S1.DL}} := \frac{M_{\text{FB.DL}}}{S_x.\text{FB5.S1}} = 0.89 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB5.S1.DL}} := \frac{V_{\text{FB.DL}}}{A_{\text{plate.FB5.S1}}} = 0.7 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{\text{FB5.S1.LL}} := \frac{(1 + I_{\text{FB}}) \cdot M_{\text{FB.LL}}}{S_x.\text{FB5.S1}} = 14.76 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB5.S1.LL}} := \frac{(1 + I_{\text{FB}}) \cdot V_{\text{FB.LL}}}{A_{\text{plate.FB5.S1}}} = 11.14 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{\text{FB5.S1.}\sigma} := \frac{F_{\text{allow.b}} - \sigma_{\text{FB5.S1.DL}}}{\sigma_{\text{FB5.S1.LL}}} \cdot 80 = 100$$

$$\text{Shear: } R_{\text{FB5.S1.}\tau} := \frac{F_{\text{allow.v}} - \tau_{\text{FB5.S1.DL}}}{\tau_{\text{FB5.S1.LL}}} \cdot 80 = 83$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{\text{FB5.S1.}\sigma} := \frac{F_{\text{max.b}} - \sigma_{\text{FB5.S1.DL}}}{\sigma_{\text{FB5.S1.LL}}} \cdot 80 = 147$$

$$\text{Shear: } \text{MaxR}_{\text{FB5.S1.}\tau} := \frac{F_{\text{max.v}} - \tau_{\text{FB5.S1.DL}}}{\tau_{\text{FB5.S1.LL}}} \cdot 80 = 146$$

Rating for Each Floor Beam in Span 2

FB1, Span 2: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.
 Dead Load Stresses

$$\text{Flexure: } \sigma_{\text{FB1.S2.DL}} := \frac{M_{\text{FB.DL}}}{S_x.\text{FB1.S2}} = 0.84 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB1.S2.DL}} := \frac{V_{\text{FB.DL}}}{A_{\text{plate.FB1.S2}}} = 0.69 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{\text{FB1.S2.LL}} := \frac{(1 + I_{\text{FB}}) \cdot M_{\text{FB.LL}}}{S_x.\text{FB1.S2}} = 13.83 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB1.S2.LL}} := \frac{(1 + I_{\text{FB}}) \cdot V_{\text{FB.LL}}}{A_{\text{plate.FB1.S2}}} = 10.9 \cdot \text{ksi}$$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{FB1.S2.\sigma} := \frac{F_{\text{allow},b} - \sigma_{FB1.S2.DL}}{\sigma_{FB1.S2.LL}} \cdot 80 = 106$$

$$\text{Shear: } R_{FB1.S2.\tau} := \frac{F_{\text{allow},v} - \tau_{FB1.S2.DL}}{\tau_{FB1.S2.LL}} \cdot 80 = 85$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{FB1.S2.\sigma} := \frac{F_{\text{max},b} - \sigma_{FB1.S2.DL}}{\sigma_{FB1.S2.LL}} \cdot 80 = 157$$

$$\text{Shear: } MaxR_{FB1.S2.\tau} := \frac{F_{\text{max},v} - \tau_{FB1.S2.DL}}{\tau_{FB1.S2.LL}} \cdot 80 = 149$$

FB2, Span 2: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.

Dead Load Stresses

$$\text{Flexure: } \sigma_{FB2.S2.DL} := \frac{M_{FB.DL}}{S_x.FB2.S2} = 0.84 \text{ ksi}$$

$$\text{Shear: } \tau_{FB2.S2.DL} := \frac{V_{FB.DL}}{A_{\text{plate.FB2.S2}}} = 0.69 \text{ ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{FB2.S2.LL} := \frac{(1 + I_{FB}) \cdot M_{FB.LL}}{S_x.FB2.S2} = 13.83 \text{ ksi}$$

$$\text{Shear: } \tau_{FB2.S2.LL} := \frac{(1 + I_{FB}) \cdot V_{FB.LL}}{A_{\text{plate.FB2.S2}}} = 10.9 \text{ ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{FB2.S2.\sigma} := \frac{F_{\text{allow},b} - \sigma_{FB2.S2.DL}}{\sigma_{FB2.S2.LL}} \cdot 80 = 106$$

$$\text{Shear: } R_{FB2.S2.\tau} := \frac{F_{\text{allow},v} - \tau_{FB2.S2.DL}}{\tau_{FB2.S2.LL}} \cdot 80 = 85$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{FB2.S2.\sigma} := \frac{F_{\text{max},b} - \sigma_{FB2.S2.DL}}{\sigma_{FB2.S2.LL}} \cdot 80 = 157$$

$$\text{Shear: } MaxR_{FB2.S2.\tau} := \frac{F_{\text{max},v} - \tau_{FB2.S2.DL}}{\tau_{FB2.S2.LL}} \cdot 80 = 149$$

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FB3, Span 2: 12"-long x3"-high hole in web at top of stringer connection, like FB2, Span 1.

Dead Load Stresses

$$\text{Flexure: } \sigma_{\text{FB3.S2.DL}} := \frac{M_{\text{FB.DL}}}{S_{x,\text{FB3.S2}}} = 0.84 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB3.S2.DL}} := \frac{V_{\text{FB.DL}}}{A_{\text{plate.FB3.S2}}} = 0.69 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{\text{FB3.S2.LL}} := \frac{(1 + I_{\text{FB}}) \cdot M_{\text{FB.LL}}}{S_{x,\text{FB3.S2}}} = 13.83 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB3.S2.LL}} := \frac{(1 + I_{\text{FB}}) \cdot V_{\text{FB.LL}}}{A_{\text{plate.FB3.S2}}} = 10.9 \cdot \text{ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{\text{FB3.S2.}\sigma} := \frac{F_{\text{allow.b}} - \sigma_{\text{FB3.S2.DL}}}{\sigma_{\text{FB3.S2.LL}}} \cdot 80 = 106$$

$$\text{Shear: } R_{\text{FB3.S2.}\tau} := \frac{F_{\text{allow.v}} - \tau_{\text{FB3.S2.DL}}}{\tau_{\text{FB3.S2.LL}}} \cdot 80 = 85$$

E-80 Maximum Load Rating

$$\text{Flexure: } \text{MaxR}_{\text{FB3.S2.}\sigma} := \frac{F_{\text{max.b}} - \sigma_{\text{FB3.S2.DL}}}{\sigma_{\text{FB3.S2.LL}}} \cdot 80 = 157$$

$$\text{Shear: } \text{MaxR}_{\text{FB3.S2.}\tau} := \frac{F_{\text{max.v}} - \tau_{\text{FB3.S2.DL}}}{\tau_{\text{FB3.S2.LL}}} \cdot 80 = 149$$

FB4, Span 2: 12"-long x2"-high area of 80% section loss in web at top of stringer connection.
 1" hole in web above bottom flanges.

Dead Load Stresses

$$\text{Flexure: } \sigma_{\text{FB4.S2.DL}} := \frac{M_{\text{FB.DL}}}{S_{x,\text{FB4.S2}}} = 0.83 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB4.S2.DL}} := \frac{V_{\text{FB.DL}}}{A_{\text{plate.FB4.S2}}} = 0.65 \cdot \text{ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{\text{FB4.S2.LL}} := \frac{(1 + I_{\text{FB}}) \cdot M_{\text{FB.LL}}}{S_{x,\text{FB4.S2}}} = 13.71 \cdot \text{ksi}$$

$$\text{Shear: } \tau_{\text{FB4.S2.LL}} := \frac{(1 + I_{\text{FB}}) \cdot V_{\text{FB.LL}}}{A_{\text{plate.FB4.S2}}} = 10.36 \cdot \text{ksi}$$

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E-80 Normal Load Rating

$$\text{Flexure: } R_{FB4.S2.\sigma} := \frac{F_{\text{allow},b} - \sigma_{FB4.S2.DL}}{\sigma_{FB4.S2.LL}} \cdot 80 = 107$$

$$\text{Shear: } R_{FB4.S2.\tau} := \frac{F_{\text{allow},v} - \tau_{FB4.S2.DL}}{\tau_{FB4.S2.LL}} \cdot 80 = 90$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{FB4.S2.\sigma} := \frac{F_{\text{max},b} - \sigma_{FB4.S2.DL}}{\sigma_{FB4.S2.LL}} \cdot 80 = 159$$

$$\text{Shear: } MaxR_{FB4.S2.\tau} := \frac{F_{\text{max},v} - \tau_{FB4.S2.DL}}{\tau_{FB4.S2.LL}} \cdot 80 = 157$$

FB5, Span 2: 11"-long x3"-high hole in web at top of stringer connection.

Dead Load Stresses

$$\text{Flexure: } \sigma_{FB5.S2.DL} := \frac{M_{FB.DL}}{S_{x.FB5.S2}} = 0.84 \text{ ksi}$$

$$\text{Shear: } \tau_{FB5.S2.DL} := \frac{V_{FB.DL}}{A_{\text{plate.FB5.S2}}} = 0.69 \text{ ksi}$$

Live Load Stresses

$$\text{Flexure: } \sigma_{FB5.S2.LL} := \frac{(1 + I_{FB}) \cdot M_{FB.LL}}{S_{x.FB5.S2}} = 13.83 \text{ ksi}$$

$$\text{Shear: } \tau_{FB5.S2.LL} := \frac{(1 + I_{FB}) \cdot V_{FB.LL}}{A_{\text{plate.FB5.S2}}} = 10.9 \text{ ksi}$$

E-80 Normal Load Rating

$$\text{Flexure: } R_{FB5.S2.\sigma} := \frac{F_{\text{allow},b} - \sigma_{FB5.S2.DL}}{\sigma_{FB5.S2.LL}} \cdot 80 = 106$$

$$\text{Shear: } R_{FB5.S2.\tau} := \frac{F_{\text{allow},v} - \tau_{FB5.S2.DL}}{\tau_{FB5.S2.LL}} \cdot 80 = 85$$

E-80 Maximum Load Rating

$$\text{Flexure: } MaxR_{FB5.S2.\sigma} := \frac{F_{\text{max},b} - \sigma_{FB5.S2.DL}}{\sigma_{FB5.S2.LL}} \cdot 80 = 157$$

$$\text{Shear: } MaxR_{FB5.S2.\tau} := \frac{F_{\text{max},v} - \tau_{FB5.S2.DL}}{\tau_{FB5.S2.LL}} \cdot 80 = 149$$

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Type	Member	Span	Normal Flexure Rating E-	Normal Shear Rating E-	Maximum Flexure Rating E-	Maximum Shear Rating E-
Stringer	S0	1	99	89	146	154
Stringer	S1	1	104	89	152	154
Stringer	S2	1	99	89	146	154
Stringer	S3	1	105	88	154	152
Stringer	S4	1	76	89	111	154
Stringer	S5	1	102	89	150	154
Stringer	S6	1	105	89	155	154
Stringer	S7	1	98	89	144	154
Stringer	S8	1	93	89	137	154
Stringer	S9	1	99	89	146	154
Stringer	S10	1	105	89	155	154
Stringer	S11	1	90	89	133	154
Stringer	S0	2	105	89	155	154
Stringer	S1	2	105	89	155	154
Stringer	S2	2	105	89	155	154
Stringer	S3	2	105	89	155	154
Stringer	S4	2	105	89	155	154
Stringer	S5	2	105	89	155	154
Stringer	S6	2	105	89	155	154
Stringer	S7	2	105	89	155	154
Stringer	S8	2	105	89	155	154
Stringer	S9	2	105	89	155	154
Stringer	S10	2	105	89	155	154
Stringer	S11	2	97	89	142	154
Floorbeam	FB1	1	109	101	160	177
Floorbeam	FB2	1	106	85	157	149
Floorbeam	FB3	1	106	85	157	149
Floorbeam	FB4	1	106	83	156	146
Floorbeam	FB5	1	100	83	147	146
Floorbeam	FB1	2	106	85	157	149
Floorbeam	FB2	2	106	85	157	149
Floorbeam	FB3	2	106	85	157	149
Floorbeam	FB4	2	107	90	159	157
Floorbeam	FB5	2	106	85	157	149

Max. (Stringer per Plans)	105	89	155	154
Min. (Stringer w/Sec. Loss)	76	88	111	152

Max. (Floorbeam per Plans)	109	101	160	177
Min. (Floorbeam w/Sec. Loss)	100	83	147	146

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Moment and Shear in Stringers

Values for a 20 foot span at 1/10*L increments. See STAAD.Pro output attached.

Moment (kip-ft)	0.1*L	0.2*L	0.3*L	0.4*L	0.5*L	0.6*L	0.7*L	0.8*L	0.9*L	1.0*L
E-80	336.00	544.00	704.00	816.00	824.00	824.00	816.00	704.00	544.00	336.00
263-kip	224.40	352.24	446.75	518.16	562.25	554.20	523.59	439.28	371.28	225.76
286-kip	246.67	364.65	526.24	564.24	605.67	628.48	609.18	504.07	397.54	248.82
315-kip	229.95	459.90	540.23	612.67	685.12	685.91	607.95	522.90	437.85	242.55
Shear (kip)	0.1*L	0.2*L	0.3*L	0.4*L	0.5*L	0.6*L	0.7*L	0.8*L	0.9*L	1.0*L
E-80	200.00	152.00	120.00	96.00	70.40	-84.00	-108.00	-136.00	-168.00	-200.00
263-kip	135.66	112.20	87.72	71.74	56.78	-54.40	-68.34	-92.82	-99.62	-129.54
286-kip	135.66	123.35	91.16	73.44	61.13	-56.49	-77.94	-92.82	-124.41	-133.76
315-kip	135.66	114.97	114.97	79.54	56.10	-62.21	-85.84	-92.82	-121.28	-156.71

Equivalent Load Ratings

Stringers

Moments

Equivalent Rating to E-80

$$M_{E80} := 824 \text{ kip}\cdot\text{ft}$$

$$M_{263} := 562.25 \text{ kip}\cdot\text{ft}$$

$$\frac{M_{263}}{M_{E80}} \cdot 80 = 55$$

$$M_{286} := 628.48 \text{ kip}\cdot\text{ft}$$

$$\frac{M_{286}}{M_{E80}} \cdot 80 = 61$$

$$M_{315} := 685.91 \text{ kip}\cdot\text{ft}$$

$$\frac{M_{315}}{M_{E80}} \cdot 80 = 67$$

Shears

$$V_{E80} := 200 \text{ kip}$$

$$V_{263} := 135.66 \text{ kip}$$

$$\frac{V_{263}}{V_{E80}} \cdot 80 = 54$$

$$V_{286} := 135.66 \text{ kip}$$

$$\frac{V_{286}}{V_{E80}} \cdot 80 = 54$$

$$V_{315} := 156.71 \text{ kip}$$

$$\frac{V_{315}}{V_{E80}} \cdot 80 = 63$$

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Floor Beams

The rail does not rest on the floorbeams, instead the shears from the stringers is transferred to the floor beams. Therefore the rating equivalents loads for the floorbeam are the same as those for the shear in the stringers.

Moment Equivalent Rating to E-80

$$V_{E80} \cdot 4.75\text{ft} = 950 \cdot \text{kip}\cdot\text{ft}$$

$$\frac{V_{263} \cdot 4.75\text{ft}}{V_{E80} \cdot 4.75\text{ft}} \cdot 80 = 54$$

$$\frac{V_{286} \cdot 4.75\text{ft}}{V_{E80} \cdot 4.75\text{ft}} \cdot 80 = 54$$

$$\frac{V_{315} \cdot 4.75\text{ft}}{V_{E80} \cdot 4.75\text{ft}} \cdot 80 = 63$$

Shears

$$V_{E80} = 200 \cdot \text{kip}$$

$$\frac{V_{263}}{V_{E80}} \cdot 80 = 54$$

$$\frac{V_{286}}{V_{E80}} \cdot 80 = 54$$

$$\frac{V_{315}}{V_{E80}} \cdot 80 = 63$$

Ratings		Normal	Maximum	263-kip Unit Train	286-kip Unit Train	315-kip Unit Train
Stringers	Flexure	E-76	E-111	E-55	E-61	E-67
	Shear	E-88	E-152	E-54	E-54	E-63
Floor Beams	Flexure	E-100	E-147	E-54	E-54	E-63
	Shear	E-83	E-146	E-54	E-54	E-63

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 Approved _____ Date _____
 Title SCCRTC Br. MP 19.43
 Superstructure Rating



Job No. 252.1
 Sheet _____ of _____
 By M. Ponce Date 8/31/12

Stringer Repair Calculations

Stringers S4, and S11 in Span 1 (S0 and S7 on the repair plans)

Bolt plate 1/2"x12" to the bottom flange for the entire length of the stringer.

Plate thickness: $t_{plate} := \frac{1}{2} \text{ in}$

Bolts to be used: A325 Bolts

Bolt diameter: $d_{bolt} := \frac{7}{8} \text{ in}$

Bolt area: $A_{bolt} := \frac{d_{bolt}^2 \cdot \pi}{4} = 0.6 \cdot \text{in}^2$

Bolt shear strength: $\tau_{bolt} := 17 \text{ ksi}$

Bolt capacity: $V_{boltCap} := A_{bolt} \cdot \tau_{bolt} = 10.22 \cdot \text{kip}$

Determining the necessary bolt spacing to transfer the horizontal shears.

$$S_r := \frac{V_r \cdot Q}{I} \quad (\text{kips/in}) \quad \text{AREMA (15-1.7.9.2j)}$$

Composite Inertia: $I_{wPlates} := \left[\frac{1}{12} \left[\frac{3}{8} \text{ in} \cdot (44 \text{ in})^3 \right] + 4 \cdot I_y \cdot \text{angle.S} \dots + \frac{1}{12} \cdot 2 \cdot \left[12 \text{ in} \cdot (t_{plate})^3 \right] \dots + 4A_{angle.S} \left(\frac{44.5 \text{ in}}{2} - x_{angle.S} \right)^2 \dots + 2 \cdot (12 \text{ in} \cdot t_{plate}) \cdot \left(\frac{44.5 \text{ in}}{2} + \frac{t_{plate}}{2} \right)^2 \right] = 19268 \cdot \text{in}^4$

Static Moment: $Q := (12 \text{ in} \cdot t_{plate}) \cdot \left(\frac{44.5 \text{ in}}{2} + t_{plate} \right) = 136 \cdot \text{in}^3$

Shear Load at ends: $V_{r.End} := V_{E80}$

The bolt spacing from the quarter points to the end will be determined from this shear value.

Horizontal shear at ends: $S_{r.End} := \frac{V_{r.End} \cdot Q}{I_{wPlates}} = 1.42 \cdot \frac{\text{kip}}{\text{in}}$

Bolt spacing at ends: $s_{bolt.End} := \frac{2 \cdot V_{boltCap}}{S_{r.End}} = 1.2 \text{ ft}$

Checked _____ Date _____
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Job No. 252.1 _____
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By M. Ponce Date 8/31/12

Shear Load at 0.30*L: $V_{r.Mid} := 120\text{kip}$

The bolt spacing between the quarter points (the middle) will be determined from this shear value.

Horizontal shear at ends: $S_{r.Mid} := \frac{V_{r.Mid} \cdot Q}{I_{wPlates}} = 0.85 \cdot \frac{\text{kip}}{\text{in}}$

Bolt spacing in the middle: $s_{bolt.Mid} := \frac{2 \cdot V_{boltCap}}{S_{r.Mid}} = 2 \text{ ft}$

Minimum spacing of bolts: $s_{min} := \frac{2 \cdot d_{bolt} f_p}{F_u} + \frac{d_{bolt}}{2}$ AREMA (15-1.9.3b)

or $3 \cdot d_{bolt} = 2.63 \cdot \text{in}$

Bearing stress on bolt: $f_p := \frac{\frac{S_{r.End} \cdot s_{bolt.End}}{2}}{(d_{bolt} \cdot t_{plate})} = 23.37 \cdot \text{ksi}$

Tensile strength: $F_u := 60 \text{ ksi}$

Minimum spacing of bolts: $s_{min} := \max \left(3d_{bolt}, \frac{2 \cdot d_{bolt} f_p}{F_u} + \frac{d_{bolt}}{2} \right) = 2.63 \cdot \text{in}$

Maximum spacing of bolts: $s_{max} := \min(4\text{in} + 4 \cdot t_{plate}, 7\text{in}) = 6 \cdot \text{in}$ AREMA (15-1.5.13)

Minimum edge distance: $s_{min.Edge} := \frac{2 \cdot d_{bolt} f_p}{F_u} = 0.68 \cdot \text{in}$

Maximum edge distance: $s_{max.Edge} := \min(1.5\text{in} + 4 \cdot t_{plate}, 6\text{in}) = 3.5 \cdot \text{in}$

Use 7/8" bolts on both long edges spaced at 6" throughout, 2-1/2" from edge.

Checked _____ Date _____
Approved _____ Date _____
Title SCCRTC Br. MP 19.43
Superstructure Rating



Job No. 252.1
Sheet of
By M. Ponce Date 8/31/12

Attachments

```
*****
* STAAD.Pro V8i SELECTseries2
* Version 20.07.07.32
* Proprietary Program of
* Bentley Systems, Inc.
* Date= AUG 10, 2012
* Time= 11:13:48
*
* USER ID:
*****
```

```
1. STAAD SPACE MP 19.43 OF SCCRTC, RATING CALC.
INPUT FILE: MP-19.43.STD
2. START JOB INFORMATION
3. JOB NAME SCCRTC BRIDGE RATING- SAN LORENZO BRIDGE
4. JOB NO 252.1
5. JOB COMMENT LOAD CASE 1 IS FOR 1 KIPS/FT DEAD LOAD
6. JOB COMMENT LOAD CASE 2 TO 51 ARE FOR E-1 LOADING
7. JOB COMMENT LOAD CASE 52 TO 111 ARE FOR 286-KIP UNIT-TRAIN LOADING
8. JOB COMMENT LOAD CASE 112 TO 171 ARE FOR 315-KIP UNIT-TRAIN LOADING
9. JOB COMMENT LOAD CASE 172 TO 231 ARE FOR 263-KIP UNIT-TRAIN LOADING
10. ENGINEER DATE 08-10-12
11. ENGINEER DATE 08-10-12
12. ENGINEER NAME M. PONCE
13. END JOB INFORMATION
14. INPUT WIDTH 79
15. UNIT FEET KIP
16. JOINT COORDINATES
17. 1 0 0 0; 2 2 0 0; 3 4 0 0; 4 6 0 0; 5 8 0 0; 6 10 0 0; 7 12 0 0; 8 14 0 0
18. 9 16 0 0; 10 18 0 0; 11 20 0 0
19. MEMBER INCIDENCES
20. 1 1 2; 2 2 3; 3 3 4; 4 4 5; 5 5 6; 6 6 7; 7 7 8; 8 8 9; 9 9 10; 10 10 11
21. DEFINE PMEMBER
22. 1 PMEMBER 1
23. DEFINE MATERIAL START
24. ISOTROPIC STEEL
25. E 4.176E+006
26. POISSON 0.3
27. DENSITY 0.489024
28. ALPHA 6.5E-006
29. DAMP 0.03
30. END DEFINE MATERIAL
31. MEMBER PROPERTY AMERICAN
32. 1 TO 9 -
33. 10 PRIS AX 0.8188 AY 0.8188 AZ 0.8188 IX 0.01 IY 0.05821 IZ 9.3717 -
34. YD 8.17 ZD 1.5
35. CONSTANTS
36. MATERIAL STEEL ALL
37. SUPPORTS
38. 1 PINNED
39. 11 FIXED BUT FX MY MZ
40. DEFINE MOVING LOAD
```

WARNING- One or more lines are too long and will be split into 2 lines.

This may not work for all commands. Please check.

41. TYPE 1 LOAD 0.5 1 1 1 1 0.65 0.65 0.65 0.65 0.5 1 1 1 1 0.65 0.65 0.65 0.65 -
 42. 0.5 -
 43. 1 1 1 1 0.65 0.65 0.65 0.65
 44. DIST 8 5 5 5 9 5 6 5 8 8 5 5 5 9 5 6 5 8 8 5 5 5 9 5 6 5
 45. TYPE 2 LOAD 68 68 68 68 68 68 68 68 71.5 71.5 71.5 71.5 71.5 71.5 71.5 71.5 71.5
 46. DIST 6.7 6.7 13.7 6.7 6.7 33.9 6.7 6.7 10.2 5.8 30.3 6.7 5.8 5.8 30.3 6.7
 47. TYPE 3 LOAD 68 68 68 68 68 68 68 68 78.75 78.75 78.75 78.75 78.75 78.75 78.75 -
 48. 78.75 78.75
 49. DIST 6.7 6.7 13.7 6.7 6.7 33.9 6.7 6.7 10.1 6 35.2 6 6.5 6 35.2 6
 50. TYPE 4 LOAD 68 68 68 68 68 68 68 68 68 68 65.75 65.75 65.75 65.75 65.75 -
 51. 65.75 65.75 65.75 65.75 65.75 65.75 65.75 65.75
 52. DIST 6.7 6.7 33.9 6.7 6.7 13.7 6.7 6.7 33.9 6.7 6.7 10.2 5.8 30.3 6.7 5.8 5.8 -
 53. 30.3 6.7 5.8 5.8 30.3 5.8
 54. * DEAD LOAD
 55. LOAD 1 LOADTYPE DEAD TITLE DEAD LOAD
 56. MEMBER LOAD
 57. 1 TO 10 UNI Y -4.763
 58. * E-1 LOADING
 59. LOAD GENERATION 50
 60. TYPE 1 -119 0 0 XINC 3
 61. * 286-KIP UNIT TRAIN
 62. LOAD GENERATION 60
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 1 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 2 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 3 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 4 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 5 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 6 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 7 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 8 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 9 OF 27
 **WARNING-A MOVING LOAD THAT WOULD HAVE BEEN APPLIED BEYOND THE X AND Z RANGES
 OF THE STRUCTURE HAS BEEN IGNORED. CASE= 2 WHEEL 10 OF 27
 *ADDITIONAL MOVING LOAD MESSAGES SUPPRESSED
 *ADDITIONAL MOVING LOAD MESSAGES SUPPRESSED
 63. TYPE 2 -135 0 0 XINC 3
 64. * 315-KIP UNIT TRAIN
 65. LOAD GENERATION 60
 66. TYPE 3 -135 0 0 XINC 3
 67. * 263-KIP UNIT TRAIN
 68. LOAD GENERATION 60
 69. TYPE 4 -135 0 0 XINC 3
 70. PERFORM ANALYSIS

PROBLEM STATISTICS

NUMBER OF JOINTS/MEMBER+ELEMENTS/SUPPORTS = 11/ 10/ 2

SOLVER USED IS THE OUT-OF-CORE BASIC SOLVER

ORIGINAL/FINAL BAND-WIDTH= 1/ 1/ 12 DOF
TOTAL PRIMARY LOAD CASES = 231, TOTAL DEGREES OF FREEDOM = 60
SIZE OF STIFFNESS MATRIX = 1 DOUBLE KILO-WORDS
REQRD/AVAIL. DISK SPACE = 12.3/-972785.9 MB

**** WARNING : AVAILABLE HARD DISK SPACE MAY NOT BE
ENOUGH TO COMPLETE EXECUTION. IF YOUR AVAILABLE HARD DISK
SPACE ON THE ANALYSIS DRIVE IS GREATER THAN 3GB THIS MESSAGE
MAY BE ERRONEOUS

71. * THE FOLLOWING OUTPUTS ARE FOR DEAD LOAD
72. LOAD LIST 1
73. PRINT MAXFORCE ENVELOPE ALL

MEMBER FORCE ENVELOPE

ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

MEMB	FY/	DIST	LD	MZ/	DIST	LD	FX	DIST	LD
	FZ	DIST	LD	MY	DIST	LD			
1 MAX	47.63	0.00	1	0.00	0.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	38.10	2.00	1	-85.73	2.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
2 MAX	38.10	0.00	1	-85.73	0.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	28.58	2.00	1	-152.42	2.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
3 MAX	28.58	0.00	1	-152.42	0.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	19.05	2.00	1	-200.05	2.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
4 MAX	19.05	0.00	1	-200.05	0.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	9.53	2.00	1	-228.62	2.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
5 MAX	9.53	0.00	1	-228.62	0.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	0.00	2.00	1	-238.15	2.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
6 MAX	0.00	0.00	1	-228.62	2.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	-9.53	2.00	1	-238.15	0.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
7 MAX	-9.53	0.00	1	-200.05	2.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	-19.05	2.00	1	-228.62	0.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
8 MAX	-19.05	0.00	1	-152.42	2.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			
MIN	-28.58	2.00	1	-200.05	0.00	1	0.00	2.00	1
	0.00	2.00	1	0.00	2.00	1			
9 MAX	-28.58	0.00	1	-85.73	2.00	1	0.00	0.00	1
	0.00	0.00	1	0.00	0.00	1			

MP 19.43 OF SCCRTC, RATING CALC.

-- PAGE NO.

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MIN	-38.10	2.00	1	-152.42	0.00	1			
	0.00	2.00	1	0.00	2.00	1	0.00	2.00	1
10 MAX	-38.10	0.00	1	0.00	2.00	1			
	0.00	0.00	1	0.00	0.00	1	0.00	0.00	1
MIN	-47.63	2.00	1	-85.73	0.00	1			
	0.00	2.00	1	0.00	2.00	1	0.00	2.00	1

***** END OF FORCE ENVELOPE FROM INTERNAL STORAGE *****

74. * THE FOLLOWING OUTPUTS ARE FOR E-1 LOADING

75. LOAD LIST 2 TO 51

76. PRINT MAXFORCE ENVELOPE ALL

MEMBER FORCE ENVELOPE

ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

MEMB	FY/ FZ	DIST	LD	MZ/ MY	DIST	LD	FX	DIST	LD
		DIST	LD		DIST	LD			
1 MAX	2.50	0.00	39	0.00	0.00	2			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	0.00	2.00	51	-4.20	2.00	21			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
2 MAX	1.90	0.00	40	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	0.00	2.00	51	-6.80	2.00	3			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
3 MAX	1.50	0.00	22	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	-0.19	2.00	36	-8.80	2.00	2			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
4 MAX	1.20	0.00	4	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	-0.45	2.00	18	-10.20	2.00	40			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
5 MAX	0.88	0.00	42	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	-0.58	2.00	37	-10.30	1.00	3			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
6 MAX	0.58	0.00	24	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	-1.05	2.00	38	-10.30	1.00	2			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
7 MAX	0.33	0.00	6	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	-1.35	2.00	20	-10.20	0.00	21			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
8 MAX	0.10	0.00	47	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	-1.70	2.00	2	-8.80	0.00	3			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
9 MAX	0.03	0.00	48	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2

E-1
↓

MP 19.43 OF SCCRTC, RATING CALC.

-- PAGE NO. 7

MIN	-2.10	2.00	40	-6.80	0.00	2			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51
10 MAX	0.03	0.00	48	0.00	0.00	49			
	0.00	0.00	2	0.00	0.00	2	0.00	0.00	2
MIN	-2.50	2.00	22	-4.20	0.00	40			
	0.00	2.00	51	0.00	2.00	51	0.00	2.00	51

***** END OF FORCE ENVELOPE FROM INTERNAL STORAGE *****

77. * THE FOLLOWING OUTPUTS ARE FOR 286-KIP UNIT-TRAIN LOADING

78. LOAD LIST 52 TO 111

79. PRINT MAXFORCE ENVELOPE ALL

MEMBER FORCE ENVELOPE

ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

MEMB	FY/ FZ	DIST	LD	MZ/ MY	DIST	LD	FX	DIST	LD
		DIST	LD		DIST	LD			
1 MAX	135.66	0.00	97	0.00	0.00	52			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-6.44	2.00	63	-246.67	2.00	53			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
2 MAX	123.34	0.00	53	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-6.44	2.00	63	-364.65	2.00	54			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
3 MAX	91.16	0.00	54	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-17.16	2.00	64	-526.24	2.00	52			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
4 MAX	73.44	0.00	90	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-35.04	2.00	65	-564.85	2.00	53			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
5 MAX	61.13	0.00	55	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-43.86	1.83	71	-605.67	0.83	53			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
6 MAX	40.89	0.00	68	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-56.49	2.00	66	-628.48	1.50	52			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
7 MAX	30.94	0.00	92	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-77.94	2.00	67	-609.18	0.00	52			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
8 MAX	21.09	0.00	57	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52
MIN	-92.82	1.83	73	-504.07	0.00	53			
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111
9 MAX	10.37	0.00	58	0.00	0.00	59			
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52

286 k ↓

MP 19.43 OF SCCRTC, RATING CALC.

-- PAGE NO. 9

MIN	-124.41	2.00	52	-397.54	0.00	52				
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111	
10 MAX	0.00	0.00	59	0.00	0.00	59				
	0.00	0.00	52	0.00	0.00	52	0.00	0.00	52	
MIN	-133.76	2.00	69	-248.82	0.00	52				
	0.00	2.00	111	0.00	2.00	111	0.00	2.00	111	

***** END OF FORCE ENVELOPE FROM INTERNAL STORAGE *****

80. * THE FOLLOWING OUTPUTS ARE FOR 315-KIP UNIT-TRAIN LOADING

81. LOAD LIST 112 TO 171

82. PRINT MAXFORCE ENVELOPE ALL

MEMBER FORCE ENVELOPE

ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

MEMB	FY/	DIST	LD	MZ/	DIST	LD	FX	DIST	LD
	FZ	DIST	LD	MY	DIST	LD			
1 MAX	135.66	0.00	157	0.00	0.00	112			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-7.48	2.00	123	-229.95	2.00	125			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
2 MAX	114.97	0.00	112	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-7.48	2.00	123	-459.90	2.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
3 MAX	114.97	0.00	112	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-19.29	2.00	124	-540.23	2.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
4 MAX	79.54	0.00	113	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-38.59	2.00	125	-612.67	2.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
5 MAX	56.10	0.00	135	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-43.47	1.83	131	-685.12	2.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
6 MAX	54.34	0.00	114	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-62.21	2.00	126	-685.91	0.17	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
7 MAX	30.94	0.00	152	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-85.84	2.00	127	-607.95	0.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
8 MAX	19.04	0.00	137	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-92.82	1.83	133	-522.90	0.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
9 MAX	15.36	0.00	116	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112

315 K ↓

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MIN	-121.28	2.00	112	-437.85	0.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171
10 MAX	3.54	0.00	117	0.00	0.00	118			
	0.00	0.00	112	0.00	0.00	112	0.00	0.00	112
MIN	-156.71	2.00	113	-242.55	0.00	112			
	0.00	2.00	171	0.00	2.00	171	0.00	2.00	171

***** END OF FORCE ENVELOPE FROM INTERNAL STORAGE *****

83. * THE FOLLOWING OUTPUTS ARE FOR 263-KIP UNIT-TRAIN LOADING

84. LOAD LIST 172 TO 231

85. PRINT MAXFORCE ENVELOPE ALL

MEMBER FORCE ENVELOPE

ALL UNITS ARE KIP FEET

MAX AND MIN FORCE VALUES AMONGST ALL SECTION LOCATIONS

MEMB	FY/	DIST	LD	MZ/	DIST	LD	FX	DIST	LD
	FZ	DIST	LD	MY	DIST	LD			
1 MAX	135.66	0.00	217	0.00	0.00	172			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-4.76	2.00	213	-224.40	2.00	202			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
2 MAX	112.20	0.00	202	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-12.92	1.83	189	-352.24	2.00	218			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
3 MAX	87.72	0.00	178	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-14.96	1.83	214	-446.75	2.00	219			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
4 MAX	71.74	0.00	192	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-27.54	2.00	215	-518.16	2.00	177			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
5 MAX	56.78	0.00	204	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-43.86	1.83	191	-562.25	1.67	218			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
6 MAX	44.37	0.00	172	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-54.40	2.00	203	-554.20	0.00	218			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
7 MAX	21.42	0.00	181	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-68.34	2.00	217	-523.59	0.00	203			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
8 MAX	19.38	0.00	206	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172
MIN	-92.82	2.00	193	-439.28	0.00	177			
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231
9 MAX	11.22	0.00	182	0.00	0.00	184			
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172

263 k ↓

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MIN	-99.62	2.00	205	-371.28	0.00	193					
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231		
10 MAX	1.02	0.00	183	0.00	0.00	184					
	0.00	0.00	172	0.00	0.00	172	0.00	0.00	172		
MIN	-129.54	2.00	219	-225.76	0.00	178					
	0.00	2.00	231	0.00	2.00	231	0.00	2.00	231		

***** END OF FORCE ENVELOPE FROM INTERNAL STORAGE *****

86. FINISH

***** END OF THE STAAD.Pro RUN *****

**** DATE= AUG 10, 2012 TIME= 11:13:56 ****

 * For questions on STAAD.Pro, please contact *
 * Bentley Systems or Partner offices *
 *
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 *

Friday, August 10, 2012, 12:59 PM

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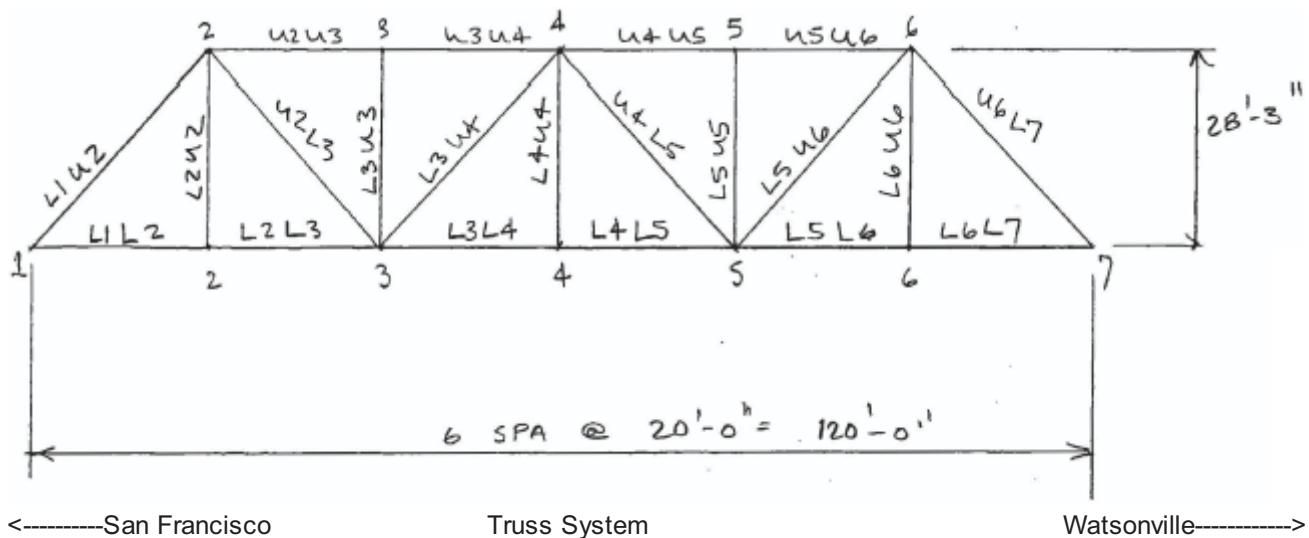


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 By M. Ponce Date 8/31/12

SCCRTC-San Lorenzo River-Spans 1 & 2

Steel Warren ThroughTruss- Properties Calculations

By M. Ponce



<-----San Francisco

Truss System

Watsonville----->

Note: Member numbering in these calculations follows numbering in prior ratings calculation and does not necessarily match MMI's numbering, but properties do.

Member Section Properties

L1U2 & U6L7 END POSTS

(L0U1 on as-built plans Sheet 2)

Gross Section: 2 channels- C15x55
 1 plate 7/16"x18"
 Lattice on bottom is not included in section.

Gross area of Section (Sheet 1): $A_{g,L1U2} := 40.24 \text{ in}^2$

Area of Plate: $A_{plate,L1U2} := 18 \text{ in} \cdot \left(\frac{7}{16} \text{ in} \right) = 7.87 \cdot \text{in}^2$

Area of Channel: $A_{ch,L1U2} := \frac{A_{g,L1U2} - A_{plate,L1U2}}{2} = 16.18 \cdot \text{in}^2$

Vertical c.g.: $y_{L1U2} := \frac{\left(15 \text{ in} + \frac{7}{32} \text{ in} \right) \cdot A_{plate,L1U2} + \frac{15 \text{ in}}{2} \cdot A_{ch,L1U2} \cdot 2}{A_{g,L1U2}} = 9.01 \cdot \text{in}$

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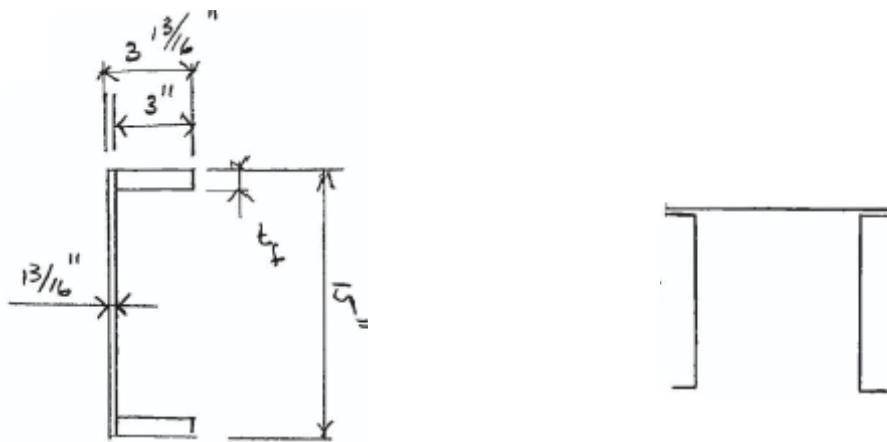
There is limited info available for the C15x55 channel from Sheet 2. Therefore work backwards from known information to determine flange thickness.

Channel web thickness: $\frac{13}{16}$ in

Channel depth: 15 in

Channel flange width: $3 + \frac{13}{16}$ in

Use a channel with the following dimensions.



Gross area of channel: $A_{g.ch.L1U2} := 15\text{in} \cdot \left(\frac{13}{16}\text{in}\right) + 3\text{in} \cdot (t_f.L1U2) \cdot 2$

Flange thickness on channel: $t_f.L1U2 := \frac{A_{ch.L1U2} - 15\text{in} \cdot \left(\frac{13}{16}\text{in}\right)}{6\text{in}} = 0.67 \cdot \text{in}$

Inertia of channel about x-axis: $I_{x.ch.L1U2} := \left[\frac{1}{12} \cdot \left(\frac{13}{16} \text{in} \cdot (15\text{in})^3 + 3\text{in} \cdot (t_f.L1U2)^3 \cdot 2 \right) \dots \right] = 433.87 \cdot \text{in}^4$
 $\left[+ 2 \cdot (t_f.L1U2) \cdot 3\text{in} \cdot \left(\frac{15\text{in}}{2} - \frac{t_f.L1U2}{2} \right)^2 \right]$

Y-axis channel c.g.: $x_{ch.L1U2} := \frac{15\text{in} \left(\frac{13}{16} \text{in} \right) \cdot \frac{13}{32} \text{in} + 2 \cdot (3\text{in}) \cdot t_f.L1U2 \cdot \left(\frac{13}{16} \text{in} + 1.5\text{in} \right)}{A_{ch.L1U2}} = 0.88 \cdot \text{in}$

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Inertia of channel about y-axis: $I_{y, \text{ch}, L1U2} := \left[\frac{1}{12} \left[15\text{in} \cdot \left(\frac{13}{16}\text{in} \right)^3 + 2 \cdot (t_f, L1U2) \cdot (3\text{in})^3 \right] \dots + 15\text{in} \left(\frac{13}{16}\text{in} \right) \cdot \left(x_{\text{ch}, L1U2} - \frac{13}{32}\text{in} \right)^2 \dots + 2 \cdot 3\text{in} \cdot (t_f, L1U2) \cdot \left(\frac{13}{16}\text{in} + 1.5\text{in} - x_{\text{ch}, L1U2} \right)^2 \right] = 14.6 \cdot \text{in}^4$

X-axis inertia of section: $I_{x, L1U2} := \left[\frac{1}{12} \cdot 18\text{in} \cdot \left(\frac{7}{16}\text{in} \right)^3 + 2 \cdot (I_{x, \text{ch}, L1U2}) \dots + A_{\text{plate}, L1U2} \cdot \left(15\text{in} + \frac{7}{32}\text{in} - y_{L1U2} \right)^2 \dots + 2 \cdot A_{\text{ch}, L1U2} \cdot \left(\frac{15\text{in}}{2} - y_{L1U2} \right)^2 \right] = 1245.24 \cdot \text{in}^4$

Y-axis inertia of section: $I_{y, L1U2} := \left[\frac{1}{12} \cdot \left(\frac{7}{16}\text{in} \right) \cdot (18\text{in})^3 + 2 \cdot I_{y, \text{ch}, L1U2} \dots + 2 \cdot (A_{\text{ch}, L1U2}) \cdot \left[\frac{18\text{in}}{2} - \left[\left(3 + \frac{13}{16} \right) \text{in} - x_{\text{ch}, L1U2} \right]^2 \right] \right] = 1432.09 \cdot \text{in}^4$

X radius of gyration: $r_{x, L1U2} := \sqrt{\frac{I_{x, L1U2}}{A_{g, L1U2}}} = 5.56 \cdot \text{in}$

Y radius of gyration: $r_{y, L1U2} := \sqrt{\frac{I_{y, L1U2}}{A_{g, L1U2}}} = 5.97 \cdot \text{in}$

Rivet hole size: $\text{hole} := \frac{15}{16}\text{in}$

Channel rivet holes: $\text{holes}_{\text{ch}, L1U2} := 2 \cdot 4 \cdot \text{hole} \cdot \frac{13}{16}\text{in} = 6.09 \cdot \text{in}^2$

Top plate rivet holes: $\text{holes}_{\text{plate}, L1U2} := 2 \cdot \text{hole} \cdot \left(\frac{7}{16}\text{in} + t_f, L1U2 \right) = 2.07 \cdot \text{in}^2$

Gross area of section: $A_{g, L1U2} = 40.24 \cdot \text{in}^2$

Net area of section: $A_{n, L1U2} := A_{g, L1U2} - \text{holes}_{\text{ch}, L1U2} - \text{holes}_{\text{plate}, L1U2} = 32.08 \cdot \text{in}^2$

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L1U2 & U6L7 END POSTS Properties for Any Section Loss

Span 1

L1U2 Right, Span 1: No section loss.

$$\text{Gross Area: } A_g.L1U2.RS1 := A_g.L1U2 = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_n.L1U2.RS1 := A_n.L1U2 = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_x.L1U2.RS1 := I_x.L1U2 = 1245 \cdot \text{in}^4$$

$$I_y.L1U2.RS1 := I_y.L1U2 = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_x.L1U2.RS1 := r_x.L1U2 = 5.56 \cdot \text{in}$$

$$r_y.L1U2.RS1 := r_y.L1U2 = 5.97 \cdot \text{in}$$

L1U2 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_g.L1U2.LS1 := A_g.L1U2 = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_n.L1U2.LS1 := A_n.L1U2 = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_x.L1U2.LS1 := I_x.L1U2 = 1245 \cdot \text{in}^4$$

$$I_y.L1U2.LS1 := I_y.L1U2 = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_x.L1U2.LS1 := r_x.L1U2 = 5.56 \cdot \text{in}$$

$$r_y.L1U2.LS1 := r_y.L1U2 = 5.97 \cdot \text{in}$$

U6L7 Right, Span 1: No section loss.

$$\text{Gross Area: } A_g.U6L7.RS1 := A_g.L1U2 = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_n.U6L7.RS1 := A_n.L1U2 = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_x.U6L7.RS1 := I_x.L1U2 = 1245 \cdot \text{in}^4$$

$$I_y.U6L7.RS1 := I_y.L1U2 = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_x.U6L7.RS1 := r_x.L1U2 = 5.56 \cdot \text{in}$$

$$r_y.U6L7.RS1 := r_y.L1U2 = 5.97 \cdot \text{in}$$

U6L7 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_g.U6L7.LS1 := A_g.L1U2 = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_n.U6L7.LS1 := A_n.L1U2 = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_x.U6L7.LS1 := I_x.L1U2 = 1245 \cdot \text{in}^4$$

$$I_y.U6L7.LS1 := I_y.L1U2 = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_x.U6L7.LS1 := r_x.L1U2 = 5.56 \cdot \text{in}$$

$$r_y.U6L7.LS1 := r_y.L1U2 = 5.97 \cdot \text{in}$$

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Span 2

L1U2 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,L1U2.RS2} := A_{g,L1U2} = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L1U2.RS2} := A_{n,L1U2} = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L1U2.RS2} := I_{x,L1U2} = 1245 \cdot \text{in}^4$$

$$I_{y,L1U2.RS2} := I_{y,L1U2} = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L1U2.RS2} := r_{x,L1U2} = 5.56 \cdot \text{in}$$

$$r_{y,L1U2.RS2} := r_{y,L1U2} = 5.97 \cdot \text{in}$$

L1U2 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,L1U2.LS2} := A_{g,L1U2} = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L1U2.LS2} := A_{n,L1U2} = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L1U2.LS2} := I_{x,L1U2} = 1245 \cdot \text{in}^4$$

$$I_{y,L1U2.LS2} := I_{y,L1U2} = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L1U2.LS2} := r_{x,L1U2} = 5.56 \cdot \text{in}$$

$$r_{y,L1U2.LS2} := r_{y,L1U2} = 5.97 \cdot \text{in}$$

U6L7 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,U6L7.RS2} := A_{g,L1U2} = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U6L7.RS2} := A_{n,L1U2} = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U6L7.RS2} := I_{x,L1U2} = 1245 \cdot \text{in}^4$$

$$I_{y,U6L7.RS2} := I_{y,L1U2} = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U6L7.RS2} := r_{x,L1U2} = 5.56 \cdot \text{in}$$

$$r_{y,U6L7.RS2} := r_{y,L1U2} = 5.97 \cdot \text{in}$$

U6L7 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,U6L7.LS2} := A_{g,L1U2} = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U6L7.LS2} := A_{n,L1U2} = 32.08 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U6L7.LS2} := I_{x,L1U2} = 1245 \cdot \text{in}^4$$

$$I_{y,U6L7.LS2} := I_{y,L1U2} = 1432 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U6L7.LS2} := r_{x,L1U2} = 5.56 \cdot \text{in}$$

$$r_{y,U6L7.LS2} := r_{y,L1U2} = 5.97 \cdot \text{in}$$

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U2U3, U3U4, U4U5 & U5U6 TOP CHORDS

(U1U3 on as-built plans Sheet 2)

Gross Section (Sheet 1): 2 channels- C15x40
 1 plate 7/16"x18"
 Lattice on bottom is not included in section.

Gross Area of Section: $A_{g,U2U3} := 31.40 \text{ in}^2$

C15x40:

Gross Area: $A_{ch,U2U3} := 11.8 \text{ in}^2$

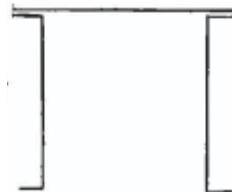
Inertia about X-axis: $I_{x,ch,U2U3} := 349 \text{ in}^4$

Inertia about Y-axis: $I_{y,ch,U2U3} := 9.23 \text{ in}^4$

Y-axis c.g.: $x_{ch,U2U3} := 0.778 \text{ in}$

Web thickness: $t_{w,U2U3} := 0.52 \text{ in}$

Flange thickness: $t_{f,U2U3} := 0.65 \text{ in}$



X-axis c.g. for section: $y_{U2U3} := \frac{18\text{in} \cdot \left(\frac{7}{16}\text{in}\right) \cdot \left(15\text{in} + \frac{7}{32}\text{in}\right) + 2 \cdot (A_{ch,U2U3}) \cdot \left(\frac{15}{2}\text{in}\right)}{A_{g,U2U3}} = 9.45 \cdot \text{in}$

X-axis inertia of section: $I_{x,U2U3} := \left[\frac{1}{12} 18\text{in} \cdot \left(\frac{7}{16}\text{in}\right)^3 \dots + 18\text{in} \cdot \left(\frac{7}{16}\text{in}\right) \cdot \left(15\text{in} + \frac{7}{32}\text{in} - y_{U2U3}\right)^2 \dots + 2 \cdot A_{ch,U2U3} \cdot \left(\frac{15\text{in}}{2} - y_{U2U3}\right)^2 + 2 \cdot I_{x,ch,U2U3} \right] = 1050 \cdot \text{in}^4$

Y-axis inertia of section: $I_{y,U2U3} := \left[\frac{1}{12} \cdot \left(\frac{7}{16}\text{in}\right) \cdot (18\text{in})^3 + 2 \cdot (I_{y,ch,U2U3}) \dots + 2 \cdot A_{ch,U2U3} \cdot \left[\frac{18\text{in}}{2} - (3.52\text{in} - x_{ch,U2U3})\right]^2 \right] = 1155.32 \cdot \text{in}^4$

X radius of gyration: $r_{x,U2U3} := \sqrt{\frac{I_{x,U2U3}}{A_{g,U2U3}}} = 5.78 \cdot \text{in}$

Y radius of gyration: $r_{y,U2U3} := \sqrt{\frac{I_{y,U2U3}}{A_{g,U2U3}}} = 6.07 \cdot \text{in}$

Channel rivet holes: $\text{holes}_{ch,U2U3} := 2 \cdot 4 \cdot \text{hole} \cdot t_{w,U2U3} = 3.9 \cdot \text{in}^2$

Top plate rivet holes: $\text{holes}_{plate,U2U3} := 2 \cdot \text{hole} \cdot \left(\frac{7}{16}\text{in} + t_{f,U2U3}\right) = 2.04 \cdot \text{in}^2$

Gross area of section: $A_{g,U2U3} = 31.4 \cdot \text{in}^2$

Net area of section: $A_{n,U2U3} := A_{g,U2U3} - \text{holes}_{ch,U2U3} - \text{holes}_{plate,U2U3} = 25.46 \cdot \text{in}^2$

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U2U3, U3U4, U4U5 & U5U6 TOP CHORDS Properties for Any Section Loss

Span 1

U2U3 Right, Span 1: No section loss.

$$\text{Gross Area: } A_{g.U2U3.RS1} := A_{g.U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.U2U3.RS1} := A_{nU2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x.U2U3.RS1} := I_{x.U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y.U2U3.RS1} := I_{y.U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x.U2U3.RS1} := r_{x.U2U3} = 5.78 \cdot \text{in}$$

$$r_{yU2U3.RS1} := r_{yU2U3} = 6.07 \cdot \text{in}$$

U2U3 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_{g.U2U3.LS1} := A_{g.U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.U2U3.LS1} := A_{nU2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x.U2U3.LS1} := I_{x.U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y.U2U3.LS1} := I_{y.U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x.U2U3.LS1} := r_{x.U2U3} = 5.78 \cdot \text{in}$$

$$r_{yU2U3.LS1} := r_{yU2U3} = 6.07 \cdot \text{in}$$

U3U4 Right, Span 1: No section loss.

$$\text{Gross Area: } A_{g.U3U4.RS1} := A_{g.U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.U3U4.RS1} := A_{nU2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x.U3U4.RS1} := I_{x.U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y.U3U4.RS1} := I_{y.U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x.U3U4.RS1} := r_{x.U2U3} = 5.78 \cdot \text{in}$$

$$r_{yU3U4.RS1} := r_{yU2U3} = 6.07 \cdot \text{in}$$

U3U4 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_{g.U3U4.LS1} := A_{g.U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n.U3U4.LS1} := A_{nU2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x.U3U4.LS1} := I_{x.U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y.U3U4.LS1} := I_{y.U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x.U3U4.LS1} := r_{x.U2U3} = 5.78 \cdot \text{in}$$

$$r_{yU3U4.LS1} := r_{yU2U3} = 6.07 \cdot \text{in}$$

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U4U5 Right, Span 1: No section loss.

Gross Area: $A_g.U4U5.RS1 := A_g.U2U3 = 31.4 \cdot \text{in}^2$

Net Area: $A_n.U4U5.RS1 := A_n.U2U3 = 25.46 \cdot \text{in}^2$

Inertias: $I_x.U4U5.RS1 := I_x.U2U3 = 1050 \cdot \text{in}^4$

$I_y.U4U5.RS1 := I_y.U2U3 = 1155 \cdot \text{in}^4$

R. of gyration: $r_x.U4U5.RS1 := r_x.U2U3 = 5.78 \cdot \text{in}$

$r_y.U4U5.RS1 := r_y.U2U3 = 6.07 \cdot \text{in}$

U4U5 Left, Span 1: No Section loss.

Gross Area: $A_g.U4U5.LS1 := A_g.U2U3 = 31.4 \cdot \text{in}^2$

Net Area: $A_n.U4U5.LS1 := A_n.U2U3 = 25.46 \cdot \text{in}^2$

Inertias: $I_x.U4U5.LS1 := I_x.U2U3 = 1050 \cdot \text{in}^4$

$I_y.U4U5.LS1 := I_y.U2U3 = 1155 \cdot \text{in}^4$

R. of gyration: $r_x.U4U5.LS1 := r_x.U2U3 = 5.78 \cdot \text{in}$

$r_y.U4U5.LS1 := r_y.U2U3 = 6.07 \cdot \text{in}$

U5U6 Right, Span 1: No section loss.

Gross Area: $A_g.U5U6.RS1 := A_g.U2U3 = 31.4 \cdot \text{in}^2$

Net Area: $A_n.U5U6.RS1 := A_n.U2U3 = 25.46 \cdot \text{in}^2$

Inertias: $I_x.U5U6.RS1 := I_x.U2U3 = 1050 \cdot \text{in}^4$

$I_y.U5U6.RS1 := I_y.U2U3 = 1155 \cdot \text{in}^4$

R. of gyration: $r_x.U5U6.RS1 := r_x.U2U3 = 5.78 \cdot \text{in}$

$r_y.U5U6.RS1 := r_y.U2U3 = 6.07 \cdot \text{in}$

U5U6 Left, Span 1: No Section loss.

Gross Area: $A_g.U5U6.LS1 := A_g.U2U3 = 31.4 \cdot \text{in}^2$

Net Area: $A_n.U5U6.LS1 := A_n.U2U3 = 25.46 \cdot \text{in}^2$

Inertias: $I_x.U5U6.LS1 := I_x.U2U3 = 1050 \cdot \text{in}^4$

$I_y.U5U6.LS1 := I_y.U2U3 = 1155 \cdot \text{in}^4$

R. of gyration: $r_x.U5U6.LS1 := r_x.U2U3 = 5.78 \cdot \text{in}$

$r_y.U5U6.LS1 := r_y.U2U3 = 6.07 \cdot \text{in}$

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Span 2

U2U3 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,U2U3.RS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U2U3.RS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U2U3.RS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U2U3.RS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U2U3.RS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U2U3.RS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

U2U3 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,U2U3.LS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U2U3.LS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U2U3.LS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U2U3.LS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U2U3.LS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U2U3.LS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

U3U4 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,U3U4.RS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U3U4.RS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U3U4.RS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U3U4.RS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U3U4.RS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U3U4.RS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

U3U4 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,U3U4.LS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U3U4.LS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U3U4.LS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U3U4.LS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U3U4.LS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U3U4.LS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

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U4U5 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,U4U5.RS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U4U5.RS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U4U5.RS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U4U5.RS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U4U5.RS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U4U5.RS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

U4U5 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,U4U5.LS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U4U5.LS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U4U5.LS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U4U5.LS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U4U5.LS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U4U5.LS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

U5U6 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,U5U6.RS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U5U6.RS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U5U6.RS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U5U6.RS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U5U6.RS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U5U6.RS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

U5U6 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,U5U6.LS2} := A_{g,U2U3} = 31.4 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U5U6.LS2} := A_{n,U2U3} = 25.46 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U5U6.LS2} := I_{x,U2U3} = 1050 \cdot \text{in}^4$$

$$I_{y,U5U6.LS2} := I_{y,U2U3} = 1155 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U5U6.LS2} := r_{x,U2U3} = 5.78 \cdot \text{in}$$

$$r_{y,U5U6.LS2} := r_{y,U2U3} = 6.07 \cdot \text{in}$$

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L3U4 & U4L5 MAIN DIAGONALS

(U3L2 on as-built plans Sheet 3)

Gross Section: 2 channels- C12x35
4 plates 7/16"x 3-1/2"
Lattice on top and bottom is not included in section.

Gross area of Section (Sheet 1): $A_g.L3U4 := 26.70 \text{ in}^2$

Area of Plate: $A_{plate.L3U4} := 3.5 \text{ in} \cdot \left(\frac{7}{16} \text{ in} \right) = 1.53 \cdot \text{in}^2$

Area of Channels: $A_{ch.L3U4} := \frac{A_g.L3U4 - 4 \cdot A_{plate.L3U4}}{2} = 10.29 \cdot \text{in}^2$

There is limited info available for the C12x35 channel from Sheet 2. Therefore work backwards from known information to determine flange thickness.

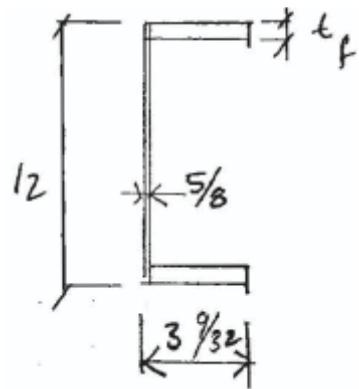
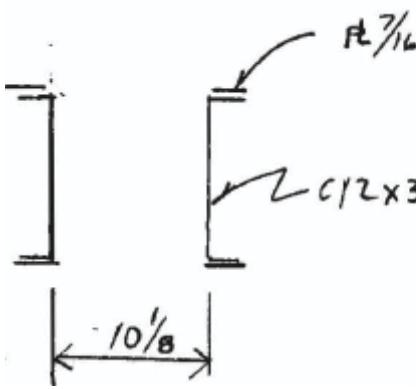
Channel web thickness: $\frac{5}{8} \text{ in}$

Channel depth: 12in

Channel flange width: $3 + \frac{9}{32} \text{ in}$

Short leg width: $l_s.L3U4 := \left(3 + \frac{9}{32} \right) \text{ in} - \frac{5}{8} \text{ in} = 2.66 \cdot \text{in}$

Use a channel with the following dimensions.



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Gross area of channel: $A_{g.ch.L3U4} := 12\text{in} \cdot \left(\frac{5}{8}\text{in}\right) + l_{s.L3U4} \cdot (t_{f.L3U4}) \cdot 2$

Flange thickness on channel: $t_{f.L3U4} := \frac{A_{ch.L3U4} - 12\text{in} \cdot \left(\frac{5}{8}\text{in}\right)}{l_{s.L3U4} \cdot 2} = 0.52\text{-in}$

X-axis c.g. of section: $y_{L3U4} := \frac{12\text{in} + 2 \cdot \frac{7}{16}\text{in}}{2} = 6.44\text{-in}$

Inertia of channel about x-axis: $I_{x.ch.L3U4} := \left[\frac{1}{12} \cdot \left[\frac{5}{8}\text{in} \cdot (12\text{in})^3 + l_{s.L3U4} \cdot (t_{f.L3U4})^3 \right] \dots \right] = 181.8 \cdot \text{in}^4$
 $\left[+ 2 \cdot (t_{f.L3U4}) \cdot l_{s.L3U4} \left(\frac{12\text{in}}{2} - \frac{t_{f.L3U4}}{2} \right)^2 \right]$

Y-axis channel c.g.: $x_{ch.L3U4} := \frac{12\text{in} \left(\frac{5}{8}\text{in} \right) \cdot \frac{5}{16}\text{in} + 2 \cdot (l_{s.L3U4}) \cdot t_{f.L3U4} \cdot \left(\frac{5}{8}\text{in} + \frac{l_{s.L3U4}}{2} \right)}{A_{ch.L3U4}} = 0.76\text{-in}$

Inertia of channel about y-axis: $I_{y.ch.L3U4} := \left[\frac{1}{12} \left[12\text{in} \cdot \left(\frac{5}{8}\text{in} \right)^3 + 2 \cdot (t_{f.L3U4}) \cdot (l_{s.L3U4})^3 \right] \dots \right] = 7.35 \cdot \text{in}^4$
 $\left[+ 12\text{in} \left(\frac{5}{8}\text{in} \right) \cdot \left(x_{ch.L3U4} - \frac{5}{16}\text{in} \right)^2 \dots \right]$
 $\left[+ 2 \cdot l_{s.L3U4} \cdot (t_{f.L3U4}) \cdot \left(\frac{5}{8}\text{in} + \frac{l_{s.L3U4}}{2} - x_{ch.L3U4} \right)^2 \right]$

X-axis inertia of section: $I_{x.L3U4} := \left[\frac{1}{12} \cdot 4(3.5\text{in}) \left(\frac{7}{16}\text{in} \right)^3 + 2 \cdot (I_{x.ch.L3U4}) \dots \right] = 600.57 \cdot \text{in}^4$
 $\left[+ 4A_{plate.L3U4} \left[\left(\frac{7}{32}\text{in} \right) - y_{L3U4} \right]^2 \right]$

Y-axis inertia of section: $I_{y.L3U4} := \left[\frac{1}{12} \cdot 4 \left(\frac{7}{16}\text{in} \right) \cdot (3.5\text{in})^3 + 2 \cdot I_{y.ch.L3U4} \dots \right] = 1002.04 \cdot \text{in}^4$
 $\left[+ 2 \cdot (A_{ch.L3U4}) \cdot \left[\frac{\left(10 + \frac{1}{8} \right)\text{in}}{2} + x_{ch.L3U4} \right]^2 \dots \right]$
 $\left[+ 4A_{plate.L3U4} \left[\frac{\left(10 + \frac{1}{8} \right)\text{in}}{2} + \frac{3.5\text{in}}{2} \right]^2 \right]$

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X radius of gyration: $r_{x,L3U4} := \sqrt{\frac{I_{x,L3U4}}{A_{g,L3U4}}} = 4.74 \cdot \text{in}$

Y radius of gyration: $r_{y,L3U4} := \sqrt{\frac{I_{y,L3U4}}{A_{g,L3U4}}} = 6.13 \cdot \text{in}$

Channel rivet holes: $\text{holes}_{ch,L3U4} := 2 \cdot 3 \cdot \text{hole} \cdot \frac{5}{8} \text{in} = 3.52 \cdot \text{in}^2$

Top plate rivet holes: $\text{holes}_{plate,L3U4} := 2 \cdot 2 \cdot \text{hole} \cdot \left(\frac{7}{16} \text{in} + t_{f,L3U4} \right) = 3.61 \cdot \text{in}^2$

Gross area of section: $A_{g,L3U4} = 26.7 \cdot \text{in}^2$

Net area of section: $A_{n,L3U4} := A_{g,L3U4} - \text{holes}_{ch,L3U4} - \text{holes}_{plate,L3U4} = 19.58 \cdot \text{in}^2$

L3U4 & U4L5 MAIN DIAGONALS Properties for Any Section Loss

Span 1

L3U4 Right, Span 1: 50% section loss on top plates.

Gross Area: $A_{g,L3U4.RS1} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$

Net Area: $A_{n,L3U4.RS1} := A_{n,L3U4} - 0.5 \cdot 2 \cdot A_{plate,L3U4} = 18.04 \cdot \text{in}^2$

Inertias: $I_{x,L3U4.RS1} := \left[\frac{1}{12} \cdot 3 \left(3.5 \text{in} \right) \left(\frac{7}{16} \text{in} \right)^3 + 2 \cdot (I_{x,ch,L3U4}) \dots \right] = 541 \cdot \text{in}^4$
 $+ 3A_{plate,L3U4} \cdot \left[\left(\frac{7}{32} \text{in} \right) - y_{L3U4} \right]^2$

$$I_{y,L3U4.RS1} := \left[\frac{1}{12} \cdot 3 \left(\frac{7}{16} \text{in} \right) \cdot (3.5 \text{in})^3 + 2 \cdot I_{y,ch,L3U4} \dots \right] = 929 \cdot \text{in}^4$$

 $+ 2 \cdot (A_{ch,L3U4}) \cdot \left[\frac{\left(10 + \frac{1}{8} \right) \text{in}}{2} + x_{ch,L3U4} \right]^2$
 $+ 3A_{plate,L3U4} \cdot \left[\frac{\left(10 + \frac{1}{8} \right) \text{in}}{2} + \frac{3.5 \text{in}}{2} \right]^2$

R. of gyration: $r_{x,L3U4.RS1} := \sqrt{\frac{I_{x,L3U4.RS1}}{A_{g,L3U4.RS1}}} = 4.5 \cdot \text{in}$

$r_{y,L3U4.RS1} := \sqrt{\frac{I_{y,L3U4.RS1}}{A_{g,L3U4.RS1}}} = 5.9 \cdot \text{in}$

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L3U4 Left, Span 1: No Section loss.

Gross Area: $A_{g,L3U4,LS1} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$

Net Area: $A_{n,L3U4,LS1} := A_{n,L3U4} = 19.58 \cdot \text{in}^2$

Inertias: $I_{x,L3U4,LS1} := I_{x,L3U4} = 601 \cdot \text{in}^4$

$$I_{y,L3U4,LS1} := I_{y,L3U4} = 1002 \cdot \text{in}^4$$

R. of gyration: $r_{x,L3U4,LS1} := r_{x,L3U4} = 4.74 \cdot \text{in}$

$$r_{y,L3U4,LS1} := r_{y,L3U4} = 6.13 \cdot \text{in}$$

U4L5 Right, Span 1: 50% section loss on top plates.

Gross Area: $A_{g,U4L5,RS1} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$

Net Area: $A_{n,U4L5,RS1} := A_{n,L3U4} - 0.5 \cdot 2 \cdot A_{\text{plate},L3U4} = 18.04 \cdot \text{in}^2$

Inertias: $I_{x,U4L5,RS1} := \left[\frac{1}{12} \cdot 3(3.5\text{in}) \left(\frac{7}{16} \text{in} \right)^3 + 2 \cdot (I_{x,\text{ch},L3U4}) \dots \right] = 541 \cdot \text{in}^4$
 $+ 3A_{\text{plate},L3U4} \left[\left(\frac{7}{32} \text{in} \right) - y_{L3U4} \right]^2$

$$I_{y,U4L5,RS1} := \left[\frac{1}{12} \cdot 3 \left(\frac{7}{16} \text{in} \right) \cdot (3.5\text{in})^3 + 2 \cdot I_{y,\text{ch},L3U4} \dots \right] = 929 \cdot \text{in}^4$$

 $+ 2 \cdot (A_{\text{ch},L3U4}) \cdot \left[\frac{\left(10 + \frac{1}{8} \right) \text{in}}{2} + x_{\text{ch},L3U4} \dots \right]^2$
 $+ 3A_{\text{plate},L3U4} \cdot \left[\frac{\left(10 + \frac{1}{8} \right) \text{in}}{2} + \frac{3.5\text{in}}{2} \right]^2$

R. of gyration: $r_{x,U4L5,RS1} := \sqrt{\frac{I_{x,L3U4,RS1}}{A_{g,L3U4,RS1}}} = 4.5 \cdot \text{in}$

$$r_{y,U4L5,RS1} := \sqrt{\frac{I_{y,L3U4,RS1}}{A_{g,L3U4,RS1}}} = 5.9 \cdot \text{in}$$

U4L5 Left, Span 1: No Section loss.

Gross Area: $A_{g,U4L5,LS1} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$

Net Area: $A_{n,U4L5,LS1} := A_{n,L3U4} = 19.58 \cdot \text{in}^2$

Inertias: $I_{x,U4L5,LS1} := I_{x,L3U4} = 601 \cdot \text{in}^4$

$$I_{y,U4L5,LS1} := I_{y,L3U4} = 1002 \cdot \text{in}^4$$

R. of gyration: $r_{x,U4L5,LS1} := r_{x,L3U4} = 4.74 \cdot \text{in}$

$$r_{y,U4L5,LS1} := r_{y,L3U4} = 6.13 \cdot \text{in}$$

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Span 2

L3U4 Right, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,L3U4.RS2} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3U4.RS2} := A_{n,L3U4} = 19.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L3U4.RS2} := I_{x,L3U4} = 601 \cdot \text{in}^4$$

$$I_{y,L3U4.RS2} := I_{y,L3U4} = 1002 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L3U4.RS2} := r_{x,L3U4} = 4.74 \cdot \text{in}$$

$$r_{y,L3U4.RS2} := r_{y,L3U4} = 6.13 \cdot \text{in}$$

L3U4 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,L3U4.LS2} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3U4.LS2} := A_{n,L3U4} = 19.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L3U4.LS2} := I_{x,L3U4} = 601 \cdot \text{in}^4$$

$$I_{y,L3U4.LS2} := I_{y,L3U4} = 1002 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L3U4.LS2} := r_{x,L3U4} = 4.74 \cdot \text{in}$$

$$r_{y,L3U4.LS2} := r_{y,L3U4} = 6.13 \cdot \text{in}$$

U4L5 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,U4L5.RS2} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U4L5.RS2} := A_{n,L3U4} = 19.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U4L5.RS2} := I_{x,L3U4} = 601 \cdot \text{in}^4$$

$$I_{y,U4L5.RS2} := I_{y,L3U4} = 1002 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U4L5.RS2} := r_{x,L3U4} = 4.74 \cdot \text{in}$$

$$r_{y,U4L5.RS2} := r_{y,L3U4} = 6.13 \cdot \text{in}$$

U4L5 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,U4L5.LS2} := A_{g,L3U4} = 26.7 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U4L5.LS2} := A_{n,L3U4} = 19.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U4L5.LS2} := I_{x,L3U4} = 601 \cdot \text{in}^4$$

$$I_{y,U4L5.LS2} := I_{y,L3U4} = 1002 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U4L5.LS2} := r_{x,L3U4} = 4.74 \cdot \text{in}$$

$$r_{y,U4L5.LS2} := r_{y,L3U4} = 6.13 \cdot \text{in}$$

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L3L4 & L4L5 BOTTOM CHORDS

(L2L2 on as-built plans Sheet 3)

Gross Section: 4 angles- L6x3-1/2x13/16
 1 plate 8-1/2"x13/16"

Gross area of Section (Sheet 1): $A_{g,L3L4} := 35.15 \text{ in}^2$

Area of Plate: $A_{plate,L3L4} := 8.5 \text{ in} \cdot \left(\frac{13}{16} \text{ in}\right) = 6.91 \cdot \text{in}^2$

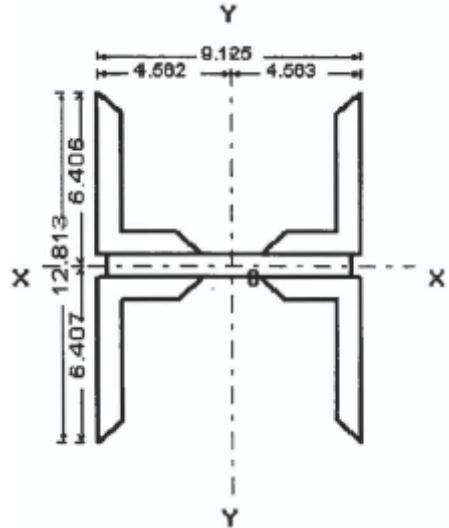
Area of Angles: $A_{angle,L3L4} := \frac{A_{g,L3L4} - A_{plate,L3L4}}{4} = 7.06 \cdot \text{in}^2$

Angle L6x3-1/2x13/16 is not in the steel manual.
 Therefore section properties need to be calculated.

Angle thickness: $\frac{13}{16} \text{ in}$

Angle depth: 6in

Angle width: $\left(3 + \frac{1}{2}\right) \text{ in}$



Short leg width: $l_{s,L3L4} := 3.5 \text{ in} - \frac{13}{16} \text{ in} = 2.69 \cdot \text{in}$

X-axis c.g. of angle: $y_{angle,L3L4} := \frac{\left(6 \text{ in} \cdot \frac{13}{16} \text{ in}\right) \cdot 3 \text{ in} + \left(l_{s,L3L4} \cdot \frac{13}{16} \text{ in}\right) \cdot \frac{13}{32} \text{ in}}{A_{angle,L3L4}} = 2.2 \cdot \text{in}$

Y-axis c.g. of angle: $x_{angle,L3L4} := \frac{\left(6 \text{ in} \cdot \frac{13}{16} \text{ in}\right) \cdot \frac{13}{32} \text{ in} + \left(l_{s,L3L4} \cdot \frac{13}{16} \text{ in}\right) \cdot \left(\frac{13}{16} \text{ in} + \frac{l_{s,L3L4}}{2}\right)}{A_{angle,L3L4}} = 0.95 \cdot \text{in}$

Inertia of angle about x-axis: $I_{x,angle,L3L4} := \left[\frac{1}{12} \cdot \frac{13}{16} \text{ in} \cdot (6 \text{ in})^3 + \frac{1}{12} \cdot l_{s,L3L4} \left(\frac{13}{16} \text{ in}\right)^3 \dots + \left(6 \text{ in} \cdot \frac{13}{16} \text{ in}\right) \cdot (3 \text{ in} - y_{angle,L3L4})^2 \dots + \left(l_{s,L3L4} \cdot \frac{13}{16} \text{ in}\right) \cdot \left(\frac{13}{32} \text{ in} - y_{angle,L3L4}\right)^2 \right] = 24.89 \cdot \text{in}^4$

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Inertia of angle about y-axis: $I_{y,angle,L3L4} := \left[\frac{1}{12} \cdot \left(\frac{13}{16} \text{in} \right)^3 \cdot 6\text{in} + \frac{1}{12} \cdot (l_s, L3L4)^3 \cdot \frac{13}{16} \text{in} \dots + \left(6\text{in} \cdot \frac{13}{16} \text{in} \right) \cdot \left(\frac{13}{32} \text{in} - x_{angle,L3L4} \right)^2 \dots + \left(l_s, L3L4 \cdot \frac{13}{16} \text{in} \right) \cdot \left[\left(\frac{13}{16} \text{in} + \frac{l_s, L3L4}{2} \right) - x_{angle,L3L4} \right]^2 \right] = 6.2 \cdot \text{in}^4$

X-axis inertia of section: $I_{x,L3L4} := \left[\frac{1}{12} 8.5\text{in} \cdot \left(\frac{13}{16} \text{in} \right)^3 + 4 \cdot I_{x,angle,L3L4} \dots + 4A_{angle,L3L4} \cdot \left(\frac{13}{32} \text{in} + y_{angle,L3L4} \right)^2 \right] = 291.33 \cdot \text{in}^4$

Y-axis inertia of section: $I_{y,L3L4} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{13}{16} \text{in} + 4 \cdot I_{y,angle,L3L4} \dots + 4A_{angle,L3L4} \cdot \left(\frac{9.125}{2} \text{in} - x_{angle,L3L4} \right)^2 \right] = 435.52 \cdot \text{in}^4$

X radius of gyration: $r_{x,L3L4} := \sqrt{\frac{I_{x,L3L4}}{A_{g,L3L4}}} = 2.88 \cdot \text{in}$

Y radius of gyration: $r_{y,L3L4} := \sqrt{\frac{I_{y,L3L4}}{A_{g,L3L4}}} = 3.52 \cdot \text{in}$

Angle rivet holes: $\text{holes}_{angle,L3L4} := 1 \cdot 4 \cdot \text{hole} \cdot \frac{13}{16} \text{in} = 3.05 \cdot \text{in}^2$

Plate rivet holes: $\text{holes}_{plate,L3L4} := 2 \cdot \text{hole} \cdot \frac{13}{16} \text{in} = 1.52 \cdot \text{in}^2$

Gross area of section: $A_{g,L3L4} = 35.15 \cdot \text{in}^2$

Net area of section: $A_{n,L3L4} := A_{g,L3L4} - \text{holes}_{angle,L3L4} - \text{holes}_{plate,L3L4} = 30.58 \cdot \text{in}^2$

L3L4 & L4L5 BOTTOM CHORDS Properties for Any Section Loss

Span 1

L3L4 Right, Span 1: Thickness of top legs of top angles reduced to 1/2" from 13/16".

Gross Area: $A_{g,L3L4.RS1} := A_{g,L3L4} = 35.15 \cdot \text{in}^2$

Net Area: $A_{n,L3L4.RS1} := A_{n,L3L4} - 2 \left(\frac{13}{16} \text{in} - \frac{1}{2} \text{in} \right) \cdot 6\text{in} = 26.83 \cdot \text{in}^2$

Section loss of the angle requires a recalculation of the angle inertia to calculate the section I.

Angle area: $A_{angle,L3L4,top} := A_{angle,L3L4} - \left(\frac{13}{16} \text{in} - \frac{1}{2} \text{in} \right) \cdot 6\text{in} = 5.19 \cdot \text{in}^2$

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$$\text{X-axis c.g. of angle: } y_{\text{angle.L3L4.top}} := \left[\frac{\left(6\text{in} \cdot \frac{1}{2}\text{in} \right) \cdot 3\text{in} + \left(l_s \cdot L3L4 \cdot \frac{13}{16}\text{in} \right) \cdot \frac{13}{32}\text{in}}{A_{\text{angle.L3L4.top}}} \right] = 1.91 \cdot \text{in}$$

$$\text{Y-axis c.g. of angle: } x_{\text{angle.L3L4.top}} := \left[\frac{\left(6\text{in} \cdot \frac{1}{2}\text{in} \right) \cdot \frac{13}{32}\text{in} \dots + \left(l_s \cdot L3L4 \cdot \frac{13}{16}\text{in} \right) \cdot \left(\frac{13}{16}\text{in} + \frac{l_s \cdot L3L4}{2} \right)}{A_{\text{angle.L3L4.top}}} \right] = 1.14 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,\text{angle.L3L4.top}} := \left[\frac{1}{12} \cdot \frac{1}{2} \cdot \text{in} \cdot (6\text{in})^3 + \frac{1}{12} \cdot l_s \cdot L3L4 \left(\frac{13}{16}\text{in} \right)^3 \dots + \left(6\text{in} \cdot \frac{1}{2}\text{in} \right) \cdot (3\text{in} - y_{\text{angle.L3L4.top}})^2 \dots + \left(l_s \cdot L3L4 \cdot \frac{13}{16}\text{in} \right) \cdot \left(\frac{13}{32}\text{in} - y_{\text{angle.L3L4.top}} \right)^2 \right] = 17.62 \cdot \text{in}^4$$

Inertia of angle about y-axis:

$$I_{y,\text{angle.L3L4.top}} := \left[\frac{1}{12} \cdot \left(\frac{1}{2}\text{in} \right)^3 \cdot 6\text{in} + \frac{1}{12} \cdot (l_s \cdot L3L4)^3 \cdot \frac{13}{16}\text{in} \dots + \left(6\text{in} \cdot \frac{1}{2}\text{in} \right) \cdot \left(\frac{13}{32}\text{in} - x_{\text{angle.L3L4.top}} \right)^2 \dots + \left(l_s \cdot L3L4 \cdot \frac{13}{16}\text{in} \right) \cdot \left[\left(\frac{13}{16}\text{in} + \frac{l_s \cdot L3L4}{2} \right) - x_{\text{angle.L3L4.top}} \right]^2 \right] = 5.25 \cdot \text{in}^4$$

$$\text{Inertias: } I_{x,L3L4.RS1} := \left[\frac{1}{12} \cdot 8.5\text{in} \cdot \left(\frac{13}{16}\text{in} \right)^3 + 2 \cdot I_{x,\text{angle.L3L4}} \dots + 2 \cdot I_{x,\text{angle.L3L4.top}} \dots + 2A_{\text{angle.L3L4}} \cdot \left(\frac{13}{32}\text{in} + y_{\text{angle.L3L4}} \right)^2 \dots + 2A_{\text{angle.L3L4.top}} \cdot \left(\frac{13}{32}\text{in} + y_{\text{angle.L3L4.top}} \right)^2 \right] = 237 \cdot \text{in}^4$$

$$I_{y,L3L4.RS1} := \left[\frac{1}{12} \cdot (8.5\text{in})^3 \cdot \frac{13}{16}\text{in} + 2 \cdot I_{y,\text{angle.L3L4}} \dots + 2 \cdot I_{y,\text{angle.L3L4.top}} \dots + 2A_{\text{angle.L3L4}} \cdot \left(\frac{9.125\text{in}}{2} - x_{\text{angle.L3L4}} \right)^2 \dots + 2A_{\text{angle.L3L4.top}} \cdot \left(\frac{9.125\text{in}}{2} - x_{\text{angle.L3L4.top}} \right)^2 \right] = 370 \cdot \text{in}^4$$

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$$\text{R. of gyration: } r_{x,L3L4.RS1} := \sqrt{\frac{I_{x,L3L4.RS1}}{A_{g,L3L4.RS1}}} = 2.59 \cdot \text{in}$$

$$r_{y,L3L4.RS1} := \sqrt{\frac{I_{y,L3L4.RS1}}{A_{g,L3L4.RS1}}} = 3.25 \cdot \text{in}$$

L3L4 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_{g,L3L4.LS1} := A_{g,L3L4} = 35.15 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3L4.LS1} := A_{n,L3L4} = 30.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L3L4.LS1} := I_{x,L3L4} = 291 \cdot \text{in}^4$$

$$I_{y,L3L4.LS1} := I_{y,L3L4} = 436 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L3L4.LS1} := r_{x,L3L4} = 2.88 \cdot \text{in}$$

$$r_{y,L3L4.LS1} := r_{y,L3L4} = 3.52 \cdot \text{in}$$

L4L5 Right, Span 1: 20% section loss on top angle legs. (80% remaining)

$$\text{Gross Area: } A_{g,L4L5.RS1} := A_{g,L3L4} = 35.15 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L4L5.RS1} := A_{n,L3L4} - 2\left(\frac{13}{16} \cdot 0.20\right) \cdot 6 \cdot \text{in} = 28.63 \cdot \text{in}^2$$

Section loss of the angle requires a recalculation of the angle inertia to calculate the section I.

$$\text{Angle area: } A_{\text{angle},L4L5.top} := A_{\text{angle},L3L4} - \left(\frac{13}{16} \cdot 0.20\right) \cdot 6 \cdot \text{in} = 6.09 \cdot \text{in}^2$$

X-axis c.g. of angle:

$$y_{\text{angle},L4L5.top} := \frac{\left[\left(6 \cdot \frac{13}{16} \cdot 0.8 \right) \cdot 3 \cdot \text{in} + \left(I_{s,L3L4} \cdot \frac{13}{16} \cdot \text{in} \right) \cdot \frac{13}{32} \right]}{A_{\text{angle},L4L5.top}} = 2.07 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{\text{angle},L4L5.top} := \frac{\left[\begin{aligned} & \left(6 \cdot \frac{13}{16} \cdot 0.8 \right) \cdot \frac{13}{32} \cdot \text{in} \dots \\ & + \left(I_{s,L3L4} \cdot \frac{13}{16} \cdot \text{in} \right) \cdot \left(\frac{13}{16} \cdot \text{in} + \frac{I_{s,L3L4}}{2} \right) \end{aligned} \right]}{A_{\text{angle},L4L5.top}} = 1.03 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,\text{angle},L4L5.top} := \left[\begin{aligned} & \frac{1}{12} \cdot \frac{13}{16} \cdot \text{in} \cdot 0.8 \cdot (6 \cdot \text{in})^3 + \frac{1}{12} \cdot I_{s,L3L4} \left(\frac{13}{16} \cdot \text{in} \right)^3 \dots \\ & + \left(6 \cdot \frac{13}{16} \cdot 0.8 \right) \cdot (3 \cdot \text{in} - y_{\text{angle},L4L5.top})^2 \dots \\ & + \left(I_{s,L3L4} \cdot \frac{13}{16} \cdot \text{in} \right) \cdot \left(\frac{13}{32} \cdot \text{in} - y_{\text{angle},L4L5.top} \right)^2 \end{aligned} \right] = 21.24 \cdot \text{in}^4$$

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Inertia of angle about y-axis:

$$I_{y, \text{angle.L4L5.top}} := \left[\frac{1}{12} \cdot \left(\frac{13}{16} \text{in} \cdot 0.8 \right)^3 \cdot 6 \text{in} + \frac{1}{12} \cdot (l_s, L3L4)^3 \cdot \frac{13}{16} \text{in} \dots \right. \\ \left. + \left(6 \text{in} \cdot \frac{13}{16} \text{in} \cdot 0.8 \right) \cdot \left(\frac{13}{32} \text{in} - x_{\text{angle.L4L5.top}} \right)^2 \dots \right. \\ \left. + \left(l_s, L3L4 \cdot \frac{13}{16} \text{in} \right) \cdot \left[\left(\frac{13}{16} \text{in} + \frac{l_s, L3L4}{2} \right) - x_{\text{angle.L4L5.top}} \right]^2 \right] = 5.74 \cdot \text{in}^4$$

Inertias:

$$I_{x, L4L5.RS1} := \left[\frac{1}{12} 8.5 \text{in} \cdot \left(\frac{13}{16} \text{in} \right)^3 + 2 \cdot I_{x, \text{angle.L3L4}} \dots \right. \\ \left. + 2 \cdot I_{x, \text{angle.L4L5.top}} \dots \right. \\ \left. + 2A_{\text{angle.L3L4}} \cdot \left(\frac{13}{32} \text{in} + y_{\text{angle.L3L4}} \right)^2 \dots \right. \\ \left. + 2A_{\text{angle.L4L5.top}} \cdot \left(\frac{13}{32} \text{in} + y_{\text{angle.L4L5.top}} \right)^2 \right] = 263 \cdot \text{in}^4$$

$$I_{y, L4L5.RS1} := \left[\frac{1}{12} (8.5 \text{in})^3 \cdot \frac{13}{16} \text{in} + 2 \cdot I_{y, \text{angle.L3L4}} \dots \right. \\ \left. + 2 \cdot I_{y, \text{angle.L4L5.top}} \dots \right. \\ \left. + 2A_{\text{angle.L3L4}} \cdot \left(\frac{9.125 \text{in}}{2} - x_{\text{angle.L3L4}} \right)^2 \dots \right. \\ \left. + 2A_{\text{angle.L4L5.top}} \cdot \left(\frac{9.125 \text{in}}{2} - x_{\text{angle.L4L5.top}} \right)^2 \right] = 402 \cdot \text{in}^4$$

R. of gyration:

$$r_{x, L4L5.RS1} := \sqrt{\frac{I_{x, L4L5.RS1}}{A_{g, L4L5.RS1}}} = 2.73 \cdot \text{in}$$

$$r_{y, L4L5.RS1} := \sqrt{\frac{I_{y, L4L5.RS1}}{A_{g, L4L5.RS1}}} = 3.38 \cdot \text{in}$$

L4L5 Left, Span 1: No Section loss.

Gross Area: $A_{g, L4L5.LS1} := A_{g, L3L4} = 35.15 \cdot \text{in}^2$

Net Area: $A_{n, L4L5.LS1} := A_{n, L3L4} = 30.58 \cdot \text{in}^2$

Inertias: $I_{x, L4L5.LS1} := I_{x, L3L4} = 291 \cdot \text{in}^4$

$$I_{y, L4L5.LS1} := I_{y, L3L4} = 436 \cdot \text{in}^4$$

R. of gyration: $r_{x, L4L5.LS1} := r_{x, L3L4} = 2.88 \cdot \text{in}$

$$r_{y, L4L5.LS1} := r_{y, L3L4} = 3.52 \cdot \text{in}$$

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Span 2

L3L4 Right, Span 2: 20% section loss on top angle legs like on L4L5 Right, Span 1.

$$\text{Gross Area: } A_{g,L3L4.RS2} := A_{g,L3L4} = 35.15 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3L4.RS2} := A_{n,L4L5.RS1} = 28.63 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L3L4.RS2} := I_{x,L4L5.RS1} = 263 \cdot \text{in}^4$$

$$I_{y,L3L4.RS2} := I_{y,L4L5.RS1} = 402 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L3L4.RS2} := r_{x,L4L5.RS1} = 2.73 \cdot \text{in}$$

$$r_{y,L3L4.RS2} := r_{y,L4L5.RS1} = 3.38 \cdot \text{in}$$

L3L4 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,L3L4.LS2} := A_{g,L3L4} = 35.15 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3L4.LS2} := A_{n,L3L4} = 30.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L3L4.LS2} := I_{x,L3L4} = 291 \cdot \text{in}^4$$

$$I_{y,L3L4.LS2} := I_{y,L3L4} = 436 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L3L4.LS2} := r_{x,L3L4} = 2.88 \cdot \text{in}$$

$$r_{y,L3L4.LS2} := r_{y,L3L4} = 3.52 \cdot \text{in}$$

L4L5 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,L4L5.RS2} := A_{g,L3L4} = 35.15 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L4L5.RS2} := A_{n,L3L4} = 30.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L4L5.RS2} := I_{x,L3L4} = 291 \cdot \text{in}^4$$

$$I_{y,L4L5.RS2} := I_{y,L3L4} = 436 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L4L5.RS2} := r_{x,L3L4} = 2.88 \cdot \text{in}$$

$$r_{y,L4L5.RS2} := r_{y,L3L4} = 3.52 \cdot \text{in}$$

L4L5 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,L4L5.LS2} := A_{g,L3L4} = 35.15 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L4L5.LS2} := A_{n,L3L4} = 30.58 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L4L5.LS2} := I_{x,L3L4} = 291 \cdot \text{in}^4$$

$$I_{y,L4L5.LS2} := I_{y,L3L4} = 436 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L4L5.LS2} := r_{x,L3L4} = 2.88 \cdot \text{in}$$

$$r_{y,L4L5.LS2} := r_{y,L3L4} = 3.52 \cdot \text{in}$$

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L1L2, L2L3, L5L6, & L6L7 BOTTOM CHORDS

(L0L2 on as-built plans Sheet 3)

Gross Section: 4 angles- L6x3-1/2x9/16
 Lattice zigzagging between angles

Gross area of Section (Sheet 1): $A_{g,L1L2} := 20.12 \text{ in}^2$

Area of Angles: $A_{angle,L1L2} := \frac{A_{g,L1L2}}{4} = 5.03 \cdot \text{in}^2$

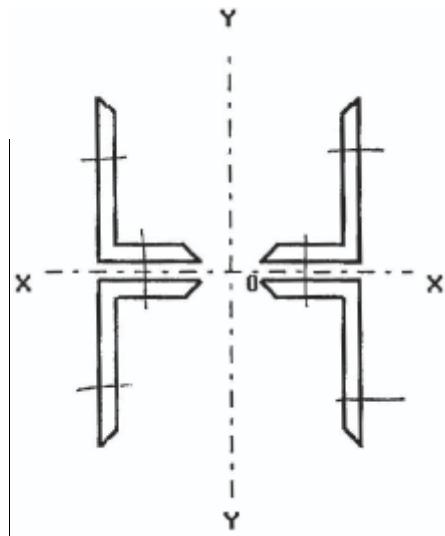
Angle L6x3-1/2x13/16 is not in the steel manual.
 Therefore section properties need to be calculated.

Angle thickness: $\frac{9}{16} \text{ in}$

Angle depth: 6in

Angle width: $\left(3 + \frac{1}{2}\right) \text{ in}$

Short leg width: $l_{s,L1L2} := 3.5 \text{ in} - \frac{9}{16} \text{ in} = 2.94 \cdot \text{in}$



X-axis c.g. of angle: $y_{angle,L1L2} := \frac{\left(6 \text{ in} \cdot \frac{9}{16} \text{ in}\right) \cdot 3 \text{ in} + \left(l_{s,L1L2} \cdot \frac{9}{16} \text{ in}\right) \cdot \frac{9}{32} \text{ in}}{A_{angle,L1L2}} = 2.11 \cdot \text{in}$

Y-axis c.g. of angle: $x_{angle,L1L2} := \frac{\left(6 \text{ in} \cdot \frac{9}{16} \text{ in}\right) \cdot \frac{9}{32} \text{ in} + \left(l_{s,L1L2} \cdot \frac{9}{16} \text{ in}\right) \cdot \left(\frac{9}{16} \text{ in} + \frac{l_{s,L1L2}}{2}\right)}{A_{angle,L1L2}} = 0.86 \cdot \text{in}$

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Inertia of angle about x-axis: $I_{x.\text{angle.L1L2}} := \left[\frac{1}{12} \cdot \frac{9}{16} \text{in} \cdot (6\text{in})^3 + \frac{1}{12} \cdot I_{s.\text{L1L2}} \left(\frac{9}{16} \text{in} \right)^3 \dots \right. \\ \left. + \left(6\text{in} \cdot \frac{9}{16} \text{in} \right) \cdot (3\text{in} - y_{\text{angle.L1L2}})^2 \dots \right. \\ \left. + \left(I_{s.\text{L1L2}} \cdot \frac{9}{16} \text{in} \right) \cdot \left(\frac{9}{32} \text{in} - y_{\text{angle.L1L2}} \right)^2 \right] = 18.37 \cdot \text{in}^4$

Inertia of angle about y-axis: $I_{y.\text{angle.L1L2}} := \left[\frac{1}{12} \cdot \left(\frac{9}{16} \text{in} \right)^3 \cdot 6\text{in} + \frac{1}{12} \cdot \left(I_{s.\text{L1L2}} \right)^3 \cdot \frac{9}{16} \text{in} \dots \right. \\ \left. + \left(6\text{in} \cdot \frac{9}{16} \text{in} \right) \cdot \left(\frac{9}{32} \text{in} - x_{\text{angle.L1L2}} \right)^2 \dots \right. \\ \left. + \left(I_{s.\text{L1L2}} \cdot \frac{9}{16} \text{in} \right) \cdot \left[\left(\frac{9}{16} \text{in} + \frac{I_{s.\text{L1L2}}}{2} \right) - x_{\text{angle.L1L2}} \right]^2 \right] = 4.67 \cdot \text{in}^4$

X-axis inertia of section: $I_{x.\text{L1L2}} := 4 \cdot I_{x.\text{angle.L1L2}} \dots = 188.07 \cdot \text{in}^4$
 $\quad \quad \quad + 4A_{\text{angle.L1L2}} \cdot \left(\frac{9}{32} \text{in} + y_{\text{angle.L1L2}} \right)^2$

Y-axis inertia of section: $I_{y.\text{L1L2}} := 4 \cdot I_{y.\text{angle.L1L2}} \dots = 295.11 \cdot \text{in}^4$
 $\quad \quad \quad + 4A_{\text{angle.L1L2}} \cdot \left(\frac{9.125 \text{in}}{2} - x_{\text{angle.L1L2}} \right)^2$

X radius of gyration: $r_{x.\text{L1L2}} := \sqrt{\frac{I_{x.\text{L1L2}}}{A_{g.\text{L1L2}}}} = 3.06 \cdot \text{in}$

Y radius of gyration: $r_{y.\text{L1L2}} := \sqrt{\frac{I_{y.\text{L1L2}}}{A_{g.\text{L1L2}}}} = 3.83 \cdot \text{in}$

Angle rivet holes: $\text{holes}_{\text{angle.L1L2}} := 2 \cdot 4 \cdot \text{hole} \cdot \frac{9}{16} \text{in} = 4.22 \cdot \text{in}^2$

Gross area of section: $A_{g.\text{L1L2}} = 20.12 \cdot \text{in}^2$

Net area of section: $A_{n.\text{L1L2}} := A_{g.\text{L1L2}} - \text{holes}_{\text{angle.L1L2}} = 15.9 \cdot \text{in}^2$

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L1L2, L2L3, L5L6, & L6L7 BOTTOM CHORDS Properties for Any Section Loss

Span 1

L1L2 Right, Span 1: 20% section loss on top angle legs. (80% remaining)

$$\text{Gross Area: } A_{g,L1L2.RS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L1L2.RS1} := A_{n,L1L2} - 2\left(\frac{13}{16} \text{in} \cdot 0.20\right) \cdot 6 \text{in} = 13.95 \cdot \text{in}^2$$

Section loss of the angle requires a recalculation of the angle inertia to calculate the section I.

$$\text{Angle area: } A_{angle,L1L2.top} := A_{angle,L1L2} - \left(\frac{9}{16} \text{in} \cdot 0.20\right) \cdot 6 \text{in} = 4.36 \cdot \text{in}^2$$

X-axis c.g. of angle:

$$y_{angle,L1L2.top} := \left[\frac{\left(6 \text{in} \cdot \frac{9}{16} \text{in} \cdot 0.8\right) \cdot 3 \text{in} + \left(l_{s,L1L2} \cdot \frac{9}{16} \text{in}\right) \cdot \frac{9}{32} \text{in}}{A_{angle,L1L2.top}} \right] = 1.97 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{angle,L1L2.top} := \left[\frac{\left(6 \text{in} \cdot \frac{9}{16} \text{in} \cdot 0.8\right) \cdot \frac{9}{32} \text{in} \dots + \left(l_{s,L1L2} \cdot \frac{9}{16} \text{in}\right) \cdot \left(\frac{9}{16} \text{in} + \frac{l_{s,L1L2}}{2}\right)}{A_{angle,L1L2.top}} \right] = 0.95 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,angle,L1L2.top} := \left[\frac{1}{12} \cdot \frac{9}{16} \text{in} \cdot 0.8 \cdot (6 \text{in})^3 + \frac{1}{12} \cdot l_{s,L1L2} \left(\frac{9}{16} \text{in}\right)^3 \dots + \left(6 \text{in} \cdot \frac{9}{16} \text{in} \cdot 0.8\right) \cdot (3 \text{in} - y_{angle,L1L2.top})^2 \dots + \left(l_{s,L1L2} \cdot \frac{9}{16} \text{in}\right) \cdot \left(\frac{9}{32} \text{in} - y_{angle,L1L2.top}\right)^2 \right] = 15.72 \cdot \text{in}^4$$

Inertia of angle about y-axis:

$$I_{y,angle,L1L2.top} := \left[\frac{1}{12} \cdot \left(\frac{9}{16} \text{in} \cdot 0.8\right)^3 \cdot 6 \text{in} + \frac{1}{12} \cdot \left(l_{s,L1L2}\right)^3 \cdot \frac{9}{16} \text{in} \dots + \left(6 \text{in} \cdot \frac{9}{16} \text{in} \cdot 0.8\right) \cdot \left(\frac{9}{32} \text{in} - x_{angle,L1L2.top}\right)^2 \dots + \left(l_{s,L1L2} \cdot \frac{9}{16} \text{in}\right) \cdot \left[\left(\frac{9}{16} \text{in} + \frac{l_{s,L1L2}}{2}\right) - x_{angle,L1L2.top}\right]^2 \right] = 4.37 \cdot \text{in}^4$$

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Inertias:

$$I_{x,L1L2.RS1} := \left[2 \cdot I_{x,\text{angle},L1L2} + 2 \cdot I_{x,\text{angle},L1L2,top} \dots + 2A_{\text{angle},L1L2} \cdot \left(\frac{9}{32} \text{in} + y_{\text{angle},L1L2} \right)^2 \dots + 2A_{\text{angle},L1L2,top} \cdot \left(\frac{9}{32} \text{in} + y_{\text{angle},L1L2,top} \right)^2 \right] = 169 \cdot \text{in}^4$$

$$I_{y,L1L2.RS1} := \left[2 \cdot I_{y,\text{angle},L1L2} + 2 \cdot I_{y,\text{angle},L1L2,top} \dots + 2A_{\text{angle},L1L2} \cdot \left(\frac{9.125 \text{in}}{2} - x_{\text{angle},L1L2} \right)^2 \dots + 2A_{\text{angle},L1L2,top} \cdot \left(\frac{9.125 \text{in}}{2} - x_{\text{angle},L1L2,top} \right)^2 \right] = 270 \cdot \text{in}^4$$

R. of gyration:

$$r_{x,L1L2.RS1} := \sqrt{\frac{I_{x,L1L2.RS1}}{A_{g,L1L2.RS1}}} = 2.9 \cdot \text{in}$$

$$r_{y,L1L2.RS1} := \sqrt{\frac{I_{y,L1L2.RS1}}{A_{g,L1L2.RS1}}} = 3.67 \cdot \text{in}$$

L1L2 Left, Span 1: No Section loss.

Gross Area: $A_{g,L1L2.LS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L1L2.LS1} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L1L2.LS1} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$$I_{y,L1L2.LS1} := I_{y,L1L2} = 295 \cdot \text{in}^4$$

R. of gyration: $r_{x,L1L2.LS1} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$$r_{y,L1L2.LS1} := r_{y,L1L2} = 3.83 \cdot \text{in}$$

L2L3 Right, Span 1: 30% section loss on top angle legs. (70% remaining)

Gross Area: $A_{g,L2L3.RS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L2L3.RS1} := A_{n,L3L4} - 2 \left(\frac{13}{16} \text{in} \cdot 0.30 \right) \cdot 6 \text{in} = 27.65 \cdot \text{in}^2$

Section loss of the angle requires a recalculation of the angle inertia to calculate the section I.

Angle area: $A_{\text{angle},L2L3,top} := A_{\text{angle},L1L2} - \left(\frac{9}{16} \text{in} \cdot 0.30 \right) \cdot 6 \text{in} = 4.02 \cdot \text{in}^2$

Length of short leg: $l_{s,L1L2} = 2.94 \cdot \text{in}$

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X-axis c.g. of angle:

$$y_{\text{angle.L2L3.top}} := \left[\frac{\left(6\text{in} \cdot \frac{9}{16}\text{in} \cdot 0.7 \right) \cdot 3\text{in} + \left(l_s \cdot L1L2 \cdot \frac{9}{16}\text{in} \right) \cdot \frac{9}{32}\text{in}}{A_{\text{angle.L2L3.top}}} \right] = 1.88\text{in}$$

Y-axis c.g. of angle:

$$x_{\text{angle.L2L3.top}} := \left[\frac{\left(6\text{in} \cdot \frac{9}{16}\text{in} \cdot 0.7 \right) \cdot \frac{9}{32}\text{in} \dots + \left(l_s \cdot L1L2 \cdot \frac{9}{16}\text{in} \right) \cdot \left(\frac{9}{16}\text{in} + \frac{l_s \cdot L1L2}{2} \right)}{A_{\text{angle.L2L3.top}}} \right] = 1\text{in}$$

Inertia of angle about x-axis:

$$I_x \cdot \text{angle.L2L3.top} := \left[\frac{1}{12} \cdot \frac{9}{16}\text{in} \cdot 0.7 \cdot (6\text{in})^3 + \frac{1}{12} \cdot l_s \cdot L1L2 \left(\frac{9}{16}\text{in} \right)^3 \dots + \left(6\text{in} \cdot \frac{9}{16}\text{in} \cdot 0.7 \right) \cdot (3\text{in} - y_{\text{angle.L2L3.top}})^2 \dots + \left(l_s \cdot L1L2 \cdot \frac{9}{16}\text{in} \right) \cdot \left(\frac{9}{32}\text{in} - y_{\text{angle.L2L3.top}} \right)^2 \right] = 14.32 \cdot \text{in}^4$$

Inertia of angle about y-axis:

$$I_y \cdot \text{angle.L2L3.top} := \left[\frac{1}{12} \cdot \left(\frac{9}{16}\text{in} \cdot 0.7 \right)^3 \cdot 6\text{in} + \frac{1}{12} \cdot \left(l_s \cdot L1L2 \right)^3 \cdot \frac{9}{16}\text{in} \dots + \left(6\text{in} \cdot \frac{9}{16}\text{in} \cdot 0.7 \right) \cdot \left(\frac{9}{32}\text{in} - x_{\text{angle.L2L3.top}} \right)^2 \dots + \left(l_s \cdot L1L2 \cdot \frac{9}{16}\text{in} \right) \cdot \left[\left(\frac{9}{16}\text{in} + \frac{l_s \cdot L1L2}{2} \right) - x_{\text{angle.L2L3.top}} \right]^2 \right] = 4.2 \cdot \text{in}^4$$

Inertias:

$$I_x \cdot L2L3.RS1 := \left[2 \cdot I_x \cdot \text{angle.L1L2} + 2 \cdot I_x \cdot \text{angle.L2L3.top} \dots + 2A_{\text{angle.L1L2}} \cdot \left(\frac{9}{32}\text{in} + y_{\text{angle.L1L2}} \right)^2 \dots + 2A_{\text{angle.L2L3.top}} \cdot \left(\frac{9}{32}\text{in} + y_{\text{angle.L2L3.top}} \right)^2 \right] = 160 \cdot \text{in}^4$$

$$I_y \cdot L2L3.RS1 := \left[2 \cdot I_y \cdot \text{angle.L1L2} + 2 \cdot I_y \cdot \text{angle.L2L3.top} \dots + 2A_{\text{angle.L1L2}} \cdot \left(\frac{9.125\text{in}}{2} - x_{\text{angle.L1L2}} \right)^2 \dots + 2A_{\text{angle.L2L3.top}} \cdot \left(\frac{9.125\text{in}}{2} - x_{\text{angle.L2L3.top}} \right)^2 \right] = 258 \cdot \text{in}^4$$

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$$\begin{aligned} \text{R. of gyration: } r_{x,L2L3.RS1} &:= \sqrt{\frac{I_{x,L2L3.RS1}}{A_{g,L2L3.RS1}}} = 2.82 \cdot \text{in} \\ r_{y,L2L3.RS1} &:= \sqrt{\frac{I_{y,L2L3.RS1}}{A_{g,L2L3.RS1}}} = 3.58 \cdot \text{in} \end{aligned}$$

L2L3 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_{g,L2L3.LS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L2L3.LS1} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L2L3.LS1} := I_{x,L1L2} = 188 \cdot \text{in}^4$$

$$I_{y,L2L3.LS1} := I_{y,L1L2} = 295 \cdot \text{in}^4$$

$$\begin{aligned} \text{R. of gyration: } r_{x,L2L3.LS1} &:= r_{x,L1L2} = 3.06 \cdot \text{in} \\ r_{y,L2L3.LS1} &:= r_{y,L1L2} = 3.83 \cdot \text{in} \end{aligned}$$

L5L6 Right, Span 1: No section loss.

$$\text{Gross Area: } A_{g,L5L6.RS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L5L6.RS1} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L5L6.RS1} := I_{x,L1L2} = 188 \cdot \text{in}^4$$

$$I_{y,L5L6.RS1} := I_{y,L1L2} = 295 \cdot \text{in}^4$$

$$\begin{aligned} \text{R. of gyration: } r_{x,L5L6.RS1} &:= r_{x,L1L2} = 3.06 \cdot \text{in} \\ r_{y,L5L6.RS1} &:= r_{y,L1L2} = 3.83 \cdot \text{in} \end{aligned}$$

L5L6 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_{g,L5L6.LS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L5L6.LS1} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L5L6.LS1} := I_{x,L1L2} = 188 \cdot \text{in}^4$$

$$I_{y,L5L6.LS1} := I_{y,L1L2} = 295 \cdot \text{in}^4$$

$$\begin{aligned} \text{R. of gyration: } r_{x,L5L6.LS1} &:= r_{x,L1L2} = 3.06 \cdot \text{in} \\ r_{y,L5L6.LS1} &:= r_{y,L1L2} = 3.83 \cdot \text{in} \end{aligned}$$

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L6L7 Right, Span 1: No section loss.

Gross Area: $A_{g,L6L7.RS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L6L7.RS1} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L6L7.RS1} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L6L7.RS1} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L6L7.RS1} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L6L7.RS1} := r_{y,L1L2} = 3.83 \cdot \text{in}$

L6L7 Left, Span 1: No Section loss.

Gross Area: $A_{g,L6L7.LS1} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L6L7.LS1} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L6L7.LS1} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L6L7.LS1} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L6L7.LS1} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L6L7.LS1} := r_{y,L1L2} = 3.83 \cdot \text{in}$

Span 2

L1L2 Right, Span 2: 20% section loss on top angle legs like on L1L2 Right, Span 1.

Gross Area: $A_{g,L1L2.RS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L1L2.RS2} := A_{n,L1L2.RS1} = 13.95 \cdot \text{in}^2$

Inertias: $I_{x,L1L2.RS2} := I_{x,L1L2.RS1} = 169 \cdot \text{in}^4$

$I_{y,L1L2.RS2} := I_{y,L1L2.RS1} = 270 \cdot \text{in}^4$

R. of gyration: $r_{x,L1L2.RS2} := r_{x,L1L2.RS1} = 2.9 \cdot \text{in}$

$r_{y,L1L2.RS2} := r_{y,L1L2.RS1} = 3.67 \cdot \text{in}$

L1L2 Left, Span 2: No Section loss.

Gross Area: $A_{g,L1L2.LS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L1L2.LS2} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L1L2.LS2} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L1L2.LS2} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L1L2.LS2} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L1L2.LS2} := r_{y,L1L2} = 3.83 \cdot \text{in}$

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L2L3 Right, Span 2: No section loss.

Gross Area: $A_{g,L2L3.RS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L2L3.RS2} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L2L3.RS2} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L2L3.RS2} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L2L3.RS2} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L2L3.RS2} := r_{y,L1L2} = 3.83 \cdot \text{in}$

L2L3 Left, Span 2: No Section loss.

Gross Area: $A_{g,L2L3.LS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L2L3.LS2} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L2L3.LS2} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L2L3.LS2} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L2L3.LS2} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L2L3.LS2} := r_{y,L1L2} = 3.83 \cdot \text{in}$

L5L6 Right, Span 2: No section loss.

Gross Area: $A_{g,L5L6.RS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L5L6.RS2} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L5L6.RS2} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L5L6.RS2} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L5L6.RS2} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L5L6.RS2} := r_{y,L1L2} = 3.83 \cdot \text{in}$

L5L6 Left, Span 2: No Section loss.

Gross Area: $A_{g,L5L6.LS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L5L6.LS2} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L5L6.LS2} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L5L6.LS2} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L5L6.LS2} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L5L6.LS2} := r_{y,L1L2} = 3.83 \cdot \text{in}$

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L6L7 Right, Span 2: No section loss.

Gross Area: $A_{g,L6L7.RS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L6L7.RS2} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L6L7.RS2} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L6L7.RS2} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L6L7.RS2} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L6L7.RS2} := r_{y,L1L2} = 3.83 \cdot \text{in}$

L6L7 Left, Span 2: No Section loss.

Gross Area: $A_{g,L6L7.LS2} := A_{g,L1L2} = 20.12 \cdot \text{in}^2$

Net Area: $A_{n,L6L7.LS2} := A_{n,L1L2} = 15.9 \cdot \text{in}^2$

Inertias: $I_{x,L6L7.LS2} := I_{x,L1L2} = 188 \cdot \text{in}^4$

$I_{y,L6L7.LS2} := I_{y,L1L2} = 295 \cdot \text{in}^4$

R. of gyration: $r_{x,L6L7.LS2} := r_{x,L1L2} = 3.06 \cdot \text{in}$

$r_{y,L6L7.LS2} := r_{y,L1L2} = 3.83 \cdot \text{in}$

U2L3 & L5U6 DIAGONALS

(U1L2 on as-built plans Sheet 3)

Gross Section: 4 angles- L6x3-1/2x1/2
 1 plate 8-1/2"x11/16"

Gross area of Section (Sheet 1): $A_{g,U2L3} := 23.84 \cdot \text{in}^2$

Area of Plate: $A_{plate,U2L3} := 8.5 \cdot \text{in} \cdot \left(\frac{11}{16} \cdot \text{in} \right) = 5.84 \cdot \text{in}^2$

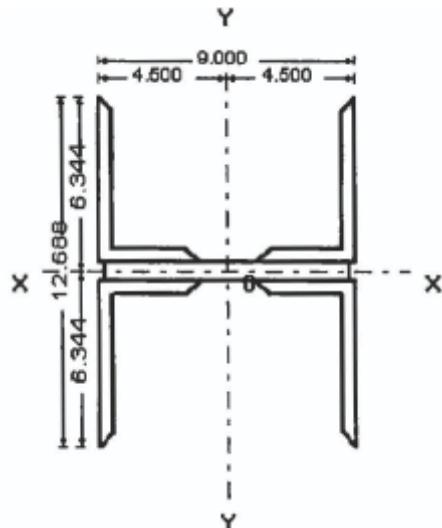
Area of Angles: $A_{angle,U2L3} := 4.48 \cdot \text{in}^2$

X-axis c.g. of angle: $y_{angle,U2L3} := 2.08 \cdot \text{in}$

Y-axis c.g. of angle: $x_{angle,U2L3} := 0.833 \cdot \text{in}$

Inertia of angle about x-axis: $I_{x,angle,U2L3} := 16.6 \cdot \text{in}^4$

Inertia of angle about y-axis: $I_{y,angle,U2L3} := 4.23 \cdot \text{in}^4$



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X-axis inertia of section: $I_{x,U2L3} := \left[\frac{1}{12} 8.5\text{in} \cdot \left(\frac{11}{16}\text{in} \right)^3 + 4 \cdot I_{x,\text{angle},U2L3} \dots \right] = 164 \cdot \text{in}^4$

Y-axis inertia of section: $I_{y,U2L3} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{11}{16}\text{in} + 4 \cdot I_{y,\text{angle},U2L3} \dots \right] = 293 \cdot \text{in}^4$
 $\quad \quad \quad + 4A_{\text{angle},U2L3} \cdot \left(\frac{9}{2}\text{in} - x_{\text{angle},U2L3} \right)^2 \right]$

X radius of gyration: $r_{x,U2L3} := \sqrt{\frac{I_{x,U2L3}}{A_{g,U2L3}}} = 2.62 \cdot \text{in}$

Y radius of gyration: $r_{y,U2L3} := \sqrt{\frac{I_{y,U2L3}}{A_{g,U2L3}}} = 3.51 \cdot \text{in}$

Angle rivet holes: $\text{holes}_{\text{angle},U2L3} := 2 \cdot 4 \cdot \text{hole} \cdot \frac{1}{2}\text{in} = 3.75 \cdot \text{in}^2$

Plate rivet holes: $\text{holes}_{\text{plate},U2L3} := 2 \cdot \text{hole} \cdot \frac{11}{16}\text{in} = 1.29 \cdot \text{in}^2$

Gross area of section: $A_{g,U2L3} = 23.84 \cdot \text{in}^2$

Net area of section: $A_{n,U2L3} := A_{g,U2L3} - \text{holes}_{\text{angle},U2L3} - \text{holes}_{\text{plate},U2L3} = 18.8 \cdot \text{in}^2$

U2L3 & L5U6 DIAGONALS Properties for Any Section Loss

Span 1

U2L3 Right, Span 1: No section loss.

Gross Area: $A_{g,U2L3.RS1} := A_{g,U2L3} = 23.84 \cdot \text{in}^2$

Net Area: $A_{n,U2L3.RS1} := A_{n,U2L3} = 18.8 \cdot \text{in}^2$

Inertias: $I_{x,U2L3.RS1} := I_{x,U2L3} = 164 \cdot \text{in}^4$

$I_{y,U2L3.RS1} := I_{y,U2L3} = 293 \cdot \text{in}^4$

R. of gyration: $r_{x,U2L3.RS1} := r_{x,U2L3} = 2.62 \cdot \text{in}$

$r_{y,U2L3.RS1} := r_{y,U2L3} = 3.51 \cdot \text{in}$

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U2L3 Left, Span 1: No Section loss.

$$\text{Gross Area: } A_{g,U2L3,LS1} := A_{g,U2L3} = 23.84 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U2L3,LS1} := A_{n,U2L3} = 18.8 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U2L3,LS1} := I_{x,U2L3} = 164 \cdot \text{in}^4$$

$$I_{y,U2L3,LS1} := I_{y,U2L3} = 293 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U2L3,LS1} := r_{x,U2L3} = 2.62 \cdot \text{in}$$

$$r_{y,U2L3,LS1} := r_{y,U2L3} = 3.51 \cdot \text{in}$$

L5U6 Right, Span 1: 30% section loss on top angle legs. (70% remaining)

$$\text{Gross Area: } A_{g,L5U6,RS1} := A_{g,U2L3} = 23.84 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L5U6,RS1} := A_{n,U2L3} - \left(\frac{1}{2} \cdot 0.30 \right) \cdot 6 \cdot \text{in} = 17.9 \cdot \text{in}^2$$

Section loss of one angle requires a recalculation of the angle inertia to calculate the section I.

$$\text{Angle area: } A_{\text{angle},L5U6,top} := A_{\text{angle},U2L3} - \left(\frac{1}{2} \cdot 0.30 \right) \cdot 6 \cdot \text{in} = 3.58 \cdot \text{in}^2$$

$$\text{Length of short leg: } l_{s,U2L3} := 3.5 \cdot \text{in} - \frac{1}{2} \cdot \text{in} = 3 \cdot \text{in}$$

X-axis c.g. of angle:

$$y_{\text{angle},L5U6,top} := \left[\frac{\left(6 \cdot \frac{1}{2} \cdot 0.7 \right) \cdot 3 \cdot \text{in} + \left(l_{s,U2L3} \cdot \frac{1}{2} \cdot \text{in} \right) \cdot \frac{1}{4} \cdot \text{in}}{A_{\text{angle},L5U6,top}} \right] = 1.86 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{\text{angle},L5U6,top} := \left[\frac{\left(6 \cdot \frac{1}{2} \cdot 0.7 \right) \cdot \frac{1}{4} \cdot \text{in} \dots + \left(l_{s,U2L3} \cdot \frac{1}{2} \cdot \text{in} \right) \cdot \left(\frac{1}{2} \cdot \text{in} + \frac{l_{s,U2L3}}{2} \right)}{A_{\text{angle},L5U6,top}} \right] = 0.98 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,\text{angle},L5U6,top} := \left[\frac{1}{12} \cdot \frac{1}{2} \cdot 0.7 \cdot (6 \cdot \text{in})^3 + \frac{1}{12} \cdot l_{s,U2L3} \left(\frac{1}{2} \cdot \text{in} \right)^3 \dots + \left(6 \cdot \frac{1}{2} \cdot 0.7 \right) \cdot (3 \cdot \text{in} - y_{\text{angle},L5U6,top})^2 \dots + \left(l_{s,U2L3} \cdot \frac{1}{2} \cdot \text{in} \right) \cdot \left(\frac{1}{4} \cdot \text{in} - y_{\text{angle},L5U6,top} \right)^2 \right] = 12.95 \cdot \text{in}^4$$

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Inertia of angle about y-axis:

$$I_{y, \text{angle.L5U6.top}} := \left[\frac{1}{12} \cdot \left(\frac{1}{2} \text{in} \cdot 0.7 \right)^3 \cdot 6\text{in} + \frac{1}{12} \cdot (I_{s,U2L3})^3 \cdot \frac{1}{2} \text{in} \dots \right. \\ \left. + \left(6\text{in} \cdot \frac{1}{2} \text{in} \cdot 0.7 \right) \cdot \left(\frac{1}{4} \text{in} - x_{\text{angle.L5U6.top}} \right)^2 \dots \right. \\ \left. + \left(I_{s,U2L3} \cdot \frac{1}{2} \text{in} \right) \cdot \left[\left(\frac{1}{2} \text{in} + \frac{I_{s,U2L3}}{2} \right) - x_{\text{angle.L5U6.top}} \right]^2 \right] = 3.83 \cdot \text{in}^4$$

Inertias:

$$I_{x,L5U6.RS1} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{11}{16} \text{in} + 3 \cdot I_{x,\text{angle.L1L2}} \dots \right. \\ \left. + I_{x,\text{angle.L2L3.top}} \dots \right. \\ \left. + 3A_{\text{angle.L1L2}} \cdot \left(\frac{1}{4} \text{in} + y_{\text{angle.L1L2}} \right)^2 \dots \right. \\ \left. + A_{\text{angle.L5U6.top}} \cdot \left(\frac{1}{4} \text{in} + y_{\text{angle.L5U6.top}} \right)^2 \right] = 204 \cdot \text{in}^4$$

$$I_{y,L5U6.RS1} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{11}{16} \text{in} + 3 \cdot I_{y,\text{angle.L1L2}} \dots \right. \\ \left. + I_{y,\text{angle.L2L3.top}} \dots \right. \\ \left. + 3A_{\text{angle.L1L2}} \cdot \left(\frac{9}{2} \text{in} - x_{\text{angle.L1L2}} \right)^2 \dots \right. \\ \left. + A_{\text{angle.L5U6.top}} \cdot \left(\frac{9}{2} \text{in} - x_{\text{angle.L5U6.top}} \right)^2 \right] = 298 \cdot \text{in}^4$$

R. of gyration:

$$r_{x,L5U6.RS1} := \sqrt{\frac{I_{x,L5U6.RS1}}{A_{g,L5U6.RS1}}} = 2.93 \cdot \text{in}$$

$$r_{y,L5U6.RS1} := \sqrt{\frac{I_{y,L5U6.RS1}}{A_{g,L5U6.RS1}}} = 3.54 \cdot \text{in}$$

L5U6 Left, Span 1: No Section loss.

Gross Area: $A_{g,L5U6.LS1} := A_{g,U2L3} = 23.84 \cdot \text{in}^2$

Net Area: $A_{n,L5U6.LS1} := A_{n,U2L3} = 18.8 \cdot \text{in}^2$

Inertias: $I_{x,L5U6.LS1} := I_{x,U2L3} = 164 \cdot \text{in}^4$

$I_{y,L5U6.LS1} := I_{y,U2L3} = 293 \cdot \text{in}^4$

R. of gyration: $r_{x,L5U6.LS1} := r_{x,U2L3} = 2.62 \cdot \text{in}$

$r_{y,L5U6.LS1} := r_{y,U2L3} = 3.51 \cdot \text{in}$

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Span 2

U2L3 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,U2L3.RS2} := A_{g,L1U2} = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U2L3.RS2} := A_{n,U2L3} = 18.8 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U2L3.RS2} := I_{x,U2L3} = 164 \cdot \text{in}^4$$

$$I_{y,U2L3.RS2} := I_{y,U2L3} = 293 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U2L3.RS2} := r_{x,U2L3} = 2.62 \cdot \text{in}$$

$$r_{y,U2L3.RS2} := r_{y,U2L3} = 3.51 \cdot \text{in}$$

U2L3 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,U2L3.LS2} := A_{g,L1U2} = 40.24 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,U2L3.LS2} := A_{n,U2L3} = 18.8 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,U2L3.LS2} := I_{x,U2L3} = 164 \cdot \text{in}^4$$

$$I_{y,U2L3.LS2} := I_{y,U2L3} = 293 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,U2L3.LS2} := r_{x,U2L3} = 2.62 \cdot \text{in}$$

$$r_{y,U2L3.LS2} := r_{y,U2L3} = 3.51 \cdot \text{in}$$

L5U6 Right, Span 2: No section loss.

$$\text{Gross Area: } A_{g,L5U6.RS2} := A_{g,U2L3} = 23.84 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L5U6.RS2} := A_{n,U2L3} = 18.8 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L5U6.RS2} := I_{x,U2L3} = 164 \cdot \text{in}^4$$

$$I_{y,L5U6.RS2} := I_{y,U2L3} = 293 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L5U6.RS2} := r_{x,U2L3} = 2.62 \cdot \text{in}$$

$$r_{y,L5U6.RS2} := r_{y,U2L3} = 3.51 \cdot \text{in}$$

L5U6 Left, Span 2: No Section loss.

$$\text{Gross Area: } A_{g,L5U6.LS2} := A_{g,U2L3} = 23.84 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L5U6.LS2} := A_{n,U2L3} = 18.8 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L5U6.LS2} := I_{x,U2L3} = 164 \cdot \text{in}^4$$

$$I_{y,L5U6.LS2} := I_{y,U2L3} = 293 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L5U6.LS2} := r_{x,U2L3} = 2.62 \cdot \text{in}$$

$$r_{y,L5U6.LS2} := r_{y,U2L3} = 3.51 \cdot \text{in}$$

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L2U2, L3U3, L4U4, L5U5, L6U6 POSTS

(U1L1, U2L2, U3L3 on as-built plans Sheet 3)

Gross Section: 4 angles- L4x3x3/8
 1 plate 8-1/2" x1/2"

Gross area of Section (Sheet 1): $A_g.L2U2 := 14.17 \text{ in}^2$

Area of Plate: $A_{plate.L2U2} := 8.5 \text{ in} \cdot \left(\frac{1}{2} \text{ in}\right) = 4.25 \cdot \text{in}^2$

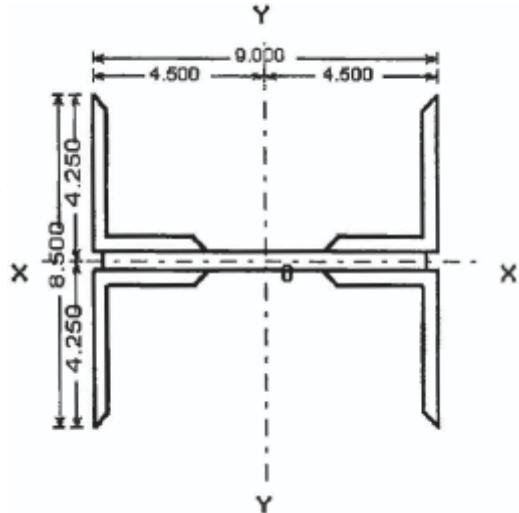
Area of Angles: $A_{angle.L2U2} := 2.49 \text{ in}^2$

X-axis c.g. of angle: $y_{angle.L2U2} := 1.27 \text{ in}$

Y-axis c.g. of angle: $x_{angle.L2U2} := 0.775 \text{ in}$

Inertia of angle about x-axis: $I_{x.angle.L2U2} := 3.94 \text{ in}^4$

Inertia of angle about y-axis: $I_{y.angle.L2U2} := 1.89 \text{ in}^4$



X-axis inertia of section: $I_{x.L2U2} := \left[\frac{1}{12} 8.5 \text{ in} \cdot \left(\frac{1}{2} \text{ in}\right)^3 + 4 \cdot I_{x.angle.L2U2} \dots + 4A_{angle.L2U2} \cdot \left(\frac{1}{4} \text{ in} + y_{angle.L2U2}\right)^2 \right] = 39 \cdot \text{in}^4$

Y-axis inertia of section: $I_{y.L2U2} := \left[\frac{1}{12} (8.5 \text{ in})^3 \cdot \frac{1}{2} \text{ in} + 4 \cdot I_{y.angle.L2U2} \dots + 4A_{angle.L2U2} \cdot \left(\frac{9 \text{ in}}{2} - x_{angle.L2U2}\right)^2 \right] = 171 \cdot \text{in}^4$

X radius of gyration: $r_{x.L2U2} := \sqrt{\frac{I_{x.L2U2}}{A_{g.L2U2}}} = 1.66 \cdot \text{in}$

Y radius of gyration: $r_{y.L2U2} := \sqrt{\frac{I_{y.L2U2}}{A_{g.L2U2}}} = 3.48 \cdot \text{in}$

Angle rivet holes: $\text{holes}_{angle.L2U2} := 2 \cdot 4 \cdot \text{hole} \cdot \frac{3}{8} \text{ in} = 2.81 \cdot \text{in}^2$

Plate rivet holes: $\text{holes}_{plate.L2U2} := 2 \cdot \text{hole} \cdot \frac{1}{2} \text{ in} = 0.94 \cdot \text{in}^2$

Gross area of section: $A_{g.L2U2} = 14.17 \cdot \text{in}^2$

Net area of section: $A_{n.L2U2} := A_{g.L2U2} - \text{holes}_{angle.L2U2} - \text{holes}_{plate.L2U2} = 10.42 \cdot \text{in}^2$

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L2U2, L3U3, L4U4, L5U5, L6U6 POSTS Properties for Any Section Loss

Span 1

L2U2 Right, Span 1: 20% section loss on inside angle legs. (80% remains)

$$\text{Gross Area: } A_{g,L2U2,RS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L2U2,RS1} := A_{n,L2U2} - 2\left(\frac{3}{8} \cdot \text{in} \cdot 0.20\right) \cdot 6\text{in} = 9.52 \cdot \text{in}^2$$

Section loss at inside angles requires a recalc. of the angle inertia to.

$$\text{Angle area: } A_{angle,L2U2,in} := A_{angle,L2U2} - \left(\frac{3}{8} \cdot \text{in} \cdot 0.20\right) \cdot 6\text{in} = 2.04 \cdot \text{in}^2$$

$$\text{Length of short leg: } l_{s,L2U2} := 3\text{in} - \frac{3}{8}\text{in} = 2.62 \cdot \text{in}$$

X-axis c.g. of angle:

$$y_{angle,L2U2,in} := \left[\frac{\left(4\text{in} \cdot \frac{3}{8} \cdot \text{in} \cdot 0.8\right) \cdot 2\text{in} + \left(l_{s,L2U2} \cdot \frac{3}{8} \cdot \text{in}\right) \cdot \frac{3}{16} \cdot \text{in}}{A_{angle,L2U2,in}} \right] = 1.27 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{angle,L2U2,in} := \left[\frac{\left(4\text{in} \cdot \frac{3}{8} \cdot \text{in} \cdot 0.8\right) \cdot \frac{3}{16} \cdot \text{in} \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \cdot \text{in}\right) \cdot \left(\frac{3}{8} \cdot \text{in} + \frac{l_{s,L2U2}}{2}\right)}{A_{angle,L2U2,in}} \right] = 0.92 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,angle,L2U2,in} := \left[\frac{1}{12} \cdot \frac{3}{8} \cdot \text{in} \cdot 0.8 \cdot (4\text{in})^3 + \frac{1}{12} \cdot l_{s,L2U2} \left(\frac{3}{8} \cdot \text{in}\right)^3 \dots + \left(4\text{in} \cdot \frac{3}{8} \cdot \text{in} \cdot 0.8\right) \cdot \left(2\text{in} - y_{angle,L2U2,in}\right)^2 \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \cdot \text{in}\right) \cdot \left(\frac{3}{16} \cdot \text{in} - y_{angle,L2U2,in}\right)^2 \right] = 3.4 \cdot \text{in}^4$$

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Inertia of angle about y-axis:

$$I_{y.\text{angle.L2U2.in}} := \left[\frac{1}{12} \cdot \left(\frac{3}{8} \text{in} \cdot 0.8 \right)^3 \cdot 4 \text{in} + \frac{1}{12} \cdot (l_s.\text{L2U2})^3 \cdot \frac{3}{8} \text{in} \dots \right. \\ \left. + \left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.8 \right) \cdot \left(\frac{3}{16} \text{in} - x_{\text{angle.L2U2.in}} \right)^2 \dots \right. \\ \left. + \left(l_s.\text{L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left[\left(\frac{3}{8} \text{in} + \frac{l_s.\text{L2U2}}{2} \right) - x_{\text{angle.L2U2.in}} \right]^2 \right] = 1.8 \cdot \text{in}^4$$

Inertias:

$$I_{x.\text{L2U2.RS1}} := \left[\frac{1}{12} 8.5 \text{in} \cdot \left(\frac{1}{2} \text{in} \right)^3 + 2 \cdot I_{x.\text{angle.L2U2}} \dots \right. \\ \left. + 2 \cdot I_{x.\text{angle.L2U2.in}} \dots \right. \\ \left. + 2A_{\text{angle.L2U2}} \cdot \left(\frac{1}{4} \text{in} + y_{\text{angle.L2U2}} \right)^2 \dots \right. \\ \left. + 2A_{\text{angle.L2U2.in}} \cdot \left(\frac{1}{4} \text{in} + y_{\text{angle.L2U2.in}} \right)^2 \right] = 36 \cdot \text{in}^4$$

$$I_{y.\text{L2U2.RS1}} := \left[\frac{1}{12} (8.5 \text{in})^3 \cdot \frac{1}{2} \text{in} + 2 \cdot I_{y.\text{angle.L2U2}} \dots \right. \\ \left. + 2 \cdot I_{y.\text{angle.L2U2.in}} \dots \right. \\ \left. + 2A_{\text{angle.L2U2}} \cdot \left(\frac{9}{2} \text{in} - x_{\text{angle.L2U2}} \right)^2 \dots \right. \\ \left. + 2A_{\text{angle.L2U2.in}} \cdot \left(\frac{9}{2} \text{in} - x_{\text{angle.L2U2.in}} \right)^2 \right] = 154 \cdot \text{in}^4$$

R. of gyration: $r_{x.\text{L2U2.RS1}} := \sqrt{\frac{I_{x.\text{L2U2.RS1}}}{A_{g.\text{L2U2.RS1}}}} = 1.59 \cdot \text{in}$

$r_{y.\text{L2U2.RS1}} := \sqrt{\frac{I_{y.\text{L2U2.RS1}}}{A_{g.\text{L2U2.RS1}}}} = 3.3 \cdot \text{in}$

L2U2 Left, Span 1: No section loss.

Gross Area: $A_{g.\text{L2U2.LS1}} := A_{g.\text{L2U2}} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n.\text{L2U2.LS1}} := A_{n.\text{L2U2}} = 10.42 \cdot \text{in}^2$

Inertias: $I_{x.\text{L2U2.LS1}} := I_{x.\text{L2U2}} = 39 \cdot \text{in}^4$

$I_{y.\text{L2U2.LS1}} := I_{y.\text{L2U2}} = 171 \cdot \text{in}^4$

R. of gyration: $r_{x.\text{L2U2.LS1}} := r_{x.\text{L2U2}} = 1.66 \cdot \text{in}$

$r_{y.\text{L2U2.LS1}} := r_{y.\text{L2U2}} = 3.48 \cdot \text{in}$

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L3U3 Right, Span 1: 15% section loss on inside angle legs. (85% remains)

$$\text{Gross Area: } A_{g,L3U3.RS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3U3.RS1} := A_{n,L2U2} - 2 \left(\frac{3}{8} \text{in} \cdot 0.15 \right) \cdot 6 \text{in} = 9.75 \cdot \text{in}^2$$

Section loss at inside angles requires a recalc. of the angle inertia to.

$$\text{Angle area: } A_{\text{angle},L3U3.in} := A_{\text{angle},L2U2} - \left(\frac{3}{8} \text{in} \cdot 0.15 \right) \cdot 6 \text{in} = 2.15 \cdot \text{in}^2$$

$$\text{Length of short leg: } l_{s,L2U2} = 2.62 \cdot \text{in}$$

X-axis c.g. of angle:

$$y_{\text{angle},L3U3.in} := \left[\frac{\left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.85 \right) \cdot 2 \text{in} + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \frac{3}{16} \text{in}}{A_{\text{angle},L3U3.in}} \right] = 1.27 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{\text{angle},L3U3.in} := \left[\frac{\left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.85 \right) \cdot \frac{3}{16} \text{in} \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left(\frac{3}{8} \text{in} + \frac{l_{s,L2U2}}{2} \right)}{A_{\text{angle},L3U3.in}} \right] = 0.88 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,\text{angle},L3U3.in} := \left[\frac{1}{12} \cdot \frac{3}{8} \text{in} \cdot 0.85 \cdot (4 \text{in})^3 + \frac{1}{12} \cdot l_{s,L2U2} \left(\frac{3}{8} \text{in} \right)^3 \dots + \left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.85 \right) \cdot (2 \text{in} - y_{\text{angle},L3U3.in})^2 \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left(\frac{3}{16} \text{in} - y_{\text{angle},L3U3.in} \right)^2 \right] = 3.54 \cdot \text{in}^4$$

Inertia of angle about y-axis:

$$I_{y,\text{angle},L3U3.in} := \left[\frac{1}{12} \cdot \left(\frac{3}{8} \text{in} \cdot 0.85 \right)^3 \cdot 4 \text{in} + \frac{1}{12} \cdot \left(l_{s,L2U2} \right)^3 \cdot \frac{3}{8} \text{in} \dots + \left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.85 \right) \cdot \left(\frac{3}{16} \text{in} - x_{\text{angle},L3U3.in} \right)^2 \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left[\left(\frac{3}{8} \text{in} + \frac{l_{s,L2U2}}{2} \right) - x_{\text{angle},L3U3.in} \right]^2 \right] = 1.83 \cdot \text{in}^4$$

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Inertias:

$$I_{x,L3U3.RS1} := \left[\frac{1}{12} 8.5\text{in} \cdot \left(\frac{1}{2}\text{in} \right)^3 + 2 \cdot I_{x,\text{angle},L2U2} \dots + 2 \cdot I_{x,\text{angle},L3U3,in} \dots + 2A_{\text{angle},L2U2} \cdot \left(\frac{1}{4}\text{in} + y_{\text{angle},L2U2} \right)^2 \dots + 2A_{\text{angle},L3U3,in} \cdot \left(\frac{1}{4}\text{in} + y_{\text{angle},L3U3,in} \right)^2 \right] = 37 \cdot \text{in}^4$$

$$I_{y,L3U3.RS1} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{1}{2}\text{in} + 2 \cdot I_{y,\text{angle},L2U2} \dots + 2 \cdot I_{y,\text{angle},L3U3,in} \dots + 2A_{\text{angle},L2U2} \cdot \left(\frac{9}{2}\text{in} - x_{\text{angle},L2U2} \right)^2 \dots + 2A_{\text{angle},L3U3,in} \cdot \left(\frac{9}{2}\text{in} - x_{\text{angle},L3U3,in} \right)^2 \right] = 158 \cdot \text{in}^4$$

R. of gyration: $r_{x,L3U3.RS1} := \sqrt{\frac{I_{x,L3U3.RS1}}{A_{g,L3U3.RS1}}} = 1.61 \cdot \text{in}$

$$r_{y,L3U3.RS1} := \sqrt{\frac{I_{y,L3U3.RS1}}{A_{g,L3U3.RS1}}} = 3.34 \cdot \text{in}$$

L3U3 Left, Span 1: 5% section loss on inside angle legs. (95% remains)

Gross Area: $A_{g,L3U3.LS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L3U3.LS1} := A_{n,L2U2} - 2 \left(\frac{3}{8}\text{in} \cdot 0.05 \right) \cdot 6\text{in} = 10.2 \cdot \text{in}^2$

Section loss at inside angles requires a recalc. of the angle inertia to.

Angle area: $A_{\text{angle},L3U3,inL} := A_{\text{angle},L2U2} - \left(\frac{3}{8}\text{in} \cdot 0.05 \right) \cdot 6\text{in} = 2.38 \cdot \text{in}^2$

Length of short leg: $l_{s,L2U2} = 2.62 \cdot \text{in}$

X-axis c.g. of angle:

$$y_{\text{angle},L3U3,inL} := \left[\frac{\left(4\text{in} \cdot \frac{3}{8}\text{in} \cdot 0.95 \right) \cdot 2\text{in} + \left(l_{s,L2U2} \cdot \frac{3}{8}\text{in} \right) \cdot \frac{3}{16}\text{in}}{A_{\text{angle},L3U3,inL}} \right] = 1.28 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{\text{angle},L3U3,inL} := \left[\frac{\left(4\text{in} \cdot \frac{3}{8}\text{in} \cdot 0.95 \right) \cdot \frac{3}{16}\text{in} \dots + \left(l_{s,L2U2} \cdot \frac{3}{8}\text{in} \right) \cdot \left(\frac{3}{8}\text{in} + \frac{l_{s,L2U2}}{2} \right)}{A_{\text{angle},L3U3,inL}} \right] = 0.81 \cdot \text{in}$$

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Inertia of angle about x-axis:

$$I_{x.\text{angle}.L3U3.inL} := \left[\frac{1}{12} \cdot \frac{3}{8} \text{in} \cdot 0.95 \cdot (4\text{in})^3 + \frac{1}{12} \cdot I_{s.L2U2} \left(\frac{3}{8} \text{in} \right)^3 \dots + \left(4\text{in} \cdot \frac{3}{8} \text{in} \cdot 0.95 \right) \cdot \left(2\text{in} - y_{\text{angle}.L3U3.inL} \right)^2 \dots + \left(I_{s.L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left(\frac{3}{16} \text{in} - y_{\text{angle}.L3U3.inL} \right)^2 \right] = 3.82 \cdot \text{in}^4$$

Inertia of angle about y-axis:

$$I_{y.\text{angle}.L3U3.inL} := \left[\frac{1}{12} \cdot \left(\frac{3}{8} \text{in} \cdot 0.95 \right)^3 \cdot 4\text{in} + \frac{1}{12} \cdot \left(I_{s.L2U2} \right)^3 \cdot \frac{3}{8} \text{in} \dots + \left(4\text{in} \cdot \frac{3}{8} \text{in} \cdot 0.95 \right) \cdot \left(\frac{3}{16} \text{in} - x_{\text{angle}.L3U3.inL} \right)^2 \dots + \left(I_{s.L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left[\left(\frac{3}{8} \text{in} + \frac{I_{s.L2U2}}{2} \right) - x_{\text{angle}.L3U3.inL} \right]^2 \right] = 1.89 \cdot \text{in}^4$$

Inertias:

$$I_{x.L3U3.LS1} := \left[\frac{1}{12} 8.5\text{in} \cdot \left(\frac{1}{2} \text{in} \right)^3 + 2 \cdot I_{x.\text{angle}.L2U2} \dots + 2 \cdot I_{x.\text{angle}.L3U3.inL} \dots + 2A_{\text{angle}.L2U2} \cdot \left(\frac{1}{4} \text{in} + y_{\text{angle}.L2U2} \right)^2 \dots + 2A_{\text{angle}.L3U3.inL} \cdot \left(\frac{1}{4} \text{in} + y_{\text{angle}.L3U3.inL} \right)^2 \right] = 38 \cdot \text{in}^4$$

$$I_{y.L3U3.LS1} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{1}{2} \text{in} + 2 \cdot I_{y.\text{angle}.L2U2} \dots + 2 \cdot I_{y.\text{angle}.L3U3.inL} \dots + 2A_{\text{angle}.L2U2} \cdot \left(\frac{9}{2} \text{in} - x_{\text{angle}.L2U2} \right)^2 \dots + 2A_{\text{angle}.L3U3.inL} \cdot \left(\frac{9}{2} \text{in} - x_{\text{angle}.L3U3.inL} \right)^2 \right] = 167 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x.L3U3.LS1} := \sqrt{\frac{I_{x.L3U3.LS1}}{A_{g.L3U3.LS1}}} = 1.64 \cdot \text{in}$$

$$r_{y.L3U3.LS1} := \sqrt{\frac{I_{y.L3U3.LS1}}{A_{g.L3U3.LS1}}} = 3.43 \cdot \text{in}$$

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L4U4 Right, Span 1: 30% section loss on inside angle legs. (70% remains)

$$\text{Gross Area: } A_{g,L4U4.RS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L4U4.RS1} := A_{n,L2U2} - 2 \left(\frac{3}{8} \text{in} \cdot 0.30 \right) \cdot 6 \text{in} = 9.07 \cdot \text{in}^2$$

Section loss at inside angles requires a recalc. of the angle inertia to.

$$\text{Angle area: } A_{\text{angle},L4U4.in} := A_{\text{angle},L2U2} - \left(\frac{3}{8} \text{in} \cdot 0.30 \right) \cdot 6 \text{in} = 1.82 \cdot \text{in}^2$$

$$\text{Length of short leg: } l_{s,L2U2} = 2.62 \cdot \text{in}$$

X-axis c.g. of angle:

$$y_{\text{angle},L4U4.in} := \left[\frac{\left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.7 \right) \cdot 2 \text{in} + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \frac{3}{16} \text{in}}{A_{\text{angle},L4U4.in}} \right] = 1.26 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{\text{angle},L4U4.in} := \left[\frac{\left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.7 \right) \cdot \frac{3}{16} \text{in} \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left(\frac{3}{8} \text{in} + \frac{l_{s,L2U2}}{2} \right)}{A_{\text{angle},L4U4.in}} \right] = 1.02 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,\text{angle},L4U4.in} := \left[\frac{1}{12} \cdot \frac{3}{8} \text{in} \cdot 0.7 \cdot (4 \text{in})^3 + \frac{1}{12} \cdot l_{s,L2U2} \left(\frac{3}{8} \text{in} \right)^3 \dots + \left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.7 \right) \cdot (2 \text{in} - y_{\text{angle},L4U4.in})^2 \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left(\frac{3}{16} \text{in} - y_{\text{angle},L4U4.in} \right)^2 \right] = 3.12 \cdot \text{in}^4$$

Inertia of angle about y-axis:

$$I_{y,\text{angle},L4U4.in} := \left[\frac{1}{12} \cdot \left(\frac{3}{8} \text{in} \cdot 0.7 \right)^3 \cdot 4 \text{in} + \frac{1}{12} \cdot \left(l_{s,L2U2} \right)^3 \cdot \frac{3}{8} \text{in} \dots + \left(4 \text{in} \cdot \frac{3}{8} \text{in} \cdot 0.7 \right) \cdot \left(\frac{3}{16} \text{in} - x_{\text{angle},L4U4.in} \right)^2 \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \text{in} \right) \cdot \left[\left(\frac{3}{8} \text{in} + \frac{l_{s,L2U2}}{2} \right) - x_{\text{angle},L4U4.in} \right]^2 \right] = 1.74 \cdot \text{in}^4$$

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Inertias:

$$I_{x,L4U4.RS1} := \left[\frac{1}{12} 8.5\text{in} \cdot \left(\frac{1}{2}\text{in} \right)^3 + 2 \cdot I_{x,\text{angle},L2U2} \dots + 2 \cdot I_{x,\text{angle},L4U4,\text{in}} \dots + 2A_{\text{angle},L2U2} \cdot \left(\frac{1}{4}\text{in} + y_{\text{angle},L2U2} \right)^2 \dots + 2A_{\text{angle},L4U4,\text{in}} \cdot \left(\frac{1}{4}\text{in} + y_{\text{angle},L4U4,\text{in}} \right)^2 \right] = 34 \cdot \text{in}^4$$

$$I_{y,L4U4.RS1} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{1}{2}\text{in} + 2 \cdot I_{y,\text{angle},L2U2} \dots + 2 \cdot I_{y,\text{angle},L4U4,\text{in}} \dots + 2A_{\text{angle},L2U2} \cdot \left(\frac{9}{2}\text{in} - x_{\text{angle},L2U2} \right)^2 \dots + 2A_{\text{angle},L4U4,\text{in}} \cdot \left(\frac{9}{2}\text{in} - x_{\text{angle},L4U4,\text{in}} \right)^2 \right] = 146 \cdot \text{in}^4$$

R. of gyration: $r_{x,L4U4.RS1} := \sqrt{\frac{I_{x,L4U4.RS1}}{A_{g,L4U4.RS1}}} = 1.55 \cdot \text{in}$

$r_{y,L4U4.RS1} := \sqrt{\frac{I_{y,L4U4.RS1}}{A_{g,L4U4.RS1}}} = 3.21 \cdot \text{in}$

L4U4 Left, Span 1: 5% section loss on inside angle legs, same as L3U3 Left, Span 1.

Gross Area: $A_{g,L4U4.LS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L4U4.LS1} := A_{n,L3U3.LS1} = 10.2 \cdot \text{in}^2$

Inertias: $I_{x,L4U4.LS1} := I_{x,L3U3.LS1} = 38 \cdot \text{in}^4$

$I_{y,L4U4.LS1} := I_{y,L3U3.LS1} = 167 \cdot \text{in}^4$

R. of gyration: $r_{x,L4U4.LS1} := r_{x,L3U3.LS1} = 1.64 \cdot \text{in}$

$r_{y,L4U4.LS1} := r_{y,L3U3.LS1} = 3.43 \cdot \text{in}$

L5U5 Right, Span 1: 20% section loss on inside angle legs, same as L2U2 Right, Span 1.

Gross Area: $A_{g,L5U5.RS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L5U5.RS1} := A_{n,L2U2.RS1} = 9.52 \cdot \text{in}^2$

Inertias: $I_{x,L5U5.RS1} := I_{x,L2U2.RS1} = 36 \cdot \text{in}^4$

$I_{y,L5U5.RS1} := I_{y,L2U2.RS1} = 154 \cdot \text{in}^4$

R. of gyration: $r_{x,L5U5.RS1} := r_{x,L2U2.RS1} = 1.59 \cdot \text{in}$

$r_{y,L5U5.RS1} := r_{y,L2U2.RS1} = 3.3 \cdot \text{in}$

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L5U5 Left, Span 1: 10% section loss on inside angle legs. (90% remains)

$$\text{Gross Area: } A_{g,L5U5,LS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L5U5,LS1} := A_{n,L2U2} - 2\left(\frac{3}{8} \cdot 0.1\right) \cdot 6\text{in} = 9.97 \cdot \text{in}^2$$

Section loss at inside angles requires a recalc. of the angle inertia to.

$$\text{Angle area: } A_{angle,L5U5,in} := A_{angle,L2U2} - \left(\frac{3}{8} \cdot 0.1\right) \cdot 6\text{in} = 2.27 \cdot \text{in}^2$$

$$\text{Length of short leg: } l_{s,L2U2} = 2.62 \cdot \text{in}$$

X-axis c.g. of angle:

$$y_{angle,L5U5,in} := \left[\frac{\left(4\text{in} \cdot \frac{3}{8} \cdot 0.9\right) \cdot 2\text{in} + \left(l_{s,L2U2} \cdot \frac{3}{8} \cdot \text{in}\right) \cdot \frac{3}{16} \cdot \text{in}}{A_{angle,L5U5,in}} \right] = 1.27 \cdot \text{in}$$

Y-axis c.g. of angle:

$$x_{angle,L5U5,in} := \left[\frac{\left(4\text{in} \cdot \frac{3}{8} \cdot 0.9\right) \cdot \frac{3}{16} \cdot \text{in} \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \cdot \text{in}\right) \cdot \left(\frac{3}{8} \cdot \text{in} + \frac{l_{s,L2U2}}{2}\right)}{A_{angle,L5U5,in}} \right] = 0.85 \cdot \text{in}$$

Inertia of angle about x-axis:

$$I_{x,angle,L5U5,in} := \left[\frac{1}{12} \cdot \frac{3}{8} \cdot \text{in} \cdot 0.9 \cdot (4\text{in})^3 + \frac{1}{12} \cdot l_{s,L2U2} \left(\frac{3}{8} \cdot \text{in}\right)^3 \dots + \left(4\text{in} \cdot \frac{3}{8} \cdot 0.9\right) \cdot (2\text{in} - y_{angle,L5U5,in})^2 \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \cdot \text{in}\right) \cdot \left(\frac{3}{16} \cdot \text{in} - y_{angle,L5U5,in}\right)^2 \right] = 3.69 \cdot \text{in}^4$$

Inertia of angle about y-axis:

$$I_{y,angle,L5U5,in} := \left[\frac{1}{12} \cdot \left(\frac{3}{8} \cdot \text{in} \cdot 0.9\right)^3 \cdot 4\text{in} + \frac{1}{12} \cdot \left(l_{s,L2U2}\right)^3 \cdot \frac{3}{8} \cdot \text{in} \dots + \left(4\text{in} \cdot \frac{3}{8} \cdot 0.9\right) \cdot \left(\frac{3}{16} \cdot \text{in} - x_{angle,L5U5,in}\right)^2 \dots + \left(l_{s,L2U2} \cdot \frac{3}{8} \cdot \text{in}\right) \cdot \left[\left(\frac{3}{8} \cdot \text{in} + \frac{l_{s,L2U2}}{2}\right) - x_{angle,L5U5,in}\right]^2 \right] = 1.86 \cdot \text{in}^4$$

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Inertias:

$$I_{x,L5U5,LS1} := \left[\frac{1}{12} 8.5\text{in} \cdot \left(\frac{1}{2}\text{in} \right)^3 + 2 \cdot I_{x,\text{angle},L2U2} \dots + 2 \cdot I_{x,\text{angle},L5U5,\text{in}} \dots + 2A_{\text{angle},L2U2} \cdot \left(\frac{1}{4}\text{in} + y_{\text{angle},L2U2} \right)^2 \dots + 2A_{\text{angle},L5U5,\text{in}} \cdot \left(\frac{1}{4}\text{in} + y_{\text{angle},L5U5,\text{in}} \right)^2 \right] = 37 \cdot \text{in}^4$$

$$I_{y,L5U5,LS1} := \left[\frac{1}{12} (8.5\text{in})^3 \cdot \frac{1}{2}\text{in} + 2 \cdot I_{y,\text{angle},L2U2} \dots + 2 \cdot I_{y,\text{angle},L5U5,\text{in}} \dots + 2A_{\text{angle},L2U2} \cdot \left(\frac{9}{2}\text{in} - x_{\text{angle},L2U2} \right)^2 \dots + 2A_{\text{angle},L5U5,\text{in}} \cdot \left(\frac{9}{2}\text{in} - x_{\text{angle},L5U5,\text{in}} \right)^2 \right] = 163 \cdot \text{in}^4$$

R. of gyration: $r_{x,L5U5,LS1} := \sqrt{\frac{I_{x,L5U5,LS1}}{A_{g,L5U5,LS1}}} = 1.62 \cdot \text{in}$

$r_{y,L5U5,LS1} := \sqrt{\frac{I_{y,L5U5,LS1}}{A_{g,L5U5,LS1}}} = 3.39 \cdot \text{in}$

L6U6 Right, Span 1: 10% section loss on inside angle legs, same as L5U5 Left, Span 1.

Gross Area: $A_{g,L6U6,RS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L6U6,RS1} := A_{n,L5U5,LS1} = 9.97 \cdot \text{in}^2$

Inertias: $I_{x,L6U6,RS1} := I_{x,L5U5,LS1} = 37 \cdot \text{in}^4$

$I_{y,L6U6,RS1} := I_{y,L5U5,LS1} = 163 \cdot \text{in}^4$

R. of gyration: $r_{x,L6U6,RS1} := r_{x,L5U5,LS1} = 1.62 \cdot \text{in}$

$r_{y,L6U6,RS1} := r_{y,L5U5,LS1} = 3.39 \cdot \text{in}$

L6U6 Left, Span 1: 10% section loss on inside angle legs, same as L5U5 Left, Span 1.

Gross Area: $A_{g,L6U6,LS1} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L6U6,LS1} := A_{n,L5U5,LS1} = 9.97 \cdot \text{in}^2$

Inertias: $I_{x,L6U6,LS1} := I_{x,L5U5,LS1} = 37 \cdot \text{in}^4$

$I_{y,L6U6,LS1} := I_{y,L5U5,LS1} = 163 \cdot \text{in}^4$

R. of gyration: $r_{x,L6U6,LS1} := r_{x,L5U5,LS1} = 1.62 \cdot \text{in}$

$r_{y,L6U6,LS1} := r_{y,L5U5,LS1} = 3.39 \cdot \text{in}$

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Span 2

L2U2 Right, Span 2: 10% section loss on inside angle legs, same as L5U5 Left, Span 1.

$$\text{Gross Area: } A_{g,L2U2.RS2} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L2U2.RS2} := A_{n,L5U5.LS1} = 9.97 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L2U2.RS2} := I_{x,L5U5.LS1} = 37 \cdot \text{in}^4$$

$$I_{y,L2U2.RS2} := I_{y,L5U5.LS1} = 163 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L2U2.RS2} := r_{x,L5U5.LS1} = 1.62 \cdot \text{in}$$

$$r_{y,L2U2.RS2} := r_{y,L5U5.LS1} = 3.39 \cdot \text{in}$$

L2U2 Left, Span 2: 5% section loss on inside angle legs, same as L3U3 Left, Span 1.

$$\text{Gross Area: } A_{g,L2U2.LS2} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L2U2.LS2} := A_{n,L3U3.LS1} = 10.2 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L2U2.LS2} := I_{x,L3U3.LS1} = 38 \cdot \text{in}^4$$

$$I_{y,L2U2.LS2} := I_{y,L3U3.LS1} = 167 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L2U2.LS2} := r_{x,L3U3.LS1} = 1.64 \cdot \text{in}$$

$$r_{y,L2U2.LS2} := r_{y,L3U3.LS1} = 3.43 \cdot \text{in}$$

L3U3 Right, Span 2: 15% section loss on inside angle legs, same as L3U3 Right, Span 1.

$$\text{Gross Area: } A_{g,L3U3.RS2} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3U3.RS2} := A_{n,L3U3.RS1} = 9.75 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L3U3.RS2} := I_{x,L3U3.RS1} = 37 \cdot \text{in}^4$$

$$I_{y,L3U3.RS2} := I_{y,L3U3.RS1} = 158 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L3U3.RS2} := r_{x,L3U3.RS1} = 1.61 \cdot \text{in}$$

$$r_{y,L3U3.RS2} := r_{y,L3U3.RS1} = 3.34 \cdot \text{in}$$

L3U3 Left, Span 2: 15% section loss on inside angle legs, same as L3U3 Right, Span 1.

$$\text{Gross Area: } A_{g,L3U3.LS2} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$$

$$\text{Net Area: } A_{n,L3U3.LS2} := A_{n,L3U3.RS1} = 9.75 \cdot \text{in}^2$$

$$\text{Inertias: } I_{x,L3U3.LS2} := I_{x,L3U3.RS1} = 37 \cdot \text{in}^4$$

$$I_{y,L3U3.LS2} := I_{y,L3U3.RS1} = 158 \cdot \text{in}^4$$

$$\text{R. of gyration: } r_{x,L3U3.LS2} := r_{x,L3U3.RS1} = 1.61 \cdot \text{in}$$

$$r_{y,L3U3.LS2} := r_{y,L3U3.RS1} = 3.34 \cdot \text{in}$$

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L4U4 Right, Span 2: 20% section loss on inside angle legs, same as L2U2 Right, Span 1.

Gross Area: $A_{g,L4U4.RS2} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L4U4.RS2} := A_{n,L2U2.RS1} = 9.52 \cdot \text{in}^2$

Inertias: $I_{x,L4U4.RS2} := I_{x,L2U2.RS1} = 36 \cdot \text{in}^4$

$I_{y,L4U4.RS2} := I_{y,L2U2.RS1} = 154 \cdot \text{in}^4$

R. of gyration: $r_{x,L4U4.RS2} := r_{x,L2U2.RS1} = 1.59 \cdot \text{in}$

$r_{y,L4U4.RS2} := r_{y,L2U2.RS1} = 3.3 \cdot \text{in}$

L4U4 Left, Span 2: 20% section loss on inside angle legs, same as L2U2 Right, Span 1.

Gross Area: $A_{g,L4U4.LS2} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L4U4.LS2} := A_{n,L2U2.RS1} = 9.52 \cdot \text{in}^2$

Inertias: $I_{x,L4U4.LS2} := I_{x,L2U2.RS1} = 36 \cdot \text{in}^4$

$I_{y,L4U4.LS2} := I_{y,L2U2.RS1} = 154 \cdot \text{in}^4$

R. of gyration: $r_{x,L4U4.LS2} := r_{x,L2U2.RS1} = 1.59 \cdot \text{in}$

$r_{y,L4U4.LS2} := r_{y,L2U2.RS1} = 3.3 \cdot \text{in}$

L5U5 Right, Span 2: 30% section loss on inside angle legs, same as L4U4 Right, Span 1.

Gross Area: $A_{g,L5U5.RS2} := A_{g,L2U2} = 14.17 \cdot \text{in}^2$

Net Area: $A_{n,L5U5.RS2} := A_{n,L4U4.RS1} = 9.07 \cdot \text{in}^2$

Inertias: $I_{x,L5U5.RS2} := I_{x,L4U4.RS1} = 34 \cdot \text{in}^4$

$I_{y,L5U5.RS2} := I_{y,L4U4.RS1} = 146 \cdot \text{in}^4$

R. of gyration: $r_{x,L5U5.RS2} := r_{x,L4U4.RS1} = 1.55 \cdot \text{in}$

$r_{y,L5U5.RS2} := r_{y,L4U4.RS1} = 3.21 \cdot \text{in}$

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L5U5 Left, Span 2: 10% section loss on inside angle legs, same as L5U5 Left, Span 1.

Gross Area: $A_g.L5U5.LS2 := A_g.L2U2 = 14.17 \cdot \text{in}^2$

Net Area: $A_n.L5U5.LS2 := A_n.L5U5.LS1 = 9.97 \cdot \text{in}^2$

Inertias: $I_x.L5U5.LS2 := I_x.L5U5.LS1 = 37 \cdot \text{in}^4$

$I_y.L5U5.LS2 := I_y.L5U5.LS1 = 163 \cdot \text{in}^4$

R. of gyration: $r_x.L5U5.LS2 := r_x.L5U5.LS1 = 1.62 \cdot \text{in}$

$r_y.L5U5.LS2 := r_y.L5U5.LS1 = 3.39 \cdot \text{in}$

L6U6 Right, Span 2: 10% section loss on inside angle legs, same as L5U5 Left, Span 1.

Gross Area: $A_g.L6U6.RS2 := A_g.L2U2 = 14.17 \cdot \text{in}^2$

Net Area: $A_n.L6U6.RS2 := A_n.L5U5.LS1 = 9.97 \cdot \text{in}^2$

Inertias: $I_x.L6U6.RS2 := I_x.L5U5.LS1 = 37 \cdot \text{in}^4$

$I_y.L6U6.RS2 := I_y.L5U5.LS1 = 163 \cdot \text{in}^4$

R. of gyration: $r_x.L6U6.RS2 := r_x.L5U5.LS1 = 1.62 \cdot \text{in}$

$r_y.L6U6.RS2 := r_y.L5U5.LS1 = 3.39 \cdot \text{in}$

L6U6 Left, Span 2: 15% section loss on inside angle legs, same as L3U3 Right, Span 1.

Gross Area: $A_g.L6U6.LS2 := A_g.L2U2 = 14.17 \cdot \text{in}^2$

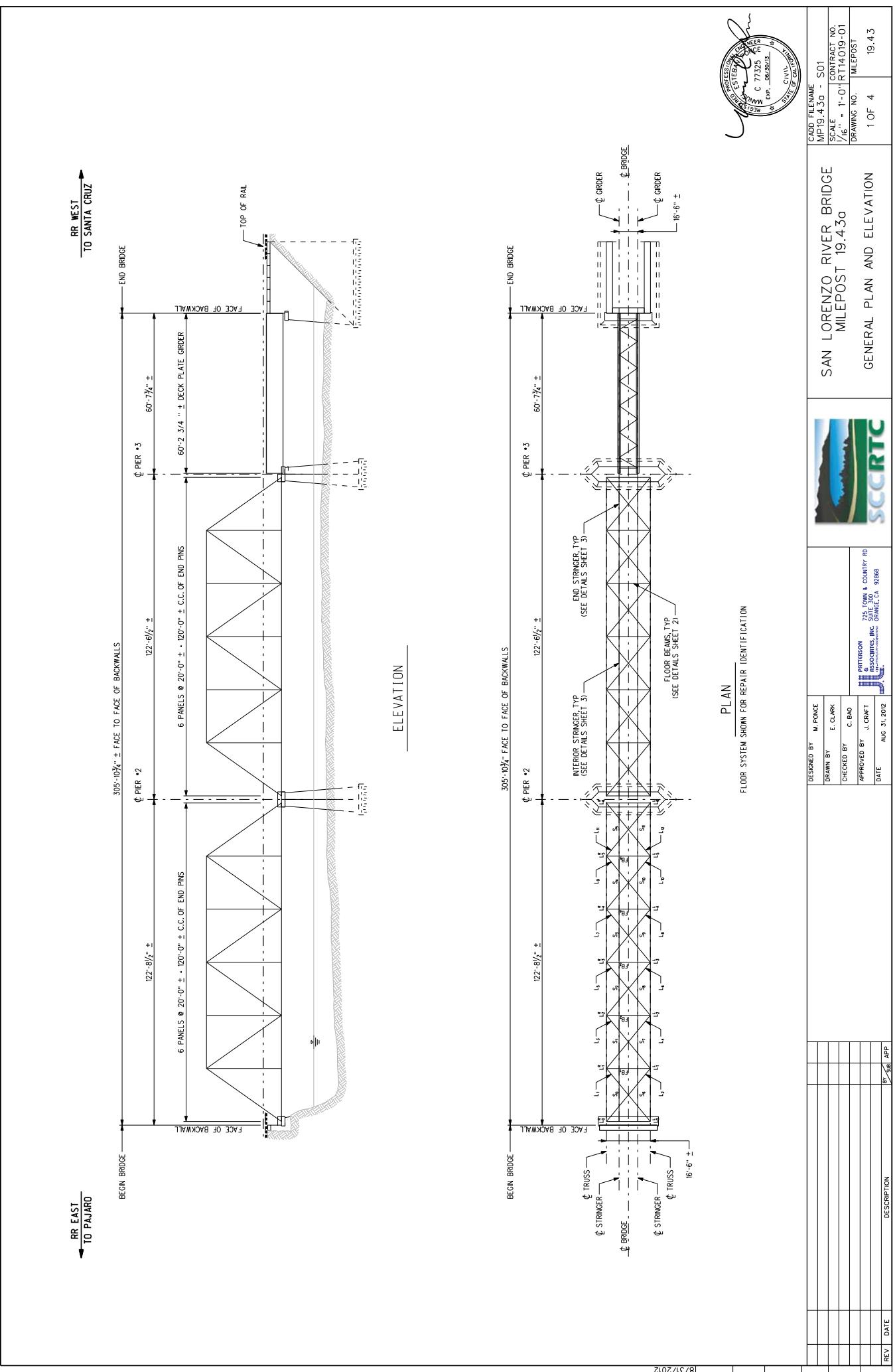
Net Area: $A_n.L6U6.LS2 := A_n.L3U3.RS1 = 9.75 \cdot \text{in}^2$

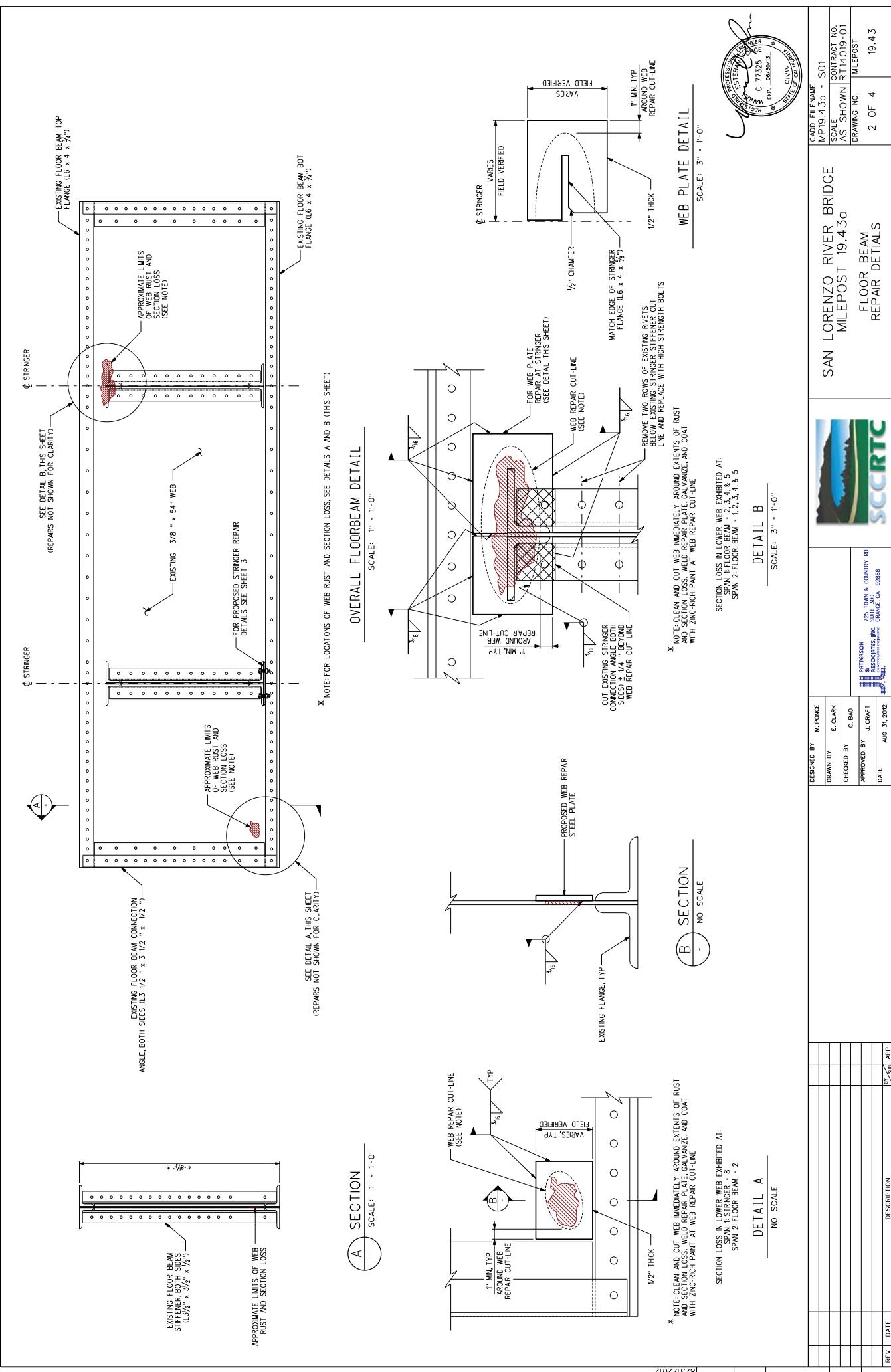
Inertias: $I_x.L6U6.LS2 := I_x.L3U3.RS1 = 37 \cdot \text{in}^4$

$I_y.L6U6.LS2 := I_y.L3U3.RS1 = 158 \cdot \text{in}^4$

R. of gyration: $r_x.L6U6.LS2 := r_x.L3U3.RS1 = 1.61 \cdot \text{in}$

$r_y.L6U6.LS2 := r_y.L3U3.RS1 = 3.34 \cdot \text{in}$





GENERAL NOTES

ALL MATERIAL AND CONSTRUCTION SHALL CONFORM TO THE AMERICAN RAILWAY ENGINEERING AND MANUFACTURERS ASSOCIATION MANUAL FOR RAILWAY JACKING PROCEDURE SHALL BE DEVELOPED BY CONTRACTOR AND SUBMITTED TO ENGINEER FOR APPROVAL.

CONTRACTOR SHALL PROVIDE NEW SEISMIC ISOLATION BEARINGS FOR THE TRUSS SUBMITTED TO ENGINEER FOR APPROVAL. A GEOTECHNICAL STUDY OF THE SITE WILL BE NEEDED TO PROVIDE THE DESIGN PARAMETERS AT THE BRIDGE SITE TO DETERMINE THE TYPE OF ISOLATION BEARINGS NECESSARY. DEAD WEIGHT OF ONE TRUSS IS 406 kip. LIVE LOAD ON ONE TRUSS PER COOPER E80 LOADING IS 158k kip. LIVE LOAD ON TRUSS PER 264 kip. LIVE LOAD ON TROSS PER 266 UNIT TRAIN IS 655 kip.

TRUSS BEARING ANCHOR BOLTS SHALL BE REMOVED AND REPAIRED. CONTRACTOR SHALL SUBMIT DETAILS FOR DOING SO TO ENGINEER FOR APPROVAL.

ALL WORK SHALL CONFORM TO THE REQUIREMENTS OF ASTM A709 GRADE 50. THE BOLTS SHALL BE 7/8" DIAMETER, ASTM A25 TYPE 3. EACH BOLT SHALL HAVE ONE HARDENED WASHER UNDER THE TURNED NUT. ELEMENT BOLTS SHALL BE TIGHTENED BY THE TURN OF THE NUT METHOD AS PER ELEMENT CHAPTER 15, SECTION 12. ALL DIMENSIONS TO BE USED TO CONNECT REQUIRED METALWORK SHALL BE FIELD VERIFIED.

NO FLAME CUTTING SHALL BE ALLOWED FOR THE REMOVAL OF MATERIAL SYSTEM FOR MATERIAL WHICH WILL BE DISPOSED. THE CUT SURFACE OF THE WEB PLATES SHALL BE GROUND TO 1000 MORNOS.

NO FLAME CUTTING SHALL BE ALLOWED FOR REMOVAL OF EXISTING RIVETS ON PORTIONS OF THE EXISTING METALWORK THAT WILL BE RE-INSTALLED.

ALL NEW METALWORK TO BE LEFT PERMANENTLY IN THE STRUCTURE SHALL BE COATED. THE COATING SHALL BE A TWO-PART INORGANIC TOP COAT SYSTEM. SURFACE PREPARATION AND COATING SYSTEMS TO BE SUBMITTED TO ENGINEER FOR REVIEW AND APPROVAL PRIOR TO ORDERING OF COATING MATERIAL.

FOR FURTHER DETAILS, EXISTING DIMENSIONS, AND LAYOUT REFER TO AS-BUILT PLANS.

SCOPE OF WORK

THE BRIDGE AT MP 14.93A, ALSO KNOWN AS THE SAN LORENZO RIVER BRIDGE IS LOCATED ON THE SANTA CRUZ BRANCH LINE IN SANTA CRUZ, CALIFORNIA. THE REPORTS ON THIS STRUCTURE INCLUDE THE FOLLOWING:

1. REMOVE AND REPLACE LATICE THAT HAS 50% OR GREATER SECTION LOSS ANYWHERE ALONG ITS LENGTH OR AROUND THE RIVET HOLES. ATTACH REPLACEMENTS USING BOLTS
2. REMOVE RIVETS THAT DISPLAY SECTION LOSS OF 30% OR GREATER. REPLACE WITH BOLTS
3. JACK BRIDGE, REMOVE AND REPLACE ALL ANCHOR BOLTS FOR THE 3 SPANS. REPLACE BEARINGS WITH SEISMIC ISOLATION BEARINGS AT PERS 2 AND 3.
4. 1/2" STEEL PLATES TO BE BOLTED TO THE CLEARED BOTTOM FLANGE OF STRINGERS. 3/8" SPACER PLATE TO THE CLEARED BOTTOM FLANGE OF BRACING. ADD A 1/8" SPACER PLATE TO THE GUSSET CONNECTION TO MAINTAIN A LEVEL BRACING CONNECTION AT BOTH ENDS.
5. SPAN 1 END STRINGER BASE PLATE AT S7 TO BE REMOVED AND REPLACED PER ORIGINAL AS-BUILT PLANS
6. HOLES IN THE WEBS OF FLLOORBEAMS AND STRINGERS ARE TO BE CLEANED, CUT BEYOND THE RUST, WELDABLE MATERIAL PATCHED BY WELDING A 1/2" STEEL PLATE OVER THE HOLE, AND SPRAY-POLISHED. THE LIMITS OF THE WELDED PLATE SHOULD EXTEND A MINIMUM OF 1" BEYOND THE CUT HOLE OR EXTEND TO THE EDGE OF AN ADJACENT STEEL MEMBER MINUS A 1/8" GAP TO ALLOW FOR FILLET WELD
7. ALL BOTTOM FLANGE MEMBERS ARE TO BE REPLACED. PER ORIGINAL AS-BUILD DRAWINGS AND BOLTED TO CONNECTING GUSSET PLATES. GUSSET PLATES WITH 50% OR MORE SECTION LOSS ARE TO BE REPLACED. PER ORIGINAL AS-BUILD DRAWINGS AND BOLTED TO CONNECTING MEMBERS

FIELD WELDING

ALL FIELD WELDING OPERATIONS, INCLUDING CLEANING, INSPECTION AND NON-DESTRUCTIVE TESTING, SHALL BE PERFORMED IN ACCORDANCE WITH THE ASHTO/AWS BRIDGE WELDING CODE D 15-20D (BWC) AND ADDITIONAL REQUIREMENTS AS SPECIFIED IN THESE NOTES.

EXISTING STEEL BASE MATERIALS TO BE WELDED HAVE BEEN TESTED AND APPROVED FOR USE. THE FLLOORBEAMS AND STRINGERS ARE APPROXIMATELY V-22 AND Q-28. THEREFORE THE SPECIAL WELD PROCEDURE QUALIFICATION TESTING AND NON-DESTRUCTIVE INVESTIGATION REQUIRED BY CLAUSE 4.3 OF THE BWC ARE NOT REQUIRED TO BE PERFORMED BY THE CONTRACTOR.

ALL FIELD WELDING SHALL BE PERFORMED BY THE MANUAL SHIELDED METAL ARC WELDING ISAW PROCESS. OTHER WELDING PROCESSES WILL NOT BE CONSIDERED OR APPROVED. WELDING ELECTRODES USED TO REFURBISH THE WPS SHALL BE E70W-54R CLASSIFICATION. WELDING ELECTRODE STORAGE AND HANDLING ON THE WORK SITE SHALL BE IN ACCORDANCE WITH CLAUSE 4.5 OF THE BWC.

PRIOR TO START OF THE WORK, THE CONTRACTOR SHALL SUBMIT TO THE ENGINEER FOR APPROVAL A PROPERLY PREPARED WELDING PROCEDURE SPECIFICATION (WPS) FOR THE FULLER WELDING OF THE WEB REPAIR PLATES. THE WPS SHALL INCLUDE ALL INFORMATION AS REQUIRED BY THE BWC.

WELDING PREHEAT

PREHEATING OPERATIONS SHALL BE IN ACCORDANCE WITH CLAUSE 4 OF THE BWC EXCEPT THAT THE MINIMUM PREHEAT AND INTERPASS TEMPERATURE FOR ALL WELDING TO THE EXISTING WEB PLATE SHALL BE A MINIMUM OF 250 DEGREES F.

WELD QUALITY AND FINISHING

WELD QUALITY SHALL MEET THE REQUIREMENTS OF CLAUSE 6.2B OF THE BWC.

NON-DESTRUCTIVE TESTING OF WELDS

FILET WELDS CONNECTING NEW PLATES TO WEBS SHALL BE 100% INSPECTED FOR MAGNETIC PARTICLE TESTING (MT). COSTS FOR NOT SHALL BE BORNE BY THE CONTRACTOR AND INCLUDED IN THE VARIOUS ITEMS OF WORK. NO SEPARATE PAYMENT WILL BE MADE FOR NOT.

CONTRACTOR QUALITY CONTROL (QC) INSPECTION

ALL PHASES OF THE WORK INCLUDING THERMAL CUTTING OF EXISTING MEMBERS, CLEANING AND PREPARATION OF ALL REPAIRS, AS WELL AS INSPECTION OF ALL WELDS SHALL BE ENGAGED BY THE CONTRACTOR. QC WILL BE PROVIDED AS PER CLAUSE 6.3.3 OF THE BWC.

THE QC SHALL BE EMPLOYED/ENGAGED BY THE CONTRACTOR AND COSTS WILL BE INCIDENTAL TO THE VARIOUS ITEMS OF WORK. NO SEPARATE PAYMENT WILL BE MADE FOR INSPECTION COSTS. SCHEDULING OF QC CW INSPECTION IS THE CONTRACTOR'S RESPONSIBILITY.

THE CONTRACTOR QC CM SHALL PREPARE DAILY REPORTS SUITABLE TO THE ENGINEER WHICH DOCUMENT THE WORK INSPECTED AND WELDS APPROVED

ORIGINAL AS-BUILT PLANS

6. HOLES IN THE WEBS OF FLLOORBEAMS AND STRINGERS ARE TO BE CLEANED, CUT BEYOND THE RUST, WELDABLE MATERIAL PATCHED BY WELDING A 1/2" STEEL PLATE OVER THE HOLE, AND SPRAY-POLISHED. THE LIMITS OF THE WELDED PLATE SHOULD EXTEND A MINIMUM OF 1" BEYOND THE CUT HOLE OR EXTEND TO THE EDGE OF AN ADJACENT STEEL MEMBER MINUS A 1/8" GAP TO ALLOW FOR FILLET WELD

7. ALL BOTTOM FLANGE MEMBERS ARE TO BE REPLACED. PER ORIGINAL AS-BUILD DRAWINGS AND BOLTED TO CONNECTING GUSSET PLATES. GUSSET PLATES WITH 50% OR MORE SECTION LOSS ARE TO BE REPLACED. PER ORIGINAL AS-BUILD DRAWINGS AND BOLTED TO CONNECTING MEMBERS

8/31/2012
J-PRO/elec/SCCRIC/Brige Inspection/BR-MP-19.4-3/Reports/MP-19.4-3-S04.dwg

PROJECT COST	LINE ELEMENT	STRUCTURE	DETAIL	DESIGN	REV.
				M. PONCE	AUG 31 2012
				E. CLARK	
				C. BAO	
				J. CRAFT	
				PRATHERSON ASSOCIATES, INC.	
				725 TOWER COUNTRY RD SUITE 300 ORANGE, CA 92868	
				APPROVED	
				DATE	
				4	19.4.3



CADD FILENAME: MP-19.4-3.dwg
SCALE: 1:500
CONTRACT NO.: 4-3-04
DRAWING NO.: RT1409-01
EXP. 08/28/2013
C-773725
C-773725
ESTABLISHED 1913
CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING
C-773725
C-773725

SAN LORENZO RIVER BRIDGE
MILEPOST 19.4.3a
GENERAL NOTES
