Building&Safety: Roshanak Amirazizi 1/18/2023

Revision: 5
Permits: BNR21-0604. R5

County of Orange - OC Public Works
OC Development Services
APPROVED
This set of plans and specifications must be kept on the job at all times. It is unlawful to make any changes or alterations to these plans without written permission from OC Public Works, OC Development Services of Orange County. The stamping of these plan specifications SHALL NOT be held to permit or be an approval of the violation of any provisions of any County Ordinance or State law.
Hadi Tabatabaee
BUILDING OFFICIAL
5

Bellingham MARINE®

January 13, 2023

Roshanak Amirazizi P.E.
Civil Engineer
OC Development Services / Building and Safety
Orange County, CA

RE: BNR21-0604 Dana Point Harbor, 80 ft. Gangway Deferred Submittal

Dear Roshanak,

Please find the attached revised drawings and calculations for the 80’ aluminum gangway ramps to be used in the Dana Point Harbor Revitalization Project (permit number BNR21-0604). The drawings and calculations are dated 1/13/2023 and 1/4/2023 respectively.

The gangways are a manufactured product from Topper Industries and have been engineered and sealed by Grantham Engineering. As Engineer-of-Record for the marina portion of the redevelopment, I have reviewed the drawings and calculations for general conformance with the project requirements. This includes review of the attachment of the gangways to the existing seawall.

Sincerely,

Bellingham Marine Engineering

Craig S. Funston, P.E., S.E.

Attachments:
Topper 80’ Gangway Drawing
Topper 80’ Gangway Calculation Set

Bellingham Marine Engineering
144 River Rd.
Lynden, Washington 98264
T 360.392.1433

Building&Safety: Roshanak Amirazizi 1/18/2023

Revision: 5
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Hadi Tabatabaee
BUILDING OFFICIAL
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STRUCTURAL CALCULATIONS FOR

5FT X 80FT GANGWAY

AT

DANA POINT MARINA

BELLINGHAM MARINE INDUSTRIES, INC.

☒ NO EXCEPTIONS TAKEN

☐ REVISE AND RESUBMIT (RAR)

☐ OTHER: ____________________________

REVIEW IS ONLY FOR GENERAL CONFORMANCE WITH THE DESIGN CONCEPT OF THE PROJECT AND GENERAL COMPLIANCE WITH THE INFORMATION GIVEN IN THE CONTRACT DOCUMENTS, ANY ACTION SHOWN IS SUBJECT TO THE REQUIREMENTS OF THE PLANS AND SPECIFICATIONS. CONTRACTOR IS RESPONSIBLE FOR DIMENSIONS WHICH SHALL BE CONFIRMED AND CORRELATED AT THE JOB SITE; ENGINEERING; FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION; COORDINATION OF THEIR WORK WITH THAT OF ALL OTHER TRADES AND THE SATISFACTORY PERFORMANCE OF THEIR WORK.

Craig Funston P.E., S.E.

01/13/2023

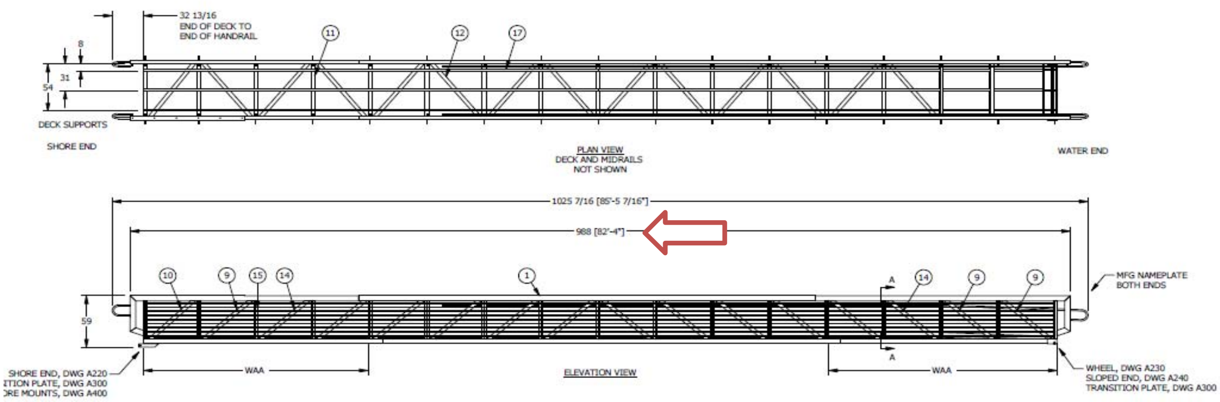
REGISTERED PROFESSIONAL ENGINEER
FREDERICK WILLIAM GRANTHAM
No. 82413
CIVIL
STATE OF CALIFORNIA

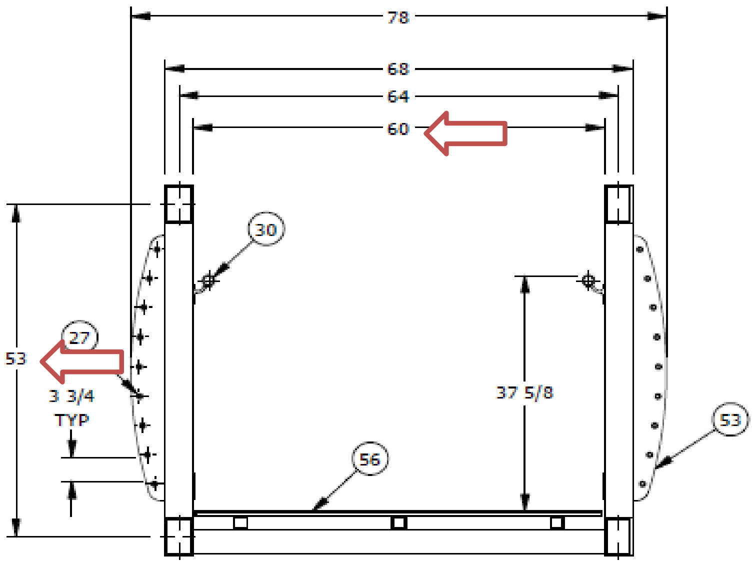
January 4, 2023

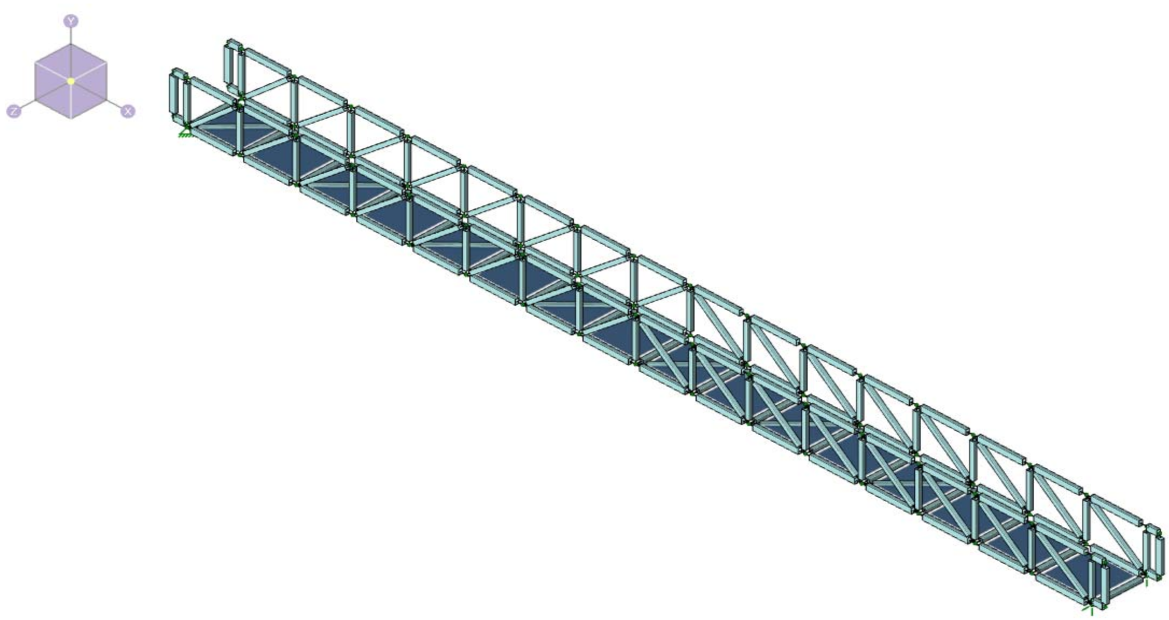
Prepared By:

Grantham Engineering, Inc.
7807 Hillandale Drive
San Diego, CA 92120
(619) 994-0748

GRANTHAM ENGINEERING
Civil • Mechanical • Marine

1	**Structural Calculations for Dana Landing 5ft x 80ft Gangway**
2	**Applicable Codes**
3	ASCE 7-16 Minimum Design Loads for Building and other Structures
4	Aluminum Design Manual 2015 and 2020
5	**Analytical Software**
6	RISA 3D Version 20 (Structural) and Solidworks 2020
7	**Overall Drawing of Gangway**
8	

<table>
<tr><td>9</td><td colspan="3">

SECTION A-A</td></tr>
<tr><td>10</td><td>Length of Gangway, L (ft)</td><td>80.00</td><td>See above (deck length)</td></tr>
<tr><td>11</td><td>Width of Gangway, W (ft)</td><td>5.00</td><td>See above</td></tr>
<tr><td>12</td><td colspan="3">A RISA Model is created of the gangway.</td></tr>
<tr><td>13</td><td colspan="3"></td></tr>
<tr><td>14</td><td colspan="3">The Section Sets define the major structural components of the Model match the parts list defined on the drawing</td></tr>
</table>

15

MAJOR COMPONENT LIST					
ITEM	COMPONENT	DESCRIPTION	MATERIAL	SIZE	NOTE
1	CHORD	RECT TUBE	ALUMINUM	6x4x.250	
11	BRIDGE	SQUARE TUBE	ALUMINUM	4x4x.188	
12	BOTTOM DIAGONAL	SQUARE TUBE	ALUMINUM	4x4x.125	
14	SIDE DIAGONAL	SQUARE TUBE	ALUMINUM	4x4x.125	WAA (4) BAYS EACH END
15	POST	SQUARE TUBE	ALUMINUM	4x4x.188	WAA
17	DECK SUPPORT	SQUARE TUBE	ALUMINUM	2x2x.125	
27	MIDRAIL	PIPE	ALUMINUM	1/2" SCH 40	
30	HANDRAIL	PIPE	ALUMINUM	1 1/4" SCH 40	
53	POST PLATE	PLATE POST	ALUMINUM	1/2x5	
56	DECK, SANDBLASTED	DECK, TOPPER	ALUMINUM	3/4x6	

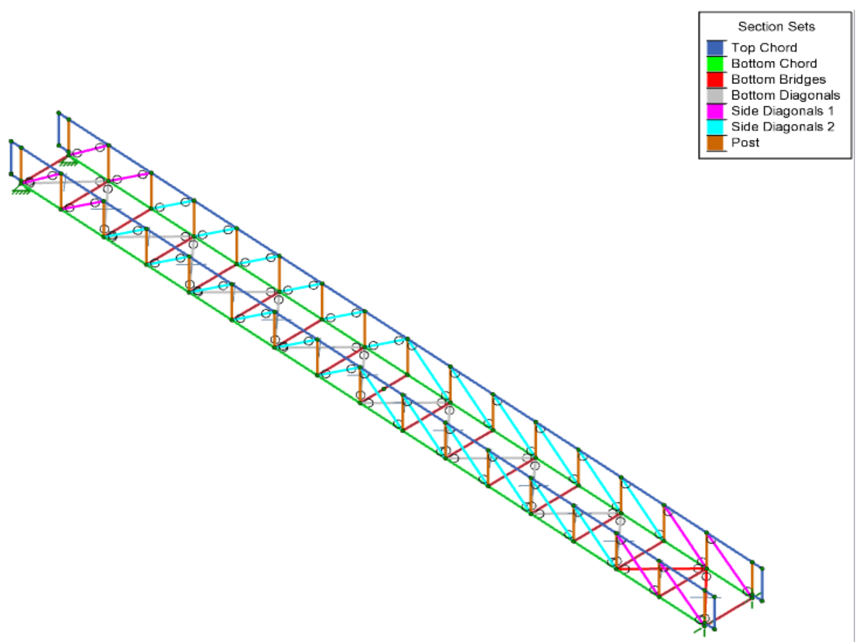
16

Aluminum Section Sets

Hot Rolled | Cold Formed | Wood | Concrete | Aluminum | Stainless | General

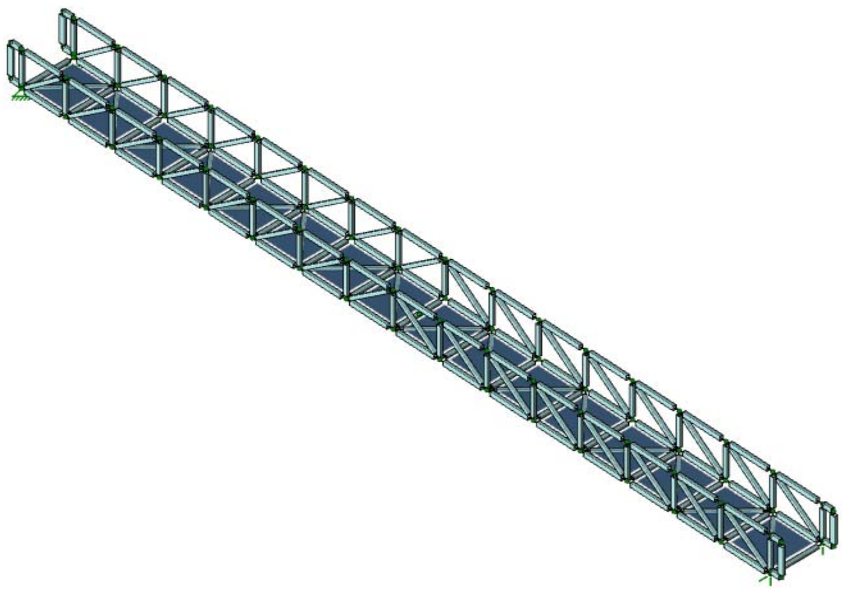
	Label	Shape	Type	Design List	Material
1	Top Chord	RT4X6X0.25	None	None	Top Chord T6 (6 x 4) W
2	Bottom Chord	RT4X6X0.25	None	None	Bottom Chord T6 (6 x 4) W
3	Bottom Bridges	RT4X4X0.188	None	None	6061-T6
4	Bottom Diagonals	RT4X4X0.188	None	None	6061-T6
5	Side Diagonals 1	RT4X4X0.188	None	None	6061-T6
6	Side Diagonals 2	RT4X4X0.125	None	None	6061-T6
7	Post	RT4X4X0.188	None	None	6061-T6

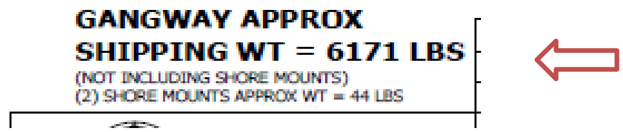
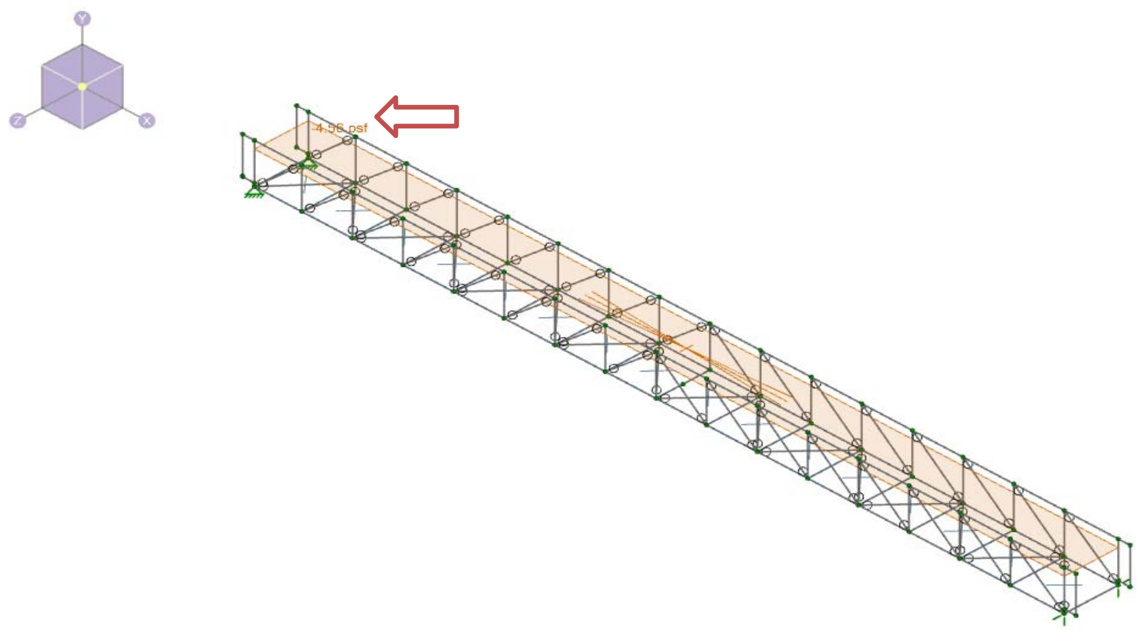
17

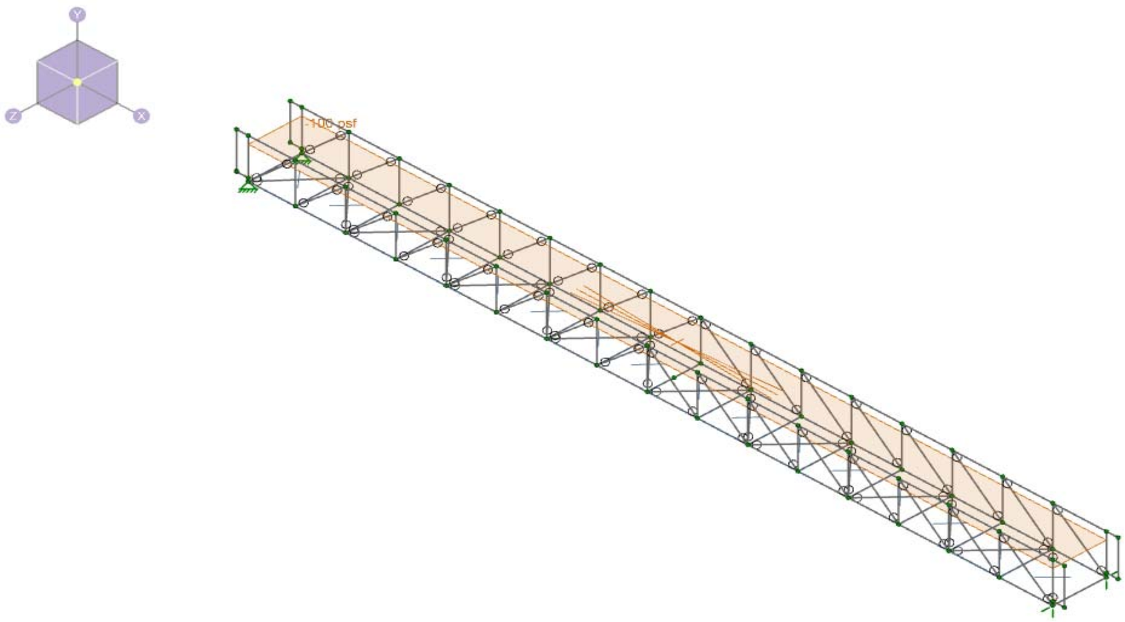


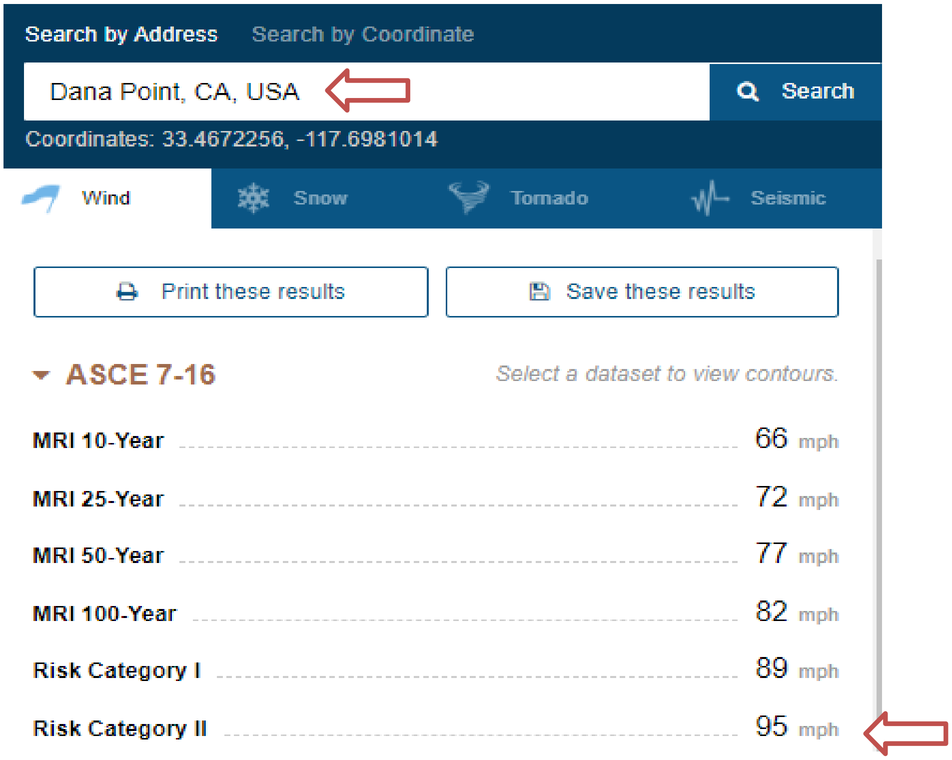
18

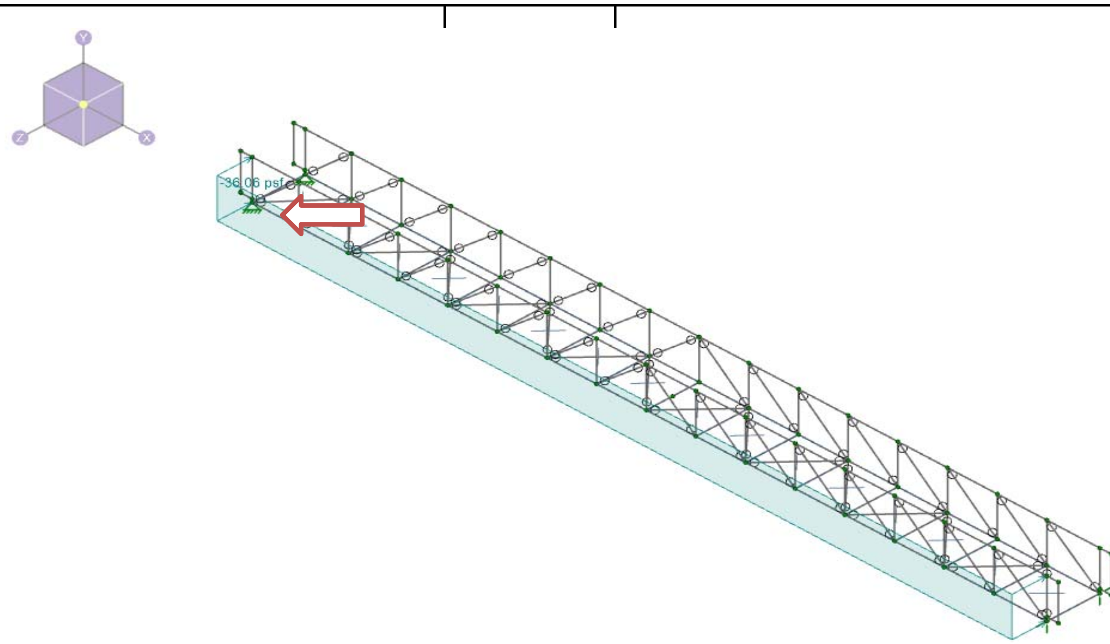
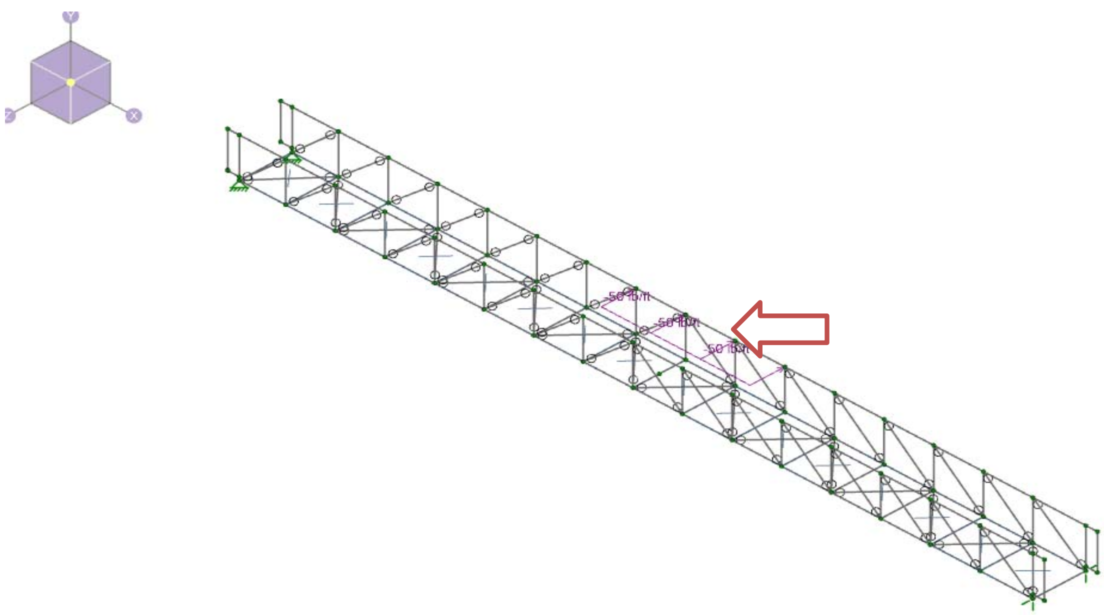
Add the Deck Load

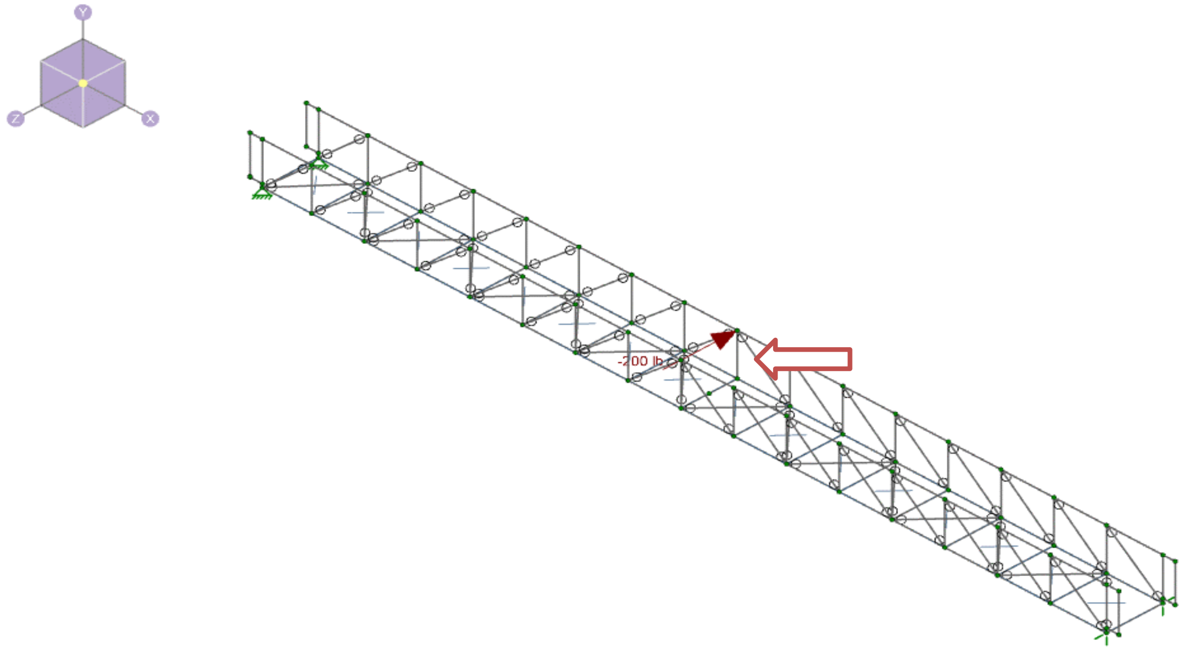
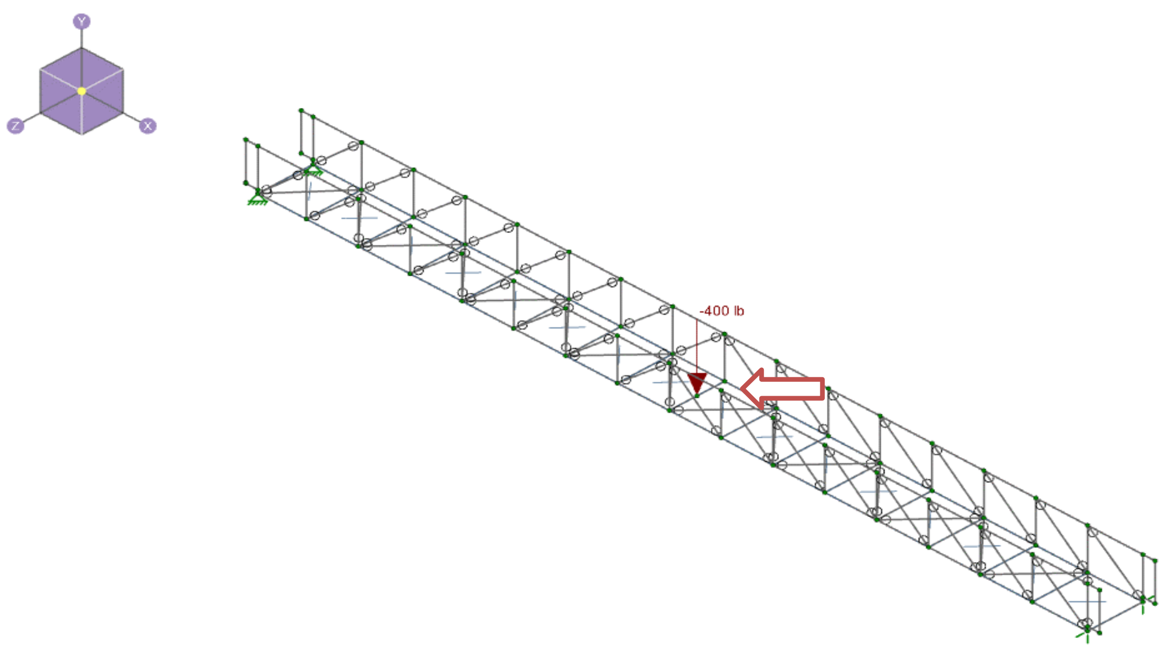
19	DECK, TOPPER — ALUMINUM — 3/4x6 **Plate** Material: Deck Gen... Thickness, in: 0.125		
20			
21	Run the Load Combination to determine the dead weight of the gangway model.		
22	1 — Self Weight — ☑ — Y — DL — 1		
23	Totals: — 0 — 4346.004		
24	Model Weight, MW (lbs.)	4346	See above
25	Dead Load of Gangway, DL (lbs.):	6171	See below

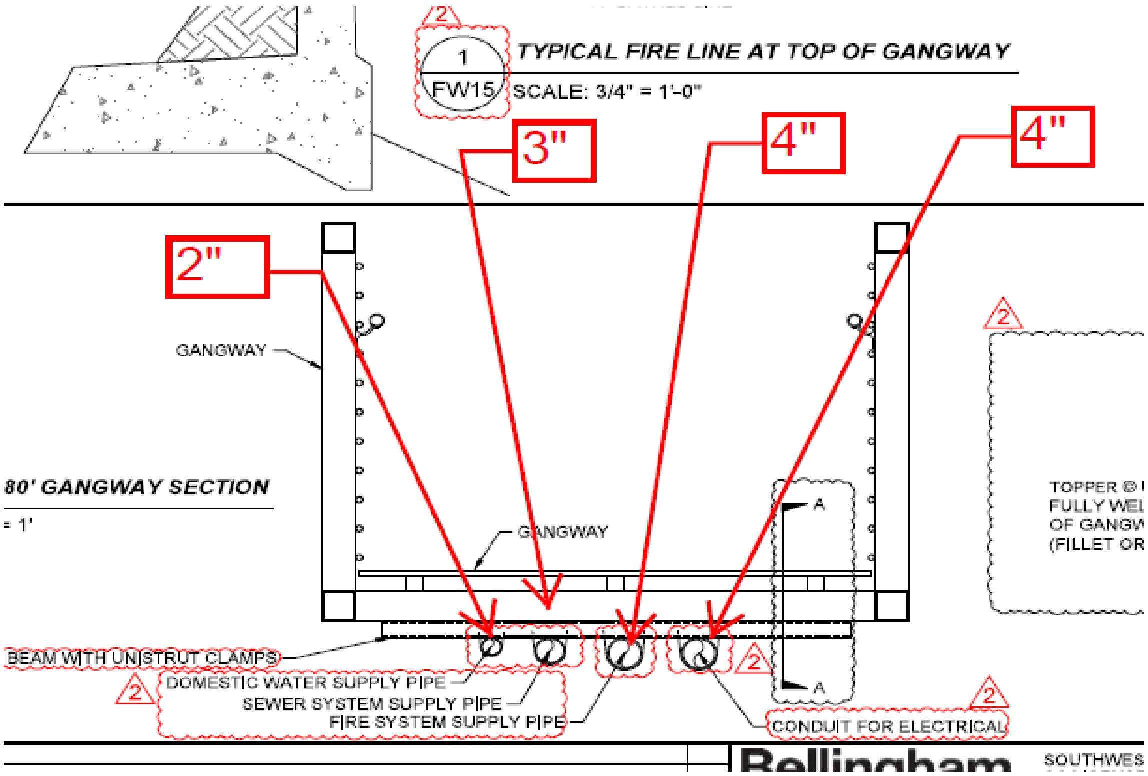
26			
27	Difference, D (lbs)	1825	DL - MW
28	Average Deadload added to model, ADL (psf)	4.56	D / (L x W)
29			
30	Run Dead Load Again to confirm the model weight approximates the Gangway Dead Load		
31	1 | Totals: | 0 | 6291.604 | 0		
32	Model Weight, MW (lbs.)	6291	See above
33	Dead Load of Gangway, DL (lbs.):	6171	See below
34	Weight Difference Ratio, R	0.98	DL/MW approx. 1 OK
35	Loading the RISA Model		
36	Uniform Live Load, LL (psf)	100	See above

37	 ; Topper truss design, 100psf live load, L/240 deflection, T
38	 Y Z X -100 psf

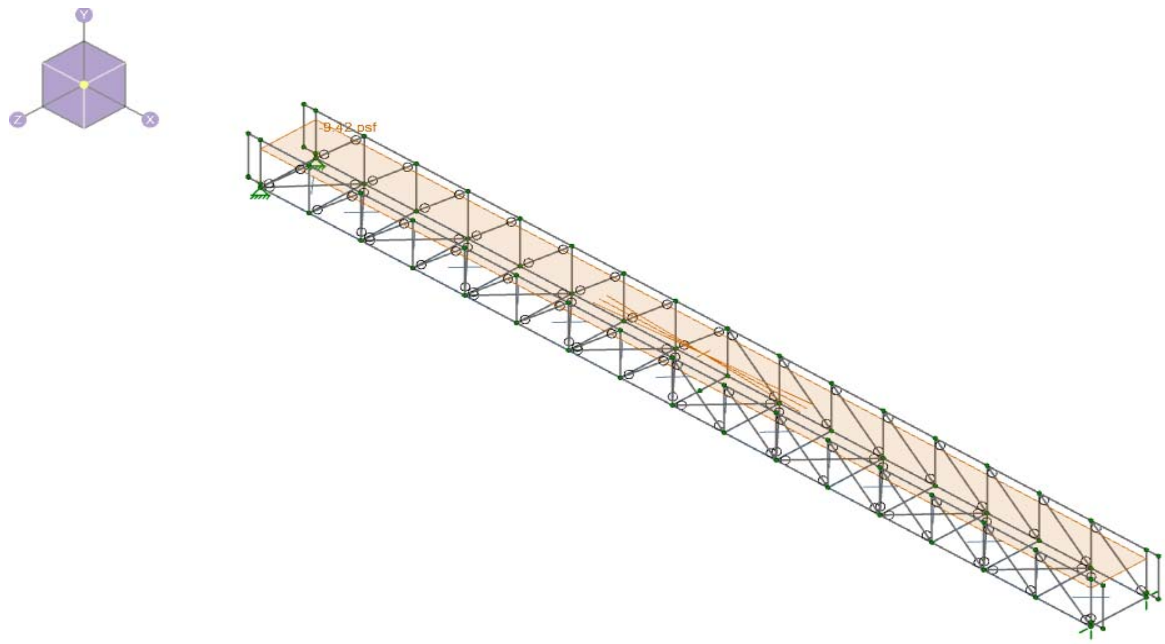
39	**Wind Loads:**		
40	Basic Wind Speed, V (mph)	95.00	See below
41			
42	Wind Directionality factor, Kd	0.85	Section 26.6-1
43	Exposure Category	D	
44	Gust effect factor, G	0.85	per Section 26.9.1
45	Cf	1.8	Figure 29.4-2
46	e	0.27	Figure 29.4-2
47	Wind Pressure, q (lbs./ft^2)	36.06	0.00256 x kz x kzt x Kd x Ws^2 x Cf, Kz = .85, Kzt = 1.2, Kd =.75 Use in RISA analysis

48			
49	Uniform Guardrail Load is applied to the model		
50	Uniform Guardrail Load, Ug (lbs.)	50	
51			
52	Concentrated Guardrail Load is applied to the model		
53	Concentrated Guardrail Load, Cg (lbs.)	200	

54			
55	Midspan Point Load is applied to the model		
56	Midspan Point Load, P (lbs.)	400	See below
57			

58	Add Utility Loads		
59			
60	Weight of Domestic Water Line, Ww (plf)	5	2" Line
61	Weight of Sewer Water Line, Ws (plf)	10.8	3" line
62	Weight of Fire Water Line, Wf (plf)	16.3	4"
63	Weight of Utility Line, Wu (plf)	15	**Dustin Saldivar, P.E.** | *Engineer* Bellingham Marine **P:** 360.543.5810
64	Average Electric Utility Load (psf)	9.42	(Wu+Wf+Ws+Ww)/ Gangway Width

65



66

Define Basic Cases. The -1 in the Y-gravity accounts for the self weight of the members

67

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Nodal	Point	Distributed	Area(Member)
1	Dead Load	DL		-1					1
2	Live Load	LL							1
3	Wind Load	WL							1
4	Utillity Load	OL4							1
5	BLC 1 Transient Area Loads							182	
6	Concentrated Handrail Load	OL2				1			
7	Uniform Handrail Load	OL1						3	
8		None							
9		None							
10	Mid Span Point Load	OL3				1			

68

Define Load Combinations

69

Load Combinations

Combinations | Design

LC Generator | RSA Scaling Factor

	Description	Solve	P-Delta	SRSS	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Dead Load	☑	Y		DL	1						
2	Concentrated handrail load	☑	Y		DL	1	OL2	1.6	OL3	1.6	OL4	1.2
3	handrail uniform load	☑	Y		DL	1	OL1	1.6	OL3	1.6	OL4	1.2
4	Service	☑	Y		DL	1	LL	1			OL4	1
5	Load Combination 1	☑	Y		DL	1.4					OL4	1.4
6	Load Combination 2	☑	Y		DL	1.2	LL	1.6			OL4	1.2
7	Load Combination 4	☑	Y		DL	1.2	WL	1	LL	0.5	OL4	1.2
8	Load Combination 6	☑	Y		DL	0.9	WL	1			OL4	0.9

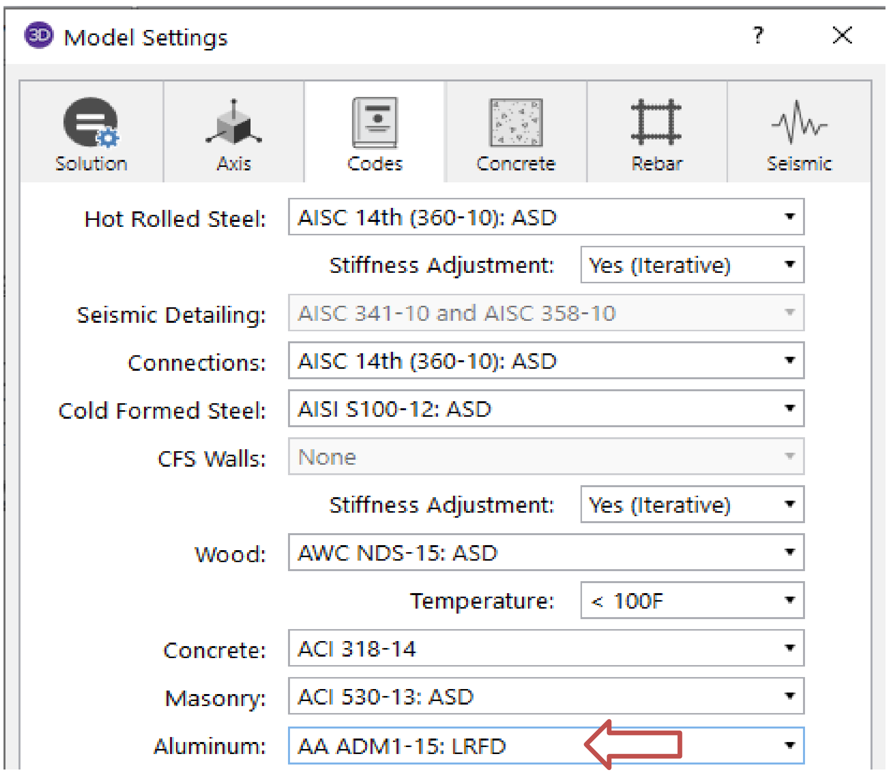
70 **Deflection Analysis**

71 Verify Codes

72

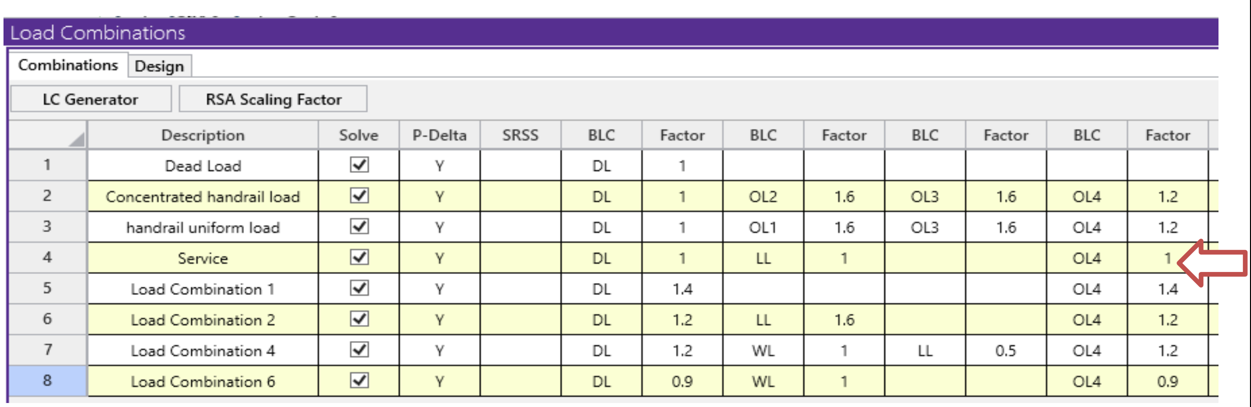
GENERAL STRUCTURAL NOTES
CONFORMS TO 2015 AND 2020 ADM AND 2019 CA BUILDING CODE STANDARDS (TITLE 24) EFFECTIVE 1-1-19.

73



74 Run the Service Load Combinations to determine the largest deflection

75



Load Combinations

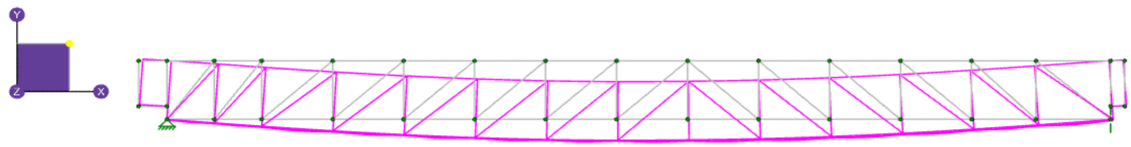
Combinations | Design

LC Generator | RSA Scaling Factor

	Description	Solve	P-Delta	SRSS	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	Dead Load	☑	Y		DL	1						
2	Concentrated handrail load	☑	Y		DL	1	OL2	1.6	OL3	1.6	OL4	1.2
3	handrail uniform load	☑	Y		DL	1	OL1	1.6	OL3	1.6	OL4	1.2
4	Service	☑	Y		DL	1	LL	1			OL4	1
5	Load Combination 1	☑	Y		DL	1.4					OL4	1.4
6	Load Combination 2	☑	Y		DL	1.2	LL	1.6			OL4	1.2
7	Load Combination 4	☑	Y		DL	1.2	WL	1	LL	0.5	OL4	1.2
8	Load Combination 6	☑	Y		DL	0.9	WL	1			OL4	0.9

76	**For 100 psf deflection**		

77

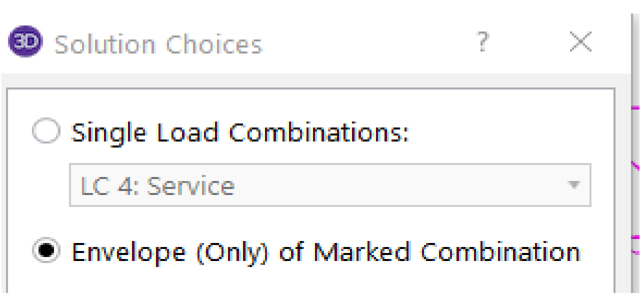


Node Displacements (By Combination)

	LC	Node Label	X [in]	Y [in]	Z [in]	X Rotation [rad]
1	4	N103	0.228	-3.942	06	-3.508e-4
2	4	N122	0.228	-3.903	0	1.957e-3
3	4	N68	0.236	-3.898	0.105	1.951e-3
4	4	N121	0.228	-3.885	-0.011	-2.512e-3

78	Max Allowable Deflection, Dam (in)	4.000	L x 12 / 240 Per Guidelines. See above
79	; Topper truss design, 100psf live load, L/240 deflection, T		
80	Max Deflection, Dm (in)	3.920	See above
81	**Safety Factor**	**1.02**	**Dam/Dm > 1 OK**
82	Run the all Load Combinations.		

83



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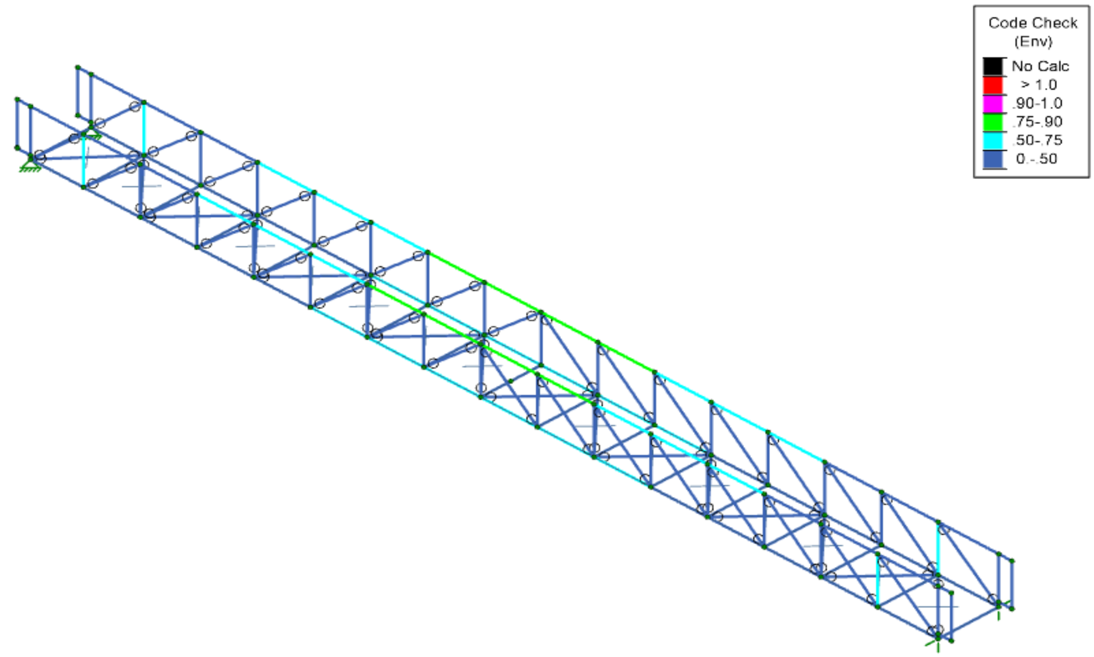
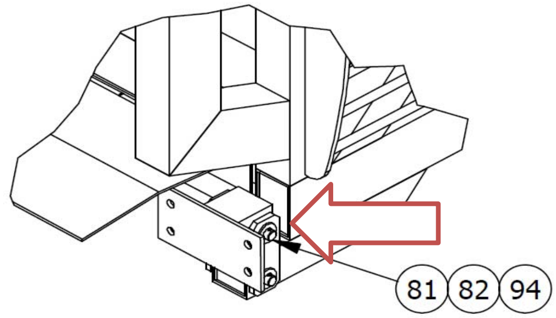
<tr><td>84</td><td>
</td></tr>
<tr><td>85</td><td>
Envelope AA ADM1-15: LRFD - Building Aluminum Code Checks
Hot Rolled Steel | Cold Formed Steel | Wood | Concrete Beams | Concrete Columns | Aluminum | Stainless
<table>
<tr><th></th><th>Member</th><th>Shape</th><th>Code Check</th><th>Loc[in]</th><th>LC</th><th>Shear Check</th><th>Loc[in]</th><th>Dir</th><th>LC</th></tr>
<tr><td>1</td><td>M52</td><td>RT4X6X0.25</td><td>0.834</td><td>0</td><td>6</td><td>0.009</td><td>0</td><td>z</td><td>3</td></tr>
<tr><td>2</td><td>M51</td><td>RT4X6X0.25</td><td>0.83</td><td>0</td><td>6</td><td>0.031</td><td>0</td><td>z</td><td>3</td></tr>
<tr><td>3</td><td>M43</td><td>RT4X6X0.25</td><td>0.824</td><td>60</td><td>6</td><td>0.004</td><td>60</td><td>z</td><td>7</td></tr>
<tr><td>4</td><td>M42A</td><td>RT4X6X0.25</td><td>0.82</td><td>0</td><td>6</td><td>0.014</td><td>0</td><td>z</td><td>7</td></tr>
</table>
</td></tr>
<tr><td>86</td><td>The code check values are the UC Max and Shear UC shown on the bridge. The colors represent a factored ratio of actual to allowable load for LFRD based on the provisions of the Aluminum Design Manual 2015. Ratios greater than 1 are shown in RED; therefore, any member in RED is not acceptable.</td></tr>
<tr><td>87</td><td>Abutment Pin Hinge Analysis</td></tr>
</table>

88



81	HINGE PIN, 4" CHORD, 00006	STEEL 4142	1" DIA

89 Run all load combinations

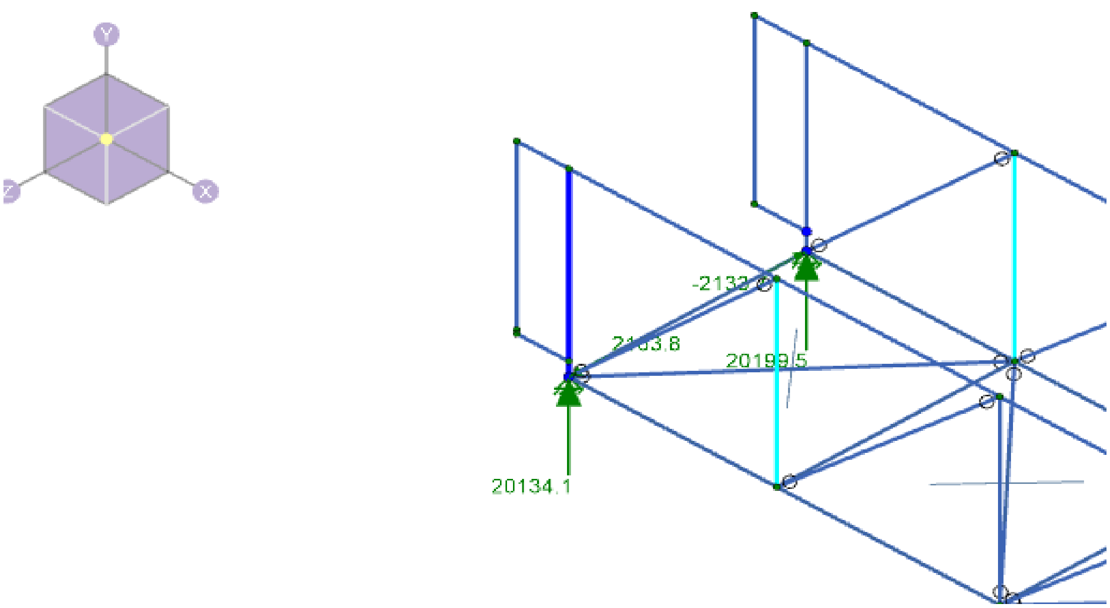
90

Envelope Node Reactions

	Node Label		X [lb]	LC	Y [lb]	LC	Z [lb]	LC
1	N43	max	31183.979	7	20199.527	6	[illegible]438	8
2		min	11.226	1	1578.791	1	-2133.715	6
3	N87	max	0	8	20167.934	6	3211.045	7

91 Load Combination 6 is controlling

92

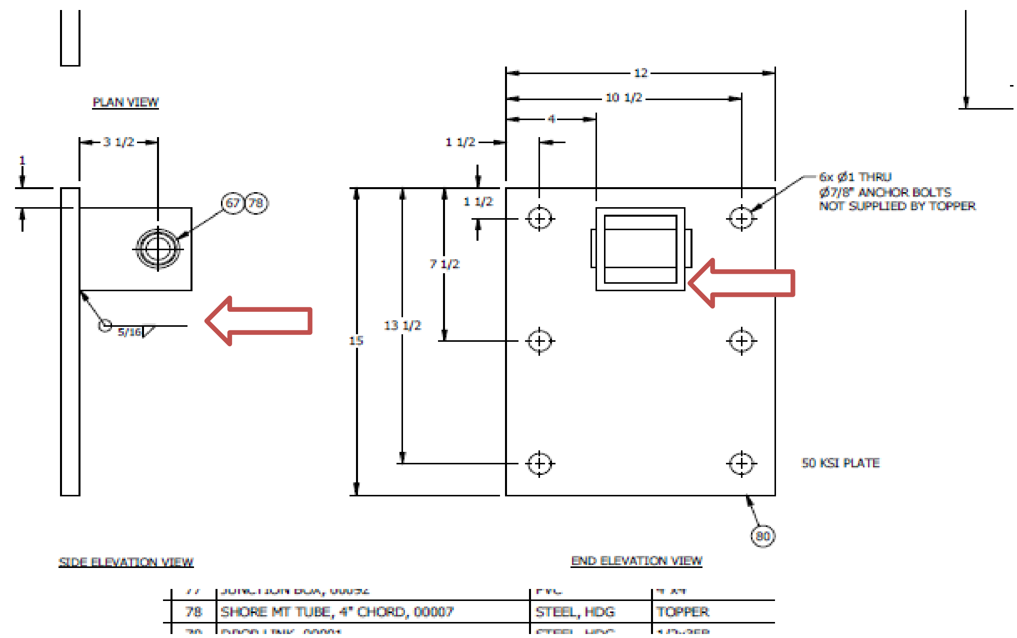


93

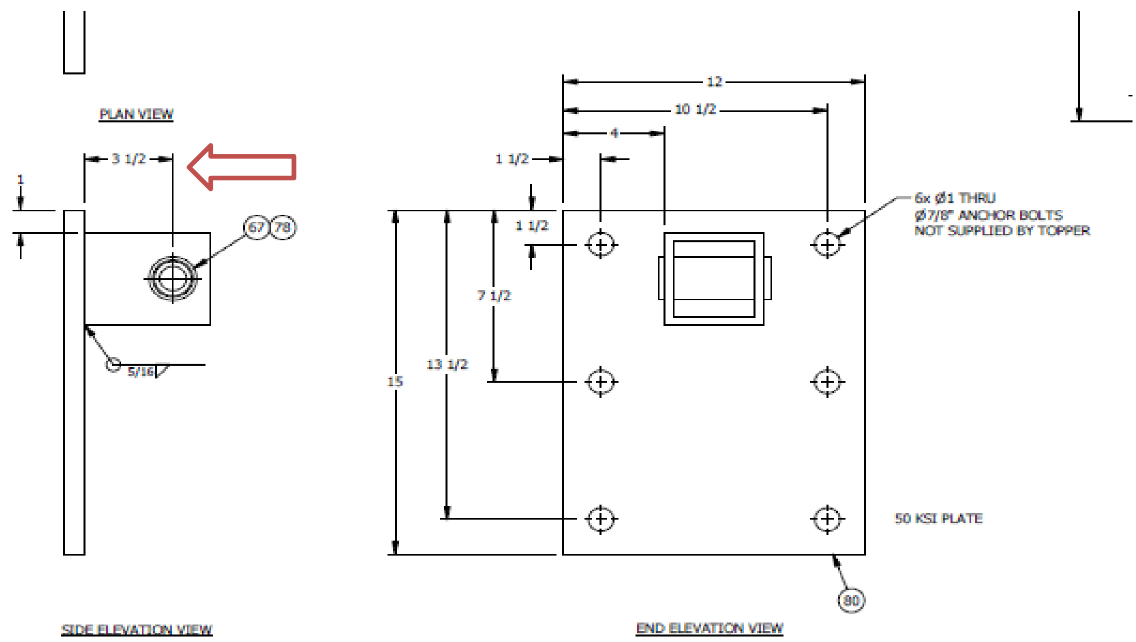
Node Reactions (By Combination)

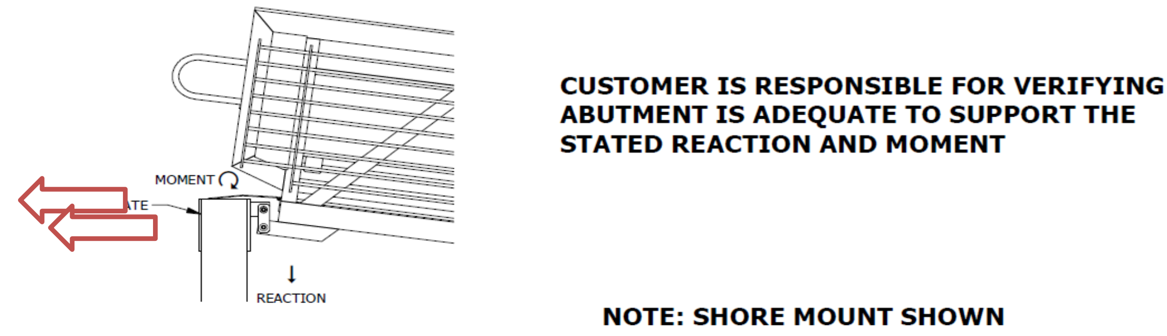
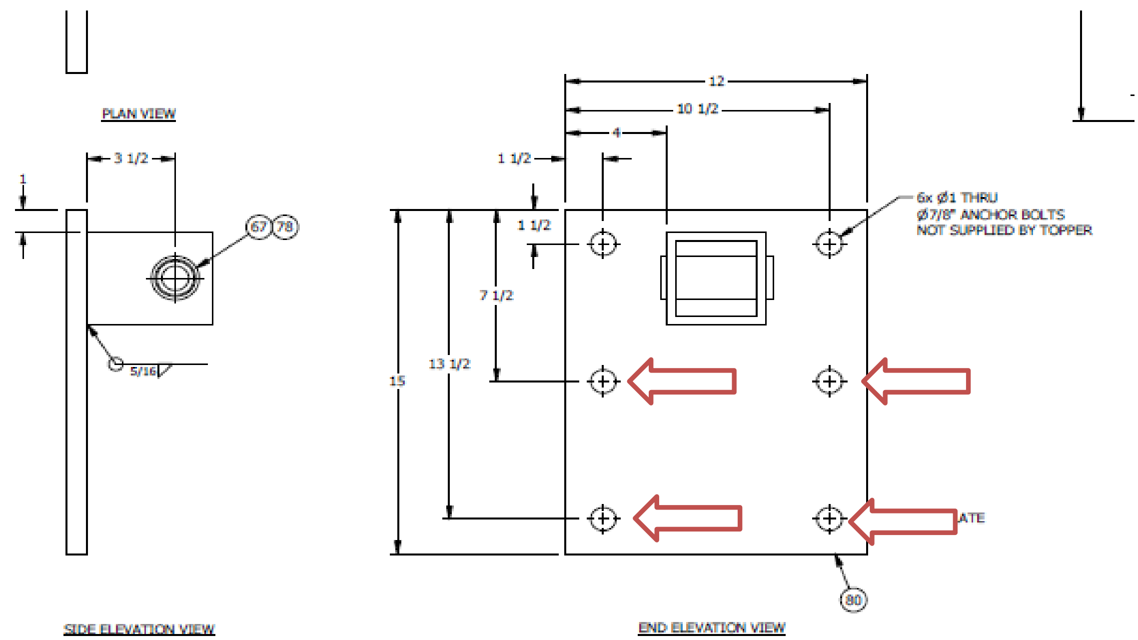
	LC	Node Label	X [lb]	Y [lb]	Z [lb]
1	6	N1	-453.714	20134.146	2163.776
2	6	N43	453.714	20199.527	-2133.715

94	Factored Vertical Load on each abutment tube, CL (lbs)	20,134	See above
95	Factored Horizontal Load on each abutment tube, HL (lbs)	2,163	See above
96	Diameter of Pin, Rd (in)	1.00	See below
97	74 HINGE PIN, 4" CHORD, 00006	STEEL 4142	1" DIA
98	Cross Sectional Area of Pin, Ar (in^2)	1.57	1/4 x 3.141 x Rd^2 x 2 surfaces
99	Ultimate Yield Strength of, Fy (psi)	70,000.00	4142 Steel
100	Shear strength of Pin Material, Vr (psi)	40,390.00	0.577 x Fy
101	Shear Strength of Pin, Vrr (lbs)	63,432.50	Vr x Ar
102	Shear Load on each Pin, Ll (lbs)	20,134	See above
103	**Safety Factor**	**3.15**	**Vrr/Ll OK**
104	**Shore Mount Analysis (Flush Mount)**		

105			

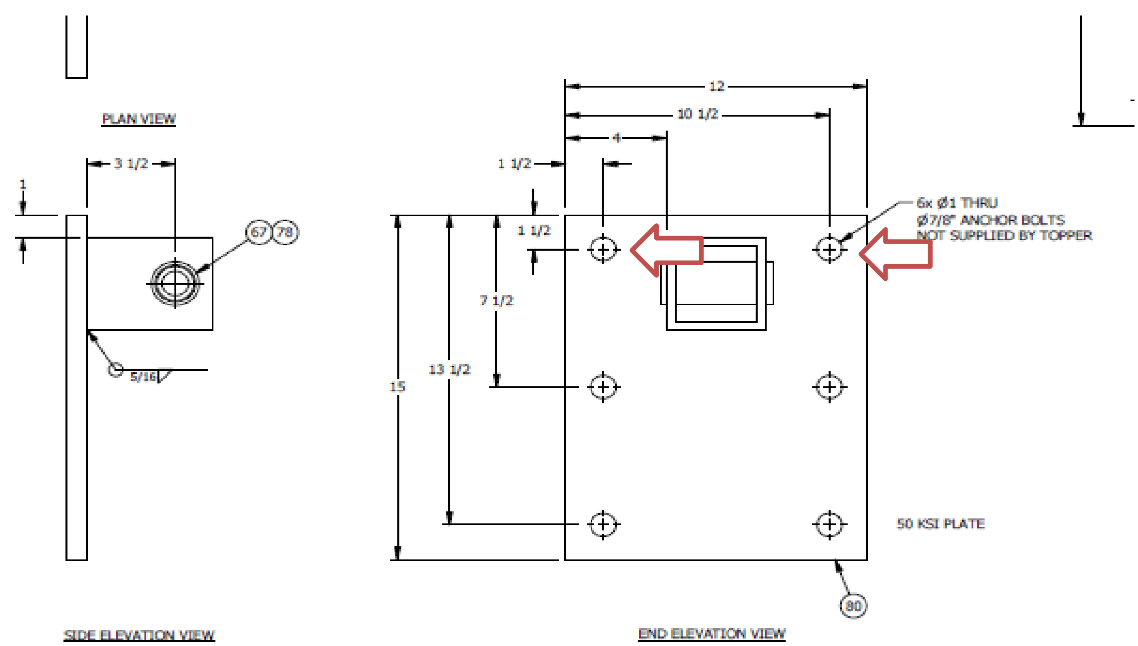
106	Vertical Load on Weld		
107	Shear Load in the Y direction on each Pin, Lly (lbs.)	20,134	See above
108	Resultant Shear Load on Connection, R (kips)	20.13	Vr / 1000
109	Length of Weld per connection, Lw (in)	8.00	4" x 2 sides Vertical sides only
110	Shear Load per inch of Weld, Vn (kips/in)	2.52	Vxy / Lw
111	Strength of a Fillet Weld, Fn (ksi)	65	
112	Weld size in 16ths of an inch, D (in)	5.000	5/16" fillet
113	Shear Capacity of FILLET Weld, Vc (kips/in)	6.46	0.6 x Fn x 2^.6/2 x D/16 x 0.75 (LFRD) Per Steel Manual Section 8-8
114	**Safety factor**	**2.57**	**Vc / Vn >>1**
115	**Moment Load on top of Tab**		

116			
117	Factored Shear Load, TL (lbs)	20,134.00	See above
118	Moment Arm from pin center to weld point, Ma (in)	3.50	See above
119	Total Moment Load on tabs, M (lbs-in)	70,469.00	TL x Ma
120	Depth of shore mount, Tt (in)	4.00	See above
121	Moment Arm weld line, Maw (in)	4.00	Tt
122	Strength of a Fillet Weld, Fn (ksi)	65	
123	Weld size in 16ths of an inch, D (in)	5.000	5/16" fillet
124	Tension Capacity of FILLET Weld, Vc (kips/in)	6.46	0.6 x Fn x 2^.6/2 x D/16 x 0.75 (LFRD) Per Steel Manual Section 8-8
125	Length of Weld per connection, Lw (in)	4.00	Top side only
126	Tension Capacity of Weld, Tc (lbs)	25,853.59	Lw x Vs x 1000
127	Moment Capacity of Weld, Mc (lbs-in)	103,414.37	Tc x Maw
128	**Safety factor**	**1.47**	**Mc / M >1 OK**

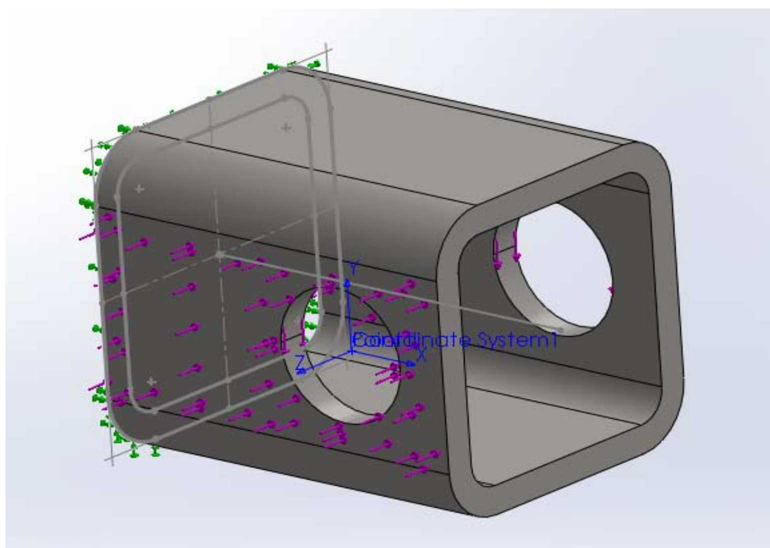
129	**Abutment Attachment**		
130			
131			
132	**Shear Load is resisted by the 4 center and bottom bolts**		
133	Factored Vertical Shear Load, TL (lbs)	20,134.00	See above
134	Shear Load in the Z Direction, Vz (lbs)	2,163.00	See above
135	Total Shear Load, TV (lbs)	22,297.00	TL + Vz
136	Diameter of Bolt, D (in)	0.88	See above
137	Cross Sectional Area of Pin, Ar (in^2)	0.60	.25 x 3.141 x D^2

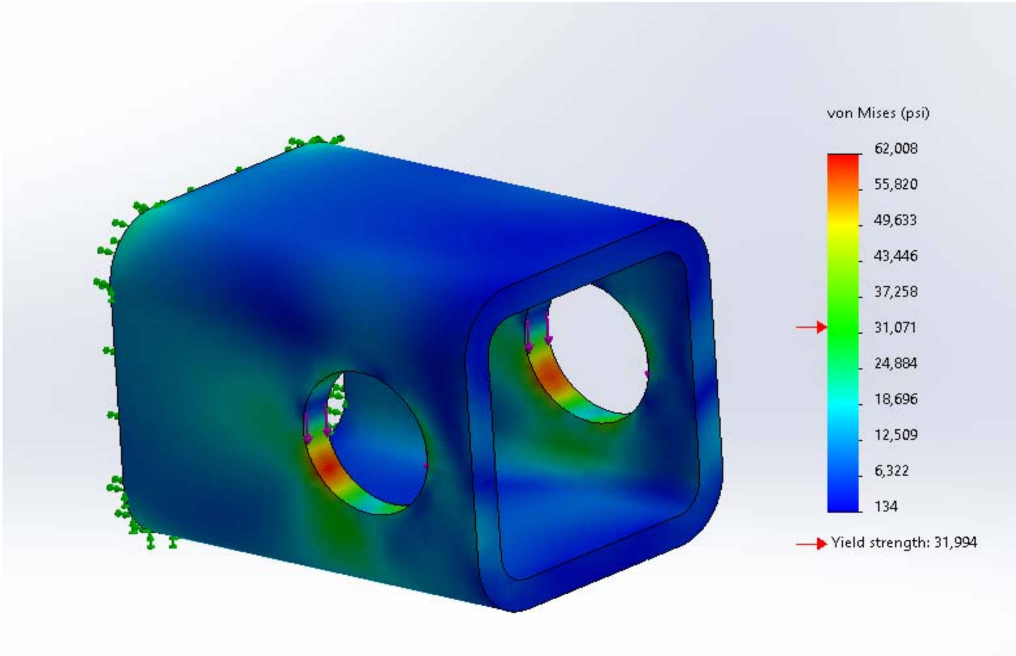
138	Yield Strength of, Fy (psi)	42,100.00	316 SS
139	Tensile Strength, Yield	290 MPa	42100 psi
140	Shear strength of Bolt Material, Vr (psi)	24,291.70	0.577 x Fy
141	Shear Strength of Bolt, Vrr (lbs)	10,953.26	Vr x Ar x .75 (strength factor for shear)
142	Shear Load on each Bolt, Ll (lbs)	5,034	TV / 4 bolts
143	**Safety Factor**	**2.18**	**Vrr/Ll OK**
144	**Moment Load is resisted by the two Top bolts**		
145	Factored Shear Load, TL (lbs)	20,134.00	See above
146	Moment Arm from pin center to weld point, Ma (in)	3.00	See above
147	Total Moment Load on both tabs, M (lbs-in)	60,402.00	TL x Ma

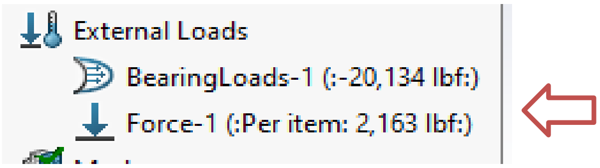
148

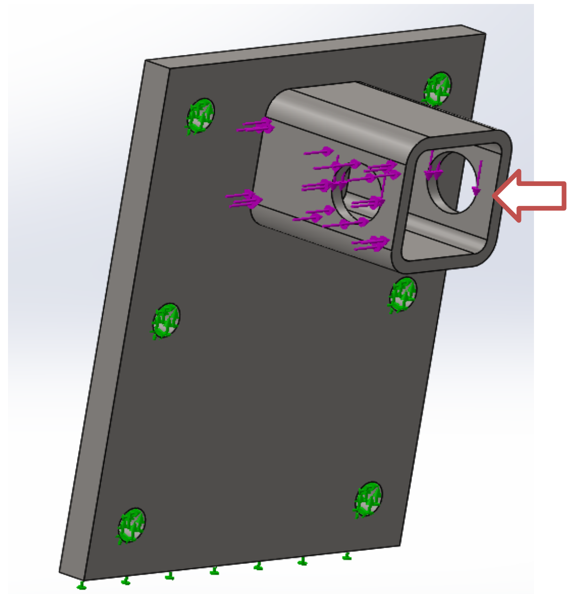
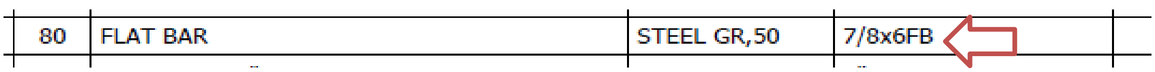
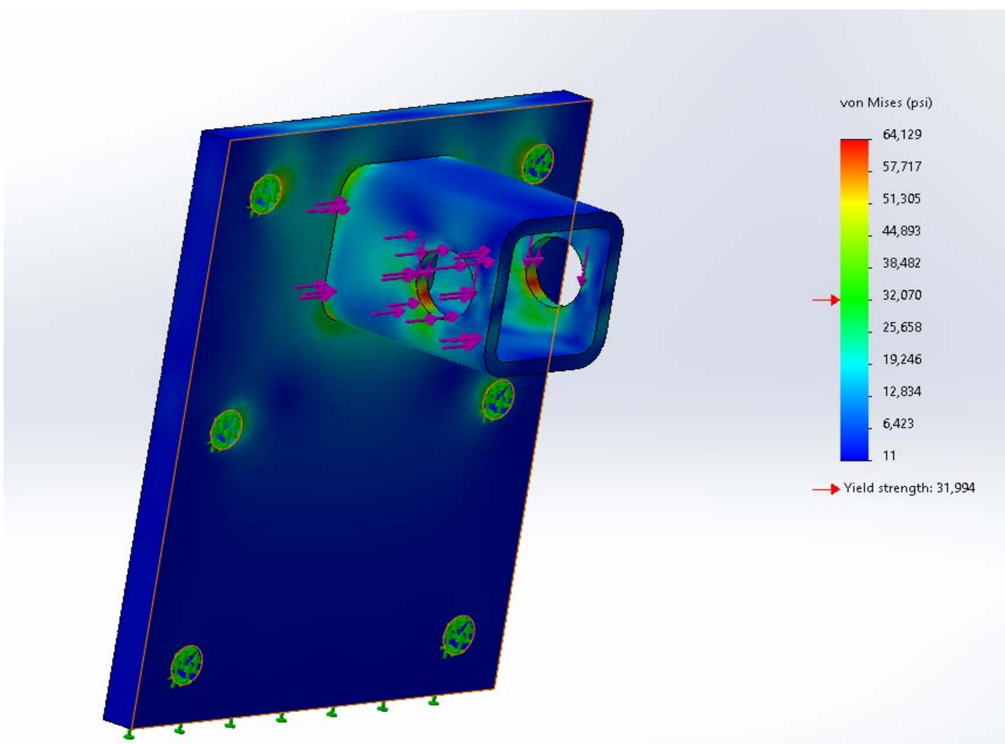


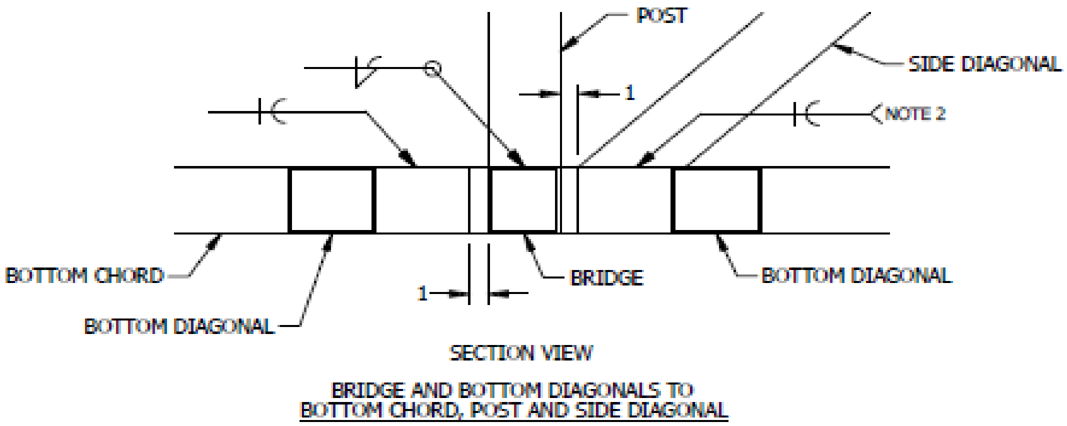
149	Diameter of Bolt, D (in)	0.88	See above
150	Cross Sectional Area of Pin, Ar (in^2)	0.60	.25 x 3.141 x D^2
151	Yield Strength of, Fy (psi)	42,100.00	316 SS

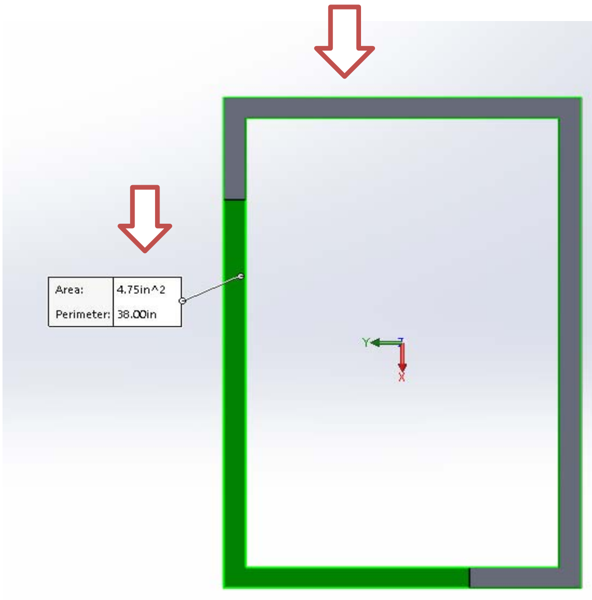
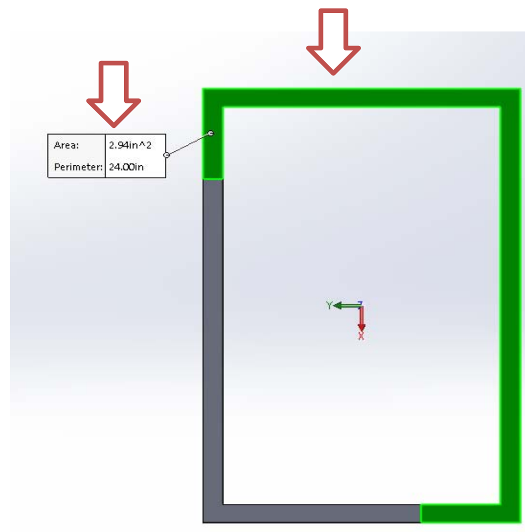
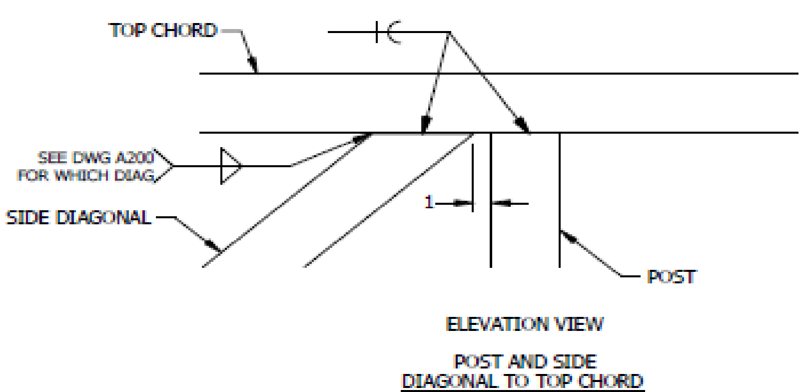
152	Tensile Strength, Yield	290 MPa	42100 psi
153	Tensile Strength of Bolt, Tb (lbs)	22,779.73	Vr x Ar x .9 (strength reduction factor for Tension)
154	Distance from center of middle bolts to center of bolt, Db (in)	6.00	See above. 7.5 - 1.5
155	Moment Capacity of Bolt, Mc (lbs-in)	273,357	Tb x Db x 2 bolts
156	**Safety Factor**	**4.53**	**MC / M >1 OK**
157	**Check Stub Material Yielding**		
158	Factored Vertical Shear Load, TL (lbs)	20,134.00	See above
159	Factored Horizontal Load on each abutment tube, HL (lbs)	2,163	See above
160	BearingLoads-1 (:-10,067 lbf:) BearingLoads-2 (:-10,067 lbf:) Force-1 (:Per item: 2,163 lbf:) 		

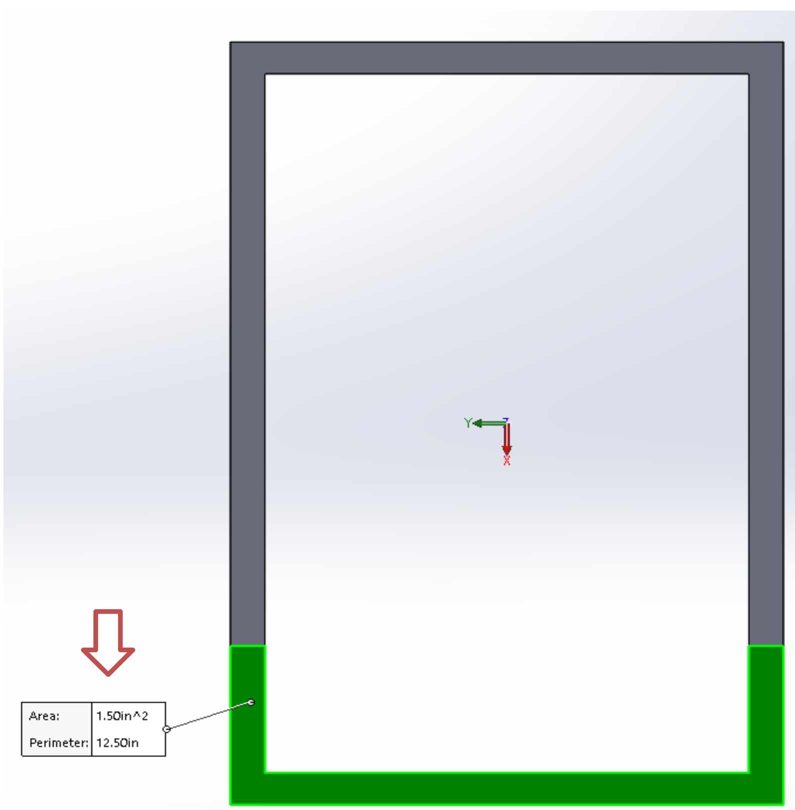
161			
162	Yield Stress on Shore Mount Tube, Fy (ksi)	50.00	Steel
163	Max Stress on Shore Mount Tube, Fm (ksi)	42.00	See above
164	**Safety Factor**	**1.19**	**Fy / Fm > 1 OK**
165	**Verify the Abutment Plate does not yield**		

<table>
<tr><td>166</td><td colspan="3">



80 | FLAT BAR | STEEL GR,50 | 7/8x6FB</td></tr>
<tr><td>167</td><td colspan="3">
</td></tr>
<tr><td>168</td><td>Yield Stress on Shore Mount Tube, Fy (ksi)</td><td>50.00</td><td>Steel</td></tr>
</table>

169	Max Stress on Shore Mount Tube, Fm (ksi)	38.50	See above
170	**Safety Factor**	**1.30**	**Fy / Fm > 1 OK**
171	**Verify the Cast in Plate Shore Mount will not yield**		
172	Yield Stress on Shore Mount Tube, Fy (ksi)	50.00	Steel
173	Max Stress on Shore Mount Tube, Fm (ksi)	34.00	See above
174	**Safety Factor**	**1.47**	**Fy / Fm > 1 OK**
175	**Strength Reduction Analysis of Tension and compression members with partial welds (Bottom Chord)**		
176			
177	The weighted-average approach means that the strengths of the unaffected portion of the section and the weld-affected portion of the section are weighted in proportion to their share of the full cross section. One simplification is used: If the weld-affected portion of the cross section is less than 15%, the strength reduction from welding is deemed too small to worry about, and the effect of welding can be neglected. (See Aluminum Specification Section 7.1.2.) The inaccuracy introduced by this simplification is on the order of 5% $F_{pw} = F_n - (A_w/A)(F_n - F_w)$		
178	Allowable Stress, Fpw (psi)	29,334.74	The weighted average. See above
179	Allowable Stress, Fn (psi)	38,000.00	allowable stress for the cross section if none of it were weld affected
180	Allowable Stress, Fw (psi)	24,000.00	allowable stress for the cross section if the entire cross section allowable stress for the cross section if the entire cross section were weld-affected. For ultimate tensile strength, use 0.9Ftuw

181	Cross Sectional Area of Heat Affected Zone (HAZ), Aw (in^2)	2.94	See below
182	Total Area , A (in^2)	4.75	See below
183	 		
184	**Strength Reduction Analysis of Tension and compression members with partial welds (Top Chord)**		
185			

186	The weighted-average approach means that the strengths of the unaffected portion of the section and the weld-affected portion of the section are weighted in proportion to their share of the full cross section. One simplification is used: If the weld-affected portion of the cross section is less than 15%, the strength reduction from welding is deemed too small to worry about, and the effect of welding can be neglected. (See Aluminum Specification Section 7.1.2.) The inaccuracy introduced by this simplification is on the order of 5%. $$F_{pw} = F_n - (A_w/A)(F_n - F_w)$$		
187	Allowable Stress, Fpw (psi)	33,578.95	The weighted average. See above
188	Allowable Stress, Fn (psi)	38,000.00	allowable stress for the cross section if none of it were weld affected
189	Allowable Stress, Fw (psi)	24,000.00	allowable stress for the cross section if the entire cross section allowable stress for the cross section if the entire cross section were weld-affected. For ultimate tensile strength, use 0.9Ftuw
190	Cross Sectional Area of Heat Affected Zone (HAZ), Aw (in^2)	1.50	See below
191	Total Area , A (in^2)	4.75	See below
192			

193

Aluminum Properties

Hot Rolled | Cold Formed | Wood | Concrete | Masonry | Aluminum | Stainless | General

	Label	E [ksi]	G [ksi]	Nu	Therm. Coeff. [1e⁵°F⁻¹]	Density [k/ft³]	Table B.4	kt	Ftu [ksi]	Fty [ksi]	Fcy [ksi]	Fsu [ksi]
1	3003-H14	10100	3787.5	0.33	1.3	0.173	Table B.4-1	1	19	16	13	12
2	6061-T6	10100	3787.5	0.33	1.3	0.173	Table B.4-2	1	38	35	35	24
3	6063-T5	10100	3787.5	0.33	1.3	0.173	Table B.4-2	1	22	16	16	13
4	6063-T6	10100	3787.5	0.33	1.3	0.173	Table B.4-2	1	30	25	25	19
5	5052-H34	10200	3787.5	0.33	1.3	0.173	Table B.4-1	1	34	26	24	20
6	6061-T6 W	10100	3787.5	0.33	1.3	0.173	Table B.4-1	1	24	15	15	15
7	Top Chord T6 (6 x 4) W	10100	3787.5	0.33	1.3	0.173	Table B.4-1	1	33.6	33.6	35	24
8	Bottom Chord T6 (6 x 4) W	10100	3787.5	0.33	1.3	0.173	Table B.4-1	1	29.3	29.3	35	24

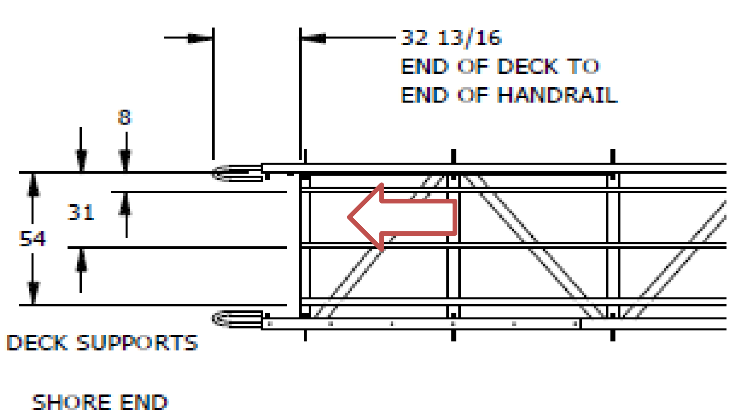
194

Deck Analysis

195

49	DECK, SANDBLASTED	DECK, 3/4x6	ALUMINUM	TOPPER

196

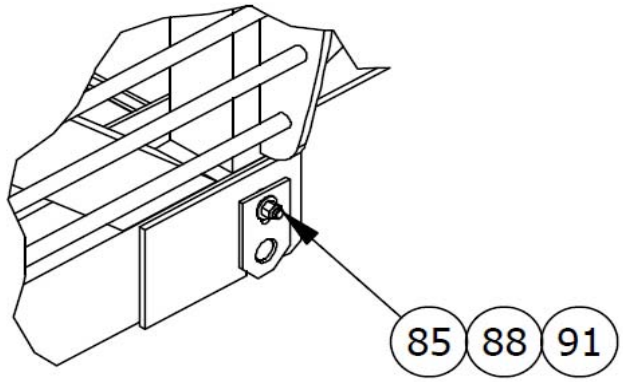
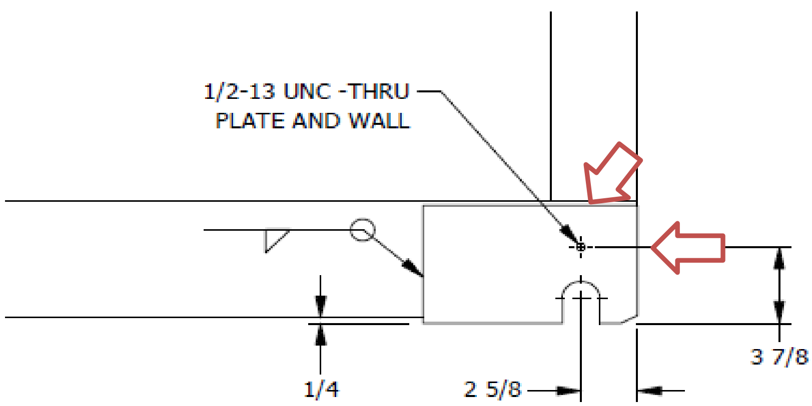


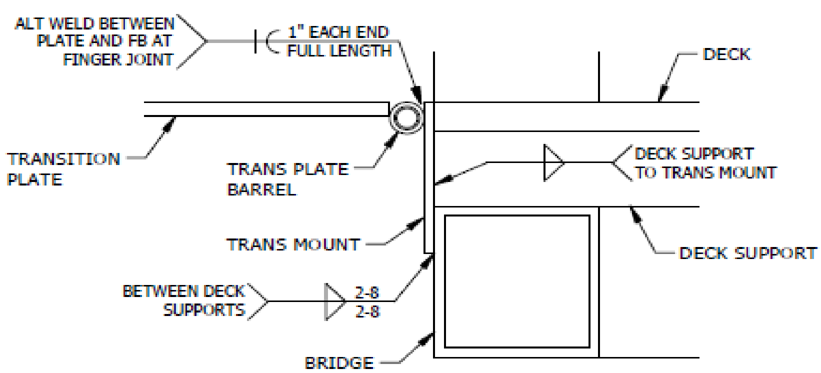
197	Deck Span, Ds (in)	23.00	See above.

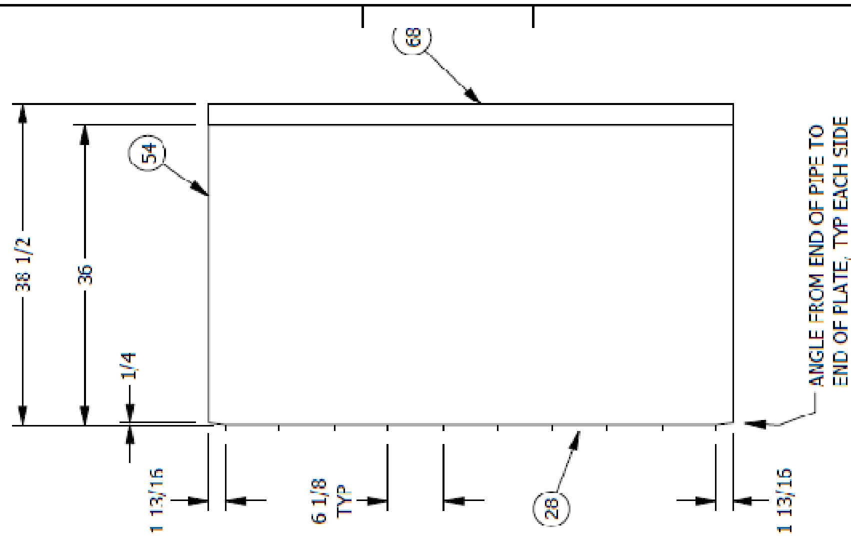
198

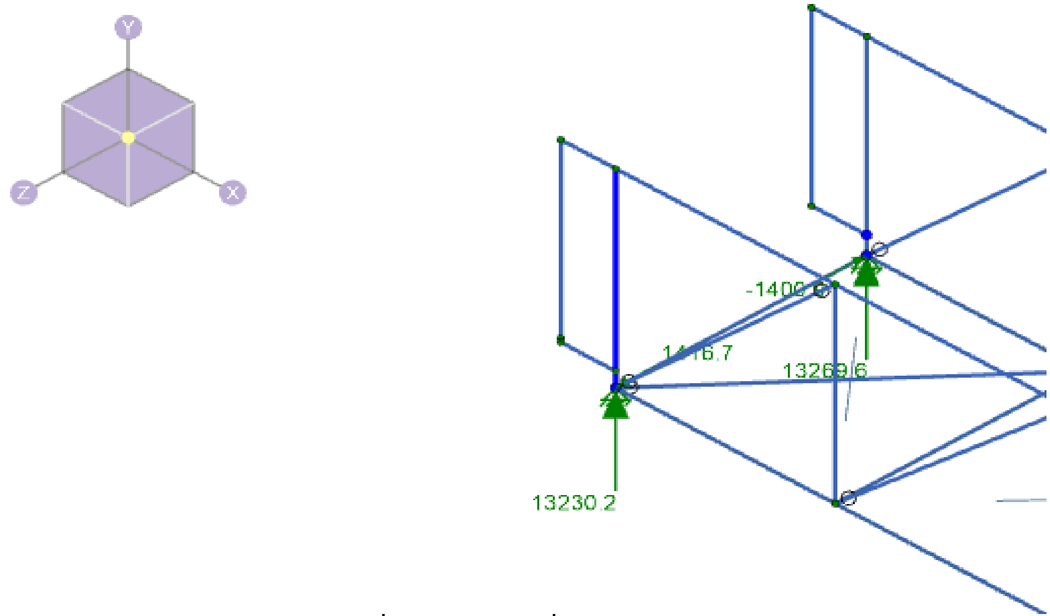
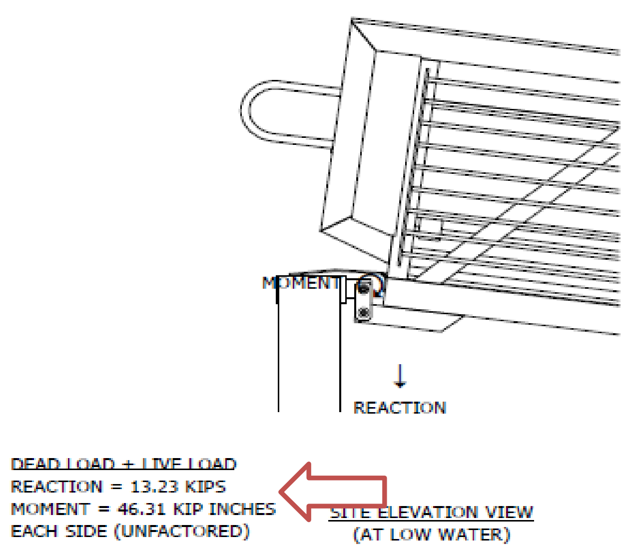
Topper Deck® Span Table				
Span	100 psf Uniform Load		400 lb Concentrated Load	
Inches	Stress ksi	Deflection inches	Stress ksi	Deflection Inches
12	0.5	0	2.5	0.00
18	1.1	0	3.8	0.02
24	2	0.02	5	0.05
30	3.1	0.06	6.3	0.93
36	4.4	0.12	7.5	0.16
42	6.0	0.22	8.75	0.26
48	7.9	0.37	10	0.38

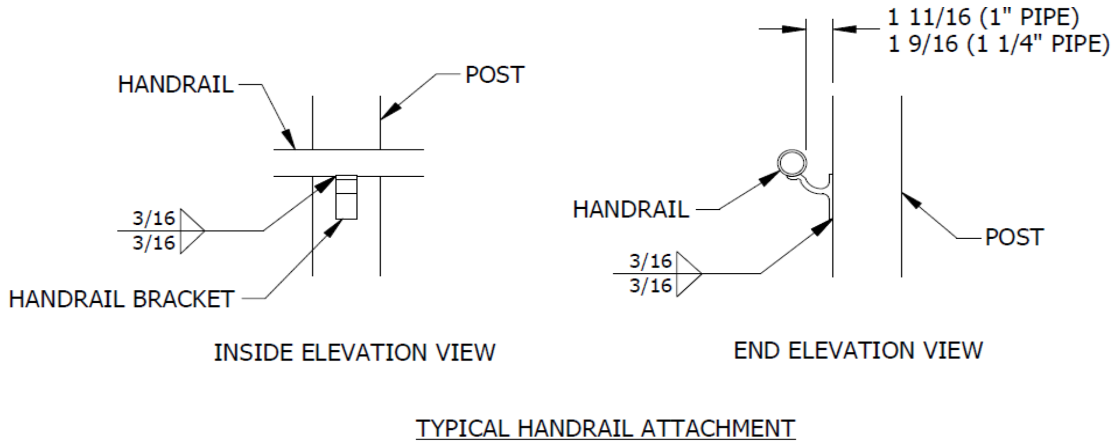
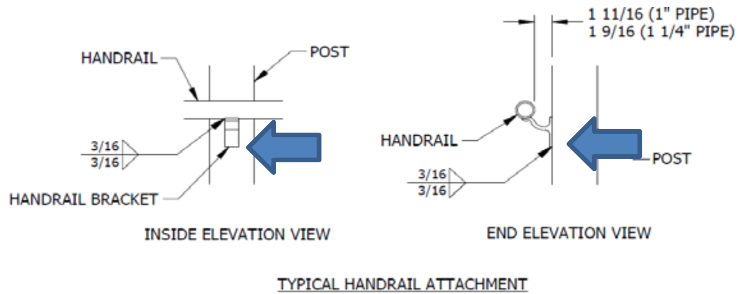
199	Deck Yield Stress, Fd (ksi)	2	See above.

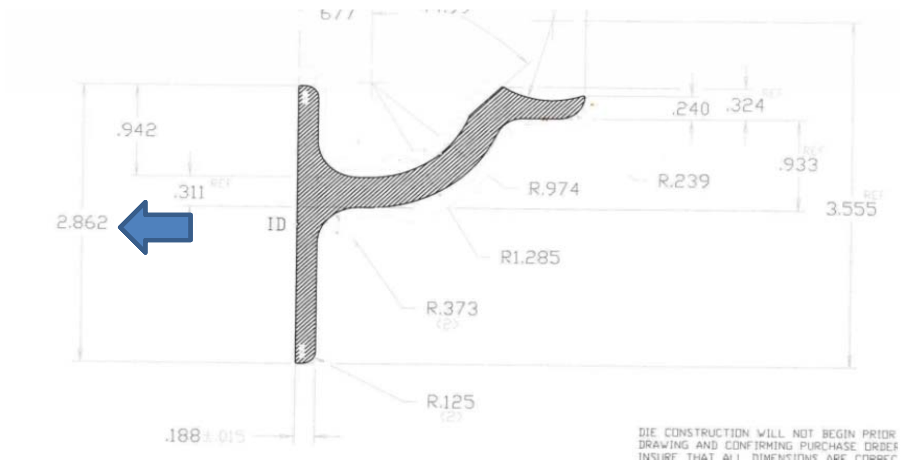
200	Yield Strength of Deck, Fy (ksi)	38	6061 AL
201	**Safety Factor**	**19.00**	**Udc/Rdc > 1 Ok**
202	**Wheel Plate Weld Analysis**		
203	 DETAIL B		
204	 WHEEL PLATE WELDING		
205	Factored Shear Load, TL (lbs)	20,134.00	See above
206	Resultant Shear Load on Connection, R (kips)	20.13	Vr / 1000

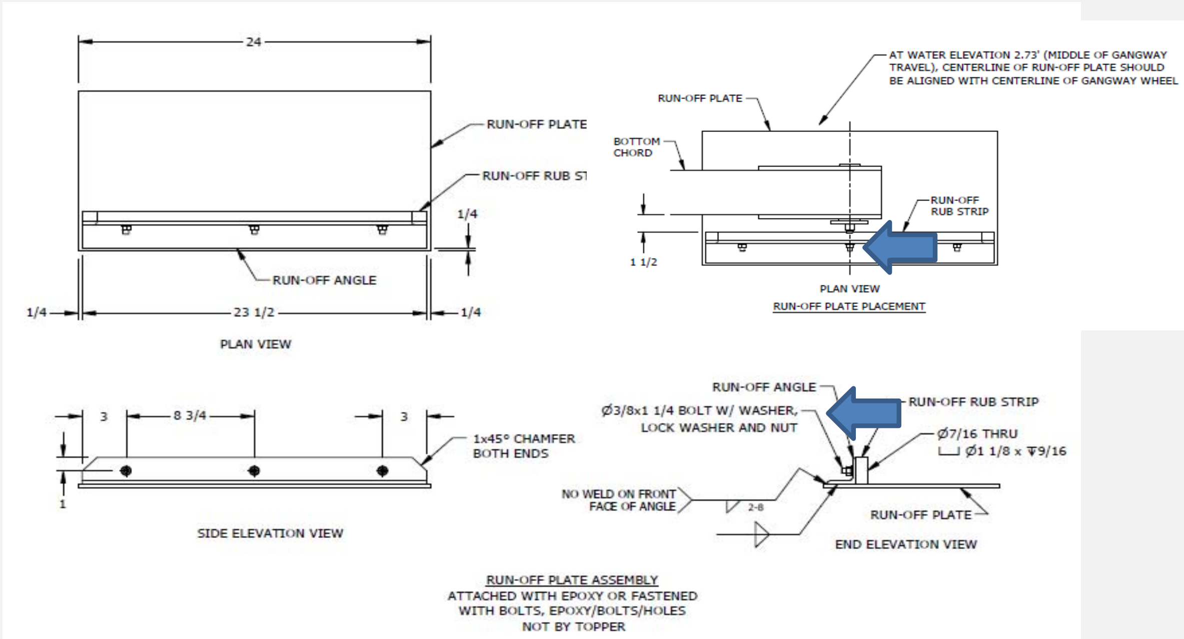
207	Length of Weld per connection, Lw (in)	31.00	(10+5.5)" x 2 sides
208	Shear Load per inch of Weld, Vn (kips/in)	0.65	Vxy / Lw
209	Strength of a Fillet Weld, Fn (ksi)	15	For 6061 T-6 Al welded material
210	Weld size in 16ths of an inch, D (in)	4.000	4/16" Fillet
211	Shear Capacity of FILLET Weld, Vc (kips/in)	1.19	0.6 x Fn x 2^.6/2 x D/16 x 0.75 (LFRD) Per Steel Manual Section 8-8
212	**Safety factor**	**1.84**	**Vc / Vn >>1**
213	**Transition Plate Weld Analysis**		
214	**Both Welds resist the same load. The Transition Plate Weld has less weld length do to the 2-8 weld designation that will be the controlling weld design**		
215	 TYPICAL WELD DETAILS		
216	Vertical Load on Weld		
217	Transition Plate		

218			
219	Area of Transition Plate, AT (sf)	15.57	(58.125 x 38.5) / 144
220	Factored Live Load, LL (psf)	160	100 x 1.6
221	Total Load, TL (lbs)	2,491.81	AT x LL
222	Shear Load on Weld, V (lbs)	1,245.90	TL / 2 Ends
223	Factored Shear Load, TL (lbs)	1,245.90	V
224	Resultant Shear Load on Connection, R (kips)	1.25	Vr / 1000
225	Length of Weld per connection, Lw (in)	38.75	77.5/ 2 (only half the length is welded)
226	Shear Load per inch of Weld, Vn (kips/in)	0.03	Vxy / Lw
227	Strength of a Fillet Weld, Fn (ksi)	15	For 6061 T-6 Al welded material
228	Weld size in 16ths of an inch, D (in)	2.000	2/16" Fillet
229	Shear Capacity of FILLET Weld, Vc (kips/in)	0.60	0.6 x Fn x 2^.6/2 x D/16 x 0.75 (LFRD) Per Steel Manual Section 8-8
230	**Safety factor**	**18.56**	**Vc / Vn >>1**
231	**Abutment Loading**		
232	**Run Service Load Combination**		

233			
234	**Dead Load+Live Load Reaction, R (kips)**	**13.23**	**(13230)/1000 See above**
235	**Moment Load, M (kip-in)**	**46.31**	**R x Ma**
236			
237	Hand Rail Bracket Analysis		

238			
239	Spacing between brackets, S (ft)	5	See drawing
240	Vertical Load on Handrail Bracket, Vl (lbs)	250	S x 50 plf
241	Resultant Shear Load on Connection, R (kips)	0.25	Vr / 1000
242	Length of Weld per connection, Lw (in)	1.00	Width of Bracket
243			
244	Shear Load per inch of Weld, Vn (kips/in)	0.25	Vxy / Lw
245	Strength of a Fillet Weld, Fn (ksi)	15	For 6061 T6 AL
246	Weld size in 16ths of an inch, D (in)	3.000	3/16" fillet
247	Shear Capacity of FILLET Weld, Vc (kips/in)	0.89	0.6 x Fn x 2^.6/2 x D/16 x 0.75 (LFRD) Per Steel Manual Section 8-8
248	**Safety factor**	**3.58**	**Vc / Vn >>1**
249	Moment Load on Top Weld		
250	Vertical Load on Handrail Bracket, Vl (lbs)	250.00	See above
251	Moment Arm from bracket to center of bracket support, Ma (in)	2.31	1 11/16 + 1.25/2 See above

252			
253	Total Moment Load on Bracket, M (lbs-in)	578.13	TL x Ma
254	Depth of bracket, Tt (in)	2.86	See above
255	Moment Arm weld line, Maw (in)	2.86	Tt
256	Strength of a Fillet Weld, Fn (ksi)	15	For 6061 T6 AL
257	Weld size in 16ths of an inch, D (in)	3.000	3/16" fillet
258	Tension Capacity of FILLET Weld, Vc (kips/in)	0.89	0.6 x Fn x 2^.6/2 x D/16 x 0.75 (LFRD) Per Steel Manual Section 8-8
259	Length of Weld per connection, Lw (in)	1.00	Width of Bracket
260	Tension Capacity of Weld, Tc (lbs)	894.93	Lw x Vs x 1000
261	Moment Capacity of Weld, Mc (lbs-in)	2,562.19	Tc x Maw
262	**Safety factor**	**4.43**	**Mc / M >1 OK**
263	**Run-off Plate Bolt Analysis**		

264			
265	These bolts attache the Run off Strip to the angle and run-off plate. The shear load applied to the bolts comes from the gangway sliding back and forth with the tide levels. The weight of the gangway keeps the run off plate stationary.		
266	Factored Horizontal Load on each abutment tube, HL (lbs)	2,163	See above
267	Friction Coefficient of HDPE and Aluminum, f	0.28	
268	Net shear load on bolts, Lb (lbs)	201.88	HL x f / 3 bolts
269	Diameter of Bolt, D (in)	0.38	See above
270	Cross Sectional Area of Pin, Ar (in^2)	0.11	.25 x 3.141 x D^2
271	Yield Strength of, Fy (psi)	42,100.00	316 SS
272	Tensile Strength, Yield	290 MPa	42100 psi
273	Shear strength of Bolt Material, Vr (psi)	24,291.70	0.577 x Fy
274	Shear Strength of Bolt, Vrr (lbs)	2,011.82	Vr x Ar x .75 (strength factor for shear)
275	Shear Load on each Bolt, Ll (lbs)	202	Se ablve
276	**Safety Factor**	**9.97**	**Vrr/Ll OK**
277	End of Analysis		

Topper Industries

Project:	5x80 Gangway Dana Pt
Job#:	8115
Engineer:	BG
Date:	November-22

(Version 14.1 2-2-22)

Aluminum Gangway Design - Design Input/Summary

All Calculations Per Aluminum Design Manual 2020

Loading

Live Load: LL =	100	psf
Dead Load: DL =	15	psf
Utility Load: UL =	9.42	psf
Point Load (mid span): P =	400	lb
Wind Load: WL =		mph
LL Deflection Criteria: L/	240	Δ_{LL} = 3.62 in
LL Deflection: L/	265	
Hand Rail Load	50	plf

Gangway Dimensions

Span: L =	80	ft
Width: w =	5	ft
Effective Width: w =	5.33	ft
Ctr. to Ctr. Chord Height: h =	53	in

Safety Factors

(From Sec. D.1, and Sec. F.1 - ADM 2020)

Ωu =	1.95
Ω_c =	1.65

Material Properties

Alloy:	6061-T6	B221
Weld Filler:	5356	
Modulus of Elasticity: E =	1E+07	psi

Ultimate Stresses

(From Table A4.3 - ADM 2020)

Un-Welded:	F_{tu} =	38.00	ksi
	F_{ty} =	35.00	ksi

(From Table A4.3 - ADM 2020)

Welded:	F_{tuw} =	24.00	ksi

(From Table A.4.6 & J2.2 - ADM 2020)

Filler 5356:

$F_{nBM} = 0.6 * F_{tuw}$ =	14.40	ksi
$F_{nw} = -0.6*0.85*F_{tuy}$ =	12.24	ksi

Truss Analysis

(Analysis performed on one side truss of the gangway)

Uniform Ld: $w_L = 1/2(LL*w_E + DL*w + UL*w)$

w_L = **327.7** plf

End Reaction: $R = {}^{1}/_{2}(w_L*L+P)$

R = **13.31** kips

Maximum Moment: $M = 1/8*w_L L^2 + 1/4*PL$

M = **270.17** k-ft

Chord Force: $F = M/h$

F = 61.17 kips

Design Summary

Chords:

Selected Member:	6x4x0.250
Stress Status:	Section Good
Deflection Status:	Meets Deflection Criteria

Diagonals:

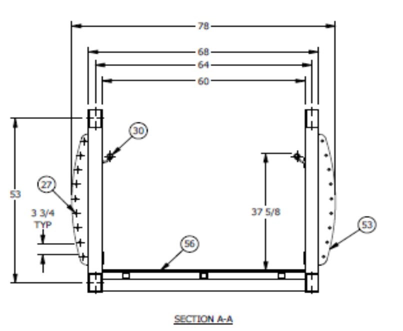
Largest Member:	4x4x0.188
Stress Status:	Section Good
Weld Status:	Weld Good
	Weld All Around (4) Bay

Bridges:

Selected Member:	4x4x0.188
Stress Status:	Section Good
Weld Status:	Weld Good
Max Spacing:	5 ft.

Posts:

Selected Member:	4x4x0.188
Top Chord Bracing:	Section Good
Weld Status:	Weld Good
Combined Stress:	Section Good



Topper Industries

Project:	5x80 Gangway Dana Pt
Job#:	8115
Engineer:	BG
Date:	November-22

(Version 14.1 2-2-22)

Aluminum Gangway Design - Chord Design

Chord Member

Use 6x4x0.250 Top and Bottom Chord

d (in)	b (in)	t (in)	A (in^2)	S_x (in^3)	I_x (in^4)	r (in)	J (in^4)
6	**4**	**0.25**	**4.75**	**7.82**	**23.5**	**1.61**	**24.5**

Top Chord Compression Check

(Use Vertical Posts to Brace Compression Chord)

Perimeter of Section: A = **20** in

Weld Affected Perim.: A_w = 4 in

Chord K Factor: K = 1.2

Dist. Between Posts: L_p = 60 in

Compression In Columns: Sec. E.2

$\lambda = KL_p/r$ λ = **44.72**

$F_w = 9.1$	for	$\lambda \le 21.8$
$F_w = 0.00007*\lambda^2 - 0.066\lambda + 10.5$	for	$21.8 < \lambda < 133$
$F_w = 51352/\lambda^2$	for	$\lambda \ge 133$
Weld Affected: F_w =	**7.69**	ksi
$F_n = 21.2$	for	$\lambda \le 17.8$
$F_n = 0.00047\lambda^2 - 0.232\lambda + 25.2$	for	$17.8 < \lambda < 66$
$F_n = 51352/\lambda^2$	for	$\lambda \ge 66$
Non-Weld Affected: F_N =	**15.76**	ksi

Column Allowable Stress: $F_{pw} = F_n(1-A_w/A)+F_w(A_w/A)$

F_{pw} = **14.15** ksi

Compression In Column Elements: Sec. B.5.4.2

$\lambda = b/t$ λ = **16.00**

$F_w = 9.1$	for	$\lambda \le 28.2$
$F_w = 12.0 - 0.105\lambda$	for	$28.2 < \lambda < 58$
$F_w = 346/\lambda$	for	$\lambda \ge 58$
Weld Affected: F_w =	**9.10**	ksi
$F_n = 21.2$	for	$\lambda \le 20.8$
$F_n = 27.3 - 0.291\lambda$	for	$20.8 < \lambda < 33$
$F_n = 580/\lambda$	for	$\lambda \ge 33$
Non-Weld Affected: F_n =	**21.20**	ksi

Element Allowable Stress: $F_{pw} = F_n(1-A_w/A)+F_w(A_w/A)$

F_{pw} = **18.78** ksi

Elastic Buckling Stress: Sec. B.5.6

Elastic Buckling Stress: $MIN(F_N, F_e = (\pi^2 E/(1.6b/t)^2$

F_e = **15.76** ksi

Allowable Stress: $F_e = \pi^2 E/((kL/r)^2)^{1/3} * F_e^{2/3}/n_y$

F_p = **14.02** ksi

Allowable Compression Stress:

Chord Allowable Stress = **14.02** ksi

Top Chord Actual Stress: $f_a = F/A$

f_a = **12.88** ksi

Demand/Capacity: $D/C = f_a/F_{pw}$

D/C = **0.9** Section Good

Bottom Chord Tension Check

Perimeter of Section: A = **20** in

Weld Affected Perim.: A_w = 6 in

Axial Tension: Sec. D.2

Allowable Yield Stress: $P_{ty} = F_{ty}(A_g - A_{wz}) + F_{tyw} A_{wz}$

19.70 k/in

Allowable Rupture Stress $P_{nt} = F_{tu}(A_e - A_{ewz}) + F_{tuw} A_{ewz}$

17.34 k/in

Allowable Tension Stress:

Bottom Chord Actual Stress = $f_a = F/A$

f_a = **12.88** ksi

Demand/Capacity: $D/C = f_a/(Min\ F_{ty}, F_{nt})$

D/C = **0.74** Section Good

Aluminum Gangway Design - Chord Design

Gangway Deflection Check

(Based on Top and Bottom Chord Section Properties)

Truss Moment of Inertia: $I=2[I+A(h/2)^2]$

I = **6718** in^4

Live Load Deflection: $\Delta_{LL} = 5w_L L^4/384EI$

Δ_{LL} = **3.62** in

L/ **265**

Deflection Meets Criteria

Vertical Posts Bracing Top Chord

(Brace top chord of truss with (3) verticals to resist 2% of axial compression)

Vertical Post Member: 4x4x0.188

b (in)	t (in)	S_y (in^3)	I_y (in^4)
4	**0.188**	**3.48**	**6.96**
d (in)	C_b	A (in^2)	L_b (in)
4	1.3	**2.87**	49

Perimeter of Section: A = **16** in

Weld Affected Perim.: A_w = 12 in

Compression In Beams: Sec. B.5.4.2

$\lambda = b/t$ λ = **21.3**

$F_w = 9.1$	for	$\lambda \le 28.2$
$F_w = 12.0-0.105\lambda$	for	$28.2 < \lambda < 58$
$F_w = 346/\lambda$	for	$\lambda \ge 58$
Weld Affected: F_w =	**9.10**	ksi
$F_n = 21.2$	for	$\lambda \le 20.8$
$F_n = 27.3-0.291\lambda$	for	$20.8 < \lambda < 33$
$F_n = 580/\lambda$	for	$\lambda \ge 33$
Non-Weld Affected: F_n =	**21.11**	ksi

Element Allowable Stress: $F_{pw} = F_n(1-A_w/A_f)+F_w(A_w/A_f)$

F_{pw} = **12.10** ksi

Flexural Compression In Beam Elements: Sec. B.5.5.1

$\lambda = b/t$ λ = **21.28**

$F_w = 13.6$	for	$\lambda<13.6$
$F_w = 16-0.065\lambda$	for	$36.2<\lambda<123$
$F_w = 982/\lambda$	for	
Weld Affected: F_w =	**13.60**	ksi
$F_n = 31.8$	for	$\lambda<33.1$
$F_n = 40.5-0.262\lambda$	for	$33.1<\lambda<77$
$F_n = 1563/\lambda$	for	$\lambda>77$
Non-Weld Affected: F_n =	**31.80**	ksi

Element Allowable Stress: $F_{pw} = F_n(1-A_w/A_f)+F_w(A_w/A_f)$

F_{pw} = **18.15** ksi

Tension In Beams: Table 2-19 & 2-19W Sec. D.2a

Weld Affected Tension: F_w = **9.10** ksi

Non-Weld Affect Tens.: F_n = **21.20** ksi

Allowable Tension Stress: $P=F_{ty}(A_g-A_{wz})+F_{tyw}A_w$

F_{pw} = **12.13** ksi

Allowable Bending & Combined Stress:

Allowable Bending Stress: F_{pw} = **12.10** ksi

Max Bracing Moment : $M=0.02Fh/3$

M = **21.61** k-in

Post Bending Stress: $f_b = M/S$

f_b = 6.21 ksi

$D/C = f_b/F_{pw}$ = 0.3 Section Good

`

Combined Stress: $P_r/P_c + M/M_r \le 1.0$

P_r = **12.5** kips

P_c = 60.8 kips

M = 21.61 k-in

M_r = 63.16 k-in

Comb. Stress= 0.5 Section Good

Job#:	8115
Engineer:	BG
Date:	November-22

(Version 14.1 2-2-22)

Aluminum Gangway Design - Chord Design

Vertical Post Weld to Chord

(Weld Top and Bottom of Post)

Allowable V_w = **12.24** ksi
Allowable P_w = **12.24** ksi

End Reaction: $R_p = 0.02F$
R_p = **1.22** kip

A_w of Weld: $A_w = 2b$
A_w = **7.50** in
S_w of Weld: $S_w = bd$
S_w = **15.00** in^2

Shear Demand at Weld: $f_v = R_p / A_w$
f_v = **0.16** kip/in
Tension Demand at Weld: $f_v = M/S_w$
f_t = **1.44** kip/in

Weld Thickness Required: $t_w = f_p/V_w + f_t/P_w$

t_w = **0.131** in

Min Post/Chord Thickness = **0.188** in

Demand/Capacity: $D/C = t_w/t$
D/C = **0.70** Weld Good

Vertical Post to Chord for Combined Brace & Rail Load

(Weld Bottom of Post for Brace & Handrail Load)

V_w = **12.24** ksi
P_w = **12.24** ksi

Shear: f_p = **0.66** kip
M_p = **31.30** k*in
(handrail load @ height of rail+deck+deck support-verify)

A_w of Weld: $A_w = 2b$
A_w = **8.00** in
S_w of Weld: $S_w = bd$
S_w = **16.00** in^2

Shear Demand at Weld: $f_v = f_p / A_w$
f_v = **0.08** kip/in
Tension Demand at Weld: $f_t = M_p/S_w$
f_t = **1.96** kip/in

Weld Thickness Required: $t_w = f_p/V_w + f_t/P_w$

t_w = **0.167** in

Min Post/Chord Thickness = **0.188** in

Demand/Capacity: $D/C = t_w/t$
D/C = **0.89** Weld Good

Vertical Post Weld to Chord

(Weld Bottom of Post All Around when D/C Above Right is > 1.0)

V_w = **12.24** ksi
P_w = **12.24** ksi

End Reaction: $R_p = 0.02F$
R_p = **1.22** kip

A_w of Weld: $A_w = 4b$
A_w = **16.00** in
S_w of Weld: $S_w = bd + d^2/3$
S_w = **21.33** in^2

Shear Demand at Weld: $f_v = f_p / A_w$
f_v = **0.04** kip/in
Tension Demand at Weld: $f_v = M_p/S_w$
f_t = **1.47** kip/in

Weld Thickness Required: $t_w = f_p/V_w + f_t/P_w$

t_w = **0.123** in

Min Post/Chord Thickness = **0.188** in

Demand/Capacity: $D/C = t_w/t_{min}$
D/C = **0.66** Weld All Around

Topper Industries

Project:	5x80 Gangway Dana Pt
Job#:	8115
Engineer:	BG
Date:	November-22

Aluminum Gangway Design - Diagonal Design

Nominal (Ult) Weld Stress

(From Table J.2.2)

Nominal (Ult) Shear Stress: $V_{uw} = 0.6*0.85 * F_{tuw}$
V_{uw} = **12.24** ksi

Nominal (Ult) Tension Stress: $P_{uw} = 0.6 *0.85* F_{tuw}$
P_{uw} **12.24** ksi

1st Diagonal

Use 4x4x0.188 Diagonals

b (in)	d (in)	t (in)	A (in^2)	S_y (in^3)	I_y (in^4)	r_y (in)
4	**4**	**0.188**	**2.87**	**3.48**	**6.96**	**1.56**

Diagonal Compression Check

Chord K Factor: K = 1
Panel Length: L_{pan} = 60 in
Gangway Span at Diag. = 80 ft

Angle of Diagonal: $\varphi = arctan(h/L_{pan})$
ϕ = **41.46** degrees
Length of Diagonal: $L_{diag} = h/\sin\phi$
L_{diag} = **80.06** in
Reaction at Diagonal: R = $R=1/2(w_L L+P_{DL})$
R = **13.3087** kips
Compression in Diagonal: $C_{diag} = R/\sin\phi$
C_{diag} = **20.10** kips

Diagonal Actual Stress: $f_a = C_{diag}/A$
f_a = **7.00** ksi

Compression In Columns: Sec. E.2

$\lambda = KL_{diag}/r$ λ **51.32**
$F_w = 9.1$ for $\lambda \le 17.8$
$F_n = 0.00047\lambda^2 - 0.232\lambda + 25.2$ for $17.8 < \lambda < 66$
$F_n = 51352/\lambda^2$ for $\lambda \ge 66$
Non-Weld Affected: F_N = **25.67** ksi

Compression In Column Elements: Sec. B.5.4.2

$\lambda = b/t$ λ = **21.28**

$F_n = 21.2$ for $\lambda < 20.8$
$F_n = 27.3 - 0.291\lambda$ for $20.8 < \lambda < 33$
$F_n = 580/\lambda$ for $\lambda \ge 33$
Non-Weld Affected: F_n = **21.11** ksi

Flat Elements Direct Strength Method: Sec. B.5.5.5

Elastic Buckling Stress: $MIN\ (F_N, F_e = (\pi^2 E/(1.6b/t)^2$
F_e = **25.67** ksi

$\lambda_{eq} = \pi(E/F_e)^{1/2}$ λ_{eq} = **62.31**

$\lambda_{eq} = 31.8$ for $\lambda < 21.5$
$\lambda_{eq} = 40.5 - 0.403\lambda$ for $21.5 < \lambda < 50$
$\lambda_{eq} = 1016/\lambda$ for $\lambda \ge 50$
Non-Weld Affected: Fds = **16.30** ksi

Allowable Compression Stress:

$Min(F_n, F_N, F_{ds})$
Diagonal Allowable Stress = **16.30** ksi

Demand/Capacity: $D/C = f_a/F_{pw}$
D/C = **0.4** Section Good

Diagonal Weld Design

Weld All Around Diagonal? Yes

Length of Weld Provided: $L_w = 2*d/\sin\varphi + 2*b$
L_w = **20.08** in
Weld Area Provided: $A_{wprov} = 2*0.8*t*L_w$
A_{wprov} = **5.339** in^2
Weld Area Required:
$A_{wreq} = (R_n/P_{uw} + R_n/\tan(\varphi)*V_{uw})*\Omega$
A_{wreq} = **4.521** in^2
D/C = A_{wporv}/A_{wreq} = **0.8** Weld Good

Topper Industries

Project:	5x80 Gangway Dana Pt
Job#:	8115
Engineer:	BG
Date:	November-22

Aluminum Gangway Design - Diagonal Design Continued

3rd Diagonal

Use 4x4x0.125 Diagonals

b (in)	d (in)	t (in)	A (in^2)	S_y (in^3)	I_y (in^4)	r_y (in)
4	4	0.125	1.94	2.43	4.85	1.58

Diagonal Compression Check

Chord K Factor: K = 1

Panel Length: L_{pan} = 60 in

Gangway Span at Diag. = 60 ft

Angle of Diagonal: $\varphi = arctan(h/L_{pan})$

ϕ = 41.46 degrees

Length of Diagonal: $L_{diag} = h/\sin\phi$

L_{diag} = 80.06 in

Reaction at Diagonal: R = $R = 1/2(w_L L + P_{DL})$

R = 10.0315 kips

Compression in Diagonal: $C_{diag} = R/\sin\phi$

C_{diag} = 15.15 kips

Diagonal Actual Stress: $f_a = C_{diag}/A$

f_a = 7.81 ksi

Compression In Columns: Sec. E.2

$\lambda = KL_{diag}/r$ λ 50.67

$F_n = 0.00047\lambda^2 - 0.232S\lambda + 25.2$ for $\lambda < 66$

$F_n = 51352/\lambda^2$ for $\lambda \geq 66$

Non-Weld Affected: F_N = 25.51 ksi

Compression In Column Elements: Sec. B.5.4.2

$\lambda = b/t$ λ = 32.00

$F_n = 21.2$ for $\lambda < 20.8$

$F_n = 27.3 - 0.291\lambda$ for $20.8 < \lambda < 33$

$F_n = 580/\lambda$ for $\lambda \geq 33$

Non-Weld Affected: F_n = 17.99 ksi

Flat Elements Direct Strength Method: Sec. B.5.5.5

Elastic Buckling Stress: $MIN(F_N, F_e = (\pi^2 E/(1.6b/t)^2$

F_e = 25.51 ksi

$\lambda_{eq} = \pi(E/F_e)^{1/2}$ λ_{eq} = 62.51

$\lambda_{eq} = 31.8$ for $\lambda < 21.5$

$\lambda_{eq} = 40.5 - 0.403\lambda$ for $21.5 < \lambda < 50$

$\lambda_{eq} = 1016/\lambda$ for $\lambda \geq 50$

Non-Weld Affected: Fds = 16.25 ksi

Allowable Compression Stress:

$Min(F_n, F_N, F_{ds})$

Diagonal Allowable Stress = 16.25 ksi

Demand/Capacity: $D/C = f_a/F_{pw}$

D/C = 0.5 Section Good

Diagonal Weld Design

Weld All Around Diagonal? Yes

Length of Weld Provided: $L_w = 2*d/\sin\varphi + 2*b$

L_w = 20.08 in

Weld Area Provided: $A_{wprov} = 2*0.8*t*L_w$

A_{wprov} = 4.017 in^2

Weld Area Required:

$A_{wreq} = (R_n/P_{uw} + R_n/\tan(\varphi)*V_{uw})*\Omega$

A_{wreq} = 3.407 in^2

D/C = A_{wporv}/A_{wreq} = 0.85 Weld Good

Aluminum Gangway Design - Diagonal Design Continued

5th Diagonal

Use 4x4x0.125 Diagonals

b (in)	d (in)	t (in)	A (in^2)	S_y (in^3)	I_y (in^4)	r_y (in)
4	4	0.125	1.94	2.43	4.85	1.58

Diagonal Compression Check

Chord K Factor: K = 1
Panel Length: L_{pan} = 60 in
Gangway Span at Diag. = 40 ft

Angle of Diagonal: $\varphi = arctan(h/L_{pan})$
ϕ = 41.46 degrees
Length of Diagonal: $L_{diag} = h/\sin\phi$
L_{diag} = 80.06 in
Reaction at Diagonal: R = $R=1/2(w_L L+P_{DL})$
R = 6.75433 kips
Compression in Diagonal: $C_{diag} = R/\sin\phi$
C_{diag} = 10.20 kips

Diagonal Actual Stress: $f_a = C_{diag}/A$
f_a = 5.26 ksi

Compression In Columns: Sec. E.2

$\lambda = KL_{diag}/r$ λ 50.67

$F_n = 0.00047\lambda^2-0.232S\lambda+25.2$ for $\lambda < 66$
$F_n = 51352/\lambda^2$ for $\lambda \geq 66$
Non-Weld Affected: F_N = 25.51 ksi

Compression In Column Elements: Sec. B.5.4.2

$\lambda = b/t$ λ = 32.00

$F_n = 21.2$ for $\lambda < 20.8$
$F_n = 27.3-0.291\lambda$ for $20.8 < \lambda < 33$
$F_n = 580/\lambda$ for $\lambda \geq 33$
Non-Weld Affected: F_n = 17.99 ksi

Flat Elements Direct Strength Method: Sec. B.5.5.5

Elastic Buckling Stress: $MIN (F_N, F_e = (\pi^2 E/(1.6b/t)^2$
F_e = 25.51 ksi

$\lambda_{eq} = \pi(E/F_e)^{1/2}$ λ_{eq} = 62.51

$\lambda_{eq} = 31.8$ for $\lambda < 21.5$
$\lambda_{eq} = 40.5-0.403\lambda$ for $21.5 < \lambda < 50$
$\lambda_{eq} = 1016/\lambda$ for $\lambda \geq 50$
Non-Weld Affected: Fds = 16.25 ksi

Allowable Compression Stress:

$Min(F_n, F_N, F_{ds})$
Diagonal Allowable Stress = 16.25 ksi

Demand/Capacity: $D/C = f_a/F_{pw}$
D/C = 0.3 Section Good

Diagonal Weld Design

Weld All Around Diagonal? No

Length of Weld Provided: $L_w = 2*d/\sin\varphi + 2*b$
L_w = 12.08 in
Weld Area Provided: $A_{wprov} = 2*0.8*t*L_w$
A_{wprov} = 2.417 in^2
Weld Area Required:
$A_{wreq} = (R_n/P_{uw} + R_n/tan(\varphi)*V_{uw})*\Omega$
A_{wreq} = 2.294 in^2

D/C = A_{wporv}/A_{wreq} = 0.95 Weld Good

Topper Industries

Project:	5x80 Gangway Dana Pt
Job#:	8115
Engineer:	BG
Date:	November-22

(Version 14.1 2-2-22)

Aluminum Gangway Design - Bridge Design

Bridge Member

Use 4x4x0.188 Bridges

b (in)	t (in)	A (in^2)	S_x (in^3)	I_x (in^4)	r (in)	I_y (in^4)	d (in)
4	**0.188**	**2.87**	**3.48**	**6.96**	**1.56**	**6.96**	**4**

Bridge Flexural Demand

(Design Bridge members with fixed ends)

Bridge Spacing: S = 5 ft

Design Point Load: P = 400 lbs

Total Line Load:

w_{btot} = **575** plf

Dead Line Load:

w_{bdead} = **75** plf

Uniform Utility Load:

w_{UL} = **47** lbf

Uniform Load Moment: $M = {}^{1}/_{12} * (w_{btot} + w_{UL}) * w^2$

M = **15.55** kip-in

Point Load Moment: $M = {}^{1}/_{12} * (w_{UL} + w_{DL}) * w^2 + {}^{1}/_{8} * P * w$

M = **3.00** kip-in

Max Bending Stress:

f_b = **4.47** ksi

Bridge Design Input

Perimeter of Section: A = **16** in

Weld Affected Perim.: A_w = 12 in

Unbraced Length: L_b = 30 in

Compression In Column Elements: Sec. B.5.4.2

$\lambda = b/t$ λ = **21.28**

$F_w = 9.1$	for	$\lambda \leq 28.2$
$F_w = 12.0 - 0.105\lambda$	for	$28.2 < \lambda < 58$
$F_w = 346/\lambda$	for	$\lambda \geq 58$
Weld Affected: F_w =	**9.10**	ksi
$F_n = 21.2$	for	$\lambda \leq 20.8$
$F_n = 27.3 - 0.291\lambda$	for	$20.8 < \lambda < 33$
$F_n = 580/\lambda$	for	$\lambda \geq 33$
Non-Weld Affected: F_n =	**21.11**	ksi

Element Allowable Stress: $F_{pw} = F_n(1-A_w/A) + F_w(A_w/A)$

F_{pw} = **12.10** ksi

Flat Element Bending In Own Plane: Sec. B.5.5.1

b = **4** in

$\lambda = b/t$ λ = **21**

$F_w = 13.6$	for	$\lambda < 36.2$
$F_w = 16.0 - 0.065\lambda$	for	$36.2 < \lambda < 123$
$F_w = 982/\lambda$	for	$\lambda \geq 123$
Weld Affected: F_w =	**13.60**	ksi
$F = 31.8$	for	$\lambda < 33.1$
$F = 40.5 - 0.262\lambda$	for	$33.1 < \lambda < 77$
$F = 1563/\lambda$	for	$\lambda \geq 77$
Non-Weld Affected: F_n =	**31.80**	ksi

Allowable Stress: $F_{pw} = F_n - (A_w/A)(F_n - F_w)$

F_{pw} = **18.15** ksi

Aluminum Gangway Design - Bridge Design

Allowable Tension In Beams: Sec D.2b

Weld Affected Tension: F_w = **9.10** ksi
Non-Weld Affect Tens.: F_n = **19.50** ksi

Allowable Tension Stress: $F_{pw} = F_n - (A_w/A)(F_n - F_w)$
F_{pw} = **11.70** ksi

Allowable Bending Stress:

Allow Bending Stress: F_{pw} = **11.7** ksi

Demand/Capacity: $D/C = f_a/F_{pw}$
D/C = **0.38** Section Good

(Weld All Around Bridge to Chord When D/C to Right is > 1.0)

Aw of Weld = 2*b+2*d
Aw = 16 in
Sw of Weld = $b*d+d^2/3$
Sw = 21.3 in^2

Shear Demand at Weld:
fv = 0.09 kip/in
Tension Demand at Weld:
ft = 0.73 kip/in

Weld Thickness Required:

t_w = 0.13 in

Min Bridge/Chord Thickness = **0.188** in

Demand/Capacity: $D/C = t_w/t$
D/C = 0.70 Weld All Around

Bridge Weld Design

$V_w = V_{uw}/\Omega$ V_w = **6.28** ksi
P_w = **6.28** ksi

Uniform Load End Reaction: $R_b = 1/2 w_{tot} w$
R_b = **1461.05** lb
Point Load End Reaction: $R_b = 1/2 w_{bdead} w + P$
R_b = **587.50** lb

(Weld Top and Bottom of Bridge to Chord)

A_w of Weld: $A_w = 2b$
A_w = **8.00** in
S_w of Weld: $S_w = bd$
S_w = **16.00** in^2

Shear Demand at Weld: $f_v = R_b/A_w$
f_v = **0.18** kip/in
Tension Demand at Weld: $f_t = M/S_w$
f_t = **0.97** kip/in

Weld Thickness Required: $t_w = f_v/V_w + f_t/P_w$

t_w = **0.184** in

Min Bridge/Chord Thickness = **0.188** in

Demand/Capacity: $D/C = t_w/t$
D/C = **0.98** Weld Good