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CFS Engineering Group, Inc.

Project: Casa Robles – Stair Architectural Guardrail

Date: 08/05/2026

Casa Robles Stair Architectural Guardrail

CALCULATION REPORT

6545 SW 131 Street, Pinecrest, FL 33156

SPECIALTY ENGINEER SHOP DRAWING REVIEW

Review of design calculations and drawings prepared by delegated engineer (Specialty Engineer) does not constitute a detailed check of calculations, nor does it relieve the Specialty Engineer from the responsibility of the detailing of the specialty component or system.

Review is limited to confirming the following:

- That the specialty engineering documents conform with the intent of the engineer of record as expressed on the Structural Documents and have been prepared by a structural engineer registered in Florida;
- That the effect of the Specialty Engineer's work on the structural frame conforms with the intent of the Structural Documents.

- | | |
|---|--|
| ☒ NO EXCEPTIONS TAKEN | ☐ EXCEPTIONS NOTED |
| ☐ SUBMIT SPECIFIED ITEM | ☐ REVISE & RESUBMIT |
| ☐ NON-COMPLIANT SUBMITTAL | ☐ REJECTED |
| ☐ ACKNOWLEDGE RECEIPT FOR RECORD | |

CFS ENGINEERING GROUP, INC.

BY CS DATE 09-01-26

Reviewed only for compliance with loading criteria and conformance to general design intent.



Digitally signed by Erick Guillen
Location: Casa Robles -
Architectural Guardrail
Reason: This item has been
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Guillen, PE on 09/17/2026. Printed
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Date: 2026.09.17 14:38:53-04'00'

EGV Engineering
12090 SW 116th St, Miami, FL 33186
PE #92192

REVISION	DATE	CALCULATED BY	CHECKED BY	NOTES
00	04/16/2026			Structural Calculations for an Stair Architectural Guardrail
01	08/05/2026			Revised per EOR Comments

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1. SCOPE

This report shows the results of the analysis & design of all structural elements of the Guardrail for the above mentioned project.

1.1. Codes & Standards

All calculations contained herein have been reviewed and meets or exceed all specifications and recommendations of the following codes and standards:

- *FBC 2023. Florida Building Code 8th edition (2023) with amendments..*
- *ASCE 7-22. Minimum Design Loads and Associated Criteria for Buildings and Others Structures 2022.*
- *AISC 360-16. Specification for Structural Steel Buildings. Steel Construction Manual 15TH Edition.*
- *ADM-2020. Aluminum Design Manual.*
- *ACI 318-19. Building Code Requirements for Structural Concrete.*

2. LOADS

2.1. Dead Loads (D)

- Aluminum Structure Self-Weight

2.2. Live Loads (L)

- 200 lbs → Railing
- 50 plf → Railing
- 5 psf → Interior Walls and Partitions

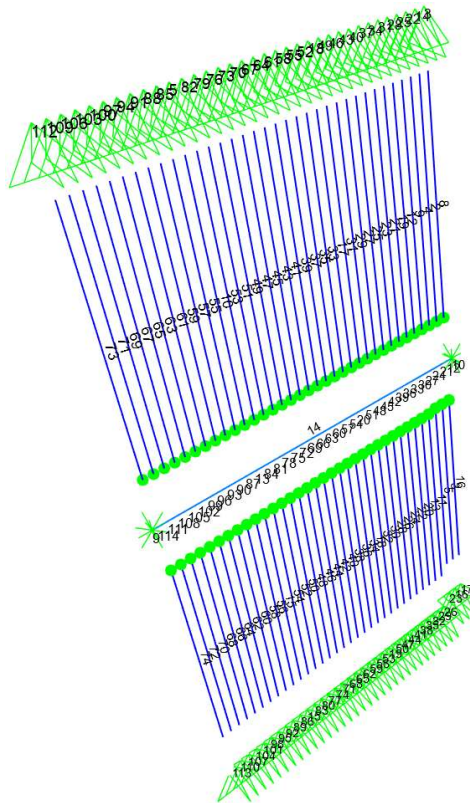
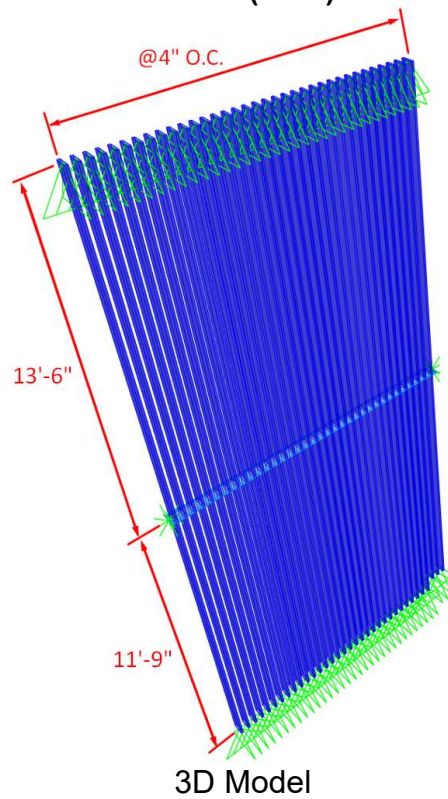
3. LOAD COMBINATIONS

- Combo-1 = 1.0 D + 1.0 L

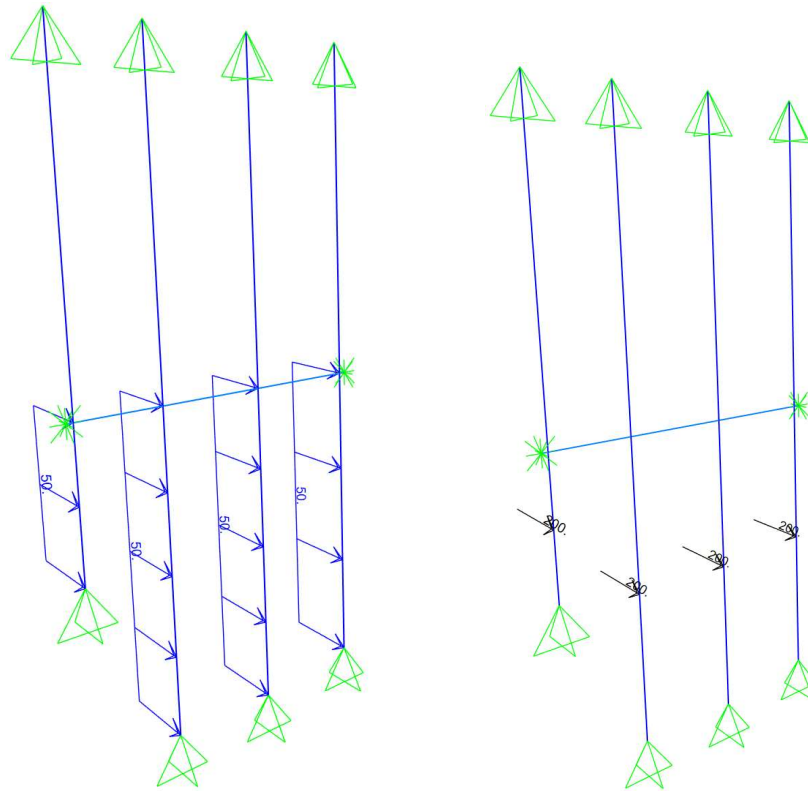
4. MATERIALS

- Aluminum Alloy 6061-T6
 - Compressive Yield Strength, $F_{cy} = 35.0$ ksi
 - Tensile Yield Strength, $F_{ty} = 35.0$ ksi
 - Tensile Ultimate Strength, $F_{tu} = 38.0$ ksi
 - Shear Ultimate Strength, $F_{su} = 24.0$ ksi

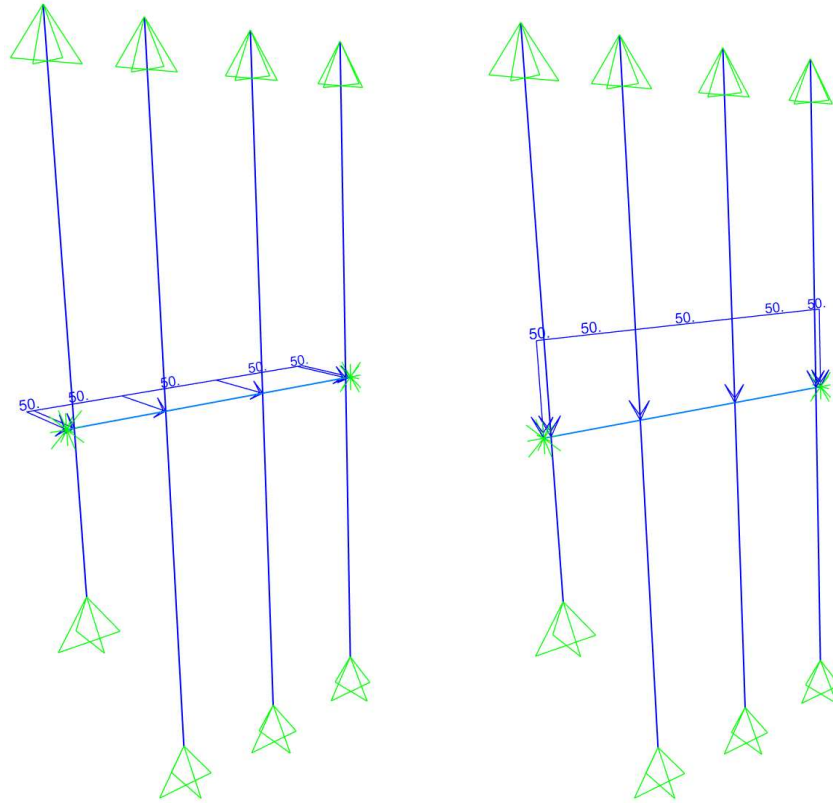
5. ALUMINUM GUARDRAIL – ANALYSIS (ASD)



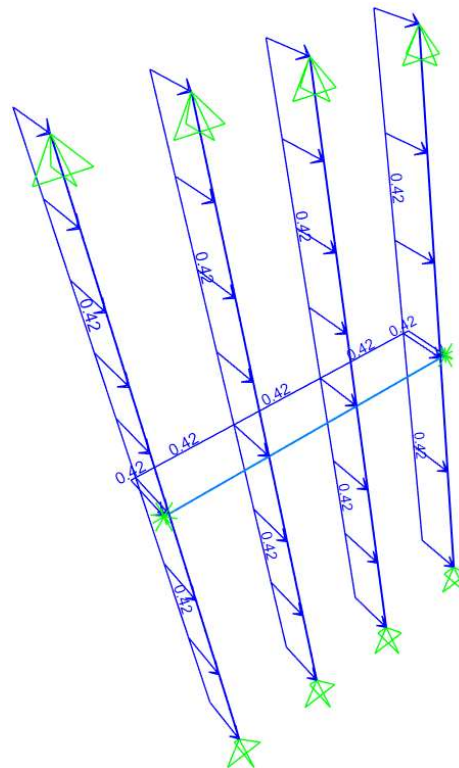
Note: For clarity, selected members have been hidden from the views presented below to prevent overlapping member and load labels. The members remaining visible identify the representative members and loaded portions being evaluated. This graphical simplification does not represent a modification of the analytical model; all structural members, including those hidden from view, are included in the complete three-dimensional analysis model.



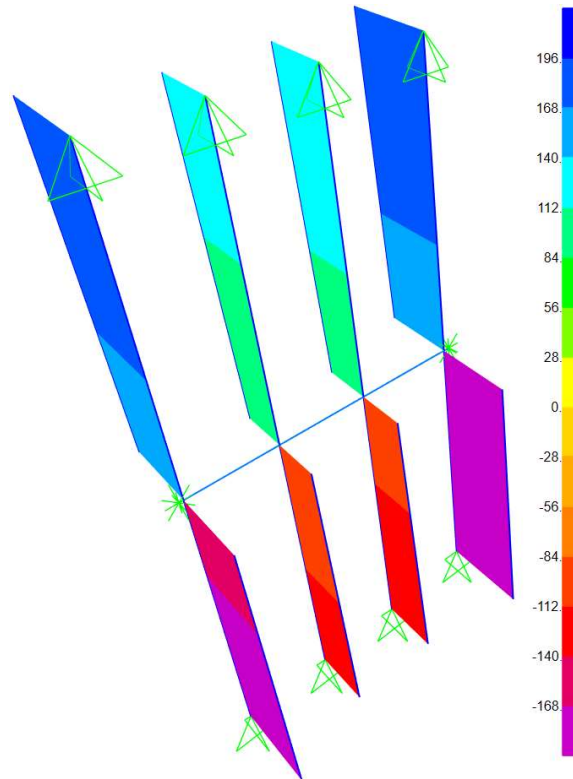
Live Load for Vertical Tubes Check (plf; lb)



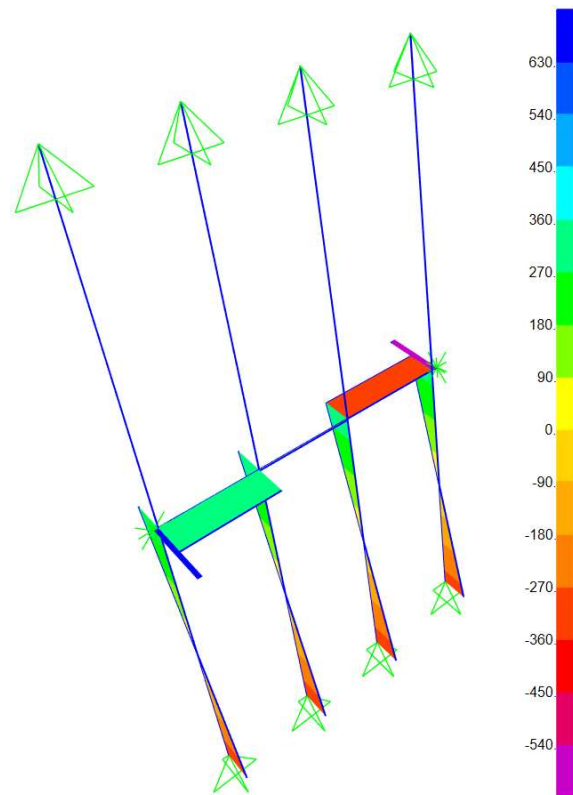
Live Load for Horizontal Tube Check (plf)



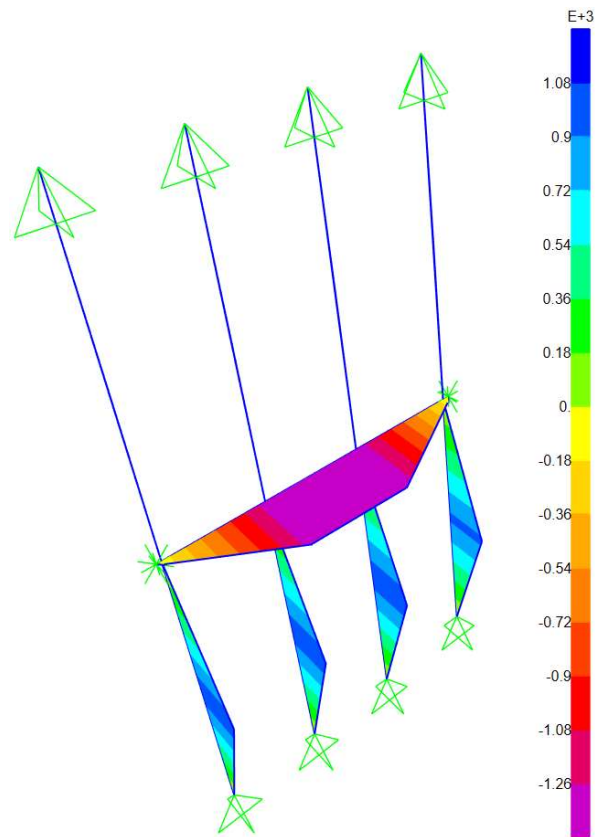
Interior Walls and Partitions Live Load Acting Concurrently with Railing Live Load (plf)



Axial Load (lbs) for Combo-1 = 1.0 D + 1.0 L

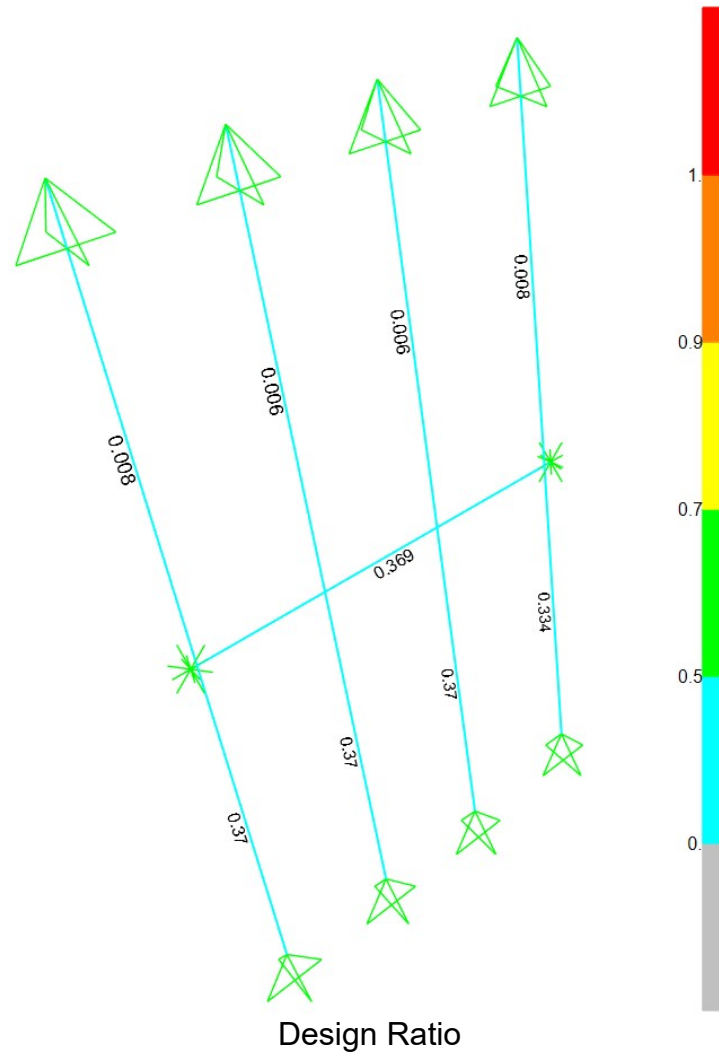


Shear Force (lbs) for Combo-1 = 1.0 D + 1.0 L

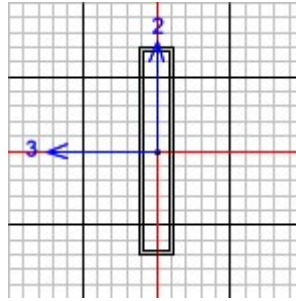


Bending Moment (lb-ft) for Combo-1 = 1.0 D + 1.0 L

6. FENCE & GATE – DESIGN



6.1. Guardrail Vertical Tube (RT 1" x 6" x 1/8")



AA 2020 ALUMINUM SECTION CHECK Units: Kip, in, F

FRAME ELEMENT INFORMATION

	Frame ID	Section ID	Stat Loc	FilletRad	LatFac	UseLatFac
	54	ST 1" x 6" x 1/8"	77.	0.	1.	No
	L	K	iBraceLoc	jBraceLoc	LTB Restraint	Buckl./Bend. Axes
Major	154.	1.	0.	154.	No	Geometric
Minor	154.	1.	0.	154.		
LTB	154.	1.	0.	154.		

MATERIAL PROPERTIES

Designation	E	Fcy	Fty	Fsy	Fy	Ftu	Fsu
6061-T6 Wrought Alloy	10100.	35.	35.	21.	35.	38.	24.

BUCKLING CONSTANTS

Bc	Dc	Cc	Bp	Dp	Cp	Bt	Dt	Ct	Ebr	Dbr	Cbr
39.	0.246	65.673	45.001	0.3	61.423	43.186	1.558	8.26E-05	66.824	0.666	66.92
Btb	Dtb	Ctb	Bs	Ds	Cs	K1c	K2c	K1b	K2b		
65.	4.458	7.446	27.241	0.141	78.946	0.35	2.27	0.5	2.04		

SAFETY FACTORS

OmegaTy	OmegaTr	OmegaC	OmegaBo	OmegaBr	OmegaVo	OmegaVr	Kt
1.65	1.95	1.65	1.65	1.95	1.65	1.95	1.

SECTION PROPERTIES

L	A	I22	I33	s22	s33	r22	r33
154.	1.685	0.298	6.109	0.595	2.036	0.42	1.904
G	J	Cw	z22	z33			
0.	0.978	0.	0.69	2.797			

COMBINED RATIO EQUATION - (H.1-1) - GOVERNS THE DESIGN

	Pr/Pc	Mrx/Mcx	Mry/Mcy
COMBINED RATIO	0.37 =	0.026 +	0.344 + 0.

COMBINED RATIO LIMIT 1.

Combo	P	M33	M22	V2	V3
DEMANDSCombo-1.4=1.0D+1.0Ld	-0.017	12.456	7.627E-16	2.143E-17	0.
CAPACITIES	0.644	36.197	9.046	17.329	2.305
DEMAND/CAPACITY	0.026	0.344	0.	0.	0.

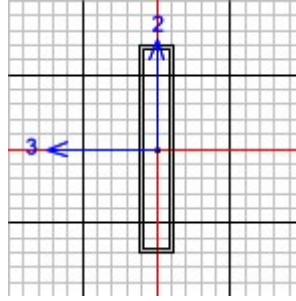
AXIAL - TENSION	Area Ag	Area Ae	Yielding Pnt/OmegaTy	Rupture Pnt/OmegaTr	Tension Pnt/Omega
	1.685	1.685	35.74	32.834	32.834

AXIAL - COMPRESSION

MEMBER BUCKLING	Lambda	Lambda1	Lambda2	Fc	Fe Pnc/OmegaC
Flex	366.483	17.762	65.673	0.631	N/A 0.644**

LOCAL BUCKLING	Lambda	Lambdal	Lambda2	Fc	Area	Pnc/OmegaC		
Flange	6.013	20.81	32.771	35.	0.187	3.973		
Web	46.077	20.81	32.771	20.759	1.435	18.057		
Intersection	N/C	N/C	N/C	35.	0.062	1.322		
Total						23.352		
INTERACTION	Lambda	Fcr	Pnc/OmegaC					
Local: Flange	6.013	1077.022	92.02					
Web	46.077	18.341	6.091					
Member: Flex	366.483*	0.631	N/N					
* used in calculation of Pnc limit for interaction								
** MEMBER FLEXURAL BUCKLING governs AXIAL COMPRESSION CAPACITY								
FLEXURE								
YIELDING/RUPTURE	St	Sc	Z*Fcy /OmegaBo	1.5St*Fty /OmegaBo	1.5Sc*Fcy /OmegaBo	Mnp /OmegaBo	Mnu /OmegaBr	
MAJOR	2.036	2.036	59.322	64.796	64.796	59.322	54.498	
MINOR	0.595	0.595	14.647	18.933	18.933	14.647	13.456	
LOCAL BUCKLING	Lambda	Lambdal	Lambda2	Fb(or Fc)	If(or Iw)	Mnlb /OmegaBo		
MAJOR								
Flange	6.013	20.81	32.771	35.	2.154	15.556		
Web	46.077	33.103	77.216	46.886	3.955	39.089		
Total						54.644		
MINOR								
Flange	6.013	33.103	77.216	52.5	0.009	0.745		
Web	46.077	20.81	32.771	20.759	0.289	8.301		
Total						9.046**		
LTB BUCKLING	Lambda	Cc	Me	Rye	Lb	MnLTB /OmegaBo	MnLTBLim /OmegaBo	
MAJOR	49.314	65.673	N/N	N/N	154.	36.197**	N/A	
	Cb	C1	C2	y0	go	betax	Iyf	Rm
	1.265	N/N	N/N	N/N	N/N	N/N	0.01	1.
** LATERAL-TORSIONAL BUCKLING governs MAJOR MOMENT CAPACITY								
** LOCAL BUCKLING governs MINOR MOMENT CAPACITY								
SHEAR	Lambda	Lambdal	Lambda2	Fs	Yield Av	Rupture An	Yield Vn /OmegaVo	Rupture Vn /OmegaVr
MAJOR	46.077	35.292	63.157	19.093	1.498	1.435	17.329	17.665
MINOR	6.013	35.292	63.157	21.	0.25	0.187	3.177	2.305
N/A: Not Applicable								
N/C: Not Calculated								
N/N: Not Needed								

6.2. Guardrail Horizontal Tube (RT 1" x 6" x 1/8")



AA 2020 ALUMINUM SECTION CHECK Units: Kip, in, F

FRAME ELEMENT INFORMATION

	Frame ID	Section ID	Stat Loc	FilletRad	LatFac	UseLatFac
	14	RT 1" x 6" x 1/8"	90.	0.	1.	No
	L	K	iBraceLoc	jBraceLoc	LTB Restraint	Buckl./Bend. Axes
Major	141.	1.	0.	141.	No	Geometric
Minor	44.	1.	46.	90.		
LTB	44.	1.	46.	90.		

MATERIAL PROPERTIES

Designation	E	Fcy	Fty	Fsy	Fy	Ftu	Fsu
6061-T6 Wrought Alloy	10100.	35.	35.	21.	35.	38.	24.

BUCKLING CONSTANTS

Bc	Dc	Cc	Bp	Dp	Cp	Bt	Dt	Ct	Bbr	Dbr	Cbr
39.	0.246	65.673	45.001	0.3	61.423	43.186	1.558	8.26E-05	66.824	0.666	66.92
Btb	Dtb	Ctb	Bs	Ds	Cs	K1c	K2c	K1b	K2b		
65.	4.458	7.446	27.241	0.141	78.946	0.35	2.27	0.5	2.04		

SAFETY FACTORS

OmegaTy	OmegaTr	OmegaC	OmegaBo	OmegaBr	OmegaVo	OmegaVr	Kt
1.65	1.95	1.65	1.65	1.95	1.65	1.95	1.

SECTION PROPERTIES

L	A	I22	I33	s22	s33	r22	r33
141.	1.688	0.298	6.118	0.596	2.039	0.42	1.904
G	J	Cw	z22	z33			
0.	0.979	0.	0.691	2.801			

COMBINED RATIO EQUATION - (H.1-1) - GOVERNS THE DESIGN

	Pr/Pc	Mrx/Mcx	Mry/Mcy
COMBINED RATIO	0.369 =	0. +	0.365 + 0.003

COMBINED RATIO LIMIT 1.

Combo	P	M33	M22	V2	V3
DEMANDS Combo-1.4=1.0D+1.0Ld	-1.928E-16	-16.658	0.032	-0.313	0.004
CAPACITIES					
	7.9	45.603	9.072	17.369	2.308
DEMAND/CAPACITY					
	0.	0.365	0.003	0.018	0.002

AXIAL - TENSION	Area Ag	Area Ae	Yielding Pnt/OmegaTy	Rupture Pnt/OmegaTr	Tension Pnt/Omega
	1.688	1.688	35.795	32.885	32.885

AXIAL - COMPRESSION

MEMBER BUCKLING	Lambda	Lambda1	Lambda2	Fc	Fe Pnc/OmegaC
Flex	104.731	17.762	65.673	7.725	N/A 7.9**

LOCAL BUCKLING	Lambda	Lambda1	Lambda2	Fc	Area	Pnc/OmegaC
Flange	6.	20.81	32.771	35.	0.188	3.977
Web	46.	20.81	32.771	20.793	1.438	18.115
Intersection	N/C	N/C	N/C	35.	0.063	1.326
Total						23.418

INTERACTION	Lambda	Fcr	Pnc/OmegaC
Local: Flange	6.	1081.63	213.031
Web	46.	18.402	14.092
Member: Flex	104.731*	7.725	N/N

* used in calculation of Pnc limit for interaction

** MEMBER FLEXURAL BUCKLING governs AXIAL COMPRESSION CAPACITY

FLEXURE

YIELDING/RUPTURE	St	Sc	Z*Fcy /OmegaBo	1.5St*Fty /OmegaBo	1.5Sc*Fcy /OmegaBo	Mnp /OmegaBo	Mnu /OmegaBr
MAJOR	2.039	2.039	59.411	64.89	64.89	59.411	54.579
MINOR	0.596	0.596	14.666	18.954	18.954	14.666	13.474

LOCAL BUCKLING	Lambda	Lambda1	Lambda2	Fb(or Fc)	If(or Iw)	Mnlb /OmegaBo
MAJOR						
Flange	6.	20.81	32.771	35.	2.158	15.58
Web	46.	33.103	77.216	46.919	3.961	39.174
Total						54.754
MINOR						
Flange	6.	33.103	77.216	52.5	0.009	0.746
Web	46.	20.81	32.771	20.793	0.289	8.326
Total						9.072**

LTB BUCKLING	Lambda	Cc	Me	Rye	Lb	MnLTB /OmegaBo	MnLTBLim /OmegaBo
MAJOR	29.399	65.673	N/N	N/N	44.	45.603**	N/A

Cb	C1	C2	y0	go	betax	Iyf	Rm
1.017	N/N	N/N	N/N	N/N	N/N	0.01	1.

** LATERAL-TORSIONAL BUCKLING governs MAJOR MOMENT CAPACITY

** LOCAL BUCKLING governs MINOR MOMENT CAPACITY

SHEAR

	Lambda	Lambda1	Lambda2	Fs	Yield	Av	Rupture	An	Yield Vn /OmegaVo	Rupture Vn /OmegaVr
MAJOR	46.	35.292	63.157	19.106	1.5	1.438			17.369	17.692
MINOR	6.	35.292	63.157	21.	0.25	0.188			3.182	2.308

N/A: Not Applicable

N/C: Not Calculated

N/N: Not Needed

7. CONNECTIONS

7.1. Side-Mounted Tube to Concrete Connection

7.1.1. Aluminum Tube Side

Checking for $V_{conn.} = 200.00 \text{ lb}$

Fastener Strengths^{1,2,3,4,5,6,7}

Description	Tension (lbf)			Shear (lbf)			Minimum Torsional Strength (in-lbs)
	Ultimate	ASD	LRFD	Ultimate	ASD	LRFD	
#10-16	2,275	760	1,140	1,460	485	730	61
#10-24	2,610	870	1,305	1,080	360	540	65
#12-14	3,215	1,070	1,610	1,990	665	995	92
#12-14 (PUFH)	2,150	715	1,075	1,980	660	990	92
#12-24	3,255	1,085	1,625	1,935	645	965	100
1/4"-14	4,360	1,455	2,180	2,690	895	1,345	150
1/4"-20	4,360	1,455	2,180	2,615	870	1,310	156
5/16"-18	7,220	2,405	3,610	4,565	1,520	2,285	425
5/16"-24	8,755	2,920	4,380	4,960	1,655	2,480	425

1. Ultimate strengths are based on laboratory tests.
2. Allowable (ASD) strengths are based on a safety factor Ω , of 3.0 in accordance with ICC-ES AC118 and AISI S100-16.
3. Design (LRFD) strengths are based on a resistance factor, ϕ , of 0.50 in accordance with ICC-ES AC118 and AISI S100-16.
4. For ASD tension connections, the lower of the ASD tension strength, ASD pull-out strength and ASD pull-over strength must be used for design.
5. For LRFD tension connections, the lower of the LRFD tension strength, LRFD pull-out strength and LRFD pull-over strength must be used for design.
6. For ASD shear connections, the lower of the ASD Shear (Bearing) Capacity and the ASD Fastener Shear Strength must be used for design.
7. For LRFD shear connections, the lower of the LRFD Shear (Bearing) Capacity and the LRFD Fastener Shear Strength must be used for design.

Allowable (ASD) Shear (Bearing) Capacity of Screw Connections in Aluminum, lbf^{1,2,3,4,5,6}

Screw Size	Head Styles	Point Type	6063-T5 ($F_y = 16 \text{ ksi}$, $F_u = 22 \text{ ksi}$)				6063-T6 ($F_y = 25 \text{ ksi}$, $F_u = 30 \text{ ksi}$)				6061-T6 ($F_y = 35 \text{ ksi}$, $F_u = 38 \text{ ksi}$)			
			1/16" - 1/16"	1/16" - 1/8"	1/8" - 1/8"	1/8" - 1/4"	1/16" - 1/16"	1/16" - 1/8"	1/8" - 1/8"	1/8" - 1/4"	1/16" - 1/16"	1/16" - 1/8"	1/8" - 1/8"	1/8" - 1/4"
#10-16	PPH	#2	130	130	260	-	180	180	355	-	225	225	450	-
#10-16	HWH	#3	130	130	260	-	180	180	355	-	225	225	450	-
#10-24	PWH	#3	160	-	-	-	205	-	-	-	205	-	-	-
#12-14	HWH	#2	150	150	295	-	205	205	405	-	255	255	515	-
#12-14	HWH	#3	150	150	295	-	205	205	405	-	255	255	515	-
#12-14	PUFH	#3	170	325	-	-	215	415	-	-	215	415	-	-
#12-24	HWH	#5	150	150	435	695	205	205	580	760	255	255	635	760
1/4"-14	HWH	#3	170	170	345	-	235	235	470	-	295	295	595	-
1/4"-20	HWH	#4	170	170	500	-	235	235	665	-	295	295	725	-
1/4"-20	HWH	#5	170	170	500	760	235	235	655	760	295	295	685	760
5/16"-18	HWH	#3	-	-	585 ^(R)	825 ^(R)	-	-	710 ^(R)	1,005 ^(R)	-	-	710 ^(R)	1,005 ^(R)
5/16"-24	HWH	#4	-	-	505 ^(R)	785 ^(R)	-	-	615 ^(R)	955 ^(R)	-	-	615 ^(R)	955 ^(R)

1. Allowable (ASD) strengths are based on a safety factor, $\Omega = 3.0$, determined in accordance with the Aluminum Design Manual, AA ADM-2020.
2. The first thickness listed is of the aluminum in contact with the screw head, the second thickness listed is of the aluminum not in contact with the screw head.
3. Unless otherwise noted, allowable strengths in shaded cells are applicable to screws which are self-drilled through both pieces of aluminum.
4. Allowable strengths in unshaded cells are applicable to screws which are self-drilled through both pieces of aluminum and to screws which are installed through existing holes in the aluminum in contact with the screw head and self-drilled into the receiving member. Clearance holes have the following dimensions: 0.177 inch for #8 screws; 0.201 inch for #10 screws; 0.228 inch for #12 screws; 0.266 inch for 1/4-inch screws.
5. Allowable Strengths are applicable to screws which are installed through existing holes ($D=21/64"$) in the aluminum in contact with the screw head and self-drilled into the receiving member.
6. For ASD shear connections, the lower of the ASD Shear (Bearing) Capacity and the ASD Fastener Shear Strength must be used for design.

Taken from Dewalt Anchors & Fasteners Catalog

Using #12-14 x 1" long. Undercut Flat Head Self-Drilling Structural Screws

$$V_{allow.} = \min. (660; 415) = 415.00 \text{ lb} > 200.00 \text{ lb} \rightarrow \text{PASS}$$

7.1.2. Concrete Landing Side

Checking for Tconn.= 200.00 lb

Tapcon® Anchors Ultimate Tension and Shear Values (Lbs/kN) in Concrete									
ANCHOR DIA. In. (mm)	MIN. DEPTH OF EMBEDMENT In. (mm)	f'c = 2000 PSI (13.8 MPa)		f'c = 3000 PSI (20.7 MPa)		f'c = 4000 PSI (27.6 MPa)		f'c = 5000 PSI (34.5 MPa)	
		TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)
3/16 (4.8)	1 (25.4)	600 (2.7)	720 (3.2)	625 (2.8)	720 (3.2)	650 (2.9)	720 (3.2)	800 (3.6)	860 (3.8)
	1-1/4 (31.8)	845 (3.7)	720 (3.2)	858 (3.8)	720 (3.2)	870 (3.9)	720 (3.2)	1,010 (4.5)	860 (3.8)
	1-1/2 (38.1)	1,090 (4.8)	860 (3.8)	1,090 (4.8)	860 (3.8)	1,090 (4.8)	860 (3.8)	1,220 (5.4)	860 (3.8)
	1-3/4 (44.5)	1,450 (6.5)	870 (3.9)	1,455 (6.5)	870 (3.9)	1,460 (6.5)	990 (4.4)	1,730 (7.7)	990 (4.4)

Safe working loads for single installation under static loading should not exceed 25% of the ultimate load capacity.

Tapcon® Anchors Allowable Edge and Spacing Distances							
PARAMETER	ANCHOR DIA. In. (mm)	NORMAL WEIGHT CONCRETE			CONCRETE MASONRY UNITS (CMU)		
		FULL CAPACITY (Critical Distance Inches)	REDUCED CAPACITY (Minimal Distance Inches)	LOAD REDUCTION FACTOR	FULL CAPACITY (Critical Distance Inches)	REDUCED CAPACITY (Minimal Distance Inches)	LOAD REDUCTION FACTOR
Spacing Between Anchors - Tension	3/16	3	1-1/2	0.73	3	1-1/2	1.00
	1/4	4	2	0.66	4	2	0.84
Spacing Between Anchors - Shear	3/16	3	1-1/2	0.83	3	1-1/2	1.00
	1/4	4	2	0.82	4	2	0.81
Edge Distance - Tension	3/16	1-7/8	1	0.83	4	2	0.91
	1/4	2-1/2	1-1/4	0.82	4	2	0.88
Edge Distance - Shear	3/16	2-1/4	1-1/8	0.70	4	2	0.93
	1/4	3	1-1/2	0.59	4	2	0.80

Taken from RED HEAD Concrete Anchoring

Using Ø 3/16" Red Head Tapcon w/ 1-1/2" min. embedment, 3" min. spacing and 1-7/8" min. edge distance.

$$V_{allow.} = \frac{1090 \text{ lb}}{4} = 272.50 \text{ lb}$$

$$V_{conn.} = 200.00 \text{ lb} < 272.50 \text{ lb} \rightarrow \text{PASS}$$

Note: Load Reduction Factor are not applicable because we are complying with the full capacity spacing and edge distance.

7.2. End Bearing Connection to Concrete

7.2.1. Aluminum Tube Side

Checking for $V_{conn.} = P \times L / 2 = 50.00 \text{ plf} \times 12.83 \text{ ft} / 2 = 320.83 \text{ lb}$

Fastener Strengths^{1,2,3,4,5,6,7}

Description	Tension (lbf)			Shear (lbf)			Minimum Torsional Strength (in-lbs)
	Ultimate	ASD	LRFD	Ultimate	ASD	LRFD	
#10-16	2,275	760	1,140	1,460	485	730	61
#10-24	2,610	870	1,305	1,080	360	540	65
#12-14	3,215	1,070	1,610	1,990	665	995	92
#12-14 (PUFH)	2,150	715	1,075	1,980	660	990	92
#12-24	3,255	1,085	1,625	1,935	645	965	100
1/4"-14	4,360	1,455	2,180	2,690	895	1,345	150
1/4"-20	4,360	1,455	2,180	2,615	870	1,310	156
5/16"-18	7,220	2,405	3,610	4,565	1,520	2,285	425
5/16"-24	8,755	2,920	4,380	4,960	1,655	2,480	425

1. Ultimate strengths are based on laboratory tests.
2. Allowable (ASD) strengths are based on a safety factor Ω , of 3.0 in accordance with ICC-ES AC118 and AISI S100-16.
3. Design (LRFD) strengths are based on a resistance factor, ϕ , of 0.50 in accordance with ICC-ES AC118 and AISI S100-16.
4. For ASD tension connections, the lower of the ASD tension strength, ASD pull-out strength and ASD pull-over strength must be used for design.
5. For LRFD tension connections, the lower of the LRFD tension strength, LRFD pull-out strength and LRFD pull-over strength must be used for design.
6. For ASD shear connections, the lower of the ASD Shear (Bearing) Capacity and the ASD Fastener Shear Strength must be used for design.
7. For LRFD shear connections, the lower of the LRFD Shear (Bearing) Capacity and the LRFD Fastener Shear Strength must be used for design.

Allowable (ASD) Shear (Bearing) Capacity of Screw Connections in Aluminum, lbf^{1,2,3,4,5,6}

Screw Size	Head Styles	Point Type	6063-T5 ($F_y = 16 \text{ ksi}$, $F_u = 22 \text{ ksi}$)				6063-T6 ($F_y = 25 \text{ ksi}$, $F_u = 30 \text{ ksi}$)				6061-T6 ($F_y = 35 \text{ ksi}$, $F_u = 38 \text{ ksi}$)			
			1/16" - 1/16"	1/16" - 1/8"	1/8" - 1/8"	1/8" - 1/4"	1/16" - 1/16"	1/16" - 1/8"	1/8" - 1/8"	1/8" - 1/4"	1/16" - 1/16"	1/16" - 1/8"	1/8" - 1/8"	1/8" - 1/4"
#10-16	PPH	#2	130	130	260	-	180	180	355	-	225	225	450	-
#10-16	HWH	#3	130	130	260	-	180	180	355	-	225	225	450	-
#10-24	PWH	#3	160	-	-	-	205	-	-	-	205	-	-	-
#12-14	HWH	#2	150	150	295	-	205	205	405	-	255	255	515	-
#12-14	HWH	#3	150	150	295	-	205	205	405	-	255	255	515	-
#12-14	PUFH	#3	170	325	-	-	215	415	-	-	215	415	-	-
#12-24	HWH	#5	150	150	435	695	205	205	580	760	255	255	635	760
1/4"-14	HWH	#3	170	170	345	-	235	235	470	-	295	295	595	-
1/4"-20	HWH	#4	170	170	500	-	235	235	665	-	295	295	725	-
1/4"-20	HWH	#5	170	170	500	760	235	235	655	760	295	295	685	760
5/16"-18	HWH	#3	-	-	585 ^(B)	825 ^(B)	-	-	710 ^(B)	1,005 ^(B)	-	-	710 ^(B)	1,005 ^(B)
5/16"-24	HWH	#4	-	-	505 ^(B)	785 ^(B)	-	-	615 ^(B)	955 ^(B)	-	-	615 ^(B)	955 ^(B)

1. Allowable (ASD) strengths are based on a safety factor, $\Omega = 3.0$, determined in accordance with the Aluminum Design Manual, AA ADM-2020.
2. The first thickness listed is of the aluminum in contact with the screw head, the second thickness listed is of the aluminum not in contact with the screw head.
3. Unless otherwise noted, allowable strengths in shaded cells are applicable to screws which are self-drilled through both pieces of aluminum.
4. Allowable strengths in unshaded cells are applicable to screws which are self-drilled through both pieces of aluminum and to screws which are installed through existing holes in the aluminum in contact with the screw head and self-drilled into the receiving member. Clearance holes have the following dimensions: 0.177 inch for #8 screws; 0.201 inch for #10 screws; 0.228 inch for #12 screws; 0.266 inch for 1/4-inch screws.
5. Allowable Strengths are applicable to screws which are installed through existing holes ($D=21/64"$) in the aluminum in contact with the screw head and self-drilled into the receiving member.
6. For ASD shear connections, the lower of the ASD Shear (Bearing) Capacity and the ASD Fastener Shear Strength must be used for design.

Taken from Dewalt Anchors & Fasteners Catalog

Using #12-14 x 1" long. Undercut Flat Head Self-Drilling Structural Screws

$$V_{allow.} = \min. (660; 415) = 415.00 \text{ lb} > 320.83 \text{ lb} \rightarrow \text{PASS}$$

Note: The self-drilling screw evaluated in this section for the tube-to-concrete connection is also used for tube-to-tube connections (vertical tube to horizontal tube). The demand and governing failure modes for the tube-to-tube configuration are equal to or less critical than those considered herein. Therefore, the present calculation is deemed applicable, and no additional verification is required.

7.2.2. Concrete Beam Side

Checking for $V_{conn.} = P \times L / 2 = 50.00 \text{ plf} \times 12.83 \text{ ft} / 2 = 320.83 \text{ lb}$

Tapcon®		Ultimate Tension and Shear Values (Lbs/kN) in Concrete							
ANCHOR DIA. In. (mm)	MIN. DEPTH OF EMBEDMENT In. (mm)	$f'_c = 2000 \text{ PSI (13.8 MPa)}$		$f'_c = 3000 \text{ PSI (20.7 MPa)}$		$f'_c = 4000 \text{ PSI (27.6 MPa)}$		$f'_c = 5000 \text{ PSI (34.5 MPa)}$	
		TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)
1/4 (6.4)	1 (25.4)	750 (3.3)	900 (4.0)	775 (3.4)	900 (4.0)	800 (3.6)	1,360 (6.1)	950 (4.2)	1,440 (6.4)
	1-1/4 (31.8)	1,050 (4.7)	900 (4.0)	1,160 (5.2)	900 (4.0)	1,270 (5.6)	1,360 (6.1)	1,515 (6.7)	1,440 (6.4)
	1-1/2 (38.1)	1,380 (6.1)	1,200 (5.3)	1,600 (7.2)	1,200 (5.3)	1,820 (8.1)	1,380 (6.1)	2,170 (9.7)	1,670 (7.4)
	1-3/4 (44.5)	2,020 (9.0)	1,670 (7.4)	2,200 (9.8)	1,670 (7.4)	2,380 (10.6)	1,670 (7.4)	2,770 (12.3)	1,670 (7.4)

Safe working loads for single installation under static loading should not exceed 25% of the ultimate load capacity.

Tapcon® Anchors		Allowable Edge and Spacing Distances					
PARAMETER	ANCHOR DIA. In. (mm)	NORMAL WEIGHT CONCRETE			CONCRETE MASONRY UNITS (CMU)		
		FULL CAPACITY (Critical Distance Inches)	REDUCED CAPACITY (Minimal Distance Inches)	LOAD REDUCTION FACTOR	FULL CAPACITY (Critical Distance Inches)	REDUCED CAPACITY (Minimal Distance Inches)	LOAD REDUCTION FACTOR
Spacing Between Anchors - Tension	3/16	3	1-1/2	0.73	3	1-1/2	1.00
	1/4	4	2	0.66	4	2	0.84
Spacing Between Anchors - Shear	3/16	3	1-1/2	0.83	3	1-1/2	1.00
	1/4	4	2	0.82	4	2	0.81
Edge Distance - Tension	3/16	1-7/8	1	0.83	4	2	0.91
	1/4	2-1/2	1-1/4	0.82	4	2	0.88
Edge Distance - Shear	3/16	2-1/4	1-1/8	0.70	4	2	0.93
	1/4	3	1-1/2	0.59	4	2	0.80

Taken from RED HEAD Concrete Anchoring

Using Ø 1/4" Red Head Tapcon w/ 1-3/4" min. embedment, 4" min. spacing and 3" min. edge distance.

$$V_{allow.} = \frac{1670 \text{ lb}}{4} = 417.50 \text{ lb}$$

$$V_{conn.} = 320.83 \text{ lb} < 417.50 \text{ lb} \rightarrow \text{PASS}$$

Note: Load Reduction Factor are not applicable because we are complying with the full capacity spacing and edge distance.

8. HANDRAIL

Material:	Aluminum 6061-T6	
Fy=	35.00	ksi
Fb=	21.00	ksi
Fv=	12.60	ksi
Profile:	P 1-1/4 (Ø 1.66" sch 40)	
A=	0.669	in ²
Sx=	0.235	in ³
Sy=	0.235	in ³
W=	50	lb/ft
W=	4.167	lbs/in
P=	200	lbs
L=	48	in

Horizontal checking:

$$\begin{aligned}
 M_1 &= WxL^2/8 = 1.200 \text{ kips-in} \\
 M_2 &= PxL/4 = 2.400 \text{ kips-in} \\
 M &= 2.400 \text{ kips-in} \\
 f_d &= \frac{2.400}{0.235} = 10.213 \text{ ksi}
 \end{aligned}$$

$$\text{Stress} = 10.213 \text{ ksi} < 21.000 \text{ ksi}$$

$$\text{Ratio} = \frac{10.213}{21.000} = 0.49 < 1 \quad \text{PASS}$$

Vertical checking:

$$\begin{aligned}
 M_1 &= WxL^2/8 = 1.200 \text{ kips-in} \\
 M_2 &= PxL/4 = 2.400 \text{ kips-in} \\
 M &= 2.400 \text{ kips-in} \\
 f_d &= \frac{2.400}{0.235} = 10.213 \text{ ksi}
 \end{aligned}$$

$$\text{Stress} = 10.213 \text{ ksi} < 21.000 \text{ ksi}$$

$$\text{Ratio} = \frac{10.213}{21.000} = 0.49 < 1 \quad \text{PASS}$$

Use: P 1-1/4 (Ø 1.66" sch 40) Aluminum 6061-T6

8.1. Handrail Bracket Connection to Concrete Wall

Checking for $V_{conn.} = 200.00 \text{ lb}$

Tapcon® Anchors		Ultimate Tension and Shear Values (Lbs/kN) in Concrete							
ANCHOR DIA. In. (mm)	MIN. DEPTH OF EMBEDMENT In. (mm)	$f'c = 2000 \text{ PSI (13.8 MPa)}$		$f'c = 3000 \text{ PSI (20.7 MPa)}$		$f'c = 4000 \text{ PSI (27.6 MPa)}$		$f'c = 5000 \text{ PSI (34.5 MPa)}$	
		TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)	TENSION Lbs. (kN)	SHEAR Lbs. (kN)
3/16 (4.8)	1 (25.4)	600 (2.7)	720 (3.2)	625 (2.8)	720 (3.2)	650 (2.9)	720 (3.2)	800 (3.6)	860 (3.8)
	1-1/4 (31.8)	845 (3.7)	720 (3.2)	858 (3.8)	720 (3.2)	870 (3.9)	720 (3.2)	1,010 (4.5)	860 (3.8)
	1-1/2 (38.1)	1,090 (4.8)	860 (3.8)	1,090 (4.8)	860 (3.8)	1,090 (4.8)	860 (3.8)	1,220 (5.4)	860 (3.8)
	1-3/4 (44.5)	1,450 (6.5)	870 (3.9)	1,455 (6.5)	870 (3.9)	1,460 (6.5)	990 (4.4)	1,730 (7.7)	990 (4.4)

Safe working loads for single installation under static loading should not exceed 25% of the ultimate load capacity.

Tapcon® Anchors		Allowable Edge and Spacing Distances					
PARAMETER	ANCHOR DIA. In. (mm)	NORMAL WEIGHT CONCRETE			CONCRETE MASONRY UNITS (CMU)		
		FULL CAPACITY (Critical Distance Inches)	REDUCED CAPACITY (Minimal Distance Inches)	LOAD REDUCTION FACTOR	FULL CAPACITY (Critical Distance Inches)	REDUCED CAPACITY (Minimal Distance Inches)	LOAD REDUCTION FACTOR
Spacing Between Anchors - Tension	3/16	3	1-1/2	0.73	3	1-1/2	1.00
	1/4	4	2	0.66	4	2	0.84
Spacing Between Anchors - Shear	3/16	3	1-1/2	0.83	3	1-1/2	1.00
	1/4	4	2	0.82	4	2	0.81
Edge Distance - Tension	3/16	1-7/8	1	0.83	4	2	0.91
	1/4	2-1/2	1-1/4	0.82	4	2	0.88
Edge Distance - Shear	3/16	2-1/4	1-1/8	0.70	4	2	0.93
	1/4	3	1-1/2	0.59	4	2	0.80

Taken from RED HEAD Concrete Anchoring

Using Ø 3/16" Red Head Tapcon w/ 1-1/2" min. embedment, 3" min. spacing and 2-1/4" min. edge distance.

$$V_{allow.} = \frac{860 \text{ lb}}{4} = 215.00 \text{ lb}$$

$$V_{conn.} = 200.00 \text{ lb} < 215.00 \text{ lb} \rightarrow \text{PASS}$$

Note: Load Reduction Factor are not applicable because we are complying with the full capacity spacing and edge distance.