WAYPOINT ENGINEERING

STRUCTURAL CALCULATIONS

Stainless Cable Solutions Aluminum Railing

Prepared For:

Stainless Cable Solutions, LLC.

15806 SE 114th Ave
Clackamas, OR 97015

OREGON



DATE LOG

Date:	February 9, 2024
Revision(s):	

Scope of Work

Development and design for an aluminum cable railing system including:
Termination post, intermediate post, top rail, rail connecting blocks, cables, end cap, flat infill, base plate, stair railling, stair intermeadiate cap, and attachments.

General

The enclosed calculations were intended to be to designed and submitted in conformance with the following:

Professional Engineer Seals
- State of Washington
- State of Oregon
- State of California

Building Codes (Meets or Exceeds Requirements)
- 2024 International Building and Residential Codes
- Compliant with 2025 Oregon Structural Specialty Code and 2025 California Building Code

Additional Design References
- 2020 Aluminum Design Manual
- 2019 Building Code Requirements for Structural Concrete (ACI318-19)
- AISC Steel Construction Manual, 15th Edition
- 2018 National Design Specification for Wood Construction
- ICC Report AC273: Acceptance Criteria for Handrails and Guards

Materials

6061-T6, T6510, T6511 Extrusions	Tensile Ultimate Strength,	F_{tu} =	38 ksi
	Tensile Yield Strength,	F_{ty} =	35 ksi
	Compressive Yield Strength,	F_{cy} =	35 ksi
	Tensile Ultimate Strength at Weld Zone,	F_{tuw} =	24 ksi
A554 Stainless Steel Grade 304/304L	Yield Stress,	F_y =	30 ksi
	Tensile Stress,	F_u =	75 ksi
Stainless Steel 18-8 Self Tapping Screws	Yield Stress,	F_y =	20 ksi
	Tensile Stress,	F_u =	65 ksi
Type 316 Stainless Steel Wire Rope	1x19 Strand Core		
	1/8" dia. with breaking strength =		1869 lbs
	7x7 Strand Core		
	1/8" dia. with breaking strength =		1566 lbs
Weld Filler Material 4043	Tensile Ultimate Strength,	F_{tuw} =	24 ksi

Guardrail Loading Conditions

Uniform Load

Per 2021 IBC §1607.8.1, the uniform load shall be applied to the handrail in any direction. This loading is only applicable to commercial projects with public access and is not applicable to residential guardrails. The railing system covered in this package covers all commercial and residential, thus this loading condition shall apply. — p = 50 plf

Concentrated Load

Per IBC §1607.8.1.1, the concentrated load shall be applied to the handrail in any direction — P = 200 lbs

Per IBC §1607.8.1.2, components including intermediate rails, balusters, and cables shall be designed for a concentrated load applied normal and horizontally over an area of $1ft^2$. — P = 50 lbs

Per IBC §1015.4 and IRC §312.1.3 opening limitations shall not allow the passage of a sphere 4" in diameter through.

Part Numbers and Descriptions

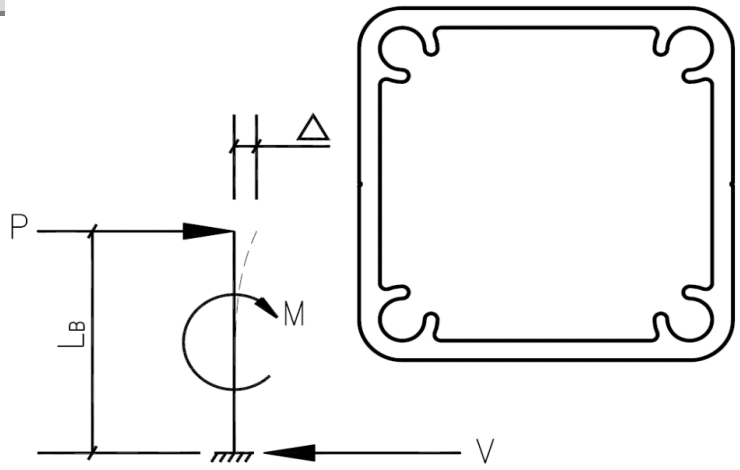
IP100 - SCS Extruded Aluminum Intermediate Posts	Page 4, 5
TR100 - SCS Extruded Aluminum Top Rail	Page 6, 7
FI200 - SCS Extruded Aluminum Flat Infill	
EC100 - SCS Top Rail End Cap	
BP100 - SCS Base Plate	Page 8, 9
SR200 - SCS Extruded Aluminum Stair Rail	Page 10, 11
RCB100 - SCS Stair Grab Rail Connecting Block	Page 12
Stainless Steel Wire Rope	Page 13
TP100 - SCS Extruded Aluminum Termination Posts	Page 14, 15
Post Spacing	Page 16
ISPA200 - SCS Stair Post Cap Assembly Intermediate Stair Post Adapter	Page 17, 18
Wood Top Rail	Page 19-21
Concrete anchorage	Page 22-28

Aluminum Cable Guardrail System Summary

Residential/ Commercial	Yes
Total Post/Handrail Height Including Base Plate	42 in
Maximum Post Spacing	4'-9" oc
Maximum Stair Rail Post Spacing	4'-9" oc
Cable Prestressing	255 lbs
Cable Spacing (On-Center)	3.125 in

Extruded Aluminum Post Input

Post Spacing, s =	4.75 ft
(See Page 3) Applied Load At Top, P =	200 lbs
Unbraced Length = 40 5/8", L_B =	40.63 in
Post Area, A_p =	1.146 in²
Modulus of Elasticity, E =	10100 ksi
Section Modulus, S =	0.744 in³
Plastic Section Modulus, Z =	0.848 in³
Moment of Inertia, I_{min} =	0.837 in⁴
Torsion Constant, J =	0.073 in
Clear Height of Shear Area, h =	2.250 in
Thickness of Shear Area, t =	0.125 in
C_b =	1.3
k_t =	1.0



Flexural Yielding and Rupture 6061-T6 (ADM 2020 Section F.2)

yielding moment strength, Mnp =	29.67 kip-in	
rupture moment strength, Mnu =	32.21 kip-in	
all other limit states, Ω_b =	1.65	
rupture limit state, Ω_b =	1.95	
Allowable Moment, M_{nmb}/Ω_b =	**16.52 kip-in**	
Applied Moment, P*L_B = $M_{applied}$ =	**8.13 kip-in**	**OK**

Flexural Local Buckling 6061-T6 (ADM 2020 Section F.3)

Slenderness, λ =	16.0	
Slenderness, λeq =	25.6	
Fe =	152.0 ksi	element supported on both edges, Table B.5.1
Allowable Stress, λeq≤λ1 =	24.2 ksi	◄ Controls
Slenderness Limit, λ1 =	33.5	
Allowable Stress, λ1<λeq<λ2 =	-169.4 ksi	
Slenderness Limit, λ2 =	61.0	
Allowable Stress, λeq≥λ2 =	32.6 ksi	
Allowable Bending Stress, F_b/Ω =	24.2 ksi	
Allowable Moment, S*Fb/Ω = M_{allow} =	**17.98 kip-in**	
Applied Moment, P*L_B = $M_{applied}$ =	**8.13 kip-in**	**OK**

Flexural Lateral Torsional Buckling 6061-T6 (ADM 2020 Section F.4)

Slenderness, λ =	22.3	for closed shape member, F.4.2.3
inelastic buckling, M_{nmb} =	19.86 ksi	◄ Controls
elastic buckling, M_{nmb} =	148.92 ksi	
Ω_b =	1.65	
Allowable Moment, M_{nmb}/Ω_b =	**12.03 kip-in**	
Applied Moment, P*L_B = $M_{applied}$ =	**8.13 kip-in**	**OK**

Deflection Check, ΔMAX = L_B/12 (ICC Report AC273)

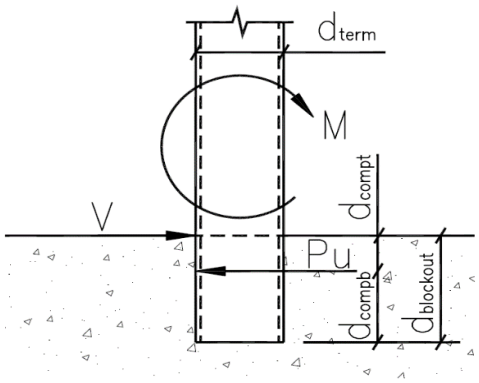
Allowable Deflection, Δ_{allow} =	3.385 in	
Applied Deflection, $PL_B^3/3EI = \Delta_{applied}$ =	0.529 in	**OK**

Shear in Elements, Gross Section 6061-T6 (ADM 2020 Table Section G.2)

Allowable Stress, λ≤λ1 =	12.7 ksi	
Slenderness Limit, λ1 =	35.3	
Allowable Stress, λ1<λ<λ2 =	14.8 ksi	
Slenderness Limit, λ2 =	63.0	
Allowable Stress, λ≥λ2 =	151.0 ksi	
Allowable Shear Stress, F_s/Ω =	13 ksi	
Allowable Shear, Ap*F_s/Ω = V_{allow} =	**14.557 kips**	
Applied Shear, P = $V_{applied}$ =	**0.200 kips**	**OK**

Core Mounted Posts Bearing Check

Existing Concrete Strength, f'_c =	2500 psi	
$V_{applied}$ =	0.200 kips	*(See Page 4)*
$M_{applied\ from\ post}$ =	8.125 kip-in	*(See Page 4)*
$M_{applied\ from\ shear}$ =	0.600 kip-in	
M_{total} =	8.725 kip-in	
Depth of Concrete Blockout, $d_{blockout}$ =	3.000 in	
Dist Bottom of Blockout to Applied P_u, d_{compb} =	2.000 in	
Dist from Applied P_u to Top of Concrete, d_{compt} =	1.000 in	
Width of Post, d_{term} =	2.250 in	
Loaded Area, A_1 =	2.250 in²	
Area of the Lower Base of Largest Fulcrum, A_2 =	6.500 in²	
Compression Load at Blockout, P_u =	4.363 kips	
Strength Reduction Factor, Ø =	0.65	*(Per ACI 318-16 §21.2)*
Concrete Bearing Strength, f_b =	5282 psi	*(Per ACI 318-16 §22.8)*
Maximum Applied Compression Load, f_{bmax} =	**1939 psi**	**OK < 5282 psi**



Core Mounted Posts Edge Distance Check

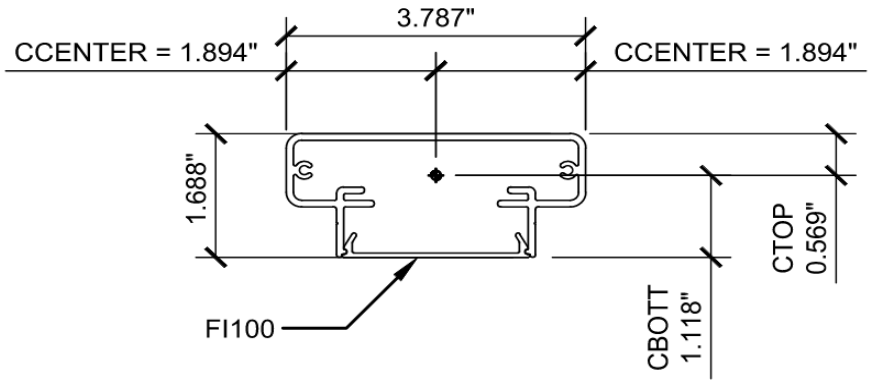
Distance from Center of Post to Edge of Concrete, c_{a1} =	6.750 in	
Distance from Post Face to Edge of Concrete, c_{post} =	4.500 in	
Thickness of Concrete, h_{a1} =	4.000 in	
Projected Concrete Failure Area, A_{Vco} =	205.031 in²	*(Per ACI 318-16 §17.5.2.1)*
Projected Concrete Failure Area, A_{Vc} =	90.000 in²	*(Per ACI 318-16 §17.5.2.1)*
Shear Strength Modification Factor, $\psi_{ed,V}$ =	1.00	*(Per ACI 318-16 §17.5.2.6)*
Cracked Concrete Modification Factor, $\psi_{c,V}$ =	1.00	*(Per ACI 318-16 §17.5.2.7)*
Cracked Concrete Modification Factor, $\psi_{h,V}$ =	1.59	*(Per ACI 318-16 §17.5.2.8)*
Lightweight Concrete Factor, λ =	1.00	*(Per ACI 318-16 §19.2.4.2)*
Basic Concrete Breakout Strength, V_b =	9.752 kips	*(Per ACI 318-16 §17.5.2.2)*
Nominal Concrete Breakout Strength, V_{cb} =	6.811 kips	*(Per ACI 318-16 §17.5.2.1)*
Max Nominal Concrete Breakout Strength, V_{max} =	**6.811 kips**	**OK < 4.3625 kips**

Use 4,000psi Non-Shrink Grout in Min 3"SQx4"Deep Blockout or 3" Diax4"Deep Hole with 4 ½" Min Edge Distance (No Rebar) or 1 ¼" Min Edge Distance when #3 or Larger Slab Edge Rebar Present

Check Top Connection

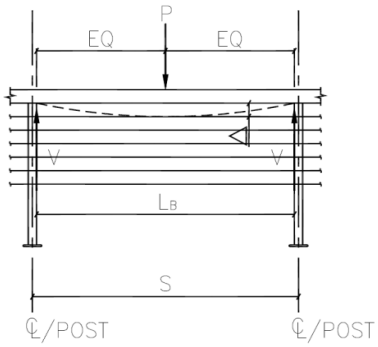
Note: Lateral loads on top rail bears directly on post side. Only uplift loads affecting attachment are considered.

Diameter of Screw, d_{screw} =	0.194 in	
Thickness of Post, t_{post} =	0.125 in	
Area of Engaged Post in Shear, A_{Vpost} =	0.024 in²	
Number of Screws in Shear =	2	
Factor of Safety on Screw Connections, n_s =	3.00	
Tensile Ultimate Strength of Member Not in Contact with Screw Head, F_{tu2} =	38 ksi	
Shear Strength of Screw, V_{screw} =	**0.614 kips**	**OK > 0.250 kips**

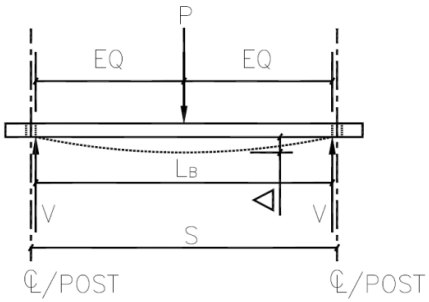


Extruded Aluminum Rail Input

Post Spacing, s =	4.75 ft	Left/Right to Centroid, c_{center} =	1.895 in
(See Page 4) Applied Load At Top, P =	200 lbs	Section Modulus Top, S_{xx} =	0.373 in³
Unbraced Length, L_B = 5'-0" x 12" - 2.25" =	54.750 in	Section Modulus Bottom, S_{xx} =	0.190 in³
Compressive Modulus of Elasticity, E =	10100 ksi	Section Modulus Top, Z_{xx} =	0.560 in³
Rail Area, A_r =	0.928 in²	Section Modulus Bottom, Z_{xx} =	0.285 in³
Moment of Inertia x, I_{xx} =	0.212 in⁴	Section Modulus , S_{yy} =	0.879 in³
Moment of Inertia y, I_{yy} =	1.664 in⁴	Torsion Constant, J =	0.005 in
Top of Member to Centroid, c_{top} =	0.569 in	Clear Height of Shear Area, h =	1.643 in
Bottom of Member to Centroid, c_{bott} =	1.118 in	Thickness of Shear Area, t =	0.090 in
C_b =	1.31		
k_t =	1.0		



Vertical Loading Diagram



Horizontal Loading Diagram

Flexural Yielding and Rupture 6061-T6 (ADM 2020 Section F.2)

yielding moment strength, Mnp =	9.97 kip-in	
rupture moment strength, Mnu =	10.83 kip-in	
all other limit states, Ω_b =	1.65	
rupture limit state, Ω_b =	1.95	
Allowable Moment, M_{nmb}/Ω_b =	**5.55 kip-in**	
Applied Moment, P*s/4 = $M_{applied}$ =	**0.24 kip-in**	**OK**

Flexural Local Buckling 6061-T6 (ADM 2020 Section F.3)

λ =	10.69	
Slenderness, λeq =	17.1	
Fe =	341 ksi	element supported on both edges, Table B.5.1
Allowable Stress, λ≤λ1 =	31.8 ksi	◄ Controls
Slenderness Limit, λ1 =	33.5	
Allowable Stress, λ1<λ<λ2 =	-215.9 ksi	
Slenderness Limit, λ2 =	61.0	
Allowable Stress, λ≥λ2 =	48.8 ksi	
Allowable Bending Stress, Fb/Ω =	31.8 ksi	
Allowable Moment, S*Fb/Ω = Mallow =	**6.04 kip-in**	
Applied Moment, P*s/4 = Mapplied =	**0.24 kip-in**	**OK**

Flexural Lateral Torsional Buckling 6061-T6 (ADM 2020 Section F.4)

d_{top}=	3.787 in	
t_{top} =	0.090 in	
Area of top element =	0.340 in³	
d_{side}=	1.138 in	
t_{side} =	0.090 in	
Area of side element =	0.102 in³	
Slenderness, λ =	31.3	any shape F4.2.5
Me =	19.34 kip-in	
U =	0.49	
go =	0.000 in	
C1 =	0.50	
C2 =	0.50	
Bx =	-1.94	
Shear Center, yo =	1.12	
inelastic buckling, M_{nmb} =	5.35 ksi	◄ Controls
elastic buckling, M_{nmb} =	34.63 ksi	
Ω_b =	1.65	
Allowable Moment, M_{nmb}/Ω_b =	**3.24 kip-in**	
Applied Moment, P*s/4 = Mapplied =	**0.24 kip-in**	**OK**

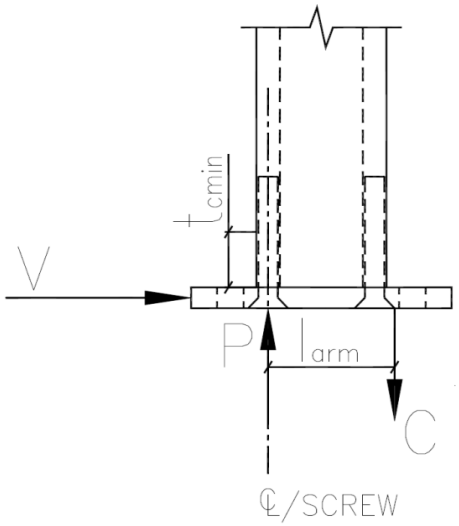
Deflection Check, ΔMAX = LB/12 (ICC Report AC273)

Allowable Deflection, ΔALLOW =	4.563 in	
Applied Deflection, $PL_B^3/48EI$ = ΔAPPLIED =	0.319 in	**OK**

Shear in Elements, Gross Section 6061-T6 (ADM 2020 Table Section G.2)

Slenderness, λ =	10.69	
Allowable Stress, λ≤λ1 =	12.7 ksi	◄ Controls
Slenderness Limit, λ1 =	35.3 in³	
Allowable Stress, λ1<λ<λ2 =	15.357 ksi	
Slenderness Limit, λ2 =	63 in³	
Allowable Stress, λ≥λ2 =	338.650 ksi	
Allowable Shear Stress, Fs/Ω =	12.7 ksi	
Allowable Shear, Ap*Fs/Ω = Vallow =	**11.780 kips**	
Applied Shear, P = Vapplied =	**0.200 kips**	**OK**

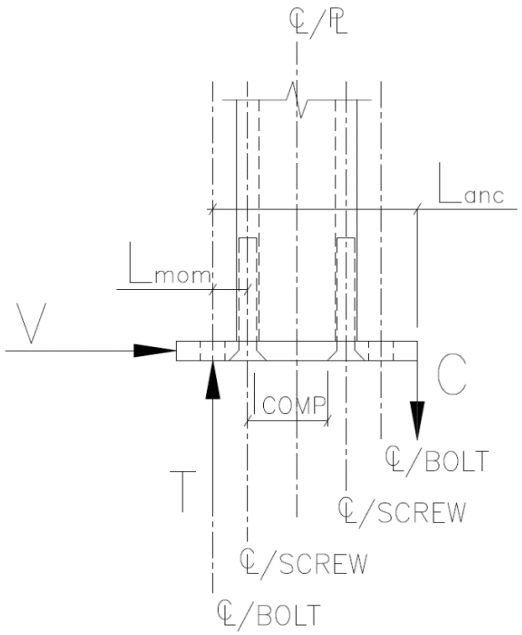
Tension Capacity of Screw (ADM 2020 Section J5.4, AISC DG 27)



$M_{APPLIED}$ =	8.125 kip-in	
	(Page 4)	
Number of Screws in Tension =	2	
Resisting Moment Arm, Center of Screw to Compression Face, larm =	2.000 in	
Tension Applied, Papplied =	**2.0313 kips**	
Thread Stripping Area of Internal Thread Per Inch, Asn =	0.663 in²	
Depth of Full Thread Engagement into tube, Le =	1.000 in	
Tensile Ult Strength of Member Not in Contact with Screw Head, Ftu2 =	38 ksi	
Nominal Pull-Out Strength, Rn =	**14.613 kips**	
	(Eq. J.5-3)	
Thickness of Member in Contact with Screw Head, t1 =	0.375 in	
Tensile Yield Strength of Member in Contact with Screw Head, Fty1 =	35 ksi	
Nominal Screw Head Diameter Abs Min, D =	0.568 in	
t1/D =	0.66	<1.1
Nominal Pull-Over Strength, Rn =	**9.150 kips**	
	(Eq. J5-11)	
Tensile Strength of Screw, Fnt =	56 ksi	Stainless Steel
Tensile Stress Area of Screw, As =	0.077 in²	
Nominal Tensile Strength of a Screw, Rn =	**4.312 kips**	*(Eq. AISC DG 27 Eq. J3-1)*
Ω, Aluminum =	3.00	
Ω, Steel =	2.00	
Pull-Out Strength, Rn/Ω =	**4.871 kips**	**OK > 2.03125 kips**
Pull-Over Strength, Rn/Ω =	**3.050 kips**	**OK > 2.03125 kips**
Tensile Strength, Rn/Ω =	**2.156 kips**	**OK > 2.03125 kips**

Shear Capacity of Screw (ADM 2020 J5.5, AISC DG 27)

$V_{APPLIED}$ =	3.515 kips	
Number of Screws in Shear =	4	
Shear Applied, Vapplied =	**0.879 kips**	**Per Screw**
diameter of screw, d =	0.313 in	
Tensile Ultimate Strength of Member in Contact with Screw Head, Ftu =	38 ksi	Note: 1/2 of depth subtracted from t1
dist from screw center to edge of connected part, de =	0.500 in	as screw is countersunk
thickness of connected part, t =	0.375 in	
Screw Bearing Strength, Rn =	**3.563 kips**	*(Eq. J.5-13)*
Shear Strength of Screw, Fnv =	34 ksi	Stainless Steel
Shear Stress Area of Screw, As =	0.077 in²	
Nominal Shear Strength of a Screw, Rn =	**2.587 kips**	*(Eq. AISC DG 27 Eq. J3-1)*
Ω, Aluminum =	3.00	
Ω, Steel =	2.00	
Bearing Strength, Rn /Ω =	**1.188 kips**	**OK > 0.87875 kips**
Shear Strength, Rn /Ω =	**1.294 kips**	**OK > 0.87875 kips**



Base Plate Anchorage (Lag Screws) Per 2018 National Design Specification for Wood Construction

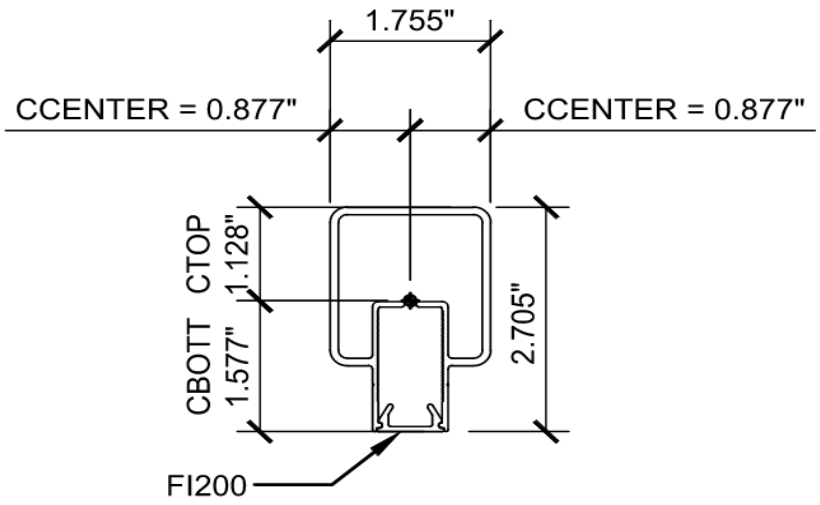
Applied Moment at TP100, $M_{applied}$ =	8.125 kip-in	*(Page 4)*
Edge of Baseplate to Centerline of Tension Anchorage, l_{anc} =	4.360 in	
Number of Screws in Tension =	2	
Applied Tension at Anchor Bolt/Screw, $T_{applied}$ =	**0.932 kips**	
$V_{applied}$ =	0.200 kips	*(Page 4)*
Number of Screws in Shear =	4	
Shear Applied, $V_{applied}$ =	**0.050 kips**	**Per Screw**
Lag Screw Ref Withdrawl Design Value (G=0.46, D=3/8"), W =	214 lbs	*(Per Simpson Strong-Tie)*
Penetration Depth, d =	4.500 in	
Allowable Lag Screw Tension, $T_{allowable}$ =	**1.541 kips**	**OK > 0.932 kips**
Lag Screw Reference Lateral Design Value (G=0.46, D=3/8"), Z =	405 lbs	*(Per Simpson Strong-Tie)*
Allowable Lag Screw Shear, $V_{allowable}$ =	**0.405 kips**	**OK > 0.05 kips**

Use (4) Simpson 0.220" Dia x 6" SDWS Timber Screw with 6" Min Penetration into Min (1) 6x6 or (2) 3x6 Hem-Fir #2 (1.5" Min Edge Distance)

Base Plate Anchorage (Thru-Bolts) Per 2018 National Design Specification for Wood Construction

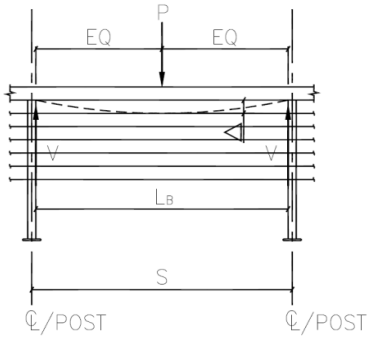
Bolt diameter =	0.375 in	
Diameter of washer =	2.500 in	
Area of Bearing under washer =	4.758 in²	
Washer bearing, $F_{c\ perp}$ =	521 psi	*(Per Table 4A)*
Allowable Thru-Bolt Tension, $T_{allowable}$ =	**2.209 kips**	**OK > 0.932 kips**
Lag Screw Reference Lateral Design Value (G=0.46, D=3/8"), Z =	405 lbs	(No Thru-Bolt Values < 1/2" In NDS - Use Table 11K)
Allowable Thru-Bolt Shear, $V_{allowable}$ =	**0.405 kips**	**OK > 0.05 kips**

Use (4) ⅜" Dia SS304 Thru-Bolts with Min 2" Dia Heavy Washer into Min (1) 6x or (2) 3x Hem-Fir #2

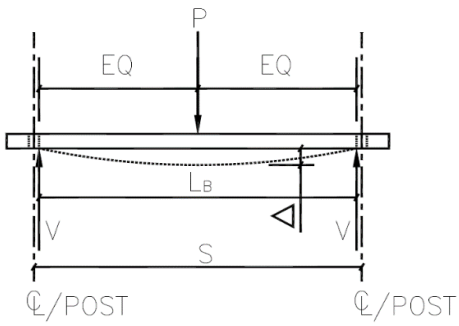


Extruded Aluminum Stair Rail Input

Post Spacing, s =	4.75 ft	Left/Right to Centroid, c_{center} =	0.878 in
Applied Load At Top, P =	200 lbs	Section Modulus Top, S_{xx} =	0.414 in³
Unbraced Length, L_B = 6'x12"-2.25" =	54.750 in	Section Modulus Bottom, S_{xx} =	0.296 in³
Compressive Modulus of Elasticity, E =	10100 ksi	Section Modulus Top, Z_{xx} =	0.621 in³
Rail Area, A_r =	0.761 in²	Section Modulus Bottom, Z_{xx} =	0.444 in³
Moment of Inertia x, I_{xx} =	0.467 in⁴	Section Modulus , S_{yy} =	0.350 in³
Moment of Inertia y, I_{yy} =	0.307 in⁴	Torsion Constant, J =	0.005 in
Top of Member to Centroid, c_{top} =	1.128 in	Clear Height of Shear Area, h =	2.660 in
Bottom of Member to Centroid, c_{bott} =	1.577 in	Thickness of Shear Area, t =	0.090 in
C_b =	1.0		
k_t =	1.0		



Vertical Loading Diagram



Horizontal Loading Diagram

Flexural Yielding and Rupture 6061-T6 (ADM 2020 Section F.2)

yielding moment strength, Mnp =	15.55 kip-in	
rupture moment strength, Mnu =	16.88 kip-in	
all other limit states, Ω_b =	1.65	
rupture limit state, Ω_b =	1.95	
Allowable Moment, M_{nmb}/Ω_b =	**8.66 kip-in**	
Applied Moment, P*s/4 = Mapplied =	**0.24 kip-in**	**OK**

Flexural Local Buckling 6061-T6 (ADM 2020 Section F.3)

Slenderness, λ =	19.53	
Slenderness, λeq =	31.3	
Fe =	102 ksi	element supported on both edges, Table B.5.1
Allowable Stress, $\lambda \le \lambda_1$ =	31.8 ksi	◄ Controls
Slenderness Limit, λ_1 =	33.5	
Allowable Stress, $\lambda_1 < \lambda < \lambda_2$ =	-436.7 ksi	
Slenderness Limit, λ_2 =	61.0	
Allowable Stress, $\lambda \ge \lambda_2$ =	26.7 ksi	
Allowable Bending Stress, F_b/Ω =	31.8 ksi	
Allowable Moment, $S*F_b/\Omega = M_{allow}$ =	**9.42 kip-in**	
Applied Moment, $P*s/4 = M_{applied}$ =	**0.24 kip-in**	**OK**

Flexural Lateral Torsional Buckling 6061-T6 (ADM 2020 Section F.4)

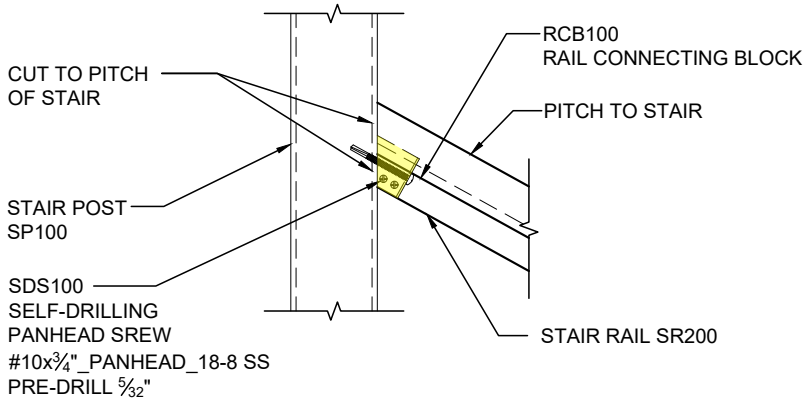
d_{top}=	3.787 in	
t_{top} =	0.090 in	
Area of top element =	0.340 in³	
d_{side}=	1.138 in	
t_{side} =	0.090 in	
Area of side element =	0.102 in³	
Slenderness, λ =	34.1	any shape F4.2.5
Me =	25.43 kip-in	
U =	0.53	
go =	0.000 in	
C1 =	0.50	
C2 =	0.50	
Bx =	-2.11	
Shear Center, yo =	1.58	
inelastic buckling, M_{nmb} =	7.61 ksi	◄ Controls
elastic buckling, M_{nmb} =	29.22 ksi	
Ω_b =	1.65	
Allowable Moment, M_{nmb}/Ω_b =	**4.61 kip-in**	
Applied Moment, $P*s/4 = M_{applied}$ =	**0.24 kip-in**	**OK**

Deflection Check, $\Delta_{MAX} = L_B/12$ (ICC Report AC273)

Allowable Deflection, Δ_{ALLOW} =	4.563 in	
Applied Deflection, $PL_B^3/48EI = \Delta_{APPLIED}$ =	0.145 in	**OK**

Shear in Elements, Gross Section 6061-T6 (ADM 2020 Table Section G.2)

Slenderness, λ =	19.53	
Allowable Stress, $\lambda \le \lambda_1$ =	12.7 ksi	◄ Controls
Slenderness Limit, λ_1 =	35.3 in³	
Allowable Stress, $\lambda_1 < \lambda < \lambda_2$ =	14.410 ksi	
Slenderness Limit, λ_2 =	63 in³	
Allowable Stress, $\lambda \ge \lambda_2$ =	101.330 ksi	
Allowable Shear Stress, F_s/Ω =	12.7 ksi	
Allowable Shear, $Ap*F_s/\Omega = V_{allow}$ =	**9.665 kips**	
Applied Shear, $P = V_{applied}$ =	**0.200 kips**	**OK**



Tension Capacity of Screw (ADM 2020 Section J5.4, AISC DG 27) SDS100

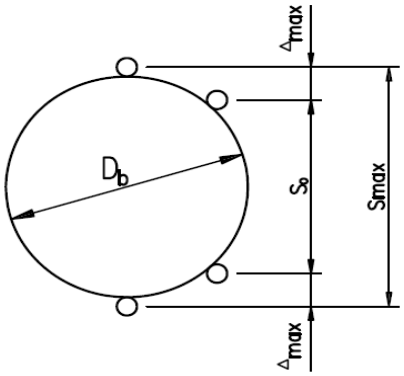
Note: Uses (2) #10_3/4" Phillips Pan Head Sheet Metal Screws - Type A, 18-8 Stainless Steel

Tension Load =	0.200 kips	*(Page 4)*
Screw Diamter, d =	0.138 in	
Number of Screws =	2	
Screw Tension Load =	**0.100 kips**	*(Page 4)*
Thread Stripping Area of Internal Thread Per Inch, A_{sn} =	0.401 in²	*(Table5-6)*
Depth of Full Thread Engagement into tube, L_e =	0.500 in	
Tensile Ult Strength of Member Not in Contact with Screw Head, F_{tu2} =	38 ksi	
Nominal Pull-Out Strength, R_n =	**4.419 kips**	*(Eq. J.5-3)*
Thickness of Member in Contact with Screw Head, t_1 =	0.050 in	
Tensile Yield Strength of Member in Contact with Screw Head, F_{ty1} =	35 ksi	
Nominal Screw Head Diameter Abs Min, D =	0.376 in	
t_1/D =	0.13	<1.1
Nominal Pull-Over Strength, Rn =	**0.305 kips**	*(Eq. J5-11)*
Tensile Strength of Screw, F_{nt} =	49 ksi	18-8 Stainless Steel
Tensile Stress Area of Screw, A_s =	0.015 in²	
ısile Strength of a Screw, Rn =	**0.729 kips**	*(Eq. AISC DG 27 Eq. J3-1)*
Ω, Aluminum =	3.00	
Ω, Steel =	2.00	
Pull-Out Strength, Rn/Ω =	**1.473 kips**	**OK > 0.1 kips**
Pull-Over Strength, Rn/Ω =	**0.102 kips**	**OK > 0.1 kips**
Tensile Strength, R_n/Ω =	**0.364 kips**	**OK > 0.1 kips**

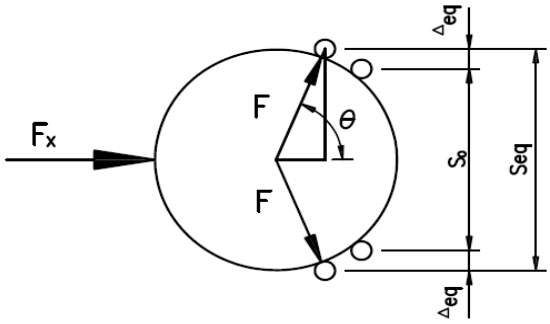
Screw Capacity of Screw (ADM 2020 Section J5.5, AISC DG 27) RCB200

Note: Uses (1) #6 x 1 1/2 Phillips Pan Head Screws - Type A, 18-8 Stainless Steel

Shear Load =	0.200 kips	*(Page 4)*
Number of Screws in Shear =	1	
Screw Shear Load =	**0.200 kips**	
Tensile Ultimate Strength of Member in Contact with Screw Head, F_{tu} =	38 ksi	
dist from screw center to edge of connected part, de =	0.500 in	
thickness of connected part, t =	0.125 in	
Screw Bearing Strength, Rn =	**1.311 kips**	*(Eq. J.5-13)*
Shear Strength of Screw, F_{nv} =	29 ksi	18-8 Stainless Steel
Screw Diamter, d =	0.138 in	
Shear Stress Area of Screw, A_s =	0.015 in²	
Nominal Shear Strength of a Screw, Rn =	**0.437 kips**	*(Eq. AISC DG 27 Eq. J3-1)*
Ω, Aluminum =	3.00	
Ω, Steel =	2.00	
Bearing Strength, R_n /Ω =	**0.437 kips**	**OK > 0.2 kips**
Shear Strength, R_n /Ω =	**0.219 kips**	**OK > 0.2 kips**



Initial and Pass–Through Conditions



Conditions at Equilibrium

Check Cable Deflection

Note: A min load of 50psf shall be applied to a 4" sphere. Spacing and deflection of the cables shall not allow the sphere to pass through.

Diameter of Cable, D =	0.125 in	
Intermediate Post Spacing, L =	4.75 ft	
Prestress Force, F_{ps} =	255 ft	
Sphere Diameter, D_b =	4.000 in	
Initial Cable Spacing, S_o =	3.125 in	
Termination Post Spacing, L_T =	30 ft	
Load Applied to Sphere, w_{sphere} =	50.0 psf	
Projected Area of Sphere, A_{sphere} =	12.566 in²	
Impact Factor, I_f =	2.00	
Force Applied to Sphere, $F_{xsphere}$ =	8.727 lbs	
Spread at Pass-Thru = D_b+D_{cable}, S_{max} =	4.125 in	
Final Cable Spacing, $S_{final} = S_{eq}$ =	4.124 in	
Deflection at Pass-Thru = $(S_{max}-S_o)/2$, Δ'_{max} =	0.500 in	
Deflection, $\Delta = \Delta_{eq}$ =	0.500	
Applied Angle = $\sin((S_o+2\Delta)/(D_b+D))$, θ =	88.7 °	
Force Applied to Cable, T = F =	198.171 lbs	
Maximum Cable Deflection = $(D_b+D-S_o)/2$, Δ_{max} =	0.500 in	
Modulous of Elasticity, E =	29000 ksi	
Moment of Inertia, I =	0.00001198 in⁴	
Cross Sectional Area, A =	0.012 in²	
Extensible, Flexible Cable, P_{ef} =	0.303 lbs	
Flexural Bending, P_b =	0.045 lbs	
Prestressing, P_{ps} =	8.938 lbs	
Force in Cable Resisting Sphere, $F_{xcable} = P$ =	9.287 lbs	**OK**
1/8" Diameter 1x19 Strand Core Breaking Strength =	1869 lbs	
1/8" Diameter 7x7 Strand Core Breaking Strength =	1566 lbs	**◄ Controls (OK < 310lbs)**

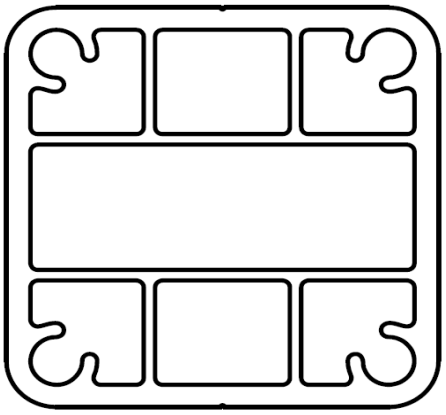
$$P_{ef} = \frac{4\Delta EA}{L} \times \frac{\sqrt{4\Delta^2 + L^2} - L}{\sqrt{4\Delta^2 + L^2} + L_T - L}$$

$$P_b = \frac{48EI\Delta}{L^3}$$

$$P_{ps} = \frac{4F_{ps}\Delta}{L}$$

Extruded Aluminum Termination Post Input

Post Spacing, s =	4'-9" oc	
Prestress Force, F_{ps} =	255 lbs	*(Page 11)*
Initial Cable Spacing, S_o =	3.125 in	
Unbraced Length = 40 5/8", L_B =	40.63 in	
Distributed Load, w =	81.6 lb/in	
Post Area, A_p =	1.529 in²	
Modulus of Elasticity, E =	10100 ksi	
Section Modulus, S =	0.847 in³	
Approx. Plastic Section Modulus, Z =	1.032 in³	
Moment of Inertia, I =	0.953 in⁴	
Approx. Torsion Constant, J =	0.143 in	
Clear Height of Shear Area, h =	2.250 in	
Thickness of Shear Area, t =	0.125 in	
C_b =	2.1	
k_t =	1.0	
Shear Load from Point Load, $V_{applied}$ =	200 lbs	*(Page 4)*
Shear Load from Cable Prestress, $V_{applied}$ =	3315 lbs	
Shear from Point Load and Cable, V_{tot} =	3515 lbs	
Moment From Point Load, M_{pnt} *=	8.125 kip-in	
Moment From Cable Prestress, M_{pstr} *=	16.834 kip-in	◄ Controls



*At end post, applied moments do not occur at same location along length of cross section (i.e. base vs mid point), therefore max moment will govern design. At corner post, field test for bi-directional bending due to 90° cable turn.

Flexural Yielding and Rupture 6061-T6 (ADM 2020 Section F.2)

Tensile Rupture Capacity, Ftu =	38.0 ksi			
Tensile Yield Capacity, Fty =	35.0 ksi			
Compression Yield Capacity, Fcy =	35.0 ksi			
yielding moment strength, Mnp =	36.13 kip-in			
rupture moment strength, Mnu =	39.23 kip-in			
all other limit states, Ω_b =	1.65			
rupture limit state, Ω_b =	1.95			
Allowable Moment, M_{nmb}/Ω_b =	**20.12 kip-in**			
Applied Moment, M =	**16.834 kip-in**	**OK**	DCR =	0.84

Flexural Local Buckling 6061-T6 (ADM 2020 Section F.3)

Slenderness, λ =	6.10			
Slenderness, λeq =	9.8			
Fe =	1046.8 ksi	element supported on both edges, Table B.5.1		
Allowable Stress, λeq≤λ1 =	23.0 ksi	◄ Controls		
Slenderness Limit, λ1 =	33.3			
Allowable Stress, λ1<λeq<λ2 =	-56.5 ksi			
Slenderness Limit, λ2 =	61.0			
Allowable Stress, λeq≥λ2 =	85.5 ksi			
Allowable Bending Stress, $F_{b/\Omega}$ =	23.0 ksi			
Allowable Moment, S*Fb/Ω = Mallow =	**19.46 kip-in**			
Applied Moment, M =	**16.834 kip-in**	**OK**	DCR =	0.86

Flexural Lateral Torsional Buckling 6061-T6 (ADM 2020 Section F.4)

Slenderness, λ =	15.4	for closed shape member, F.4.2.3		
inelastic buckling, M_{nmb} =	27.98 ksi	◄ Controls		
elastic buckling, M_{nmb} =	357.39 ksi			
Ω_b =	1.65			
Allowable Moment, M_{nmb}/Ω_b =	**16.96 kip-in**			
Applied Moment, M =	**16.834 kip-in**	**OK**	DCR =	0.99

Deflection Check, $\Delta_{MAX} = L_B/12$ (ICC Report AC273)

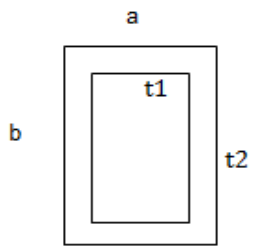
Allowable Deflection, Δ_{allow} =	3.385 in	
Applied Deflection, $PL_B^3/3EI = \Delta_{applied}$ =	0.592 in	**OK**

Shear in Elements, Gross Section 6061-T6 (ADM 2020 Table Section G.2)

Allowable Stress, $\lambda \leq \lambda_1$ =	12.7 ksi	◄ Controls
Slenderness Limit, λ_1 =	35.3	
Allowable Stress, $\lambda_1 < \lambda < \lambda_2$ =	15.8 ksi	
Slenderness Limit, λ_2 =	63.0	
Allowable Stress, $\lambda \geq \lambda_2$ =	1040.5 ksi	
Allowable Shear Stress, F_s/Ω =	13 ksi	
Allowable Shear, $A_p * F_s/\Omega = V_{allow}$ =	**19.418 kips**	
Applied Shear, V_{tot} =	**3.515 kips**	**OK**

Extruded Aluminum Stair Handrail Connection Input

Post Spacing, s =	4.75 ft	*(4' 9")*	t1 =	0.125 in
Force, F =	200 lbs	*(Page 4)*	t2 =	0.125 in
Moment Arm =	2.750 in		a =	0.625 in
Initial Cable Spacing, So =	0.000 in		b =	1.750 in
Unbraced Length, LB =	1.600 in		J =	0.096 in⁴
Post Area, Ap =	0.531 in²		Sx =	0.178 in³
Compressive Modulus of Elasticity, E =	10100 ksi		Sy =	0.079 in³
Compression Section Modulus, Sy =	0.079 in³		Ix =	0.100 in⁴
Compression Section Modulus, Zy =	0.118 in³		Iy =	0.019 in⁴
Moment of Inertia, Iy =	0.019 in⁴		Area =	0.531 in²
Torsion Constant, J =	0.096 in⁴		wall/thick =	13.000
Moment From Railing, M =	0.550 kip-in			
C_b =	1.3			
k_t =	1.0			



Flexural Yielding and Rupture 6061-T6 (ADM 2020 Section F.2)

yielding moment strength, Mnp =	4.14 kip-in	
rupture moment strength, Mnu =	4.49 kip-in	
all other limit states, Ω_b =	1.65	
rupture limit state, Ω_b =	1.95	
Allowable Moment, M_{nmb}/Ω_b =	**2.30 kip-in**	
Applied Moment, Mapplied =	**0.55 kip-in**	**OK**

Flexural Local Buckling 6061-T6 (ADM 2020 Section F.3)

Slenderness, λ =	12.00	
Slenderness, λeq =	19.2	
Fe =	270.1 ksi	element supported on both edges, Table B.5.1
Allowable Stress, λ≤λ1 =	31.8 ksi	◄ Controls
Slenderness Limit, λ1 =	45.1	
Allowable Stress, λ1<λ<λ2 =	-486.4 ksi	
Slenderness Limit, λ2 =	123.0	
Allowable Stress, λ≥λ2 =	28.9 ksi	
Allowable Bending Stress, Fb/Ω =	31.8 ksi	
Allowable Moment, S*Fb/Ω = Mallow =	**2.51 kip-in**	
Applied Moment, Mapplied =	**0.55 kip-in**	**OK**

Flexural Lateral Torsional Buckling 6061-T6 (ADM 2020 Section F.4)

Slenderness, λ =	3.5	for closed shape member, F.4.2.3
inelastic buckling, M_{nmb} =	3.94 ksi	◄ Controls
elastic buckling, M_{nmb} =	646.25 ksi	
Ω_b =	1.65	
Allowable Moment, M_{nmb}/Ω_b =	**2.39 kip-in**	
Applied Moment, Mapplied =	**0.55 kip-in**	**OK**

Deflection Check, ΔMAX = LB/12 (ICC Report AC273)

Allowable Deflection, Δallow =	0.133 in	
Applied Deflection, $PL_B^3/3EI$ = Δapplied =	0.001 in	**OK**

Shear in Elements, Gross Section 6061-T6 (ADM 2020 Table Section G.2)

Allowable Stress, $\lambda \le \lambda_1$ =	5.1	◄ Controls
Slenderness Limit, λ_1 =	47.5	
Allowable Stress, $\lambda_1 < \lambda < \lambda_2$ =	7.1 ksi	
Slenderness Limit, λ_2 =	126.0	
Allowable Stress, $\lambda \ge \lambda_2$ =	1486.5 ksi	
Allowable Shear Stress, $F_{s/\Omega}$ =	5 ksi	
Allowable Shear, $A_p * F_s/\Omega$ = V_{allow} =	**2.709 kips**	
Applied Shear, P = $V_{applied}$ =	**0.200 kips**	**OK**

Weld Strength at Base (ADM 2020 J.2.5)

Nominal Strength of weld, F_{nw} =	20 ksi	Table A.4.3
Base Metal Strength, F_{nBM} =	14 ksi	Table A.4.6
Fillet Weld Size, Sw =	0.188 in	
Effective Fillet Weld Size, Swe =	0.133 in	
Weld Section Modulus, S =	0.086 in³	
Base Metal Area, Aw =	0.328 in²	
Ω =	1.95	
Allowable Base Metal Strength, F_{nBM}/Ω =	**7.385 ksi**	
Applied Metal Stress, (M/a)/Aw =	**2.682 ksi**	**OK**
Allowable Weld Strength, F_{nw}/Ω =	**10.043 ksi**	
Applied Weld Stress, M/S =	**6.390 ksi**	**OK**

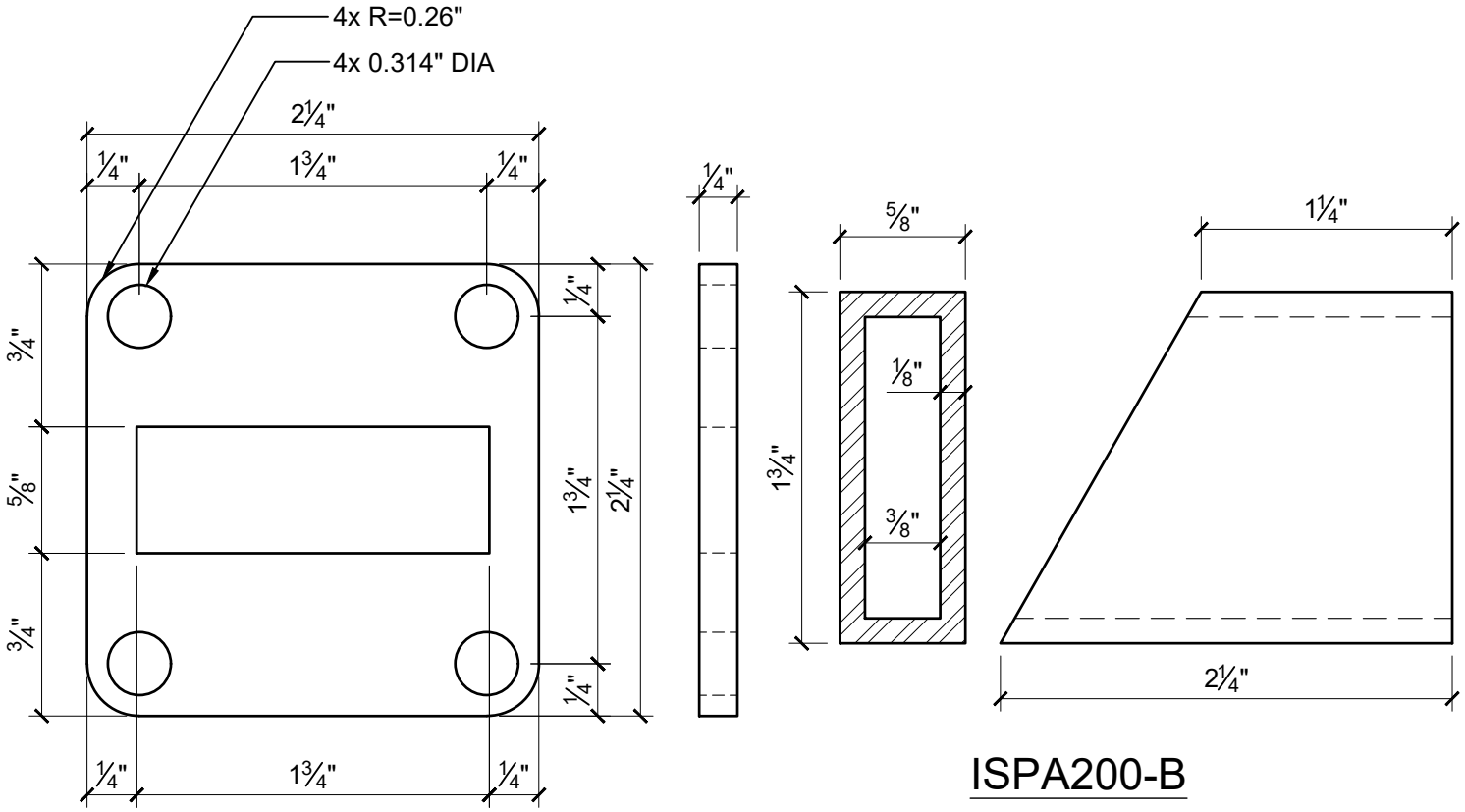
Shear Capacity of Screw at Top fo Handrail (ADM 2020 J.5.5.1) #6 x 1 1/2"_RCBS200

$V_{APPLIED}$ =	0.200 kips	
Number of Screws in Shear =	1	
Shear Applied, $V_{applied}$ =	**0.200 kips**	**Per Screw**
diameter of screw, d =	0.138 in	
sile Ultimate Strength of Member in Contact with Screw Head, F_{tu} =	38 ksi	
dist from screw center to edge of connected part, de =	0.250 in	
thickness of connected part, t =	0.140 in	
Screw Bearing Strength, Rn =	**1.330 kips**	*(Eq. J.5-13)*
Shear Strength of Screw, F_{nv} =	34 ksi	Stainless Steel
Shear Stress Area of Screw, A_s =	0.015 in²	
Nominal Shear Strength of a Screw, Rn =	**0.505 kips**	*(Eq. AISC DG 27 Eq. J3-1)*
Ω, Aluminum =	3.00	
Ω, Steel =	2.00	
Bearing Strength, R_n/Ω =	**0.443 kips**	**OK > 0.2 kips**
Shear Strength, R_n/Ω =	**0.252 kips**	**OK > 0.2 kips**

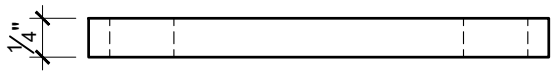
WAYPOINT ENGINEERING

PROJECT: 23353 - Stainless Cable Solutions
SUBJECT: Aluminum Intermediate Stair post adapter

DATE: 12/08/2023
DESIGN: CT
PAGE: 18



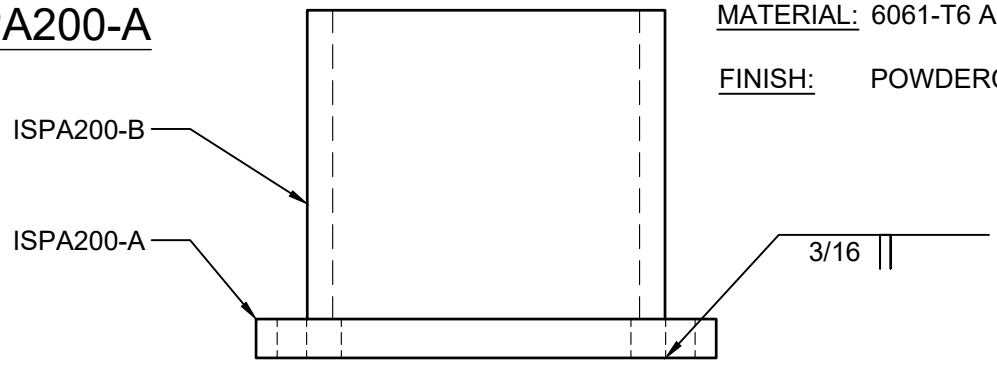
ISPA200-B



ISPA200-A

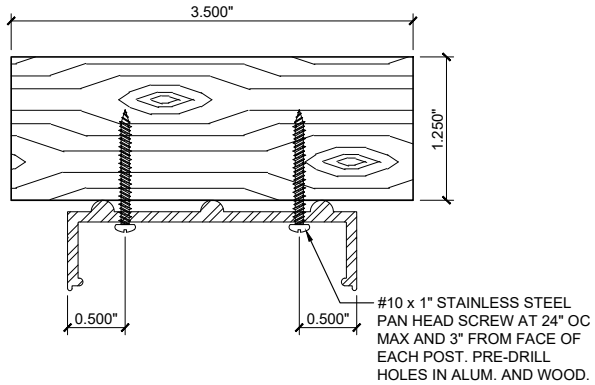
MATERIAL: 6061-T6 ALUMINUM

FINISH: POWDERCOAT 6 MIL MIN



INTERMEDIATE STAIR POST ADAPTER (ISPA200A) ASSEMBLY

Wood Top Rail Check



Note: 200 lbs point load controls as screws are spaced at 24" OC

Shear demand to handrail, V =	200 lbs	
Number of screws, n =	2	
Shear demand to handrail, V =	100 lbs	
Screw Diameter, D =	0.151 in	
Sphere Diameter, Db =	4.000 in	
Main member screw bearing length, Lm =	1 in	
Side member bearing length, Ls =	0.09 in	
Specific gravity of wood, G =	0.85	
Perpendicular allowable bearing stress, Femperp =	12048.34 psi	
Aluminum allowable bearing stress, Fes	15385 psi	
Yield of 6061 T5 aluminum, Fyb	30000 psi	
Reduction Term NDS Table 12.3.1B, Rd =	2.2	
Fem/Fes, Re =	0.783	
Im/Is, Rt =	11.11	
k1 =	3.12	
k2 =	2.92	
k3 =	5.38	
Im =	273 lbs	
Is =	198 lbs	
II =	111 lbs	◄ **Controls**
IIIm =	149 lbs	
IIIS =	124 lbs	
IV =	174 lbs	
Controlling DCR	0.91	**OK < 1**

Waypoint Engineering
601 Main Street #400
Vancouver, WA 98660

Project Title: Stainless Cable Solutions Aluminum
Engineer: CT
Project ID: 23353
Project Descr:

Wood Column

Project File: 23353 - Stainless Gravity.ec6

LIC# : KW-06015354, Build:20.23.12.07 Waypoint Engineering, Inc. (c) ENERCALC INC 1983-2023

DESCRIPTION: Wood Top Rail W/ compression force from cables

Code References

Calculations per NDS 2018, IBC 2018, CBC 2019, ASCE 7-16
Load Combinations Used : IBC 2021

General Information

Analysis Method	Allowable Stress Design		
End Fixities	Top & Bottom Pinned		
Overall Column Height	5 ft		
(Used for non-slender calculations)			
Wood Species	IPE		
Wood Grade	Sawn, No. 3 -> Sel Str		
Fb +	22560 psi	Fv	2060 psi
Fb -	22560 psi	Ft	200 psi
Fc - Prll	10350 psi	Density	35 pcf
Fc - Perp	13010 psi		

E : Modulus of Elasticity . . .	x-x Bending	y-y Bending	Axial
Basic	3140	3140	3140 ksi
Minimum	3140	3140	

Wood Section Name	**2x4**		
Wood Grading/Manuf.	Graded Lumber		
Wood Member Type	Sawn		
Exact Width	**1.50** in	Allow Stress Modification Factors	
Exact Depth	**3.50** in	Cf or Cv for Bending	1.0
Area	5.250 in^2	Cf or Cv for Compressio	1.0
Ix	5.359 in^4	Cf or Cv for Tension	1.0
Iy	0.9844 in^4	Cm : Wet Use Factor	1.0
		Ct : Temperature Fact	1.0
		Cfu : Flat Use Factor	1.0
		Kf : Built-up columns	1.0
		Use Cr : Repetitive ?	No

Column Buckling Condition:
Fully braced against buckling ABOUT X-X Axis
Fully braced against buckling ABOUT Y-Y Axis

Applied Loads

Service loads entered. Load Factors will be applied for calculations.

Column self weight included : 6.380 lbs * Dead Load Factor
AXIAL LOADS . . .
Compression load (310lbs/cable *10cables)/2: Axial Load at 5.0 ft, D = 1.550 k
BENDING LOADS . . .
Live load: Lat. Point Load at 2.50 ft creating Mx-x, L = 0.20 k

DESIGN SUMMARY

Bending & Shear Check Results

PASS Max. Axial+Bending Stress Ratio = **0.09338 : 1**

Load Combination	+D+L
Governing NDS Forumla	Comp + Mxx, NDS Eq. 3.9-3
Location of max.above base	2.517 ft
At maximum location values are .	
Applied Axial	1.556 k
Applied Mx	0.2483 k-ft
Applied My	0.0 k-ft
Fc : Allowable	10,350.0 psi

PASS Maximum Shear Stress Ratio = **0.01387 : 1**

Load Combination	+D+L
Location of max.above base	5.0 ft
Applied Design Shear	42.857 psi
Allowable Shear	2,060.0 psi

Maximum SERVICE Lateral Load Reactions . .

Top along Y-Y	0.10 k	Bottom along Y-Y	0.10 k
Top along X-X	0.0 k	Bottom along X-X	0.0 k

Maximum SERVICE Load Lateral Deflections . . .

Along Y-Y 0.05402 in at 2.517 ft above base
for load combination : +D+L

Along X-X 0.0 in at 0.0 ft above base
for load combination : n/a

Other Factors used to calculate allowable stresses . . .

	Bending	Compression	Tension

Load Combination Results

Load Combination	C_D	C_P	Maximum Axial + Bending Stress Ratios: Stress Ratio	Status	Location	Maximum Shear Ratios: Stress Ratio	Status	Location
D Only	0.900	1.000	0.03183	PASS	0.0 ft	0.0	PASS	5.0 ft
+D+L	1.000	1.000	0.09338	PASS	2.517 ft	0.01387	PASS	5.0 ft
+D+0.750L	1.250	1.000	0.06906	PASS	2.517 ft	0.008322	PASS	2.483 ft
+0.60D	1.600	1.000	0.01074	PASS	0.0 ft	0.0	PASS	5.0 ft

Maximum Reactions

Note: Only non-zero reactions are listed.

Load Combination	X-X Axis Reaction k @ Base	@ Top	Y-Y Axis Reaction @ Base	@ Top	Axial Reaction @ Base	My - End Moments k-ft @ Base	@ Top	Mx - End Moments @ Base	@ Top
D Only					1.556				

Waypoint Engineering
601 Main Street #400
Vancouver, WA 98660

Project Title: Stainless Cable Solutions Aluminum
Engineer: CT
Project ID: 23353
Project Descr:

Wood Column

Project File: 23353 - Stainless Gravity.ec6

LIC# : KW-06015354, Build:20.23.12.07 Waypoint Engineering, Inc. (c) ENERCALC INC 1983-2023

DESCRIPTION: Wood Top Rail W/ compression force from cables

Maximum Reactions

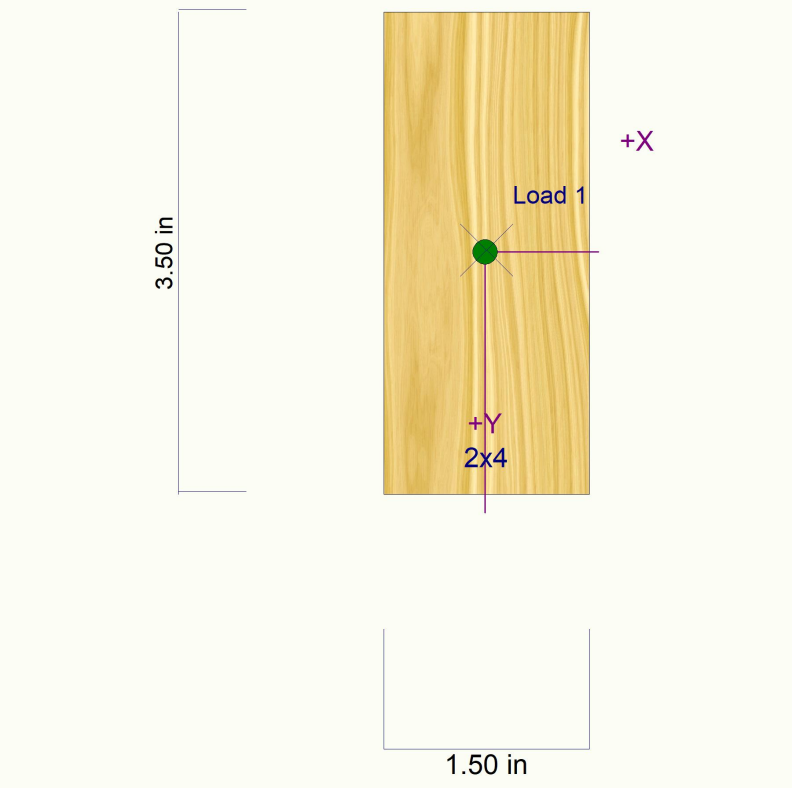
Note: Only non-zero reactions are listed.

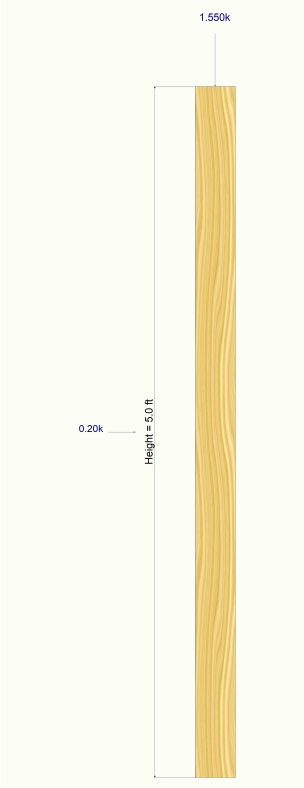
Load Combination	X-X Axis Reaction @ Base	@ Top	k	Y-Y Axis Reaction @ Base	@ Top	Axial Reaction @ Base	My - End Moments @ Base	@ Top	k-ft	Mx - End Moments @ Base	@ Top
+D+L				0.100	0.100	1.556					
+D+0.750L				0.075	0.075	1.556					
+0.60D						0.934					
L Only				0.100	0.100						

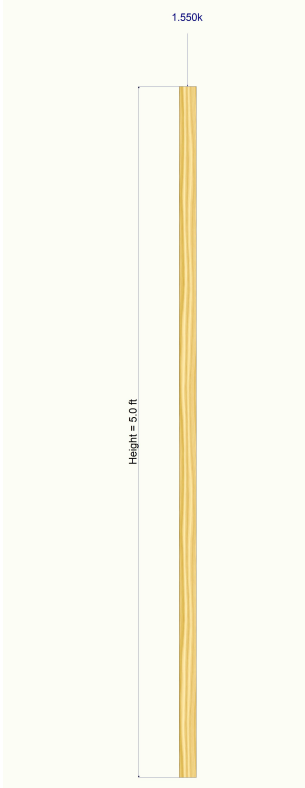
Maximum Deflections for Load Combinations

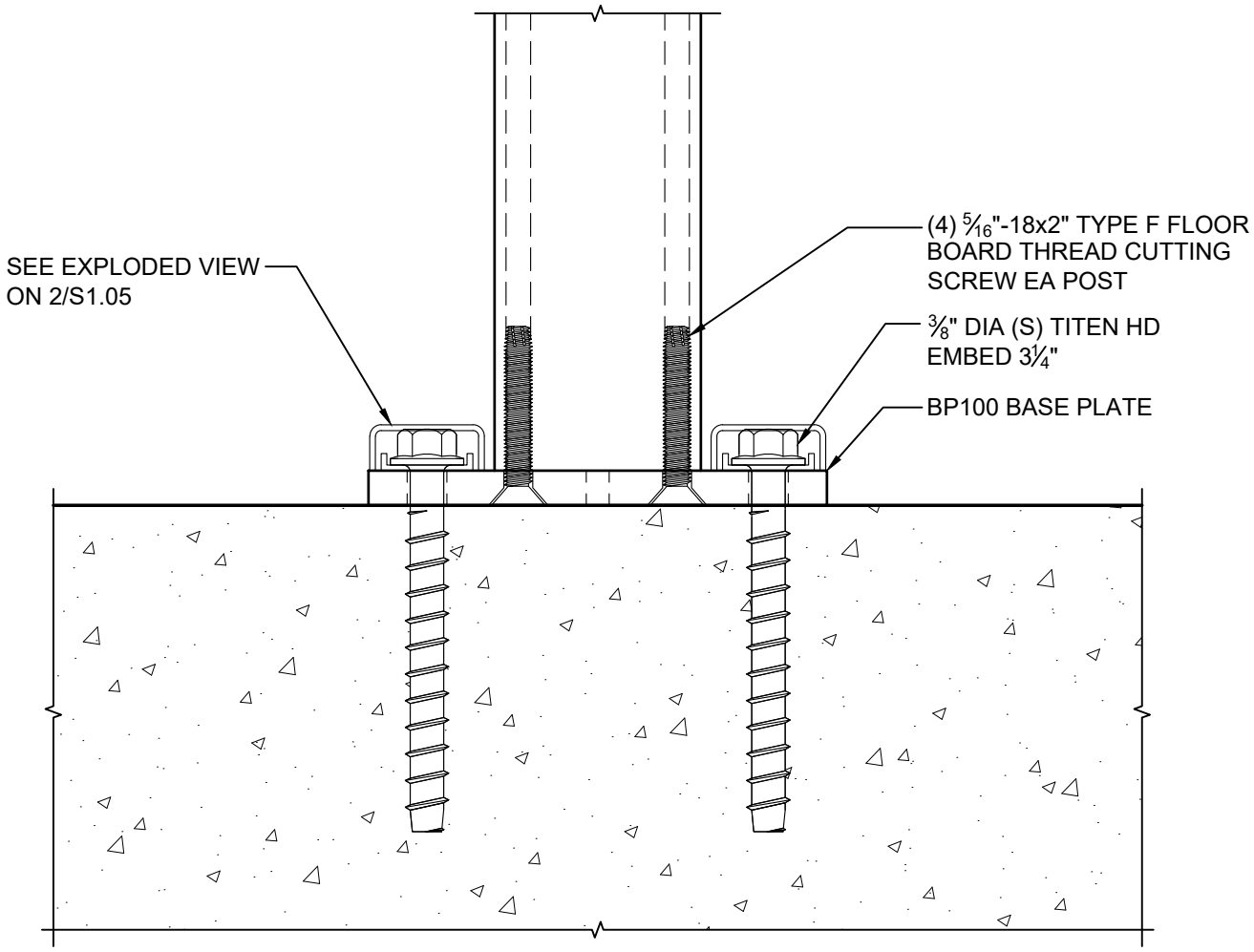
Load Combination	Max. X-X Deflection	Distance	Max. Y-Y Deflection	Distance
D Only	0.0000 in	0.000ft	0.000 in	0.000 ft
+D+L	0.0000 in	0.000ft	0.054 in	2.517 ft
+D+0.750L	0.0000 in	0.000ft	0.041 in	2.517 ft
+0.60D	0.0000 in	0.000ft	0.000 in	0.000 ft
L Only	0.0000 in	0.000ft	0.054 in	2.517 ft

Sketches








SEE EXPLODED VIEW
ON 2/S1.05
(4) 5/16"-18x2" TYPE F FLOOR
BOARD THREAD CUTTING
SCREW EA POST
3/8" DIA (S) TITEN HD
EMBED 3 1/4"
BP100 BASE PLATE

Company:		Date:	2/9/2024
Engineer:	CT	Page:	1/6
Project:	Stainless Cable Solutions Concrete Anchorage		
Address:			
Phone:			
E-mail:			

1.Project information

Customer company:
Customer contact name:
Customer e-mail:
Comment:

Project description:
Location:
Fastening description:

2. Input Data & Anchor Parameters

General
Design method:ACI 318-14
Units: Imperial units

Anchor Information:
Anchor type: Concrete screw
Material: Carbon Steel
Diameter (inch): 0.375
Nominal Embedment depth (inch): 3.250
Effective Embedment depth, h_{ef} (inch): 2.400
Code report: ICC-ES ESR-2713
Anchor category: 1
Anchor ductility: No
h_{min} (inch): 5.00
c_{ac} (inch): 3.63
C_{min} (inch): 1.75
S_{min} (inch): 3.00

Base Material
Concrete: Normal-weight
Concrete thickness, h (inch): 5.00
State: Cracked
Compressive strength, f'_c (psi): 2500
$\Psi_{c,V}$: 1.0
Reinforcement condition: B tension, B shear
Supplemental reinforcement: Not applicable
Reinforcement provided at corners: No
Ignore concrete breakout in tension: No
Ignore concrete breakout in shear: No
Ignore 6do requirement: Not applicable
Build-up grout pad: No

Base Plate
Length x Width x Thickness (inch): 5.00 x 5.00 x 0.25

Recommended Anchor
Anchor Name: Titen HD® - 3/8"Ø Titen HD, hnom:3.25" (83mm)
Code Report: ICC-ES ESR-2713

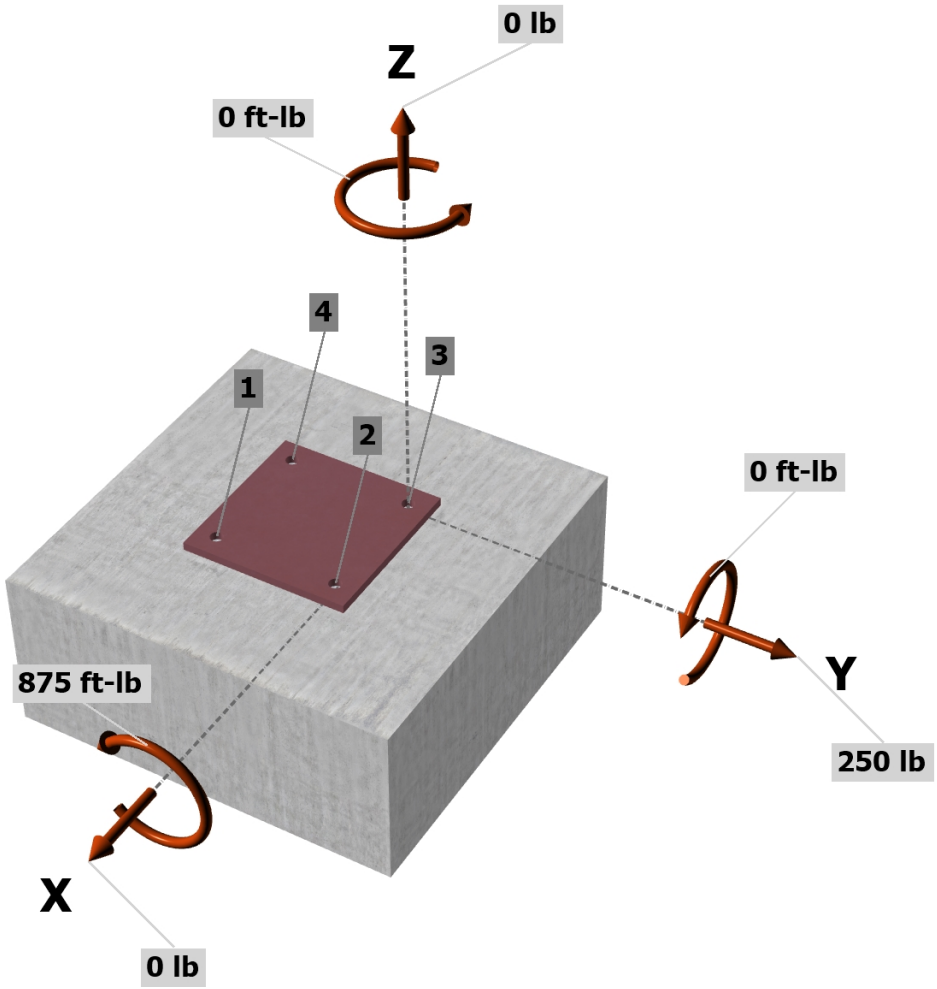


Load and Geometry
Load factor source: ACI 318 Section 5.3
Load combination: not set
Seismic design: No
Anchors subjected to sustained tension: Not applicable
Apply entire shear load at front row: No
Anchors only resisting wind and/or seismic loads: No

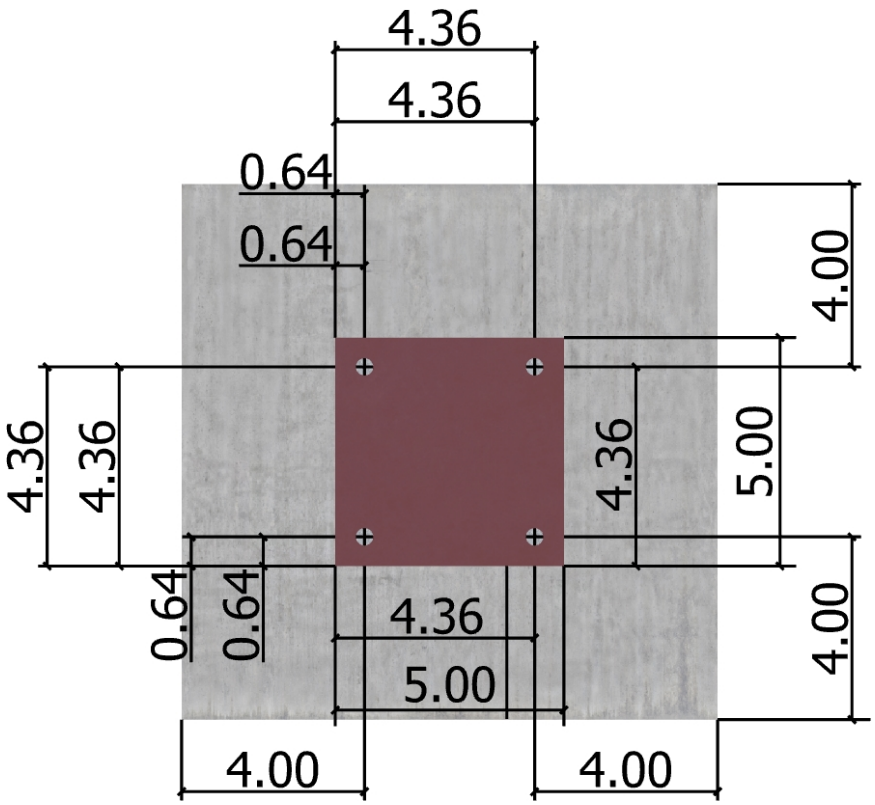
Strength level loads:

N_{ua} [lb]: 0
V_{uax} [lb]: 0
V_{uay} [lb]: 250
M_{ux} [ft-lb]: 875
M_{uy} [ft-lb]: 0
M_{uz} [ft-lb]: 0

<Figure 1>



<Figure 2>

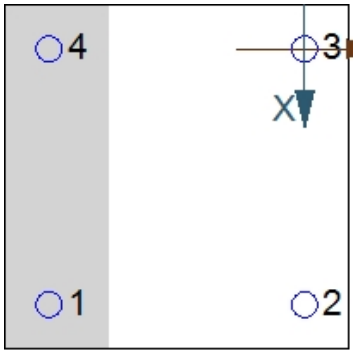


3. Resulting Anchor Forces

Anchor	Tension load, N_{ua} (lb)	Shear load x, V_{uax} (lb)	Shear load y, V_{uay} (lb)	Shear load combined, $\sqrt{(V_{uax})^2+(V_{uay})^2}$ (lb)
1	0.0	-31.2	31.3	44.2
2	1361.6	31.2	31.3	44.2
3	1361.6	31.2	93.7	98.8
4	0.0	-31.2	93.7	98.8
Sum	2723.1	0.0	250.0	286.0

Maximum concrete compression strain (‰): 0.17
Maximum concrete compression stress (psi): 719
Resultant tension force (lb): 2723
Resultant compression force (lb): 2723
Eccentricity of resultant tension forces in x-axis, e'_{Nx} (inch): 0.00
Eccentricity of resultant tension forces in y-axis, e'_{Ny} (inch): 0.00
Eccentricity of resultant shear forces in x-axis, e'_{Vx} (inch): 0.00
Eccentricity of resultant shear forces in y-axis, e'_{Vy} (inch): 0.00

<Figure 3>



4. Steel Strength of Anchor in Tension (Sec. 17.4.1)

N_{sa} (lb)	ϕ	ϕN_{sa} (lb)
10890	0.65	7079

5. Concrete Breakout Strength of Anchor in Tension (Sec. 17.4.2)

$N_b = k_c \lambda_a \sqrt{f'_c} h_{ef}^{1.5}$ (Eq. 17.4.2.2a)

k_c	λ_a	f'_c (psi)	h_{ef} (in)	N_b (lb)
17.0	1.00	2500	2.400	3160

$\phi N_{cbg} = \phi \, (A_{Nc} / A_{Nco}) \, \Psi_{ec,N} \, \Psi_{ed,N} \, \Psi_{c,N} \, \Psi_{cp,N} N_b$ (Sec. 17.3.1 & Eq. 17.4.2.1b)

A_{Nc} (in^2)	A_{Nco} (in^2)	$c_{a,min}$ (in)	$\Psi_{ec,N}$	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	ϕN_{cbg} (lb)
78.62	51.84	4.00	1.000	1.000	1.00	1.000	3160	0.65	3116

6. Pullout Strength of Anchor in Tension (Sec. 17.4.3)

$\phi N_{pn} = \phi \Psi_{c,P} \lambda_a N_p (f'_c / 2{,}500)^n$ (Sec. 17.3.1, Eq. 17.4.3.1 & Code Report)

$\Psi_{c,P}$	λ_a	N_p (lb)	f'_c (psi)	n	ϕ	ϕN_{pn} (lb)
1.0	1.00	2700	2500	0.50	0.65	1755

8. Steel Strength of Anchor in Shear (Sec. 17.5.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\phi_{grout}\phi V_{sa}$ (lb)
4460	1.0	0.60	2676

9. Concrete Breakout Strength of Anchor in Shear (Sec. 17.5.2)

Shear perpendicular to edge in x-direction:

$V_{bx} = \min\left|7(l_e / d_a)^{0.2}\sqrt{d_a}\lambda_a\sqrt{f'_c}c_{a1}^{1.5};\ 9\lambda_a\sqrt{f'_c}c_{a1}^{1.5}\right|$ (Eq. 17.5.2.2a & Eq. 17.5.2.2b)

l_e (in)	d_a (in)	λ_a	f'_c (psi)	c_{a1} (in)	V_{bx} (lb)
2.40	0.375	1.00	2500	5.15	3628

$\phi V_{cbgx} = \phi\,(A_{Vc} / A_{Vco})\,\Psi_{ec,V}\,\Psi_{ed,V}\,\Psi_{c,V}\,\Psi_{h,V}\,V_{bx}$ (Sec. 17.3.1 & Eq. 17.5.2.1b)

A_{Vc} (in²)	A_{Vco} (in²)	$\Psi_{ec,V}$	$\Psi_{ed,V}$	$\Psi_{c,V}$	$\Psi_{h,V}$	V_{bx} (lb)	ϕ	ϕV_{cbgx} (lb)
58.60	119.20	1.000	0.855	1.000	1.243	3628	0.70	1327

Shear perpendicular to edge in y-direction:

$V_{by} = \min\left|7(l_e / d_a)^{0.2}\sqrt{d_a}\lambda_a\sqrt{f'_c}c_{a1}^{1.5};\ 9\lambda_a\sqrt{f'_c}c_{a1}^{1.5}\right|$ (Eq. 17.5.2.2a & Eq. 17.5.2.2b)

l_e (in)	d_a (in)	λ_a	f'_c (psi)	c_{a1} (in)	V_{by} (lb)
2.40	0.375	1.00	2500	3.33	1891

$\phi V_{cbgy} = \phi\,(A_{Vc} / A_{Vco})\,\Psi_{ec,V}\,\Psi_{ed,V}\,\Psi_{c,V}\,\Psi_{h,V}\,V_{by}$ (Sec. 17.3.1 & Eq. 17.5.2.1b)

A_{Vc} (in²)	A_{Vco} (in²)	$\Psi_{ec,V}$	$\Psi_{ed,V}$	$\Psi_{c,V}$	$\Psi_{h,V}$	V_{by} (lb)	ϕ	ϕV_{cbgy} (lb)
58.60	50.00	0.843	0.940	1.000	1.000	1891	0.70	1229

Shear parallel to edge in x-direction:

$V_{by} = \min\left|7(l_e / d_a)^{0.2}\sqrt{d_a}\lambda_a\sqrt{f'_c}c_{a1}^{1.5};\ 9\lambda_a\sqrt{f'_c}c_{a1}^{1.5}\right|$ (Eq. 17.5.2.2a & Eq. 17.5.2.2b)

l_e (in)	d_a (in)	λ_a	f'_c (psi)	c_{a1} (in)	V_{by} (lb)
2.40	0.375	1.00	2500	3.33	1891

$\phi V_{cbgx} = \phi\ (2)(A_{Vc} / A_{Vco})\,\Psi_{ec,V}\,\Psi_{ed,V}\,\Psi_{c,V}\,\Psi_{h,V}\,V_{by}$ (Sec. 17.3.1, 17.5.2.1(c) & Eq. 17.5.2.1b)

A_{Vc} (in²)	A_{Vco} (in²)	$\Psi_{ec,V}$	$\Psi_{ed,V}$	$\Psi_{c,V}$	$\Psi_{h,V}$	V_{by} (lb)	ϕ	ϕV_{cbgx} (lb)
58.60	50.00	1.000	1.000	1.000	1.000	1891	0.70	3102

Shear parallel to edge in y-direction:

$V_{bx} = \min\left|7(l_e / d_a)^{0.2}\sqrt{d_a}\lambda_a\sqrt{f'_c}c_{a1}^{1.5};\ 9\lambda_a\sqrt{f'_c}c_{a1}^{1.5}\right|$ (Eq. 17.5.2.2a & Eq. 17.5.2.2b)

l_e (in)	d_a (in)	λ_a	f'_c (psi)	c_{a1} (in)	V_{bx} (lb)
2.40	0.375	1.00	2500	3.33	1891

$\phi V_{cbgy} = \phi\ (2)(A_{Vc} / A_{Vco})\,\Psi_{ec,V}\,\Psi_{ed,V}\,\Psi_{c,V}\,\Psi_{h,V}\,V_{bx}$ (Sec. 17.3.1, 17.5.2.1(c) & Eq. 17.5.2.1b)

A_{Vc} (in²)	A_{Vco} (in²)	$\Psi_{ec,V}$	$\Psi_{ed,V}$	$\Psi_{c,V}$	$\Psi_{h,V}$	V_{bx} (lb)	ϕ	ϕV_{cbgy} (lb)
58.60	50.00	1.000	1.000	1.000	1.000	1891	0.70	3102

10. Concrete Pryout Strength of Anchor in Shear (Sec. 17.5.3)

$\phi V_{cp} = \phi k_{cp} N_{cb} = \phi k_{cp}(A_{Nc} / A_{Nco})\,\Psi_{ed,N}\,\Psi_{c,N}\,\Psi_{cp,N} N_b$ (Sec. 17.3.1 & Eq. 17.5.3.1a)

k_{cp}	A_{Nc} (in²)	A_{Nco} (in²)	$\Psi_{ed,N}$	$\Psi_{c,N}$	$\Psi_{cp,N}$	N_b (lb)	ϕ	ϕV_{cp} (lb)
1.0	29.81	51.84	1.000	1.000	1.000	3160	0.70	1272

11. Results

Interaction of Tensile and Shear Forces (Sec. 17.6.)

Tension	Factored Load, N_{ua} (lb)	Design Strength, øN_n (lb)	Ratio	Status
Steel	1362	7079	0.19	Pass
Concrete breakout	**2723**	**3116**	**0.87**	**Pass (Governs)**
Pullout	1362	1755	0.78	Pass

Shear	Factored Load, V_{ua} (lb)	Design Strength, øV_n (lb)	Ratio	Status
Steel	99	2676	0.04	Pass
T Concrete breakout x-	62	1327	0.05	Pass
T Concrete breakout y+	250	1229	0.20	Pass
|| Concrete breakout x-	187	3102	0.06	Pass
|| Concrete breakout y+	62	3102	0.02	Pass
Concrete breakout, combined	**-**	**-**	**0.21**	**Pass (Governs)**
Pryout	99	1272	0.08	Pass

Interaction check	$N_{ua}/\phi N_n$	$V_{ua}/\phi V_n$	Combined Ratio	Permissible	Status
Sec. 17.6..1	0.87	0.00	87.4%	1.0	Pass

3/8"Ø Titen HD, hnom:3.25" (83mm) meets the selected design criteria.

12. Warnings

- Designer must exercise own judgement to determine if this design is suitable.

- Refer to manufacturer's product literature for hole cleaning and installation instructions.