

Schletter, Inc.	Standard PVMini Racking System Representative Calculations - ASCE 7-10	30° Tilt w/ Seismic Design
HCV		

1. INTRODUCTION

1.1 Project Description

The following sections will cover the determination of forces and structural design calculations for the Schletter, Inc. PVMini ground mount system.

1.2 Construction

Photovoltaic modules are attached to aluminum purlins using clamp fasteners. Purlins are clamped to inclined aluminum girders, which are then connected to aluminum struts. Each support structure is equally spaced.

PV modules are required to meet the following specifications:

	Maximum	Minimum
Height =	1700 mm	1550 mm
Width =	1050 mm	970 mm
Dead Load =	3.00 psf	1.75 psf

Modules Per Row = 1
Module Tilt = 30°
Maximum Height Above Grade = 3 ft

1.3 Technical Codes

- ASCE 7-10 - Chapter 26-31, Wind Loads
- ASCE 7-10 - Chapter 7, Snow Loads
- ASCE 7-10 - Chapter 2, Combination of Loads
- International Building Code, IBC, 2012, 2015
- Aluminum Design Manual, Eighth Edition, 2005

2. LOAD ACTIONS

2.1 Permanent Loads

g_{MAX} =	3.00 psf
g_{MIN} =	1.75 psf



Self-weight of the PV modules.

Typical loading conditions of the module dead loads, snow loads, and wind loads are shown on the left.

2.2 Snow Loads

Ground Snow Load, P_g =	30.00 psf	
Sloped Roof Snow Load, P_s =	16.49 psf	(ASCE 7-10, Eq. 7.4-1)
I_s =	1.00	
C_s =	0.73	
C_e =	0.90	
C_t =	1.20	

2.3 Wind Loads

Design Wind Speed, V =	110 mph	Exposure Category = C
Height \leq	15 ft	Importance Category = II

Peak Velocity Pressure, q_z = 19.00 psf Including the gust factor, $G=0.85$. (ASCE 7-10, Eq. 27.3-1)

Pressure Coefficients

$C_{f+ TOP}$ =	1.15	(Pressure)
$C_{f+ BOTTOM}$ =	1.85	
$C_{f- TOP}$ =	-2.3	(Suction)
$C_{f- BOTTOM}$ =	-1.1	

Provided pressure coefficients are the result of wind tunnel testing done by Ruscheweyh Consult. Coefficients are located in test report # 1127/0611-1e. Negative forces are applied away from the surface.

2.4 Seismic Loads

S_S =	2.50	R = 1.25
S_{DS} =	1.67	C_s = 0.8
S_1 =	1.00	ρ = 1.3
S_{D1} =	1.00	Ω = 1.25
T_a =	0.04	C_d = 1.25

ASCE 7, Section 12.8.1.3: A maximum S_S of 1.5 may be used to calculate the base shear, C_s , of structures under five stories and with a period, T , of 0.5 or less. Therefore, a S_{ds} of 1.0 was used to calculate C_s .

2.5 Combination of Loads

ASCE 7 requires that all structures be checked by specified combinations of loads. Applicable load combinations are provided below.

Strength Design, LRFD

Component stresses are checked using the following LRFD load combinations:

$$\begin{aligned}
 &1.2D + 1.6S + 0.5W \\
 &1.2D + 1.0W + 0.5S \\
 &0.9D + 1.0W^M \\
 &1.54D + 1.3E + 0.2S^R \quad (\text{ASCE 7, Eq 2.3.2-1 through 2.3.2-7}) \text{ \& } (\text{ASCE 7, Section 12.4.3.2}) \\
 &0.56D + 1.3E^R \\
 &1.54D + 1.25E + 0.2S^O \\
 &0.56D + 1.25E^O
 \end{aligned}$$

Allowable Stress Design, ASD

Member deflection checks and foundation designs are done according to the following ASD load combinations:

$$\begin{aligned}
 &1.0D + 1.0S \\
 &1.0D + 0.6W \\
 &1.0D + 0.75L + 0.45W + 0.75S \\
 &0.6D + 0.6W^M \quad (\text{ASCE 7, Eq 2.4.1-1 through 2.4.1-8}) \text{ \& } (\text{ASCE 7, Section 12.4.3.2}) \\
 &1.238D + 0.875E^O \\
 &1.1785D + 0.65625E + 0.75S^O \\
 &0.362D + 0.875E^O
 \end{aligned}$$

^M Uses the minimum allowable module dead load.

^R Include redundancy factor of 1.3.

^O Includes overstrength factor of 1.25. Used to check seismic drift.

3. STRUCTURAL ANALYSIS

3.1 RISA Results

Appendix B.1 contains outputs from the structural analysis software package, RISA. These outputs are used to accurately determine resultant member and reaction forces from the loads seen throughout Section 2.

3.2 RISA Components

A member and node list has been provided below to correlate the RISA components with the design calculations in Section 4. Items of significance have been listed.

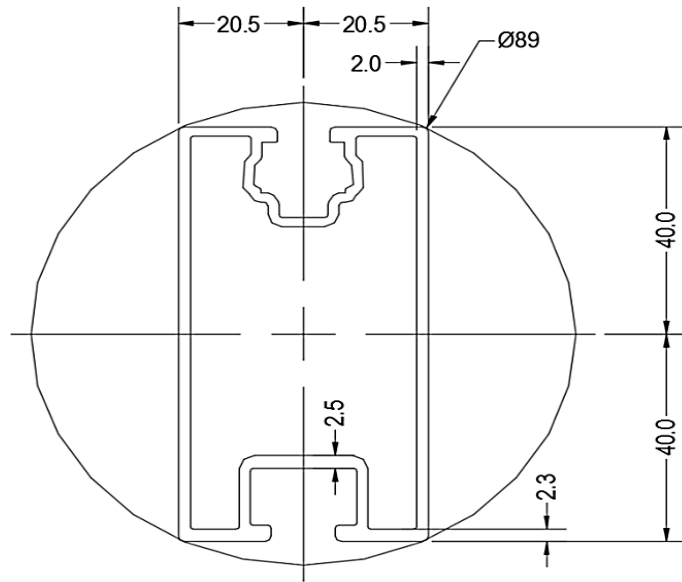
<u>Purlins</u>	<u>Location</u>	<u>Diagonal Struts</u>	<u>Location</u>	<u>Front Reactions</u>	<u>Location</u>
M13	Top	M3	Outer	N7	Outer
M16	Bottom	M7	Inner	N15	Inner
		M11	Outer	N23	Outer
<u>Girders</u>	<u>Location</u>	<u>Rear Struts</u>	<u>Location</u>	<u>Rear Reactions</u>	<u>Location</u>
M1	Outer	M2	Outer	N8	Outer
M5	Inner	M6	Inner	N16	Inner
M9	Outer	M10	Outer	N24	Outer
<u>Front Struts</u>	<u>Location</u>	<u>Bracing</u>			
M4	Outer	M15			
M8	Inner	M16A			
M12	Outer				

4. MEMBER DESIGN CALCULATIONS

4.1 Purlin Design

Aluminum purlins are used to transfer loads to the support structure. Purlins are designed as continuous beams with cantilevers. These are considered beams with internal hinges that can be joined with splices at 25% of the support respective span. See Appendix A.1 for detailed member calculations. Section units are in (mm).

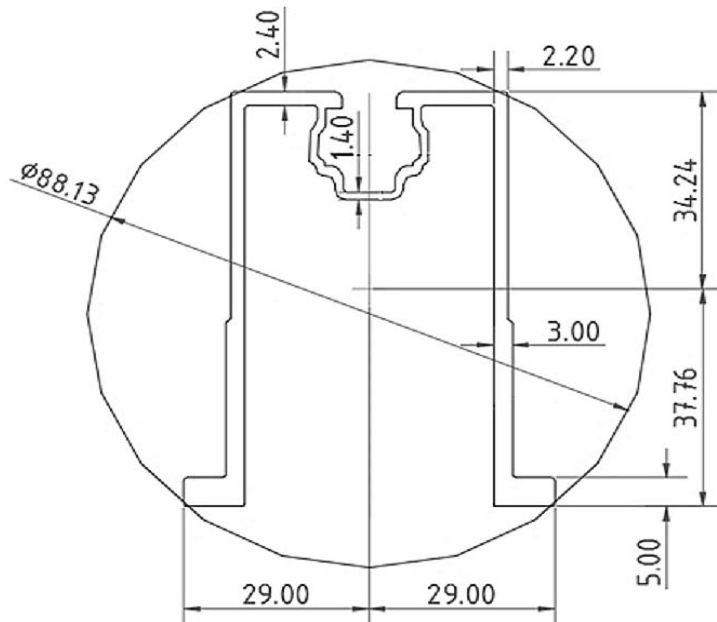
Purlin Type =	ProfiPlusXT
Aluminum Type =	6105-T5
F_{ty} =	35 ksi
L_b =	93 in
ΦF_{ty} STRONG-AXIS =	28.83 ksi
ΦF_{ty} WEAK-AXIS =	22.71 ksi
S_y =	0.75 in ³
S_x =	0.44 in ³
E =	10100 ksi
I_y =	1.20 in ⁴
I_x =	0.36 in ⁴
A =	0.96 in ²
g =	1.15 lbs/ft
M_y =	0.898 k-ft
M_z =	0.236 k-ft
$M_{y \text{ allowable}}$ =	1.791 k-ft
$M_{z \text{ allowable}}$ =	0.838 k-ft
Utilization =	78%



4.2 Girder Design

Loads from purlins are transferred using an inclined girder, which is connected to a set of aluminum struts. Loads on the girder result from the support reactions of the purlins. See Appendix A.2 for detailed member calculations. Section units are in (mm).

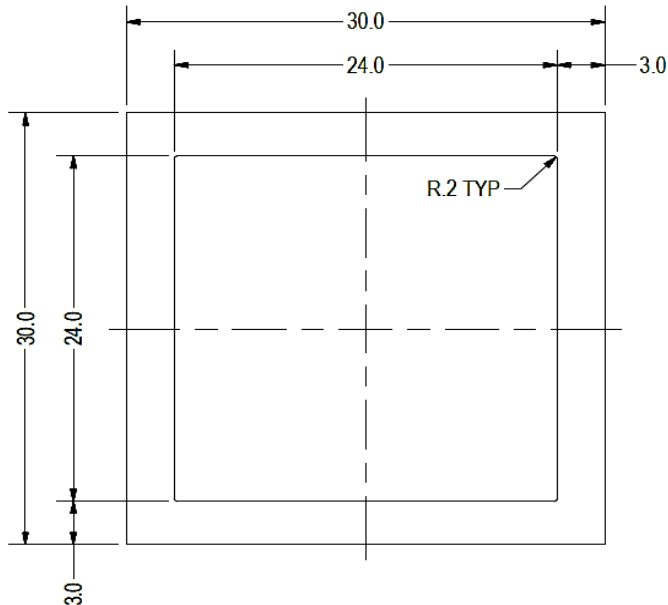
Girder Type =	Flex Profi
Aluminum Type =	6105-T5
F_{ty} =	35 ksi
L_b =	33.78 in
ΦF_{ty} AXIAL =	14.29 ksi
ΦF_{ty} STRONG-AXIS =	29.82 ksi
ΦF_{ty} WEAK-AXIS =	13.46 ksi
S_y =	0.59 in ³
S_x =	0.46 in ³
E =	10100 ksi
I_y =	0.88 in ⁴
I_x =	0.52 in ⁴
A =	0.89 in ²
g =	1.07 lbs/ft
M_y =	0.598 k-ft
M_z =	0.000 k-ft
P_n =	0.318 k
$M_{y \text{ allowable}}$ =	1.463 k-ft
$M_{z \text{ allowable}}$ =	0.513 k-ft
$P_{n \text{ allowable}}$ =	12.764 k
Utilization =	43%



4.3 Front Strut Design

The front aluminum strut connects a portion of the girder to the foundation. Vertical girder forces are then transferred down through the strut into the foundation. The strut is attached with single M8 bolts at each end. See Appendix A.3 for detailed member calculations. Section units are in (mm).

Strut Type =	30x30x3
Aluminum Type =	6105-T5
F_{ty} =	35 ksi
L_b =	18.00 in
$\Phi F_{ty \text{ AXIAL}}$ =	24.52 ksi
$\Phi F_{ty \text{ BENDING}}$ =	31.19 ksi
S_y =	0.16 in ³
S_x =	0.16 in ³
E =	10100 ksi
I_y =	0.10 in ⁴
I_x =	0.10 in ⁴
A =	0.50 in ²
g =	0.60 lbs/ft
M_y =	0.000 k-ft
M_z =	-0.053 k-ft
P_n =	0.267 k
$M_{y \text{ allowable}}$ =	0.423 k-ft
$M_{z \text{ allowable}}$ =	0.423 k-ft
$P_{n \text{ allowable}}$ =	12.310 k
Utilization =	15%



4.4 Diagonal Strut Design

A diagonal aluminum strut braces the support structure. It connects at a front portion of the girder and transfers horizontal forces to the rear foundation connection. The strut is attached with single M8 bolts at each end. See Appendix A.4 for detailed member calculations. Section units are in (mm).

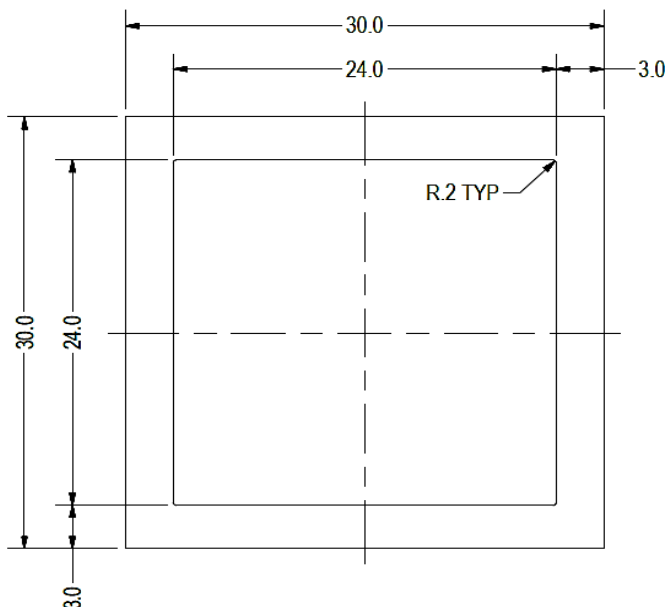
Strut Type =	30x30x3
Aluminum Type =	6105-T5
F_{ty} =	35 ksi
L_b =	46.38 in
$\Phi F_{ty \text{ AXIAL}}$ =	7.60 ksi
$\Phi F_{ty \text{ BENDING}}$ =	29.80 ksi
S_y =	0.16 in ³
S_x =	0.16 in ³
E =	10100 ksi
I_y =	0.10 in ⁴
I_x =	0.10 in ⁴
A =	0.50 in ²
g =	0.60 lbs/ft
M_y =	0.000 k-ft
M_z =	0.000 k-ft
P_n =	0.634 k
$M_{y \text{ allowable}}$ =	0.404 k-ft
$M_{z \text{ allowable}}$ =	0.404 k-ft
$P_{n \text{ allowable}}$ =	3.814 k
Utilization =	17%



4.5 Rear Strut Design

An aluminum strut connects the rear portion of the girder to the rear foundation connection. Both vertical and horizontal forces are transferred from the girder. The strut is attached with single M8 bolts at each end. See Appendix A.5 for detailed member calculations. Section units are in (mm).

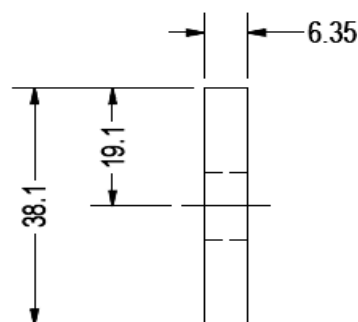
Strut Type =	30x30x3
Aluminum Type =	6105-T5
F_{ty} =	35 ksi
L_b =	39.29 in
$\Phi F_{ty \text{ AXIAL}}$ =	10.06 ksi
$\Phi F_{ty \text{ BENDING}}$ =	30.09 ksi
S_y =	0.16 in ³
S_x =	0.16 in ³
E =	10100 ksi
I_y =	0.10 in ⁴
I_x =	0.10 in ⁴
A =	0.50 in ²
g =	0.60 lbs/ft
M_y =	0.000 k-ft
M_z =	0.000 k-ft
P_n =	1.008 k
$M_{y \text{ allowable}}$ =	0.408 k-ft
$M_{z \text{ allowable}}$ =	0.408 k-ft
$P_{n \text{ allowable}}$ =	5.050 k
Utilization =	<u>20%</u>



4.6 Cross Brace Design

In order to resist weak side loading, aluminum cross bracing kits are provided. The cross bracing is attached at one end of a rear aluminum strut diagonally down to the bottom end of an adjacent strut. Single M10 bolts are provided at each of the cross bracing. Section units are in (mm).

Brace Type =	1.5x0.25
Aluminum Type =	6061-T6
F_{ty} =	35 ksi
Φ =	0.90
S_y =	0.02 in ³
E =	10100 ksi
I_y =	33.25 in ⁴
A =	0.38 in ²
g =	0.45 lbs/ft
M_y =	0.007 k-ft
P_n =	0.261 k
$M_{y \text{ allowable}}$ =	0.046 k-ft
$P_{n \text{ allowable}}$ =	11.813 k
Utilization =	<u>18%</u>



A cross brace kit is required every 11 bays and is to be installed in centermost bays.

5. FOUNDATION DESIGN CALCULATIONS

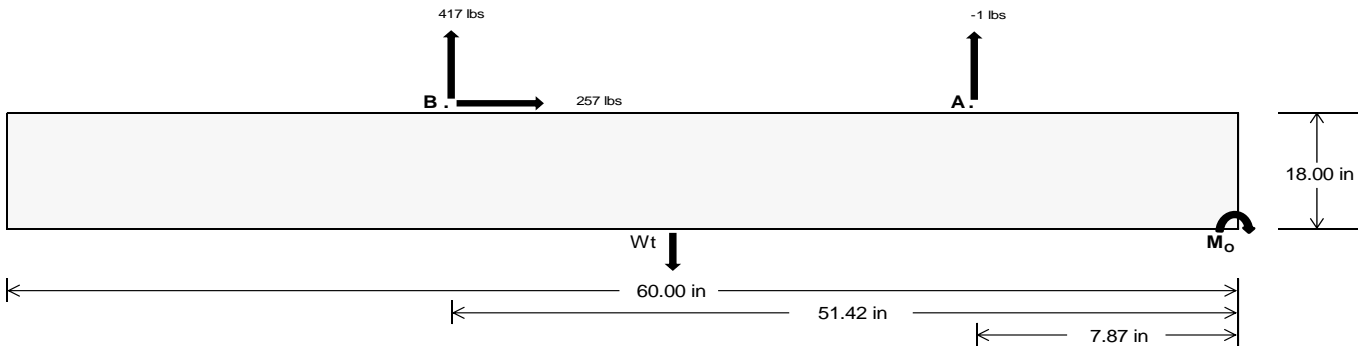
5.1 Helical Pile Foundations

The following LRFD loads include a safety factor of 1.3, and are to be used in conjunction with a Schletter, Inc. Geotechnical Investigation Report. The forces below should fall within the guidelines provided in the Geotechnical Investigation Report. If a Geotechnical Investigation Report is not present, please proceed to Section 5.2 for a concrete foundation design.

	<u>Maximum</u>	<u>Front</u>	<u>Rear</u>
Tensile Load =	<u>5.80</u>	<u>1813.67</u>	k
Compressive Load =	<u>1563.90</u>	<u>1380.88</u>	k
Lateral Load =	<u>42.97</u>	<u>1115.69</u>	k
Moment (Weak Axis) =	<u>0.07</u>	<u>0.00</u>	k

5.2 Design of Ballast Foundations

Ballast foundations are used to secure the racking structure in place. The foundations are checked for potential overturning and sliding. Bearing pressures applied by the racking and ballast foundations are checked against the allowable bearing pressures provided by the IBC table 1806.2 (2012, 2015).



Concrete Properties

Weight of Concrete = 145 pcf
Compressive Strength = 2500 psi
Yield Strength = 60000 psi

Overturning Check

$M_o = 26073.0$ in-lbs
Resisting Force Required = 869.10 lbs
S.F. = 1.67
Weight Required = 1448.50 lbs
Minimum Width = 21 in
Weight Provided = 1903.13 lbs

Sliding

Force = 257.25 lbs
Friction = 0.4
Weight Required = 643.13 lbs
Resisting Weight = 1903.13 lbs
Additional Weight Required = 0 lbs

Cohesion

Sliding Force = 257.25 lbs
Cohesion = 130 psf
Area = 8.75 ft²
Resisting = 951.56 lbs
Additional Weight Required = 0 lbs

Shear Key

Additional Force = 0 lbs
Lateral Bearing Pressure = 200 psf/ft
Required Depth = 0.00 ft
 $f'_c = 2500$ psi
Length = 8 in

Footing Reinforcement

Use fiber reinforcing with (1) #5 rebar.

A minimum 60in long x 21in wide x 18in tall ballast foundation is required to resist overturning.

Use a 60in long x 21in wide x 18in tall ballast foundation to resist sliding. Friction is OK.

Use a 60in long x 21in wide x 18in tall ballast foundation. Cohesion is OK.

Shear key is not required.

Bearing Pressure

$P_{ftg} = (145 \text{ pcf})(5 \text{ ft})(1.5 \text{ ft})(1.75 \text{ ft}) =$

Ballast Width			
21 in	22 in	23 in	24 in
1903 lbs	1994 lbs	2084 lbs	2175 lbs

ASD LC	1.0D + 1.0S				1.0D + 0.6W				1.0D + 0.75L + 0.45W + 0.75S				0.6D + 0.6W			
Width	21 in	22 in	23 in	24 in	21 in	22 in	23 in	24 in	21 in	22 in	23 in	24 in	21 in	22 in	23 in	24 in
F_A	612 lbs	612 lbs	612 lbs	612 lbs	432 lbs	432 lbs	432 lbs	432 lbs	728 lbs	728 lbs	728 lbs	728 lbs	2 lbs	2 lbs	2 lbs	2 lbs
F_B	429 lbs	429 lbs	429 lbs	429 lbs	554 lbs	554 lbs	554 lbs	554 lbs	698 lbs	698 lbs	698 lbs	698 lbs	-834 lbs	-834 lbs	-834 lbs	-834 lbs
F_V	73 lbs	73 lbs	73 lbs	73 lbs	471 lbs	471 lbs	471 lbs	471 lbs	402 lbs	402 lbs	402 lbs	402 lbs	-515 lbs	-515 lbs	-515 lbs	-515 lbs
P_{total}	2944 lbs	3035 lbs	3125 lbs	3216 lbs	2889 lbs	2980 lbs	3071 lbs	3161 lbs	3329 lbs	3419 lbs	3510 lbs	3601 lbs	309 lbs	364 lbs	418 lbs	472 lbs
M	473 lbs-ft	473 lbs-ft	473 lbs-ft	473 lbs-ft	512 lbs-ft	512 lbs-ft	512 lbs-ft	512 lbs-ft	699 lbs-ft	699 lbs-ft	699 lbs-ft	699 lbs-ft	720 lbs-ft	720 lbs-ft	720 lbs-ft	720 lbs-ft
e	0.16 ft	0.16 ft	0.15 ft	0.15 ft	0.18 ft	0.17 ft	0.17 ft	0.16 ft	0.21 ft	0.20 ft	0.20 ft	0.19 ft	2.33 ft	1.98 ft	1.72 ft	1.52 ft
$L/6$	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft	0.83 ft
f_{min}	271.6 psf	269.1 psf	266.9 psf	264.8 psf	259.9 psf	258.0 psf	256.3 psf	254.6 psf	284.5 psf	281.5 psf	278.7 psf	276.1 psf	0.0 psf	0.0 psf	0.0 psf	0.0 psf
f_{max}	401.4 psf	393.0 psf	385.4 psf	378.4 psf	400.5 psf	392.2 psf	384.6 psf	377.6 psf	476.4 psf	464.6 psf	453.9 psf	444.0 psf	690.8 psf	254.7 psf	187.1 psf	161.4 psf

Maximum Bearing Pressure = 691 psf
Allowable Bearing Pressure = 1500 psf

Use a 60in long x 21in wide x 18in tall ballast foundation for an acceptable bearing pressure.

Seismic Design

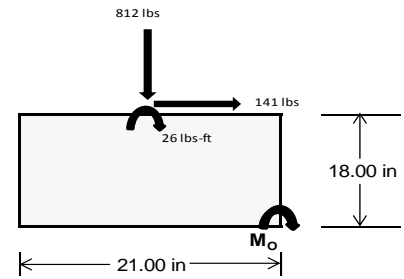
Overturning Check

$M_o = 473.9 \text{ ft-lbs}$
 Resisting Force Required = 541.64 lbs
 S.F. = 1.67
 Weight Required = 902.74 lbs
 Minimum Width = 21 in
 Weight Provided = 1903.13 lbs

A minimum 60in long x 21in wide x 18in tall ballast foundation is required to resist overturning.

Bearing Pressure

ASD LC	1.238D + 0.875E			1.1785D + 0.65625E + 0.75S			0.362D + 0.875E		
Width	21 in			21 in			21 in		
Support	Outer	Inner	Outer	Outer	Inner	Outer	Outer	Inner	Outer
F_v	151 lbs	169 lbs	90 lbs	347 lbs	812 lbs	300 lbs	87 lbs	3 lbs	30 lbs
F_v	23 lbs	186 lbs	24 lbs	15 lbs	141 lbs	18 lbs	23 lbs	185 lbs	23 lbs
P_{total}	2507 lbs	2525 lbs	2446 lbs	2590 lbs	3055 lbs	2543 lbs	776 lbs	692 lbs	719 lbs
M	65 lbs-ft	314 lbs-ft	70 lbs-ft	41 lbs-ft	237 lbs-ft	56 lbs-ft	68 lbs-ft	314 lbs-ft	70 lbs-ft
e	0.03 ft	0.12 ft	0.03 ft	0.02 ft	0.08 ft	0.02 ft	0.09 ft	0.45 ft	0.10 ft
$L/6$	0.29 ft	1.50 ft	1.69 ft	1.72 ft	1.59 ft	1.71 ft	1.58 ft	0.84 ft	1.56 ft
f_{min}	261.0 sqft	165.4 sqft	252.0 sqft	279.9 sqft	256.3 sqft	268.9 sqft	62.1 sqft	-43.9 sqft	54.7 sqft
f_{max}	311.9 psf	411.8 psf	307.1 psf	312.1 psf	442.0 psf	312.4 psf	115.2 psf	202.1 psf	109.6 psf



Maximum Bearing Pressure = 442 psf
 Allowable Bearing Pressure = 1500 psf

Use a 60in long x 21in wide x 18in tall ballast foundation for an acceptable bearing pressure.

Foundation Requirements: 60in long x 21in wide x 18in tall ballast foundation and fiber reinforcing with (1) #5 rebar.

5.3 Foundation Anchors

Threaded rods are anchored to the the ballast foundations using the Simpson AT-XP epoxy solution. LRFD load results are compared to the allowable strengths of the epoxy solution. Please see the supplementary calculations provided by the Simpson Anchor Designer software.

6. DESIGN OF JOINTS AND CONNECTIONS

6.1 Anchorage of Modules to Purlins and Connection of Purlins to Girders

Modules are secured to the purlins with Schletter, Inc. Rapid2+ mounting clamps. Purlins are secured to the girders with the use of a Schletter, Inc. Klicktop connector. The reliability of calculations is uncertain due to limited standards, therefore the strength of the fasteners has been evaluated by load testing.

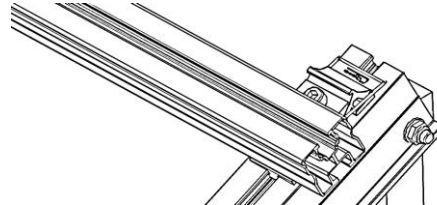
Fastening of Modules to Purlins

Maximum Uplifting Force =	0.405 k
Allowable Uplift =	1.214 k
Utilization =	<u>33%</u>



Fastening of Purlins to Girders

Maximum Uplifting Force =	1.107 k
Allowable Uplift =	1.116 k
Utilization =	<u>99%</u>



6.2 Bolted Connections

The aluminum struts connect the aluminum girder ends to custom brackets with mounting holes. Cross bracing is attached to rear struts to provide lateral stability. Single M8 bolts are used to attach each end of the strut to the girder and post. ASTM A193/A193M-86 equivalent stainless steel bolts are used.

Front Strut

Maximum Axial Load =	1.203 k
M8 Bolt Capacity =	5.692 k
Strut Bearing Capacity =	7.952 k
Utilization =	<u>21%</u>

Diagonal Strut

Maximum Axial Load =	0.634 k
M8 Bolt Shear Capacity =	5.692 k
Strut Bearing Capacity =	7.952 k
Utilization =	<u>11%</u>



Rear Strut

Maximum Axial Load =	1.190 k
M8 Bolt Capacity =	5.692 k
Strut Bearing Capacity =	7.952 k
Utilization =	<u>21%</u>

Bracing

Maximum Axial Load =	0.261 k
M10 Bolt Capacity =	8.894 k
Strut Bearing Capacity =	7.952 k
Utilization =	<u>3%</u>

Bolt and bearing capacities are accounting for double shear (ASCE 8-02, Eq. 5.3.4-1). Struts under compression are shown to demonstrate the load transfer from the girder. Single M8 bolts are located at each end of the strut and are subjected to double shear.

7. SEISMIC DESIGN

7.1 Seismic Drift

The racking structure has been analyzed under seismic loading. The allowable story drift of the structure must fall within the limits provided by (ASCE 7, Table 12.12-1).

Mean Height, h_{sx} =	32.32 in
Allowable Story Drift for All Other Structures, Δ = {	0.020 h_{sx}
	0.646 in
Max Drift, Δ_{MAX} =	0.111 in
	<u>0.111 ≤ 0.646. OK.</u>

The racking structure's reaction to seismic loads is shown to the right. The deflections have been magnified to provide a clear portrayal of potential story drift.



APPENDIX A

A.1 Design of Aluminum Purlins - Aluminum Design Manual, 2005 Edition

Purlin = **ProfiPlus XT**

Strong Axis:

3.4.14

$$L_b = 93.00 \text{ in}$$

$$J = 0.427$$

$$193.965$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} Fcy}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((LbSc)/(Cb \sqrt{(IyJ)/2}))}]$$

$$\phi F_L = 28.8 \text{ ksi}$$

Weak Axis:

3.4.14

$$L_b = 93.00 \text{ in}$$

$$J = 0.427$$

$$210.771$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} Fcy}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((LbSc)/(Cb \sqrt{(IyJ)/2}))}]$$

$$\phi F_L = 28.6$$

3.4.16

$$b/t = 6.6$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi y Fcy$$

$$\phi F_L = 33.3 \text{ ksi}$$

3.4.16

$$b/t = 37.95$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi b [Bp - 1.6Dp \cdot b/t]$$

$$\phi F_L = 22.7 \text{ ksi}$$

3.4.16.1 Not Used

$$Rb/t = 0.0$$

$$S1 = \left(\frac{Bt - 1.17 \frac{\theta_y}{\theta_b} Fcy}{1.6Dt} \right)^2$$

$$S1 = 1.1$$

$$S2 = C_t$$

$$S2 = 141.0$$

$$\phi F_L = 1.17 \phi y Fcy$$

$$\phi F_L = 38.9 \text{ ksi}$$

3.4.16.1

N/A for Weak Direction

3.4.18

$$\begin{aligned}
 h/t &= 37.95 \\
 S1 &= \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr} \\
 S1 &= 38.1 \\
 m &= 0.63 \\
 C_0 &= 40.784 \\
 Cc &= 39.216 \\
 S2 &= \frac{k_1 Bbr}{mDbr} \\
 S2 &= 79.7 \\
 \phi F_L &= 1.3\phi_y Fcy \\
 \phi F_L &= 43.2 \text{ ksi} \\
 \phi F_L St &= 28.8 \text{ ksi} \\
 I_x &= 498305 \text{ mm}^4 \\
 &= 1.197 \text{ in}^4 \\
 y &= 40.784 \text{ mm} \\
 S_x &= 0.746 \text{ in}^3 \\
 M_{\max} St &= 1.791 \text{ k-ft}
 \end{aligned}$$

3.4.18

$$\begin{aligned}
 h/t &= 6.6 \\
 S1 &= \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr} \\
 S1 &= 36.9 \\
 m &= 0.65 \\
 C_0 &= 20.5 \\
 Cc &= 20.5 \\
 S2 &= \frac{k_1 Bbr}{mDbr} \\
 S2 &= 77.3 \\
 \phi F_L &= 1.3\phi_y Fcy \\
 \phi F_L &= 43.2 \text{ ksi} \\
 \phi F_L Wk &= 22.7 \text{ ksi} \\
 I_y &= 148662 \text{ mm}^4 \\
 &= 0.357 \text{ in}^4 \\
 x &= 20.5 \text{ mm} \\
 S_y &= 0.443 \text{ in}^3 \\
 M_{\max} Wk &= 0.838 \text{ k-ft}
 \end{aligned}$$

Compression

3.4.9

$$\begin{aligned}
 b/t &= 6.6 \\
 S1 &= 12.21 \text{ (See 3.4.16 above for formula)} \\
 S2 &= 32.70 \text{ (See 3.4.16 above for formula)} \\
 \phi F_L &= \phi_y Fcy \\
 \phi F_L &= 33.3 \text{ ksi} \\
 b/t &= 37.95 \\
 S1 &= 12.21 \\
 S2 &= 32.70 \\
 \phi F_L &= (\phi c k^2 \sqrt{(BpE)}) / (1.6b/t) \\
 \phi F_L &= 21.4 \text{ ksi}
 \end{aligned}$$

3.4.10

$$\begin{aligned}
 Rb/t &= 0.0 \\
 S1 &= \left(\frac{Bt - \frac{\theta_y}{\theta_b} Fcy}{Dt} \right)^2 \\
 S1 &= 6.87 \\
 S2 &= 131.3 \\
 \phi F_L &= \phi_y Fcy \\
 \phi F_L &= 33.25 \text{ ksi} \\
 \phi F_L &= 21.42 \text{ ksi} \\
 A &= 620.02 \text{ mm}^2 \\
 &= 0.96 \text{ in}^2 \\
 P_{\max} &= 20.59 \text{ kips}
 \end{aligned}$$

A.2 Design of Aluminum Girders - Aluminum Design Manual, 2005 Edition

Girder = **Flex Profi**

Strong Axis:

3.4.11

$$\begin{aligned}
 L_b &= 33.78 \text{ in} \\
 r_y &= 1.374 \\
 C_b &= 1.36 \\
 &21.0529 \\
 S1 &= \frac{1.2(Bc - \frac{\theta_y}{\theta_b} Fcy)}{Dc} \\
 S1 &= 1.37733 \\
 S2 &= 1.2C_c \\
 S2 &= 79.2 \\
 \phi F_L &= \phi b[Bc - Dc * Lb / (1.2 * r_y * \sqrt{(Cb)})] \\
 \phi F_L &= 29.8 \text{ ksi}
 \end{aligned}$$

3.4.15

N/A for Strong Direction

3.4.16

$$\begin{aligned}
 b/t &= 4.29 \\
 S1 &= \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp} \\
 S1 &= 12.2 \\
 S2 &= \frac{k_1 Bp}{1.6Dp} \\
 S2 &= 46.7 \\
 \phi F_L &= \phi y Fcy \\
 \phi F_L &= 33.3 \text{ ksi}
 \end{aligned}$$

3.4.16

N/A for Strong Direction

Weak Axis:

3.4.11

$$\begin{aligned}
 L_b &= 33.78 \text{ in} \\
 r_y &= 1.374 \\
 C_b &= 1.36 \\
 &24.5845 \\
 S1 &= \frac{1.2(Bc - \frac{\theta_y}{\theta_b} Fcy)}{Dc} \\
 S1 &= 1.37733 \\
 S2 &= 1.2C_c \\
 S2 &= 79.2 \\
 \phi F_L &= \phi b[Bc - Dc * Lb / (1.2 * r_y * \sqrt{(Cb)})] \\
 \phi F_L &= 29.8 \text{ ksi}
 \end{aligned}$$

3.4.15

$$\begin{aligned}
 b/t &= 24.46 \\
 S1 &= \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{5.1Dp} \\
 S1 &= 3.8 \\
 S2 &= \frac{k_1 Bp}{5.1Dp} \\
 S2 &= 14.7 \\
 F_{UT} &= (\phi b k_2 * \sqrt{(BpE)}) / (5.1b/t) \\
 F_{UT} &= 9.4 \text{ ksi}
 \end{aligned}$$

3.4.16

N/A for Weak Direction

3.4.16

$$\begin{aligned}
 b/t &= 24.46 \\
 S1 &= \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp} \\
 S1 &= 12.2 \\
 S2 &= \frac{k_1 Bp}{1.6Dp} \\
 S2 &= 46.7 \\
 F_{ST} &= \phi b[Bp - 1.6Dp * b/t] \\
 F_{ST} &= 28.2 \text{ ksi}
 \end{aligned}$$

3.4.16.1 Not Used

$$Rb/t = 0.0$$

$$S1 = \left(\frac{Bt - 1.17 \frac{\theta_y}{\theta_b} Fcy}{1.6Dt} \right)^2$$

$$S1 = 1.1$$

$$S2 = C_t$$

$$S2 = 141.0$$

$$\phi F_L = 1.17 \phi_y Fcy$$

$$\phi F_L = 38.9 \text{ ksi}$$

3.4.16.2

N/A for Strong Direction

3.4.16.1

N/A for Weak Direction

$$b/t = 24.46$$

$$t = 2.6$$

$$ds = 6.05$$

$$rs = 3.49$$

$$S = 21.70$$

$$\rho_{st} = 0.22$$

$$F_{UT} = 9.37$$

$$F_{ST} = 28.24$$

$$\phi F_L = F_{ut} + (F_{st} - F_{ut}) \rho_{st} < F_{st}$$

$$\phi F_L = 13.5 \text{ ksi}$$

3.4.18

$$h/t = 24.46$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr}$$

$$S1 = 34.4$$

$$m = 0.70$$

$$C_0 = 34.23$$

$$Cc = 37.77$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 72.1$$

$$\phi F_L = 1.3 \phi_y Fcy$$

$$\phi F_L = 43.2 \text{ ksi}$$

$$\phi F_L St = 29.8 \text{ ksi}$$

$$I_x = 364470 \text{ mm}^4$$

$$0.876 \text{ in}^4$$

$$y = 37.77 \text{ mm}$$

$$S_x = 0.589 \text{ in}^3$$

$$M_{\max} St = 1.463 \text{ k-ft}$$

3.4.18

$$h/t = 4.29$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr}$$

$$S1 = 36.9$$

$$m = 0.65$$

$$C_0 = 29$$

$$Cc = 29$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 77.3$$

$$\phi F_L = 1.3 \phi_y Fcy$$

$$\phi F_L = 43.2 \text{ ksi}$$

$$\phi F_L Wk = 13.5 \text{ ksi}$$

$$I_y = 217168 \text{ mm}^4$$

$$0.522 \text{ in}^4$$

$$x = 29 \text{ mm}$$

$$S_y = 0.457 \text{ in}^3$$

$$M_{\max} Wk = 0.513 \text{ k-ft}$$

Compression

3.4.7

$$\lambda = 0.46067$$

$$r = 1.374 \text{ in}$$

$$S1^* = \frac{Bc - Fcy}{1.6Dc^*}$$

$$S1^* = 0.33515$$

$$S2^* = \frac{Cc}{\pi} \sqrt{Fcy/E}$$

$$S2^* = 1.23671$$

$$\phi_{cc} = 0.90326$$

$$\phi F_L = \phi_{cc} (Bc - Dc^* \lambda)$$

$$\phi F_L = 30.1251 \text{ ksi}$$

3.4.8

$$\begin{aligned} b/t &= 24.46 \\ S1 &= 3.83 \\ S2 &= 10.30 \\ \phi F_L &= (\phi c k^2 \sqrt{(B p E)}) / (5.1 b/t) \\ \phi F_L &= 10.4 \text{ ksi} \end{aligned}$$

3.4.9

$$\begin{aligned} b/t &= 4.29 \\ S1 &= 12.21 \text{ (See 3.4.16 above for formula)} \\ S2 &= 32.70 \text{ (See 3.4.16 above for formula)} \\ \phi F_L &= \phi_y F_{cy} \\ \phi F_L &= 33.3 \text{ ksi} \\ b/t &= 24.46 \\ S1 &= 12.21 \\ S2 &= 32.70 \\ \phi F_L &= \phi_c [B p - 1.6 D p^* b/t] \\ \phi F_L &= 28.2 \text{ ksi} \end{aligned}$$

3.4.9.1

$$\begin{aligned} b/t &= 24.46 \\ t &= 2.6 \\ d_s &= 6.05 \\ r_s &= 3.49 \\ S &= 21.70 \\ \rho_{st} &= 0.22 \\ F_{UT} &= 10.43 \\ F_{ST} &= 28.24 \\ \phi F_L &= F_{ut} + (F_{st} - F_{ut}) \rho_{st} < F_{st} \\ \phi F_L &= 14.3 \text{ ksi} \end{aligned}$$

3.4.10

$$\begin{aligned} R b/t &= 0.0 \\ S1 &= \left(\frac{B t - \frac{\theta_y}{\theta_b} F_{cy}}{D t} \right)^2 \\ S1 &= 6.87 \\ S2 &= 131.3 \\ \phi F_L &= \phi_y F_{cy} \\ \phi F_L &= 33.25 \text{ ksi} \\ \phi F_L &= 14.29 \text{ ksi} \\ A &= 576.21 \text{ mm}^2 \\ &= 0.89 \text{ in}^2 \\ P_{\max} &= 12.76 \text{ kips} \end{aligned}$$

A.3 Design of Aluminum Struts (Front) - Aluminum Design Manual, 2005 Edition

Strut = **30x30x3**

Strong Axis:

3.4.14

$$L_b = 18.00 \text{ in}$$

$$J = 0.16$$

$$47.2194$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} Fcy}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((LbSc)/(Cb \sqrt{(IyJ)/2}))}]$$

$$\phi F_L = 31.2 \text{ ksi}$$

Weak Axis:

3.4.14

$$L_b = 18.00 \text{ in}$$

$$J = 0.16$$

$$47.2194$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} Fcy}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((LbSc)/(Cb \sqrt{(IyJ)/2}))}]$$

$$\phi F_L = 31.2$$

3.4.16

$$b/t = 7.75$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi y Fcy$$

$$\phi F_L = 33.3 \text{ ksi}$$

3.4.16

$$b/t = 7.75$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi y Fcy$$

$$\phi F_L = 33.3 \text{ ksi}$$

3.4.16.1 Not Used

$$Rb/t = 0.0$$

$$S1 = \left(\frac{Bt - 1.17 \frac{\theta_y}{\theta_b} Fcy}{1.6Dt} \right)^2$$

$$S1 = 1.1$$

$$S2 = C_t$$

$$S2 = 141.0$$

$$\phi F_L = 1.17 \phi y Fcy$$

$$\phi F_L = 38.9 \text{ ksi}$$

3.4.16.1

N/A for Weak Direction

3.4.18

$$h/t = 7.75$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr}$$

$$S1 = 36.9$$

$$m = 0.65$$

$$C_0 = 15$$

$$Cc = 15$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 77.3$$

$$\phi F_L = 1.3 \phi y Fcy$$

$$\phi F_L = 43.2 \text{ ksi}$$

3.4.18

$$h/t = 7.75$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr}$$

$$S1 = 36.9$$

$$m = 0.65$$

$$C_0 = 15$$

$$Cc = 15$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 77.3$$

$$\phi F_L = 1.3 \phi y Fcy$$

$$\phi F_L = 43.2 \text{ ksi}$$

$$\phi F_L St = 31.2 \text{ ksi}$$

$$I_x = 39958.2 \text{ mm}^4$$

$$0.096 \text{ in}^4$$

$$y = 15 \text{ mm}$$

$$S_x = 0.163 \text{ in}^3$$

$$M_{\max} St = 0.423 \text{ k-ft}$$

$$\phi F_L Wk = 31.2 \text{ ksi}$$

$$I_y = 39958.2 \text{ mm}^4$$

$$0.096 \text{ in}^4$$

$$x = 15 \text{ mm}$$

$$S_y = 0.163 \text{ in}^3$$

$$M_{\max} Wk = 0.423 \text{ k-ft}$$

Compression

3.4.7

$$\lambda = 0.77182$$

$$r = 0.437 \text{ in}$$

$$S1^* = \frac{Bc - Fcy}{1.6Dc^*}$$

$$S1^* = 0.33515$$

$$S2^* = \frac{Cc}{\pi} \sqrt{Fcy/E}$$

$$S2^* = 1.23671$$

$$\phi_{cc} = 0.83792$$

$$\phi_{FL} = \phi_{cc}(Bc - Dc^* \lambda)$$

$$\phi_{FL} = 24.5226 \text{ ksi}$$

3.4.9

$$b/t = 7.75$$

$$S1 = 12.21 \text{ (See 3.4.16 above for formula)}$$

$$S2 = 32.70 \text{ (See 3.4.16 above for formula)}$$

$$\phi_{FL} = \phi_y F_{cy}$$

$$\phi_{FL} = 33.3 \text{ ksi}$$

$$b/t = 7.75$$

$$S1 = 12.21$$

$$S2 = 32.70$$

$$\phi_{FL} = \phi_y F_{cy}$$

$$\phi_{FL} = 33.3 \text{ ksi}$$

3.4.10

$$Rb/t = 0.0$$

$$S1 = \left(\frac{Bt - \frac{\theta_y}{\theta_h} Fcy}{Dt} \right)^2$$

$$S1 = 6.87$$

$$S2 = 131.3$$

$$\phi_{FL} = \phi_y F_{cy}$$

$$\phi_{FL} = 33.25 \text{ ksi}$$

$$\phi_{FL} = 24.52 \text{ ksi}$$

$$A = 323.87 \text{ mm}^2$$

$$0.50 \text{ in}^2$$

$$P_{\max} = 12.31 \text{ kips}$$

A.4 Design of Aluminum Struts (Diagonal) - Aluminum Design Manual, 2005 Edition

Strut = **30x30x3**

Strong Axis:

3.4.14

$$L_b = 46.38 \text{ in}$$

$$J = 0.16$$

$$121.663$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} Fcy}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((LbSc)/(Cb \sqrt{(IyJ)/2}))}]$$

$$\phi F_L = 29.8 \text{ ksi}$$

Weak Axis:

3.4.14

$$L_b = 46.38 \text{ in}$$

$$J = 0.16$$

$$121.663$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} Fcy}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((LbSc)/(Cb \sqrt{(IyJ)/2}))}]$$

$$\phi F_L = 29.8$$

3.4.16

$$b/t = 7.75$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi y Fcy$$

$$\phi F_L = 33.3 \text{ ksi}$$

3.4.16

$$b/t = 7.75$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} Fcy}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi y Fcy$$

$$\phi F_L = 33.3 \text{ ksi}$$

3.4.16.1 Not Used

$$Rb/t = 0.0$$

$$S1 = \left(\frac{Bt - 1.17 \frac{\theta_y}{\theta_b} Fcy}{1.6Dt} \right)^2$$

$$S1 = 1.1$$

$$S2 = C_t$$

$$S2 = 141.0$$

$$\phi F_L = 1.17 \phi y Fcy$$

$$\phi F_L = 38.9 \text{ ksi}$$

3.4.16.1

N/A for Weak Direction

3.4.18

$$h/t = 7.75$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr}$$

$$S1 = 36.9$$

$$m = 0.65$$

$$C_0 = 15$$

$$Cc = 15$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 77.3$$

$$\phi F_L = 1.3 \phi y Fcy$$

$$\phi F_L = 43.2 \text{ ksi}$$

3.4.18

$$h/t = 7.75$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3Fcy}{mDbr}$$

$$S1 = 36.9$$

$$m = 0.65$$

$$C_0 = 15$$

$$Cc = 15$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 77.3$$

$$\phi F_L = 1.3 \phi y Fcy$$

$$\phi F_L = 43.2 \text{ ksi}$$

$$\phi F_L St = 29.8 \text{ ksi}$$

$$I_x = 39958.2 \text{ mm}^4$$

$$0.096 \text{ in}^4$$

$$y = 15 \text{ mm}$$

$$S_x = 0.163 \text{ in}^3$$

$$M_{\max} St = 0.404 \text{ k-ft}$$

$$\phi F_L Wk = 33.3 \text{ ksi}$$

$$I_y = 39958.2 \text{ mm}^4$$

$$0.096 \text{ in}^4$$

$$x = 15 \text{ mm}$$

$$S_y = 0.163 \text{ in}^3$$

$$M_{\max} Wk = 0.450 \text{ k-ft}$$

Compression

3.4.7

$$\begin{aligned}\lambda &= 1.98863 \\ r &= 0.437 \text{ in} \\ S1^* &= \frac{Bc - Fcy}{1.6Dc^*} \\ S1^* &= 0.33515 \\ S2^* &= \frac{Cc}{\pi} \sqrt{Fcy/E} \\ S2^* &= 1.23671 \\ \phi_{cc} &= 0.85841 \\ \phi_{FL} &= (\phi_{cc} Fcy)/(\lambda^2) \\ \phi_{FL} &= 7.59722 \text{ ksi}\end{aligned}$$

3.4.9

$$\begin{aligned}b/t &= 7.75 \\ S1 &= 12.21 \text{ (See 3.4.16 above for formula)} \\ S2 &= 32.70 \text{ (See 3.4.16 above for formula)} \\ \phi_{FL} &= \phi_y Fcy \\ \phi_{FL} &= 33.3 \text{ ksi} \\ b/t &= 7.75 \\ S1 &= 12.21 \\ S2 &= 32.70 \\ \phi_{FL} &= \phi_y Fcy \\ \phi_{FL} &= 33.3 \text{ ksi}\end{aligned}$$

3.4.10

$$\begin{aligned}Rb/t &= 0.0 \\ S1 &= \left(\frac{Bt - \frac{\theta_y}{\theta_b} Fcy}{Dt} \right)^2 \\ S1 &= 6.87 \\ S2 &= 131.3 \\ \phi_{FL} &= \phi_y Fcy \\ \phi_{FL} &= 33.25 \text{ ksi} \\ \phi_{FL} &= 7.60 \text{ ksi} \\ A &= 323.87 \text{ mm}^2 \\ &= 0.50 \text{ in}^2 \\ P_{max} &= 3.81 \text{ kips}\end{aligned}$$

A.5 Design of Aluminum Struts (Rear) - Aluminum Design Manual, 2005 Edition

Strut = **30x30x3**

Strong Axis:

3.4.14

$$L_b = 39.29 \text{ in}$$

$$J = 103.073$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} F_{cy}}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((L_b S_c)/(C_b \sqrt{(I_y J)/2}))}]$$

$$\phi F_L = 30.1 \text{ ksi}$$

Weak Axis:

3.4.14

$$L_b = 39.29 \text{ in}$$

$$J = 103.073$$

$$S1 = \left(\frac{Bc - \frac{\theta_y}{\theta_b} F_{cy}}{1.6Dc} \right)^2$$

$$S1 = 0.51461$$

$$S2 = \left(\frac{C_c}{1.6} \right)^2$$

$$S2 = 1701.56$$

$$\phi F_L = \phi b [Bc - 1.6Dc \sqrt{((L_b S_c)/(C_b \sqrt{(I_y J)/2}))}]$$

$$\phi F_L = 30.1$$

3.4.16

$$b/t = 7.75$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} F_{cy}}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi_y F_{cy}$$

$$\phi F_L = 33.3 \text{ ksi}$$

3.4.16

$$b/t = 7.75$$

$$S1 = \frac{Bp - \frac{\theta_y}{\theta_b} F_{cy}}{1.6Dp}$$

$$S1 = 12.2$$

$$S2 = \frac{k_1 Bp}{1.6Dp}$$

$$S2 = 46.7$$

$$\phi F_L = \phi_y F_{cy}$$

$$\phi F_L = 33.3 \text{ ksi}$$

3.4.16.1 Not Used

$$Rb/t = 0.0$$

$$S1 = \left(\frac{Bt - 1.17 \frac{\theta_y}{\theta_b} F_{cy}}{1.6Dt} \right)^2$$

$$S1 = 1.1$$

$$S2 = C_t$$

$$S2 = 141.0$$

$$\phi F_L = 1.17 \phi_y F_{cy}$$

$$\phi F_L = 38.9 \text{ ksi}$$

3.4.16.1

N/A for Weak Direction

3.4.18

$$h/t = 7.75$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3F_{cy}}{mDbr}$$

$$S1 = 36.9$$

$$m = 0.65$$

$$C_0 = 15$$

$$Cc = 15$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 77.3$$

$$\phi F_L = 1.3 \phi_y F_{cy}$$

$$\phi F_L = 43.2 \text{ ksi}$$

$$\phi F_L St = 30.1 \text{ ksi}$$

$$I_x = 39958.2 \text{ mm}^4$$

$$0.096 \text{ in}^4$$

$$y = 15 \text{ mm}$$

$$S_x = 0.163 \text{ in}^3$$

$$M_{\max} St = 0.408 \text{ k-ft}$$

3.4.18

$$h/t = 7.75$$

$$S1 = \frac{Bbr - \frac{\theta_y}{\theta_b} 1.3F_{cy}}{mDbr}$$

$$S1 = 36.9$$

$$m = 0.65$$

$$C_0 = 15$$

$$Cc = 15$$

$$S2 = \frac{k_1 Bbr}{mDbr}$$

$$S2 = 77.3$$

$$\phi F_L = 1.3 \phi_y F_{cy}$$

$$\phi F_L = 43.2 \text{ ksi}$$

$$\phi F_L Wk = 33.3 \text{ ksi}$$

$$I_y = 39958.2 \text{ mm}^4$$

$$0.096 \text{ in}^4$$

$$x = 15 \text{ mm}$$

$$S_y = 0.163 \text{ in}^3$$

$$M_{\max} Wk = 0.450 \text{ k-ft}$$



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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 318-05
Units: Imperial units

Anchor Information:

Anchor type: Bonded anchor
Material: A193 Grade B8/B8M (304/316SS)
Diameter (inch): 0.500
Effective Embedment depth, h_{ef} (inch): 6.000
Code report: IAPMO UES ER-263
Anchor category: -
Anchor ductility: Yes
 h_{min} (inch): 8.50
 C_{ac} (inch): 9.67
 C_{min} (inch): 1.75
 S_{min} (inch): 3.00

Load and Geometry

Load factor source: ACI 318 Section 9.2
Load combination: not set
Seismic design: No
Anchors subjected to sustained tension: No
Apply entire shear load at front row: No
Anchors only resisting wind and/or seismic loads: No

Base Material

Concrete: Normal-weight
Concrete thickness, h (inch): 18.00
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
Do not evaluate concrete breakout in tension: No
Do not evaluate concrete breakout in shear: No
Hole condition: Dry concrete
Inspection: Periodic
Temperature range, Short/Long: 110/75°F
Ignore 6do requirement: Not applicable
Build-up grout pad: No

Base Plate

Length x Width x Thickness (inch): 4.00 x 4.00 x 0.28

<Figure 1>



Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

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<Figure 2>



Recommended Anchor

Anchor Name: AT-XP® - AT-XP w/ 1/2"Ø A193 Gr. B8/B8M (304/316SS)
Code Report: IAPMO UES ER-263





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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	405.0	6.0	101.0	101.2
Sum	405.0	6.0	101.0	101.2

Maximum concrete compression strain (%): 0.00
 Maximum concrete compression stress (psi): 0
 Resultant tension force (lb): 405
 Resultant compression force (lb): 0
 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. D.5.1)

N_{sa} (lb)	ϕ	ϕN_{sa} (lb)
8095	0.75	6071

5. Concrete Breakout Strength of Anchor in Tension (Sec. D.5.2)

$$N_b = k_c \lambda \sqrt{f_c} h_{ef}^{1.5} \text{ (Eq. D-7)}$$

k_c	λ	f_c (psi)	h_{ef} (in)	N_b (lb)
17.0	1.00	2500	5.333	10469

$$\phi N_{cb} = \phi (A_{Nc} / A_{Nco}) \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b \text{ (Sec. D.4.1 & Eq. D-4)}$$

A_{Nc} (in ²)	A_{Nco} (in ²)	$\psi_{ed,N}$	$\psi_{c,N}$	$\psi_{cp,N}$	N_b (lb)	ϕ	ϕN_{cb} (lb)
253.92	256.00	0.995	1.00	1.000	10469	0.65	6717

6. Adhesive Strength of Anchor in Tension (AC308 Sec. 3.3)

$$\tau_{k,cr} = \tau_{k,cr} f_{short-term} K_{sat}$$

$\tau_{k,cr}$ (psi)	$f_{short-term}$	K_{sat}	$\tau_{k,cr}$ (psi)
1035	1.00	1.00	1035

$$N_{a0} = \tau_{k,cr} \pi d_a h_{ef} \text{ (Eq. D-16f)}$$

$\tau_{k,cr}$ (psi)	d_a (in)	h_{ef} (in)	N_{a0} (lb)
1035	0.50	6.000	9755

$$\phi N_a = \phi (A_{Na} / A_{Na0}) \psi_{ed,Na} \psi_{p,Na} N_{a0} \text{ (Sec. D.4.1 & Eq. D-16a)}$$

A_{Na} (in ²)	A_{Na0} (in ²)	$\psi_{ed,Na}$	$\psi_{p,Na}$	N_{a0} (lb)	ϕ	ϕN_a (lb)
109.66	109.66	1.000	1.000	9755	0.55	5365

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

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8. Steel Strength of Anchor in Shear (Sec. D.6.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\phi_{grout}\phi V_{sa}$ (lb)
4855	1.0	0.65	3156

9. Concrete Breakout Strength of Anchor in Shear (Sec. D.6.2)

Shear perpendicular to edge in y-direction:

$$V_{by} = 7(l_e / d_a)^{0.2} \sqrt{d_a \lambda} \sqrt{f'_c c_{a1}}^{1.5} \text{ (Eq. D-24)}$$

l_e (in)	d_a (in)	λ	f'_c (psi)	c_{a1} (in)	V_{by} (lb)
4.00	0.50	1.00	2500	8.00	8488

$$\phi V_{cbx} = \phi (A_{Vc} / A_{Vco}) \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_{by} \text{ (Sec. D.4.1 & Eq. D-21)}$$

A_{Vc} (in ²)	A_{Vco} (in ²)	$\psi_{ed,V}$	$\psi_{c,V}$	$\psi_{h,V}$	V_{by} (lb)	ϕ	ϕV_{cbx} (lb)
238.44	288.00	0.897	1.000	1.000	8488	0.70	4411

Shear perpendicular to edge in x-direction:

$$V_{bx} = 7(l_e / d_a)^{0.2} \sqrt{d_a \lambda} \sqrt{f'_c c_{a1}}^{1.5} \text{ (Eq. D-24)}$$

l_e (in)	d_a (in)	λ	f'_c (psi)	c_{a1} (in)	V_{bx} (lb)
4.00	0.50	1.00	2500	7.87	8282

$$\phi V_{cbx} = \phi (A_{Vc} / A_{Vco}) \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_{bx} \text{ (Sec. D.4.1 & Eq. D-21)}$$

A_{Vc} (in ²)	A_{Vco} (in ²)	$\psi_{ed,V}$	$\psi_{c,V}$	$\psi_{h,V}$	V_{bx} (lb)	ϕ	ϕV_{cbx} (lb)
188.88	278.72	0.903	1.000	1.000	8282	0.70	3549

Shear parallel to edge in x-direction:

$$V_{by} = 7(l_e / d_a)^{0.2} \sqrt{d_a \lambda} \sqrt{f'_c c_{a1}}^{1.5} \text{ (Eq. D-24)}$$

l_e (in)	d_a (in)	λ	f'_c (psi)	c_{a1} (in)	V_{by} (lb)
4.00	0.50	1.00	2500	8.00	8488

$$\phi V_{cbx} = \phi (2)(A_{Vc} / A_{Vco}) \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_{by} \text{ (Sec. D.4.1, D.6.2.1(c) & Eq. D-21)}$$

A_{Vc} (in ²)	A_{Vco} (in ²)	$\psi_{ed,V}$	$\psi_{c,V}$	$\psi_{h,V}$	V_{by} (lb)	ϕ	ϕV_{cbx} (lb)
238.44	288.00	1.000	1.000	1.000	8488	0.70	9838

Shear parallel to edge in y-direction:

$$V_{bx} = 7(l_e / d_a)^{0.2} \sqrt{d_a \lambda} \sqrt{f'_c c_{a1}}^{1.5} \text{ (Eq. D-24)}$$

l_e (in)	d_a (in)	λ	f'_c (psi)	c_{a1} (in)	V_{bx} (lb)
4.00	0.50	1.00	2500	7.87	8282

$$\phi V_{cbx} = \phi (2)(A_{Vc} / A_{Vco}) \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_{bx} \text{ (Sec. D.4.1, D.6.2.1(c) & Eq. D-21)}$$

A_{Vc} (in ²)	A_{Vco} (in ²)	$\psi_{ed,V}$	$\psi_{c,V}$	$\psi_{h,V}$	V_{bx} (lb)	ϕ	ϕV_{cbx} (lb)
188.88	278.72	1.000	1.000	1.000	8282	0.70	7858

10. Concrete Pryout Strength of Anchor in Shear (Sec. D.6.3)

$$\phi V_{cp} = \phi \min[k_{cp} N_a; k_{cp} N_{cb}] = \phi \min[k_{cp}(A_{Na} / A_{Na0}) \psi_{ed,Na} \psi_{p,Na} N_{a0}; k_{cp}(A_{Nc} / A_{Nco}) \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b] \text{ (Eq. D-30a)}$$

k_{cp}	A_{Na} (in ²)	A_{Na0} (in ²)	$\psi_{ed,Na}$	$\psi_{p,Na}$	N_{a0} (lb)	N_a (lb)
2.0	109.66	109.66	1.000	1.000	9755	9755

A_{Nc} (in ²)	A_{Nco} (in ²)	$\psi_{ed,N}$	$\psi_{c,N}$	$\psi_{cp,N}$	N_b (lb)	N_{cb} (lb)	ϕ	ϕV_{cp} (lb)
253.92	256.00	0.995	1.000	1.000	10469	10334	0.70	13657

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

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11. Results

Interaction of Tensile and Shear Forces (Sec. D.7)

Tension	Factored Load, N _{ua} (lb)	Design Strength, ϕN _n (lb)	Ratio	Status	
Steel	405	6071	0.07	Pass	
Concrete breakout	405	6717	0.06	Pass	
Adhesive	405	5365	0.08	Pass (Governs)	
Shear	Factored Load, V _{ua} (lb)	Design Strength, ϕV _n (lb)	Ratio	Status	
Steel	101	3156	0.03	Pass (Governs)	
T Concrete breakout y+	101	4411	0.02	Pass	
T Concrete breakout x+	6	3549	0.00	Pass	
Concrete breakout y+	6	9838	0.00	Pass	
Concrete breakout x+	101	7858	0.01	Pass	
Concrete breakout, combined	-	-	0.02	Pass	
Pryout	101	13657	0.01	Pass	
Interaction check	N _{ua} /ϕN _n	V _{ua} /ϕV _n	Combined Ratio	Permissible	Status
Sec. D.7.1	0.08	0.00	7.5 %	1.0	Pass

AT-XP w/ 1/2"Ø A193 Gr. B8/B8M (304/316SS) with hef = 6.000 inch meets the selected design criteria.

12. Warnings

- This temperature range is currently outside the scope of ACI 318-11 and ACI 355.4, and is provided for historical purposes.
- Designer must exercise own judgement to determine if this design is suitable.
- Refer to manufacturer's product literature for hole cleaning and installation instructions.



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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 318-05
Units: Imperial units

Anchor Information:

Anchor type: Bonded anchor
Material: A193 Grade B8/B8M (304/316SS)
Diameter (inch): 0.500
Effective Embedment depth, h_{ef} (inch): 6.000
Code report: IAPMO UES ER-263
Anchor category: -
Anchor ductility: Yes
 h_{min} (inch): 8.50
 C_{ac} (inch): 9.67
 C_{min} (inch): 1.75
 S_{min} (inch): 3.00

Load and Geometry

Load factor source: ACI 318 Section 9.2
Load combination: not set
Seismic design: No
Anchors subjected to sustained tension: No
Apply entire shear load at front row: No
Anchors only resisting wind and/or seismic loads: No

Base Material

Concrete: Normal-weight
Concrete thickness, h (inch): 18.00
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
Do not evaluate concrete breakout in tension: No
Do not evaluate concrete breakout in shear: No
Hole condition: Dry concrete
Inspection: Periodic
Temperature range, Short/Long: 110/75°F
Ignore 6do requirement: Not applicable
Build-up grout pad: No

Base Plate

Length x Width x Thickness (inch): 9.00 x 4.00 x 0.28

<Figure 1>



Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

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<Figure 2>



Recommended Anchor

Anchor Name: AT-XP® - AT-XP w/ 1/2"Ø A193 Gr. B8/B8M (304/316SS)

Code Report: IAPMO UES ER-263





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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	732.5	499.5	0.0	499.5
2	732.5	499.5	0.0	499.5
Sum	1465.0	999.0	0.0	999.0

Maximum concrete compression strain (‰): 0.00
Maximum concrete compression stress (psi): 0
Resultant tension force (lb): 1465
Resultant compression force (lb): 0
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. D.5.1)

N _{sa} (lb)	φ	φN _{sa} (lb)
8095	0.75	6071

5. Concrete Breakout Strength of Anchor in Tension (Sec. D.5.2)

$$N_b = k_c \lambda \sqrt{f'_c} h_{ef}^{1.5} \text{ (Eq. D-7)}$$

k _c	λ	f' _c (psi)	h _{ef} (in)	N _b (lb)
17.0	1.00	2500	5.333	10469

$$\phi N_{cbg} = \phi (A_{Nc} / A_{Nco}) \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b \text{ (Sec. D.4.1 \& Eq. D-5)}$$

A _{Nc} (in ²)	A _{Nco} (in ²)	ψ _{ec,N}	ψ _{ed,N}	ψ _{c,N}	ψ _{cp,N}	N _b (lb)	φ	φN _{cbg} (lb)
314.72	256.00	1.000	0.865	1.00	1.000	10469	0.65	7233

6. Adhesive Strength of Anchor in Tension (AC308 Sec. 3.3)

$$\tau_{k,cr} = \tau_{k,cr} f_{short-term} K_{sat}$$

τ _{k,cr} (psi)	f _{short-term}	K _{sat}	τ _{k,cr} (psi)
1035	1.00	1.00	1035

$$N_{a0} = \tau_{k,cr} \pi d_a h_{ef} \text{ (Eq. D-16f)}$$

τ _{k,cr} (psi)	d _a (in)	h _{ef} (in)	N _{a0} (lb)
1035	0.50	6.000	9755

$$\phi N_{ag} = \phi (A_{Na} / A_{Na0}) \psi_{ed,Na} \psi_{g,Na} \psi_{ec,Na} \psi_{p,Na} N_{a0} \text{ (Sec. D.4.1 \& Eq. D-16b)}$$

A _{Na} (in ²)	A _{Na0} (in ²)	ψ _{ed,Na}	ψ _{g,Na}	ψ _{ec,Na}	ψ _{p,Na}	N _{a0} (lb)	φ	φN _{ag} (lb)
177.03	109.66	0.952	1.021	1.000	1.000	9755	0.55	8418

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

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8. Steel Strength of Anchor in Shear (Sec. D.6.1)

V_{sa} (lb)	ϕ_{grout}	ϕ	$\phi_{grout}\phi V_{sa}$ (lb)
4855	1.0	0.65	3156

9. Concrete Breakout Strength of Anchor in Shear (Sec. D.6.2)

Shear perpendicular to edge in x-direction:

$$V_{bx} = 7(l_e / d_a)^{0.2} \sqrt{d_a \lambda} \sqrt{f'_c c_{at}}^{1.5} \text{ (Eq. D-24)}$$

l_e (in)	d_a (in)	λ	f'_c (psi)	c_{at} (in)	V_{bx} (lb)
4.00	0.50	1.00	2500	12.00	15593

$$\phi V_{cbx} = \phi (A_{Vc} / A_{Vco}) \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_{bx} \text{ (Sec. D.4.1 & Eq. D-21)}$$

A_{Vc} (in ²)	A_{Vco} (in ²)	$\psi_{ed,V}$	$\psi_{c,V}$	$\psi_{h,V}$	V_{bx} (lb)	ϕ	ϕV_{cbx} (lb)
288.00	648.00	0.833	1.000	1.000	15593	0.70	4043

Shear parallel to edge in x-direction:

$$V_{by} = 7(l_e / d_a)^{0.2} \sqrt{d_a \lambda} \sqrt{f'_c c_{at}}^{1.5} \text{ (Eq. D-24)}$$

l_e (in)	d_a (in)	λ	f'_c (psi)	c_{at} (in)	V_{by} (lb)
4.00	0.50	1.00	2500	8.00	8488

$$\phi V_{cbgx} = \phi (2)(A_{Vc} / A_{Vco}) \psi_{ec,V} \psi_{ed,V} \psi_{c,V} \psi_{h,V} V_{by} \text{ (Sec. D.4.1, D.6.2.1(c) & Eq. D-22)}$$

A_{Vc} (in ²)	A_{Vco} (in ²)	$\psi_{ec,V}$	$\psi_{ed,V}$	$\psi_{c,V}$	$\psi_{h,V}$	V_{by} (lb)	ϕ	ϕV_{cbgx} (lb)
284.04	288.00	1.000	1.000	1.000	1.000	8488	0.70	11720

10. Concrete Pryout Strength of Anchor in Shear (Sec. D.6.3)

$$\phi V_{cpg} = \phi \min[k_{cp} N_{ag} ; k_{cp} N_{cbg}] = \phi \min[k_{cp}(A_{Na} / A_{Na0}) \psi_{ed,Na} \psi_{g,Na} \psi_{ec,Na} \psi_{p,Na} N_{a0} ; k_{cp}(A_{Nc} / A_{Nco}) \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b] \text{ (Eq. D-30b)}$$

k_{cp}	A_{Na} (in ²)	A_{Na0} (in ²)	$\psi_{ed,Na}$	$\psi_{g,Na}$	$\psi_{ec,Na}$	$\psi_{p,Na}$	N_{a0} (lb)	N_a (lb)
2.0	177.03	109.66	0.952	1.021	1.000	1.000	9755	15305

A_{Nc} (in ²)	A_{Nco} (in ²)	$\psi_{ec,N}$	$\psi_{ed,N}$	$\psi_{c,N}$	$\psi_{cp,N}$	N_b (lb)	N_{cb} (lb)	ϕ
314.72	256.00	1.000	0.865	1.000	1.000	10469	11128	0.70

ϕV_{cpg} (lb)
15580

11. Results

Interaction of Tensile and Shear Forces (Sec. D.7)

Tension	Factored Load, N _{ua} (lb)	Design Strength, ϕN _n (lb)	Ratio	Status	
Steel	733	6071	0.12	Pass	
Concrete breakout	1465	7233	0.20	Pass (Governs)	
Adhesive	1465	8418	0.17	Pass	
Shear	Factored Load, V _{ua} (lb)	Design Strength, ϕV _n (lb)	Ratio	Status	
Steel	500	3156	0.16	Pass	
T Concrete breakout x+	999	4043	0.25	Pass (Governs)	
Concrete breakout y-	999	11720	0.09	Pass (Governs)	
Pryout	999	15580	0.06	Pass	
Interaction check	N _{ua} /ϕN _n	V _{ua} /ϕV _n	Combined Ratio	Permissible	Status

Input data and results must be checked for agreement with the existing circumstances, the standards and guidelines must be checked for plausibility.

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Sec. D.7.3	0.20	0.25	45.0 %	1.2	Pass
------------	------	------	--------	-----	------

AT-XP w/ 1/2"Ø A193 Gr. B8/B8M (304/316SS) with hef = 6.000 inch meets the selected design criteria.

12. Warnings

- This temperature range is currently outside the scope of ACI 318-11 and ACI 355.4, and is provided for historical purposes.
- Designer must exercise own judgement to determine if this design is suitable.
- Refer to manufacturer's product literature for hole cleaning and installation instructions.

Compression

3.4.7

$$\begin{aligned}\lambda &= 1.68476 \\ r &= 0.437 \text{ in} \\ S1^* &= \frac{Bc - Fcy}{1.6Dc^*} \\ S1^* &= 0.33515 \\ S2^* &= \frac{Cc}{\pi} \sqrt{Fcy/E} \\ S2^* &= 1.23671 \\ \phi_{cc} &= 0.81587 \\ \phi_{FL} &= (\phi_{cc} Fcy) / (\lambda^2) \\ \phi_{FL} &= 10.0603 \text{ ksi}\end{aligned}$$

3.4.9

$$\begin{aligned}b/t &= 7.75 \\ S1 &= 12.21 \text{ (See 3.4.16 above for formula)} \\ S2 &= 32.70 \text{ (See 3.4.16 above for formula)} \\ \phi_{FL} &= \phi_y Fcy \\ \phi_{FL} &= 33.3 \text{ ksi} \\ b/t &= 7.75 \\ S1 &= 12.21 \\ S2 &= 32.70 \\ \phi_{FL} &= \phi_y Fcy \\ \phi_{FL} &= 33.3 \text{ ksi}\end{aligned}$$

3.4.10

$$\begin{aligned}Rb/t &= 0.0 \\ S1 &= \left(\frac{Bt - \frac{\theta_y}{\theta_b} Fcy}{Dt} \right)^2 \\ S1 &= 6.87 \\ S2 &= 131.3 \\ \phi_{FL} &= \phi_y Fcy \\ \phi_{FL} &= 33.25 \text{ ksi} \\ \phi_{FL} &= 10.06 \text{ ksi} \\ A &= 323.87 \text{ mm}^2 \\ &= 0.50 \text{ in}^2 \\ P_{max} &= 5.05 \text{ kips}\end{aligned}$$

APPENDIX B

B.1

The following pages will contain the results from RISA. Please refer back to Section 2 for load information and Section 4-5 for member and foundation design.