SOLAR PV GROUND MOUNT STRUCTURAL CALCULATIONS

APA SOLAR RACKING
20-345 County Road X, PO Box 326
Ridgeville Corners, OH 43555

Office: 419.267.5280
Fax: 419.267.5214

LOCATION

Illinois

PRINT PACKAGE NUMBER:

240822

REVISION: A

ON:

10/25/2024

DESIGN CRITERIA:

TITAN
25° TILT
20 PSF SNOW
101 MPH WIND, RISK CAT I, EX. C.

ASCE7-16
Allowable Stress Design (ASD)

the jdi group
architects & engineers

360 W. Dussel Drive
Maumee, OH 43537
Office: 419.725.7161
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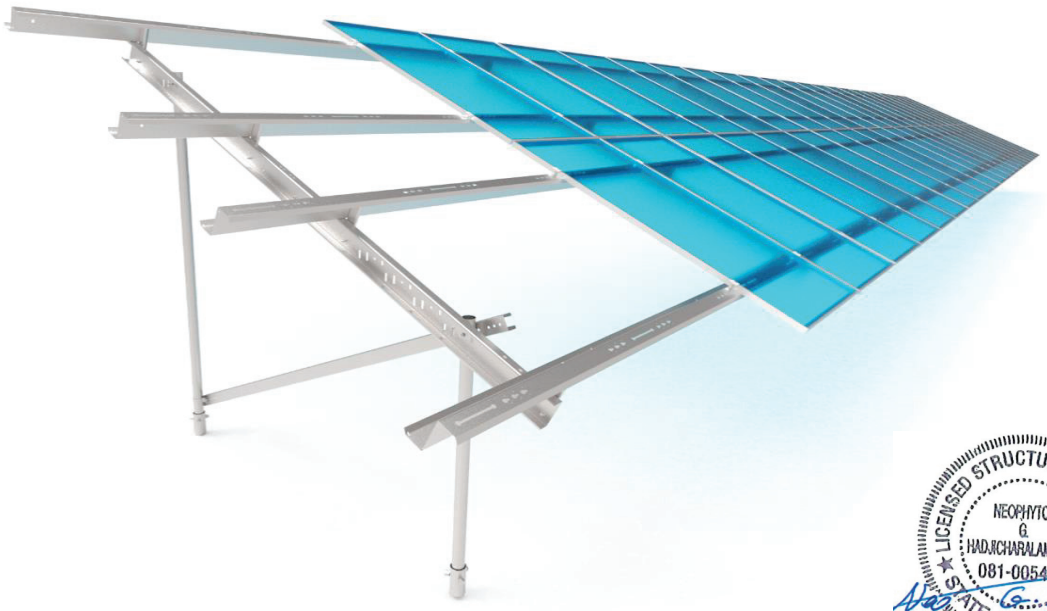

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LOAD CALCULATIONS

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General Calculations

General Dimensions

Quantity of PV Modules, Vertically (Cartridge)	PV_Q =	**1**
PV Module Tilt	PVT =	**25°**
PV Module Length	PVL =	**97.01 in**
PV Module Width	PVW =	**44.65 in**
PV Module Area	PVA = PVL × PVW =	**30.08 ft^2**
PV Module Weight	PV_{LB} =	**69 lbs**
Force Resisting Members Quantity	M_Q =	**2**
Vertical Section Flat Length (chord)	$PV_{FL} = PV_L \times PV_Q$ =	**8.08 ft**
Vertical Section Profile Length (at tilt)	$PV_{PL} = PV_{FL} \times \cos(PV_T)$ =	**7.33 ft**
Horizontal Width (at tilt)	$PV_{PW} = PV_W$ =	**3.72 ft**
Profile Height (at tilt)	$PV_{PH} = PV_{FL} \times \sin(PV_T)$ =	**3.42 ft**
Area Projected Vertically	$PV_{AV} = PV_{PL} \times PV_{PW}$ =	**27.26 ft^2**
Area Projected Horizontally	$PV_{AH} = PV_{PH} \times PV_{PW}$ =	**12.71 ft^2**

Dead Loading

Force Resisting Member Weight	M_W =	**2.75 lbs/ft**
Cartridge Weight per Member	$PV_{LBT} = PV_{LB} / PV_Q / M_Q$ =	**34.5 lbs**
Misc. Hardware Weight per Vertical Section	W_{MH} =	**5.00 lbs**
Dead Load per Vertical Section	$DL_T = -(PV_{LB} \times PV_Q + M_W \times PV_W \times M_Q \times PV_Q + W_{MH})$ =	**-94.46 lbs**
TD: Distributed Dead Load on Member	$DL_o = DL_T / PV_Q / M_Q / PV_W$ =	**12.69 lbs/ft**

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SNOW

Snow loading (ASCE7-16)

Tedds calculation version 1.0.09

Building details

Roof type	Monoslope	
Width of roof	b=	**7.33 ft**
Slope of roof 1	α=	**25 deg**

Ground snow load

Ground snow load	Pg=	**20 lb/ft^2**
Density of snow	ɣ=	**16.6 lb/ft^3**
Terrain type	C (see Section 26.7)	
Exposure condition (Table 7-2)	Fully Exposed	
Exposure factor (Table 7-2)	Ce=	**0.9**
Thermal condition (Table 7-3)	Unheated and open air structures	
Thermal factor (Table 7-3)	Ct=	**1.2**
Risk category (Table 1-1)	I	
Risk factor (Table 7-4)	Is=	**0.8**
Flat roof snow load (Sect 7.3)	pf = 0.7*Ce*Ct Is*pg =	**12.096 lb/ft^2**

Cold roof slope factor (Ct > 1.0)

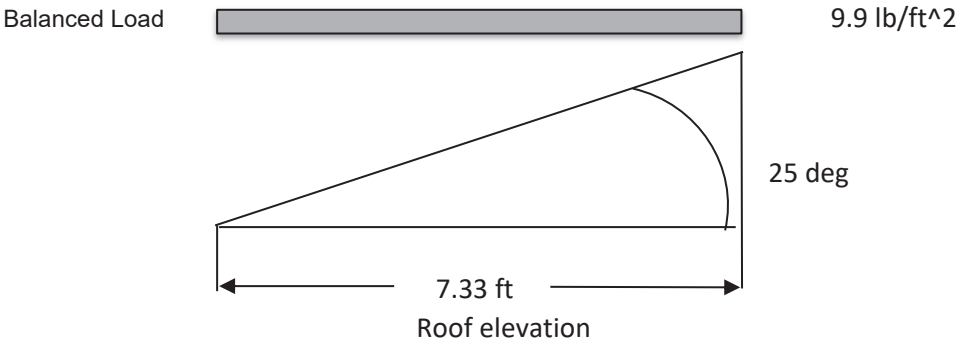
Roof surface type	Slippery	
Ventilation	Ventilated	
Thermal resistance (R-value)	R=	**30**
Roof slope factor Fig 7-2c (dashed line)	Cs=	**0.82**

Monoslope

Sloped roof snow load (Cl.7.4)	ps = Cs x pf =	**9.9 lb/ft^2**

Distributed Snow Loading

Snow Load per Vertical Section	$SL_T = -(p_s \times PV_{AV})$ =	**269.89 lbs**
TD: Distributed Snow Load on Member	$SL = SL_T/PV_Q/M_Q/PV_W$ =	**36.27 lbs/ft/mem.**



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SEISMIC

Seismic Forces (ASCE7-16)

Tedds calculation version 3.1.01

Site parameters

Site class	D	
Mapped acceleration parameters (Section 11.4.1)		
at short period	S_S =	**0.149**
at 1 sec period	S_1 =	**0.087**
Site coefficientshort period (Table 11.4-1)	F_a =	**1.6**
at 1 sec period (Table 11.4-2)	F_v =	**2.4**

Spectral response acceleration parameters

at short period (Eq. 11.4-1)	S_{MS} =	**0.2384**
at 1 sec period (Eq. 11.4-2)	S_{M1} =	**0.2088**

Design spectral acceleration parameters (Sect 11.4.4)

at short period (Eq. 11.4-3)	S_{DS} =	**0.1589333**
at 1 sec period (Eq. 11.4-4)	S_{D1} =	**0.1392**

Seismic design category

Risk category (Table 1.5-1)	I	
Seismic design category	A	

Approximate fundamental period

Height above base to highest level of building	h_n =	**10.48 ft.**
From Table 12.8-2:		
Structure type	All other systems	
Building period parameter Ct	C_t =	**0.02**
Building period parameter x	x =	**0.75**
Approximate fundamental period (Eq 12.8-7)	T_a =	**0.116 sec**
Building fundamental period (Sect 12.8.2)	T =	**0.116**
Long-period transition period	T_L =	**12**

Seismic response coefficient

Seismic force-resisting system (Table 12.2-1)	G. CANTILEVERED COLUMN SYSTEMS DETAILED TO CONFORM TO THE REQUIRE 2. Steel ordinary cantilever column systems	
Response modification factor (Table 12.2-1)	R =	**1.25**
Seismic importance factor (Table 1.5-2)	I_e =	**1.00**
Seismic response coefficient (Sect 12.8.1.1)		

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Maximum ((Eq 12.8-3))	C_{s_max} =	**0.9560**	
Minimum:			
Eq 12.8-5	C_{s_min} =	**0.01**	
Calculated (Eq 12.8-3)	C_{s_calc} =	**0.1271467**	
Seismic response coefficient	C_s =	**0.1271467**	
Seismic base shear (Sect 12.8.1)			
Effective seismic weight of the structure	W =	**10.391104**	**kips**
Seismic base shear (Eq 12.8-1)	$V = C_s \times W$ =	**1.3**	**kips**
Distributed Seismic Loading			
Analyzed Rack Length	AR_L =	**2522.45**	**in**
Analyzed Rack Weight	$AR_{LB} = AR_L / (PW_{PW} \times 0.75) \times 2 \times DL_T$ =		**10391 lbs**
Analyzed Rack Anchor Qty	AR_A =	22	
Load per node (top of post)	$EL = V/AR_A$ =	**60.05 lbs/post**	

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WIND

Wind Loading (ASCE7-16)

General wind load requirements

Basic wind speed	V =	**101 mph**
Risk category	I	
Velocity pressure exponent coeff(Table26.6-1)	K_d =	**0.85**
Exposure category (cl.26.7.3)	C	

Topography

Topography factor not significant	K_{zt} =	**1.00**

Velocity pressure

Velocity pressure coefficient (T.29.3-1)	K_z =	**0.85**
Velocity pressure	$q_h=0.00256 \times K_z \times K_{zt} \times K_d \times V^2 \times 1psf/mph2$ =	**18.84 psf**

Pressures and forces

Net pressure	p = qh × GCN
Net force	$F_w = p \times A_{ref}$
Area (per zone)	$A_{ref} = PV_A$

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CPP Wind Loading Table
Titan

	Load Case	Load Case Desc.	Panel Load Loc.	CPP Pressure Coeff. G_{CN}	Net Pressure, p (psf)	Net Force, F_w (lbs)	Rails	Net Force per Rail (lbs/ft)
Green Zone	1	CPP E-W Rail-Up	1	-1.47	-27.65	-207.95	4	112
			2	-0.73	-13.73	-103.25		55
			3	-0.51	-9.61	-72.28		39
			4	-0.32	-6.11	-45.98		25
	2	CPP Half Chord-Up	1	-1.38	-26.07	-196.03		105
			2	-1.01	-18.99	-142.78		77
			3	-0.60	-11.29	-84.87		46
			4	-0.37	-6.91	-51.98		28
	3	CPP Post Pair-Up	1	-1.96	-36.96	-277.96		149
			2	-1.52	-28.60	-215.07		116
			3	-1.14	-21.52	-161.86		87
			4	-0.69	-13.09	-98.47		53
	4	CPP Post Pair-Down	1	0.38	7.17	53.90		-29
			2	0.54	10.10	75.99		-41
			3	0.67	12.59	94.66		-51
			4	0.69	12.99	97.69		-53
	5	CPP Half Chord-Down	1	0.24	4.55	34.19		-18
			2	0.38	7.23	54.34		-29
			3	0.53	10.02	75.38		-41
			4	0.63	11.81	88.79		-48
	6	CPP E-W Rail-Down	1	0.25	4.73	35.58		-19
			2	0.42	7.95	59.76		-32
			3	0.53	9.94	74.72		-40
			4	0.51	9.65	72.60		-39

	Load Case	Load Case Desc.	Panel Load Loc.	CPP Pressure Coeff. G_{CN}	Net Pressure, p (psf)	Net Force, F_w (lbs)	Rails	Net Force per Rail (lbs/ft)
	1	CPP E-W Rail-Up	1	-1.86	-35.06	-263.62		142
			2	-0.91	-17.24	-129.64		70
			3	-0.67	-12.56	-94.44		51
			4	-0.43	-8.11	-60.96		33
	2	CPP Half Chord-Up	1	-1.77	-33.43	-251.36		135
			2	-1.33	-25.02	-188.17		101
			3	-0.75	-14.23	-107.03		58
			4	-0.44	-8.29	-62.34		34
one			1	-2.31	-43.51	-327.17		176

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Yellow Zc	3	CPP Post Pair-Up	2	-1.94	-36.54	-274.79	4	148
			3	-1.54	-29.09	-218.75		118
			4	-0.99	-18.59	-139.79		75
	4	CPP Post Pair-Down	1	0.53	10.00	75.22		-40
			2	0.90	17.01	127.94		-69
			3	1.24	23.45	176.37		-95
			4	1.38	26.05	195.91		-105
	5	CPP Half Chord-Down	1	0.35	6.58	49.46		-27
			2	0.61	11.44	86.00		-46
			3	0.95	17.94	134.89		-73
			4	1.08	20.45	153.81		-83
	6	CPP E-W Rail-Down	1	0.35	6.67	50.15		-27
			2	0.59	11.14	83.79		-45
			3	0.80	15.08	113.37		-61
			4	1.10	20.84	156.70		-84

Orange Zone	Load Case	Load Case Desc.	Panel Load Loc.	CPP Pressure Coeff. G_{CN}	Net Pressure, p (psf)	Net Force, F_w (lbs)	Rails	Net Force per Rail (lbs/ft)
	1	CPP E-W Rail-Up	1	-2.52	-47.48	-357.04	4	192
			2	-0.86	-16.30	-122.59		66
			3	-0.55	-10.44	-78.50		42
			4	-0.38	-7.13	-53.61		29
	2	CPP Half Chord-Up	1	-2.65	-49.96	-375.69		202
			2	-1.32	-24.92	-187.42		101
			3	-0.96	-18.18	-136.68		73
			4	-0.69	-13.02	-97.94		53
	3	CPP Post Pair-Up	1	-3.90	-73.50	-552.70		297
			2	-2.21	-41.72	-313.73		169
			3	-1.76	-33.23	-249.88		134
			4	-1.27	-23.89	-179.69		97
	4	CPP Post Pair-Down	1	0.76	14.42	108.46		-58
			2	1.17	22.09	166.08		-89
			3	1.80	33.97	255.44		-137
			4	2.03	38.38	288.64		-155
	5	CPP Half Chord-Down	1	0.68	12.87	96.77		-52
			2	1.06	20.02	150.58		-81
			3	1.81	34.08	256.25		-138
			4	2.01	37.86	284.71		-153
	6	CPP E-W Rail-Down	1	0.45	8.41	63.28		-34
			2	0.58	10.96	82.45		-44
			3	1.05	19.87	149.44		-80
			4	1.54	29.01	218.13		-117

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Load data - with ASD Combos (for reactions)

GLOSSARY

Load conditions

Condition	Description	Comb.	Category
DL	Dead Load	No	DL
SL	Snow Load	No	SNOW
WL1	Wind - APA_CPP - EW Rail / Up - 0° (S-N)	No	WIND
WL2	Wind - APA_CPP - Half Chord/ Up - 0° (S-N)	No	WIND
WL3	Wind - APA_CPP - Post Pair / Up - 0° (S-N)	No	WIND
WL4	Wind - APA_CPP - Post Pair / Down - 180° (N-S)	No	WIND
WL5	Wind - APA_CPP - Half Chord / Down - 180° (N-S)	No	WIND
WL6	Wind - APA_CPP - EW Rail / Down - 180° (N-S)	No	WIND
EL1	Seismic Left	No	EQ
EL2	Seismic Right	No	EQ
EL3	Seismic North	No	EQ
EL4	Seismic South	No	EQ
D1	DL	Yes	
D2	DL+SL	Yes	
D3	DL+0.75SL	Yes	
D4	DL+0.6WL1	Yes	
D5	DL+0.6WL2	Yes	
D6	DL+0.7EL1	Yes	
D7	DL+0.7EL2	Yes	
D8	DL+0.7EL3	Yes	
D9	DL+0.7EL4	Yes	
D10	DL+0.75SL+0.45WL1	Yes	
D11	DL+0.75SL+0.45WL2	Yes	
D12	DL+0.75SL+0.525EL1	Yes	
D13	DL+0.75SL+0.525EL2	Yes	
D14	DL+0.75SL+0.525EL3	Yes	
D15	DL+0.75SL+0.525EL4	Yes	
D16	0.6DL+0.6WL1	Yes	
D17	0.6DL+0.6WL2	Yes	
D18	0.6DL+0.7EL1	Yes	
D19	0.6DL+0.7EL2	Yes	
D20	0.6DL+0.7EL3	Yes	
D21	0.6DL+0.7EL4	Yes	
D22	DL+0.6WL3	Yes	
D23	DL+0.6WL4	Yes	
D24	DL+0.6WL5	Yes	
D25	DL+0.6WL6	Yes	
D26	DL+0.75SL+0.45WL3	Yes	

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D27	DL+0.75SL+0.45WL4	Yes
D28	DL+0.75SL+0.45WL5	Yes
D29	DL+0.75SL+0.45WL6	Yes
D30	0.6DL+0.6WL3	Yes
D31	0.6DL+0.6WL4	Yes
D32	0.6DL+0.6WL5	Yes
D33	0.6DL+0.6WL6	Yes

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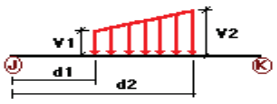
Load on nodes

Condition	Node	FX	FY	FZ	MX	MY	MZ
		[Lb]	[Lb]	[Lb]	[Lb*ft]	[Lb*ft]	[Lb*ft]
EL1	153	60.05	0.00	0.00	0.00	0.00	0.00
EL2	153	-60.05	0.00	0.00	0.00	0.00	0.00
EL3	153	0.00	0.00	60.05	0.00	0.00	0.00
EL4	153	0.00	0.00	-60.05	0.00	0.00	0.00

Distributed Forces on Members



Condition	Member	Dir1	Val1	Val2	Dist1	%	Dist2	%
			[Lb/ft]	[Lb/ft]	[in]		[in]	
DL	376	Y	-12.69	-12.69	0.00	Yes	100.00	Yes
SL	376	Y	-36.27	-36.27	0.00	Yes	100.00	Yes
WL1	See Pages 9-10							
WL2	See Pages 9-10							
WL3	See Pages 9-10							
WL4	See Pages 9-10							
WL5	See Pages 9-10							
WL6	See Pages 9-10							

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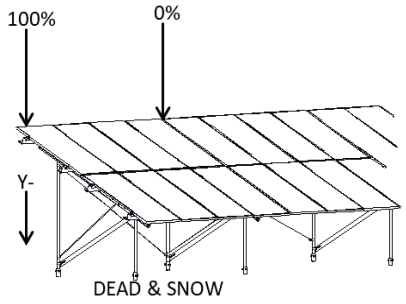

Figure 1: Load Direction Y

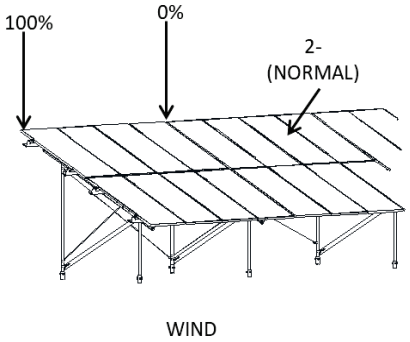

Figure 2: Load Direction 2

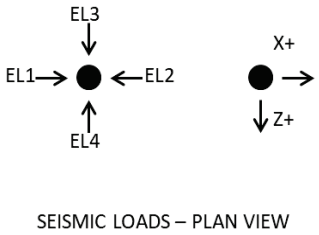

Figure 3: Load Direction X & Z

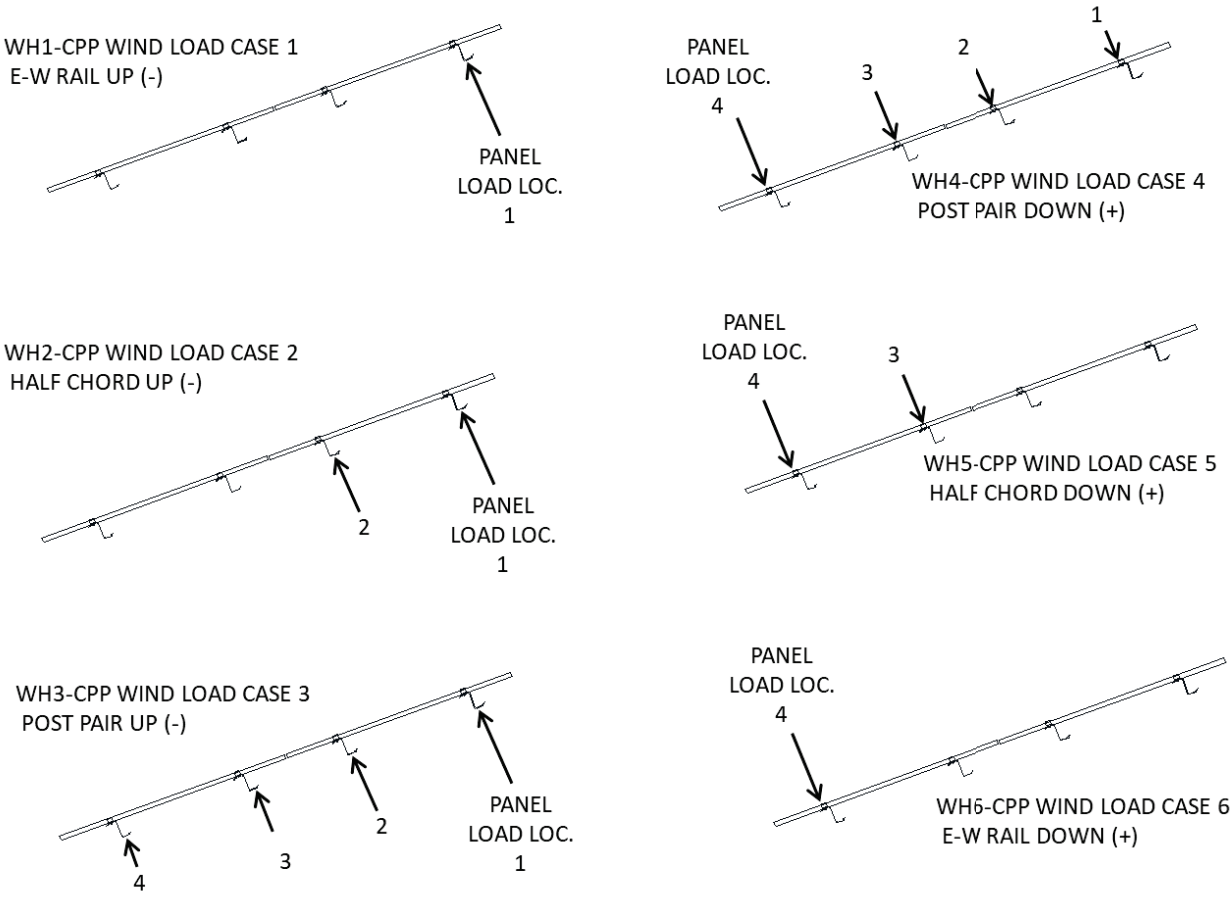

Figure 4: Load CPP Wind Loads

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WIND TUNNEL DATA

CERMAK PETERKA PETERSEN

CPP Project 17649 -
Wind Tunnel Tests and Wind Load Analysis for APA Solar FIXED-TILT GROUND MOUNT

Executive Summary

CPP, Inc. has evaluated wind loads on a generic array of fixed-tilt ground-mounted photovoltaic (PV) solar panels produced by APA Solar. The wind tunnel data used in the analysis is from the CPP proprietary ground mount wind loads database. This database consists of simultaneous surface pressure measurements at a large number of locations on the solar panels. The database contains data for a large number of configurations with varying combinations of tilt, ground clearance, and row spacing. The geometric parameters of the APA Solar system studied are summarized below:

	Range of applicability
Chord length:	140 in to 200 in, with results presented for two chord lengths and interpolation appropriate between the presented chord lengths
Tilt:	5°, 15°, 22.5°, 30° and 45°, allowable with interpolation appropriate between presented results.
Height (low edge of modules):	≤0.5L, with results presented for three low-edge heights (0.2L, 0.35L & 0.5L) and interpolation appropriate between the presented heights.
Row spacing (clear gap):	≤4LSin(tilt), with results presented for 1.5, 2.75 and 4LSin(tilt) and interpolation appropriate between the presented row spacings
Post spacing (along row):	≥0.5L, with results presented for 4 post spacings of 0.5L, 1L, 1.5L and 2.75L and interpolations appropriate between the presented post spacings

The wind loads determined by CPP are based upon measurements obtained in an atmospheric boundary layer wind tunnel study conducted in accordance with the test procedures described in ASCE 7. The primary goal of this study was to determine peak forces on an array of panels for the purpose of calculating design wind loads. The results are presented as load cases, defined in this document. These loads vary with position within the array and, as expected, the worst case- loads were found at the array perimeter. Interior portions of the array were generally found to have substantially lower wind loads than perimeter locations due to sheltering

Wind Tunnel Load Cases

The load cases are listed below. In some cases the load effect is the peak load on a fraction of the chord (e.g. the high rail or half the chord).

$GC_{N\text{-}Post\ \ pair}$ – Peak net pressure on a post-pair tributary area; uplift and downforces; for designs of posts, N-S strut/beam and braces. The tributary area considered includes the full chord and spans halfway to the next post pair; the nominal tributary area for a pair of posts in a dual-post system.

GCN-Post half-chord – Peak net pressure on a single post tributary area; uplift on upper post and downforce on lower post cases; for design of posts, N-S strut, and braces. The tributary area considered includes half of the chord and spans halfway to the next post pair; the nominal tributary area for a single post in a dual-post system.

GCN Rail– Peak net pressure on E-W rails spanning between posts, supporting modules; uplift and downforce cases. The tributary area considered includes one quarter of the chord and spans from one post pair to the next post pair; the nominal tributary area for a rail .

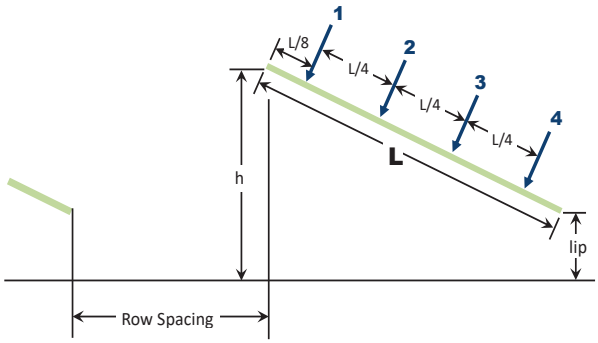

Figure 5: Wind Tunnel Load Distribution Schematic

Wind Tunnel Zone Map

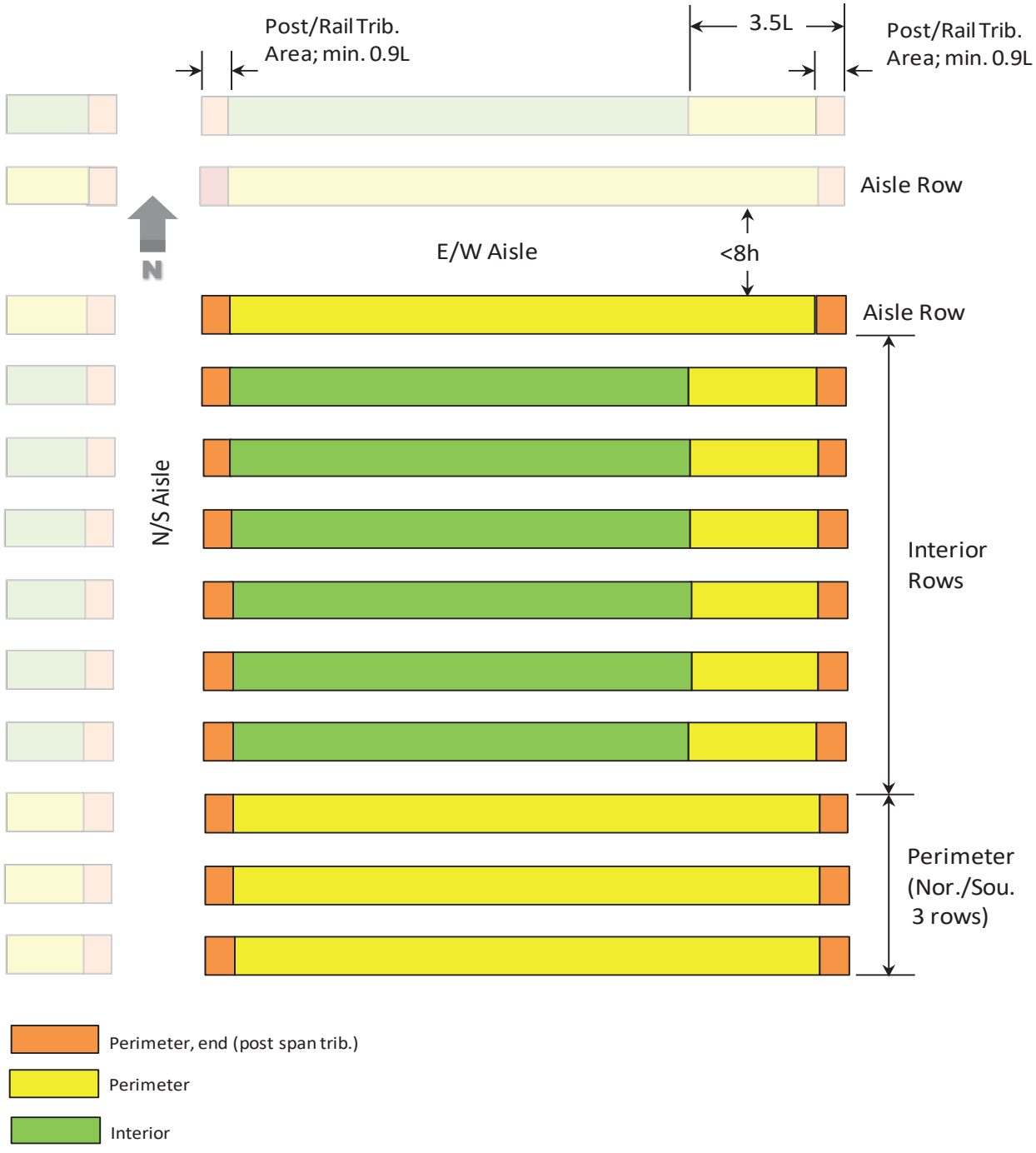

Figure 6: Wind Tunnel Zone Map

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SETUP & ANALYSIS

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Parts list

Note.- Only the graphically selected elements are listed below

Profile	Length [in]	N° of pieces
CABLE BRACE - 1/8	206.87	4
CABLE BRACE - 1/8	248.21	4
STD. BIG ZEE - 6 X 3 X 0...	168	8
STD. BIG ZEE - 6 X 3 X 0...	197.5	16
STD. BIG ZEE - 6 X 3 X 0...	243.25	16
STD. BIG ZEE - 6 X 3 X 0.055	67.73	8
STD. BIG ZEE SPLICE - 6 ...	16	72
STD. TITAN DUO POST - 2...	41.57	11
STD. TITAN DUO POST - 2...	93.55	11
STD. TITAN KNEE BRAC...	117.95	11
STD. TITAN NS CHORD -...	154.63	11
Total N° of pieces		172

List of materials

Profile	Material	Uweight [Lb/ft]	Length [in]	Weight [Lb]
CABLE BRACE - 1/8	APA - A36 - CABLES	1.67E-01	1820.339	25.355
STD. BIG ZEE - 6 X 3 X 0.055	A653 SS 80-1	2.51E+00	8937.84	1872.306
STD. BIG ZEE SPLICE - 6 X 3 X 0.11	A653 SS 80-1	4.97E+00	1152	477.435
STD. TITAN DUO POST - 2.375 X 0.095	APA - A570 GR50	2.34E+00	1486.32	289.857
STD. TITAN KNEE BRACE - 3 X 2 X 0...	A653 SS 80-1	1.99E+00	1297.497	215.651
STD. TITAN NS CHORD - 6 X 2 X 0.108	A653 SS 80-1	3.72E+00	1700.962	527.516
Total weight [Lb]				3408.121

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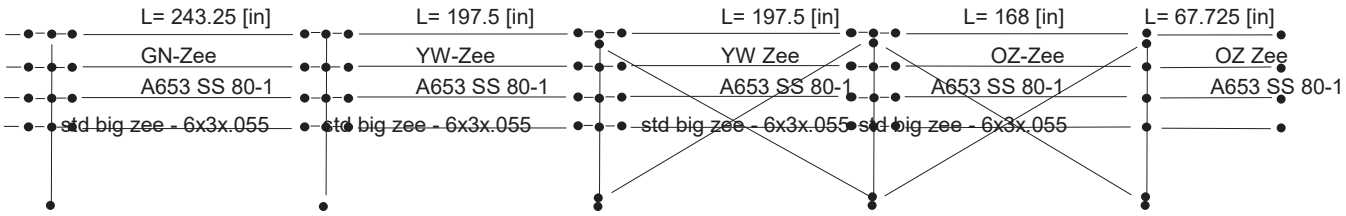

Figure 7: - Member Length, Name, Material, And Section - ORANGE,YELLOW, & GREEN ZONE

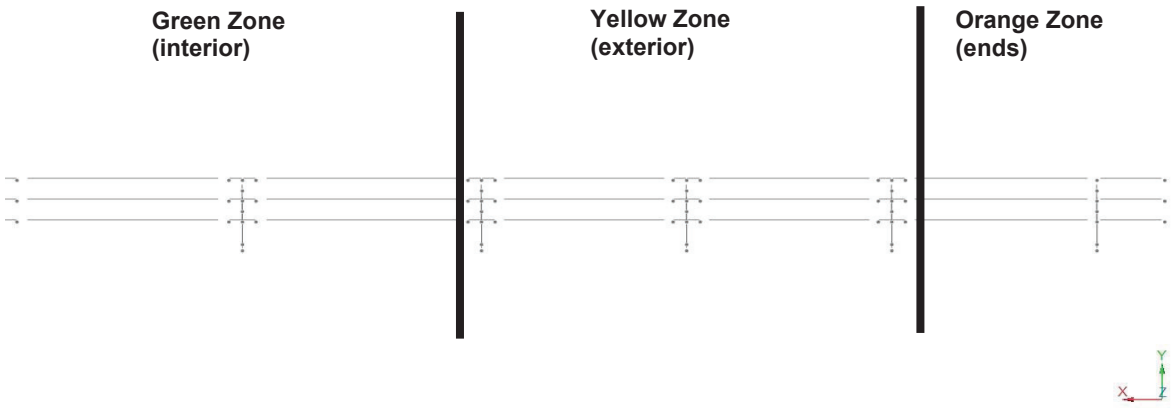

Figure 8: - Racking Zones

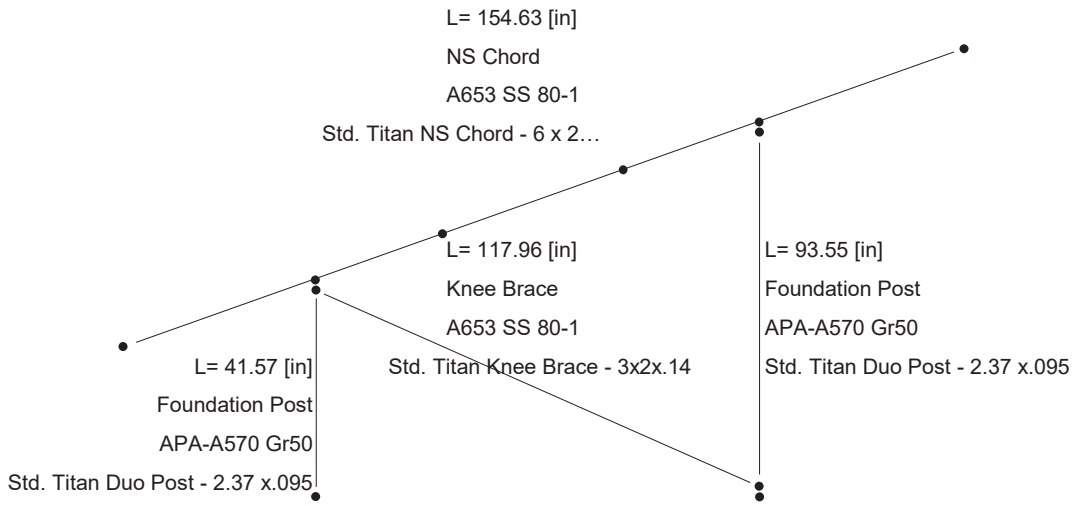

Figure 9: - Member Length, Name, Material, and Section

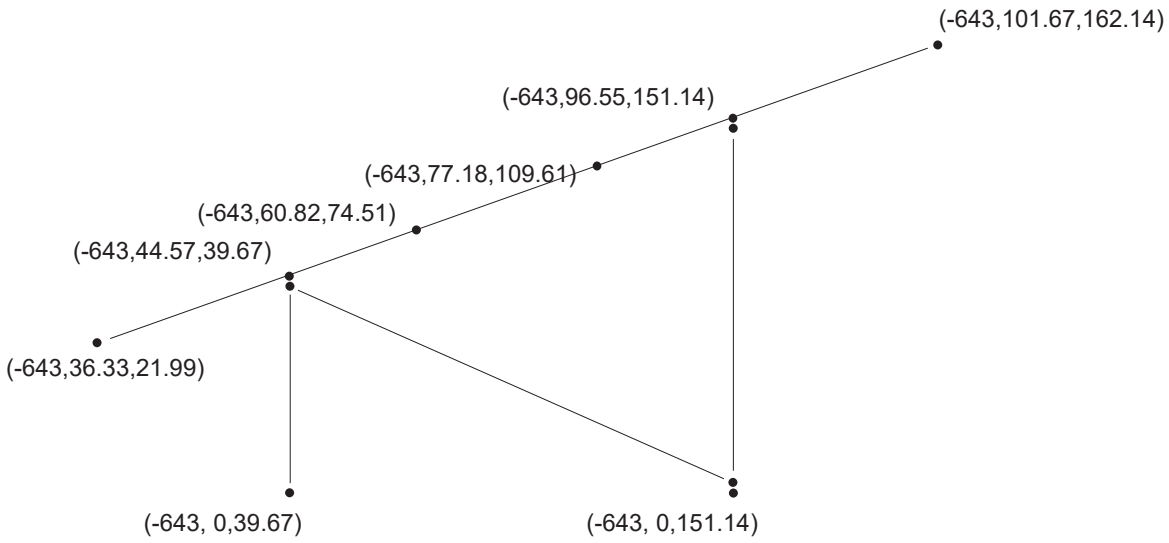

Figure 10: - Node X,Y,Z Coordinate

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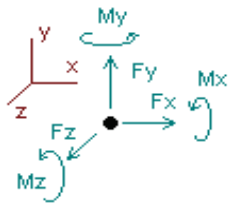
Analysis - Reaction Envelope - ASD

Reactions



Direction of positive forces and moments

Max Uplift:	**-5271 lbs (D30)**
Max Down Load:	**2857 lbs (D27)**
Max Lateral:	**2783 lbs (D30)**

	Forces					Moments	
Node	Fx [Lb]	lc	Fy [Lb]	lc	Fz [Lb]	lc	My [Lb*ft]	lc
145-max	227.882	D7	2796.28	D27	2553.501	D22	137.0321	D27
145-min	-0.01	D27	-4609.55	D30	-1555.87	D31	-241.3218	D30
151-max	0.002	D26	2252.91	D27	2360.583	D30	131.2238	D13
151-min	-234.365	D18	-4676.06	D30	-1494.92	D23	-232.5468	D30
173-max	-0.006	D19	2781.3	D27	2549.398	D22	148.688	D13
173-min	-231.527	D6	-4611.66	D30	-1551.83	D31	-222.1885	D30
174-max	232.356	D19	2195.55	D27	2290.41	D22	109.4247	D27
174-min	-0.008	D27	-4629.86	D30	-1439.2	D31	-232.7829	D30
185-max	237.682	D7	2810.44	D27	2747.74	D30	144.3788	D13
185-min	-236.338	D6	-5256.89	D30	-1679.68	D23	-237.2037	D30
195-max	229.473	D19	2856.87	D27	2783.21	D30	137.9805	D27
195-min	-227.08	D18	-5271.34	D30	-1708.2	D23	-257.9423	D30
205-max	0.009	D30	2766.97	D27	2504.137	D30	145.6055	D27
205-min	-0.009	D27	-4610.14	D30	-1287.74	D23	-222.71	D30
212-max	0.008	D30	2760.47	D27	2493.232	D22	147.3382	D27
212-min	-0.009	D13	-4602.29	D30	-1277.68	D31	-225.3231	D30
213-max	0.008	D30	2758.97	D27	2431.145	D30	149.836	D27
213-min	-0.009	D13	-4535.87	D30	-1027.48	D23	-220.8001	D30
214-max	0.008	D30	2703.9	D27	2408.635	D22	147.0178	D27
214-min	-0.009	D13	-4477.58	D30	-1042.94	D31	-218.1424	D30

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215-max	0.008 D30	2758.44 D27	2430.269 D30	150.3325 D27
215-min	-0.009 D13	-4535.39 D30	-1026.59 D23	-221.5082 D30
294-max	0.022 D27	2663.71 D27	38.245 D31	257.1537 D27
294-min	-0.021 D30	-158.551 D30	-62.768 D22	-161.4562 D30
296-max	0.02 D27	2082.88 D28	36.747 D23	213.0918 D28
296-min	-0.018 D30	152.302 D20	-58.026 D30	-125.0661 D30
298-max	0.021 D27	2666.99 D27	38.146 D31	257.612 D27
298-min	-0.019 D30	-161.731 D30	-62.668 D22	-161.6078 D30
300-max	0.019 D27	2121.37 D28	35.377 D31	210.1756 D27
300-min	-0.019 D30	144.983 D30	-56.301 D22	-123.5168 D30
302-max	0.022 D27	2674.83 D27	41.289 D23	264.9195 D27
302-min	-0.02 D30	27.593 D30	-67.543 D30	-160.1547 D30
304-max	0.022 D27	2655.21 D27	41.99 D23	264.4239 D27
304-min	-0.019 D30	52.524 D30	-68.415 D30	-159.5918 D30
306-max	0.021 D27	2608.83 D27	31.654 D23	241.6487 D27
306-min	-0.019 D30	27.313 D30	-61.555 D30	-145.4251 D30
308-max	0.02 D13	2616.18 D27	31.407 D31	242.4174 D27
308-min	-0.019 D30	20.049 D30	-61.287 D22	-145.0765 D30
310-max	0.021 D13	2573.23 D27	25.257 D23	228.611 D27
310-min	-0.019 D30	158.904 D30	-59.761 D30	-131.5438 D30
312-max	0.021 D13	2561.85 D27	25.637 D31	227.1415 D27
312-min	-0.019 D30	138.074 D30	-59.207 D22	-131.6129 D30
314-max	0.021 D13	2574.11 D27	25.235 D23	228.838 D27
314-min	-0.019 D30	158.191 D30	-59.739 D30	-131.5358 D30

Mx = 0 for all nodes at ground

Mz = 0 for all nodes at ground

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CODE CHECK

(ASCE7-16, ASD)

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Steel Code Check - SUMMARY

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*Std. Titan NS Chord - 6 x 2 x ...*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*Std. Titan Knee Brace - 3 x 2 ...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 1/8*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*Std. Titan Duo Post - 2.375 x ...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check

_ **Report: Concise**

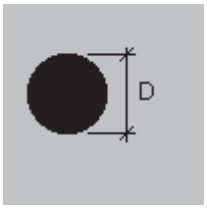
Members: Hot-rolled
Design code: AISC 360-2016 ASD

Member	**:**	**502 (Cable Brace)**
Design status	**:**	**OK**

Section information

Section name: CABLE BRACE - 1/8 **(US)**

Dimensions



D = 0.250 [in] Diameter

Properties

Section properties	**Unit**	**Major axis**	**Minor axis**
Gross area of the section. (Ag)	[in2]	0.049	
Moment of Inertia (local axes) (I)	[in4]	1.91E-04	1.91E-04
Moment of Inertia (principal axes) (I')	[in4]	1.91E-04	1.91E-04
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	0.062	0.062
Radius of gyration (principal axes) (r')	[in]	0.062	0.062
Saint-Venant torsion constant. (J)	[in4]	3.97E-04	
Section warping constant. (Cw)	[in6]	0.000	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	0.001	0.001
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	0.001	0.001
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	0.001	0.001
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	0.001	0.001
Plastic section modulus (local axis) (Z)	[in3]	0.003	0.003
Plastic section modulus (principal axis) (Z')	[in3]	0.003	0.003
Polar radius of gyration. (ro)	[in]	0.088	
Area for shear (Aw)	[in2]	0.049	0.049
Torsional constant. (C)	[in3]	0.004	

Material : APA - A36 - Cables

Properties	**Unit**	**Value**
Yield stress (Fy):	[Lb/in2]	36000.00
Tensile strength (Fu):	[Lb/in2]	58000.00
Elasticity Modulus (E):	[Lb/in2]	2.9E07

Shear modulus for steel (G):	[Lb/in2]	1.150794E07

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[in]	206.87

Distance between member lateral bracing points

Length (Lb) [in]	
Top	Bottom
206.87	206.87

Laterally unbraced length

Length [in]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
206.87	206.87	206.87	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Sway
Minor axis frame type	Sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio	:	0.26			
Capacity	:	1057.25 [Lb]	Reference	:	Cl.D2
Demand	:	273.07 [Lb]	Ctrl Eq.	:	D7 at 50.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω)	[Lb]	1057.25	Cl.D2

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio	:	0.00			
Capacity	:	0.67 [Lb]	Reference	:	Cl.E3
Demand	:	0.00 [Lb]	Ctrl Eq.	:	D18 at 0.00%

Intermediate results	Unit	Value	Reference
Factored flexural buckling strength(P_{n33}/Ω)	[Lb]	0.67	Cl.E3

Compression in the minor axis 22

Ratio	:	0.00			
Capacity	:	0.67 [Lb]	Reference	:	Cl.E3
Demand	:	0.00 [Lb]	Ctrl Eq.	:	D18 at 0.00%

Intermediate results	Unit	Value	Reference
Factored flexural buckling strength(P_{n22}/Ω)	[Lb]	0.67	Cl.E3

FLEXURAL DESIGN

Bending about major axis, M33

Ratio	:	0.00			
Capacity	:	4.30 [Lb*ft]	Reference	:	Cl.F11.1
Demand	:	0.00 [Lb*ft]	Ctrl Eq.	:	D18 at 46.88%

Intermediate results	Unit	Value	Reference
Factored yielding strength(M_n/Ω)	[Lb*ft]	4.30	Cl.F11.1

Bending about minor axis, M22

Ratio	:	0.00			
Capacity	:	4.30 [Lb*ft]	Reference	:	Cl.F11.1
Demand	:	0.01 [Lb*ft]	Ctrl Eq.	:	D13 at 50.00%

Intermediate results	Unit	Value	Reference
Factored yielding strength about a geometric axis(M_n/Ω)	[Lb*ft]	4.30	Cl.F11.1

DESIGN FOR SHEAR

Shear in major axis 33

Ratio	:	0.00			
Capacity	:	634.35 [Lb]	Reference	:	Cl.G1
Demand	:	0.00 [Lb]	Ctrl Eq.	:	D13 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	634.35	Cl.G1

Shear in minor axis 22

Ratio	:	0.00			
Capacity	:	634.35 [Lb]	Reference	:	Cl.G1
Demand	:	0.00 [Lb]	Ctrl Eq.	:	D18 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	634.35	Cl.G1

COMBINED ACTIONS DESIGN

Combined flexure and axial

Ratio	:	0.26			
Ctrl Eq.	:	D7 at 50.00%	Reference	:	Eq.H1-1a

Intermediate results	Unit	Value	Reference

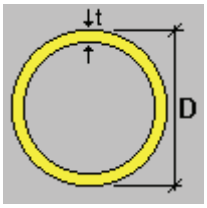
Interaction of flexure and axial force	--	0.26	Eq.H1-1a

Member : 337 (Foundation Post)
Design status : OK

Section information

Section name: Std. Titan Duo Post - 2.375 x 0.095 **(US)**

Dimensions



D	=	2.375	[in]	Diameter
T	=	0.095	[in]	Thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	0.687	
Moment of Inertia (local axes) (I)	[in4]	0.444	0.444
Moment of Inertia (principal axes) (I')	[in4]	0.444	0.444
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	0.804	0.804
Radius of gyration (principal axes) (r')	[in]	0.804	0.804
Saint-Venant torsion constant. (J)	[in4]	0.868	
Section warping constant. (Cw)	[in6]	6.25E-05	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	0.367	0.367
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	0.367	0.367
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	0.367	0.367
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	0.367	0.367
Plastic section modulus (local axis) (Z)	[in3]	0.497	0.497
Plastic section modulus (principal axis) (Z')	[in3]	0.497	0.497
Polar radius of gyration. (ro)	[in]	1.138	
Area for shear (Aw)	[in2]	0.442	0.442
Torsional constant. (C)	[in3]	0.772	

Material : APA - A570 Gr50

Properties	Unit	Value
Yield stress (Fy):	[Lb/in2]	50000.00
Tensile strength (Fu):	[Lb/in2]	65300.00
Elasticity Modulus (E):	[Lb/in2]	2.9E07
Shear modulus for steel (G):	[Lb/in2]	1.150794E07

DESIGN CRITERIA

Description	Unit	Value
Length for tension slenderness ratio (L)	[in]	93.55

Distance between member lateral bracing points

Length (Lb) [in]

Top	Bottom
93.55	93.55

Laterally unbraced length

Length [in]			Effective length factor		
Major axis(L33)	Minor axis(L22)	Torsional axis(Lt)	Major axis(K33)	Minor axis(K22)	Torsional axis(Kt)
93.55	93.55	93.55	1.0	1.0	1.0

Additional assumptions

Continuous lateral torsional restraint	No
Tension field action	No
Continuous flexural torsional restraint	No
Effective length factor value type	None
Major axis frame type	Non sway
Minor axis frame type	Non sway

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio : 0.26
Capacity : 20559.25 [Lb]
Demand : 5271.34 [Lb]
Reference : Cl.D2
Ctrl Eq. : D30 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω)	[Lb]	20559.25	Cl.D2

AXIAL COMPRESSION DESIGN ✔

Compression in the major axis 33

Ratio : 0.37
Capacity : 7631.94 [Lb]
Demand : 2856.87 [Lb]
Reference : Cl.E3
Ctrl Eq. : D27 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n33}/Ω)	[Lb]	7631.94	Cl.E3

Compression in the minor axis 22

Ratio : 0.37
Capacity : 7631.94 [Lb]
Demand : 2856.87 [Lb]
Reference : Cl.E3
Ctrl Eq. : D27 at 0.00%

Intermediate results	Unit	Value	Reference
Section classification			
Factored flexural buckling strength(P_{n22}/Ω)	[Lb]	7631.94	Cl.E3

FLEXURAL DESIGN ✔

Bending about major axis, M33

Ratio	: 0.03			
Capacity	: 1240.05 [Lb*ft]	Reference	: Cl.F8.1	
Demand	: -37.90 [Lb*ft]	Ctrl Eq.	: D19 at 3.13%	

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength(M_n/Ω)	[Lb*ft]	1240.05	Cl.F8.1

Bending about minor axis, M22

Ratio	: 0.37			
Capacity	: 1240.05 [Lb*ft]	Reference	: Cl.F8.1	
Demand	: -459.13 [Lb*ft]	Ctrl Eq.	: D30 at 3.13%	

Intermediate results	Unit	Value	Reference
Section classification			
Factored yielding strength about a geometric axis(M_n/Ω)	[Lb*ft]	1240.05	Cl.F8.1

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	: 0.45			
Capacity	: 6167.77 [Lb]	Reference	: Cl.G1	
Demand	: 2783.21 [Lb]	Ctrl Eq.	: D30 at 0.00%	

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	6167.77	Cl.G1

Shear in minor axis 22

Ratio	: 0.04			
Capacity	: 6167.77 [Lb]	Reference	: Cl.G1	
Demand	: 229.47 [Lb]	Ctrl Eq.	: D19 at 0.00%	

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	6167.77	Cl.G1

TORSION DESIGN ✔

Torsion

Ratio	: 0.22			
Capacity	: 1155.43 [Lb*ft]	Reference	: Cl.H3.1	
Demand	: 257.94 [Lb*ft]	Ctrl Eq.	: D30 at 0.00%	

Intermediate results	Unit	Value	Reference
Factored torsion capacity(T_n/Ω)	[Lb*ft]	1155.43	Cl.H3.1

COMBINED ACTIONS DESIGN ✔

Combined flexure and axial

Ratio : 0.54
Ctrl Eq. : D30 at 3.13% Reference : Eq.H1-1a

Intermediate results	Unit	Value	Reference
Interaction of flexure and axial force	--	0.54	Eq.H1-1a

Combined torsion, flexure, shear and axial

Ratio : 0.31
Ctrl Eq. : D30 at 0.00% Reference : Eq.H3-6

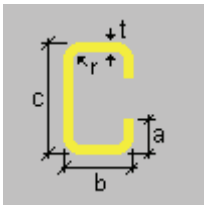
Members: Cold-formed
Design code: AISI 2016 ASD

Member : 322 (NS Chord)
Design status : OK

Section information

Section name: Std. Titan NS Chord - 6 x 2 x 0.108 **(US)**

Dimensions



a	=	0.600	[in]	Lip
b	=	2.000	[in]	Flange width
c	=	6.000	[in]	Depth
r	=	0.219	[in]	Inside bend radius
t	=	0.108	[in]	Thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	1.108	
Moment of Inertia (local axes) (I)	[in4]	5.733	0.525
Moment of Inertia (principal axes) (I')	[in4]	5.733	0.525
Bending constant for moments (principal axis) (J')	[in]	0.000	3.324
Radius of gyration (local axes) (r)	[in]	2.275	0.688
Radius of gyration (principal axes) (r')	[in]	2.275	0.688
Saint-Venant torsion constant. (J)	[in4]	0.005	
Section warping constant. (Cw)	[in6]	4.248	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	-1.466	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	1.911	0.364
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	1.911	0.942
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	1.911	0.364
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	1.911	0.942
Plastic section modulus (local axis) (Z)	[in3]	2.290	0.561
Plastic section modulus (principal axis) (Z')	[in3]	2.290	0.561
Polar radius of gyration. (ro)	[in]	2.793	
Area for shear (Aw)	[in2]	0.409	0.754
Torsional constant. (C)	[in3]	0.042	

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Properties	Unit	Value
Yield stress (Fy):	[Lb/in2]	80000.00
Tensile strength (Fu):	[Lb/in2]	82000.00
Elasticity Modulus (E):	[Lb/in2]	2.95E07
Shear modulus for steel (G):	[Lb/in2]	1.134615E07

DESIGN CRITERIA

Description	Unit	Major axis	Minor axis
Additional hypotheses			
Full lateral restraints		No	
Continuous flexural torsional restraint		No	
Local axis design		Yes	
Region between inflection points adjacent to support		No	
Span type		Simple	
Fastened to support		Unfastened	
Local shear		No	
Braced for sidesway in major axis		No	
Braced for sidesway in minor axis		No	
Loading condition		EOF	
Flange support condition		Fastened	
Bearing length	[in]	5.18	

Member lateral unbraced lengths

Length (Lb) [in]		Restraint arrangement		Rotation restraint	
Top	Bottom	Top	Bottom	Top	Bottom
19.50	123.00	FF	FF	None	None
38.45		FF		None	
38.73		FF		None	
45.82		FF		None	
12.13		FF		None	

Compression member unbraced lengths

Length (L) [in]			Effective length factor (ke)		
Major axis	Minor axis		Major axis	Minor axis	
123.00	45.82	45.82	0.00	0.00	1.0

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio : 0.02
Capacity : 45411.63 [Lb]
Demand : 707.51 [Lb]
Reference : Sec. C2
Ctrl Eq. : D27 at 63.75%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω)	[Lb]	53058.71	Sec. C2
Factored axial tensile fracture capacity(P_n/Ω)	[Lb]	45411.63	Sec. C2

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio	: 0.02		
Capacity	: 8722.08 [Lb]	Reference	: Sec G2
Demand	: -139.52 [Lb]	Ctrl Eq.	: D7 at 92.50%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	8722.08	Sec G2

Shear in minor axis 22

Ratio	: 0.12		
Capacity	: 15527.64 [Lb]	Reference	: Sec G2
Demand	: -1824.49 [Lb]	Ctrl Eq.	: D30 at 92.50%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	15527.64	Sec G2

AXIAL COMPRESSION DESIGN

Axial compression

Ratio	: 0.08		
Capacity	: 23895.53 [Lb]	Reference	: Sec. E3
Demand	: 1840.95 [Lb]	Ctrl Eq.	: D22 at 13.75%

Intermediate results	Unit	Value	Reference
Factored axial compression capacity(P_n/Ω)	[Lb]	26842.13	Sec. E2
Factored axial compression distortional buckling capacity(P_n/Ω)	[Lb]	33136.75	Sec. E4
Factored local buckling strength(P_n/Ω)	[Lb]	23895.53	Sec. E3

FLEXURAL DESIGN

Bending about major axis, M33

Ratio	: 0.86		
Capacity	: 4013.25 [Lb*ft]	Reference	: Sec. F2
Demand	: -3435.19 [Lb*ft]	Ctrl Eq.	: D30 at 62.50%

Intermediate results	Unit	Value	Reference
Factored section moment capacity(M_n/Ω)	[Lb*ft]	7629.31	Sec. F2
Factored lateral-torsional buckling strength(M_n/Ω)	[Lb*ft]	4013.25	Sec. F2
Factored moment distortional buckling capacity(M_n/Ω)	[Lb*ft]	6969.53	
Factored local buckling strength(M_n/Ω)	[Lb*ft]	4053.07	Sec. F3

Bending about the minor axis 22

Ratio	: 0.15		
Capacity	: 1452.06 [Lb*ft]	Reference	: Sec. F2
Demand	: 218.75 [Lb*ft]	Ctrl Eq.	: D30 at 100.00%

Intermediate results	Unit	Value	Reference
Factored section moment capacity(M_n/Ω)	[Lb*ft]	1452.06	Sec. F2

WEB CRIPPLING DESIGN

Web crippling

Ratio	:	0.66			
Capacity	:	5024.13 [Lb]	Reference	:	Sec. G5
Demand	:	-3324.65 [Lb]	Ctrl Eq.	:	D30 at 92.50%

Intermediate results	Unit	Value	Reference
Factored web crippling capacity(P_n/Ω)	[Lb]	5024.13	Sec. G5

COMBINED ACTIONS DESIGN

Combined bending and web crippling interaction

Ratio	:	0.22			
Ctrl Eq.	:	D27 at 13.75%	Reference	:	Sec. H3

Intermediate results	Unit	Value	Reference

Combined bending and shear interaction

Ratio	:	0.45			
Ctrl Eq.	:	D30 at 62.50%	Reference	:	Sec. H2

Intermediate results	Unit	Value	Reference
Combined bending and shear interaction (x-x)	--	0.45	Sec. H2
Combined bending and shear interaction(y-y)	--	0.00	

Combined bending and tension interaction

Ratio	:	0.86			
Ctrl Eq.	:	D30 at 63.75%	Reference	:	Eq. H1.1-2

Intermediate results	Unit	Value	Reference
Combined tensile axial and bending (flexure with tension yielding)	--	0.45	Eq. H1.1-1
Combined tensile axial and bending (flexure with buckling)	--	0.86	Eq. H1.1-2

Combined bending and compression interaction

Ratio	:	0.93			
Ctrl Eq.	:	D30 at 63.75%	Reference	:	Eq. H1.2-1

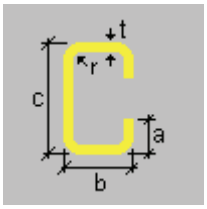
Intermediate results	Unit	Value	Reference
Combined bending and compression interaction	--	0.93	Eq. H1.2-1

Member : 339 (Knee Brace)
Design status : OK

Section information

Section name: Std. Titan Knee Brace - 3 x 2 x 0.078 **(US)**

Dimensions



a	=	0.630	[in]	Lip
b	=	2.000	[in]	Flange width
c	=	3.000	[in]	Depth
r	=	0.141	[in]	Inside bend radius
t	=	0.078	[in]	Thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	0.594	
Moment of Inertia (local axes) (I)	[in4]	0.871	0.333
Moment of Inertia (principal axes) (I')	[in4]	0.871	0.333
Bending constant for moments (principal axis) (J')	[in]	0.000	2.304
Radius of gyration (local axes) (r)	[in]	1.211	0.749
Radius of gyration (principal axes) (r')	[in]	1.211	0.749
Saint-Venant torsion constant. (J)	[in4]	0.001	
Section warping constant. (Cw)	[in6]	0.845	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	-1.909	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	0.581	0.273
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	0.581	0.427
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	0.581	0.273
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	0.581	0.427
Plastic section modulus (local axis) (Z)	[in3]	0.672	0.396
Plastic section modulus (principal axis) (Z')	[in3]	0.672	0.396
Polar radius of gyration. (ro)	[in]	2.381	
Area for shear (Aw)	[in2]	0.300	0.320
Torsional constant. (C)	[in3]	0.016	

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Properties	Unit	Value
Yield stress (Fy):	[Lb/in2]	80000.00
Tensile strength (Fu):	[Lb/in2]	82000.00
Elasticity Modulus (E):	[Lb/in2]	2.95E07
Shear modulus for steel (G):	[Lb/in2]	1.134615E07

DESIGN CRITERIA

Description	Unit	Major axis	Minor axis
Additional hypotheses			
Full lateral restraints		No	
Continuous flexural torsional restraint		No	
Local axis design		Yes	
Region between inflection points adjacent to support		No	
Span type		Simple	
Fastened to support		Unfastened	
Local shear		No	
Braced for sidesway in major axis		No	
Braced for sidesway in minor axis		No	
Loading condition		EOF	
Flange support condition		Fastened	

Member lateral unbraced lengths

Length (Lb) [in]		Restraint arrangement		Rotation restraint	
Top	Bottom	Top	Bottom	Top	Bottom
117.95	117.95	FF	FF	None	None

Compression member unbraced lengths

Length (L) [in]			Effective length factor (ke)		
Major axis	Minor axis		Major axis	Minor axis	
117.95	117.95	117.95	0.00	0.00	1.0

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio : 0.12
Capacity : 24337.19 [Lb]
Demand : 3009.44 [Lb]
Reference : Sec. C2
Ctrl Eq. : D30 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω)	[Lb]	28435.45	Sec. C2
Factored axial tensile fracture capacity(P_n/Ω)	[Lb]	24337.19	Sec. C2

DESIGN FOR SHEAR ✔

Shear in major axis 33

Ratio : 0.00
Capacity : 7310.16 [Lb]
Demand : 0.00 [Lb]
Reference : Sec G2
Ctrl Eq. : D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	7310.16	Sec G2

Shear in minor axis 22

Ratio : 0.00
Capacity : 5995.08 [Lb]
Demand : 0.00 [Lb]
Reference : Sec G2
Ctrl Eq. : D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	5995.08	Sec G2

AXIAL COMPRESSION DESIGN ✔

Axial compression

Ratio : 0.82
Capacity : 2253.34 [Lb]
Demand : 1847.05 [Lb]
Reference : Sec. E2
Ctrl Eq. : D23 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial compression capacity(P_n/Ω)	[Lb]	2253.34	Sec. E2
Factored axial compression distortional buckling capacity(P_n/Ω)	[Lb]	21111.11	Sec. E4
Factored local buckling strength(P_n/Ω)	[Lb]	2253.34	Sec. E3

FLEXURAL DESIGN

Bending about major axis, M33

Ratio : 0.00
Capacity : 744.72 [Lb*ft] Reference : Sec. F2
Demand : 0.00 [Lb*ft] Ctrl Eq. : D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored section moment capacity(M_n/Ω)	[Lb*ft]	2317.74	Sec. F2
Factored lateral-torsional buckling strength(M_n/Ω)	[Lb*ft]	744.72	Sec. F2
Factored moment distortional buckling capacity(M_n/Ω)	[Lb*ft]	2101.38	
Factored local buckling strength(M_n/Ω)	[Lb*ft]	750.63	Sec. F3

Bending about the minor axis 22

Ratio : 0.00
Capacity : 1090.14 [Lb*ft] Reference : Sec. F2
Demand : 0.00 [Lb*ft] Ctrl Eq. : D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored section moment capacity(M_n/Ω)	[Lb*ft]	1090.14	Sec. F2
Factored lateral-torsional buckling strength(M_n/Ω)	[Lb*ft]	1683.49	Sec. C3.1.2

WEB CRIPPLING DESIGN

Web crippling

Ratio : 0.00
Capacity : 799.58 [Lb] Reference : Sec. G5
Demand : 0.00 [Lb] Ctrl Eq. : D1 at 0.00%

Intermediate results	Unit	Value	Reference
Factored web crippling capacity(P_n/Ω)	[Lb]	799.58	Sec. G5

COMBINED ACTIONS DESIGN

Combined bending and web crippling interaction

Ratio : 0.00
Ctrl Eq. : D1 at 0.00% Reference : Sec. H3

Intermediate results	Unit	Value	Reference

Combined bending and shear interaction

Ratio : 0.00
Ctrl Eq. : D1 at 0.00% Reference : Sec. H2

Intermediate results	Unit	Value	Reference
Combined bending and shear interaction (x-x)	--	0.00	Sec. H2
Combined bending and shear interaction(y-y)	--	0.00	Sec. H2

Combined bending and tension interaction

Ratio : 0.12
Ctrl Eq. : D30 at 0.00% Reference : Eq. H1.1-1

Intermediate results	Unit	Value	Reference
Combined tensile axial and bending (flexure with tension yielding)	--	0.12	Eq. H1.1-1
Combined tensile axial and bending (flexure with buckling)	--	-0.12	

Combined bending and compression interaction

Ratio : 0.82
Ctrl Eq. : D23 at 0.00% Reference : Eq. H1.2-1

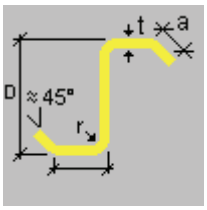
Intermediate results	Unit	Value	Reference
Combined bending and compression interaction	--	0.82	Eq. H1.2-1

Member : 351 (OG - Zee - Top)
Design status : OK

Section information

Section name: Std. Big Zee - 6 x 3 x 0.055 **(US)**

Dimensions



a	=	1.000	[in]	Lip
b	=	3.000	[in]	Flange width
D	=	6.000	[in]	Depth
r	=	0.187	[in]	Inside bend radius
t	=	0.055	[in]	Thickness

Properties

Section properties	Unit	Major axis	Minor axis
Gross area of the section. (Ag)	[in2]	0.748	
Moment of Inertia (local axes) (I)	[in4]	4.452	2.135
Moment of Inertia (principal axes) (I')	[in4]	4.452	2.135
Bending constant for moments (principal axis) (J')	[in]	0.000	0.000
Radius of gyration (local axes) (r)	[in]	2.439	1.689
Radius of gyration (principal axes) (r')	[in]	2.439	1.689

Saint-Venant torsion constant. (J)	[in4]	7.70E-04	
Section warping constant. (Cw)	[in6]	12.653	
Distance from centroid to shear center (principal axis) (xo,yo)	[in]	0.000	0.000
Top elastic section modulus of the section (local axis) (Ssup)	[in3]	1.484	0.577
Bottom elastic section modulus of the section (local axis) (Sinf)	[in3]	1.484	0.577
Top elastic section modulus of the section (principal axis) (S'sup)	[in3]	1.484	0.577
Bottom elastic section modulus of the section (principal axis) (S'inf)	[in3]	1.484	0.577
Plastic section modulus (local axis) (Z)	[in3]	1.696	0.837
Plastic section modulus (principal axis) (Z')	[in3]	1.696	0.837
Polar radius of gyration. (ro)	[in]	2.967	
Area for shear (Aw)	[in2]	0.557	0.475
Torsional constant. (C)	[in3]	0.014	

Material : A653 SS 80-1

Properties	Unit	Value
Yield stress (Fy):	[Lb/in2]	80000.00
Tensile strength (Fu):	[Lb/in2]	82000.00
Elasticity Modulus (E):	[Lb/in2]	2.95E07
Shear modulus for steel (G):	[Lb/in2]	1.134615E07

DESIGN CRITERIA

Description	Unit	Major axis	Minor axis
Additional hypotheses			
Full lateral restraints		No	
Continuous flexural torsional restraint		No	
Local axis design		Yes	
Region between inflection points adjacent to support		No	
Span type		Simple	
Fastened to support		Unfastened	
Local shear		No	
Braced for sidesway in major axis		Yes	
Braced for sidesway in minor axis		Yes	
Loading condition		IOF	
Flange support condition		Fastened	
Bearing length	[in]	3.00	

Member lateral unbraced lengths

Length (Lb) [in]		Restraint arrangement		Rotation restraint	
Top	Bottom	Top	Bottom	Top	Bottom
168.00	168.00	FF	FF	None	None

Compression member unbraced lengths

Length (L) [in]			Effective length factor (ke)		
Major axis	Minor axis		Major axis	Minor axis	
44.65	168.00	44.65	0.00	0.00	1.0

DESIGN CHECKS

AXIAL TENSION DESIGN ✔

Axial tension

Ratio : 0.00
Capacity : 30673.98 [Lb]
Demand : 14.32 [Lb]

Reference : Sec. C2
Ctrl Eq. : D22 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial tension capacity(P_n/Ω)	[Lb]	35839.32	Sec. C2
Factored axial tensile fracture capacity(P_n/Ω)	[Lb]	30673.98	Sec. C2

DESIGN FOR SHEAR

Shear in major axis 33

Ratio : 0.02
Capacity : 8054.03 [Lb]
Demand : -151.15 [Lb]
Reference : Sec G2
Ctrl Eq. : D2 at 0.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	8054.03	Sec G2

Shear in minor axis 22

Ratio : 0.47
Capacity : 2684.57 [Lb]
Demand : 1260.94 [Lb]
Reference : Sec G2
Ctrl Eq. : D30 at 100.00%

Intermediate results	Unit	Value	Reference
Factored shear capacity(V_n/Ω)	[Lb]	2684.57	Sec G2

AXIAL COMPRESSION DESIGN

Axial compression

Ratio : 0.02
Capacity : 8254.48 [Lb]
Demand : 151.45 [Lb]
Reference : Sec. E3
Ctrl Eq. : D7 at 0.00%

Intermediate results	Unit	Value	Reference
Factored axial compression capacity(P_n/Ω)	[Lb]	10732.77	Sec. E2
Factored axial compression distortional buckling capacity(P_n/Ω)	[Lb]	14180.27	Sec. E4
Factored local buckling strength(P_n/Ω)	[Lb]	8254.48	Sec. E3

FLEXURAL DESIGN

Bending about major axis, M33

Ratio : 0.83
Capacity : 3372.66 [Lb*ft]
Demand : 2794.96 [Lb*ft]
Ctrl Eq. : D30 at 100.00%

Intermediate results	Unit	Value	Reference
Factored section moment capacity(M_n/Ω)	[Lb*ft]	5923.85	Sec. F2
Factored lateral-torsional buckling strength(M_n/Ω)	[Lb*ft]	5412.22	Sec. F2
Factored moment distortional buckling capacity(M_n/Ω)	[Lb*ft]	3372.66	
Factored local buckling strength(M_n/Ω)	[Lb*ft]	4130.43	Sec. F3

Bending about the minor axis 22

Ratio	: 0.16			
Capacity	: 2304.60 [Lb*ft]	Reference	: Sec. F2	
Demand	: -372.80 [Lb*ft]	Ctrl Eq.	: D2 at 0.00%	

Intermediate results	Unit	Value	Reference
Factored section moment capacity(M_n/Ω)	[Lb*ft]	2304.60	Sec. F2

WEB CRIPPLING DESIGN ✔

Web crippling

Ratio	: 0.00			
Capacity	: 2009.74 [Lb]	Reference	: Sec. G5	
Demand	: 0.00 [Lb]	Ctrl Eq.	: D1 at 0.00%	

Intermediate results	Unit	Value	Reference
Factored web crippling capacity(P_n/Ω)	[Lb]	2009.74	Sec. G5

COMBINED ACTIONS DESIGN ✔

Combined bending and web crippling interaction

Ratio	: 0.12			
Ctrl Eq.	: D30 at 100.00%	Reference	: Sec. H3	

Intermediate results	Unit	Value	Reference

Combined bending and shear interaction

Ratio	: 0.67			
Ctrl Eq.	: D30 at 100.00%	Reference	: Sec. H2	

Intermediate results	Unit	Value	Reference
Combined bending and shear interaction (x-x)	--	0.67	Sec. H2
Combined bending and shear interaction(y-y)	--	0.09	

Combined bending and tension interaction

Ratio	: 0.92			
Ctrl Eq.	: D30 at 100.00%	Reference	: Eq. H1.1-2	

Intermediate results	Unit	Value	Reference
Combined tensile axial and bending (flexure with tension yielding)	--	0.57	Eq. H1.1-1
Combined tensile axial and bending (flexure with buckling)	--	0.92	Eq. H1.1-2

Combined bending and compression interaction

Ratio	: 0.92			
Ctrl Eq.	: D30 at 100.00%	Reference	: Eq. H1.2-1	

Intermediate results	Unit	Value	Reference
Combined bending and compression interaction	--	0.92	Eq. H1.2-1

20-345 County Road X, PO Box 326
Ridgeville Corners, OH 43555

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ADDITIONAL SNOW CODE CHECK

(ASCE 7-16, ASD)

SOLAR RACKING

20-345 County Road X, PO Box 326
Ridgeville Corners, OH 43555

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Fax:419.267.5214

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 1

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*Std. Titan Knee Brace - 3 ...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 1/8*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*Std. Titan Duo Post - 2.37...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*Std. Big Zee - 6 x 3 x 0.055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 2

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 1/2

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 2/3

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 3/4

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

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Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 4/5

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 5/6

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 6/7

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 7/8

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 8/9

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

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Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 9/10

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 10/11

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	

Steel Code Check - SUMMARY PARTIAL SNOW LOADING CASE 3, BAYS 11/12

Description	Section	Member & Ctrl Eq.	Ratio & Status	Reference	
NS Chord	*TITAN NS CHORD - 6X2X108*	322 - D30 at 63.75%	0.93 - OK	Eq. H1.2-1	
Knee Brace	*TITAN KNEE BRACE - 3X2...*	339 - D23 at 0.00%	0.82 - OK	Sec. E2	
Cable Brace	*CABLE BRACE - 5/32*	502 - D7 at 50.00%	0.26 - OK		0
Foundation F	*STD. TITAN DUO POST - 2...*	337 - D30 at 3.13%	0.54 - OK		0
Zee Purlin	*STD BIG ZEE - 6 X 3 X .055*	351 - D30 at 100.00%	0.92 - OK	Eq. H1.2-1	