GAMECHANGE SOLAR
REPOWERING THE PLANET

Calculation Package for GCS MaxSpan Plus Thin-Film System (All Row Ends, Mid Aisle)

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STATE OF NEW YORK · SCOTT VAN PELT · 092572 · LICENSED PROFESSIONAL ENGINEER

General Information

Setup	Portrait	
Tilt	20	degree
Clearance	36	in
Panel Length	78.50	in
Panel Width	39.37	in
Panel Weight	50.7	lbs
Space between Panels N-S	0.5	in
Space between Panels E-W	0.5	in
Mounting Type	Bottom	
Number of Panels Up	2	#
Number of Purlins	4	#
Rail Spacing	2	ft (O.C.)
No. of Panels Supported per Span	10	#
No. of Panel Widths per Span	5.00	#
No. of Panel Widths per Overhang	1.00	#
Purlin Span Length	16.61	ft
Post Adjustment Zone Length	6	in
Loading Code	ASCE7-10	
Occupancy Category	I	
Exposure Category	C	
Seismic Site Class	D	
Assumed Load Bearing Capacity of Soil	1	ksf
Dead Load:	3.2	psf
Ground Snow Load (Pg)	45	psf
Basic Wind Speed	105	mph
Seismic Design Values		
Ss	0.126	g
S1	0.056	g
Fa	1.6	
Fv	2.4	
SDS	0.134	g
SD1	0.090	g

1. Loading Calculations

1.1 Snow Load

Snow load is calculated per ASCE7

Pg (psf)	45.00	
Ce	0.90	Per Table 7-2.
Ct	1.20	Per Table 7-3.
Is	0.80	Per Table 7-4.
Cs	0.91	Per Figure 7-2c.

According to equation (7-1) and (7-2)

Ps=Cs*Pf = Cs*(0.7Ce*Ct*Is*Pg) Ps = 24.74

1.2 Wind Load

Wind pressure is calculated per ASCE7

V (mph)	105.00	
Kd	0.85	Per Table 26.6-1
Kz	1.00	Per Wind Tunnel Test Report
Kzt	1.00	Per Section 26.8
Iw	1.00	Wind Importance Factor equals unity for ASCE7-10

According to Equation (27.3-1)

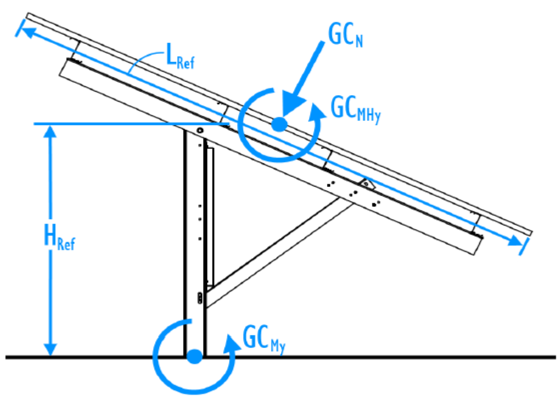
qh = 0.00256*Kd*Kz*Kzt*(V^2)*I qh = 23.99

According to equation (27.4-3)

$P=q_h GC_N$

The results of wind load factors including normal and overt urning moments provided by CPP are located in the calculation sheets. The results are given for two opposite directions of wind which causes upward and downward wind forces calculated based on worst case design wind loads.

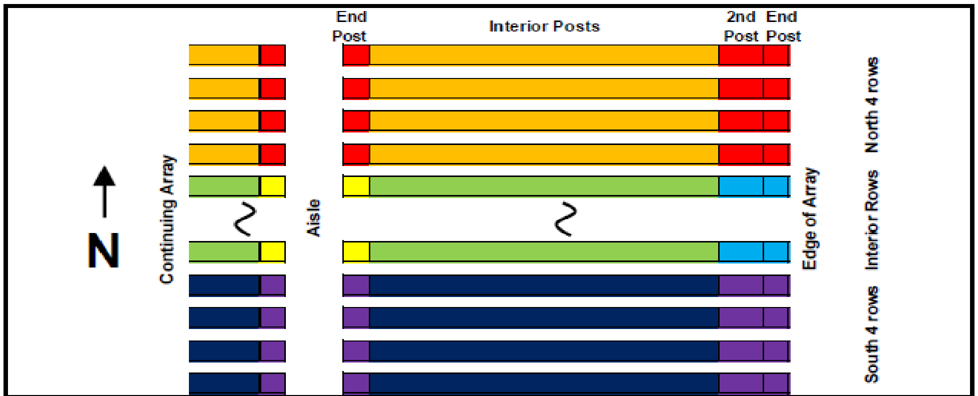
GC_N is the normal force factor, GC-My is the moment at the base of the post. The factor of safety is calculated based on the worst case scenario, when the dead load and full wind loads are present. These factors are used to generate all wind load components for the following calculations.



$$GC_N = \frac{F_N}{q_z A_{ref}}$$

$$GC_{MHy} = \frac{M_{Hy}}{q_z A_{ref} L_{ref}}$$

$$GC_{My} = \frac{M_y}{q_z A_{ref} H_{ref}}$$



Zone	Tilt/height*	GC_N		GC_{MHv}		GC_{Mv}	
		Min	Max	Min	Max	Min	Max
	15° / 0.12	-0.84	0.90	-0.18	0.04	-0.70	0.20
	15° / 0.46	-1.04	0.87	-0.22	0.06	-0.36	0.09
	30° / 0.12	-1.38	1.50	-0.19	0.06	-0.66	0.20
	30° / 0.46	-1.51	1.66	-0.24	0.06	-0.74	0.37
	15° / 0.12	-0.84	0.46	-0.19	0.03	-0.48	0.21
	15° / 0.46	-0.86	0.49	-0.22	0.06	-0.36	0.10
	30° / 0.12	-1.19	0.78	-0.19	0.05	-0.64	0.16
	30° / 0.46	-1.14	0.81	-0.25	0.08	-0.66	0.20
	15° / 0.12	-0.44	0.71	-0.09	0.03	-0.55	0.15
	15° / 0.46	-0.76	0.85	-0.10	0.03	-0.17	0.05
	30° / 0.12	-0.75	1.15	-0.12	0.06	-0.30	0.18
	30° / 0.46	-0.88	1.47	-0.15	0.05	-0.36	0.33
	15° / 0.12	-0.56	0.35	-0.14	0.02	-0.38	0.09
	15° / 0.46	-0.57	0.41	-0.15	0.03	-0.25	0.05
	30° / 0.12	-0.75	0.71	-0.09	0.04	-0.33	0.12
	30° / 0.46	-0.84	0.92	-0.14	0.03	-0.40	0.21
	15° / 0.12	-0.73	0.64	-0.13	0.04	-0.48	0.19
	15° / 0.46	-1.02	0.74	-0.17	0.04	-0.28	0.07
	30° / 0.12	-1.37	1.23	-0.17	0.04	-0.61	0.13
	30° / 0.46	-1.57	1.42	-0.22	0.04	-0.73	0.33
	15° / 0.12	-0.61	0.60	-0.15	0.03	-0.63	0.09
	15° / 0.46	-0.58	0.99	-0.19	0.03	-0.31	0.05
	30° / 0.12	-0.95	0.84	-0.12	0.04	-0.43	0.12
	30° / 0.46	-1.01	1.14	-0.19	0.04	-0.52	0.23
	15° / 0.12	-0.91	0.67	-0.15	0.04	-0.52	0.22
	15° / 0.46	-1.20	0.81	-0.19	0.05	-0.32	0.08
	30° / 0.12	-1.72	1.20	-0.23	0.04	-0.81	0.14
	30° / 0.46	-1.87	1.40	-0.27	0.05	-0.92	0.31

*Height is expressed as the ratio of the gap from the ground to the low edge of the PV divided by the chord; Interpolation between configurations is allowed

NOTE: The gust coefficients shown above are from wind tunnel testing performed in accordance with Section 6.6 of ASCE7-05 and Chapter 31 of ASCE7-10

1.3 Load Combinations:

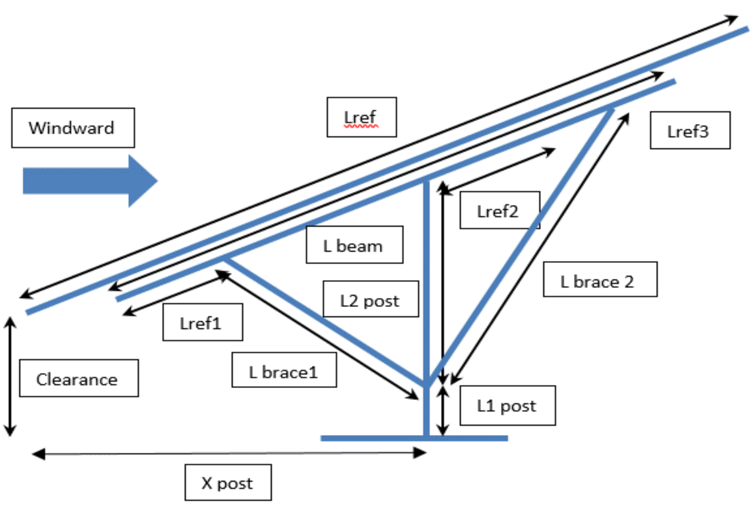
Basic load combinations are per ASCE7-10 and ASD design method.

1	D				
2	D	+	S		
3	D	+	0.60W		
4	D	+	0.75S	+	0.45W
5	0.6D	+/-	0.60W		
6	D	+	0.7E		

1.4 Safety Factors

	Ωc	Ωb	Ωv	SF_{FDN}
Safety Factor	1.5	1.5	1.5	1.5

2.0 Analysis and Design: Geometry



Tilt (degrees)	20
Href (in)	36.00
Lref (in)	157.51
Lref1 (in)	12.00
Lref2 (in)	53.00
Lref3 (in)	12.00
Bottom Overhang (in)	13.50
Top Overhang (in)	13.50
X post (in)	73.4
L1 post (in)	10.00
L2 post (in)	44.6
L post (in)	60.6
L brace1 (in)	61.1
L brace2 (in)	80.0
L beam (in)	130.5
Href (in)	72.9
Brace1 Angle w/ Horiz.	29.4
Brace2 Angle w/ Horiz.	47.7

13.50393701

NOTES:
1. Dimensions shown herein are to connection locations and may vary slightly from out-to-out dimensions shown on assembly drawing

2.1 Post Design (AISI S100-07)

Post Heavy	W6x8.5	Grade	50
Post	W6x7	Grade	50
	Material Type: Pre-Galvanized Steel		

Effective section properties at applied loads:

Post Heavy	A (in^2)	2.52	Ix(in^4)	14.9	Iy (in^4)	1.99
			Sx(t) (in^3)	5.10	Sy(l) (in^3)	1.01
			Sx(b) (in^3)	5.10	Sy(r) (in^3)	1.01
Post	A (in^2)	2.002	Ix(in^4)	11.955	Iy (in^4)	1.683
			Sx(t) (in^3)	4.14	Sy(l) (in^3)	0.85
			Sx(b) (in^3)	4.14	Sy(r) (in^3)	0.85

		Combo 2	Combo 3	Combo 4	Combo 5 (Uplift)
North Row End	Moment (kip-in)	3.72	44.44	35.90	-140.53
	Torque (kip-in)	0.00	0.00	0.00	0.00
	Axial load (kip)	5.93	4.16	7.22	-3.81
North Row Mid	Moment (kip-in)				
	Torque (kip-in)				
	Axial load (kip)				
Mid Aisle	Moment (kip-in)	3.72	35.39	29.12	-88.39
	Torque (kip-in)	0.00	0.00	0.00	0.00
	Axial load (kip)	5.93	3.54	6.76	-1.99
Mid Row Mid	Moment (kip-in)				
	Torque (kip-in)				
	Axial load (kip)				
Mid Row End	Moment (kip-in)	3.72	37.89	30.99	-111.31
	Torque (kip-in)	0.00	0.00	0.00	0.00
	Axial load (kip)	5.93	3.43	6.67	-3.43
South Row Mid	Moment (kip-in)				
	Torque (kip-in)				
	Axial load (kip)				
South Row End	Moment (kip-in)	3.72	41.48	33.69	-132.16
	Torque (kip-in)	0.00	0.00	0.00	0.00
	Axial load (kip)	5.93	3.50	6.73	-4.28

According to AISC 360 Specification for Structural Steel Buildings, Chapter H

			Pn/Ωc	Mxn/Ωb	Myn/Ωb
Post Heavy	Strength	Compress.	25.88	170.00	40.86
		Tension	101.95		
Post	Strength	Compress.	21.89	138.00	34.39
		Tension	80.99		

		Combo 2	Combo 3	Combo 4	Combo 5 (Uplift)	
North Row End	ΩcP/Pn	0.229	0.161	0.279	0.147	
	ΩbMx/(R*Mnx)	0.022	0.261	0.211	0.827	
	ΩbMy/(R*Mny)	0.000	0.000	0.000	0.000	
Post Heavy	Sum	**0.248**	**0.342**	**0.467**	**0.900**	<1 OK
North Row Mid	ΩcP/Pn					
	ΩbMx/(R*Mnx)					
	ΩbMy/(R*Mny)					
Post Heavy	Sum					
Mid Aisle	ΩcP/Pn	0.229	0.137	0.261	0.077	
	ΩbMx/(R*Mnx)	0.022	0.208	0.171	0.520	
	ΩbMy/(R*Mny)	0.000	0.000	0.000	0.000	
Post Heavy	Sum	**0.248**	**0.277**	**0.414**	**0.558**	<1 OK
Mid Row Mid	ΩcP/Pn					
	ΩbMx/(R*Mnx)					
	ΩbMy/(R*Mny)					
Post	Sum					
Mid Row End	ΩcP/Pn	0.229	0.132	0.258	0.133	
	ΩbMx/(R*Mnx)	0.022	0.223	0.182	0.655	
	ΩbMy/(R*Mny)	0.000	0.000	0.000	0.000	
Post Heavy	Sum	**0.248**	**0.289**	**0.420**	**0.721**	<1 OK
South Row Mid	ΩcP/Pn					
	ΩbMx/(R*Mnx)					
	ΩbMy/(R*Mny)					
Post Heavy	Sum					
South Row End	ΩcP/Pn	0.229	0.135	0.260	0.165	
	ΩbMx/(R*Mnx)	0.022	0.244	0.198	0.777	
	ΩbMy/(R*Mny)	0.000	0.000	0.000	0.000	
Post Heavy	Sum	**0.248**	**0.312**	**0.436**	**0.860**	<1 OK

2.2 Brace Design

Shape Cee 4.5x2.6 - 14 Ga Facing E-W Grade 80 ksi

Material Type:Pre-galvanized Steel

Effective section properties at applied loads

Ae (in^2)	0.68	Ixe (in^4)	2.26	Iye (in^4)	0.44
		Sxe(t) (in^4)	1.01	Sye(l) (in^4)	0.67
		Sxe(b) (in^4)	1.01	Sye(r) (in^4)	0.23

Loads below are for governing Brace (North or South)

					kip	kip-in	kip-in
Axial force (kip)	**Combo 2**	**Combo 3**	**Combo 4**	**Combo 5 (Up**	**P**	**Mx**	**My**
North Row End	0.01	0.51	0.39	1.93	1.93	0	1.54
North Row Mid							
Mid Aisle	0.01	0.39	0.30	1.03	1.03	0	0.82
Mid Row Mid							
Mid Row End	0.01	0.40	0.31	1.54	1.54	0	1.23
South Row Mid							
South Row End	0.01	-0.25	-0.18	1.12	1.12	0	0.90

	Pn/Ωc	**Mxn/Ωb**	**Myn/Ωb**
Strength	13.19	41.91	9.53

According to North American Specification for the Design of Cold-Formed Steel Structural Members (2007 Edition), Equation C5.2.1-1-C5.2.1.3.As ΩbP/Pn>0.15, equation C5.2.1-2 should be adopted.

$$\frac{\Omega_c P}{P_{no}} + \frac{\Omega_b M_x}{M_{nx}} + \frac{\Omega_b M_y}{M_{ny}} \leq 1.0$$

	ΩcP/Pn	ΩbMx/Mnx	ΩbMy/Mny	Sum	
North Row End	0.146	0.000	0.162	0.308	<1 OK
North Row Mid					
Mid Aisle	0.078	0.000	0.086	0.165	<1 OK
Mid Row Mid					
Mid Row End	0.117	0.000	0.129	0.246	<1 OK
South Row Mid					
South Row End	0.085	0.000	0.094	0.179	<1 OK

2.3 Beam Design (AISI S100-07)

Shape	Z 6.00*2.92 - 14 Ga	Grade	80

Material Type: Pre-galvanized Steel

Local Effects Reducer 0.85

Section Properties

A (in^2)	0.79	Ix (in^4)	4.50	Iy (in^4)	1.28
		Sx(t) (in^3)	1.50	Sy(l) (in^3)	0.45
		Sx(b) (in^3)	1.50	Sy(r) (in^3)	0.45

		Combo 2	Combo 3	Combo 4	Combo 5 (Uplift)
North Row End	Moment (kip-in)	18.86	14.70	24.08	-13.89
	Axial load (kip)	0.51	0.25	0.54	0.73
North Row Mid	Moment (kip-in)				
	Axial load (kip)				
Mid Aisle	Moment (kip-in)	18.86	12.49	22.43	-7.33
	Axial load (kip)	0.51	0.21	0.51	0.37
Mid Row Mid	Moment (kip-in)				
	Axial load (kip)				
Mid Row End	Moment (kip-in)	18.86	12.07	22.11	-12.55
	Axial load (kip)	0.51	0.21	0.51	0.55
South Row Mid	Moment (kip-in)				
	Axial load (kip)				
South Row End	Moment (kip-in)	18.86	12.34	22.31	-15.61
	Axial load (kip)	0.51	0.22	0.52	0.70

According to

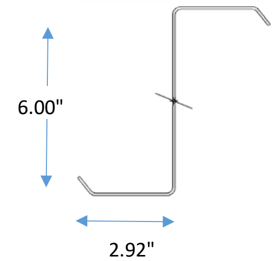
$$\frac{\Omega_c P}{P_n} + \frac{\Omega_b M_x}{M_{nx}} + \frac{\Omega_b M_y}{M_{ny}} \leq 1.0$$

	Pn/Ωc	Mxn/Ωb	Myn/Ωb
Strength	32.54	61.69	18.41

		Combo 2	Combo 3	Combo 4	Combo 5 (Uplift)	
North Row End	ΩcP/Pn	0.016	0.008	0.017	0.022	
	ΩbMx/Mnx	0.306	0.238	0.390	0.225	
	ΩbMy/Mny	0.000	0.000	0.000	0.000	
	Sum	**0.321**	**0.246**	**0.407**	**0.247**	<1 OK
North Row Mid	ΩcP/Pn					
	ΩbMx/Mnx					
	ΩbMy/Mny					
	Sum					
Mid Aisle	ΩcP/Pn	0.016	0.006	0.016	0.011	
	ΩbMx/Mnx	0.306	0.202	0.363	0.119	
	ΩbMy/Mny	0.000	0.000	0.000	0.000	
	Sum	**0.321**	**0.209**	**0.379**	**0.130**	<1 OK
Mid Row Mid	ΩcP/Pn					
	ΩbMx/Mnx					
	ΩbMy/Mny					
	Sum					
Mid Row End	ΩcP/Pn	0.016	0.006	0.016	0.017	
	ΩbMx/Mnx	0.306	0.196	0.358	0.203	
	ΩbMy/Mny	0.000	0.000	0.000	0.000	
	Sum	**0.321**	**0.202**	**0.374**	**0.220**	<1 OK
South Row Mid	ΩcP/Pn					
	ΩbMx/Mnx					
	ΩbMy/Mny					
	Sum					
South Row End	ΩcP/Pn	0.016	0.007	0.016	0.021	
	ΩbMx/Mnx	0.306	0.200	0.362	0.253	
	ΩbMy/Mny	0.000	0.000	0.000	0.000	
	Sum	**0.321**	**0.207**	**0.378**	**0.274**	<1 OK

2.4 Purlin Design

	Grade	Gauge
Heavy Grade	80	Gauge 16 - 6x2.92
Light Grade	80	Gauge 16 - 6x2.92



Effective Properties

Heavy Grade	A (in^2)	0.686	Ix (in^4)	3.881	Iy (in^4)	1.06
			Sx(t) (in^3)	1.294	Sy(l) (in^3)	0.363
			Sx(b) (in^3)	1.294	Sy(r) (in^3)	0.363
Light Grade	A (in^2)	0.686	Ix (in^4)	3.881	Iy (in^4)	1.06
			Sx(t) (in^3)	1.294	Sy(l) (in^3)	0.363
			Sx(b) (in^3)	1.294	Sy(r) (in^3)	0.363

		Combo 2	**Combo 3**	**Combo 4**	**Combo 5 (Uplift)**
North Row End	moment major (kip-in)	34.69	27.04	44.30	-25.55
	moment minor (kip-in)	3.08	0.35	2.40	0.21
North Row Mid	moment major (kip-in)				
	moment minor (kip-in)				
Mid Aisle	moment major (kip-in)	34.69	22.97	41.25	-13.49
	moment minor (kip-in)	3.08	0.35	2.40	0.21
Mid Row Mid	moment major (kip-in)				
	moment minor (kip-in)				
Mid Row End	moment major (kip-in)	34.69	22.21	40.68	-23.08
	moment minor (kip-in)	3.08	0.35	2.40	0.35
South Row Mid	moment major (kip-in)				
	moment minor (kip-in)				
South Row End	moment major (kip-in)	34.69	22.70	41.05	-28.71
	moment minor (kip-in)	3.08	0.35	2.40	0.21

Buckling Check (Per Equation C3.1.2.1-15):

	Continuous Spans		End Spans	
	Fc(x) (ksi)	**Fc(y) (ksi)**	**Fc(x) (ksi)**	**Fc(y) (ksi)**
Heavy Grade Strength	76.47	81.08	63.40	81.08
Light Grade Strength	76.47	81.08	63.40	81.08

	Mx/Ωb	**My/Ωb**	**Mx/Ωb**	**My/Ωb**
	kip-in	kip-in	kip-in	kip-in
Heavy Grade Strength	62.81	18.69	52.08	18.69
Light Grade Strength	62.81	18.69	52.08	18.69

According to North American Specification for the Design of Cold-Formed Steel Structural Members (2007 Edition), Equation C5.2.1-1-C5.2.1.3

$$\frac{\Omega_c P}{P_n} + \frac{\Omega_b M_x}{M_{nx}} + \frac{\Omega_b M_y}{M_{ny}} \le 1.0$$

		Combo 2	Combo 3	Combo 4	Combo 5 (Uplift)	
North Row End	ΩbMx/Mnx	0.666	0.519	0.851	0.491	
	ΩbMy/Mny	0.165	0.019	0.128	0.011	
Light Grade	Sum	**0.831**	**0.538**	**0.979**	**0.502**	<1 OK
North Row Mid	ΩbMx/Mnx					
	ΩbMy/Mny					
Light Grade	Sum					
Mid Aisle	ΩbMx/Mnx	0.666	0.441	0.792	0.259	
	ΩbMy/Mny	0.165	0.019	0.128	0.011	
Light Grade	Sum	**0.831**	**0.460**	**0.920**	**0.270**	<1 OK
Mid Row Mid	ΩbMx/Mnx					
	ΩbMy/Mny					
Light Grade	Sum					
Mid Row End	ΩbMx/Mnx	0.666	0.426	0.781	0.443	
	ΩbMy/Mny	0.165	0.019	0.128	0.019	
Light Grade	Sum	**0.831**	**0.445**	**0.909**	**0.462**	<1 OK
South Row Mid	ΩbMx/Mnx					
	ΩbMy/Mny					
Light Grade	Sum					
South Row End	ΩbMx/Mnx	0.666	0.436	0.788	0.551	
	ΩbMy/Mny	0.165	0.019	0.128	0.011	
Light Grade	Sum	**0.831**	**0.455**	**0.916**	**0.563**	<1 OK

Deflection Check

Allowable deflection per panel manufacturer = L/ 100 (0.01mm/mm)

	North Row Ends	North Row Mid	Mid Aisles	Mid Row Mid	Mid Row Ends	South Row Mid	South Row Ends
Max at midspan (in)	0.318		0.296		0.292		0.294
Δ / L	0.002		0.002		0.001		0.001
Check	OK		OK		OK		OK

Purlin Angle Check: OK

Note:
The Purlin analysis above accounts for the longest acceptable purlin length for this project. Some purlins supplied for this project may be shorter than this length due to site geometry or to match the number of panels in a rack with a client requested string size. As the shorter purlins will have less load applied to them and a shorter unbraced length, they have sufficient structural capacty to resist the applied loads.

3. Seismic Forces

Seismic Design Values

Ss	0.126	g	
S1	0.056	g	
Fa	1.6		
Fv	2.4		
SDS	0.13	g	
SD1	0.09	g	
R	1.25		Per Table 12.2-1 For Steel Ordinary Cantilever Columns
Ie	1		Per Table 1.5-2
W	3.22	psf	
Cs	0.11	g	Per Eq. 15.4-2
V	0.35	psf	Per Eq. 12.8-1

Seismic force is much lower than lateral wind loads calculated for analysis.

Wind load controls the design.

4. Foundation

Vertical Loading

	North Row Ends	North Row Mid	Mid Aisles	Mid Row Mid	Mid Row Ends	South Row Mid	South Row Ends
Gust Coefficient (GC_N)	1.08		0.63		1.03		1.26
Wind Uplift Pressure (psf)	25.82		15.00		24.62		30.17
Wind Uplift Force (k)	3.12		1.82		2.98		3.65
Downward Force[1] (k)	0.41		0.41		0.41		0.41
Max Net Uplift Force (Pull out resistance) (k)	**4.07**		**2.10**		**3.85**		**4.85**
Max Net Downward Force (k)	7.09		6.68		6.59		6.63

Lateral Loading

	North Row Ends	North Row Mid	Mid Aisles	Mid Row Mid	Mid Row Ends	South Row Mid	South Row Ends
Max Net Lateral Force (Lateral resistance) (k)	**1.76**		**1.46**		**1.63**		**1.99**

Note:
1. Downward force includes 0.6D load combination factor
2. Max Uplift and Lateral Foundation loads shown include safety factor