EV ENGINEERING

Structural Calculations

For

HELIODYNE SOLAR COLLECTOR RACK STRUCTURES

Gobi 410 at 35 degrees

FOR HELIODYNE, INC.

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Table of Content

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Scope of Work

This report is for the Heliodyne Rack Stucture with Gobi 410 Collector at 35 degrees. The purpose of the analysis was to determine appropriate loadings for the Heliodyne rack structure with Gobi 410 collectors at 35 degrees following the currentmost design codes with an emphasis on California. The analysis looked at Dead loads from collectors and racking, wind loads scenarios, as well as light snow loads. Both wind exposure B and C which are frequently encountered in Califonia were considered. The analysis considered obstructed wind flow as well as clear wind flow. Their respective acceptable design criteria are outlined in this report.

Conclusion

After analysis, the rack has been determined to be adequate to support imposed loads in conditions outlined below. With the exception of special wind region and High snow areas, most low altitude California areas should be covered by the tabluated conditions. All Racking and collector parts shall be designed and installed per manufacturer's approved installation specifications.

Table 1. Design Criteria for Obstructed Wind Flow

Codes: 2019 California Building Code (ASCE 7-16) & 2016 California Building Code (ASCE 7-10)

Risk Category: II

Condition 1.				Condition 2.			
Wind Load	(Monoslope Open Structure)			**Wind Load**	(Monoslope Open Structure)		
	V=	110*	mph		V=	110*	mph
	Exposure=	C	(33 feet max height)		Exposure=	C	
Dead Load	D=	3.3	psf	**Dead Load**	D=	3.3	psf
Ground Snow	S=	0	psf	**Ground Snow**	S=	30	psf
Seismic	S_S =	2.2		**Seismic**	S_S =	2.2	
	S_{DS} =	1.5			S_{DS} =	1.5	

Table 2. Design Criteria for Clear Wind Flow

Codes: 2019 California Building Code (ASCE 7-16) & 2016 California Building Code (ASCE 7-10)

Risk Category: II

Condition 3.				Condition 4.			
Wind Load	(Monoslope Open Structure)			**Wind Load**	(Monoslope Open Structure)		
	V=	110*	mph		V=	110*	mph
	Exposure=	B*	(33 feet max height)		Exposure=	B*	
Dead Load	D=	3.3	psf	**Dead Load**	D=	3.3	psf
Ground Snow	S=	0	psf	**Ground Snow**	S=	30	psf
Seismic	S_S =	2.2		**Seismic**	S_S =	2.2	
	S_{DS} =	1.5			S_{DS} =	1.5	

*It is acceptable to use exposure C with clear wind flow in cases where the wind speed is 100 mph and below.

*It is acceptable to use 65 feet height in cases where the wind speed is 96 mph and below.

References

ASCE Minimum Design Loads for Buildings and Other Structures (ASCE7-16 and ASCE 7-10)
2018 National Design Specification for Wood Construction (NDS)
2015 Aluminum Design Manual (ADM)

Notes and Limits of Scope of Work

1. Racks are Installed on both long sides of the collectors with a maximum spacing of 4'
2. The strength of the collectors is not part of the scope of this report.
3. Engineer of Record for each specific site shall be responsible for its analysis and design forces
4. This report can be used for reference only for sites meeting condition in Table 1 and/or Table 2
5. For condition 1 & 2, maximum building height considered is 20 feet for 110 mph
6. Considering the 96 mph prominent in California, the building height can be increased to 65 feet
7. Engineer of Record for each specific installation shall be responsible for the design of fasteners
8. Atmospheric Ice loading and flood loading are beyond the scope of this report.
9. The rack structure in this report is defined in a drawing package prepared by Heliodyne, Inc. Titled Heliodyne Rack Installation Guide, dated 12/15/2010.

Wind Load Back Ground

Background

After several iteration, it was evident that the mounitng clip would govern the desing. In the Heliodyne report by MATRIX Consulting Engineers, a Finite Element Analysis was performed and resulted in clip capacity at different angles. In light of this informaton, We analysed different wind speeds in combination with varying exposure categories and settled on speeds that would not result in forces greater than what the clip can handle. Both obstructed and clear wind flow were considered. All the iteration focused on condition typical to most of California.

In light of new research and studies, ASCE 7-16 was introduced with mostly reduced basic wind speed maps. With the exception of special wind region, all category II structures in California have basic wind speeds of 100 mph or less. Our analysis tailored for California was run using 110 mph in order to enveloppe wind speed in ASCE 7-16 as well as ASCE 7-10.

Velocity Pressure was calculated as follow:

$q_h = 0.00256KzK_{zt}K_dV^2$ eq. 26.10-1 ASCE 7-10

$q_h = 0.00256KzK_{zt}K_dK_eV^2$ eq. 26.10-1 ASCE 7-16

Site specific variables are:

- Basic wind speed: V
- Velocity pressure exposure coefficient, evaluated at height z: Kz
- Topographic factor: Kzt
- Ground elevation Factor Ke (Conservatively used 1)

The newly added ground elevation factor reduces with altitude, we opted to conservatively use 1 given many different altitude possibilities.

Non Site specific variables are:

- Wind directionality factor: Kd = 0.85
- Gust effect factor: G = 0.85

The Net design pressure was calculated as follow:

$p=q_hGC_N$ eq. 27.3-2 ASCE 7-16

C_N= Net pressure Coefficient determined from fig 27.3-4 of ASCE 7-16

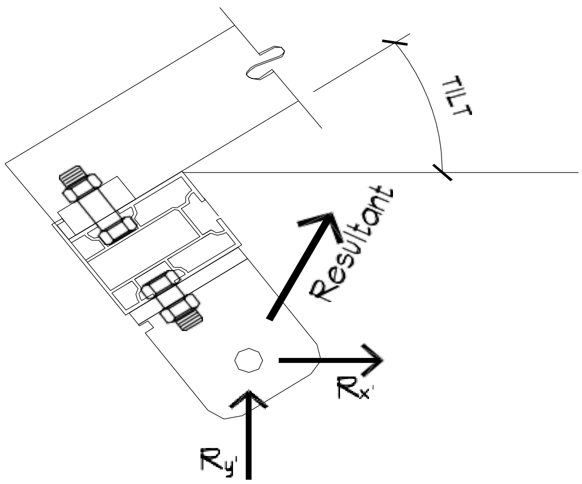
Load Combinations

Stength Level Combination (LRFD) per ASCE 7-16 Sections 2.3.1

Obstructed Wind	Clear Wind
LC1= 1.2D+1.0WA	LC9= 1.2D+1.0WE
LC2= 1.2D+1.0WB	LC10= 1.2D+1.0WF
LC3= 1.2D+1.0WC	LC11= 1.2D+1.0WG
LC4= 1.2D+1.0WD	LC12= 1.2D+1.0WH
LC5= 0.9D+1.0WA	LC13= 0.9D+1.0WE
LC6= 0.9D+1.0WB	LC14= 0.9D+1.0WF
LC7= 0.9D+1.0WC	LC15= 0.9D+1.0WG
LC8= 0.9D+1.0WD	LC16= 0.9D+1.0WH

Clip, Rail, and Foot Capacity Summary

Capacity below are extracted from the Heliodyne Rack Structure w/Gobi 410 Collector @ 35 degrees Report by MATRIX Consulting Engineers.



Tilt (Degrees)	Load Direction	Ry	Rx	Ry
35	Tension	-630	-361	-516
35	Comp.	1274	731	1044
45	Tension	-571	-404	-404
45	Comp.	721	510	510

Job Title Gobi

Client Heliodyne

Job Information

	Engineer	Checked	Approved
Name:	EM		
Date:	20-July-20		

Structure Type	SPACE FRAME

Number of Nodes	6	Highest Node	6
Number of Elements	5	Highest Beam	5

Number of Basic Load Cases	-2
Number of Combination Load Cases	25

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

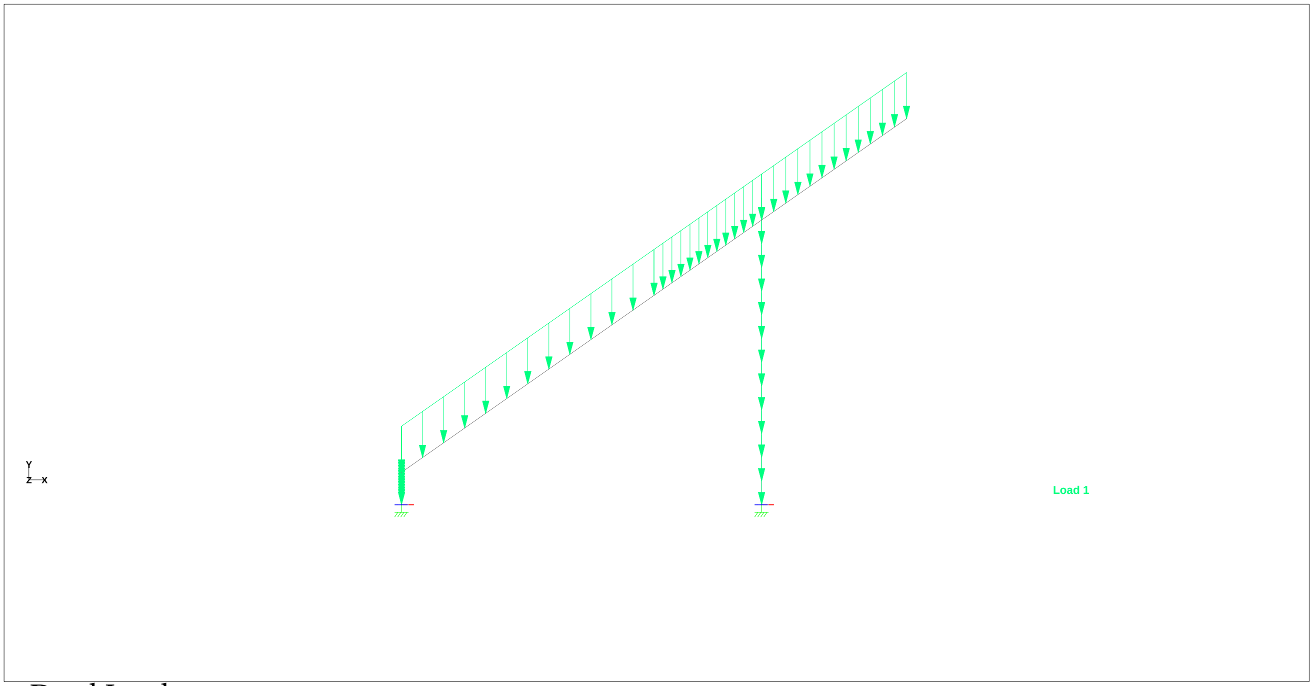
Type	L/C	Name
Primary	1	DL1 - DEAD LOAD 1
Primary	2	SL1 - SNOW LOAD 1
Primary	3	WLA
Primary	4	WLB
Primary	5	WLC
Primary	6	WLD
Primary	7	WLE
Primary	8	WLF
Primary	9	WLG
Primary	10	WLH
Combination	11	LRFD REACTION COMBOS
Combination	12	1.2DL1+1.6SL1+0.5WLA
Combination	13	1.2DL1+1.6SL1+0.5WLB
Combination	14	1.2DL1+1.6SL1+0.5WLC
Combination	15	1.2DL1+1.6SL1+0.5WLD
Combination	16	1.2DL1+1.0WLA+.5SL1
Combination	17	1.2DL1+1.0WLB+.5SL1
Combination	18	1.2DL1+1.0WLC+.5SL1
Combination	19	1.2DL1+1.0WLD+.5SL1
Combination	20	0.9DL1+1.0WLA
Combination	21	0.9DL2+1.0WLB
Combination	22	0.9DL2+1.0WLC
Combination	23	0.9DL2+1.0WLD
Combination	24	1.2DL1+1.6SL1+0.5WLE
Combination	25	1.2DL1+1.6SL1+0.5WLF
Combination	26	1.2DL1+1.6SL1+0.5WLG
Combination	27	1.2DL1+1.6SL1+0.5WLH
Combination	28	1.2DL1+1.0WLE+.5SL1
Combination	29	1.2DL1+1.0WLF+.5SL1

Job Information Cont...

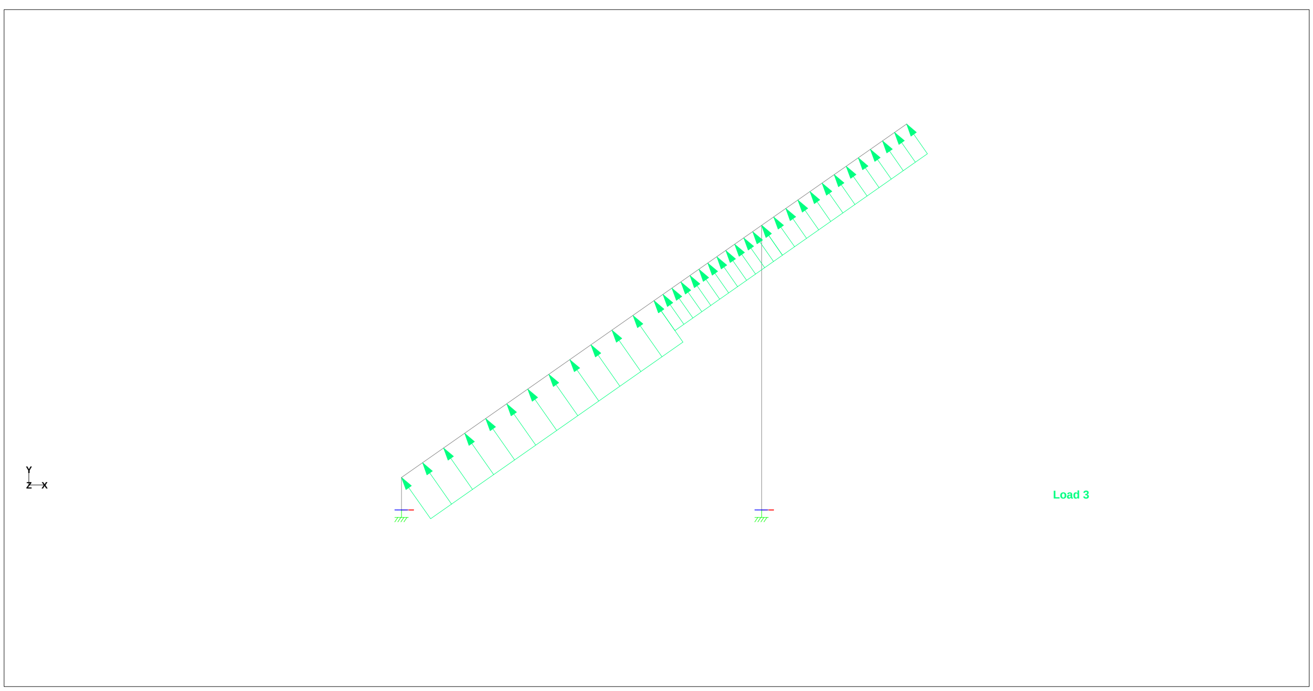
Type	L/C	Name
Combination	30	1.2DL1+1.0WLG+.5SL1
Combination	31	1.2DL1+1.0WLH+.5SL1
Combination	32	0.9DL1+1.0WLE
Combination	33	0.9DL2+1.0WLF
Combination	34	0.9DL2+1.0WLG
Combination	35	0.9DL2+1.0WLH

Job Title Gobi

Client Heliodyne



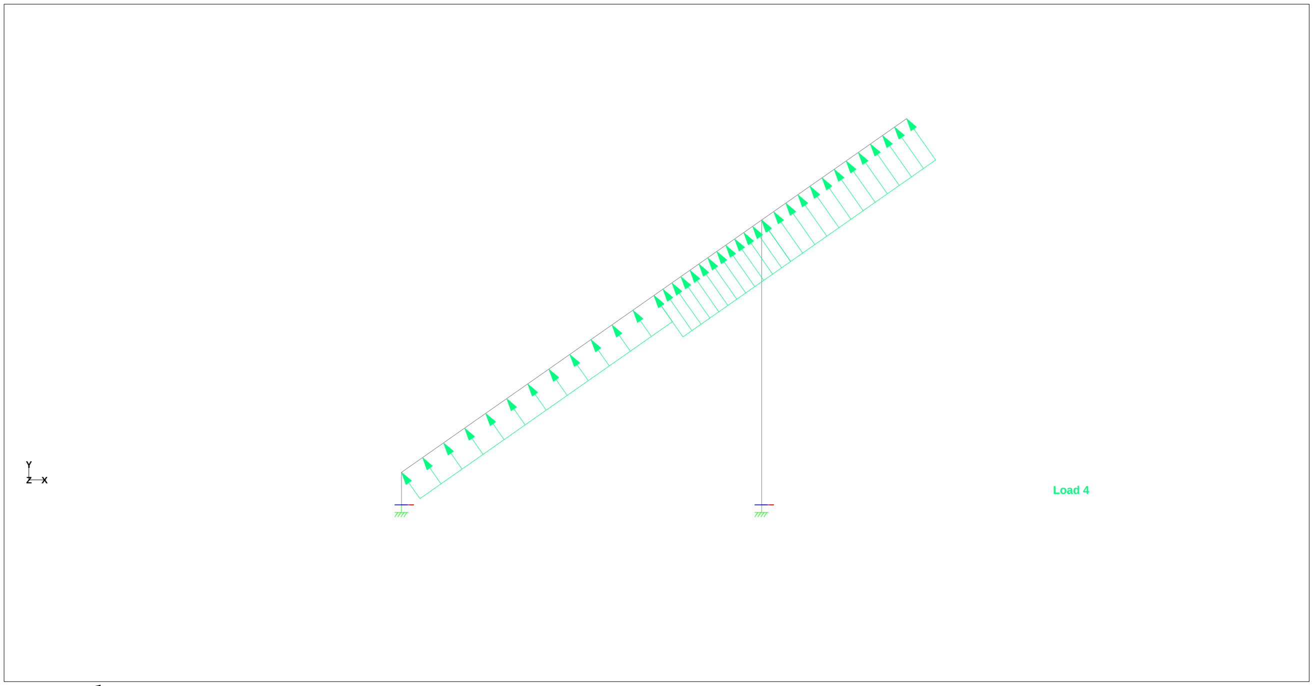
1 Dead Load



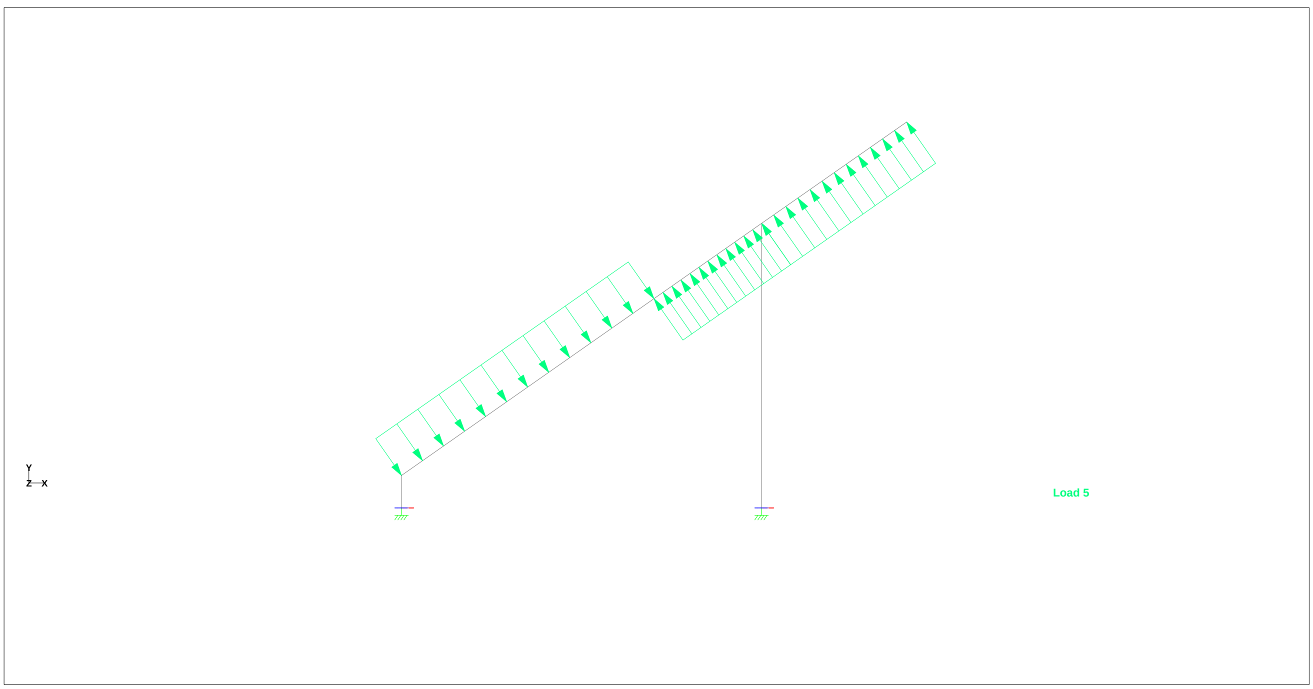
2 WInd_A

Job Title Gobi

Client Heliodyne



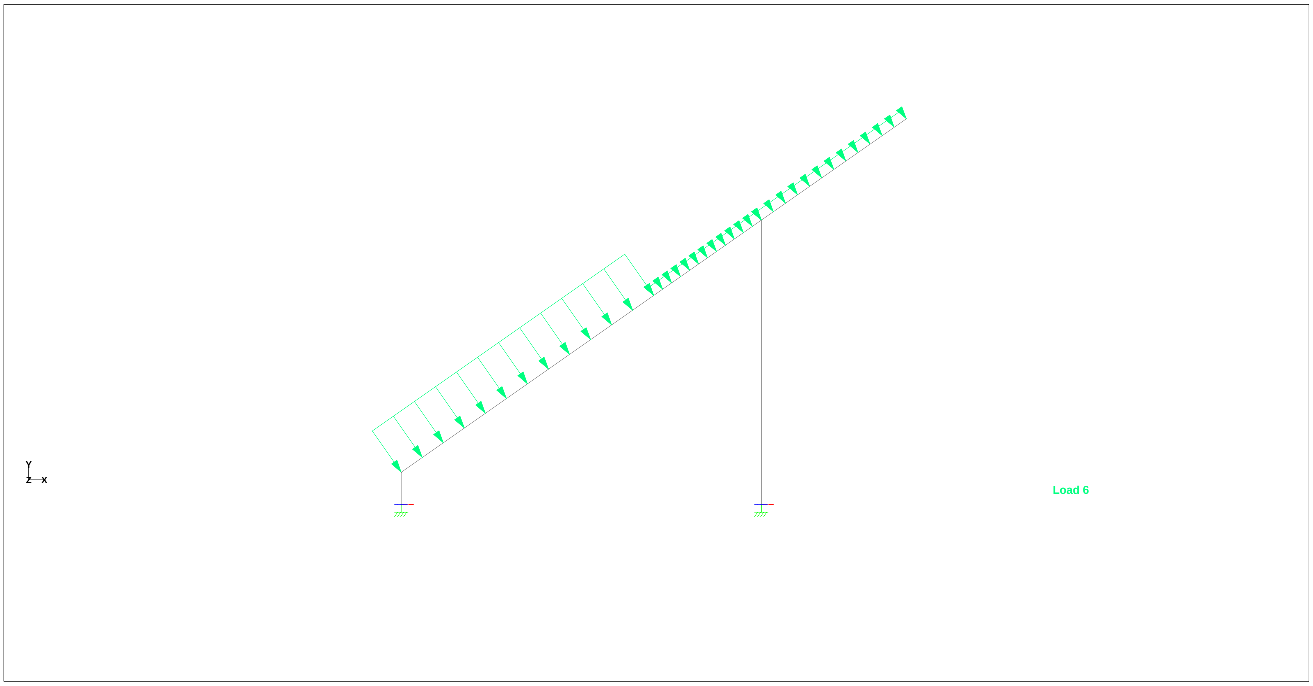
3 Wind_B



Wind_C

Job Title Gobi

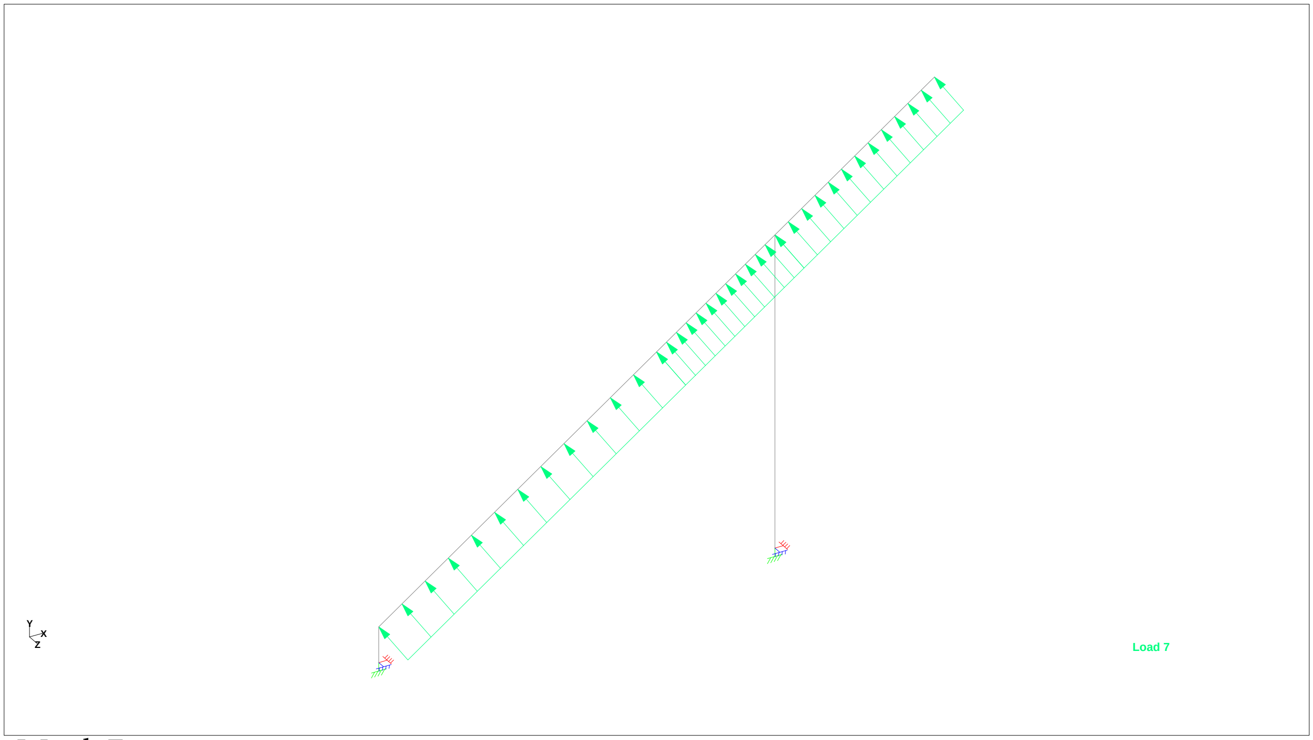
Client Heliodyne



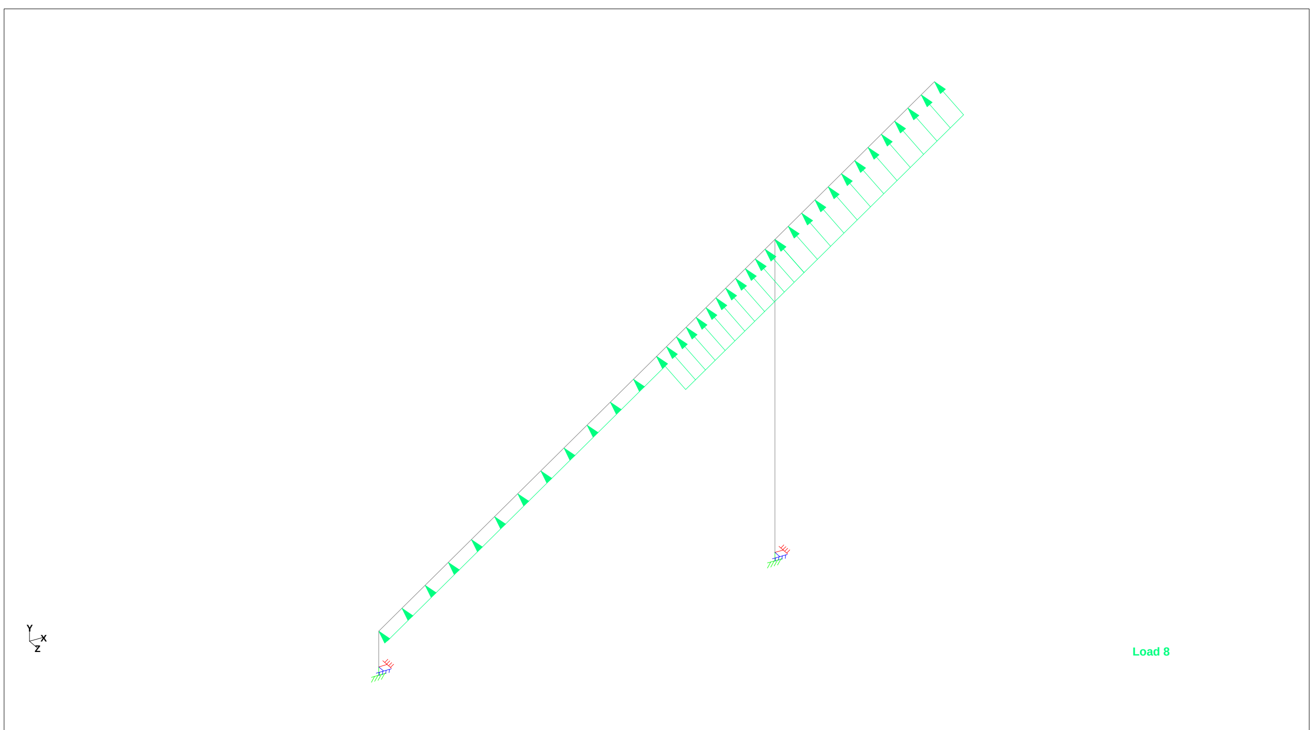
wind_D

Job Title Gobi

Client Heliodyne



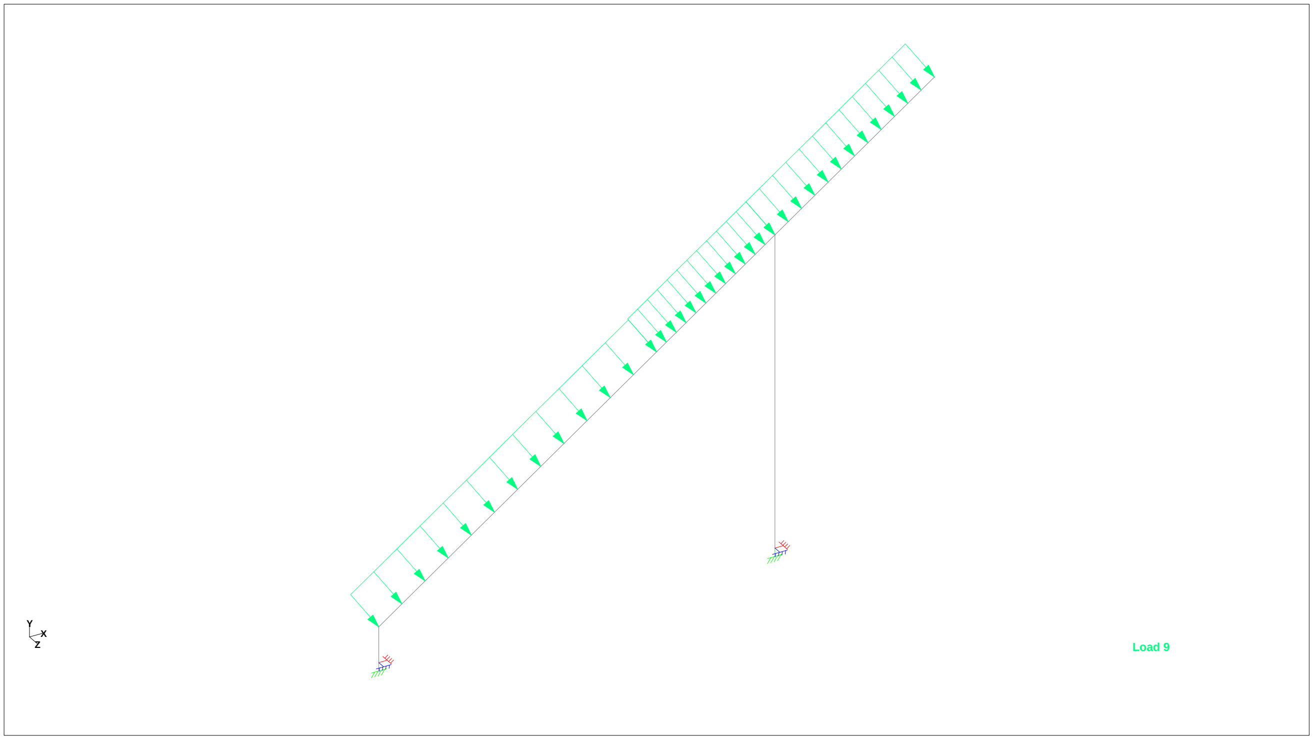
Wind_E



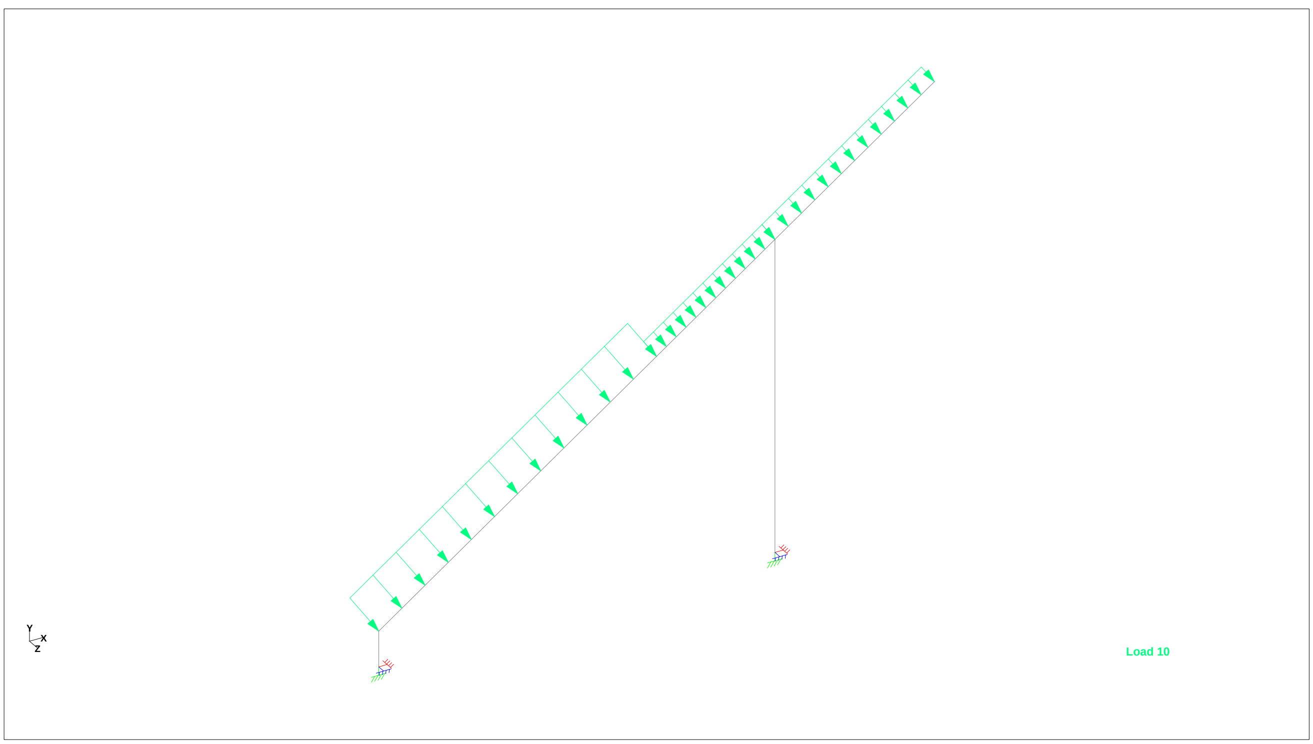
Wind_F

Job Title Gobi

Client Heliodyne

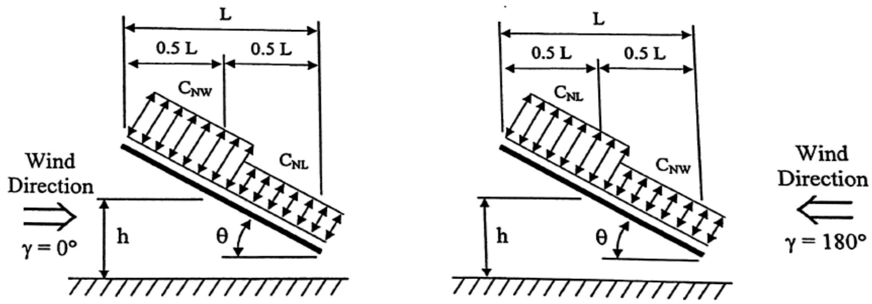


Wind_G



Wind_H

Wind Load (Exposure C)- Obstructed Wind Flow



Wind Load Calculation: $q = 0.00256K_zK_eK_dK_{zt}V^2I_w$

Wind Speed: 110 mph **Exposure:** C

K_e = 1.00 K_z = 0.9

K_{zt} = 1.00 I_w = 1.0

K_d = 0.85 Mean Roof Height (h) = 20.0 ft

q = 23.7 psf Trib Width= 4 ft

Roof Pressure Coefficients (ASCE 7-16/ASCE 7-10): Sin (Θ) = 0.574

Tilt (Θ) = 35.0 deg Cos (Θ) = 0.819

Leg Horiz. Trib. 5.064 ft

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-1.5	-1.8	0.67	-0.93
B	-2.23	-1.1	1.8	0.23

Roof Pressures ($p = qGC_N$ (psf)): G = 0.85

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-30.2	-36.3	13.5	-18.7
B	-44.9	-22.2	36.3	4.6

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-351	-501	-421	-602	157	224	-218	-311
B	-522	-671	-257	-368	421	602	54	77

Dead Load 3.3 psf

1.2D	3.96	psf		0.9D	2.97	psf
Linear	15.84	plf			11.88	plf
Per Post	80.15	lbs			60.1	lbs

Down Force 1.2D+1.0W

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-351	-421	-421	-521	157	304	-218	-231
B	-522	-591	-257	-287	421	682	54	157

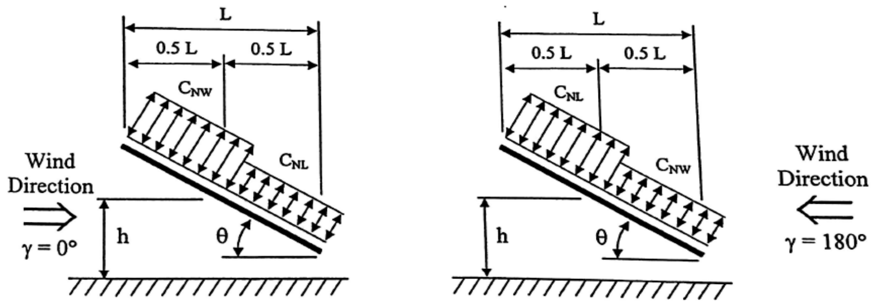
(lbs)	Loads	Capacity	Ratio	Result
Vertical +	682	1274	0.54	**OK**
Vertical -	-591	-630	0.94	**OK**
Lateral +	421	731	0.58	**OK**
Lateral -	-522	-590	0.88	**OK**

Uplift 0.9D+W

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-351	-441	-421	-541	157	284	-218	-251
B	-522	-611	-257	-308	421	662	54	137

(lbs)	Loads	Capacity	Ratio	Result
Vertical +	662	1274	0.52	**OK**
Vertical -	-611	-630	0.97	**OK**
Lateral +	421	731	0.58	**OK**
Lateral -	-522	-590	0.88	**OK**

Wind Load (Exposure B)- Clear Wind Flow



Wind Load Calculation: $q = 0.00256K_zK_eK_dK_{zt}V^2I_w$

Wind Speed:	110 mph	**Exposure:**	B
K_e =	1.00	K_z =	0.7
K_{zt} =	1.00	I_w =	1.0
K_d =	0.85	Mean Roof Height (h) =	20.0 ft
q =	**18.5 psf**		

Trib Width= 4 ft

Roof Pressure Coefficients (ASCE 7-16/ASCE 7-10):

Sin (Θ) = 0.574

Tilt (Θ) = 35.0 deg

Cos (Θ) = 0.819

Leg Horiz. Trib. 5.064 ft

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Clear Wind Flow		Clear Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-1.8	-1.8	2.1	2.16
B	-2.43	-0.56	2.66	1.06

Roof Pressures ($p = qGC_N$ (psf)): G = 0.85

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-28.2	-28.2	32.9	33.9
B	-38.1	-8.8	41.7	16.6

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-328	-469	-328	-469	383	547	394	562
B	-443	-569	-102	-146	485	692	193	276

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Dead Load 3.3 psf

1.2D	3.96	psf		0.9D	2.97	psf
Linear	15.84	plf			11.88	plf
Per Post	80.15	lbs			60.1	lbs

Down Force 1.2D+1.0W

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-328	-388	-328	-388	383	627	394	642
B	-443	-489	-102	-66	485	773	193	356

(lbs)	Loads	Capacity	Ratio	Result
Vertical +	773	1274	0.61	**OK**
Vertical -	-489	-630	0.78	**OK**
Lateral +	485	731	0.66	**OK**
Lateral -	-443	-590	0.75	**OK**

Uplift 0.9D+W

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-328	-408	-328	-408	383	607	394	622
B	-443	-509	-102	-86	485	753	193	336

(lbs)	Loads	Capacity	Ratio	Result
Vertical +	753	1274	0.59	**OK**
Vertical -	-509	-630	0.81	**OK**
Lateral +	485	731	0.66	**OK**
Lateral -	-443	-590	0.75	**OK**

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Wind (Exposure C) & Snow - Obstructed Wind flow

Wind Load Calculation: $q = 0.00256K_zK_eK_dK_{zt}V^2I_w$

Wind Speed: 110 mph **Exposure:** C

K_e = 1.00 K_z = 0.9

K_{zt} = 1.00 I_w = 1.0

K_d = 0.85 Mean Roof Height (h) = 20.0 ft

q = 23.7 psf

Trib Width 4 ft

Roof Pressure Coefficients (ASCE 7-16/ASCE 7-10): Sin (Θ) = 0.574

Tilt (Θ) = 35.0 deg Cos (Θ) = 0.819

Leg Horiz. Trib. 5.064 ft

	Wind Direction, γ = 0 deg		0.0 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-1.5	-1.8	0.67	-0.93
B	-2.23	-1.1	1.8	0.23

Roof Pressures ($p = qGC_N$ (psf)): G = 0.85

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-30.2	-36.3	13.5	-18.7
B	-44.9	-22.2	36.3	4.6

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-351	-501	-421	-602	157	224	-218	-311
B	-522	-745	-257	-368	421	602	54	77

Dead Load 3.3 psf

1.2D 3.96 psf

Linear 15.84 plf

Per Post 80.15 lbs

Snow Load Calculation: $p_f = 0.7C_eC_tI_sp_g$

ound Snow:	30.0 psf		
C_e =	0.9		
C_t =	1.2		
I_s =	1.0		
p_f =	**22.7 psf**		
P_s=Cs*p_f =	**20.0 psf**		
Trib.=	**80**	**0.5S**	**1.6S**
Per post=	**405**	203	648

Case 1 1.2D+1W+0.5S

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-351	-219	-421	-319	157	507	-218	-28
B	-522	-463	-257	-85	587	884	54	360

(lbs)	Loads	Capacity	Ratio	Result
Vertical +	884	1274	0.69	**OK**
Vertical -	-463	-690	0.67	**OK**
Lateral +	587	731	0.80	**OK**
Lateral -	-522	-600	0.87	**OK**

Case 2 1.2D+0.5W+1.6S

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-176	478	-211	428	78	840	-109	573
B	-261	356	-129	545	582	1029	27	767

(lbs)	Loads	Capacity	Ratio	Result
Vertical +	1029	1274	0.81	**OK**
Vertical -	356	-630	0.56	**OK**
Lateral +	582	731	0.80	**OK**
Lateral -	-261	-590	0.44	**OK**

Wind (Exposure B) & Snow -Clear Wind flow

Wind Load Calculation: $q = 0.00256K_zK_eK_dK_{zt}V^2I_w$

Vind Speed: 110 mph **Exposure:** B

K_e =	1.00	K_z =	0.7
K_{zt} =	1.00	I_w =	1.0
K_d =	0.85	Mean Roof Height (h) =	20.0 ft
q =	**18.5 psf**		

Trib Width 4 ft

Roof Pressure Coefficients (ASCE 7-16/ASCE 7-10):

Sin (Θ) = 0.574

Tilt (Θ) = 35.0 deg

Cos (Θ) = 0.819

Leg Horiz. Trib. 5.064 ft

	Wind Direction, γ = 0 deg		0.0 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-1.8	-1.8	2.1	2.16
B	-2.43	-0.56	2.66	1.06

Roof Pressures ($p = qGC_N$ (psf)): G = 0.85

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-28.2	-28.2	32.9	33.9
B	-38.1	-8.8	41.7	16.6

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-328	-469	-328	-469	383	547	394	562
B	-443	-633	-102	-146	485	692	193	276

Dead Load	3.3 psf
1.2D	3.96 psf
Linear	15.84 plf
Per Post	80.15 lbs

Snow Load Calculation: $p_f = 0.7C_eC_tI_sp_g$

ound Snow:	30.0 psf		
C_e =	0.9		
C_t =	1.2		
I_s =	1.0		
p_f =	**22.7 psf**		
P_s=Cs*p_f =	**20.0 psf**		
Trib.=	**80**	**0.5S**	**1.6S**
Per post=	**405**	203	648

Case 1 1.2D+1W+0.5S

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-328	-186	-328	-186	383	829	394	845
B	-443	-350	-102	137	651	975	193	559

(lbs)	Loads	Capacity	Ratio	Result
Vertical +	975	1274	0.77	**OK**
Vertical -	-350	-690	0.51	**OK**
Lateral +	651	731	0.89	**OK**
Lateral -	-443	-600	0.74	**OK**

Case 2 1.2D+0.5W+1.6S

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-164	494	-164	494	191	1002	197	1009
B	-221	412	-51	655	614	1075	97	866

(lbs)	Loads	Capacity	Ratio	Result
Vertical +	1075	1274	0.84	**OK**
Vertical -	412	-630	0.65	**OK**
Lateral +	614	731	0.84	**OK**
Lateral -	-221	-590	0.38	**OK**

Seismic Loads:

Importance Factor (I) :	I	
Site Class :	D	Assumed
Ss (0.2 sec) =	220 %g	
S1 (1.0 sec) =	93 %g	
S_{DS}=	1.5	
Number of Stories:	1	
Building System:	**Component and Cladding**	
Tributary Area=	40.5	ft^2
Amplification factor, ap =	1	
Spectral Acceleration, SDS =	1.5	
Operating Weight, Wp (psf) =	3.3	
Response Modification Factor, Rp =	1.5	
Importance Factor, Ip =	1	
Reduction Factor, ρ=	1	
Height above ground level, z (ft) =	33	
Mean height, h (ft) =	33	

Fp= $\frac{0.4 \text{ ap } S_{DS} Wp^* (1+2^*z/h)}{(Rp/Ip)}$ = 1.173 Wp

Fp Min. 0.3 S_{DS} Ip Wp= 0.44 Wp

Fp Max. 1.6 S_{DS} Ip Wp= 2.35 Wp

Forces in X-direction

Eh=ρ Fp Wp Lp=	156.9	<	328	lbs

Forces in Y-direction

Wind Governs

Ev=0.2 S_{DS} Wp Lp=	39.2	<	406	lbs

Wind Governs

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Anchor Design Envelope

Wind Load Calculation: $q = 0.00256 K_z K_e K_d K_{zt} V^2 I_w$

Wind Speed:	110 mph	**Exposure:**	C
K_e =	1.00	K_z =	1.0
K_{zt} =	1.00	I_w =	1.0
K_d =	0.85	Mean Roof Height (h) =	33.0 ft
q =	**26.3 psf**		

Trib Width 4 ft

Roof Pressure Coefficients (ASCE 7-16/ASCE 7-10):

Sin (Θ) = 0.574

Tilt (Θ) = 35.0 deg

Cos (Θ) = 0.819

Leg Horiz. Trib. 5.064 ft

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-1.5	-1.8	0.67	-0.93
B	-2.23	-1.1	1.8	0.23

Roof Pressures ($p = qGC_N$ (psf)): G = 0.85

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-33.6	-40.3	15.0	-20.8
B	-49.9	-24.6	40.3	5.1

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-390	-557	-468	-668	174	249	-242	-345
B	-580	-828	-286	-408	468	668	60	85

Snow Load Calculation: $p_f = 0.7 C_e C_t I_s p_g$

Ground Snow:	30.0 psf			
C_e =	0.9			
C_t =	1.2			
I_s =	1.0			
p_f =	**22.7 psf**			
$P_s = Cs * p_f$ =	**20.0 psf**			
Trib.=	**80**	**0.75S**	0.6D	40.08 lbs
Per post=	**405**	304		

Dead Load 3.3 psf

D	3.3 psf
Linear	13.2 plf
Per Post	66.79 lbs

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http://www.evengineersnet.com

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Case 1 **D+0.75(0.6W)+0.75S**

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-176	120	-211	70	78	483	-109	215
B	-261	-2	-129	187	211	671	27	409

Case 2 **D+0.6W**

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-234	-267	-281	-334	105	216	-145	-140
B	-348	-430	-172	-178	281	468	36	118

Case 3 **0.6D+0.6W**

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-234	-294	-281	-361	105	189	-145	-167
B	-348	-457	-172	-205	281	441	36	91

Lag Screw Connection

Attachement max. spacing=	4	ft		
3/8" Lag Screw Withdrawl Value=	305	lb/in		Table 12.2A - NDS
Lag Screw Penetration=	3	in		No. 2 DFL assumed
Prying Coefficient	1.4			
Allowable Capacity with CD=	1045.7	lbs		
Net Uplift	457	lbs		
Max shear	348	lbs	<	576 lbs **Ok**
Max Moment	**1984**	**ft-in**		
Tension/Compression	661.2	lbs		
Total Uplift (envelope)	661	lbs	<	1046 lbs **Ok**

Pv seismic dead weight is negligible to result in significant seismic uplift, therefore the wind uplift governs

Embedment is measured from the top of the framing member to the tapered tip of a lag screw. Embedment in sheading or other material does not count.

In this design, (2) 3/8" diameter lag bolts with a minimum 3" effective embedment as defined above into a DFL #2 or better is sufficient provided NDS 2015 design requirements are followed.

Design of the framing supporting Gobi 410 is not part of our scope and should be verified and comfirmed by the SEOR

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Anchor Design Envelope

Wind Load Calculation: $q = 0.00256K_zK_eK_dK_{zt}V^2I_w$

Wind Speed:	110 mph	**Exposure:**	C
K_e =	1.00	K_z =	1.0
K_{zt} =	1.00	I_w =	1.0
K_d =	0.85	Mean Roof Height (h) =	33.0 ft
q =	**26.3 psf**		

Trib Width 4 ft

Roof Pressure Coefficients (ASCE 7-16/ASCE 7-10):

Tilt (Θ) = 35.0 deg

Sin (Θ) = 0.574

Cos (Θ) = 0.819

Leg Horiz. Trib. 5.064 ft

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-1.8	-1.8	2.1	2.16
B	-2.43	-0.56	2.66	1.06

Roof Pressures ($p = qGC_N$ (psf)): G = 0.85

	Wind Direction, γ = 0 deg		Wind Direction, γ = 180 deg	
	Obstructed Wind Flow		Obstructed Wind Flow	
Load Case	C_{NW}	C_{NL}	C_{NW}	C_{NL}
A	-40.3	-40.3	47.0	48.3
B	-54.4	-12.5	59.5	23.7

	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		**Front**		**Front**		**Rear**	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-468	-668	-468	-668	546	780	562	802
B	-632	-902	-146	-208	692	988	276	394

Snow Load Calculation: $p_f = 0.7C_eC_tI_sp_g$

Ground Snow:	30.0 psf			
C_e =	0.9			
C_t =	1.2			
I_s =	1.0			
p_f =	**22.7 psf**			
$P_s=Cs*p_f$ =	**20.0 psf**			
Trib.=	**80**	**0.75S**	0.6D	40.08 lbs
Per post=	**405**	304		

Dead Load 3.3 psf

D	3.3 psf
Linear	13.2 plf
Per Post	66.79 lbs

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Case 1	D+0.75(0.6W)+0.75S							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Front		Rear	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-211	70	-211	70	246	722	253	732
B	-284	-35	-66	277	311	815	124	548

Case 2	D+0.6W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Front		Rear	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-281	-334	-281	-334	328	535	337	548
B	-379	-475	-87	-58	415	659	165	303

Case 3	0.6D+0.6W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Front		Rear	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
A	-281	-361	-281	-361	328	508	337	521
B	-379	-501	-87	-85	415	633	165	276

Lag Screw Connection

Attachement max. spacing=	4	ft		
3/8" Lag Screw Withdrawl Value=	305	lb/in	Table 12.2A - NDS	
Lag Screw Penetration=	3	in	No. 2 DFL assumed	
Prying Coefficient	1.4			
Allowable Capacity with CD=	1045.7	lbs		
Net Uplift	501	lbs		
Max shear	379	lbs	<	576 lbs **Ok**
Max Moment	**2160**	**ft-in**		
Tension/Compression	720.1	lbs		
Total Uplift (envelope)	720	lbs	<	1046 lbs **Ok**

Pv seismic dead weight is negligible to result in significant seismic uplift, therefore the wind uplift governs

Embedment is measured from the top of the framing member to the tapered tip of a lag screw. Embedment in sheading or other material does not count.

In this design, (2) 3/8" diameter lag bolts with a minimum 3" effective embedment as defined above into a DFL #2 or better is sufficient provided NDS 2015 design requirements are followed.

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