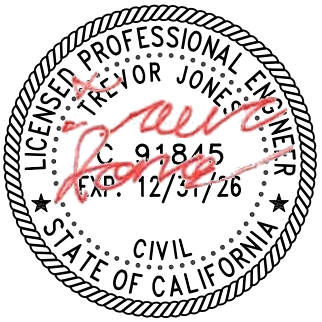
PV LETTERS

STRUCTURAL CALCULATIONS
FOR
HELIODYNE SOLAR COLLECTOR RACK STRUCTURES

Gobi 410 at 35 degrees
FOR HELIODYNE, INC.

October 30, 2025



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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. The analysis considered wind exposure B with 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: 2025 California Building Code, ASCE 7-22
Risk Category: II

Condition 1:

Wind Load (Monoslope Open Structure)

Basic wind speed V, mph:	110
Exposure Category:	B
Dead Load, psf:	3.3
Ground Snow Load, psf:	0
Seismic, S_{MS}:	2.54
Seismic, S_{M1}:	1.9

Condition 2:

Wind Load (Monoslope Open Structure)

Basic wind speed V, mph:	110
Exposure Category:	B
Dead Load, psf:	3.3
Ground Snow Load, psf:	30
Seismic, S_S:	2.54
Seismic, S_{DS}:	1.9

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Table 2: Design Criteria for Clear Wind Flow

Codes: 2025 California Building Code, ASCE 7-22
Risk Category: II

Condition 3:

Wind Load (Monoslope Open Structure)

Basic wind speed V, mph:	110
Exposure Category:	B
Dead Load, psf:	3.3
Ground Snow Load, psf:	0
Seismic, S_{MS}:	2.54
Seismic, S_{M1}:	1.9

Condition 4:

Wind Load (Monoslope Open Structure)

Basic wind speed V, mph:	110
Exposure Category:	B
Dead Load, psf:	3.3
Ground Snow Load, psf:	30
Seismic, S_{MS}:	2.54
Seismic, S_{M1}:	1.9

REFERENCES

ASCE Minimum Design Loads for Buildings and Other Structures (ASCE 7-22)
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 4ft
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 conditions 1-4, maximum building height considered is 40 feet for 110 mph
6. Engineer of Record for each specific installation shall be responsible for the design of fasteners
7. Atmospheric Ice loading and flood loading are beyond the scope of this report.
8. 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.

BACKGROUND

After some background investigation, it was evident that the mounting clip would govern the design. In the Heliodyne report by MATRIX Consulting Engineers, a Finite Element Analysis was performed and obtained clip capacity at different angles. In light of this informaton, we analyzed 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 conditions typical to most of California.

With the exception of special wind region, all Category II structures in California have basic wind speeds of 100 mph or less. Our analysis used 110 mph in order to consider special regions in California.

Velocity Pressure was calculated as follow:

$qh = 0.00256K_zK_{zt}K_eV^2$ eq. 26.10-1 ASCE 7-22

Site specific variables are:

- Basic wind speed: V
- Velocity pressure exposure coefficient, evaluated at height z: K_z
- Topographic factor: K_{zt}
- Ground elevation Factor Ke (Conservatively used 1)

Non Site specific variables are:

- Wind directionality factor: $K_d = 0.85$
- Gust effect factor: G = 0.85

The Net design pressure was calculated as follow:

$p=q_hK_dGC_N$ eq. 27.3-2 ASCE 7-22

C_N= Net pressure Coefficient determined from fig 27.3-4 of ASCE 7-22

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Snow Load Calculation

Ground Snow Load, P_g	30	psf
Exposure Factor, C_e	0.9	
Thermal Factor, C_t	1.2	
Importance Factor, I_s	1	
Flat Roof Snow Load	22.68	Eqn. 7.3-1 or jurisdiction min.
Slope	35.00	degrees
Unobstructed Slippery Surface?	Yes	
Slope Factor, C_s	0.64	
Sloped Roof Snow Load	**14.4**	psf

Dead Load Calculation

Solar Collector GOBI 410	3.3	psf

LOAD COMBINATIONS

Stength Level Combination (LRFD) per ASCE 7-22 Sections 2.3.1

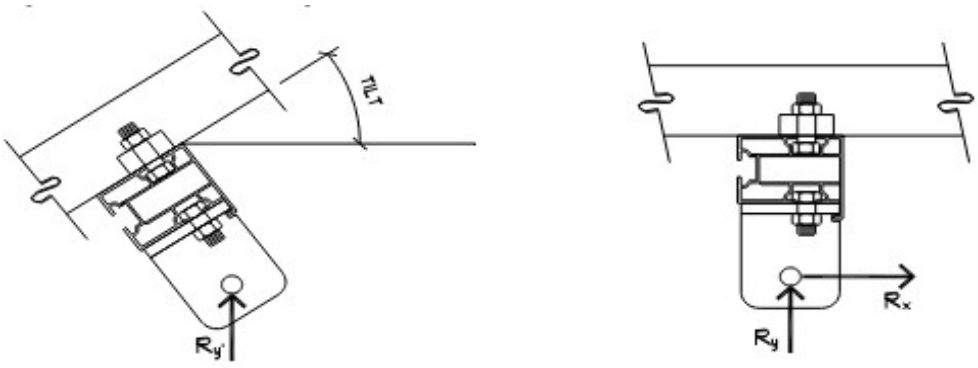
LC1: 1.2D +1.0W (0 Case A)
LC2: 1.2D +1.0W (0 Case B)
LC3: 1.2D +1.0W (180 Case A)
LC4: 1.2D +1.0W (180 Case B)
LC5: 0.9D +1.0W (0 Case A)
LC6: 0.9D +1.0W (0 Case B)
LC7: 0.9D +1.0W (180 Case A)
LC8: 0.9D +1.0W (180 Case B)
LC9: 1.2D + W + 0.5S (0 Case A)
LC10: 1.2D + W + 0.5S (0 Case B)
LC11: 1.2D + W + 0.5S (180 Case A)
LC12: 1.2D + W + 0.5S (180 Case B)
LC13: 1.2D + 0.5W + 1.6S (0 Case A)
LC14: 1.2D + 0.5W + 1.6S (0 Case B)
LC15: 1.2D + 0.5W + 1.6S (180 Case A)
LC16: 1.2D + 0.5W + 1.6S(180 Case B)

CLIP, RAIL, AND FOOT CAPACITY SUMMARY

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

Leg Clip and Rail

Figure 1 shows the loading for the rear clip and rail and Table 3 shows the corresponding capacacity



(a) (b)

Figure 1: Leg Assembly Loading: (a) Actual Orientation & (b) Corresponding Analysis Orientation

Table 3: Assembly Capacity

Tilt (degrees)	Load Direction	Ry' (lbs)	Rx (lbs)	Ry (lbs)
35	Tension	-630	-361	-516
35	Compression	1274	731	1044
45	Tension	-571	-404	-404
45	Compression	721	510	510

Wind Pressure (Condition 1&2)

Analysis performed per ASCE 7-22

Site Information:

Basic wind speed V, mph:	110
Risk Category:	II
Exposure Category:	B

Geometry:

Tributary width, ft:	4.00
Tributary length, ft:	5.06
Tilt Angle, deg:	35
Sin of angle	0.57
Cos of angle	0.82
Mean Roof Height, ft:	40.00

Pressure Calculation:

Ground elevation factor K_e:	1.00	per Table 26.9-1
Wind directionality factor K_d:	0.85	per Table 26.6-1
Topographic factor K_{zt}:	1.00	per Figure 26.8-1
Velocity pressure coefficient K_z:	0.74	per Table 26.10-1
Velocity Pressure q_h, psf:	22.92	per Equation 26.10-1
Gust effect factor G:	0.85	per C26.11.1, structure assumed rigid
Wind Flow:	Obstructed	

Net Pressure Coefficients :
(per Figure 27.3-4)

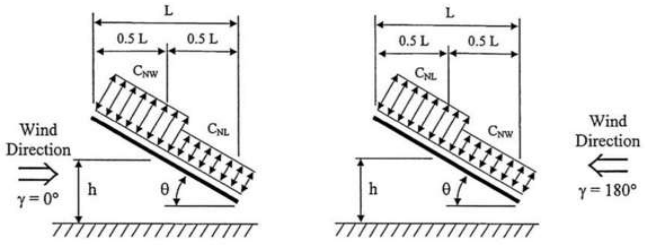
#	Dir., deg	Load Case	C_{NW}	C_{NL}
1	0	A	-1.5	-1.8
2	0	B	-2.2	-1.1
3	180	A	0.7	-0.9
4	180	B	1.8	0.2

Design Wind Forces - x-dir (lbs):
(per Equation 27.3-2)

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-288.6	-346.3
2	0	B	-429.7	-211.7
3	180	A	128.3	-179.6
4	180	B	346.3	44.9

Design Wind Forces - y-dir (lbs):
(per Equation 27.3-2)

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-412.2	-494.6
2	0	B	-613.7	-302.3
3	180	A	183.2	-256.5
4	180	B	494.6	64.1



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Wind Load (Exposure B) - Obstructed Wind Flow

Dead Load	3.3	psf

1.2D	3.96	psf	0.9D	2.97	psf
Distributed	15.84	plf	Distributed	11.88	plf
Per Post	80.21	lbs	Per Post	60.16	lbs

	1.2D + W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-289	-332	-346	-414	128	263	-180	-176
Case B	-430	-534	-212	-222	346	575	45	144

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	575	1274	0.45	OK
Vertical -	-534	-630	0.85	OK
Lateral +	346	731	0.47	OK
Lateral -	-430	-590	0.73	OK

	0.9D + W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-289	-352	-346	-434	128	243	-180	-196
Case B	-430	-554	-212	-242	346	555	45	124

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	555	1274	0.44	OK
Vertical -	-554	-630	0.88	OK
Lateral +	346	731	0.47	OK
Lateral -	-430	-590	0.73	OK

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Wind (Exposure B) & Snow - Obstructed Wind flow

Dead Load	3.3	psf	Snow Load	14.4	psf

1.2D	3.96	psf	0.5S	7.2	psf	1.6S	23.04	psf
Distributed	15.84	plf	Distributed	28.8	plf	Distributed	92.16	plf
Per Post	80.21	lbs	Per Post	145.84	lbs	Per Post	466.70	lbs

	1.2D + W + 0.5S							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-289	-186	-346	-269	128	409	-180	-30
Case B	-430	-388	-212	-76	346	721	45	290

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	721	1274	0.57	OK
Vertical -	-388	-630	0.62	OK
Lateral +	346	731	0.47	OK
Lateral -	-430	-590	0.73	OK

	1.2D + 0.5W + 1.6S							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-144	341	-173	300	64	639	-90	419
Case B	-215	240	-106	396	173	794	22	579

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	794	1274	0.62	OK
Vertical -	240	1274	0.19	OK
Lateral +	173	731	0.24	OK
Lateral -	-215	-590	0.36	OK

Wind Pressure (Condition 3&4)

Analysis performed per ASCE 7-22

Site Information:

Basic wind speed V, mph:	110
Risk Category:	II
Exposure Category:	B
Elevation, ft:	0

Geometry:

Tributary width, ft:	4.00
Tributary length, ft:	5.06
Tilt Angle, deg:	35
Sin of angle	0.57
Cos of angle	0.82
Mean Roof Height, ft:	40.00

Pressure Calculation:

Ground elevation factor K_e:	1.00	per Table 26.9-1
Wind directionality factor K_d:	0.85	per Table 26.6-1
Topographic factor K_{zt}:	1.00	per Figure 26.8-1
Velocity pressure coefficient K_z:	0.74	per Table 26.10-1
Velocity Pressure q_h, psf:	22.92	per Equation 26.10-1
Gust effect factor G:	0.85	per C26.11.1, structure assumed rigid
Wind Flow:	Clear	

Net Pressure Coefficients :
(per Figure 27.3-4)

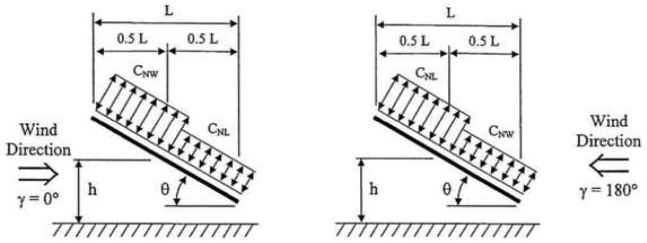
#	Dir., deg	Load Case	C_{NW}	C_{NL}
1	0	A	-1.8	-1.8
2	0	B	-2.4	-0.6
3	180	A	2.1	2.2
4	180	B	2.7	1.1

Design Wind Forces - x-dir (lbs):
(per Equation 27.3-2)

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-346.3	-346.3
2	0	B	-468.2	-109.0
3	180	A	404.1	416.9
4	180	B	513.1	205.2

Design Wind Forces - y-dir (lbs):
(per Equation 27.3-2)

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-494.6	-494.6
2	0	B	-668.7	-155.7
3	180	A	577.1	595.4
4	180	B	732.8	293.1



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Wind Load (Exposure B) - Clear Wind Flow

Dead Load	3.3	psf

1.2D	3.96	psf	0.9D	2.97	psf
Distributed	15.84	plf	Distributed	11.88	plf
Per Post	80.21	lbs	Per Post	60.16	lbs

	1.2D + W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-346	-414	-346	-414	404	657	417	676
Case B	-468	-588	-109	-76	513	813	205	373

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	813	1274	0.64	OK
Vertical -	-588	-630	0.93	OK
Lateral +	513	731	0.70	OK
Lateral -	-468	-590	0.79	OK

	0.9D + W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-346	-434	-346	-434	404	637	417	656
Case B	-468	-609	-109	-96	513	793	205	353

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	793	1274	0.62	OK
Vertical -	-609	-630	0.97	OK
Lateral +	513	731	0.70	OK
Lateral -	-468	-590	0.79	OK

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Wind (Exposure B) & Snow - Clear Wind flow

Dead Load	3.3	psf	Snow Load	14.4	psf

1.2D	3.96	psf	0.5S	7.2	psf	1.6S	23.04	psf
Distributed	15.84	plf	Distributed	28.8	plf	Distributed	92.16	plf
Per Post	80.21	lbs	Per Post	145.84	lbs	Per Post	466.70	lbs

	1.2D + W + 0.5S							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-346	-269	-346	-269	404	803	417	821
Case B	-468	-443	-109	70	513	959	205	519

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	959	1274	0.75	OK
Vertical -	-443	-630	0.70	OK
Lateral +	513	731	0.70	OK
Lateral -	-468	-590	0.79	OK

	1.2D + 0.5W + 1.6S							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-173	300	-173	300	202	835	208	845
Case B	-234	213	-55	469	257	913	103	693

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	913	1274	0.72	OK
Vertical -	213	1274	0.17	OK
Lateral +	257	731	0.35	OK
Lateral -	-234	-590	0.40	OK

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Lag Screw Check

Dead Load	3.3	psf	Snow Load	14.4	psf

1.0D	3.30	psf	0.6D	1.98	psf	0.75S	10.8	psf
Distributed	13.20	plf	Distributed	7.92	plf	Distributed	43.2	plf
Per Post	66.84	lbs	Per Post	40.11	lbs	Per Post	218.76	lbs

	D + 0.75(0.6W) + 0.75S							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	156	100	130	63	343	368	205	170
Case B	92	9	190	150	441	508	306	314

	D + 0.6W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-106	-180	-141	-230	144	177	-41	-87
Case B	-191	-301	-60	-115	275	364	94	105

	0.6D + 0.6W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-133	-207	-168	-257	117	150	-68	-114
Case B	-218	-328	-87	-141	248	337	67	79

Tension/Compression	**508**	lbs
Shear	**441**	lbs

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Lag Screw Check

Dead Load	3.3	psf	Snow Load	14.4	psf

1.0D	3.30	psf	0.6D	1.98	psf	0.75S	10.8	psf
Distributed	13.20	plf	Distributed	7.92	plf	Distributed	43.2	plf
Per Post	66.84	lbs	Per Post	40.11	lbs	Per Post	218.76	lbs

	D + 0.75(0.6W) + 0.75S							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	130	63	130	63	467	545	473	554
Case B	75	-15	237	216	517	615	378	418

	D + 0.6W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-141	-230	-141	-230	309	413	317	424
Case B	-214	-334	1	-27	375	507	190	243

	0.6D + 0.6W							
	Wind Direction, γ = 0 deg				Wind Direction, γ = 180 deg			
	Rear		Front		Rear		Front	
	C_{NW}		C_{NL}		C_{NW}		C_{NL}	
	X	Y	X	Y	X	Y	X	Y
Case A	-168	-257	-168	-257	283	386	290	397
Case B	-241	-361	-25	-53	348	480	163	216

Tension/Compression	**615**	lbs
Shear	**517**	lbs

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Seismic Load Calculation

Seismic Design Parameters

Importance Factor (I)	1.0	
Site Class	D	
S_{MS}	2.54	(conservative max for all site in CA)
S_{M1}	1.9	(conservative max for all site in CA)
S_{DS} (Equation 11.4-1)	1.69	

Calculation per ASCE 7-22 Chapter 13

Tributary Area (GOBI 410)	40.50	ft^2
Amplification factor, a_p	1.0	
Operating Weight, W_p	3.3	
Response Modification Factor, R_p	1.5	
Importance Factor, I_p	1.0	
Reduction Factor, ρ	1.0	
Height above ground level, z (ft)	40.0	
Mean height, h (ft)	40.0	

Horizontal Force, F_p	1.4 Wp	Eq. 13.3-1
Horizontal Force, F_p (max)	2.7 Wp	Eq. 13.3-2
Horizontal Force, F_p (min)	0.5 Wp	Eq. 13.3-3

Force in X-direction	
$Eh = \rho F_p W_p L_p$	181.05
Force in Y-direction	
$Ev = 0.2 S_{DS} W_p L_p$	45.26

Result: Based on the results, wind loads are greater than seismic loads. Therefore, wind governs

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Lag Screw Calculation (per ASCE 7-22)

This calculation justifies the connection of the pedestal foot to the existing roof framing members, by showing the connection capacity is equal to or greater than the uplift force demands.

Connection Demand

Shear, lbs	615.0
Tension/Compression, lbs	517.0

Connection Capacity

Attachment location	Framing	
Fastener Type	Lag Screw	
Fastener Diameter (in)	0.375	
Embedment Length (in), min	3	
Lumber Species & Grade	DFL #2 (Assumed)	
# of Screws	2	
Withdrawal Capacity, lbs	390	(https://awc.org/calculators/connection-calculator/)
Lateral Capacity, lbs	991	(https://awc.org/calculators/connection-calculator/)
Total Withdrawal Capacity, lbs	780	
Total Shear Capacity, lbs	1560	

Result

Lateral (Demand/Capacity)	**0.79**	**OK**
Withdrawal (Demand/Capacity)	**0.33**	**OK**

Capacity exceeds demands. Therefore, connection passes.