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STRUCTURAL CALCULATIONS

FOR

HELIODYNE SOLAR COLLECTOR RACK STRUCTURES

Gobi 410 at 45 degrees

FOR HELIODYNE, INC.

October 30, 2025

LICENSED PROFESSIONAL ENGINEER
TREVOR JONES
C 91845
EXP. 12/31/26
CIVIL
STATE OF CALIFORNIA

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SCOPE OF WORK

This report is for the Heliodyne Rack Stucture with Gobi 410 Collector at 45 degrees. The purpose of the analysis was to determine appropriate loadings for the Heliodyne rack structure with Gobi 410 collectors at 45 degrees following the current most 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_{MS}:	2.54
Seismic, S_{M1}:	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.

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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	45.00	degrees
Unobstructed Slippery Surface?	Yes	
Slope Factor, C_s	0.46	
Sloped Roof Snow Load	**10.3**	psf

Dead Load Calculation

Solar Collector GOBI 410	3.3	psf

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LOAD COMBINATIONS

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

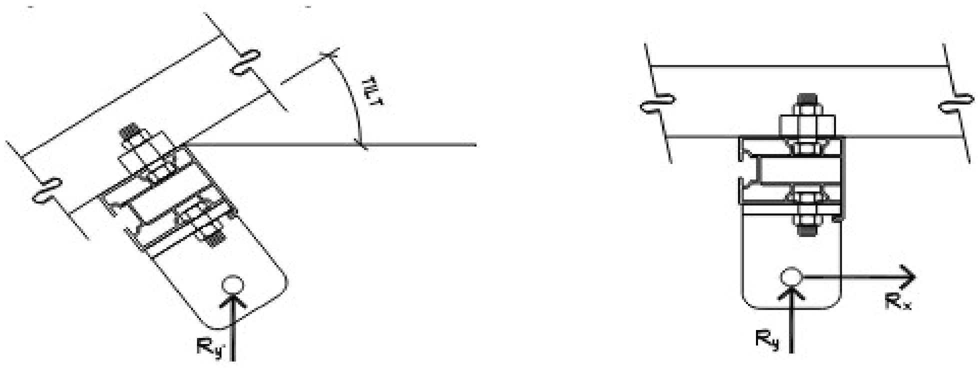
LC1: 1.2D +1.0W (0 Case A)	LC9: 1.2D + W + 0.5S (0 Case A)
LC2: 1.2D +1.0W (0 Case B)	LC10: 1.2D + W + 0.5S (0 Case B)
LC3: 1.2D +1.0W (180 Case A)	LC11: 1.2D + W + 0.5S (180 Case A)
LC4: 1.2D +1.0W (180 Case B)	LC12: 1.2D + W + 0.5S (180 Case B)
LC5: 0.9D +1.0W (0 Case A)	LC13: 1.2D + 0.5W + 1.6S (0 Case A)
LC6: 0.9D +1.0W (0 Case B)	LC14: 1.2D + 0.5W + 1.6S (0 Case B)
LC7: 0.9D +1.0W (180 Case A)	LC15: 1.2D + 0.5W + 1.6S (180 Case A)
LC8: 0.9D +1.0W (180 Case B)	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:	45
Sin of angle	0.71
Cos of angle	0.71
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)

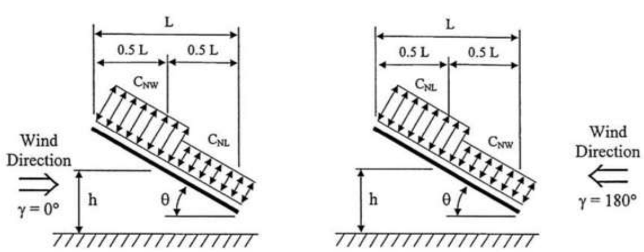
#	Dir., deg	Load Case	C_{NW}	C_{NL}
1	0	A	-1.3	-1.8
2	0	B	-1.9	-1.2
3	180	A	0.8	-0.9
4	180	B	2.1	0.4

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

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-308.4	-427.0
2	0	B	-450.7	-284.7
3	180	A	189.8	-213.5
4	180	B	498.1	94.9

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

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-308.4	-427.0
2	0	B	-530.2	-284.7
3	180	A	223.3	-213.5
4	180	B	586.0	94.9



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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	-308	-228	-427	-347	190	303	-213	-133
Case B	-451	-450	-285	-204	498	666	95	175

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	666	1274	0.52	OK
Vertical -	-450	-630	0.71	OK
Lateral +	498	731	0.68	OK
Lateral -	-451	-590	0.76	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	-308	-248	-427	-367	190	283	-213	-153
Case B	-451	-470	-285	-224	498	646	95	155

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	646	1274	0.51	OK
Vertical -	-470	-630	0.75	OK
Lateral +	498	731	0.68	OK
Lateral -	-451	-590	0.76	OK

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Wind (Exposure B) & Snow - Obstructed Wind flow

Dead Load	3.3	psf		Snow Load	10.3	psf		
1.2D	3.96	psf	0.5S	5.15	psf	1.6S	16.48	psf
Distributed	15.84	plf	Distributed	20.6	plf	Distributed	65.92	plf
Per Post	80.21	lbs	Per Post	104.32	lbs	Per Post	333.82	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	-308	-124	-427	-242	190	408	-213	-29
Case B	-451	-346	-285	-100	498	771	95	279

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	771	1274	0.60	OK
Vertical -	-346	-630	0.55	OK
Lateral +	498	731	0.68	OK
Lateral -	-451	-590	0.76	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	-154	260	-213	201	95	526	-107	307
Case B	-225	149	-142	272	249	707	47	461

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	707	1274	0.55	OK
Vertical -	149	1274	0.12	OK
Lateral +	249	731	0.34	OK
Lateral -	-225	-590	0.38	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

Geometry:

Tributary width, ft:	4.00
Tributary length, ft:	5.06
Tilt Angle, deg:	45
Sin of angle	0.71
Cos of angle	0.71
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)

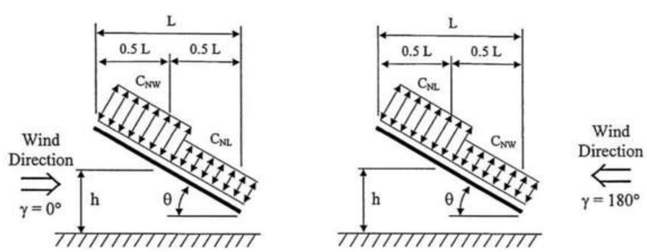
#	Dir., deg	Load Case	C_{NW}	C_{NL}
1	0	A	-1.6	-1.8
2	0	B	-2.3	-0.7
3	180	A	2.2	2.5
4	180	B	2.6	1.4

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

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-379.5	-427.0
2	0	B	-545.6	-166.0
3	180	A	521.9	593.0
4	180	B	616.7	332.1

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

#	Dir., deg	Load Case	q_hGC_{NW}	q_hGC_{NL}
1	0	A	-379.5	-427.0
2	0	B	-545.6	-166.0
3	180	A	521.9	593.0
4	180	B	616.7	332.1



Wind Pressures

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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	-380	-299	-427	-347	522	602	593	673
Case B	-546	-465	-166	-86	617	697	332	412

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	697	1274	0.55	OK
Vertical -	-465	-630	0.74	OK
Lateral +	617	731	0.84	OK
Lateral -	-546	-590	0.92	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	-380	-319	-427	-367	522	582	593	653
Case B	-546	-485	-166	-106	617	677	332	392

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	677	1274	0.53	OK
Vertical -	-485	-630	0.77	OK
Lateral +	617	731	0.84	OK
Lateral -	-546	-590	0.92	OK

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Wind (Exposure B) & Snow - Clear Wind flow

Dead Load	3.3	psf				Snow Load	10.3	psf
1.2D	3.96	psf	0.5S	5.15	psf	1.6S	16.48	psf
Distributed	15.84	plf	Distributed	20.6	plf	Distributed	65.92	plf
Per Post	80.21	lbs	Per Post	104.32	lbs	Per Post	333.82	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	-380	-195	-427	-242	522	706	593	778
Case B	-546	-361	-166	18	617	801	332	517

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	801	1274	0.63	OK
Vertical -	-361	-630	0.57	OK
Lateral +	617	731	0.84	OK
Lateral -	-546	-590	0.92	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	-190	224	-213	201	261	675	297	711
Case B	-273	141	-83	331	308	722	166	580

Forces (lbs)	Loads	Capacity	Ratio	Remarks
Vertical +	722	1274	0.57	OK
Vertical -	141	1274	0.11	OK
Lateral +	308	731	0.42	OK
Lateral -	-273	-590	0.46	OK

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Lag Screw Check

Dead Load	3.3 psf		Snow Load	10.3 psf	

1.0D	3.30 psf	0.6D	1.98 psf	0.75S	7.725 psf
Distributed	13.20 plf	Distribute	7.92 plf	Distributed	30.9 plf
Per Post	66.84 lbs	Per Post	40.11 lbs	Per Post	156.48 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	85	85	31	31	309	324	127	127
Case B	21	-15	95	95	447	487	266	266

	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	-118	-118	-189	-189	181	201	-61	-61
Case B	-204	-251	-104	-104	366	418	124	124

	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	-145	-145	-216	-216	154	174	-88	-88
Case B	-230	-278	-131	-131	339	392	97	97

Tension/Compression	**487**	lbs
Shear	**447**	lbs

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Lag Screw Check

Dead Load	3.3	psf	Snow Load	10.3	psf

1.0D	3.30	psf	0.6D	1.98	psf	0.75S	7.725	psf
Distributed	13.20	plf	Distribute	7.92	plf	Distributed	30.9	plf
Per Post	66.84	lbs	Per Post	40.11	lbs	Per Post	156.48	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	53	53	31	31	458	458	490	490
Case B	-22	-22	149	149	501	501	373	373

	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	-161	-161	-189	-189	380	380	423	423
Case B	-261	-261	-33	-33	437	437	266	266

	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	-188	-188	-216	-216	353	353	396	396
Case B	-287	-287	-60	-60	410	410	239	239

Tension/Compression	**501**	lbs
Shear	**501**	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	501.0	
Tension/Compression, lbs	501.0	

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)	**0.64**	**OK**
Withdrawal (Demand/Capacity)	**0.32**	**OK**

Capacity exceeds demands. Therefore, connection passes.