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Instant Roof Framing Analysis

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STRUCTURAL ANALYSIS

for the

ROOFTOP PV SOLAR INSTALLATION

Project: Sigfredo Matos Rodriguez, 105 Micahs Way North, Spring Lake, NC 28390

Prepared for:

FREEDOM SOLAR POWER

Freedom Solar, LLC

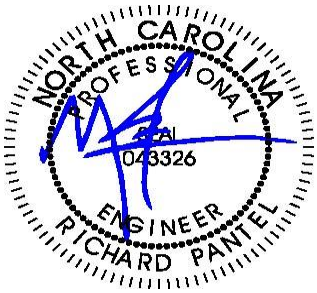
4801 Freidrich Ln, Ste 100 - Austin, TX 78744

Calculation Report Index

Project Number: 36.115404, Rev. 0

Report Date: 08/19/2024

Report Prepared by:



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Sealed 08/19/2024

Richard Pantel

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Loading Summary

Exposure and Occupancy Categories		
B		*Exposure Category (ASCE 7-10 Table 26.7.3, Page 266)*
II		*Building Use Occupancy / Risk Category (ASCE 7-10 Table 1.5-1, Page 4)*

Wind Loading:			
v	118	*mph*	*ASCE 7-10, Figure 26.5-1 A, B or C, pp 249-251. [(118 mph, 50 year wind MRI)]*
qz	21.07	*psf*	*Velocity qz, calculated at height z [ASD]*

Snow Loading			
pg	10.00	*psf*	*Ground Snow Load pg (ASCE 7-10 Table 7.2-1, Page 52-53)*
Total Snow Load			
ps	10.00	*psf*	*Effective snow load on roof and modules*

Module Data			
SunPower: SPR-M425-H-AC			
Dimensions	*mm*	*ft*	*in*
Length	1,872	6.14	73.70
Width	1,032	3.39	40.63
Area (m^2, ft^2)	1.9	20.79	
Weight	kg	lb	
Module	21.82	48.10	

Roof Panel (Cladding) Loading Summary		Module Loading Summary			
Support Point Loads		*Upward*	*Upward*	*Upward*	*Downward*
Roof Zones		1,2r	2n,3r	3e	All
Net load per module	*lb*	-151	-203	-301	154

Positive values indicate net downward force

Primary Stanchion: Pegasus Solar InstaFlash PIF-RB0

Stanchion Fastener Pull-out and Spacing Calculations					
Framing spacing			*ft*	1.33	
Rails / Module			*ea*	2	
Max proposed stanchion span			*ft*	4.00	
# fasteners per stanchion				1	
Bolt thread embedment depth			*in*	3.00	
Safety Factor				1.10	
Pull-out for 5/16 threaded fasteners			*lb/in*	220	
Factored max fastener uplift capacity			*lb*	599	
Fastener details	*Material*	Stainless	*Size*	5/16	*Predrill hole 0.16" dia or use self tapping*
Max stanchion uplift capacity			*lb*	618	
Max support point uplift capacity			*lb*	599	

Roof Zones		*1,2r*	*2n,3r*	*3e*
Net lift per module	*lb*	151	203	301
Min tot bolt thread embedment depth rq'd	*in*	0.76	1.02	1.51
Net uplift pressure 7. 0.6D - 0.6W	*psf*	-6.16	-8.27	-12.26
Allowable lift area / support point	*sf*	97.23	72.39	48.86
Max rail span per framing spacing	*ft*	4.00	4.00	4.00
Landscape Modules				
Length along rafter	*ft*	3.39		
Lift calc'ed max stanchion EW spacing	*ft*	> 6	> 6	> 6
Max stanchion EW spacing	*ft*	4.00	4.00	4.00
Maximum module area / support point	*sf*	10.16	10.16	10.16
Factored lift per support point	*lb*	-63	-84	-124
Portrait Modules				
Length along rafter	*ft*	6.14		
Lift calc'ed max stanchion EW spacing	*ft*	> 6	> 6	> 6
Max stanchion EW spacing	*ft*	4.00	4.00	4.00
Maximum module area / support point	*sf*	12.28	12.28	12.28
Factored lift per support point	*lb*	-76	-102	-151

Stanchion support threaded fastener sizes are indicated in the Module Loading Summary table above. Lift forces were determined from GCp and other coefficients contained in the ASCE nomographs

Conclusions

We were asked to review the roof of Sigfredo Matos Rodriguez, located at 105 Micahs Way North, Spring Lake, NC, by Freedom Solar, LLC, to determine its suitability to support a PV solar system installation.

The referenced building's roof structure was field measured by Freedom Solar, LLC on 08/08/2024. The attached framing analyses reflect the results of those field measurements combined with the PV solar module locations shown on the PV solar roof layout design prepared by Freedom Solar, LLC. Loads are calculated to combine the existing building and environmental loads with the proposed new PV array loads.

The SunPower InvisiMount 6000 series racking and Pegasus Solar InstaFlash PIF-RB0 stanchions were selected for this project by Freedom Solar, LLC. The racking and support stanchions shall be placed as shown on their plans, dated 08/16/2024, and shall be fastened to the roof framing using fastener sizes indicated in this report. Rack support spacing shall be no more than that shown above. Note that support points for alternating rows shall share the same rafter. Intermediate rows shall move the support points laterally to the next rafter. The support rail can be cantilevered up to 1/3 of the maximum span between modules. 1/3 maximum span = 16.00 inches.

Google Location Map

Framing Summary

	Ex. Framing	Total Ex DL
MP 1: 1.50" x 9.25" member x 23.05' span with a 38° slope @ 16" OC	1.98 psf	6.38 psf
MP 2: 1.50" x 9.25" member x 22.75' span with a 37° slope @ 16" OC	1.98 psf	6.38 psf

** Wood species used in these calculations assumes spruce, pine or fir, #2 grade.*

Based upon the attached calculations, the existing roofs' framing systems are capable of supporting the additional loading for the proposed PV solar system along with the existing building and environmental loads. No supplemental roof framing structural supports are required. Minimum required anchorage fastening is described above.

Wood fastener notes: 1) Fastener threads must be embedded in the side grain of a roof support structural member or other structural member integrated into the building's structure. 2) Fastener must be located in the middle third of the structural member. 3) Install fasteners with head and where required, washer, flush to material surface (no gap). Do not over-torque.

References and Codes:

1) *ASCE 7-10 Minimum Design Loads for Buildings and Other Structures*
2) *2015 IBC*
3) *2018 NC Building Code*
4) *American Wood Council, NDS 2018,Table 12.2A, 12.3.3A.*
5) *American Wood Council, Wood Structural Design, 1992, Figure 6.*

Geometric Data			
Θ	*deg.*	38.00	*Angle of roof plane from horizontal, in degrees*
ω	*deg.*	0.00	*Angle the solar panel makes with the roof surface*
L	*ft.*	60.00	*Length of roof plane, in feet (meters)*
W	*ft.*	19.17	*Plan view width of roof plane, in feet (meters)*
h	*ft.*	24.33	*Average height of roof above grade, in feet (meters)*

Roof Wind Zone Width			
	use, a =	3.00	*ft*

Wind Velocity Pressure, q_z evaluated at the height z						
q_z=	21.07	*psf*	*Vasd* q_z=	12.89	*psf*	Basic wind pressure
V=	118	mph				

Framing Data		
Wood type	US Spruce	
Wood source, moisture content	White 0.12%	
# Framing Members / Support		1
Rafter / Truss OC	*in*	16.00
Member Total Length	*ft*	23.05

3	# Rafters / Rack Support Width
4.00	Rack Support Spacing (ft)
48	Max. Rack Support Spacing (in)
2	Max # of mod's / Rafter

Member Properties		**Member**
Name		(1)1.5x9.25
Repetitive Member Factor (Cr)		1.15
Max Shear perp. to grain	*psi*	530
Max Shear parallel to grain	*psi*	1,100

** Mem properties based upon field measurements*

Rafter

16.00	Collar tie OC spacing, in.

Module Physical Data			
Weight	kg	lb	psf load
Module	21.82	48.10	2.31
4 Stanchions	1.36	3.0	0.14

Existing Dead Loads	*Units*	*Value*	*Description*
Framing Member	*psf*	1.98	
Roof Deck & Surface Material	*psf*	4.40	*0.50 in. Plywood w/ Standard Asphalt Shingles*

Rack Support Spacing and Loading				
Across rafters	*ft*	4.0		
Along rafter slope	*ft*	6.1		
Area / support point	*sf*	12.3		
Uphill gap between modules	*in*	1.0	0.08	*ft*

Member Total Length	*ft*	23.05	
Maximum member free span	*ft*	23.05	Rafter span
Rafter segment to calc	*ft*	23.05	Free span
Deflection Ratio		180	Use max delta 1/x for deflection

Eave Overhang Length past Rafter Plate	1.00	*ft*
Uphill Distance from Eave to Lowest Support	7.25	*ft*

Zones	1,2r	2n,3r	3e
GCp	-1.48	-1.76	-2.27

Downward, Zones All Zones
GCp 0.77

ASCE 7-10 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)				
Zones	1,2r	2n,3r	3e	All Zones
2.2 SYMBOLS AND NOTATION	*Module Upward*	*Module Upward*	*Module Upward*	*Downward*
D = dead load of PV Module + Stanchion	2.46	2.46	2.46	2.46
S = snow load	10.00	10.00	10.00	10.00
W = wind load = (Vu Windload) = (Vasd Windload / 0.6)	-19.11	-22.63	-29.27	9.96

2.4 Combining Nominal Loads Using Allowable Stress Design (in psf)				
2.4.1 Basic Combinations. Loads listed herein shall be considered to act in the following combinations; whichever produces the most unfavorable effect in the building, foundation, or structural member being considered. Effects of one or more loads not acting shall be considered.				
Combination Formulae	*Upward*	*Upward*	*Upward*	*Downward*
Use this loading combination for DOWNWARD for Proposed PV Dead Load				
6. D + 0.75L - 0.75(0 or 0.7)eE + 0.75S	12.46	12.46	12.46	14.44
Module Support point load (lb)	153	153	153	177
Cr Factored Module Support point load (lb)	133	133	133	154
Use this loading combination for UPWARD for Proposed PV Dead Load				
7. 0.6D - 0.6W	-6.16	-8.27	-12.26	5.30
Module Support point load (lb)	-76	-102	-151	65

DOWNWARD

Presume loading directly over member.

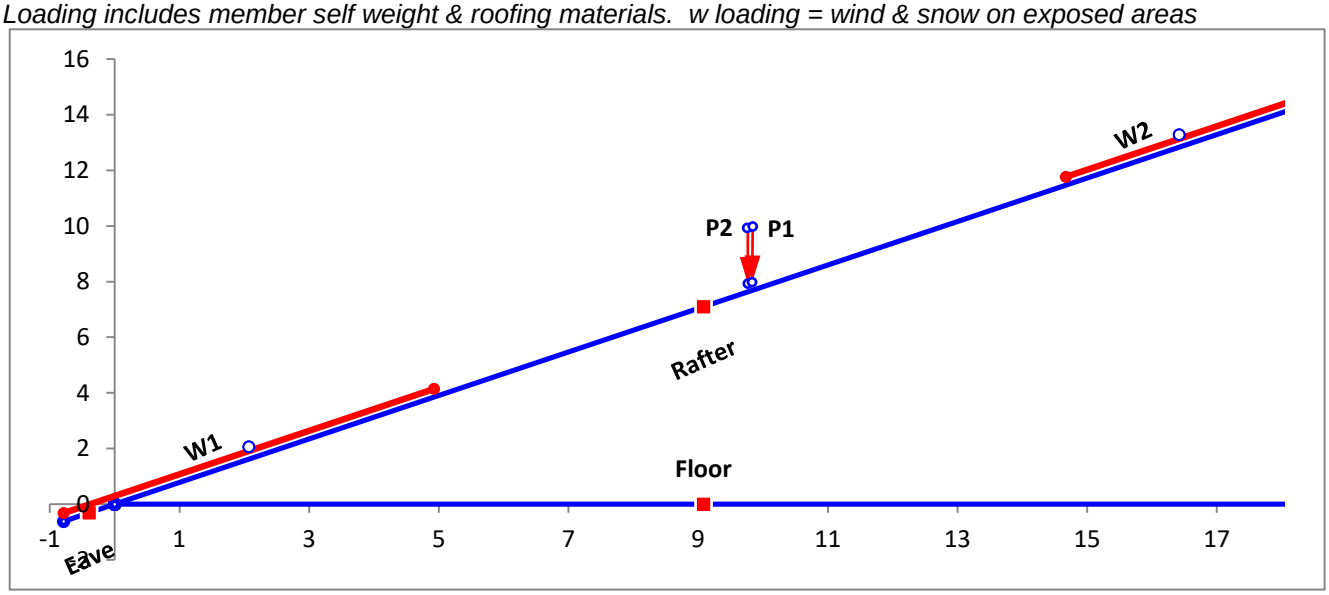
Combined Dead and Wind Pressure Downward Loading					
	Rafter span				
PV Module Row	Point load loc's from Left support		Module Support Point Load	Comment	Module Orientation
	ft from left		*lb*		
1	6.25			Support placed on adjoining rafter	Portrait
1	12.39		154		Portrait
2	12.48		154		Portrait
2	18.62			Support placed on adjoining rafter	Portrait

Analysis for PV impacted areas

5. Simple Beam - Exposed Roof Snow Load - Above and Below PV				
Parameter	*Units*	*Total*	*Allowed*	*Check*
Delta @ mid span	*in*	0.15	1.54	***OK***
M at mid span	*lb-ft*	196	11,646	***OK***

Sum Downward Loading Conditions: PV; Beam DL; Exposed Roof Environmental Load				
Parameter	*Units*	*Total*	*Allowed*	*Check*
Delta	*in*	1.33	1.54	***OK***
Percent Max Delta	*%*	86%	100%	***OK***
Moment	*lb-ft*	2,257	11,646	***OK***
fs	*psi*	1,266	6,533	***OK***

** Loading includes member self weight & roofing materials. w loading = wind & snow on exposed areas*



Framing section with max stress: Rafter span

Geometric Data			
Θ	*deg.*	37.00	*Angle of roof plane from horizontal, in degrees*
ω	*deg.*	0.00	*Angle the solar panel makes with the roof surface*
L	*ft.*	50.00	*Length of roof plane, in feet (meters)*
W	*ft.*	19.17	*Plan view width of roof plane, in feet (meters)*
h	*ft.*	24.33	*Average height of roof above grade, in feet (meters)*

Roof Wind Zone Width			
	use, a =	3.00	*ft*

Wind Velocity Pressure, q_z evaluated at the height z						
q_z=	21.07	*psf*	*Vasd* q_z=	12.89	*psf*	Basic wind pressure
V=	118	mph				

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Wood type	US Spruce	
Wood source, moisture content	White 0.12%	
# Framing Members / Support		1
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Member Total Length	*ft*	22.75

3	# Rafters / Rack Support Width
4.00	Rack Support Spacing (ft)
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Rack Support Spacing and Loading				
Across rafters	*ft*	4.0		
Along rafter slope	*ft*	6.1		
Area / support point	*sf*	12.3		
Uphill gap between modules	*in*	1.0	0.08	*ft*

Member Total Length	*ft*	22.75	
Maximum member free span	*ft*	22.75	Rafter span
Rafter segment to calc	*ft*	22.75	Free span
Deflection Ratio		180	Use max delta 1/x for deflection

Eave Overhang Length past Rafter Plate	1.00	*ft*
Uphill Distance from Eave to Lowest Support	1.75	*ft*

Zones	1,2r	2n,3r	3e
GCp	-1.48	-1.76	-2.27

Downward, Zones All Zones
GCp 0.77

ASCE 7-10 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)				
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D = dead load of PV Module + Stanchion	2.46	2.46	2.46	2.46
S = snow load	10.00	10.00	10.00	10.00
W = wind load = (Vu Windload) = (Vasd Windload / 0.6)	-19.11	-22.63	-29.27	9.96

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6. D + 0.75L - 0.75(0 or 0.7)eE + 0.75S	12.46	12.46	12.46	14.44
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7. 0.6D - 0.6W	-6.16	-8.27	-12.26	5.30
Module Support point load (lb)	-76	-102	-151	65

DOWNWARD

Presume loading directly over member.

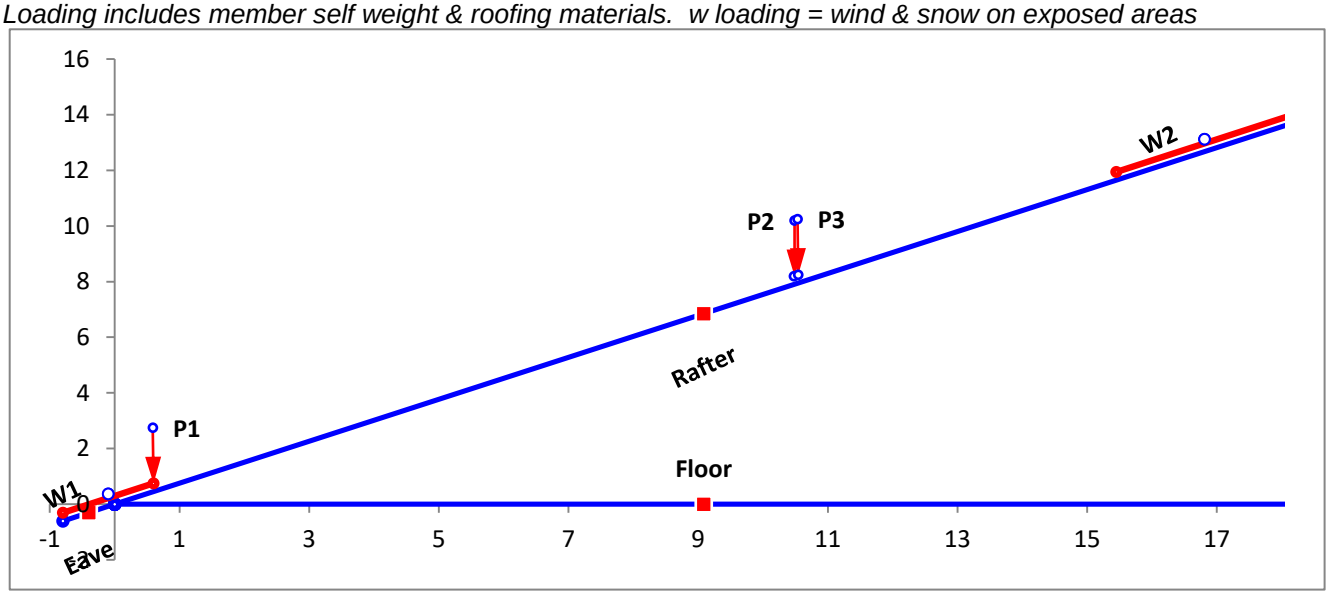
Combined Dead and Wind Pressure Downward Loading					
	Rafter span				
PV Module Row	Point load loc's from Left support		Module Support Point Load	Comment	Module Orientation
	ft from left		*lb*		
1	0.75		154		Portrait
1	6.89			Support placed on adjoining rafter	Portrait
2	6.98			Support placed on adjoining rafter	Portrait
2	13.12		154		Portrait
3	13.20		154		Portrait
3	19.34			Support placed on adjoining rafter	Portrait

Analysis for PV impacted areas

5. Simple Beam - Exposed Roof Snow Load - Above and Below PV				
Parameter	*Units*	*Total*	*Allowed*	*Check*
Delta @ mid span	*in*	0.03	1.52	***OK***
M at mid span	*lb-ft*	41	11,646	***OK***

Sum Downward Loading Conditions: PV; Beam DL; Exposed Roof Environmental Load				
Parameter	*Units*	*Total*	*Allowed*	*Check*
Delta	*in*	1.18	1.52	***OK***
Percent Max Delta	*%*	78%	100%	***OK***
Moment	*lb-ft*	1,991	11,646	***OK***
fs	*psi*	1,117	6,533	***OK***

** Loading includes member self weight & roofing materials. w loading = wind & snow on exposed areas*



Framing section with max stress: Rafter span

Snow Loading Analysis

where:

		Fully Exposed	Exposure category
Ce	=	0.9	Exposure Factor, Ce (ASCE 7-10 Table 7.3-1, Page 58)
Ct	=	1.0	Thermal Factor, Ct (ASCE 7-10 Table 7.3-2, Page 58)
Is	=	1.0	Snow Importance Factor, Is (ASCE 7-10 Table 1.5-2, Page 5)
p_g	=	10.00	Ground Snow Load pg (ASCE 7-10 Table 7.2-1, Page 52-53)

p_f = **0.7CeCtIsPg** Flat Roof Snow Load, pf (ASCE 7-10 Table 7.3-1, Page 58)

p_f = **6.30** psf

but where Pf is not less than the following:

Minimum Snow Load pm (ASCE 7-10 Table 7.3.4, Page 53)

p_m = **10.00** When Pg <=20 psf, then use Pf = Pg x Is

p_f = **10.00** psf. Resultant Snow pressure to be used with Roof slope factor below

p_s = $C_s p_f$ Sloped Roof Snow Load ps (ASCE 7-10 Table 7.4, Page 54)

Roof Type Warm Roofs

Roof slope factor Cs for Warm Roofs, where Ct = 1.0

Roof surface condition = Slippery Roof

C_s = 1.00 Roof Slope Factor, Cs (ASCE 7-10 Table 7-2a, Page 59)

Total Snow Load

p_s	=	**10.00**	**psf**	Roof snow load