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STRUCTURAL ANALYSIS
for the
ROOFTOP PV SOLAR INSTALLATION

Project: Stephen Szabo, 213 Windswept Wy, Fuquay-Varina, NC 27526

Prepared for:

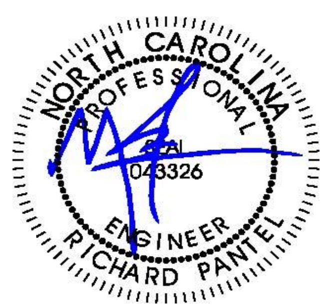
EMPWR Solar
1007 Johnnie Dodds Blvd Suite 111 - Charleston, SC 29464

Calculation Report Index

Project No: 66.414139.86, Rev. 0

Report Date: 02/14/2025

Report Prepared by:



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NC License No. 43326
Sealed 02/14/2025

V241201
ID.L1W7

Loading Summary

Exposure and Occupancy Categories		
B		*Exposure Category (ASCE 7-10 Table 26.7.3, Page 274)*
II		*Building Use Occupancy / Risk Category (ASCE 7-10 Table 1.5-1, Page 5)*

Wind Loading:			
v	116	*mph*	*ASCE 7-10, Figure 26.5-1 A, B or C, pp 249-251. [(116 mph, 50 year wind MRI)]*
qz	20.63	*psf*	*Velocity qz, calculated at height z [ASD]*

Snow Loading			
pg	15.00	*psf*	*Ground Snow Load pg (ASCE 7-10 Table 7.2-1, Page 56-60)*
Total Snow Load			
ps	15.00	*psf*	*Effective snow load on roof and modules*

Module Data			
Jinko Solar: JKM425N-54HL4-B			
Dimensions	*mm*	*ft*	*in*
Length	1,722	5.65	67.80
Width	1,134	3.72	44.65
Area (m^2, ft^2)	2.0	21.02	
Weight	kg	lb	
Module	22.00	48.50	

Roof Panel (Cladding) Loading Summary		Module Loading Summary			
Support Point Loads		*Upward*	*Upward*	*Upward*	*Downward*
Roof Zones		1	2	3	All
Net load per module	*lb*	-35	-150	-298	171

Positive values indicate net downward force

Richard Pantel Digitally signed by Richard Pantel
Date: 2025.02.14 12:38:11 -05'00'

Primary Stanchion: IronRidge HALO ULTRAGRIP - (QM-HUG-01-B1)

Stanchion Fastener Pull-out and Spacing Calculations					
Framing spacing			*ft*	2.00	
Rails / Module			*ea*	2	
Max proposed stanchion span			*ft*	4.00	
# fasteners per stanchion				2	
Bolt thread embedment depth			*in*	1.75	
Safety Factor				1.10	
Pull-out for #14 threaded fasteners			*lb/in*	134	*/in*
Factored max fastener uplift capacity			*lb*	425	
Fastener details	*Material*	Stainless	*Size*	#14	*Predrill hole 0.12" dia or use self tapping*
Max stanchion uplift capacity			*lb*	1100	
Max support point uplift capacity			*lb*	425	

Roof Zones			*1*	*2*	*3*
Net lift per module		*lb*	35	150	298
Min tot bolt thread embedment depth rq'd		*in*	0.15	0.62	1.23
Net uplift pressure	7. 0.6D - 0.6W	*psf*	-1.56	-6.64	-13.21
Allowable lift area / support point		*sf*	271.70	63.97	32.16
Max rail span per support spacing		*ft*	4.00	4.00	4.00
Landscape Modules					
Length along rafter		*ft*	3.72		
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*	7.44	7.44	7.44
Factored lift per support point		*lb*	-12	-49	-98
Portrait Modules					
Length along rafter		*ft*	5.65		
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*	11.30	11.30	11.30
Factored lift per support point		*lb*	-18	-75	-149

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 Stephen Szabo, located at 213 Windswept Wy, Fuquay-Varina, NC, by EMPWR Solar, to determine its suitability to support a PV solar system installation.

The referenced building's roof structure was field measured by EMPWR Solar. 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 EMPWR Solar. Loads are calculated to combine the existing building and environmental loads with the proposed new PV array loads.

The IronRidge XR10 Rail racking and IronRidge HALO ULTRAGRIP - (QM-HUG-01-B1) stanchions were selected for this project by EMPWR Solar. The racking and support stanchions shall be placed as shown on their plans, dated 02/13/2025, 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 truss. Intermediate rows shall move the support points laterally to the next truss.

Google Location Map

Framing Summary

	Ex. Framing	Total Ex DL
MP 1: Truss @ 24" OC	0.79 psf	5.94 psf

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

Based upon the attached calculations, the existing roof's framing system is 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. No further structural alterations or modifications are needed to support the system. 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.*

Location: MP 1
Member: Truss - Total Length 35 ft, Unsupported 35 ft

Geometric Data			
Θ	*deg.*	22.00	*Angle of roof plane from horizontal, in degrees*
ω	*deg.*	0.00	*Angle the solar panel makes with the roof surface*
L	*ft.*	40.83	*Length of roof plane, in feet (meters)*
W	*ft.*	33.33	*Plan view width of roof plane, in feet (meters)*
h	*ft.*	16.90	*Average height of roof above grade, in feet (meters)*

Roof Wind Zone Width			
	use, a =	3.33	*ft*

Wind Velocity Pressure, q_z evaluated at the height z						
q_z=	20.63	*psf*	*Vasd* q_z=	12.61	*psf*	Basic wind pressure
V=	116	mph				

Framing Data		
Wood type	US Spruce	
Wood source, moisture content	White 0.12%	
# Framing Members / Support		1
Rafter / Truss OC	*in*	24.00
Member Total Length	*ft*	35.00

2	# Rafters / Rack Support Width
4.00	Rack Support Spacing (ft)
48.00	Max. Rack Support Spacing (in)
3	Max # of mod's / Truss top chord

Member Properties		**Member**
Name		(1) 2x6
Repetitive Member Factor (Cr)		1.15

** Mem properties based upon field measurements*

Truss top chord

Module Data			
Weight	kg	lb	psf load
Module	22.00	48.50	2.31
4 Stanchions	0.91	2.0	0.10

Existing Dead Loads	*Units*	*Value*	*Description*
Roof Deck & Surface Material*	*psf*	5.15	*Truss members' self weight added to FEA analysis*

** Roof surface: Shingles, Asphalt, Architectural (Typical)*

Rack Support Spacing and Loading				
Across rafters	*ft*	4.0		
Along rafter slope	*ft*	5.6		
Area / support point	*sf*	11.3		
Uphill gap between modules	*in*	1.0	0.08	*ft*

Member Total Length	*ft*	35.00		
Maximum member free span	*ft*	35.00	Truss top chord span	
Zones	1	2	3	
GCp	-0.87	-1.54	-2.41	

Downward, Zones 1, 2 & 3
GCp 0.44

ASCE 7-10 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)				
Zones	1	2	3	1, 2 & 3
2.2 SYMBOLS AND NOTATION	*Module Upward*	*Module Upward*	*Module Upward*	*Downward*
D = dead load of PV Module + Stanchion	2.40	2.40	2.40	2.40
S = snow load	15.00	15.00	15.00	15.00
W = wind load = (Vu Windload) = (Vasd Windload / 0.6)	-10.95	-19.41	-30.35	5.49

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				
3. D + S	17.40	17.40	17.40	17.40
Module Support point load (lb)	197	197	197	197
Cr Factored Module Support point load (lb)	171	171	171	171

Use this loading combination for UPWARD for Proposed PV Dead Load				
7. 0.6D - 0.6W	-1.56	-6.64	-13.21	5.00
Module Support point load (lb)	-18	-75	-149	57

DOWNWARD

Presume loading directly over member.

Combined Dead and Wind Pressure Downward Loading					
	Truss top chord span				
PV Module Row	Point load loc's from Left support	Point Load #'s	Module Support Point Load	Comment	Module Orientation
	ft from left		*lb*		
1	16.17		171		Portrait
1	21.82			Support placed on adjoining truss	Portrait
2	21.90			Support placed on adjoining truss	Portrait
2	27.55		171		Portrait
3	27.64		171		Portrait
3	33.29			Support placed on adjoining truss	Portrait

Truss Data and Loading for MP 1

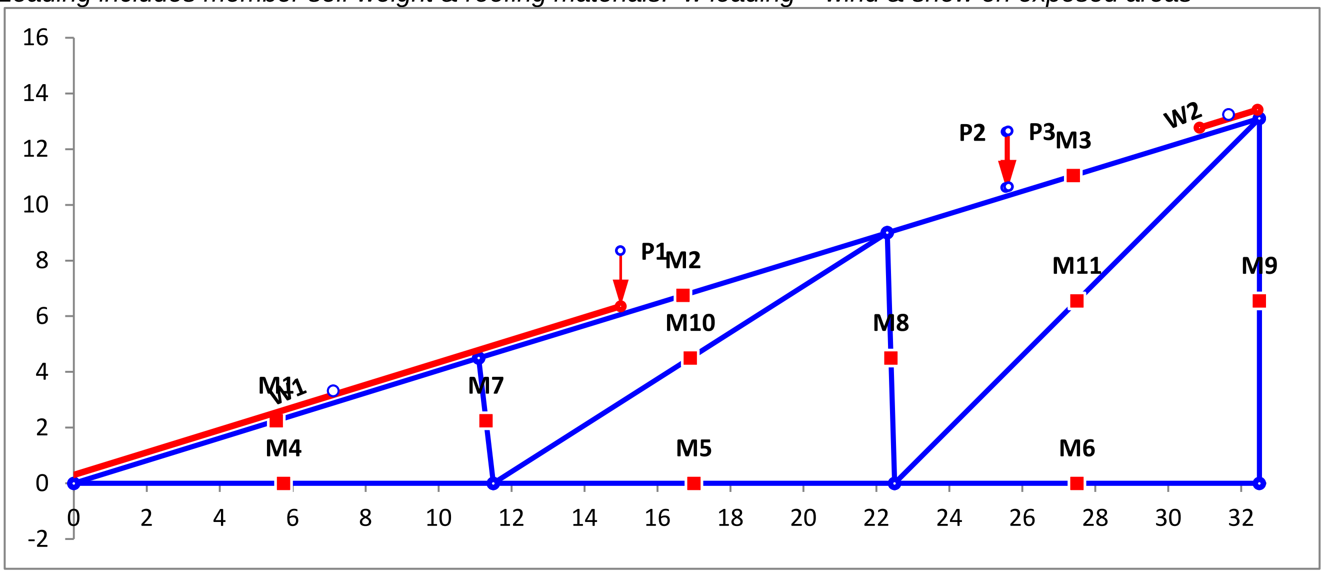
Roof slope (degrees)	22.00
Top ridge height above floor plane	13.11

	Length of roof plane	35.00
	Length of floor plane	32.50

Truss Segments

Roof Plane		*Floor Plane*		*Diagonals*		*Diagonals*	
Mem #	*Mem Type*	Mem #	*Mem Type*	Mem #	*Mem Type*	Mem #	*Mem Type*
1	2x6	4	2x6	7	2x4	10	2x4
2	2x6	5	2x6	8	2x4	11	2x4
3	2x6	6	2x6	9	2x4		

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



Snow Loading Analysis

where:

		Fully Exposed	Exposure category
Ce	=	0.9	Exposure Factor, Ce (ASCE 7-10 Table 7.3-1, Page 61)
Ct	=	1.0	Thermal Factor, Ct (ASCE 7-10 Table 7.3-2, Page 61)
Is	=	1.0	Snow Importance Factor, Is (ASCE 7-10 Table 1.5-2, Page 5)
p_g	=	15.00	Ground Snow Load pg (ASCE 7-10 Table 7.2-1, Page 56-60)
p_f	=	**0.7CeCtIsPg**	Flat Roof Snow Load, pf (ASCE 7-10 Table 7.3-1, Page 61)
p_f	=	**9.45**	psf
			but where Pf is not less than the following:
			Minimum Snow Load pm (ASCE 7-10 Table 7.3.4, Page 62)
p_m	=	**15.00**	When Pg <=20 psf, then use Pf = Pg x Is
p_f	=	**15.00**	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 61)
			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 7.4-1a, Page 62)

Total Snow Load

p_s	=	**15.00 psf**	Roof snow load

FEA Calculation Results for Roof Plane MP 1 for EMPWR Solar Client STEPHEN SZABO

IDSPL - 2D Frame Analysis of a 2D frame subject to distributed loads, point loads and moments

Equilibrium check	FX	FY
Total applied forces	0.00	2615
Total output reactions	0.00	-2615
Output error	-7.87E-13	-2.27E-12

0.00194

	Shear	Ax
Max (psi)	4	242
Allowable (psi)	115	5,610
# of segments/beam	1	

Maximum Deflections	
3.70E-03	-1.23E-02

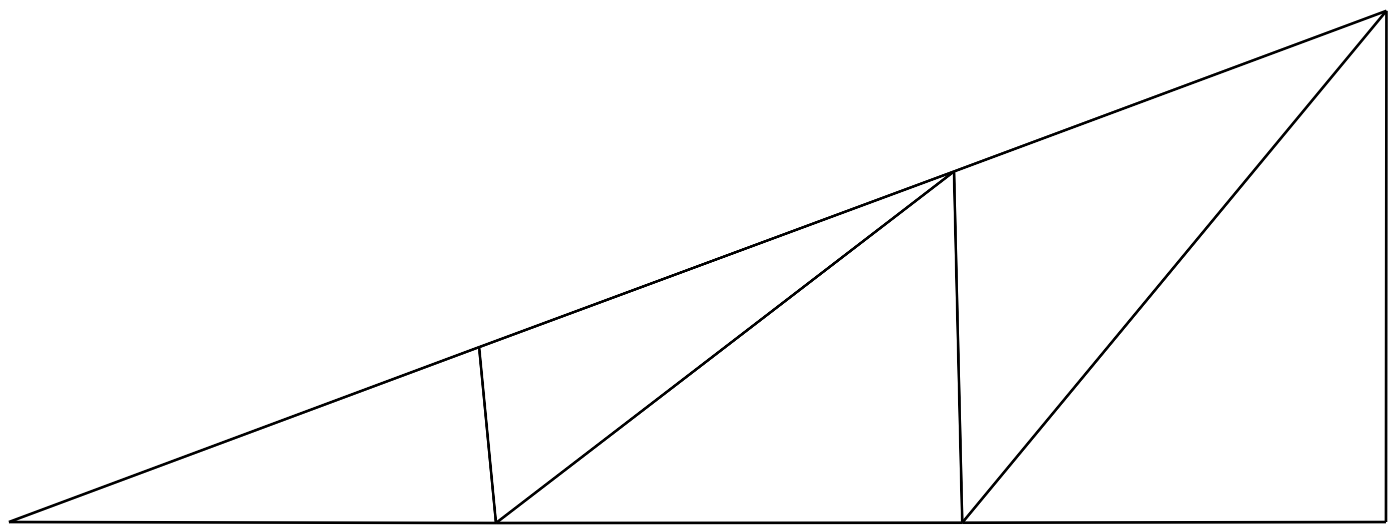
	Node Results	
Direction	Deflection	Reaction
DX1	0.00E+00	0
DY1	0.00E+00	-698
RZ1	0.00E+00	0
DX2	-3.20E-03	0
DY2	1.23E-02	0
RZ2	0.00E+00	0
DX3	-3.47E-04	0
DY3	9.50E-03	0
RZ3	0.00E+00	0
DX4	3.70E-03	0
DY4	1.67E-03	0
RZ4	0.00E+00	0
DX5	-1.46E-03	0
DY5	1.23E-02	0
RZ5	0.00E+00	0
DX6	-2.26E-03	0
DY6	8.65E-03	0
RZ6	0.00E+00	0
DX7	-2.26E-03	0
DY7	0.00E+00	-1918
RZ7	0.00E+00	0
Rel1-3	1.060E-03	0
Rel1-6	1.392E-03	0
Rel2-3	-2.943E-04	0
Rel2-6	1.101E-05	0

	Beam End Results		
Beam	Shear	Axial	BM
1-1	55	1998	0
1-2	412	1854	0
2-1	45	1963	0
2-2	404	1818	0
3-1	-402	1292	0
3-2	692	852	0
4-1	2	-1872	0
4-2	205	-1872	0
5-1	0	-1078	0
5-2	0	-1078	0
6-1	0	0	0
6-2	0	0	0
7-1	0	394	0
7-2	-1	377	0
8-1	0	1326	0
8-2	-1	1271	0
9-1	0	1918	0
9-2	0	1811	0
10-1	-28	-966	0
10-2	65	-1044	0
11-1	-30	-1690	0
11-2	69	-1818	0

** vertical deflections do not take into account any supporting intermediate walls*

Beam	X	Shear	Mom	Axial	DX	DY	RZ
1	0.00	55	0	1998	0.00E+00	0.00E+00	0.00E+00
1	11.98	143	1360	1962	-3.24E-03	-1.23E-02	1.21E-03
2	0.00	45	0	1963	-3.20E-03	-1.23E-02	0.00E+00
2	12.07	134	1255	1927	-3.78E-04	-9.48E-03	-1.53E-04
3	0.00	-402	0	1292	-3.47E-04	-9.50E-03	0.00E+00
3	10.99	248	6680	1031	3.54E-03	-1.61E-03	-1.11E-03
4	0.00	2	0	-1872	0.00E+00	0.00E+00	0.00E+00
4	11.50	91	720	-1872	-1.46E-03	-1.23E-02	1.15E-03
5	0.00	0	0	-1078	-1.46E-03	-1.23E-02	0.00E+00
5	11.00	0	0	-1078	-2.26E-03	-8.65E-03	-3.32E-04
6	0.00	0	0	0	-2.26E-03	-8.65E-03	0.00E+00
6	10.00	0	0	0	-2.26E-03	0.00E+00	-8.65E-04
7	0.00	0	0	394	-1.46E-03	-1.23E-02	0.00E+00
7	4.52	-1	0	383	-3.20E-03	-1.23E-02	3.86E-04
8	0.00	0	0	1326	-2.26E-03	-8.65E-03	0.00E+00
8	9.00	-1	0	1284	-3.47E-04	-9.50E-03	-2.15E-04
9	0.00	0	0	1918	-2.26E-03	0.00E+00	0.00E+00
9	13.10	0	0	1831	3.70E-03	-1.67E-03	-4.55E-04
10	0.00	-28	0	-966	-1.46E-03	-1.23E-02	0.00E+00
10	14.06	49	13	-1030	-3.47E-04	-9.50E-03	-2.20E-04
11	0.00	-30	0	-1690	-2.26E-03	-8.65E-03	0.00E+00
11	16.48	53	12	-1799	3.70E-03	-1.67E-03	-5.69E-04

* vertical deflections do not take into account any supporting intermediate walls



Scaled 2X Deflected Truss Plot
Roof Plane MP 1 for EMPWR Solar Client STEPHEN SZABO