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Instant Roof Framing Analysis
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STRUCTURAL ANALYSIS
for the
ROOFTOP PV SOLAR INSTALLATION

Project: Kathryn Ray, 446 Se Tribble St, Lake City, FL 32025

Prepared for:



sunergy

Sunergy

7625 Little Rd Ste 200a - New Port Richey, FL 34654

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Project Number: 66.400395.1, Rev. 0

Report Date: 12/04/2023

Report Prepared by:

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Richard Pantel, P.E. on the date adjacent to the seal.
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Loading Summary

Exposure and Occupancy Categories		
B		Exposure Category (ASCE 7-16 Table 26.7.3, Page 266)
II		Building Use Occupancy / Risk Category (ASCE 7-16 Table 1.5-1, Page 4)

Wind Loading:			
v	165	mph	Over-ridden per client request. Original data from Municipality provided wind / snow loadings.
qz	41.47	psf	Velocity qz, calculated at height z [ASD]

Snow Loading			
pg	0	psf	Ground Snow Load pg (Over-ridden per client request. Original data from Municipality provided wind / snow loadings.)

Module Data			
Mission Solar Energy LLC: MSE385SX5R			
Dimensions	mm	ft	in
Length	1,905	6.25	75.00
Width	1,041	3.42	41.00
Area (m^2, ft^2)	2.0	21.35	
Weight	kg	lb	
Module	22.23	49.00	

Roof Panel (Cladding) Loading Summary		Module Loading Summary			
Support Point Loads		Upward	Upward	Upward	Downward
Roof Zones		1,2e	2n,2r,3e	3r	All
Net load per module	lb	-101	-140	-209	56

Positive values indicate net downward force

Stanchion Fastener Pull-out and Spacing Calculations					
Fastener details	Material	Stainless	Size	1/4	Predrill hole 0.12" dia or use self tapping
Max stanchion uplift capacity			lb	400	
Max support point uplift capacity			lb	371	
Stanchion Support Calculations for Solar Foot					
Roof Zones			1,2e	2n,2r,3e	3r
Net lift per module		lb	101	140	209
Min tot bolt thread embedment depth req'd		in	0.14	0.19	0.28
Net uplift pressure	7. 0.60D - 0.6W	psf	-14.74	-20.55	-30.63
Allowable lift area / support point		sf	25.20	18.07	12.13
Max rail span per framing spacing		ft	4.00	4.00	4.00
Landscape Modules					
Length along rafter		ft	3.42		
Lift calc'ed max stanchion EW spacing		ft	> 6	> 6	6.00
Max stanchion EW spacing		ft	4.00	4.00	4.00
Maximum module area / support point		sf	6.83	6.83	6.83
Factored lift per support point		lb	-101	-140	-209
Portrait Modules					
Length along rafter		ft	6.25		
Lift calc'ed max stanchion EW spacing		ft	> 6	4.00	2.00
Max stanchion EW spacing		ft	4.00	4.00	2.00
Maximum module area / support point		sf	12.50	12.50	6.25
Factored lift per support point		lb	-184	-257	-191
Plywood Nailing Calculations					
Nail Size		Gauge	Shank Dia	Length	W
8D		10	0.134	2.5	54
10D		9	0.148	3	59
Load Duration Factor - Wind		1.6			
AWC 11.3.1 $W'=W*C_d*C_m*C_t*C_{eg}*LD$					
8D withdrawal force @ 2" penetration (lb)		138			
10D withdrawal force @ 2.5" penetration (lb)		189			
			1,2e	2n,2r,3e	3r
# 8D's Req'd / stanchion in Landscape		ea	0.73	1.02	1.51
# 10D's Req'd / stanchion in Landscape		ea	0.53	0.74	1.11
# 8D's Req'd / stanchion in Portrait		ea	1.33	1.86	1.38
# 10D's Req'd / stanchion in Portrait		ea	0.98	1.36	1.01
Maximum lift to counteract		lb	-184	-257	-209
Maximum uplift capacity of support		lb	400	400	400
Tensile capacity test			OK	OK	OK

Capacity of fasteners tying metal roof material to deck must exceed the max.lift for the subject wind zones.

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

Princeton Engineering was asked to review the roof of Kathryn Ray, located at 446 Se Tribble St, Lake City, FL, by Sunergy, to determine its suitability to support a PV solar system installation.

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

Sunergy selected the K2-Systems CrossRail 44-X racking with S5 Solar Foot stanchions for this project. The racking and support stanchions shall be placed as shown on their plans, dated 11/08/2023. Rack support spacing shall be no more than that shown above. Note that support points for alternating rows shall share the same rib



Google Location Map

Framing Summary

Based upon the attached calculations and in accordance with the FBC 2020 Section R324.4 and the FBC's reference to IRC 2018 Section 1607.12.5.2, 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. Minimum required anchorage fastening is described above.

References and Codes:

- 1) ASCE 7-16 Minimum Design Loads for Buildings and Other Structures
- 2) IBC 2018
- 3) FBC 2020
- 4) 2022 Florida Statutes and 2023 Florida Administrative Codes
- 5) American Wood Council, NDS 2018, Table 12.2A, 12.3.3A.
- 6) American Wood Council, Wood Structural Design, 1992, Figure 6.

Roof Structural Calculations for PV Solar Installation

Array AR-1

Location: MP 1

Member: Truss - Total Length 16 ft, Unsupported 16 ft

Geometric Data			
Θ	deg.	18.00	Angle of roof plane from horizontal, in degrees
ω	deg.	0.00	Angle the solar panel makes with the roof surface
L	ft.	42.92	Length of roof plane, in feet (meters)
W	ft.	16.00	Plan view width of roof plane, in feet (meters)
h	ft.	15.00	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 =	41.47	psf	$V_{asd} q_z$ =	24.96	psf
V=	165				mph
					Basic wind pressure

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	16.00

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

Member Properties	Member
Name	(1) 2x4
Repetitive Member Factor (Cr)	1.15

* Mem properties based upon field measurements

Top truss chord

Module Physical Data			
Weight	kg	lb	psf load
Module	22.23	49.00	2.29
4 Stanchions	0.78	1.7	0.08

Existing Dead Loads	Units	Value	Description
Roof Deck & Surface	psf	4.60	Truss members' self weight added to FEA analysis

Rack Support Spacing and Loading				
Across rafters	ft	4.0		
Along rafter slope	ft	3.4		
Area / support point	sf	6.8		
Uphill gap between modules	in	1.0	0.08	ft

Member Total Length	ft	16.00	
Maximum member free span	ft	16.00	Top truss chord span

Notation

L_p = Panel chord length.

p = uplift wind pressure

γ_a = Solar panel pressure equalization factor, defined in Fig. 29.4-8.

γ_E = Array edge factor as defined in Section 29.4.4.

θ = Angle of plane of roof from horizontal, in degrees.

29.4.4 Rooftop Solar Panels Parallel to the Roof Surface on Buildings of All Heights and Roof Slopes.

$\theta \geq 7$ deg

TRUE

Min.d1: Exposed **FALSE**

Max.d1: Exposed **FALSE**

Use NOT EXPOSED for uplift calculations

$1.5(L_p) = 9.38$

$\gamma_E = 1$

$\gamma_a = 0.67$

$p = qh(GC_p)(\gamma_E)(\gamma_a)$ (lb/ft²) (29.4-7)

Zones	1,2e	2n,2r,3e	3r
p, Windload (psf)	-32.33	-42.02	-58.81

ASCE 7-16 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)				
Zones	1,2e	2n,2r,3e	3r	All Zones
2.2 SYMBOLS AND NOTATION	<i>Module Upward</i>	<i>Module Upward</i>	<i>Module Upward</i>	<i>Downward</i>
D = dead load of PV Module + Stanchion	2.38	2.38	2.38	2.38
W = wind load	-32.33	-42.02	-58.81	11.80

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.				
<i>Combination Formulae</i>	<i>Upward</i>	<i>Upward</i>	<i>Upward</i>	<i>Downward</i>
Use this loading combination for DOWNWARD for Proposed PV Dead Load				
5. D - 0.6W	2.38	2.38	2.38	9.45
Module Support point load (lb)	16	16	16	65
Cr Factored Module Support point load (lb)	14	14	14	56

Use this loading combination for UPWARD for Proposed PV Dead Load				
7. 0.60D - 0.6W	-14.74	-20.55	-30.63	7.76
Module Support point load (lb)	-101	-140	-209	53

DOWNWARD

Presume loading directly over member.

Combined Dead and Wind Pressure Downward Loading					
Top truss chord span					
PV Module Row	Point load loc's from Left support	Point Load #'s	Module Support Point Load	Comment	Module Orientation

	<i>ft from left</i>		<i>lb</i>		
1	3.92		56		Landscape
1	7.34			Support placed on adjoining truss	Landscape
2	7.42			Support placed on adjoining truss	Portrait
2	13.67		56		Portrait

Truss Data and Loading for MP 1

Roof slope (degrees)	18.00
Top ridge height above floor plane	4.94

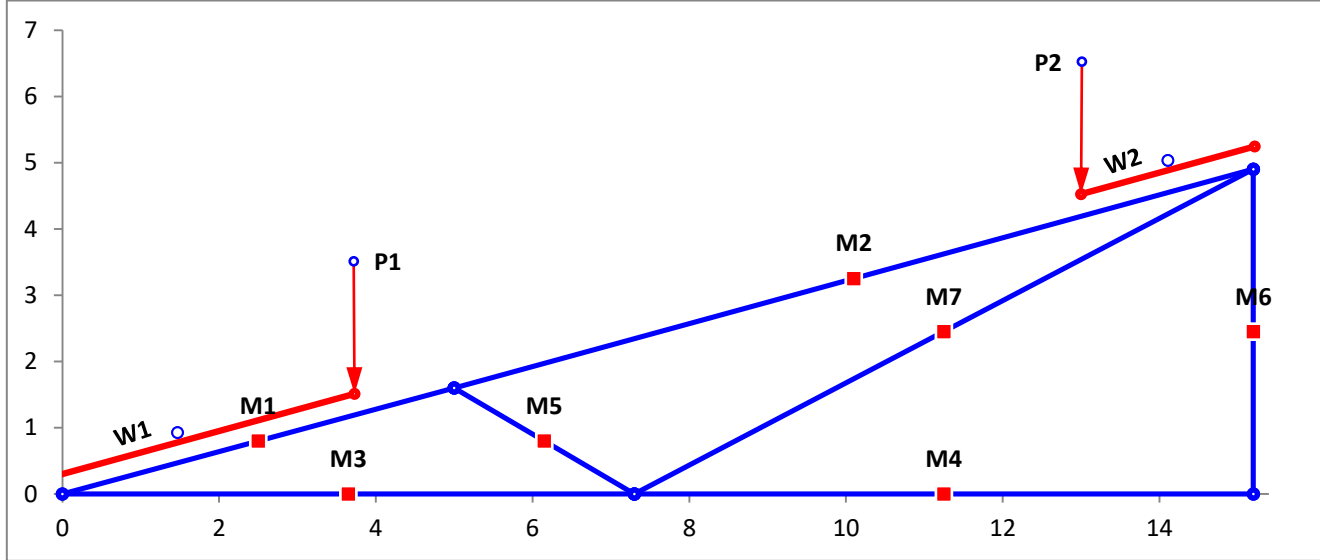
Length of roof plane	16.00
Length of floor plane	15.25

Truss Segments

Roof Plane		Floor Plane	
Mem #	Mem Type	Mem #	Mem Type
1	2x4	3	2x4
2	2x4	4	2x4

Diagonals		Diagonals	
Mem #	Mem Type	Mem #	Mem Type
5	2x4	7	2x4
6	2x4		

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



FEA Calculation Results for Roof Plane MP 1 for Sunergy Client KATHRYN RAY
IDSPL - 2D Frame Analysis of a 2D frame subject to distributed loads, point loads and moments

Equilibrium check	FX	FY	1.5E-05
Total applied forces	0.00	989	
Total output reactions	0.00	-989	
Output error	1.42E-14	1.14E-13	

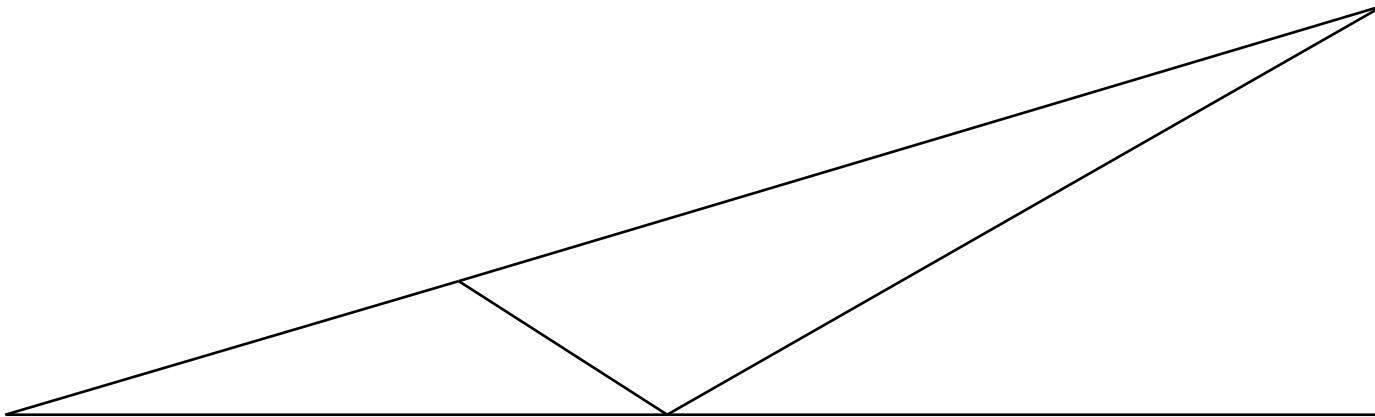
Node Results			Beam End Results			
Direction	Deflection	Reaction	Beam	Shear	Ax	BM
DX1	0.00E+00	-108	1-1	-320	216	126
DY1	0.00E+00	-484	1-2	-202	178	-1587
RZ1	1.81E-04	0	2-1	-583	50	-1649
DX2	4.36E-05	0	2-2	72	-161	-5811
DY2	2.63E-04	0	3-1	-113	0	-126
RZ2	-7.26E-05	0	3-2	-12	0	-1052
DX3	1.14E-04	0	4-1	0	0	0
DY3	0.00E+00	-121	4-2	0	0	0
RZ3	0.00E+00	-5644	5-1	134	385	-435
DX4	0.00E+00	153	5-2	129	381	-62
DY4	0.00E+00	-379	6-1	45	4	-110
RZ4	0.00E+00	-613	6-2	45	-12	110
DX5	0.00E+00	-45	7-1	-7	106	-4
DY5	0.00E+00	-4	7-2	38	78	57
RZ5	0.00E+00	110				

# of segments/beam		Maximum Deflections	
1		1.14E-04	-2.63E-04

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

Beam	X	Shear	Mom	Ax	DX	DY	RZ
1	0.00	-320	126	216	0.00E+00	0.00E+00	1.81E-04
1	5.25	-243	-1361	191	3.63E-05	-2.61E-04	-2.97E-04
2	0.00	-583	-1649	50	4.36E-05	-2.63E-04	-7.26E-05
2	10.72	-200	-3562	-73	4.01E-05	2.38E-05	-1.92E-03
3	0.00	-113	-126	0	0.00E+00	0.00E+00	1.81E-04
3	7.30	-73	-718	0	0.00E+00	2.36E-20	-2.22E-04
4	0.00	0	0	0	0.00E+00	0.00E+00	0.00E+00
4	7.90	0	0	0	0.00E+00	0.00E+00	0.00E+00
5	0.00	134	-435	385	0.00E+00	0.00E+00	0.00E+00
5	2.80	131	-63	383	4.37E-05	-2.63E-04	-2.46E-05
6	0.00	45	-110	4	0.00E+00	0.00E+00	0.00E+00
6	4.90	45	110	-8	1.14E-04	2.49E-07	6.93E-06
7	0.00	-7	-4	106	0.00E+00	0.00E+00	0.00E+00
7	9.30	30	61	83	1.14E-04	1.34E-07	2.93E-07

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



Scaled 2X Deflected Truss Plot
Roof Plane MP 1 for Sunergy Client KATHRYN RAY