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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

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

Calculation Report Index

Project Number: 66.400395.1, Rev. 0

Report Date: 11/08/2023

Report Prepared by:

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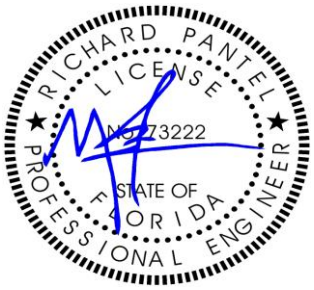

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Loading Summary

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*	-102	-141	-210	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*	102	141	210
Min tot bolt thread embedment depth rq'd			*in*	0.14	0.19	0.28
Net uplift pressure	7. 0.60D - 0.6W		*psf*	-14.86	-20.67	-30.75
Allowable lift area / support point			*sf*	24.99	17.97	12.08
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*	-102	-141	-210
Portrait Modules						
Length along rafter			*ft*	6.25		
Lift calc'ed max stanchion EW spacing			*ft*	6.00	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*	-186	-258	-192
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*Cd*Cm*Ct*Ceg*LD						
8D withdrawl force @ 2" penetration (lb)			138			
10D withdrawl force @ 2.5" penetration (lb)			189			
				1,2e	*2n,2r,3e*	*3r*
# 8D's Req'd / stanchion in Landscape			*ea*	0.73	1.02	1.52
# 10D's Req'd / stanchion in Landscape			*ea*	0.54	0.75	1.11
# 8D's Req'd / stanchion in Portrait			*ea*	1.34	1.87	1.39
# 10D's Req'd / stanchion in Portrait			*ea*	0.98	1.37	1.02
Maximum lift to counteract			*lb*	-186	-258	-210
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 Statues 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.*

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*	*Vasd* q_z=	24.96	*psf*	Basic wind pressure
V=	165	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*	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*	4.40	*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

ASCE 7-16 **Method for Calculating Uplift on PV Modules**

Notation
Lp = Panel chord length.
p = uplift wind pressure
γa = Solar panel pressure equalization factor, defined in Fig. 29.4-8.
γE = 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.

Θ >= 7 deg TRUE

Min.d1: Exposed **FALSE**
Max.d1: Exposed **FALSE** ***Use NOT EXPOSED for uplift calculations***

1.5(Lp) =	9.38
γE =	1
γa =	0.67

$p = qh(GCp)\ (\gamma_E)\ (\gamma_a)$ (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	*Module Upward*	*Module Upward*	*Module Upward*	*Downward*
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.				
Combination Formulae	*Upward*	*Upward*	*Upward*	*Downward*
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	-14.86	-20.67	-30.75	7.56
Module Support point load (lb)	-102	-141	-210	52

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

	ft from left		*lb*		
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

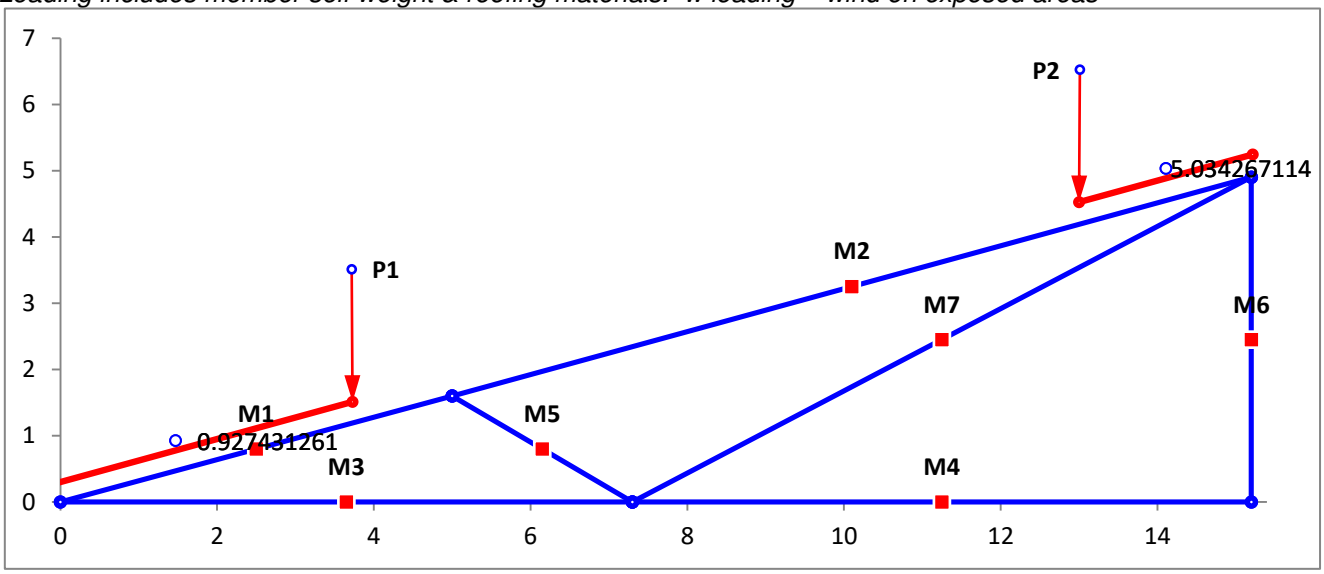
Truss Data and Loading for MP 1

Roof slope (degrees)	18.00		Length of roof plane	16.00
Top ridge height above floor plane	4.94		Length of floor plane	15.25

Truss Segments

Roof Plane		*Floor Plane*		*Diagonals*		*Diagonals*	
Mem #	*Mem Type*	Mem #	*Mem Type*	Mem #	*Mem Type*	Mem #	*Mem Type*
1	2x4	3	2x4	5	2x4	7	2x4
2	2x4	4	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
Total applied forces	0.00	980
Total output reactions	0.00	-980
Output error	-5.68E-14	3.41E-13

1.6E-05

# of segments/beam	1

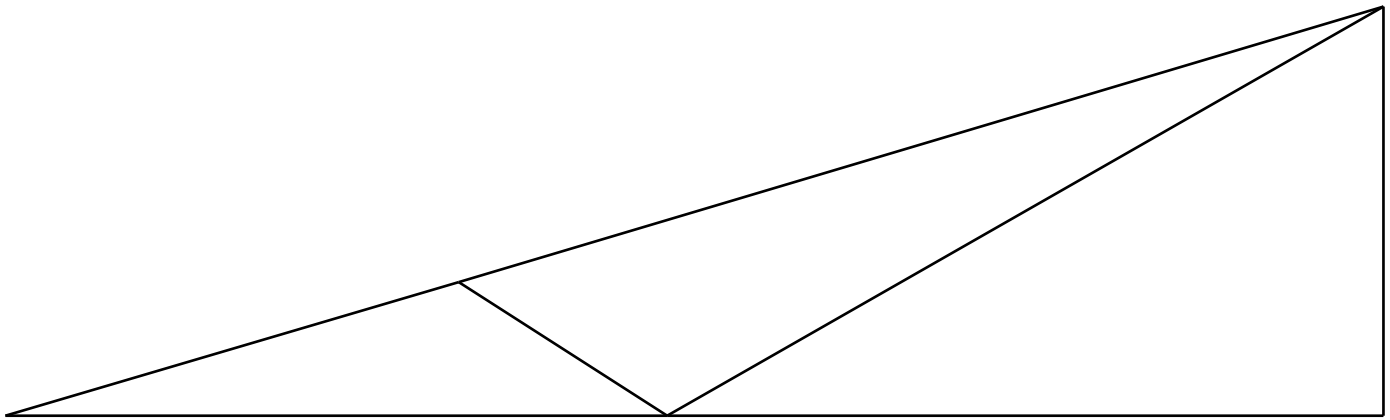
Maximum Deflections	
1.14E-04	-2.71E-04

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

Node Results			Beam End Results			
Direction	Deflection	Reaction	Beam	Shear	Ax	BM
DX1	0.00E+00	-120	1-1	-311	226	132
DY1	0.00E+00	-464	1-2	-196	189	-1526
RZ1	1.64E-04	0	2-1	-573	47	-1659
DX2	4.66E-05	0	2-2	78	-164	-5695
DY2	2.71E-04	0	3-1	-98	0	-132
RZ2	-8.80E-05	0	3-2	0	0	-931
DX3	1.14E-04	0	4-1	0	0	0
DY3	0.00E+00	-128	4-2	0	0	0
RZ3	0.00E+00	-5527	5-1	121	391	-469
DX4	0.00E+00	165	5-2	115	387	-134
DY4	0.00E+00	-384	6-1	45	4	-110
RZ4	0.00E+00	-457	6-2	45	-12	110
DX5	0.00E+00	-45	7-1	-7	106	-4
DY5	0.00E+00	-4	7-2	38	79	57
RZ5	0.00E+00	110				

Beam	X	Shear	Mom	Ax	DX	DY	RZ
1	0.00	-311	132	226	0.00E+00	0.00E+00	1.64E-04
1	5.25	-235	-1317	201	3.98E-05	-2.69E-04	-2.85E-04
2	0.00	-573	-1659	47	4.66E-05	-2.71E-04	-8.80E-05
2	10.72	-191	-3481	-77	4.16E-05	2.35E-05	-1.89E-03
3	0.00	-98	-132	0	0.00E+00	0.00E+00	1.64E-04
3	7.30	-59	-623	0	0.00E+00	-2.88E-20	-1.94E-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	121	-469	391	0.00E+00	0.00E+00	0.00E+00
5	2.80	117	-135	389	4.67E-05	-2.71E-04	-3.63E-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	6.94E-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	2.95E-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