



Instant Roof Framing Analysis

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STRUCTURAL ANALYSIS for the ROOFTOP PV SOLAR INSTALLATION

Project: Don Lennard, 2619 Sw Firefly Ln, Lee'S Summit, MO 64082

Prepared for:



Solera Energy Llc

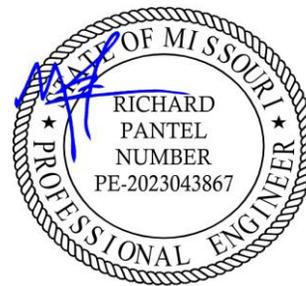
1725 N Packer Rd, 1725 N Packer Rd - Springfield, MO 65803

<u>Calculation Report Index</u>		
<u>Pages</u>	<u>Description</u>	
1	Cover	2-5 Loading Summary
<i>Roof Structural Calculations for PV Solar Installation</i>		
6-9	Location: MP 1	
10-10	Snow Loading Calculations	

Project No: 95.1097, Rev. 0

Report Date: 10/29/2025

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Loading Summary

Exposure and Occupancy Categories		
B		Exposure Category (ASCE 7-16 Table 26.7.3, Page 274)
II		Building Use Occupancy / Risk Category (ASCE 7-16 Table 1.5-1, Page 5)

Wind Loading:			
v	109	mph	ASCE 7-16, Figure 26.5-1 A, B or C, pp 249-251. [(109 mph, 50 year wind MRI)]
qz	18.19	psf	Velocity qz, calculated at height z [ASD]

Snow Loading			
pg	20.00	psf	Ground Snow Load pg (ASCE 7-16 Table 7.2-1, Page 56-60)
Total Snow Load			
ps	20.00	psf	Effective snow load on roof and modules

Module Data			
VSUN: VSUN440N-108BMH-BB			
Dimensions	<i>mm</i>	<i>ft</i>	<i>in</i>
<i>Length</i>	1,722	5.65	67.80
<i>Width</i>	1,134	3.72	44.65
<i>Area (m², ft²)</i>	2.0	21.02	
Weight	kg	lb	
<i>Module</i>	21.40	47.18	

Roof Panel (Cladding) Loading Summary		Module Loading Summary			
Support Point Loads		<i>Upward</i>	<i>Upward</i>	<i>Upward</i>	<i>Downward</i>
Roof Zones		1	2r	2e,3	All
Net load per module	<i>lb</i>	-144	-223	-223	247

Positive values indicate net downward force

Primary Stanchion: K2-Systems EverFlash XP L-Foot - Rafter, 2 Bolts

Stanchion Fastener Pull-out and Spacing Calculations				
Framing spacing	<i>ft</i>		1.33	
Rails / Module	<i>ea</i>		2	
Max proposed stanchion span	<i>ft</i>		4.00	
# fasteners per stanchion			1	
Bolt thread embedment depth	<i>in</i>		2.50	
Safety Factor			1.10	
Pull-out for 5/16 threaded fasteners	<i>lb/in</i>		220	<i>lb per inch of embedment</i>
Factored max fastener uplift capacity	<i>lb</i>		499	
Fastener details	<i>Material</i>	Stainless	<i>Size</i>	5/16
Max stanchion uplift capacity	<i>lb</i>		400	<i>Predrill hole 0.16" dia or use self tapping</i>
Max support point uplift capacity	<i>lb</i>		400	

Roof Zones					
			<i>1</i>	<i>2r</i>	<i>2e,3</i>
Net lift per module	<i>lb</i>		144	223	223
Min tot bolt thread embedment depth req'd	<i>in</i>		0.90	1.39	1.39
Net uplift pressure	7. 0.60D - 0.6W	<i>psf</i>	-6.38	-9.87	-9.87
Allowable lift area / support point		<i>sf</i>	62.68	40.54	40.54
Max rail span per support spacing		<i>ft</i>	4.00	4.00	4.00
Landscape Modules					
Length along rafter	<i>ft</i>		3.72		
Lift calc'ed max stanchion EW spacing	<i>ft</i>		> 6	> 6	> 6
Max stanchion EW spacing	<i>ft</i>		4.00	4.00	4.00
Maximum module area / support point		<i>sf</i>	11.16	11.16	11.16
Factored lift per support point		<i>lb</i>	-71	-110	-110
Portrait Modules					
Length along rafter	<i>ft</i>		5.65		
Lift calc'ed max stanchion EW spacing	<i>ft</i>		> 6	> 6	> 6
Max stanchion EW spacing	<i>ft</i>		4.00	4.00	4.00
Maximum module area / support point		<i>sf</i>	11.30	11.30	11.30
Factored lift per support point		<i>lb</i>	-72	-111	-111

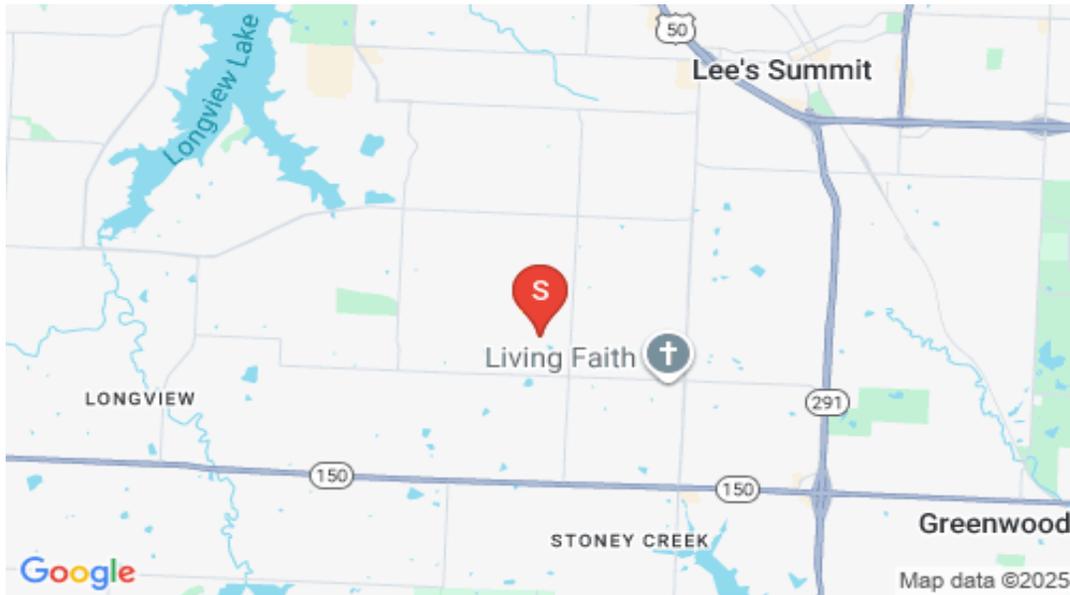
Stanchion support threaded fastener sizes are indicated in the Module Loading Summary table above. Lift forces were determined from GCp and other coefficients contained in the ASCE nomographs

Conclusions

We were asked to review the roof of Don Lennard, located at 2619 Sw Firefly Ln, Lee'S Summit, MO, by Solera Energy Llc, to determine its suitability to support a PV solar system installation.

The referenced building's roof structure was field measured by Solera Energy Llc on 10/22/2025. 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 Solera Energy Llc. Loads are calculated to combine the existing building and environmental loads with the proposed new PV array loads.

The K2-Systems CrossRail 44-X racking and K2-Systems EverFlash XP L-Foot - Rafter, 2 Bolts stanchions were selected for this project by Solera Energy Llc. The racking and support stanchions shall be placed as shown on their plans, dated 10/22/2025, 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 rafter. Intermediate rows shall move the support points laterally to the next rafter.



Google Location Map

Framing Summary

	<u>Ex. Framing</u>	<u>Total Ex DL</u>
MP 1: 2.00" x 8.00" member x 18.93' span with a 18° slope @ 16" OC	2.29 psf	6.69 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 7-16 Minimum Design Loads for Buildings and Other Structures
- 2) 2018 IBC
- 3) 2018 IRC
- 4) American Wood Council, NDS 2018, Table 12.2A, 12.3.3A.
- 5) American Wood Council, Wood Structural Design, 1992, Figure 6.

Roof Structural Calculations for PV Solar Installation

Location: MP 1

Member: Rafter - Total Length 18.93 ft, Unsupported 18.93 ft

Array AR-1

Roof shape: Hip

Geometric Data			
Θ	deg.	18.0	Angle of roof plane from horizontal, in degrees
ω	deg.	0.0	Angle the solar panel makes with the roof surface
L	ft.	40.00	Length of roof plane, in feet (meters)
W	ft.	21.00	Plan view width of roof plane, in feet (meters)
h	ft.	13.90	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			
$q_z =$	18.19	psf	$V_{asd} q_z =$ 11.01 psf Basic wind pressure
V =	109		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 18.93

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

Member Properties	Member
Name	(1)2x8.
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.
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Module Data			
Weight	kg	lb	psf load
Module	21.40	47.18	2.24
4 Stanchions	0.91	2.0	0.10

Existing Dead Loads	Units	Value	Description
Framing Member	psf	2.29	
Roof Deck & Surface Material*	psf	4.40	0.50 in. Plywood w/ Standard Asphalt Shingles

* Roof surface: Standard Asphalt Shingles

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	18.93	
Maximum member free span	ft	18.93	Rafter span
Rafter segment to calc	ft	18.93	Free span
Deflection Ratio		180	Use max delta 1/x for deflection

Eave Overhang Length past Rafter Plate	3.00	ft
Uphill Distance from Eave to Lowest Support	1.25	ft

ASCE 7-16 Method for Calculating Uplift on PV Modules

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 TRUE

Use EXPOSED for uplift calculations

$1.5(L_p) =$	5.58
$\gamma_E =$	1.5
$\gamma_a =$	0.67

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

Zones	1	2r	2e,3
GC _p	-1.78	-2.30	-2.30
p, Windload (psf)	-19.66	-25.47	-25.47

Downward, Zones All Zones
GC_p 0.57

ASCE 7-16 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)				
Zones	1	2r	2e,3	All Zones
2.2 SYMBOLS AND NOTATION	Module Upward	Module Upward	Module Upward	Downward
D = dead load of PV Module + Stanchion	2.34	2.34	2.34	2.34
S = snow load	20.00	20.00	20.00	20.00
W = wind load = (V _u Windload) = (V _{asd} Windload / 0.6)	-19.66	-25.47	-25.47	6.29

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(0.60W) + 0.75(L _r or S or R)	22.34	22.34	22.34	25.17
Module Support point load (lb)	252	252	252	284
C _r Factored Module Support point load (lb)	219	219	219	247

Use this loading combination for UPWARD for Proposed PV Dead Load				
7. 0.60D - 0.6W	-6.38	-9.87	-9.87	9.03
Module Support point load (lb)	-72	-111	-111	102

DOWNWARD

Presume loading directly over member.

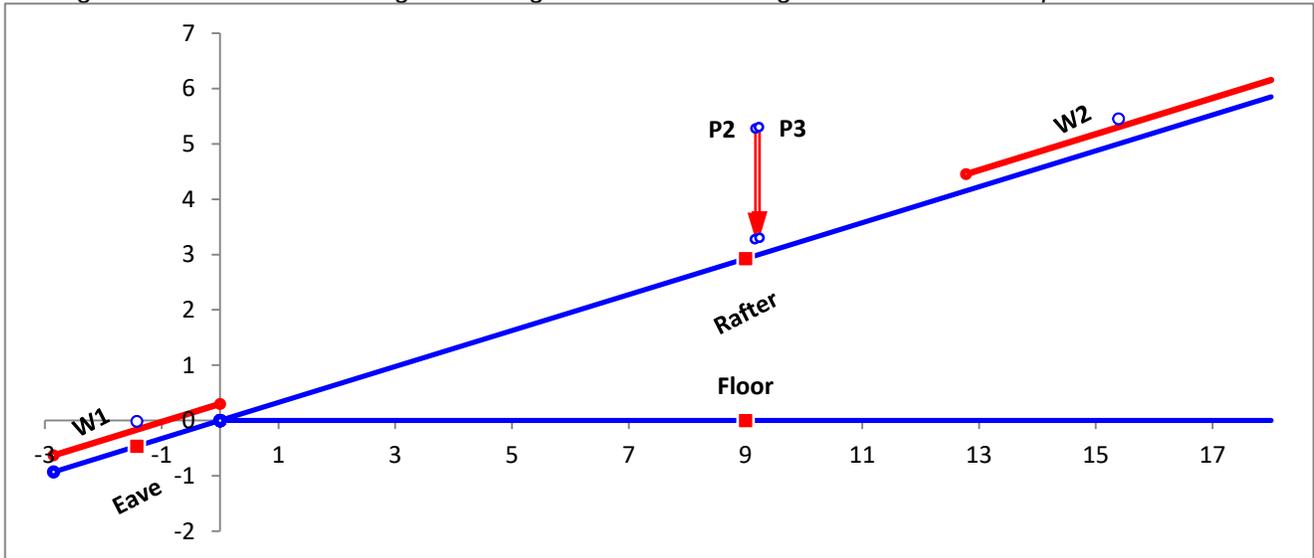
Combined Dead and Wind Pressure Downward Loading					
Rafter span					
PV Module Row	Point load loc's from Left support		Module Support Point Load	Comment	Module Orientation
	<i>ft from left</i>		<i>lb</i>		
1	-1.75			Support outside of max stressed section	Portrait
1	3.90			Support placed on adjoining rafter	Portrait
2	3.98			Support placed on adjoining rafter	Portrait
2	9.63		247		Portrait
3	9.72		247		Landscape
3	13.44			Support placed on adjoining rafter	Landscape

Analysis for PV impacted areas

5. Simple Beam - Exposed Roof Snow Load - Above and Below PV				
<i>Parameter</i>	<i>Units</i>	<i>Total</i>	<i>Allowed</i>	<i>Check</i>
Delta @ mid span	<i>in</i>	0.11	1.26	OK
M at mid span	<i>lb-ft</i>	201	11,615	OK

Sum Downward Loading Conditions: PV; Beam DL; Exposed Roof Environmental Load				
<i>Parameter</i>	<i>Units</i>	<i>Total</i>	<i>Allowed</i>	<i>Check</i>
Delta	<i>in</i>	1.21	1.26	OK
Percent Max Delta	<i>%</i>	96%	100%	OK
Moment	<i>lb-ft</i>	2,790	11,615	OK
fs	<i>psi</i>	1,569	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 |
| C_e = | 0.9 | Exposure Factor, C _e (ASCE 7-16 Table 7.3-1, Page 61) |
| C_t = | 1.0 | Thermal Factor, C _t (ASCE 7-16 Table 7.3-2, Page 61) |
| I_s = | 1.0 | Snow Importance Factor, I _s (ASCE 7-16 Table 1.5-2, Page 5) |
| p_g = | 20.00 | Ground Snow Load p _g (ASCE 7-16 Table 7.2-1, Page 56-60) |
| p_f = | 0.7C_eC_tI_sP_g | Flat Roof Snow Load, p _f (ASCE 7-16 Table 7.3-1, Page 61) |
| p_f = | 12.60 | psf |
| | | but where P _f is not less than the following: |
| | | Minimum Snow Load p _m (ASCE 7-16 Table 7.3.4, Page 62) |
| p_m = | 20.00 | When P _g <=20 psf, then use P _f = P _g x I _s |
| p_f = | 20.00 | psf. Resultant Snow pressure to be used with Roof slope factor below |
| p_s = | C_sp_f | Sloped Roof Snow Load p _s (ASCE 7-16 Table 7.4, Page 61) |
| | | Roof Type Warm Roofs |

Roof slope factor C_s for Warm Roofs, where C_t = 1.0
 Roof surface condition = Slippery Roof

C_s = 1.00 Roof Slope Factor, C_s (ASCE 7-16 Table 7.4-1a, Page 62)

Total Snow Load

p_s =	20.00 psf	Roof snow load
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