PRINCIPAL Engineering

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July 2021

Property Owner: William Hume

Property Address: 3201 Southwest Mary Street, Lee's Summit, MO 64081

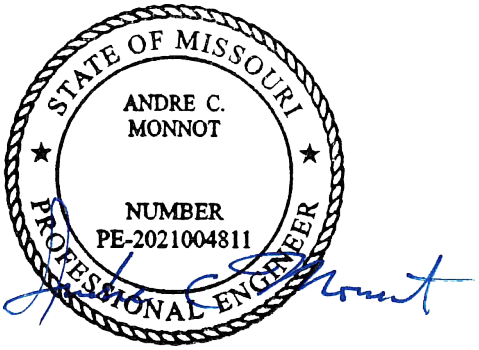
RE: Photovoltaic System Roof Installations

I have reviewed the existing structure referenced above to determine the adequacy of the existing structure support the proposed installation of an array of solar panels on the roof.

Based on my review, the existing structure is adequate to support the proposed solar panel installation. This assessment is based on recent on-site inspection by SunPro Solar inspectors and photographs of the existing structure. The photovoltaic system is designed to withstand uplift and downward forces; our assessment is regarding the structure's support of the array. Stresses induced by the introduction of individual mount loads on the rafters are within acceptable limits as shown on the attached calculations. The structural considerations used in our review and assessment include the following:

Evaluation Criteria:

Applied Codes: ASCE 7-16 IBC 2018 NEC 2017
Risk Category: II
Design Wind Speed (3-second gust): 109 MPH
Wind Exposure Category: C
Ground Snow Load: 20 PSF
Seismic Design Category: D



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Existing Structure:

Roof Material: Shingle
Roofing Structure: 2x6 rafters @ 24" O.C.
Roof Slope: 2/12

Connection of Array to Structure:

Manufacturer: UNIRAC
Mount: Flashloc Comp Kit
Mounting Connection: Flashloc Comp Kit 5/16" lag screw w/min 2.5" embedment into framing
Zone 1: 2 rails 4'-0" o.c. mounts
Zone 2: 2 rails 4'-0" o.c. mounts
Zone 3: 2 rails 4'-0" o.c. mounts

Effect of the Solar Array on Structure Loading:

Gravity Loads:

Per IBC Section 1607.12.5.1, the areas of the roof where solar panels are located are considered inaccessible, and therefore not subject to roof live loading. Live load in these areas is replaced by the dead load of the solar array, 3 psf. The total gravity load on the structure is therefore reduced and the structure may remain unaltered. Connections of the mounts to the underlying structure are to be installed in a staggered pattern, except at the array ends, to distribute the loading evenly to the roof structure. The stresses within the rafters due to the introduction of discrete mount loads are within acceptable limits, as shown on the attached calculations.

Wind Load:

The solar panel array will be flush mounted (no more than 6" above the surrounding roof surface, and parallel to the roof surface. Any additional wind loading on the structure due to the presence of the array is negligible. The array structure is designed by the manufacturer to withstand uplift and downward forces resulting from wind and snow loads. The attached calculations verify the capacity of the connection of the solar array to the roof to resist uplift due to wind loads, the governing load case.

Snow Load:

The reduced friction of the glass surface of the solar panels allows for the lower slope factor (C_s) per Section 7.4 of ASCE 7-16 resulting in a reduced design snow load for the structure. This analysis conservatively considered the snow load to be unchanged.

Seismic Load:

Analysis shows that additional seismic loads due to the array installation will be small. Even conservatively neglecting the wall materials, the solar panel installation represents an increase in the total weight of the roof and corresponding seismic load of less than 10%. This magnitude of additional forces meets the requirements of the exception in Section 11B.4 of ASCE 7-16 . The existing lateral force resisting system of the structure is therefore allowed to remain unaltered.

Conclusion:

To the best of my professional knowledge and belief, the subject construction and photovoltaic system installation will be in compliance with all state and local building codes and guidelines in effect at the time of our review.

Limitations:

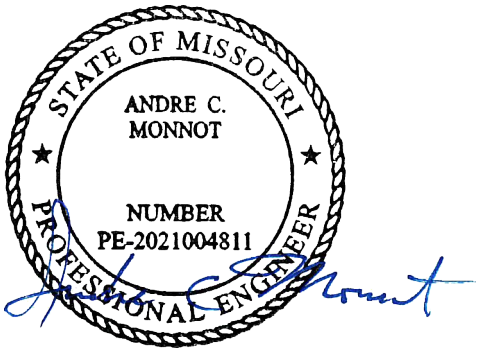
Engineer's assessment of the existing structure is based on recent field reports and current photographs of the elements of the structure that were readily accessible at the time of inspection. The design of the solar panel racking (mounts, rails, connectors, etc.), connections between the racking and panels, and electrical engineering related to the installation are the responsibility of others. The photovoltaic system installation must be by competent personnel in accordance with manufacturer recommendations and specifications and should meet or exceed industry standards for quality. The contractor is responsible for ensuring that the solar array is installed according to the approved plans and must notify the engineer of any undocumented damage or deterioration of the structure, or of discrepancies between the conditions depicted in the approved plans and those discovered on site so that the project may be reevaluated and altered as required. Engineer does not assume any responsibility for improper installation of the proposed photovoltaic system.

Uplift and Wind Downforce Calculation Summary (ASCE 7-16)
Mount, Rack, & Panel Proportioning
Point Load Check and Rafter Stress Analysis

		Max. Individual Panel Dimensions		
Property Owner:	William Hume			
Project Address:	3201 Southwest Mary Street	Length (in)	Width (in)	Area (sf)
City, State:	Lee's Summit, MO 64081	77	39	20.85

Building Characteristics, Design Input, and Adjustment Factors				
Roof Dimensions:	Length:	84	Greater Dimension	84
	Width:	27	Least Dimension:	27
Roof Height (h):		15	Fig 30.4-1, valid under 60°	✓
Pitch: 2 on 12 =		9.5°	Must be less than 45°	✓
Roof Configuration		Gable		
Roof Structure		2x Rafters		
Roof Material		Plywood		
Risk Category:		II		
Basic Wind Speed:		109	From 26.5-1	
Exposure Category:		C	Fig. 26.7	
Topographic Factor (K_{zt})		1.0	Fig. 26.8-1	
Wind Pressure @ h=30, p_{net30}		See Table Below	Fig. 30.4-1	
Ht. & Exposure Adjustment (λ)		0.82	Fig. 30.4-1	
Adjusted Wind Pressures, p_{net}		See Table Below	Eq. 30.4-1	
Effective Wind Area (sf):		10.43	(Area per individual mount)	

Roof Zone Strip (a), in ft, Fig. 30.4-1, Note 5		
1 - Least Roof Horizontal Dimension (L or W) x 0.10		2.7
2 - Roof Height x 0.4		6
3 - Least Roof Horizontal Dimension (L or W) x 0.04		1.08
4 - Least of (1) and (2)		2.7
5 - Greater of (3) and (4)		2.7
6 - Greater of (5) and 3 feet	**a=**	3



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Net Design Pressures, p_{net} (Fig 30.4-1), Components & Cladding					
	Uplift (-psf)			Factored Pressure (0.6W, ASCE 7-16)	θ
		P_{30net}	$IK_{zt}P_{30net}$		
gable /hip /flat					
Gable	Zone 1 & 2e	38.9	31.9	19.2	$7° < \theta \leq 20°$
	Zone 2n,2r,3e	56.8	46.6	28.0	
	Zone 3r	67.5	55.4	33.2	
Hip					

Snow Load		
Ground Snow Load, p_g	20.0	From ASCE 7 or AHJ
Terrain Category:	C	Para 6.5.6.3
Exposure	Fully	
Exposure FactorCe	0.9	Table 7-2
Thermal Factor, Ct	1.0	Table 7-3
Importance Factor, I_s	1.0	Table 1.5.2
Roof Configuration	Gable	
Roof Slope	09.5°	
Distance from Eave to Ridge	13.5	
p_m, Minimum required Snow Load	20.00 psf	Para. 7.3.4
pf, Calculated Snow Load	12.60	Eq. 7.3-1
pf, Design Snow Load	20.00 psf	

Rail & Mount Selection (FS=3.0)		
Manufacturer:	Unirac	Allowable Mount Spacing by Uplift Pressure
Model:	Flashloc Comp Kit	< 37 psf : 2 rails, mounts @ 4 ft. o.c.
Substrate	Wood Rafters	37 to 56 psf : 2 rails, mounts @ 2 ft. o.c.
Connector:	5/16" x 4" Lag Screw	56 to 75 psf : 3 rails, mounts @ 4 ft. o.c.
		75 to 112 psf : 3 rails, mounts @ 2 ft. o.c.
Allowable Uplift:	480 lb., max.	112 to 150 psf : 4 rails, mounts @ 2 ft. o.c.
		> 150 psf : Mount capacity exceeded

Rail & Mount Layout by Zone			
Zone 1:	2 rails, mounts @ 4 ft. o.c.	Zone 2r:	2 rails, mounts @ 4 ft. o.c.
Zone 1':	N/A	Zone 3:	N/A
Zone 2:	N/A	Zone 3e:	2 rails, mounts @ 4 ft. o.c.
Zone 2e:	2 rails, mounts @ 4 ft. o.c.	Zone 3r:	2 rails, mounts @ 4 ft. o.c.
Zone 2n:	2 rails, mounts @ 4 ft. o.c.		

(From rail analysis, allowable spacing and number of rails are controlled by individual mount pullout before rail bending)