VSE Project Number: U4584.0009.251

March 24, 2025

E&M Solar, LLC
ATTENTION: Michael Younghans
2236 Spiritwood Lane
Bellvue, CO 80512

REFERENCE: Robert Pratt Residence: 26730 County Road 14, Steamboat Springs, CO 80487
E&M Solar, LLC Project: Pratt01
Solar Array Installation

To Whom It May Concern:

We have reviewed the existing structure at the above referenced site. The purpose of our review was to determine the adequacy of the existing structure to support the proposed installation of solar panels on the roof as shown on the panel layout plan.

Based upon our review and the as-built plans from Robb Studio Inc., dated 03/02/2023, we conclude the existing structure is adequate to support the proposed solar panel installation.

Design Parameters

Code: International Residential Code, 2021 Edition
Risk Category: II
Design wind speed, Vult: 106 mph (3-sec gust)
Wind exposure category: C
Ground snow load, Pg: 111 psf
Seismic design category: D

Existing Roof Structure

Roof structure: 2x10 rafters @ 24" o.c.
Roofing material: metal seam
Roof slope: 44°

Connection to Roof

Mounting connection: (1) S-5! U Clamp to min. 26 ga steel roofing at max. 16" o.c. along rails
- Install (2) rails per row of panels, evenly spaced from panel center
- Panel length perpendicular to the rails shall not exceed 57 in
- Rail cantilever shall not exceed the lesser of 50% of the connection spacing or max cantilever allowed by manufacturer
- Connections shall be staggered so as not to overload any existing structural member

Note: Contractor shall verify min. metal gauge prior to installation of the solar panels.

Conclusions

Based upon our review, we conclude the existing structure is adequate to support the proposed solar panel installation. See attached calculations.

The solar array will be flush-mounted (no more than 10" above the roof surface) and parallel to the roof surface. Thus, we conclude that any additional wind loading on the structure related to the addition of the proposed solar array is negligible. The attached calculations verify the capacity of the connections of the solar array to the existing roof against wind (uplift), the governing load case. Regarding seismic loads, we conclude that any additional forces will be small. The installation of the solar panels represents an increase in the total weight (and resulting seismic load) of 8.8%. Increases in lateral forces less than 10% are considered acceptable. Thus the existing lateral force resisting system is permitted to remain unaltered.

Limitations

Installation of the solar panels must be performed in accordance with manufacturer recommendations. All work performed must be in accordance with accepted industry-wide methods and applicable safety standards. The contractor must notify Vector Structural Engineering, LLC should any damage, deterioration or discrepancies between the as-built condition of the structure and the condition described in this letter be found. The use of solar panel support span tables provided by others is allowed only where the building type, site conditions, site-specific design parameters, and solar panel configuration match the description of the span tables. The design of the solar panels, solar racking (mounts, rails, etc.) and electrical engineering is the responsibility of others. Waterproofing around the roof penetrations is the responsibility of others. Vector Structural Engineering assumes no responsibility for improper installation of the solar array. Vector Structural Engineering shall be notified of any changes from the approved layout prior to installation.

VECTOR STRUCTURAL ENGINEERING, LLC
CO Firm License: 20181009799

Eric S. Sumsion, P.E.
CO License: 56167 - Expires: 10/31/2025
Project Engineer

Enclosures

ESS/crs

PROJECT: Robert Pratt Residence
JOB NO.: U4584.0009.251 **SUBJECT:** SEISMIC LOADS

CHECK INCREASE IN OVERALL SEISMIC LOADS

Estimated Roof Dead Load	13.9	psf
Roof Area	1500	ft^2
Wall Dead Load	10	psf
Wall Height	8	ft
Roof Perimeter	160	ft
Existing Seismic Weight	27.2	k
Solar Dead Load	3.0	psf
Solar Area	798.4824	ft^2
% Roof Covered	53%	
Proposed Seismic Weight	29.6	k
Addt'l Seismic Weight	8.8%	

The installation of the solar panels represents an increase in the total weight (and resulting seismic load) of 8.8%. Increases in lateral forces less than 10% are considered acceptable.

PROJECT: Robert Pratt Residence
JOB NO.: U4584.0009.251

SUBJECT: WIND PRESSURE

Calculations per ASCE 7-16

Calculate Velocity Pressures

(Chapter 26)

$q_h = 0.00256 K_h K_{zt} K_e K_d V^2$ *(Eq. 26.10-1)*

Roof Plane	Risk Cat.	Wind Speed, V_{ult} [mph]	Wind Exp. Cat.	Roof Height, h [ft]	z_g [ft]	α	K_h	K_{zt}	K_e	K_d	q_h [psf]	Racking Type
Typical	II	106	C	25	900	9.5	0.95	1.00	0.77	0.85	17.8	Railed

Calculate Component and Cladding Pressures

(Chapters 29 and 30)

'-' pressure descriptions act away from panels (uplift), '+' pressure descriptions act towards panel (downard)

Pressure Description	qh [psf]	C&C Category	GCp	γ_E	γ_a	γ_c	γ_p	Pressure, P (1.0 W) [psf]
Typical: - Zone 1 (Exposed, Landscape)	17.8	Gable Roofs 27° < θ ≤ 45°	1.8	1.5	0.8	1.0	1.0	38.4
Typical: - Zone 2e (Exposed, Landscape)	17.8	Gable Roofs 27° < θ ≤ 45°	1.8	1.5	0.8	1.0	1.0	38.4
Typical: - Zone 2n (Exposed, Landscape)	17.8	Gable Roofs 27° < θ ≤ 45°	2.0	1.5	0.8	1.0	1.0	42.6
Typical: - Zone 2r (Exposed, Landscape)	17.8	Gable Roofs 27° < θ ≤ 45°	1.8	1.5	0.8	1.0	1.0	38.4
Typical: - Zone 3e (Exposed, Landscape)	17.8	Gable Roofs 27° < θ ≤ 45°	3.0	1.5	0.8	1.0	1.0	64.0
Typical: - Zone 3r (Exposed, Landscape)	17.8	Gable Roofs 27° < θ ≤ 45°	2.0	1.5	0.8	1.0	1.0	42.6

PROJECT: Robert Pratt Residence
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Calculate Uplift Forces on Connection

	Pressure (0.6 Dead - 0.6 Wind) (psf)	Max Trib. Width[1] (ft)	Max Trib. Area[2] (ft^2)	Max Uplift Force (lbs)
- Zone 1 (L)	21.2	1.3	3.1	67
- Zone 2e (L)	21.2	1.3	3.1	67
- Zone 2n (L)	23.8	1.3	3.1	75
- Zone 2r (L)	21.2	1.3	3.1	67
- Zone 3e (L)	36.6	1.3	3.1	115
- Zone 3r (L)	23.8	1.3	3.1	75

(P) = Portrait orientation relative to rails, (L) = Landscape orientation relative to rails

Calculate Connection Capacity

Roof Connector:	S-5! U Clamp
Additional Connection Info:	to min. 26 ga steel roofing
Ultimate Capacity[3] [lbs/in]:	429
Factor of Safety:	3
Qty. of Connectors:	1
Prying Coefficient:	1
Total Capacity [lbs]:	143

Determine Result

Maximum Demand:	115
Connection Capacity:	143

Result: **Capacity > Demand, Connection is adequate.**

Notes

1. 'Max Trib. Width' is the width along the rails tributary to the connection.
2. 'Max Trib Area' is the product of the 'Max. Trib Width' and 1/2 the panel width/height perpendicular to the rails. This installation uses (2) rails per row of panels. Length of the panels perpendicular to the rails shall not exceed 57".

3. Ultimate capacity values are from manufacturer testing. Metal gauge is unknown. A conservative thickness has been used. Metal gauge shall be verified in field prior to installation of solar panels. Roof deck model is unknown or has not been tested for this connector. The capacity used is based on conservative values from testing of the connector on similar roof deck model.
4. Install metal roof connector per manufacturer's written instructions with recommended fasteners when indicated.

PROJECT: Robert Pratt Residence
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GRAVITY LOADS

Roof Pitch: 11.6 :12

ROOF DEAD LOAD (D)	Design material weight [psf]	Increase due to pitch	Material weight [psf]
Metal Seam	3.5	1.39	2.5
1/2" Plywood	1.4	1.39	1.0
Framing	3.0		3.0
Insulation	0.0		0.0
1/2" Gypsum Clg.	0.0	1.39	0.0
M, E & Misc	2.0		2.0
Total Existing Roof DL	9.9		
PV Array DL	4.2	1.39	3

ROOF LIVE LOAD (Lr)

Existing Design Roof Live Load [psf]	20	ASCE 7-16 Table 4.3-1
Roof Live Load With PV Array [psf]	0	2021 IRC, Section R324.4.1.1

SNOW LOAD (S):

	Existing	w/ Solar Array	
Roof Slope [x:12]:	11.6	11.6	
Roof Slope [°]:	44	44	
Ground Snow Load, p_g [psf]	111	111	ASCE 7-16, Section 7.2
Surface Roughness Category:	C	C	ASCE 7-16, Table 7.3-1
Exposure of Roof:	Fully Exposed	Fully Exposed	ASCE 7-16, Table 7.3-1
Exposure Factor, C_e:	0.9	0.9	ASCE 7-16, Table 7.3-1
Thermal Factor, C_t:	1.1	1.1	ASCE 7-16, Table 7.3-2
Risk Category:	II	II	ASCE 7-16, Table 1.5-1
Importance Factor, I_s:	1.0	1.0	ASCE 7-16, Table 1.5-2
Flat Roof Snow Load, p_f [psf]:	77	77	ASCE 7-16, Equation 7.3-1
Minimum Roof Snow Load, p_m [psf]:	0	0	ASCE 7-16, Section 7.3.4
Unobstructed Slippery Surface?	Yes	Yes	ASCE 7-16, Section 7.4
Slope Factor Figure:	Figure 7-2b	Figure 7-2b	ASCE 7-16, Section 7.4
Roof Slope Factor, C_s:	0.43	0.43	ASCE 7-16, Figure 7.4-1
Sloped Roof Snow Load, p_s [psf]:	33	33	ASCE 7-16, Equation 7.4-1
Design Snow Load, S [psf]:	**33**	**33**	

PROJECT: Robert Pratt Residence
JOB NO.: U4584.0009.251
SUBJECT: BEAMS

DESIGN LOADS:

Load Types:	Snow	Live	Dead
Roof	33	20	10
Solar			4.2

CRITERIA (L/)

	D_{TL}	D_{LL}	D_{DL}
$A_{(BLANK)}$	120	180	

Abbrev	GRADES			F_{bxx} (psi)	F_{vxx} (psi)	E_{xx} (psi)	g (lb/ft^3)
DFL#1	DFL#1			1,000	180	1,700,000	32
DFL#2	DFL#2			900	180	1,600,000	32
DF1 (5X)	DFL#1 5X5 & LARGER			1,350	170	1,600,000	32
SPF#2	SPF#2			875	135	1,400,000	26.2
SP#2	SP#2			1,100	175	1,400,000	34.3
24F-V4	24F-V4			2,400	240	1,800,000	32
24F-V8	24F-V8			2,400	240	1,800,000	40
LVL (1.9)	LVL (1.9X106E)			2,600	285	1,900,000	40
LVL (2.0)	LVL (2.0X106E)			2,200	285	2,000,000	42
LSL	LSL (1.3X106E)			1,700	400	1,300,000	42
STL36	GRADE 36 STEEL			21,600	14,400	29,000,000	490
STL46	GRADE 46 STEEL			27,700	16,500	29,000,000	490
STL50	GRADE 50 STEEL			30,000	20,000	29,000,000	490

Label	Length 'L' (ft)	Roof Trib (ft)	Floor Trib (ft)	Wall Trib (ft)	Add'l Live Load (plf)	Add'l Solar Load (plf)	Point Load From	React (A,B)	Dist 'a' (ft)	Point Live Load 'P_{LL}' (lb)	Point Dead Load 'P_{DL}' (lb)	# PLIES	Grade	Size	"BM/HDR"	D CRITERIA	C_r	C_D	$C_{F,V}$	R_a (lb)	R_b (lb)	M_{max} (ft-lb)	M_{allow} (ft-lb)	V_{max} (lb)	V_{allow} (lb)	D_{TL} (in)	$D_{TLallow}$ (in)	D_{LL} (in)	$D_{LLallow}$ (in)	1.5DL GLB Camb	Check
Rafter	13.3	2.00				8.3						(1)	SPF#2	2x10			1.15	1.15	1.10	631	631	2104	2269	558	1436	0.486	1.333	0.342	0.889		0.93 M
GL Beams	13.3	6.55				27.3						(1)	24F-V4	5-1/8X18			1.00	1.15	1.00	2068	2068	6889	63653	1602	16974	0.049	1.333	0.035	0.889	STD	0.11 M

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SUBJECT: SOLAR LAYOUT

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