Domus Structural Engineering, LLC
P.O. Box 560
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530-864-7055
projects@domusstruc.com

August 4, 2023

To: Blue Raven Solar
1403 North Research Way, Building J
Orem, UT. 84097

Subject: Certification Letter
Roberts Residence
518 NW Main St
Lee's Summit, MO. 64063

To Whom It May Concern,

A jobsite observation of the condition of the existing framing system was performed by an audit team of Blue Raven Solar as a request from Domus Structural Engineering. All review is based on these observations and the design criteria listed below and only deemed valid if provided information is true and accurate.

On the above referenced project, the roof structural framing has been reviewed for additional loading due to the installation of the solar PV addition to the roof. The structural review only applies to the section of the roof that is directly supporting the solar PV system and its supporting elements. The observed roof framing is described below. If field conditions differ, contractor to notify engineer prior to starting construction.

The roof structure of (MP1) consists of composition shingle on roof plywood that is supported by pre-manufactured trusses that are spaced at @ 24"o.c.. The top chords, sloped at 37 degrees, are 2x4 sections, the bottom chords are 2x4 sections and the web members are 2x4 sections. The truss members are connected by steel gusset plates. The max unsupported projected horizontal top chord span is approximately 7'-0''.

The roof structure of (MP2) consists of composition shingle on roof plywood that is supported by nominal 2x6 rafters @ 19.2"o.c. with ceiling joists acting as rafter ties. The rafters have a max projected horizontal span of 12'-0", with a slope of 34 degrees. The rafters are connected at the ridge to a ridge board and are supported at the eave by a load bearing wall.

The existing roof framing system of (MP1) is judged to be adequate to withstand the loading imposed by the installation of the solar panels. No reinforcement is necessary.

The existing roof framing system of (MP2) is judged to be adequate to withstand the loading imposed by the installation of the solar panels. No reinforcement is necessary.

The spacing of the solar standoffs should be kept at 72" o.c. for landscape and 48" o.c. for portrait orientation, with a staggered pattern to ensure proper distribution of loads.

The scope of this report is strictly limited to an evaluation of the fastener attachment, underlying framing and supporting structure only. The attachment's to the existing structure are required to be in a staggered pattern to ensure proper distribution of loading. All panels, racking and hardware shall be installed per manufacturer specifications and within specified design limitations. All waterproofing shall be provided by the manufacturer. Domus Structural Engineering assumes no responsibility for misuse or improper installation of the solar PV panels or racking.

Note: Seismic check is not required since Ss<.4g and Seismic Design Category (SDC) < B

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Design Criteria:

- Applicable Codes = 2018 IBC/IRC, ASCE 7-16
- Roof Dead Load = 7 psf (MP1) -- 8 psf (MP2)
- Roof Live Load = 20 psf
- Wind Speed = 115 mph (Vult), Exposure C
- Ground Snow Load = 20 psf - Roof Snow Load = 14 psf
- Attachment: 1 - 5/16 dia. lag screw with 2.5 inch min. embedment depth, at spacing shown above.

Please contact me with any further questions or concerns regarding this project.

Sincerely,

John Calvert, P.E.
Project Engineer

Digitally signed by John A. Calvert
Date: 2023.08.04 16:44:45 -06'00'

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Gravity Loading

Roof Snow Load Calculations		
p_g = Ground Snow Load =	20.0 psf	
$p_f = 0.7\ C_e\ C_t\ I\ p_g$		(ASCE7 - Eq 7-1)
C_e = Exposure Factor =	1	(ASCE7 - Table 7-2)
C_t = Thermal Factor =	1	(ASCE7 - Table 7-3)
I = Importance Factor =	1	
p_f = Flat Roof Snow Load =	14.0 psf	
$p_s = C_s p_f$		(ASCE7 - Eq 7-2)
Cs = Slope Factor =	1	
p_s = Sloped Roof Snow Load =	**14.0 psf**	

PV Dead Load = 3 psf (Per Blue Raven Solar)	
DL Adjusted to 37 Degree Slope	3.76 psf
PV System Weight	
Weight of PV System (Per Blue Raven Solar)	3.0 psf
X Standoff Spacing =	4.00 ft
Y Standoff Spacing =	6.08 ft
Standoff Tributary Area =	24.33 sft
Point Loads of Standoffs	**73 lb**

Note: PV standoffs are staggered to ensure proper distribution of loading

Roof Live Load = 20 psf
Note: Roof live load is removed in area's covered by PV array.

Roof Dead Load (MP1)		
Composition Shingle	4.00	
Roof Plywood	2.00	
2x4 Top Chords @ 24"o.c.	0.73	
Vaulted Ceiling	0.00	(Ceiling Not Vaulted)
Miscellaneous	0.27	
Total Roof DL (MP1)	**7.0 psf**	
DL Adjusted to 37 Degree Slope	8.8 psf	

Roof Dead Load (MP2)		
Composition Shingle	4.00	
Roof Plywood	2.00	
2x6 Rafters @ 19.2"o.c.	1.44	
Vaulted Ceiling	0.00	(Ceiling Not Vaulted)
Miscellaneous	0.56	
Total Roof DL (MP2)	**8.0 psf**	
DL Adjusted to 34 Degree Slope	9.65	

DOMUS STRUCTURAL ENGINEERING, LLC

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Wind Calculations
Per ASCE 7-16 Components and Cladding

Input Variables	
Wind Speed	115 mph
Exposure Category	C
Roof Shape	Gable Roof
Roof Slope	37 degrees
Mean Roof Height	20 ft
Effective Wind Area	21.3 ft
Ground Elevation	0 ft

Design Wind Pressure Calculations		
qh = 0.00256 * Kz * Kzt * Kd * Ke * V^2		(Eq. 26.10-1)
Kz (Exposure Coefficient) =	0.90	(Table 30.3-1)
Kzt (topographic factor) =	1.00	(Fig. 26.8-1)
Kd (Wind Directionality Factor) =	0.85	(Table 26.6-1)
Ke (Ground Elevation Factor) =	1.00	
V (Design Wind Speed) =	115 mph	(Fig. 26.5-1A)
Risk Category =	II	(Table 1.5-1)
qh =	25.95	

Standoff Uplift Calculations-Portrait					
	Zone 1	Zone 2	Zone 3	Positive	
y_a =	0.67	0.77	0.80	0.67	
GCp =	-1.41	-1.93	-2.59	0.75	(Fig. 30.3)
Uplift Pressure =	-24.6 psf	-38.7 psf	-53.7 psf	13.0 psf	(Eq. 29.4-7)
ASD Uplift Pressure =	-14.8 psf	-23.2 psf	-32.2 psf	9.6 psf	
X Standoff Spacing =	4.00	4.00	2.67		
Y Standoff Spacing =	6.08	3.04166667	3.04166667		
Tributary Area =	24.33	12.17	8.11		
Dead Load on attachment =	73 lb	37 lb	24 lb		
Footing Uplift (0.6D+0.6W) =	**-315 lb**	**-261 lb**	**-247 lb**		

Standoff Uplift Calculations-Landscape					
	Zone 1	Zone 2	Zone 3	Positive	
y_a =	0.69	0.79	0.80	0.69	
GCp =	-1.48	-1.98	-2.65	0.77	(Fig. 30.3)
Uplift Pressure =	-26.5 psf	-40.8 psf	-55.0 psf	13.8 psf	(Eq. 29.4-7)
ASD Uplift Pressure (0.6W)=	-15.9 psf	-24.5 psf	-33.0 psf	9.6 psf	
X Standoff Spacing =	6.00	6.00	4.00		
Y Standoff Spacing =	3.50	1.75	1.75		
Tributary Area =	21.00	10.50	7.00		
Dead Load on attachment =	63.00	31.50	21.00		
Footing Uplift (0.6D+0.6W) =	**-296 lb**	**-238 lb**	**-218 lb**		

Standoff Uplift Check
Maximum Design Uplift = -315 lb
Standoff Uplift Capacity = 450 lb
450 lb capacity > 315 lb demand **Therefore, OK**

Fastener Capacity Check	
Fastener =	1 - 5/16" dia. lag
Number of Fasteners =	1
Embedment Depth =	2.5
Pullout Capacity Per Inch =	250 lb
Fastener Capacity =	625 lb
w/ F.S. of 1.5 & DOL of 1.6=	667 lb
667.2 lb capacity > 315 lb demand **Therefore, OK**	

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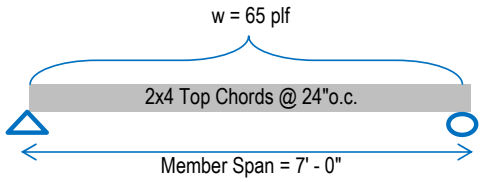
Framing Check

(MP1) **PASS**

Dead Load	8.8 psf
PV Load	3.8 psf
Snow Load	14.0 psf

Governing Load Combo = DL + LL
Total Load **32.5 psf**



Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x4	3.06	5.36	DF#2	@ 24"o.c.

Check Bending Stress

Fb (psi) = f'b x Cd x Cf x Cr (NDS Table 4.3.1)
900 x 1.25 x 1.5 x 1.15

Allowed Bending Stress = 1940.6 psi

Maximum Moment = (wL^2) / 8
= 398.3866 ft#
= 4780.639 in#

Actual Bending Stress = (Maximum Moment) / S
= 1561.1 psi

Allowed > Actual -- 80.5% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.466 in

Deflection Criteria Based on = Continuous Span

Actual Deflection (Total Load) = (w*L^4) / (185*E*I)
= 0.171 in
= L/492 > L/180 **Therefore OK**

Allowed Deflection (Live Load) = L/240
0.35 in

Actual Deflection (Live Load) = (w*L^4) / (185*E*I)
0.105 in
L/800 > L/240 **Therefore OK**

Check Shear

Member Area = 5.3 in^2 Fv (psi) = 180 psi (NDS Table 4A)

Allowed Shear = Fv * A = 945 lb Max Shear (V) = w * L / 2 = 228 lb

Allowed > Actual -- 24.1% Stressed -- Therefore, OK

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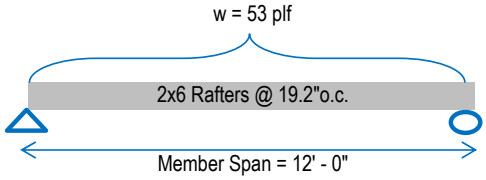
Framing Check
(MP2)

PASS

Dead Load	9.6 psf
PV Load	3.8 psf
Snow Load	14.0 psf



Governing Load Combo = DL + LL
Total Load **33.4 psf**

Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x6	7.56	20.80	DF#2	@ 19.2"o.c.

Check Bending Stress

Fb (psi) =	f'b	x	Cd	x	Cf	x	Cr	(NDS Table 4.3.1)
	900	x	1.25	x	1.3	x	1.15	

Allowed Bending Stress = 1681.8 psi

Maximum Moment = (wL^2) / 8
= 962.0971 ft#
= 11545.17 in#

Actual Bending Stress = (Maximum Moment) / S
= 1526.7 psi

Allowed > Actual - 90.8% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.8 in
Deflection Criteria Based on = Continuous Span
Actual Deflection (Total Load) = (w*L^4) / (185*E*I)
= 0.312 in
= L/462 > L/180 **Therefore OK**

Allowed Deflection (Live Load) = L/240
0.6 in
Actual Deflection (Live Load) = (w*L^4) / (185*E*I)
0.187 in
L/771 > L/240 **Therefore OK**

Check Shear

Member Area = 8.3 in^2 Fv (psi) = 180 psi (NDS Table 4A)
Allowed Shear = Fv * A = 1485 lb Max Shear (V) = w * L / 2 = 321 lb

Allowed > Actual -- 21.6% Stressed -- Therefore, OK

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Appendix A: General Notes

GENERAL

- The contractor shall verify all dimensions, property setbacks, AHJ/HOA CC&R's, elevations and site conditions before starting work and shall notify Domus Structural Engineering, LLC of any discrepancies.
- All report conclusions represent Domus Structural Engineering, LLC's best professional judgment based upon industry standards.
- Resolve any conflicts on the drawings with Domus Structural Engineering, LLC before proceeding with construction.
- The design criteria used for this project & listed on the first page of the report is based on the engineers best judgement and/or provided by the ATC council. AHJ specific requests may differ. Please contact our team if the design criteria needs to be modified.
- A site visit was not physically conducted by Domus Structural Engineering, LLC. The accompanying calculations and certification are provided with the understanding that the site building and construction standards meet an acceptable level of industry standards. It shall be the contractors responsibility to identify any irregularities such as inconsistent framing conditions, water damage, fire damage, cracked, split or noticeably deflecting framing members.
- Domus Structural Engineering, LLC is not responsible for enforcing safety measures or regulations. The contractor shall design, construct, and maintain all safety devices including shoring and bracing, and shall be solely responsible for conforming to all local, state and federal safety and health standards, laws and regulations. The contractor shall take necessary precautions to maintain and insure the integrity of the structure during construction. If a lawsuit is filed by one of the contractor's or subcontractor's employees, or any one else, the contractor will indemnify, defend and hold the owner and Domus Structural Engineering, LLC harmless of any and all such claims.
- Any and all waterproofing shall be provided by the contractor. Domus Structural Engineering, LLC is not responsible for waterproofing.
- All hardware shall be installed per manufacturer specifications and within specified design limitations. Domus Structural Engineering, LLC assumes no responsibility for incorrectly installed hardware or hardware installed outside of the manfacturer specifications.

USER RELIANCE

- Domus Structural Engineering, LLC was engaged by Blue Raven Solar (Client) to perform this assessment. This report and the information therein, are for the exclusive use of the Client. This report has no other purpose and shall not be relied upon, or used, by any other person or entity without the written consent of Dous Structural Engineering, LLC. Third parties that obtain this report, or the information within shall have no rights of recourse or recovery against Domus Structural Engineering, LLC, it’s officers or employees.

ROOF MOUNTED ARRAYS

- If an analysis of a supporting stucture is included in our scope of work, the structural assessment only applies to the section of the roof that is directly supporting the proposed solar PV system.
- No structural members can be cut for conduit, etc., unless specifically shown. Obtain prior written approval for installation of any additional conduit, etc.
- It is assumed that a standard quality of construction care was used to construct the original building. It shall be the contractors responsibility to field verify any and all framing member supporting the proposed PV array are in adequate condition. The contractor shall field inspect for sub-standard construction means, signs of dry rot, mold, fire damage, etc. and notify engineer if any compromised material is found on site prior to starting construction.
- It is assumed that there have been no additional loads (HVAC or MEP equipment, additional layers of roofing, etc) added to the building over the course of the structures histroy. The contractor and/or client shall verify this with the property owner and notify Domus Structural Engineering, LLC if additional load has been added to the structure already.
- Flexible utility connections must be used at any building seismic joint.
- Care should be taken to ensure that PV arrays do not preclude drainage of rain water.
- Unless otherwise noted, construction material shall be evenly distributed if placed on framed floors or roofs. Loads shall not exceed the allowable loading for the supporting members and their connections.
- All lags or wood screws at the roof shall be stainless steel and installed withing the middle 1/3 of the dimensional width of the framing members.
- All fasteners shall be a minimum of 6" away from any truss panel or hinge joints, truss plates and/or member ends. Field verify location of fasteners prior to starting construction. All fasteners shall be pre-drilled to avoid splitting existing lumber.
- Domus Structural Engineering, LLC is not responsible for downslope effects of snow shedding or sliding off of the PV array nor any damage to downslope decks, roofs, walkways, landscaping, automobiles, pets, people, etc.. If snow guards are requested by the customer, notify Domus Structural Engineering, LLC.