BLUE RAVEN SOLAR, LLC
Firm License No. D-0396
1403 North Research Way
Building J
Orem , UT 84097

April 20, 2020

To: Blue Raven Solar
1403 N. Reasearch Way, Bldg. J
Orem, UT. 84097

Subject: Certification Letter
Myers Residence
89 Farrah-Shea Way
Angier, NC. 27501

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. All attached structural calculations are based on these observations and the design criteria listed below.

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, including the plans and calculations only apply 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.

The roof structure of (MP1) consists of composition shingle on roof plywood that is supported by 2x8 rafters @ 24"o.c., paired with nominal -- ceiling joists @ 24"o.c.. The rafters are suported by veritcal struts which transfer gravity loads to the ceiling joists below. The rafters have a max projected horizontal span of 12'-6", with a slope of 45 degrees. The rafters are connected at the ridge to a ridge board and are supported at the eave by a load bearing wall.

The roof structure of (MP2) consists of composition shingle on roof plywood that is supported by nominal 2x8 rafters @ 24"o.c.. The rafters support a vaulted ceiling and have a max projected horizontal span of 13'-6", with a slope of 14 degrees. The rafters are supported at the ridge by a ridge beam and 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.

BLUE RAVEN SOLAR, LLC
Firm License No. D-0396
1403 North Research Way
Building J
Orem , UT 84097

Design Criteria:

- Applicable Codes = 2018 North Carolina State Building Code (NCSBC), ASCE7-10, and NDS-12
- Roof Dead Load = 12 psf (MP1) -- 12 psf (MP2)
- Roof Live Load = 20 psf
- Wind Speed = 115 mph, Exposure C
- Ground Snow Load = 15 psf - Roof Snow Load = 10.5 psf
- Attachments: (1) 5/16" dia lag screw with 2.5" 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 Calvert
Date: 2020.04.20 16:49:49
-06'00'

BLUE RAVEN SOLAR, LLC
Firm License No. D-0396
1403 North Research Way
Building J
Orem , UT 84097

Gravity Loading

Roof Snow Load Calculations		
p_g = Ground Snow Load =	15 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 =	10.5 psf	
$p_s = C_s p_f$		(ASCE7 - Eq 7-2)
Cs = Slope Factor =	1	
p_s = Sloped Roof Snow Load =	10.5 psf	

PV Dead Load = 3 psf (Per Blue Raven Solar)

PV System Weight	
Weight of PV System (Per Blue Raven Solar)	3.0 psf
X Standoff Spacing =	4.00 ft
Y Standoff Spacing =	5.50 ft
Standoff Tributary Area =	22.00 sft
Point Loads of Standoffs	66 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	
2x8 Rafters @ 24"o.c.	1.52	
Vaulted Ceiling	4.00	(Enclosed Attic)
Miscellaneous	0.48	
Total Roof DL (MP1)	12.0 psf	
DL Adjusted to 45 Degree Slope	17.0 psf	

Roof Dead Load (MP2)	
Composition Shingle	4.00
Roof Plywood	2.00
2x8 Rafters @ 24"o.c.	1.52
Vaulted Ceiling	4.00
Miscellaneous	0.48
Total Roof DL (MP2)	12.0 psf
DL Adjusted to 14 Degree Slope	12.37

BLUE RAVEN SOLAR, LLC
Firm License No. D-0396
1403 North Research Way
Building J
Orem , UT 84097

Wind Calculations

Per ASCE7-10 Components and Cladding

Input Variables	
Wind Speed	115 mph
Exposure Category	C
Roof Shape	Gable/Hip
Roof Slope	45 degrees
Mean Roof Height	20 ft
Effective Wind Area	19.3 ft

Design Wind Pressure Calculations		
Wind Pressure P = qh*G*Cn		
qh = 0.00256 * Kz * Kzt * Kd * V^2		(Eq. 30.3-1)
Kz (Exposure Coefficient) =	0.9	(Table 30.3-1)
Kzt (topographic factor) =	1	(Fig. 26.8-1)
Kd (Wind Directionality Factor) =	0.85	(Table 26.6-1)
V (Design Wind Speed) =	115 mph	(Fig. 26.5-1A)
Risk Category =	II	(Table 1.5-1)
qh =	25.90	
0.6 * qh =	15.54	

Standoff Uplift Calculations-Portrait					
	Zone 1	Zone 2	Zone 3	Positive	
GCp =	-0.92	-1.12	-1.12	0.86	(Fig. 30.4-1)
Uplift Pressure =	-14.36 psf	-17.47 psf	-17.47 psf	22.3 psf	
X Standoff Spacing =	4.00	4.00	2.67		
Y Standoff Spacing =	5.50	2.75	2.75		
Tributary Area =	22.00	11.00	7.33		
Footing Uplift =	-316 lb	-192 lb	-128 lb		

Standoff Uplift Calculations-Landscape					
	Zone 1	Zone 2	Zone 3	Positive	
GCp =	-0.92	-1.12	-1.12	0.86	(Fig. 30.4-1)
Uplift Pressure =	-14.36 psf	-17.47 psf	-17.47 psf	10.0 psf	(Minimum)
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		
Footing Uplift =	-302 lb	-183 lb	-122 lb		

Standoff Uplift Check	
Maximum Design Uplift =	-316 lb
Standoff Uplift Capacity =	450 lb
450 lb capacity > 316 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 > 316 lb demand	Therefore, OK

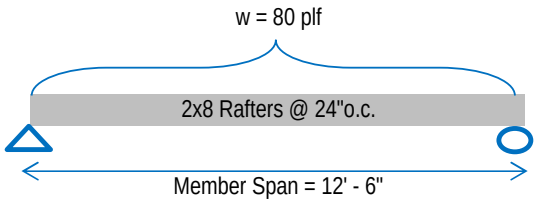
BLUE RAVEN SOLAR, LLC
Firm License No. D-0396
1403 North Research Way
Building J
Orem , UT 84097

Framing Check

(MP1) PASS

Dead Load	17.0	psf
PV Load	3.0	psf
Live Load	20.0	psf

Governing Load Combo = DL + LL
Total Load 40.0 psf



Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x8	13.14	47.63	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 1.2 x 1.15

Allowed Bending Stress = 1552.5 psi

Maximum Moment = (wL^2) / 8
= 1561.35 ft#
= 18736.2 in#

Actual Bending Stress = (Maximum Moment) / S
= 1425.9 psi

Allowed > Actual -- 91.9% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.833 in

Deflection Criteria Based on = Continuous Span

Actual Deflection (Total Load) = (w*L^4) / (185*E*I)
= 0.240 in
= L/625 > L/180 Therefore OK

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

Actual Deflection (Live Load) = (w*L^4) / (185*E*I)
0.120 in
L/1250 > L/240 Therefore OK

Check Shear

Member Area = 10.9 in^2 Fv (psi) = 180 psi (NDS Table 4A)

Allowed Shear = Fv * A = 1958 lb Max Shear (V) = w * L / 2 = 500 lb

Allowed > Actual -- 25.6% Stressed -- Therefore, OK

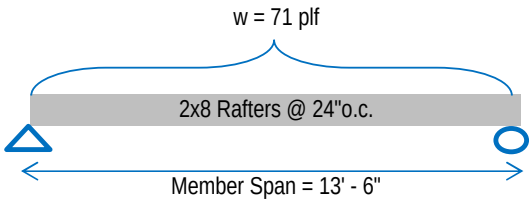
BLUE RAVEN SOLAR, LLC
Firm License No. D-0396
1403 North Research Way
Building J
Orem , UT 84097

Framing Check

(MP2)

PASS

Dead Load	12.4 psf
PV Load	3.0 psf
Live Load	20.0 psf



Governing Load Combo = DL + LL
Total Load 35.4 psf

Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x8	13.14	47.63	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 1.2 x 1.15

Allowed Bending Stress = 1552.5 psi

Maximum Moment = (wL^2) / 8
= 1611.43 ft#
= 19337.1 in#

Actual Bending Stress = (Maximum Moment) / S
= 1471.6 psi

Allowed > Actual - 94.8% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.9 in

Deflection Criteria Based on = Simple Span

Actual Deflection (Total Load) = (5*w*L^4) / (384*E*I)
= 0.694 in
= L/234 > L/180 Therefore OK

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

Actual Deflection (Live Load) = (5*w*L^4) / (384*E*I)
0.393 in
L/413 > L/240 Therefore OK

Check Shear

Member Area = 10.9 in^2 Fv (psi) = 180 psi (NDS Table 4A)

Allowed Shear = Fv * A = 1958 lb Max Shear (V) = w * L / 2 = 477 lb

Allowed > Actual -- 24.4% Stressed -- Therefore, OK