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

April 3, 2020

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

Subject: Certification Letter
Gast Residence
450 Cokesbury Park Lane
Fuquay-Varina, NC. 27526

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&2) consists of composition shingle on roof plywood that is supported by 2x8 rafters @ 16"o.c. with ceiling joists acting as rafter ties. The rafters have a max projected horizontal span of 16'-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&2) 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 64" 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.

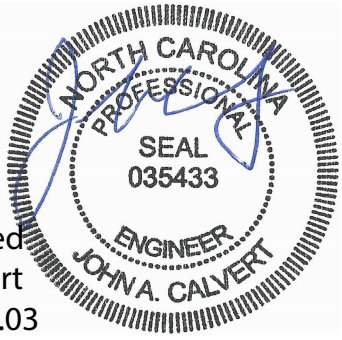
Design Criteria:

- Applicable Codes = 2018 North Carolina State Building Code (NCSBC), ASCE7-10, and NDS-12
- Roof Dead Load = 9 psf (MP1&2)
- 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



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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&2)		
Composition Shingle	4.00	
Roof Plywood	2.00	
2x8 Rafters @ 16"o.c.	2.27	
Vaulted Ceiling	0.00	(Ceiling Not Vaulted)
Miscellaneous	0.73	
Total Roof DL (MP1&2)	**9.0 psf**	
DL Adjusted to 34 Degree Slope	10.9 psf	

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Wind Calculations

Per ASCE7-10 Components and Cladding

Input Variables	
Wind Speed	115 mph
Exposure Category	C
Roof Shape	Gable/Hip
Roof Slope	34 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 =	5.33	5.33	3.56		
Y Standoff Spacing =	3.50	1.75	1.75		
Tributary Area =	18.67	9.33	6.22		
Footing Uplift =	-268 lb	-163 lb	-109 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

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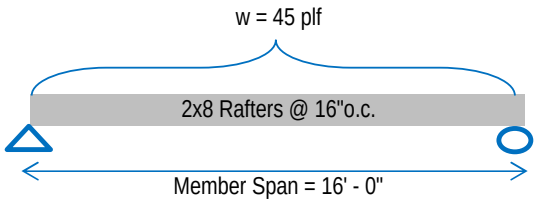
Framing Check

(MP1&2) PASS

Dead Load	10.9 psf
PV Load	3.0 psf
Live Load	20.0 psf
Governing Load Combo = DL + LL	
Total Load	33.9 psf



Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x8	13.14	47.63	DF#2	@ 16"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
= 1444.52 ft#
= 17334.3 in#

Actual Bending Stress = (Maximum Moment) / S
= 1319.2 psi

Allowed > Actual -- 85% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 1.066 in

Deflection Criteria Based on = Simple Span

Actual Deflection (Total Load) = (5*w*L^4) / (384*E*I)
= 0.874 in
= L/220 > L/180 Therefore OK

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

Actual Deflection (Live Load) = (5*w*L^4) / (384*E*I)
0.517 in
L/372 > 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 = 361 lb

Allowed > Actual -- 18.5% Stressed -- Therefore, OK