BLUE RAVEN SOLAR, LLC.
Firm License No. D-0369
1403 North Research Way , Bldg. J
Orem, UT 84097

September 29, 2021

To: Blue Raven Solar
1220 S. 630 E. Ste. 430
American Fork, UT. 84003

Subject: Certification Letter
Crawford Residence
80 Viola Ln
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 pre-manufactured trusses that are spaced at @ 24"o.c.. The top chords, sloped at 35 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'-9''.

The roof structure of (MP2) 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 25 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 8'-0''.

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.

Design Criteria:

- Applicable Codes = 2018 North Carolina State Building Code (NCSBC), ASCE7-10, and NDS-12
- Roof Dead Load = 7 psf (MP1) -- 7 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

NORTH CAROLINA PROFESSIONAL SEAL 035433 ENGINEER JOHN A. CALVERT

Digitally signed by John A. Calvert
Date: 2021.09.30 10:47:25 -06'00'

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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	35 degrees
Mean Roof Height	20 ft
Effective Wind Area	21.3 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 =	-0.94	-1.15	-1.15	0.86	(Fig. 30.4-1)
Uplift Pressure =	-14.55 psf	-17.80 psf	-17.80 psf	22.4 psf	
X Standoff Spacing =	4.00	4.00	2.67		
Y Standoff Spacing =	6.08	3.041666667	3.04166667		
Tributary Area =	24.33	12.17	8.11		
Dead Load on Attachment=	73.00	36.50	24.33		
Footing Uplift (0.6D+0.6W) =	-310 lb	-195 lb	-130 lb		

Standoff Uplift Calculations-Landscape					
	Zone 1	Zone 2	Zone 3	Positive	
GCp =	-0.94	-1.15	-1.15	0.86	(Fig. 30.4-1)
Uplift Pressure =	-14.55 psf	-17.80 psf	-17.80 psf	10.5 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)=	-268 lb	-168 lb	-112 lb		

Standoff Uplift Check	
Maximum Design Uplift =	-310 lb
Standoff Uplift Capacity =	450 lb
450 lb capacity > 310 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 > 310 lb demand	Therefore, OK

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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 =	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 35 Degree Slope	8.5 psf	

Roof Dead Load (MP2)		
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 (MP2)	7.0 psf	
DL Adjusted to 25 Degree Slope	7.72	

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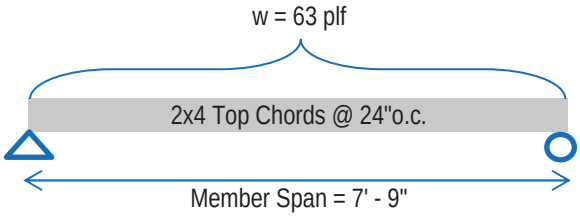
Framing Check

(MP1) PASS

Dead Load	8.5	psf
PV Load	3.0	psf
Live Load	20.0	psf

Governing Load Combo = DL + LL
Total Load 31.5 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
= 473.674 ft#
= 5684.09 in#

Actual Bending Stress = (Maximum Moment) / S
= 1856.1 psi

Allowed > Actual -- 95.7% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.516 in

Deflection Criteria Based on = Continuous Span

Actual Deflection (Total Load) = (w*L^4) / (185*E*I)
= 0.248 in
= L/375 > L/180 Therefore OK

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

Actual Deflection (Live Load) = (w*L^4) / (185*E*I)
0.158 in
L/589 > 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 = 244 lb

Allowed > Actual -- 25.9% Stressed -- Therefore, OK

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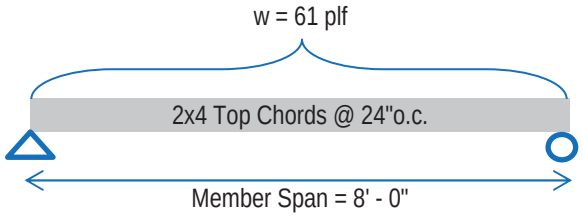
Framing Check

(MP2)

PASS

Dead Load	7.7 psf
PV Load	3.0 psf
Live Load	20.0 psf

Governing Load Combo = DL + LL
Total Load **30.7 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
= 491.578 ft#
= 5898.94 in#

Actual Bending Stress = (Maximum Moment) / S
= 1926.2 psi

Allowed > Actual - 99.3% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.533 in

Deflection Criteria Based on = Continuous Span

Actual Deflection (Total Load) = (w*L^4) / (185*E*I)
= 0.275 in
= L/350 > L/180 Therefore OK

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

Actual Deflection (Live Load) = (w*L^4) / (185*E*I)
0.179 in
L/537 > 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 = 246 lb

Allowed > Actual -- 26.1% Stressed -- Therefore, OK