



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

March 9, 2022

To: Blue Raven Solar

Subject: Certification Letter  
Liverpool-Archer Residence  
117 Emma Ct.  
Linden, NC. 28356

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 15'-0", 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 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.

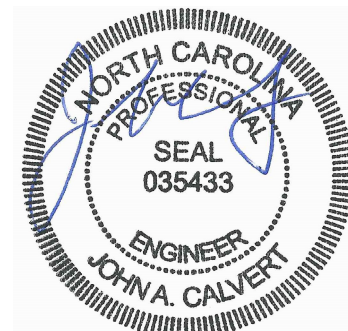
Design Criteria:

- 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





## 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	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	
$G_{Cp} =$	-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	3.041666667		
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	
$G_{Cp} =$	-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 =	5.33	5.33	3.56		
Y Standoff Spacing =	3.50	1.75	1.75		
Tributary Area =	18.67	9.33	6.22		
Dead Load on Attachment =	56.00	28.00	18.67		
Footing Uplift (0.6D+0.6W) =	-238 lb	-149 lb	-100 lb		

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

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 <b>Therefore, OK</b>	



### 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)
$C_s$ = Slope Factor =	1	
<b><math>p_s</math> = Sloped Roof Snow Load =</b>	<b>10.5 psf</b>	
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	
<b>Point Loads of Standoffs</b>	<b>73 lb</b>	
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	
<b>Total Roof DL (MP1&amp;2)</b>	<b>9.0 psf</b>	
DL Adjusted to 45 Degree Slope	12.7 psf	

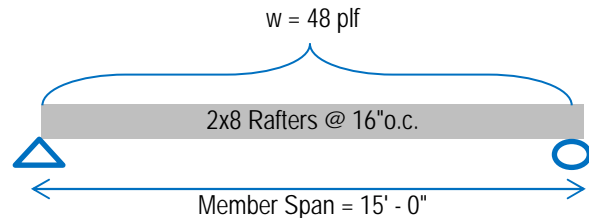


### Framing Check

(MP1&2)

PASS

Dead Load 12.7 psf  
 PV Load 3.0 psf  
 Live Load 20.0 psf



Governing Load Combo = DL + LL  
**Total Load 35.7 psf**

Member Properties				
Member Size	S (in <sup>3</sup> )	I (in <sup>4</sup> )	Lumber Sp/Gr	Member Spacing
2x8	13.14	47.63	DF#2	@ 16"o.c.

Check Bending Stress								
Fb (psi) =	fb	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 =  $(wL^2) / 8$   
 = 1339.797 ft#  
 = 16077.56 in#

Actual Bending Stress = (Maximum Moment) / S  
 = 1223.6 psi

Allowed > Actual -- 78.9% Stressed -- Therefore, OK

#### Check Deflection

Allowed Deflection (Total Load) =  $L/180$  (E = 1600000 psi Per NDS)  
 = 1 in

Deflection Criteria Based on = Simple Span  
 Actual Deflection (Total Load) =  $(5 * w * L^4) / (384 * E * I)$   
 = 0.712 in  
 = L/253 > L/180 **Therefore OK**

Allowed Deflection (Live Load) =  $L/240$   
 0.75 in  
 Actual Deflection (Live Load) =  $(5 * w * L^4) / (384 * E * I)$   
 0.400 in  
 L/450 > L/240 **Therefore OK**

#### Check Shear

Member Area = 10.9 in<sup>2</sup> Fv (psi) = 180 psi (NDS Table 4A)  
 Allowed Shear = Fv \* A = 1958 lb Max Shear (V) = w \* L / 2 = 357 lb

Allowed > Actual -- 18.3% Stressed -- Therefore, OK