



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

April 7, 2020

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

Subject: Certification Letter
Champion Residence
11454 Highway 210 North
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 2x6 rafters @ 16" o.c., paired with nominal 2x8 ceiling joists @ 16" o.c.. The rafters are supported by vertical struts which transfer gravity loads to the ceiling joists below. The rafters have a max projected horizontal span of 14'-6", with a slope of 35 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 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.

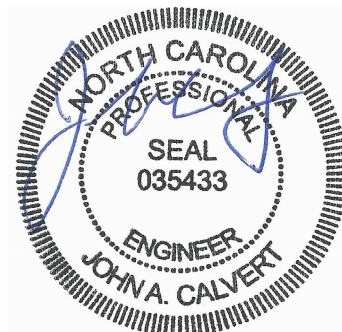
Design Criteria:

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





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 | |
| 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 | |
| 2x6 Rafters @ 16"o.c. | 1.72 | |
| Vaulted Ceiling | 4.00 | (Enclosed Attic) |
| Miscellaneous | 0.28 | |
| Total Roof DL (MP1) | 12.0 psf | |
| DL Adjusted to 35 Degree Slope | 14.6 psf | |

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 | 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 | |
| G_{Cp} = | -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 | |
| G_{Cp} = | -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 | |

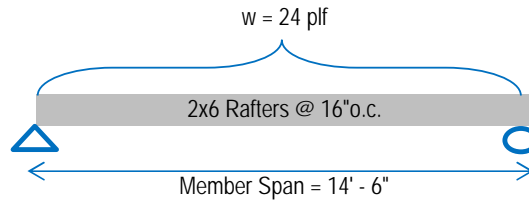


Framing Check

(MP1)

PASS

Dead Load 14.6 psf
 PV Load 3.0 psf
 Live Load 20.0 psf



Governing Load Combo = DL + SL
 Total Load 17.6 psf

| Member Properties | | | | |
|-------------------|----------------------|----------------------|--------------|----------------|
| Member Size | S (in ³) | I (in ⁴) | Lumber Sp/Gr | Member Spacing |
| 2x6 | 7.56 | 20.80 | DF#2 | @ 16"o.c. |

| Check Bending Stress | | | | | | | | |
|-------------------------------------|----------------|---|----------------|---|----------------|---|----------------|-------------------|
| Fb (psi) = | f _b | x | C _d | x | C _f | x | C _r | (NDS Table 4.3.1) |
| | 900 | x | 1.15 | x | 1.3 | x | 1.15 | |
| Allowed Bending Stress = 1547.3 psi | | | | | | | | |

Maximum Moment = $(wL^2) / 8$
 $= 618.461 \text{ ft}\#$
 $= 7421.53 \text{ in}\#$
 Actual Bending Stress = (Maximum Moment) / S
 $= 981.4 \text{ psi}$

Allowed > Actual -- 63.5% Stressed -- Therefore, OK

| Check Deflection | |
|-----------------------------------|-----------------------------------|
| Allowed Deflection (Total Load) = | $L/180$ (E = 1600000 psi Per NDS) |
| | = 0.966 in |
| Deflection Criteria Based on = | Continuous Span |
| Actual Deflection (Total Load) = | $(wL^4) / (185E*I)$ |
| | = 0.293 in |
| | = L/594 > L/180 Therefore OK |

| | |
|----------------------------------|------------------------------|
| Allowed Deflection (Live Load) = | $L/240$ |
| | 0.725 in |
| Actual Deflection (Live Load) = | $(wL^4) / (185E*I)$ |
| | 0.000 in |
| | #DIV/0! > L/240 Therefore OK |

| Check Shear | | |
|--|--------------------------------|----------------|
| Member Area = 8.3 in ² | F _v (psi) = 180 psi | (NDS Table 4A) |
| Allowed Shear = F _v * A = 1485 lb | Max Shear (V) = w * L / 2 = | 171 lb |

Allowed > Actual -- 11.5% Stressed -- Therefore, OK