January 29, 2019

Power Home Solar and Roofing
919 North Main Street
Mooresville, NC 28115

**Design Criteria:**
Wind Load (3-sec gust)- 115 mph
Ground Snow Load- 10 psf
Risk Category- II
Exposure category- C

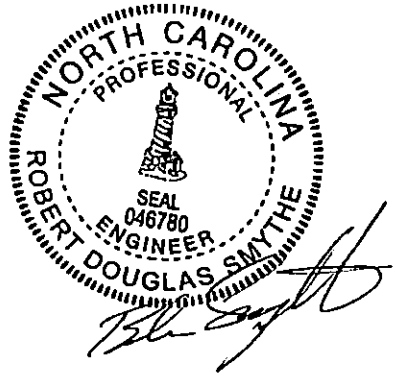
RE: Structural Roof Evaluation for the ***Rodriguez Residence: 271 Falls Creek Drive, Spring Lake, North Carolina***

As per your request, we have evaluated the roof structure under the proposed solar panel array. The information used to evaluate this structure was gathered during a field visit by Power Home Solar and Roofing on behalf of Right Angle Engineering. The roof structure consists of pre-manufactured trusses spaced at 24" on center. The roof material consists of asphalt shingles. The design criteria used to analyze this structure are listed above and included with this letter. The adopted building codes in this jurisdiction are: *the 2018 North Carolina Building Code, the 2018 North Carolina Existing Building Code,* and *ASCE 7-10.*

North Carolina Existing Building Code (NCEBC) 2018 section 807.4 indicates that alterations to an existing building that results in less than a 10% increase in the total stress may be performed without a structural evaluation of the existing building. As demonstrated in the attached calculations, the additional weight of the solar panels will be less than 10% increase in the gravity loading and the stress on the existing roof framing.

Based on our assessment we have determined that the existing roof framing will safely and adequately support the additional loads imposed by the solar panels. In order for the loads to be evenly distributed, the roof attachments should be staggered and spread evenly throughout the panel array. Attachment points should be spaced at a maximum of 48" on center. The racking system should be installed per the manufacture's specifications. There should be a minimum of 33 attachment points to the roof. Each attachment should have a 5/16" or 18/8 SS lag screw with 2.5" minimum penetration centered on each truss top chord. Waterproofing around the roof penetrations is the responsibility of others. Right Angle Engineering assumes no responsibility for improper installation of the solar panels.

Regards,




1/29/19

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## Design Criteria:

| | | |
|---|---|---|
| Design Wind Speed (3 second gust) | 115 | mph |
| Exposure Category | C | |
| Risk Category | 2 | |
| Mean Roof Height | 30 | ft |
| Roof Type | Gable Roof | |
| Building Type | enclosed | |

## Roof Dead Load- ASCE Table C3-1

| | | |
|---|---|---|
| asphalt shingles | 2 | psf |
| 7/16" Plywood Sheathing | 1.5 | psf |
| Roof Framing | 4 | psf |
| Insulation | 3.85 | psf |
| Gypsum sheathing | 2 | psf |
| Solar Panel Array | 3 | psf |
| | | |
| Dead Load Without Panels | 13.35 | psf |
| Dead Load With Solar panels | 16.35 | psf |

## Roof Live Load

| | | | |
|---|---|---|---|
| Existing Roof Live Load | 20 | psf | ASCE 7-10 Table 4-1 |
| Roof Live Load with Solar Panels | 0 | psf | 2018 NCBC 1607.12.5 |

## Roof Snow Load-ASCE 7-10

| | | | |
|---|---|---|---|
| Ground Snow Load (pg) | 10 | psf | Section 7.2 |
| Exposure Factor (Ce) | 0.9 | | Table 7-2 |
| Thermal Factor (Ct) | 1.1 | | Table 7-3 |
| Importance Factor (Is) | 1 | | Table 1.5-2 |
| Flat Roof Snow Load (Pf) | 7 | | Equation 7.3-1 |
| Slippery surface Slope Factor (Cs) | 0.86 | | Figure 7-2 |
| Nonslippery Surface Slope Factor (Cs) | 1 | | Figure 7-2 |
| | | | |
| Snow Load Without Solar Panels | 7 | psf | Equation 7.4-1 |
| Snow Load With Solar Panels | 6 | psf | Equation 7.4-2 |

## Load Combinations - ASCE 7-10 Section 2.4-1

| | Without Solar Panels | With Solar panels |
|---|---|---|
| D + Lr | 33.4 psf | 16.4 psf |
| D + S | 20.3 psf | 22.3 psf |

## Solar Array 1- Array 1

| | | | |
|---|---|---|---|
| Roof Slope | 18.5 | degrees | |
| Number of panels | 12 | | |
| Panel Area | 210 | ft^2 | |

## Wind Calculations- ASCE 7-10

| | | | |
|---|---|---|---|
| $GC_p$ Zone 1 | -1 | | Figure 30.4-(2A-5B) |
| $GC_p$ Zone 2 | -1.2 | | Figure 30.4-(2A-5B) |
| $GC_p$ Zone 3 | -1.2 | | Figure 30.4-(2A-5B) |
| Gcpi | 0.18 | | Table 26.11-1 |
| Velocity Pressure ($q_h$) | 28.2 | psf | |
| $q_h = .00256K_hK_{ht}K_dV^2$ | | | Equation 30.3-1 |
| $K_h$ | 0.98 | | Table 30.3-1 |
| $K_{ht}$ | 1 | | Equation26.8-1 |
| $K_d$ | 0.85 | | Table 26.6-1 |
| Designed wind pressure (P) | | psf | Equation 30.9-1 |
| $P = q_h(GC_h) - (GC_{hi})$ | | | |
| Zone 1 Pressure (P) | -33.3 | psf | |
| Zone 2 Pressure (P) | -38.9 | psf | |
| Zone 3 Pressure (P) | -38.9 | psf | |

## Roof Connection

| | | | |
|---|---|---|---|
| Shear Capacity | 190 | lbs | NDS 2015 Table 12K |
| Shear tributary area | 33 | ft^2 | |
| Pullout Capacity | 266 | lbs/in | |
| Lag screw embedment | 2.5 | in | |
| Total pullout capacity | 665 | lbs | NDS 2015 Table 12.2A |
| Pullout max tributary area | 17.1 | ft^2 | |
| Factor of Safety | 2.7 | | |
| Minimum number of connections | **24** | | |

## Beam Stress IEBC 2015 Section 807.4

| | | |
|---|---|---|
| Beam Span | 20 | ft |
| Spacing | 2 | ft |
| Roof Framing type | pre-manufactured trusses | |
| Panel Orientation | landscape | |
| Number of Panels per rafter | 4 | |
| Panel distance from eave | 1 | |

| | Without Solar Panels | With Solar Panels | Percent Increase | |
|---|---|---|---|---|
| Bending Moment | 3335 ft-lbs | 1870.7 ft-lbs | 56.1% | Less than 105% |
| Vertical Reaction (V1) | 667 lbs | 494.5 lbs | 74.1% | Less than 105% |
| Vertical Reaction (V2) | 667 lbs | 443.6 lbs | 66.5% | Less than 105% |

## Solar Array 2- Array 2

| | | | |
|---|---|---|---|
| Roof Slope | 18.5 | degrees | |
| Number of panels | 4 | | |
| Panel Area | 70 | ft^2 | |

## Wind Calculations- ASCE 7-10

| | | | |
|---|---|---|---|
| $GC_p$ Zone 1 | -0.9 | | Figure 30.4-(2A-5B) |
| $GC_p$ Zone 2 | -1.7 | | Figure 30.4-(2A-5B) |
| $GC_p$ Zone 3 | -2.6 | | Figure 30.4-(2A-5B) |
| Gcpi | 0.18 | | Table 26.11-1 |
| Velocity Pressure ($q_h$) | 28.2 | psf | |
| $q_h = .00256K_hK_{ht}K_dV^2$ | | | Equation 30.3-1 |
| $K_h$ | 0.98 | | Table 30.3-1 |
| $K_{ht}$ | 1 | | Equation26.8-1 |
| $K_d$ | 0.85 | | Table 26.6-1 |
| Designed wind pressure (P) | | psf | Equation 30.9-1 |
| $P = q_h(GC_h) - (GC_{hi})$ | | | |
| Zone 1 Pressure (P) | -30.5 | psf | |
| Zone 2 Pressure (P) | -53 | psf | |
| Zone 3 Pressure (P) | -78.4 | psf | |

## Lag Screw Connection

| | | | |
|---|---|---|---|
| Shear Capacity | 190 | lbs | NDS 2015 Table 12K |
| Shear tributary area | 66.9 | ft^2 | |
| Pullout Capacity | 266 | lbs/in | |
| Lag screw embedment | 2.5 | in | |
| Total pullout capacity | 665 | lbs | NDS 2015 Table 12.2A |
| Pullout max tributary area | 12.5 | ft^2 | |
| Factor of Safety | 1.7 | | |
| Minimum number of connections | **8** | | |

## Beam Stress IEBC 2015 Section 807.4

| | | |
|---|---|---|
| Beam Span | 15 | ft |
| Spacing | 1.33 | ft |
| Roof Framing type | 2x6 rafters | |
| Panel Orientation | landscape | |
| Number of Panels per rafter | 2 | |
| Panel distance from eave | 1 | |

| | Without Solar Panels | With Solar Panels | Percent Increase | |
|---|---|---|---|---|
| Bending Moment | 1247.5 ft-lbs | 648.6 ft-lbs | 52% | Less than 105% |
| Vertical Reaction (V1) | 332.7 lbs | 271.5 lbs | 81.6% | Less than 105% |
| Vertical Reaction (V2) | 332.7 lbs | 221.1 lbs | 66.5% | Less than 105% |