

May 16, 2022

Pink Energy
919 North Main Street
Mooresville, North Carolina, 28115

Design Criteria:

Wind Speed (V_{ult}) - 115.0 mph
Ground Snow Load - 15.0 psf
Risk Category - 2
Exposure Category - C

RE: Structural Roof Evaluation for the Lydell Jackson Residence: 17 Southbrook Ln, Sanford, North Carolina

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 Pink Energy on behalf of Right Angle Engineering. 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 Residential code and ASCE 7-16.

Array Name	Connection Type	Panel Quantity	Min # Connections	Reinforcements
Array 1	L-Foot	2	3	None
Array 2	L-Foot	2	3	None
Array 3	L-Foot	3	5	None
Array 4	L-Foot	2	3	None
Array 5	L-Foot	3	5	None
Array 6	L-Foot	6	9	None

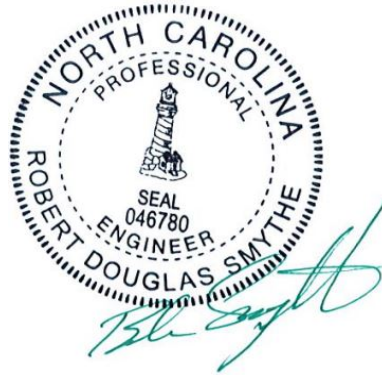
Solar Panel Anchorage

The solar panel anchorage shall be installed according to the manufactures most current installation manual. 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 inches on center. Roof anchors that are attached to the substructure should have a 5/16" or 18/8 SS lag screw with 2.5" minimum penetration centered on each truss top chord or rafter.

Conclusion

North Carolina Existing Building code 2018 section indicates that alterations to an existing building that results in less than a 5.0% 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 5.0% increase in the gravity loading and therefore the stress on the existing roof framing. Based on our assessment, we have determined that the existing roof framing is in good condition and will safely and adequately support the additional loads imposed by the solar panels without reinforcement. The equipment will not create a negative impact on the building's structural design, including any additional loads imposed (dead, snow, wind/seismic). A roof evaluation was performed with the required loading in accordance with section 324.4 of the Residential Code

Regards,



05/16/2022

Robert D. Smythe, P.E.
Right Angle Engineering

Scope of work and limitations

The evaluation is based on information provided by the client. All information is verified by the engineer from pictures, video, and third party software. Verification of the field observations is the responsibility of the contractor. The contractor shall verify the framing sizes, spacing, spans, and roof pitch noted in this letter and/or sealed plans. The contractor shall notify the engineer if there are any discrepancies, or if there is any damage to the structure (i.e., fire damage, water damage, dry rot, deflections, broken member, broken connection, etc). The scope of work is strictly limited to the fastener attachments and underlying roof framing directly under each solar array. Right Angle Engineering assumes no responsibility for improper installation of solar panels or their components. Waterproofing around the roof penetrations is the responsibility of others. Alterations to this engineering evaluation and/or sealed plans shall not be made without direct written consent of the engineer of record.

Job Details

Roof Snow Load - ASCE 7-16		Design Criteria	
Ground Snow Load (p_g) <i>Section 7.2</i>	15.0 psf	Design Wind Speed	115.0mph
Exposure Factor (C_e) <i>Table 7.3-1</i>	0.9	Exposure Category	C
Thermal Factor (C_t) <i>Table 7.3-2</i>	1.1	Risk Category	2
Importance Factor (I_s) <i>Table 1.5-2</i>	1	Mean Roof Height	30 ft
Flat Roof Snow Load (p_f) <i>Equation 7.3-1</i>	10.4 psf	Roof Type	Gable Roof
Slippery Surface Slope Factor (C_s) <i>Figure 7.4-1</i>	0.5	Building Type	Enclosed
Non-Slippery Surface Slope Factor (C_s) <i>Figure 7.4-1</i>	0.93	Roof Live Load	
Roof Snow Load <i>Equation 7.4-1</i>	9.66 psf	Existing Roof Live Load <i>ASCE 7-16 Table 4.3-1</i>	20 psf
Reduced Snow Load (Slippery Surface) <i>Equation 7.4-1</i>	5.23 psf	Roof Live Load with Solar Panels	0.0 psf

¹ Roof Dead Load			
Asphalt Shingles	2.0 psf	No Drywall	0.0 psf
5/8" Plywood Sheathing	2.0 psf	Solar Panel Array	2.39 psf
Roof Framing	3.15 psf	Dead Load Without Panels	8.35 psf
Insulation	1.2 psf	Dead Load With Panels	10.74 psf

Load Combinations - ASCE 7-16 Section 2.4.1	
D + LR / S (Without Solar Panels)	28.35 psf
D + LR / S (With Solar Panels)	15.97 psf
Load Percent Increase	0.56 %

¹Roof Dead Load is taken from the worst case scenario dead load from all arrays of the job in order to provide a more conservative evaluation.

Array 1

Array Details		Beam Stresses			
Roof Pitch	39.81°	Beam Span	120"	Panel Orientation	Portrait
Panel Quantity	2	Spacing	16.0"	# of Panels on Rafter	1
Panel Area	35.16 ft ²	Roof Framing Type	2x8 Rafter DF#2	Panel Distance From Eave	48.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 <i>Figure 30.3-(2A-5B)</i>	-1.8
GC_{pi} <i>Table 26.13-1</i>	-0.18
K_h <i>Table 26.10-1</i>	0.98
K_{ht} <i>Equation 26.8-1</i>	1
K_d <i>Table 26.6-1</i>	0.85
Velocity Pressure <i>Equation 26.10-1</i>	28.2 psf
Zone 2 Pressure <i>Equation 30.7-1</i>	-45.69 psf

Panel Area	
Shear Capacity <i>NDS 2015 Table 12k</i>	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	3
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Array 2

Array Details		Beam Stresses			
Roof Pitch	39.81°	Beam Span	132"	Panel Orientation	Landscape
Panel Quantity	2	Spacing	16.0"	# of Panels on Rafter	1
Panel Area	35.16 ft ²	Roof Framing Type	2x8 Rafter DF#2	Panel Distance From Eave	36.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 <i>Figure 30.3-(2A-5B)</i>	-1.8
GC_{pi} <i>Table 26.13-1</i>	-0.18
K_h <i>Table 26.10-1</i>	0.98
K_{ht} <i>Equation 26.8-1</i>	1
K_d <i>Table 26.6-1</i>	0.85
Velocity Pressure <i>Equation 26.10-1</i>	28.2 psf
Zone 2 Pressure <i>Equation 30.7-1</i>	-45.69 psf

Panel Area	
Shear Capacity <i>NDS 2015 Table 12k</i>	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	3
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Array 3

Array Details		Beam Stresses			
Roof Pitch	39.81°	Beam Span	120"	Panel Orientation	Landscape
Panel Quantity	3	Spacing	16.0"	# of Panels on Rafter	2
Panel Area	52.75 ft ²	Roof Framing Type	2x8 Rafter DF#2	Panel Distance From Eave	12.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 <i>Figure 30.3-(2A-5B)</i>	-1.8
GC_{pi} <i>Table 26.13-1</i>	-0.18
K_h <i>Table 26.10-1</i>	0.98
K_{ht} <i>Equation 26.8-1</i>	1
K_d <i>Table 26.6-1</i>	0.85
Velocity Pressure <i>Equation 26.10-1</i>	28.2 psf
Zone 2 Pressure <i>Equation 30.7-1</i>	-45.69 psf

Panel Area	
Shear Capacity <i>NDS 2015 Table 12k</i>	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	5
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Array 4

Array Details		Beam Stresses			
Roof Pitch	39.81°	Beam Span	96"	Panel Orientation	Landscape
Panel Quantity	2	Spacing	16.0"	# of Panels on Rafter	2
Panel Area	35.16 ft ²	Roof Framing Type	2x8 Rafter DF#2	Panel Distance From Eave	12.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 <i>Figure 30.3-(2A-5B)</i>	-1.8
GC_{pi} <i>Table 26.13-1</i>	-0.18
K_h <i>Table 26.10-1</i>	0.98
K_{ht} <i>Equation 26.8-1</i>	1
K_d <i>Table 26.6-1</i>	0.85
Velocity Pressure <i>Equation 26.10-1</i>	28.2 psf
Zone 2 Pressure <i>Equation 30.7-1</i>	-45.69 psf

Panel Area	
Shear Capacity <i>NDS 2015 Table 12k</i>	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	3
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Array 5

Array Details		Beam Stresses			
Roof Pitch	39.81°	Beam Span	120"	Panel Orientation	Landscape
Panel Quantity	3	Spacing	16.0"	# of Panels on Rafter	2
Panel Area	52.75 ft ²	Roof Framing Type	2x8 Rafter DF#2	Panel Distance From Eave	12.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 <i>Figure 30.3-(2A-5B)</i>	-1.8
GC_{pi} <i>Table 26.13-1</i>	-0.18
K_h <i>Table 26.10-1</i>	0.98
K_{ht} <i>Equation 26.8-1</i>	1
K_d <i>Table 26.6-1</i>	0.85
Velocity Pressure <i>Equation 26.10-1</i>	28.2 psf
Zone 2 Pressure <i>Equation 30.7-1</i>	-45.69 psf

Panel Area	
Shear Capacity <i>NDS 2015 Table 12k</i>	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	5
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Array 6

Array Details		Beam Stresses			
Roof Pitch	39.81°	Beam Span	144", 144"	Panel Orientation	Portrait
Panel Quantity	6	Spacing	16.0"	# of Panels on Rafter	3
Panel Area	105.5 ft ²	Roof Framing Type	2x8 Rafter DF#2	Panel Distance From Eave	60.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 <i>Figure 30.3-(2A-5B)</i>	-1.8
GC_{pi} <i>Table 26.13-1</i>	-0.18
K_h <i>Table 26.10-1</i>	0.98
K_{ht} <i>Equation 26.8-1</i>	1
K_d <i>Table 26.6-1</i>	0.85
Velocity Pressure <i>Equation 26.10-1</i>	28.2 psf
Zone 2 Pressure <i>Equation 30.7-1</i>	-45.69 psf

Panel Area	
Shear Capacity <i>NDS 2015 Table 12k</i>	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	9
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs