

March 13, 2020

Power Home Solar and Roofing 919 North Main Street Mooresville, NC 28115 **Design Criteria:**

Ultimate Wind Speed- 115 mph Ground Snow Load- 15 psf Risk Category- II Exposure category- C

RE: Structural Roof Evaluation for the Williams Residence: 36 Briarwood Place, Sanford, 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 7-16.

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 41 L-foot 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,

Robert D Smythe, P.E. Right Angle Engineering 3/13/20



Design Criteria:Design Wind Speed (3 second gust)115mphExposure CategoryCRisk Category2Mean Roof Height30ftRoof TypeGable RoofBuilding Typeenclosed
Exposure Category C Risk Category 2 Mean Roof Height 30 ft Roof Type Gable Roof
Risk Category 2 Mean Roof Height 30 ft Roof Type Gable Roof
Mean Roof Height 30 ft Roof Type Gable Roof
Roof Type Gable Roof
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Building Type enclosed
Roof Dead Load- ASCE Table C3-1
Asphalt Shingles 2 psf
3/8" Plywood Sheathing 1.2 psf
Roof Framing 4 psf
Insulation 3.85 psf
Gypsum sheathing 2 psf
Solar Panel Array 3 psf
Dead Load Without Panels 13.05 psf
Dead Load With Solar panels 16.05 psf
Roof Live Load
Existing Roof Live Load 20 psf ASCE 7-16 Table 4.3-:
Roof Live Load with Solar Panels 0 psf 2018 NCBC 1607.12.5
Noor live load with solar raneis o psi 2010 Nebe 1007.12.5
Roof Snow Load-ASCE 7-16
Ground Snow Load (pg) 15 psf Section 7.2
Exposure Factor (Ce) 0.9 Table 7.3-1
Thermal Factor (Ct) 1.1 Table 7.3-2
Importance Factor (Is) 1 Table 1.5-2
Flat Roof Snow Load (Pf) 10 Equation 7.3-1
Slippery surface Slope Factor (Cs) 0.67 Figure 7-2
Nonslippery Surface Slope Factor
(Cs) 1 Figure 7-2
Roof Snow Load 10 psf Equation 7.4-1
Reduced Roof Snow Load (Slippery
Surface) 7 psf Equation 7.4-1
Load Combinations - ASCE 7-16 Section 2.4.1
With Solar Without Solar Panels panels
D + Lr 33 psf 16 psf

		With Solar
	Without Solar Panels	panels
D+Lr	33 psf	16 psf
D + S	23.4 psf	23 psf



Solar Array 1- Plane 1				
Roof Slope	30	degrees		
Number of panels	8			
Panel Area	140	ft^2		
			_	
Wind Calculations- ASCE 7-16				
GCp Zone 1	-1		Figure 30.3	3-(2A-5B)
GCp Zone 2	-1.2		Figure 30.3	3-(2A-5B)
GCp Zone 3	-1.2		Figure 30.3	3-(2A-5B)
Gcpi	0.18		Table 26.13	3-1
Velocity Pressure (qh)	28.2	psf		
qh= .00256KhKhtKdV^2			Equation 2	6.10-1
Kh	0.98		Table 26.10	0-1
Kht	1		Equation 2	6.8-1
Kd	0.85		Table 26.6-	·1
Designed wind pressure (P)		psf	Equation 3	0.8-1
P = qh(GCh) - (GChi)				
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	38.3	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	2.4			
Minimum number of connections	16			
				1
Beam Stress NCEBC 2018 Section 80				
Beam Span	14	ft		
Spacing	2	ft		
Roof Framing type Panel Orientation	pre-manufact portrait	urea trusses		
Number of Panels per rafter	2			
Panel distance from eave	2			
	Without Sola	r With Solar	Percent	
	Panels	Panels	Increase	
Bending Momer			46.8%	Less than 105%
Vertical Reaction (V		323.2 lbs	69.9%	Less than 105%
Vertical Reaction (V2	2) 462.7 lbs	278.4 lbs	60.2%	Less than 105%



				_	
Solar Array 2- Pla	ne 2				
Roof Slope		30	degrees		
Number of panels		4			
Panel Area		70	ft^2		
Wind Calculations-	ASCE 7-16				
GC _p Zone 1	<u></u>	-1		Figure 30.3	3-(2A-5B)
GC _p Zone 2		-1.2		Figure 30.3	
GC _p Zone 3		-1.2		Figure 30.3	•
Gcpi		0.18		Table 26.13	•
Velocity Pressure (qh)		28.2	psf		_
gh= .00256			P 5.	Equation 2	6.10-1
4.1 188238. Kh		0.98		Table 26.10	
Kht		1		Equation 2	
Kd	(0.85		Table 26.6-	
Designed wind pressure (I			psf	Equation 3	
=	h) - (GChi))		P 5.	_quation s	0.0 1
Zone 1 Pressure (P)		33.3	psf		
Zone 2 Pressure (P)		38.9	psf		
Zone 3 Pressure (P)		38.9	psf		
				_	
Lag Screw Connection	<u>_</u> _		_	_	
Shear Capacity		190	lbs	NDS 2015 7	Table 12K
Shear tributary area	;	38.3	ft^2		
Pullout Capacity		266	lbs/in		
Lag screw embedment		2.5	in		
Total pullout capacity		665	lbs	NDS 2015 7	Table 12.2A
Pullout max tributary area	3	17.1	ft^2		
Factor of Safety		2.4			
Minimum number of conr	nections	8			
Beam Stress NCEBC	2018 Section 806	2			l
Beam Span	2016 Section 600.	14	ft		
Spacing		2	ft		
Roof Framing type		pre-manufactu			
Panel Orientation		, portrait			
Number of Panels per raft	ter	2			
Panel distance from eave		2			
		Without Solar	With Solar	Percent	
	Donding Manager	Panels	Panels	Increase	Locathan 1050
	Bending Moment Vertical Reaction (V1)	1619.4 ft-lbs 462.7 lbs	757.7 ft-lbs 323.2 lbs	46.8% 69.9%	Less than 105% Less than 105%
	Vertical Reaction (V2)	462.7 lbs	278.4 lbs	60.2%	Less than 105%
	vertical reaction (VZ)	102.7 103	270.7103	00.270	2000 (11011 1007)



Solar Array 3- Plane 3				
Roof Slope	30	degrees		
Number of panels	8			
Panel Area	140	ft^2		
Wind Calculations- ASCE 7-16				
GCp Zone 1	-1		Figure 30.3	-(2A-5B)
GC _P Zone 2	-1.2		Figure 30.3	
GC _p Zone 3	-1.2		Figure 30.3	
Gcpi	0.18		Table 26.13	· ·
Velocity Pressure (qh)	28.2	psf		_
qh= .00256KhKhtKdV^2	20.2	P 3.	Equation 2	6.10-1
Kh	0.98		Table 26.10	
Kht	1		Equation 2	
Kd	0.85		Table 26.6-	
Designed wind pressure (P)	0.03	psf	Equation 3	
P= qh(GCh) - (GChi))		P 3.	_qua.io.i o	0.0 1
Zone 1 Pressure (P)	-33.3	psf		
Zone 2 Pressure (P)	-38.9	psf		
Zone 3 Pressure (P)	-38.9	psf		
20116 3 1 1 233416 (1)	30.3	P 3.		
Lag Screw Connection		_		
Shear Capacity	190	lbs	NDS 2015	Гable 12К
Shear tributary area	38.3	ft^2		
Pullout Capacity	266	lbs/in		
Lag screw embedment	2.5	in		
Total pullout capacity	665	lbs	NDS 2015	Γable 12.2A
Pullout max tributary area	17.1	ft^2		
Factor of Safety	2.4			
Minimum number of connections	16			
Doom Street NCEDC 2019 Section 900	·			I
Beam Stress NCEBC 2018 Section 806	_	£.		
Beam Span	14 2	ft ft		
Spacing Roof Framing type	pre-manufact			
Panel Orientation	portrait	area trasses		
Number of Panels per rafter	2			
Panel distance from eave	2			
	Without Solar		Percent	
	Panels	Panels	Increase	
Bending Moment			46.8%	Less than 105%
Vertical Reaction (V1)		323.2 lbs	69.9%	Less than 105%
Vertical Reaction (V2)	462.7 lbs	278.4 lbs	60.2%	Less than 105%