BLUE RAVEN SOLAR, LLC.
Firm License No. D-0449
1403 North Research Way , Bldg. J
Orem, UT 84097

March 26, 2024

To: Blue Raven Solar
1403 North Research Way, Building J
Orem, UT. 84097

Subject: Certification Letter
Dowling Residence
1037 Atkins Rd
Fuquay Varina, NC. 27526

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 review is based on these observations and the design criteria listed below and only deemed valid if provided information is true and accurate.

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 only applies 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. If field conditions differ, contractor to notify engineer prior to starting construction.

The roof structure of (MP1) consists of composition shingle on roof plywood that is supported by 2x12 rafters @ 12"o.c. with ceiling joists acting as rafter ties. The rafters have a max projected horizontal span of 19'-0", with a slope of 17 degrees. The rafters are connected at the ridge to a ridge board and are supported at the eave by a load bearing wall.

The roof structure of (MP2) consists of composition shingle on roof plywood that is supported by nominal 2x12 rafters @ 12"o.c. with ceiling joists acting as rafter ties. The rafters have a max projected horizontal span of 19'-10", with a slope of 40 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 existing roof framing system of (MP2) 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 48" o.c. for landscape and 36" 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.

Note: Seismic check is not required since Ss<.4g and Seismic Design Category (SDC) < B

Design Criteria:

- Applicable Codes = 2018 North Carolina State Building Code (NCSBC), ASCE 7-10
- Roof Dead Load = 11 psf (MP1) -- 11 psf (MP2)
- Roof Live Load = 20 psf
- Wind Speed = 116 mph (Vult), Exposure C, Risk Category II
- Ground Snow Load = 15 psf - Roof Snow Load = 10.5 psf
- Attachment: 1 - 5/16 dia. lag screw with 2.5 inch min. embedment depth, at spacing shown above.

Please contact me with any further questions or concerns regarding this project.

Sincerely,

Digitally signed by John A. Calvert
Date: 2024.03.26 14:03:06 -06'00'

John Calvert, P.E.
Project Engineer

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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)
Cs = Slope Factor =	1	
p_s = Sloped Roof Snow Load =	10.5 psf	

PV Dead Load = 3 psf (Per Blue Raven Solar)	
DL Adjusted to 17 Degree Slope	3.14 psf

PV System Weight	
Weight of PV System (Per Blue Raven Solar)	3.0 psf
X Standoff Spacing =	3.00 ft
Y Standoff Spacing =	6.08 ft
Standoff Tributary Area =	18.25 sft
Point Loads of Standoffs	55 lb

Note: PV standoffs are staggered to ensure proper distribution of loading

Roof Live Load = 20 psf

Note: Roof live load is removed in areas covered by PV array.

Roof Dead Load (MP1)		
Composition Shingle	4.00	
Roof Plywood	2.00	
2x12 Rafters @ 12"o.c.	4.69	
Vaulted Ceiling	0.00	(Ceiling Not Vaulted)
Miscellaneous	0.31	
Total Roof DL (MP1)	11.0 psf	
DL Adjusted to 17 Degree Slope	11.5 psf	

Roof Dead Load (MP2)		
Composition Shingle	4.00	
Roof Plywood	2.00	
2x12 Rafters @ 12"o.c.	4.69	
Vaulted Ceiling	0.00	(Ceiling Not Vaulted)
Miscellaneous	0.31	
Total Roof DL (MP2)	11.0 psf	
DL Adjusted to 40 Degree Slope	14.36	

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Wind Calculations

Per ASCE 7-10 Components and Cladding

Input Variables	
Wind Speed	116 mph
Exposure Category	C
Roof Shape	Hip/Gable
Roof Slope	17 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) =	116 mph	(Fig. 26.5-1A)
Risk Category =	II	(Table 1.5-1)
qh =	26.35	
0.6 * qh =	15.81	

Standoff Uplift Calculations-Portrait					
	Zone 1	Zone 2	Zone 3	Positive	
GCp =	-0.85	-1.52	-2.42	0.43	(Fig. 30.4-1)
Uplift Pressure =	-13.43 psf	-24.08 psf	-38.24 psf	11.3 psf	
X Standoff Spacing =	3.00	3.00	2.00		
Y Standoff Spacing =	6.08	3.041666667	3.041666667		
Tributary Area =	18.25	9.13	6.08		
Dead Load on Attachment=	54.75	27.38	18.25		
Footing Uplift (0.6D+0.6W)=	-212 lb	-203 lb	-222 lb		

Standoff Uplift Calculations-Landscape					
	Zone 1	Zone 2	Zone 3	Positive	
GCp =	-0.85	-1.52	-2.42	0.43	(Fig. 30.4-1)
Uplift Pressure =	-13.43 psf	-24.08 psf	-38.24 psf	10.0 psf	(Minimum)
X Standoff Spacing =	4.00	4.00	2.67		
Y Standoff Spacing =	3.50	1.75	1.75		
Tributary Area =	14.00	7.00	4.67		
Dead Load on Attachment=	42.00	21.00	14.00		
Footing Uplift (0.6D+0.6W) =	-163 lb	-156 lb	-170 lb		

Standoff Uplift Check	
Maximum Design Uplift =	-222 lb
Standoff Uplift Capacity =	450 lb
450 lb capacity > 222 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 > 222 lb demand	Therefore, OK

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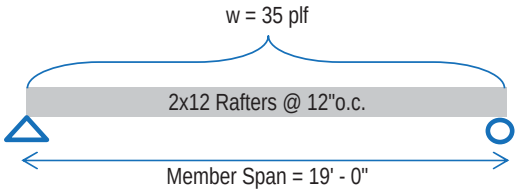
Framing Check

(MP1) PASS

Dead Load	11.5	psf
PV Load	3.1	psf
Live Load	20.0	psf



Governing Load Combo = DL + LL
Total Load 34.6 psf

Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x12	31.64	177.98	DF#2	@ 12"o.c.

Check Bending Stress

Fb (psi) =	f'b	x	Cd	x	Cf	x	Cr	(NDS Table 4.3.1)
	900	x	1.25	x	1	x	1.15	

Allowed Bending Stress = 1293.7 psi

Maximum Moment = (wL^2) / 8
= 1563.116 ft#
= 18757.39 in#

Actual Bending Stress = (Maximum Moment) / S
= 592.9 psi

Allowed > Actual -- 45.9% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 1.266 in

Deflection Criteria Based on = Simple Span
Actual Deflection (Total Load) = (5*w*L^4) / (384*E*I)
= 0.357 in
= L/639 > L/180 Therefore OK

Allowed Deflection (Live Load) = L/240
0.95 in

Actual Deflection (Live Load) = (5*w*L^4) / (384*E*I)
0.206 in
L/1107 > L/240 Therefore OK

Check Shear

Member Area = 16.9 in^2 Fv (psi) = 180 psi (NDS Table 4A)
Allowed Shear = Fv * A = 3038 lb Max Shear (V) = w * L / 2 = 329 lb

Allowed > Actual -- 10.9% Stressed -- Therefore, OK

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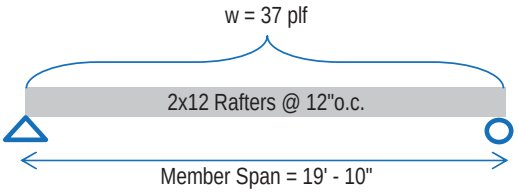
Framing Check

(MP2)

PASS

Dead Load	14.4	psf
PV Load	3.1	psf
Live Load	20.0	psf



Governing Load Combo = DL + LL
Total Load 37.5 psf

Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x12	31.64	177.98	DF#2	@ 12"o.c.

Check Bending Stress

Fb (psi) =	f'b	x	Cd	x	Cf	x	Cr	(NDS Table 4.3.1)
	900	x	1.25	x	1	x	1.15	

Allowed Bending Stress = 1293.7 psi

Maximum Moment = (wL^2) / 8
= 1843.711 ft#
= 22124.53 in#

Actual Bending Stress = (Maximum Moment) / S
= 699.3 psi

Allowed > Actual - 54.1% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 1.322 in

Deflection Criteria Based on = Simple Span

Actual Deflection (Total Load) = (5*w*L^4) / (384*E*I)
= 0.459 in
= L/519 > L/180 Therefore OK

Allowed Deflection (Live Load) = L/240
0.991 in

Actual Deflection (Live Load) = (5*w*L^4) / (384*E*I)
0.245 in
L/972 > L/240 Therefore OK

Check Shear

Member Area = 16.9 in^2 Fv (psi) = 180 psi (NDS Table 4A)

Allowed Shear = Fv * A = 3038 lb Max Shear (V) = w * L / 2 = 372 lb

Allowed > Actual -- 12.3% Stressed -- Therefore, OK