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

April 18, 2024

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

Subject: Certification Letter
Mack Residence
6037 McDougald Rd
Lillington, NC. 27546

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 2x10 rafters @ 16"o.c., paired with nominal 2x10 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 11'-0", with a slope of 43 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 2x10 rafters @ 16"o.c. with ceiling joists acting as rafter ties. The rafters have a max projected horizontal span of 14'-6", with a slope of 23 degrees. The rafters are connected at the ridge to a load bearing wall 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 64" 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.

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

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Design Criteria:

- Applicable Codes = 2018 North Carolina State Building Code (NCSBC), ASCE 7-10
- Roof Dead Load = 13 psf (MP1) -- 9 psf (MP2)
- Roof Live Load = 20 psf
- Wind Speed = 115 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,

John Calvert, P.E.
Project Engineer

Digitally signed by
John A. Calvert
Date: 2024.04.18
13:13:35 -06'00'

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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 43 Degree Slope	4.10 psf
PV System Weight	
Weight of PV System (Per Blue Raven Solar)	3.0 psf
X Standoff Spacing =	4.00 ft
Y Standoff Spacing =	6.08 ft
Standoff Tributary Area =	24.33 sft
Point Loads of Standoffs	73 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	
2x10 Rafters @ 16"o.c.	2.90	
Vaulted Ceiling	4.00	(Enclosed Attic)
Miscellaneous	0.10	
Total Roof DL (MP1)	13.0 psf	
DL Adjusted to 43 Degree Slope	17.8 psf	

Roof Dead Load (MP2)		
Composition Shingle	4.00	
Roof Plywood	2.00	
2x10 Rafters @ 16"o.c.	2.90	
Vaulted Ceiling	0.00	(Ceiling Not Vaulted)
Miscellaneous	0.10	
Total Roof DL (MP2)	9.0 psf	
DL Adjusted to 23 Degree Slope	9.78	

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Wind Calculations

Per ASCE 7-10 Components and Cladding

Input Variables	
Wind Speed	115 mph
Exposure Category	C
Roof Shape	Hip/Gable
Roof Slope	43 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) =	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	
GCp =	-0.94	-1.15	-1.15	0.86	(Fig. 30.4-1)
Uplift Pressure =	-14.55 psf	-17.80 psf	-17.80 psf	22.4 psf	
X Standoff Spacing =	4.00	4.00	2.67		
Y Standoff Spacing =	6.08	3.041666667	3.04166667		
Tributary Area =	24.33	12.17	8.11		
Dead Load on Attachment=	73.00	36.50	24.33		
Footing Uplift (0.6D+0.6W)=	-310 lb	-195 lb	-130 lb		

Standoff Uplift Calculations-Landscape	Zone 1	Zone 2	Zone 3	Positive	
GCp =	-0.94	-1.15	-1.15	0.86	(Fig. 30.4-1)
Uplift Pressure =	-14.55 psf	-17.80 psf	-17.80 psf	10.5 psf	
X Standoff Spacing =	5.33	5.33	3.56		
Y Standoff Spacing =	3.50	1.75	1.75		
Tributary Area =	18.67	9.33	6.22		
Dead Load on Attachment=	56.00	28.00	18.67		
Footing Uplift (0.6D+0.6W) =	-238 lb	-149 lb	-100 lb		

Standoff Uplift Check	
Maximum Design Uplift =	-310 lb
Standoff Uplift Capacity =	450 lb
450 lb capacity > 310 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 > 310 lb demand	Therefore, OK

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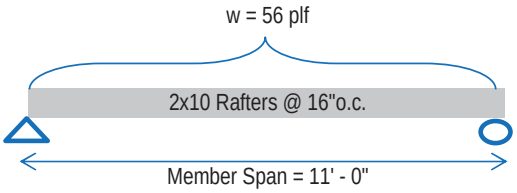
Framing Check

(MP1) PASS

Dead Load	17.8	psf
PV Load	4.1	psf
Live Load	20.0	psf



Governing Load Combo = DL + LL
Total Load 41.9 psf

Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x10	21.39	98.93	DF#2	@ 16"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	1.1	x	1.15	

Allowed Bending Stress = 1423.1 psi

Maximum Moment = (wL^2) / 8
= 844.5243 ft#
= 10134.29 in#

Actual Bending Stress = (Maximum Moment) / S
= 473.8 psi

Allowed > Actual -- 33.3% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.733 in

Deflection Criteria Based on = Continuous Span
Actual Deflection (Total Load) = (w*L^4) / (185*E*I)
= 0.049 in
= L/2694 > L/180 Therefore OK

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

Actual Deflection (Live Load) = (w*L^4) / (185*E*I)
0.024 in
L/5500 > L/240 Therefore OK

Check Shear

Member Area = 13.9 in^2 Fv (psi) = 180 psi (NDS Table 4A)

Allowed Shear = Fv * A = 2498 lb Max Shear (V) = w * L / 2 = 307 lb

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

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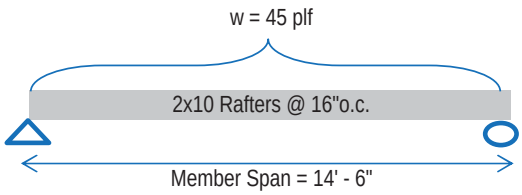
Framing Check
(MP2)

PASS

Dead Load	9.8	psf
PV Load	4.1	psf
Live Load	20.0	psf



Governing Load Combo = DL + LL
Total Load 33.9 psf

Member Properties

Member Size	S (in^3)	I (in^4)	Lumber Sp/Gr	Member Spacing
2x10	21.39	98.93	DF#2	@ 16"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	1.1	x	1.15	

Allowed Bending Stress = 1423.1 psi

Maximum Moment = (wL^2) / 8
= 1187.185 ft#
= 14246.21 in#

Actual Bending Stress = (Maximum Moment) / S
= 666.1 psi

Allowed > Actual - 46.9% Stressed -- Therefore, OK

Check Deflection

Allowed Deflection (Total Load) = L/180 (E = 1600000 psi Per NDS)
= 0.966 in

Deflection Criteria Based on = Simple Span

Actual Deflection (Total Load) = (5*w*L^4) / (384*E*I)
= 0.284 in
= L/613 > L/180 Therefore OK

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

Actual Deflection (Live Load) = (5*w*L^4) / (384*E*I)
0.168 in
L/1036 > L/240 Therefore OK

Check Shear

Member Area = 13.9 in^2 Fv (psi) = 180 psi (NDS Table 4A)

Allowed Shear = Fv * A = 2498 lb Max Shear (V) = w * L / 2 = 327 lb

Allowed > Actual -- 13.2% Stressed -- Therefore, OK