08-09-2022

Powur PBC

2683 Via De La Valle #321G

Subject: Structural Certification for Installation of Residential Solar
re job: Efrain Carmona Mote

580 Valley Oak Dr, Bunnlevel, NC 28323, USA

Attn.: To Whom It May Concern

Observation of the condition of the existing framing system was performed by an audit team of Powur PBC

After review of the field observation data, structural capacity calculations were performed in accordance with applicable building codes to determine adequacy of the existing roof framing supporting the proposed panel layout. Please see full Structural Calculations report for details regarding calculations performed and limits of scope of work and liability. The design criteria and structural adequacy are summarized below:

Design Criteria:

Code: 2018 NCSBC, IBC 2015, ASCE 7-10, Ult Wind Speed: 119 mph, Ground Snow: 10 psf, Min Snow Roof: 0 psf

ROOF 1: Shingle roofing supported by 2x4 Rafter @ 24 in. OC spacing. The roof is sloped at approximately 39 degrees and has a max beam span of 10.0 ft between supports. Roof is adequate to support the imposed loads. Therefore, no structural upgrades are required.

ROOF 2: Shingle roofing supported by 2x4 Rafter @ 24 in. OC spacing. The roof is sloped at approximately 18 degrees and has a max beam span of 10.0 ft between supports. Roof is adequate to support the imposed loads. Therefore, no structural upgrades are required.

ROOF 3: Shingle roofing supported by 2x4 Rafter @ 24 in. OC spacing. The roof is sloped at approximately 5 degrees and has a max beam span of 8.7 ft between supports. Roof is adequate to support the imposed loads. Therefore, no structural upgrades are required.

ROOF 4: Shingle roofing supported by 2x4 Rafter @ 24 in. OC spacing. The roof is sloped at approximately 33 degrees and has a max beam span of 10.0 ft between supports. Roof is adequate to support the imposed loads. Therefore, no structural upgrades are required.

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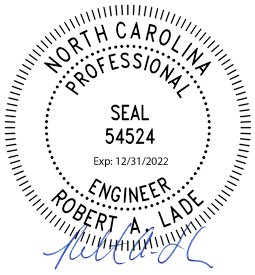

Current Renewables Engineering Inc.
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The following calculations are for the structural engineering design of the photovoltaic panels and are valid only for the structural info referenced in the stamped plan set. The verification of such info is the responsibility of others.

I certify that the roof structure has sufficient structural capacity for the applied PV loads.

All mounting equipment shall be designed and installed per manufacturer's approved installation specifications.

Design Criteria:

Code: 2018 NCSBC, IBC 2015, ASCE 7-10,
Live Load: 0 psf
Ult Wind Speed: 119 mph
Exposure Cat: C
Ground Snow: 10 psf
Min Snow Roof: 0 psf

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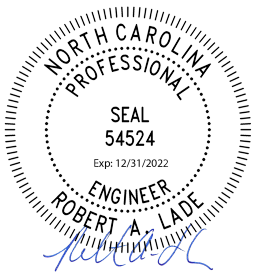

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Roof Properties:

	Roof 1	Roof 2	Roof 3	Roof 4
Roof Type =	Shingle	Shingle	Shingle	Shingle
Roof Pitch (deg) =	39.0	18.0	5.0	33.0
Mean Root Height (ft) =	23.0	23.0	23.0	23.0
Attachment Trib Width (ft) =	3.25	3.25	3.3	3.25
Attachment Spacing (ft) =	4.0	4.0	4.0	4.0
Framing Type =	Rafter	Rafter	Rafter	Rafter
Framing Size =	2x4	2x4	2x4	2x4
Framing OC Spacing (in.) =	24.0	24.0	24.0	24.0
Section Thickness, b (in) =	1.5	1.5	1.5	1.5
Section Depth, d (in) =	3.5	3.5	3.5	3.5
Section Modulus, Sx (in^3) =	3.062	3.062	3.062	3.062
Moment of Inertia, Ix (in) =	5.359	5.359	5.359	5.359
Unsupported Span (ft) =	10.0	10.0	8.7	10.0
Upper Chord Length (ft) =	13.1	15.1	10.7	12.2
Deflection Limit D+L (in) =	2.62	3.02	2.14	2.44
Deflection Limit S or W (in) =	1.747	2.013	1.427	1.627
Attachments Pattern =	Fully Staggered	Fully Staggered	Fully Staggered	Fully Staggered
Framing Upgrade =	No	No	No	No
Sister Size =	NA	NA	NA	NA
Wood Species =	DF	DF	DF	DF
Wood Fb (psi) =	900.0	900.0	900.0	900.0
Wood Fv (psi) =	180.0	180.0	180.0	180.0
Wood E (psi) =	1600000.0	1600000.0	1600000.0	1600000.0
C_D (wind) =	1.6	1.6	1.6	1.6
C_d (snow) =	1.15	1.15	1.15	1.15
C_{LS} =	1.0	1.0	1.0	1.0
$C_M = C_t = C_L = C_i$ =	1.0	1.0	1.0	1.0
C_F =	1.5	1.5	1.5	1.5
C_{fu} =	1.0	1.0	1.0	1.0
C_r =	1.15	1.15	1.15	1.15
F'b wind (psi) =	2484.0	2484.0	2484.0	2484.0
F'b snow (psi) =	1785.37	1785.37	1785.37	1785.37
F'v wind (psi) =	288.0	288.0	288.0	288.0
F'v snow (psi) =	207.0	207.0	207.0	207.0
M allowable wind (lb-ft) =	633.94	633.94	633.94	633.94
M allowable snow (lb-ft) =	455.64	455.64	455.64	455.64
V allowable wind (lbs) =	1008.0	1008.0	1008.0	1008.0
V allowable snow (lbs) =	724.5	724.5	724.5	724.5
E' (psi) =	1600000.0	1600000.0	1600000.0	1600000.0

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Load Calculation:

Dead Load Calculations:

	Roof 1	Roof 2	Roof 3	Roof 4
Panels Dead Load (psf) =	3.0	3.0	3.0	3.0
Roofing Weight (psf) =	3.0	3.0	3.0	3.0
Decking Weight (psf) =	2.0	2.0	2.0	2.0
Framing Weight (psf) =	0.602	0.602	0.602	0.602
Misc. Additional Weight (psf) =	1.0	1.0	1.0	1.0
Existing Dead Load (psf) =	6.602	6.602	6.602	6.602
Total Dead Load (psf) =	9.602	9.602	9.602	9.602

Wind Load Calculations:

Ultimate Wind Speed (mph) =	119.0	119.0	119.0	119.0
Directionality Facto r, kd =	0.85	0.85	0.85	0.85
Topographic Factor, kzt =	1.0	1.0	1.0	1.0
Velocity Press Exp Factor, kz =	0.929	0.929	0.929	0.929
Velocity Pressure, qz (psf) =	28.621	28.621	28.621	28.621
External Pressure Up, GCp_1 =	-0.94	-0.87	-0.97	-0.94
External Pressure Up, GCp_2 =	-1.14	-1.549	-1.589	-1.14
External Pressure Up, GCp_3 =	-1.14	-2.419	-2.288	-1.14
External Pressure Down, GCp =	0.87	0.44	0.27	0.87
Design Pressure Up, p_1 (psf) =	-26.898	-24.897	-27.759	-26.898
Design Pressure Up, p_2 (psf) =	-32.622	-44.348	-45.487	-32.622
Design Pressure Up, p_3 (psf) =	-32.622	-69.245	-65.492	-32.622
Design Pressure Down, p (psf) =	24.897	16.0	16.0	24.897

Snow Load Calculations:

Ground Snow Load, pg (psf) =	10.0	10.0	10.0	10.0
Min Flat Snow, pf_min (psf) =	0.0	0.0	0.0	0.0
Sloped Snow, ps_min (psf) =	0.0	0.0	0.0	0.0
Snow Importance Factor, Ic =	1.0	1.0	1.0	1.0
Exposure Factor, Ce =	0.9	0.9	0.9	0.9
Thermal Factor, Ct =	1.1	1.1	1.1	1.1
Flat Roof Snow, pf (psf) =	6.93	6.93	6.93	6.93
Slope Factor, Cs =	1.0	1.0	1.0	1.0
Sloped Roof Snow, ps (psf) =	6.93	6.93	6.93	6.93

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Lag Screw Checks:

	Roof 1	Roof 2	Roof 3	Roof 4
Ref. Withdrawal Value, W (lb/in) =	266.0	266.0	266.0	266.0
(C_m = C_t = C_{eg} = 1.0) CD =	1.6	1.6	1.6	1.6
Adjusted Withdrawal Value, W' (lb/in) =	425.6	425.6	425.6	425.6
Lag Penetration, p (in.) =	2.5	2.5	2.5	2.5
Allowable Withdrawal Force, W'p (lbs) =	1064.0	1064.0	1064.0	1064.0
Applied Uplift Force (lbs) =	-201.889	-276.924	-287.913	-200.449
Uplift DCR =	0.19	0.26	0.271	0.188
Ref. Lateral Value, Z (lbs) =	266.0	266.0	266.0	266.0
(C_m = C_t = C_Δ = C_{eg} = 1.0) CD =	1.15	1.15	1.15	1.15
Adjusted Lateral Value, Z' (lbs) =	310.5	310.5	310.5	310.5
Applied Lateral Force (lbs) =	81.239	39.891	11.424	70.307
Angle of Resultant Force, α (deg) =	1.188	1.428	1.531	1.233
Adjusted Interaction Lateral Value, Z'α (lbs) =	795.11	1013.978	1059.957	840.547
Lateral DCR =	0.102	0.039	0.011	0.084

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Roof Framing Checks:

Force Checks:

LC1: D+S

	Roof 1	Roof 2	Roof 3	Roof 4
Applied Moment (lb-ft) =	326.0	311.0	264.0	345.0
Applied Shear (lbs) =	197.0	195.0	174.0	199.0
Allowable Moment (lb-ft) =	456.0	456.0	456.0	456.0
Allowable Shear (lbs) =	724.0	724.0	724.0	724.0
Moment DCR =	0.715	0.682	0.579	0.757
Shear DCR =	0.271	0.269	0.24	0.274

LC2: D+0.6W

Applied Moment (lb-ft) =	484.0	361.0	307.0	512.0
Applied Shear (lbs) =	292.0	227.0	202.0	295.0
Allowable Moment (lb-ft) =	634.0	634.0	634.0	634.0
Allowable Shear (lbs) =	1008.0	1008.0	1008.0	1008.0
Moment DCR =	0.763	0.569	0.484	0.808
Shear DCR =	0.29	0.225	0.2	0.293

LC3: D+0.75(S+0.6W)

Applied Moment (lb-ft) =	513.0	413.0	351.0	543.0
Applied Shear (lbs) =	309.0	260.0	231.0	313.0
Allowable Moment (lb-ft) =	634.0	634.0	634.0	634.0
Allowable Shear (lbs) =	1008.0	1008.0	1008.0	1008.0
Moment DCR =	0.809	0.652	0.554	0.856
Shear DCR =	0.307	0.258	0.229	0.31

LC4: 0.6D+0.6W

Applied Moment (lb-ft) =	408.0	289.0	245.0	432.0
Applied Shear (lbs) =	246.0	181.0	161.0	249.0
Allowable Moment (lb-ft) =	634.0	634.0	634.0	634.0
Allowable Shear (lbs) =	1008.0	1008.0	1008.0	1008.0
Moment DCR =	0.644	0.455	0.387	0.681
Shear DCR =	0.244	0.18	0.16	0.247

Deflection Checks (Service Level):

LC1: D+L

Deflection (in.) =	1.129	1.172	0.636	1.083
Deflection Limit (in.) =	2.62	3.02	2.14	2.44
Deflection DCR =	0.431	0.388	0.297	0.444

LC2: S

Deflection (in.) =	0.196	0.204	0.111	0.188
Deflection Limit (in.) =	1.747	2.013	1.427	1.627
Deflection DCR =	0.112	0.101	0.077	0.116

LC3: W (Down)

Deflection (in.) =	0.296	0.197	0.107	0.284
Deflection Limit (in.) =	1.747	2.013	1.427	1.627
Deflection DCR =	0.169	0.098	0.075	0.174

LC4: W (Up)

Deflection (in.) =	0.32	0.307	0.186	0.307
Deflection Limit (in.) =	1.747	2.013	1.427	1.627
Deflection DCR =	0.183	0.153	0.13	0.188

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Seismic Check:

Existing Weight:

Wall Weight (psf) =	17.0
Tributary Wall Area (ft^2) =	3180.0
Total Wall Weight (lbs) =	54060.0
Roof Weight (psf) =	6.602
Roof Area (ft^2) =	2640.0
Total Roof Weight (lbs) =	17428.125
Total Existing Weight (lbs) =	71488.125

Total Additional PV Weight (lbs) = 2123.55

Weight Increase:

(Existing W + Additional W)/(Existing W) = 1.03

The increase in weight as a result of the solar system is less than 10% of the existing structure and therefore no further seismic analysis is required.

Limits of Scope of Work and Liability:

Existing structure is assumed to have been designed and constructed following appropriate codes at time of erection, and assumed to have appropriate permits. The calculations produced are only for the roof framing supporting the proposed PV installation referenced in the stamped planset and were completed according to generally recognized structural analysis standards and procedures, professional engineering and design experience, opinions and judgements. Existing deficiencies which are unknown or were not observable during time of inspection are not included in this scope of work. All PV modules, racking, and mounting equipment shall be designed and installed per manufacturer's approved installation specifications. The Engineer of Record and the engineering consulting firm assume no responsibility for misuse or improper installation. This analysis is not stamped for water leakage. Framing was determined based on information in provided plans and/or photos, along with engineering judgement. Prior to commencement of work, the contractor shall verify the framing sizes, spacings, and spans noted in the stamped plans, calculations, and cert letter (where applicable) and notify the Engineer of Record of any discrepancies prior to starting construction. Contractor shall also verify that there is no damaged framing that was not addressed in stamped plans, calculations, and cert letter (where applicable) and notify the Engineer of Record of any concerns prior to starting construction.