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Freedom Forever LLC
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Temecula, CA 92590

Attn.: To Whom It May Concern

re job: JESSICA & CHRISTOPHER BENOIT
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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.
After review, 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 NC Building Code ASCE 7-10		
Live Load:	20	psf	
Ult Wind Speed:	125	mph	
Exposure Cat:	B		
Ground Snow:	10	psf	Min Roof Snow: NA

Current Renewables Engineering Inc.
Professional Engineer
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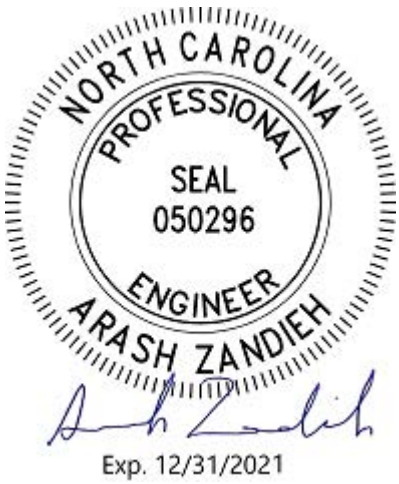

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Roof Properties:

	Roof 1
Roof Type =	Shingle
Roof Pitch (deg) =	14
Mean Roof Height (ft) =	13
Attachment Trib Width (ft) =	3.3
Attachment Spacing (ft) =	4
Framing Type =	Rafter
Framing Size =	2x4
Framing OC Spacing (in.) =	24
Section Thickness, b (in.) =	1.5
Section Depth, d (in.) =	3.5
Section Modulus, Sx (in.^3) =	3.1
Moment of Inertia, Ix (in.^4) =	5.4
Framing Span (ft) =	10
Deflection Limit D+L (in.) =	2
Deflection Limit S or W (in.) =	1.33
Attachments Pattern =	Fully Staggered
Framing Upgrade =	Adequate
Sister Size =	NA
Wood Species =	DF #2
Wood Fb (psi) =	900
Wood Fv (psi) =	180
Wood E (psi) =	1600000
C_D (Wind) =	1.6
C_D (Snow) =	1.15
C_{LS} =	1.15
$C_M = C_t = C_L = C_i$ =	1.0
C_F =	1.5
C_{fu} =	1.00
C_r =	1.15
F'b_wind (psi) =	2857
F'b_snow (psi) =	2053
F'v_wind (psi) =	288
F'v_snow (psi) =	207
M_allowable_wind (lb-ft) =	729
M_allowable_snow (lb-ft) =	524
V_allowable_wind (lbs) =	1008
V_allowable_snow (lbs) =	725
E' (psi) =	1600000

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Load Calculation:

Dead Load Calculations:

Panels Dead Load (psf) =	3.0
	Roof 1
Roofing Weight (psf) =	3.0
Decking Weight (psf) =	2.0
Framing Weight (psf) =	0.6
Misc. Additional Weight (psf) =	1.0
Existing Dead Load (psf) =	6.6
Total Dead Load (psf) =	9.6

Snow Load Calculations:

Ground Snow Load, pg (psf) =	10
Min Flat Snow, pf_min (psf) =	NA
Min Sloped Snow, ps_min (psf) =	NA
Snow Importance Factor, Ic =	1.0
Exposure Factor, Ce =	0.9
	Roof 1
Thermal Factor, Ct =	1.2
Flat Roof Snow, pf (psf) =	7.56
Slope Factore, Cs =	1.00
Sloped Roof Snow, ps (psf) =	8

Wind Load Calculations:

Ultimate Wind Speed (mph) =	125
Directionality Factor, kd =	0.85
Topographic Factor, kzt =	1.0
	Roof 1
Velocity Press Exp Factor, kz =	0.70
Velocity Pressure, qz (psf) =	23.8
External Pressure Up, GCp_1 =	-0.85
External Pressure Up, GCp_2 =	-1.55
External Pressure Up, GCp_3 =	-2.45
External Pressure Down, GCp =	0.45
Design Pressure Up, p_1 (psf) =	-20.2
Design Pressure Up, p_2 (psf) =	-36.9
Design Pressure Up, p_3 (psf) =	-58.4
Design Pressure Down, p (psf) =	16.0

Hardware Checks:

Lag Screw Checks:

	Roof 1
Ref. Widthrawal Value, W (lb/in) =	266
($C_M = C_t = C_{eg} = 1.0$) C_D =	1.6
Adjusted Widthrawal Value, W' (lb/in) =	426
Lag Penetration, p (in.) =	2.5
Allowable Widthrawal Force, W'p (lbs) =	1064
Applied Uplift Force (lbs) =	-269
Uplift DCR =	**0.25**
Ref. Lateral Value, Z (lbs) =	270
($C_M = C_t = C_\Delta = C_{eg} = 1.0$) C_D =	1.15
Adjusted Lateral Value, Z' (lbs) =	311
Applied Laeral Force (lbs) =	34
Angle of Resultant Force, α (deg) =	83
djusted Interaction Lateral Value, Z'_α (lbs) =	1026
Lateral DCR =	**0.03**

Roof Framing Checks:

Force Checks:

	Roof 1
LC1: D+S	
Applied Moment (lb-ft) =	429
Applied Shear (lbs) =	172
Allowable Moment (lb-ft) =	524
Allowable Shear (lbs) =	725
Moment DCR =	**0.82**
Shear DCR =	**0.24**
LC2: D+0.6W	
Applied Moment (lb-ft) =	480
Applied Shear (lbs) =	192
Allowable Moment (lb-ft) =	729
Allowable Shear (lbs) =	1008
Moment DCR =	**0.66**
Shear DCR =	**0.19**
LC3: D+0.75(S+0.6W)	
Applied Moment (lb-ft) =	562
Applied Shear (lbs) =	225
Allowable Moment (lb-ft) =	729

Allowable Shear (lbs) =	1008
Moment DCR =	**0.77**
Shear DCR =	**0.22**

LC4: 0.6D+0.6W

Applied Moment (lb-ft) =	160
Applied Shear (lbs) =	64
Allowable Moment (lb-ft) =	729
Allowable Shear (lbs) =	1008
Moment DCR =	**0.22**
Shear DCR =	**0.06**

Deflection Checks (Service Level):

	Roof 1
LC1: D+L	
Deflection (in.) =	0.76
Deflection Limit (in.) =	2.3
Deflection DCR =	**0.33**
LC2: S	
Deflection (in.) =	0.40
Deflection Limit (in.) =	1.53
Deflection DCR =	**0.26**
LC3: W (Down)	
Deflection (in.) =	0.35
Deflection Limit (in.) =	1.53
Deflection DCR =	**0.23**
LC4: W (Up)	
Deflection (in.) =	-0.45
Deflection Limit (in.) =	1.53
Deflection DCR =	**0.29**

Seismic Check:

Existing Weight:

Wall Weight (psf) =	17
Tributary Wall Area (ft^2) =	1000
Total Wall Weight (lbs) =	17000
Roof Weight (psf) =	7
Roof Area (ft^2) =	2400
Total Roof Weight (lbs) =	15844
Total Existing Weight (lbs) =	**32844**

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Additional PV Weight:

PV Panel Weight (lbs) =	54
Number of Panels =	29
Total Additional PV Weight (lbs) =	**1579**

Weight Increase:

(Existing W + Additional W)/(Existing W) = 105%

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.