



September 16, 2021

BES Project Number: 3119 Timothy Lemons

Power Home Solar, LLC
919 N Main St.
Mooresville, NC 28115

**Project Location: Timothy Lemons: 38 Lone Pine Trail, Sanford, NC 27332
Solar Array Installation**

To Whom It May Concern:

Per your request, BES has reviewed the existing structure at the above referenced location. The purpose of this review was to determine the adequacy of the existing structure to support the proposed installation of solar panels on the roof as shown on the attached panel layout plan.

Based upon our review, we certify that existing roof structure will adequately support with the following: Racking and attachment mounting connection: (1) 5/16" lag screw w/ min. 2.5" embedment into framing at max 48" o/c along rails (2) rails per row of panels, evenly spaced; panel length perpendicular to the rails not to exceed 67 in. Solar module mounting hardware design is by the manufacturer.

Limitations: Installation of the solar panels must be performed in accordance with manufacturer recommendations. All work performed must be in accordance with accepted industry-wide methods and applicable safety standards. The contractor must notify BES should any damage, deterioration or discrepancies between the as-built condition of the structure and the condition described in this letter be found. Connections to existing roof framing must be staggered, except at array ends, so as to not overload any existing structural member. The design of the solar panel racking (mounts, rails, etc.) is the responsibility of the manufacturer. Waterproofing around the roof penetrations is the responsibility of others. BES assumes no responsibility for improper installation of the solar array. Existing structure meets or exceeds standard building practices with current building code with assumed single layer asphalt shingles.

Sincerely,



Jermey Bowers M.E., P.E.
Principal Engineer

BOWERS ENGINEERING SERVICES
WWW.BOWERSENG.COM
121 S. MAIN ST
AUBURN, INDIANA 46706

PHONE (260) 333-0900
FAX (260) 333-0901

Bowers Engineering Services
121 S. Main ST
Auburn, IN
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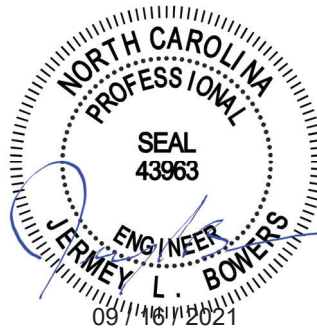
Structural Analysis

Location

38 Lone Pine Trail
Sanford, NC 27332

Roof Mount Solar

9/16/2021



Project: 3119 Timothy Lemons Rev: -

BES 121 South Main ST Auburn, IN		Date: 9/16/2021	Connections
Cust. Name:	Bowers Engineering Services	Subject:	Roof Mount
Job Number:	3119 Timothy Lemons	Originator:	0
<u>STRUCTURAL SUMMARY</u>			
<u>CODE SPEC</u>			
WIND			
IBC 2015		Speed:	116 MPH
ASCE 7-10		Exp.:	C
Risk Cat:	II		

Wind Load - uplift

		Max lb
Zone 1	-26.71 psf	-179.49 lb
Zone 2	-32.10 psf	-215.71 lb
Zone 3	-32.10 psf	-215.71 lb
Max trib	11.20 ft2	

Max loading at connection

Negative -215.71 lb/fastener

Connection (Pull Out)

Lag screw	5/16 in		
Cd	1.60 Table 2.3.2		
embedment	2.5 in		
Nominal CapacityPrying	205.00 lbs G=0.42		
Max capacity (lbs)	533.00	>	215.71 OK

Note:

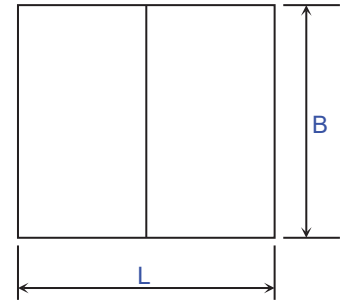
* Lag screws to be diameter 5/16x2.5inches long.

* All fasteners need to be placed at roof rafters.

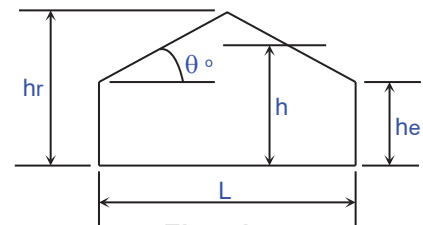
BES 121 South Main ST Auburn, IN		WIND LOADING Per ASCE 7-10	
Cust Name:	Bowers Engineering Services	Subject:	Roof Mount
Job Number:	3119 Timothy Lemons	Originator:	0
		Checker:	

Input Data:

Wind Speed, V =	116	mph (Wind Map, Figure 26.5-1A-C)
Bldg. Classification =	II	(Table 1-1 Occupancy Category)
Exposure Category =	C	(Sect. 26.7)
Ridge Height, hr =	24.08	ft. (hr >= he)
Eave Height, he =	20.00	ft. (he <= hr)
Building Width =	14.00	ft. (Normal to Building Ridge)
Building Length =	24.10	ft. (Parallel to Building Ridge)
Roof Type =	Gable	(Gable or Monoslope)
Topo. Factor, Kzt =	1.00	(Sect. 26.8 & Figure 26.8-1)
Direct. Factor, Kd =	0.85	(Table 26.6)
Enclosed? (Y/N)	Y	(Sect. 28.6-1 & Figure 26.11-1)
Hurricane Region?	N	
Component Name =	Decking	(Purlin, Joist, Decking, or Fastener)
Effective Area, Ae =	11.1	ft.^2 (Area Tributary to C&C)
Overhangs? (Y/N)	N	(if used, overhangs on all sides)



Plan



Elevation

Resulting Parameters and Coefficients:

Roof Angle, θ =	30.26	deg.
Mean Roof Ht., h =	22.04	ft. (h = (hr+he)/2, for roof angle >10 deg.)

Roof External Pressure Coefficients, GCp:

GCp Zone 1-3 Pos. =	0.90	(Fig. 30.4-2A, 30.4-2B, and 30.4-2C)
GCp Zone 1 Neg. =	-0.99	(Fig. 30.4-2A, 30.4-2B, and 30.4-2C)
GCp Zone 2 Neg. =	-1.19	(Fig. 30.4-2A, 30.4-2B, and 30.4-2C)
GCp Zone 3 Neg. =	-1.19	(Fig. 30.4-2A, 30.4-2B, and 30.4-2C)

Positive & Negative Internal Pressure Coefficients, GCpi (Figure 26.11-1):

+GCpi Coef. =	0.00	(positive internal pressure)
-GCpi Coef. =	0.00	(negative internal pressure)

If $z \leq 15$ then: $Kz = 2.01 \cdot (15/zg)^{2/\alpha}$, If $z > 15$ then: $Kz = 2.01 \cdot (z/zg)^{2/\alpha}$ (Table 30.3-1)

α =	9.50	(Table 26.9-1)
zg =	900	(Table 26.9-1)
Kh =	0.92	(Kh = Kz evaluated at z = h)

Velocity Pressure: $qz = 0.00256 \cdot Kz \cdot Kzt \cdot Kd \cdot V^2$ (Sect. 30.3.2, Eq. 30.3-1)

qh =	26.95	psf	qh = 0.00256 * Kh * Kzt * Kd * V^2 (qz evaluated at z = h)
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Design Net External Wind Pressures (Sect. 30.4 & 30.6):

For $h \leq 60$ ft.: $p = qh \cdot ((GCp) - (+/-GCpi))$ (psf)

For $h > 60$ ft.: $p = q \cdot (GCp) - qi \cdot (+/-GCpi)$ (psf)

where: $q = qh$ for roof

$qi = qh$ for roof (conservatively assumed per Sect. 30.6)

Wind Load Tabulation for Roof Components & Cladding								
Component	z (ft.)	Kh	qh (psf)	p = Net Design Pressures (psf)				
				Zone 1,2,3 (+)	Zone 1 (-)	Zone 2 (-)	Zone 3 (-)	
Decking	0	0.92	26.95	24.14	-26.71	-32.10	-32.10	
	15.00	0.92	26.95	24.14	-26.71	-32.10	-32.10	
	20.00	0.92	26.95	24.14	-26.71	-32.10	-32.10	
	For z = hr:	24.08	0.92	26.95	24.14	-26.71	-32.10	-32.10
For z = he:	20.00	0.92	26.95	24.14	-26.71	-32.10	-32.10	
For z = h:	22.04	0.92	26.95	24.14	-26.71	-32.10	-32.10	

- Notes: 1. (+) and (-) signs signify wind pressures acting toward & away from respective surfaces.
2. Width of Zone 2 (edge), 'a' =

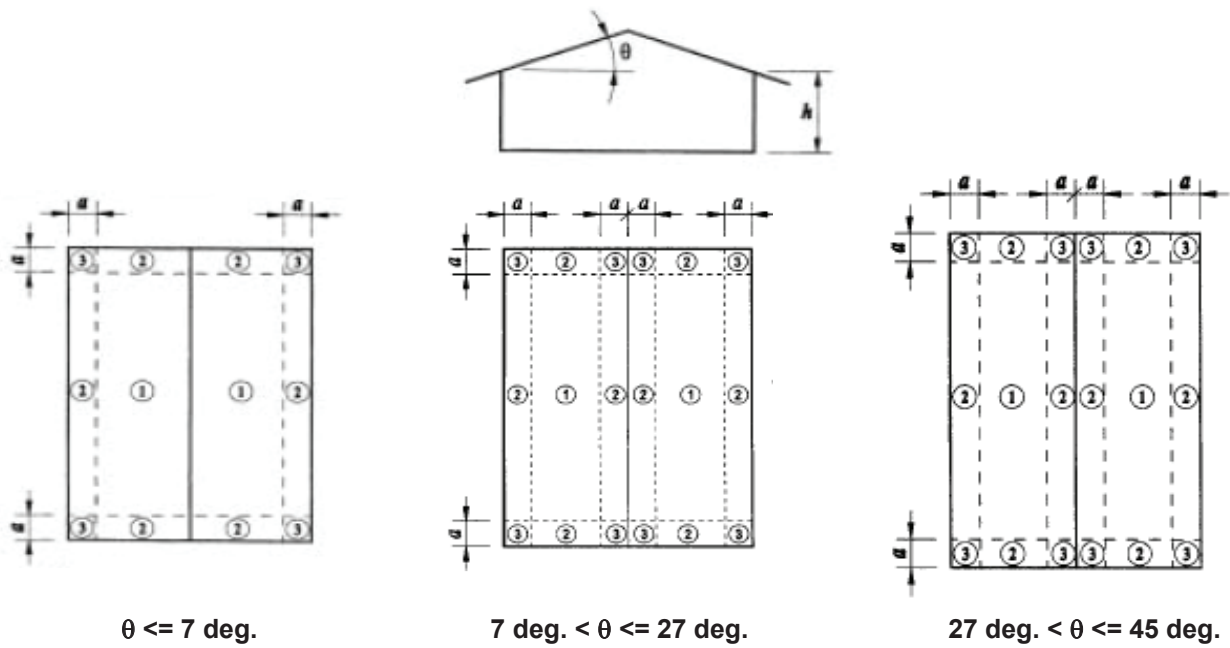
3.00

 ft.
3. Width of Zone 3 (corner), 'a' =

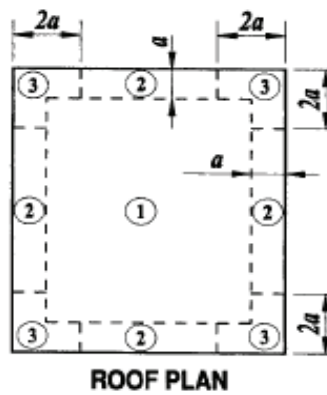
3.00

 ft.
4. For monoslope roofs with $\theta \leq 3$ degrees, use Fig. 30.4-2A for 'GCp' values with 'qh'.
5. For buildings with $h > 60'$ and $\theta > 10$ degrees, use Fig. 30.6-1 for 'GCpi' values with 'qh'.
6. For all buildings with overhangs, use Fig. 30.4-2B for 'GCp' values per Sect. 30.10.
7. If a parapet $\geq 3'$ in height is provided around perimeter of roof with $\theta \leq 10$ degrees, Zone 3 shall be treated as Zone 2.
8. **Per Code Section 30.2.2, the minimum wind load for C&C shall not be less than 16 psf.**
9. References : a. ASCE 7-02, "Minimum Design Loads for Buildings and Other Structures".
b. "Guide to the Use of the Wind Load Provisions of ASCE 7-02"
by: Kishor C. Mehta and James M. Delahay (2004).

Roof Components and Cladding:



Roof Zones for Buildings with $h \leq 60$ ft.
 (for Gable Roofs $\leq 45^\circ$ and Monoslope Roofs $\leq 3^\circ$)



Roof Zones for Buildings with $h > 60$ ft.
 (for Gable Roofs $\leq 10^\circ$ and Monoslope Roofs $\leq 3^\circ$)

Frame Design		General Info	
Cust. Name:	Bowers Engineering Services	Subject:	Roof Mount
Job Number:	3119 Timothy Lemons	Originator:	Checker:
Date:	44455	Rev:	-
Address:	38 Lone Pine Trail		
City, State:	Sanford, NC 27332		

Roof Rafter

Rafter Size= 2x4 SYP #1
 Trib. Area= 2 ft
 Rafter length= 6 ft

w= 64.50 plf

M= 290.25 lb-ft

$$fb = \frac{M * 12}{S_x}$$

$$F'b = Fb * Cd * Cr * Cf * Cm * Cl$$

Roof Loads

Dead Load= 6 psf
 Live Load= 20 psf
 Snow Load= 15 psf

Load Combination

D+0.75L+0.75S 32.3 psf

EI= 8.6E+06 ib-in
 S_x = 3.0625
 C_M= 1.0
 C_r= 1.2
 C_D= 1.15
 C_F= 1.3
 C_L= 1.0
 F_b= 1500 psi

fb= 1137.31 psi
 F'b= 2578.88 psi **OK**

$$\frac{5wl^4}{384EI}$$

ΔL= 0.14 in
 ΔS= 0.10 in
 ΔD+L= 0.18 in

Δ_{allow in}= 0.18 < 1/120 0.60 **OK**
 Δ_{allow in}= 0.14 < 1/180 0.40 **OK**

2x4 @ 2 o/c OK

Assume rafters are fully braced

Bowers Engineering Services
121 S. Main ST
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Structural Analysis

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Wind Load - uplift

		Max lb
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Zone 2	-32.28 psf	-216.95 lb
Zone 3	-32.28 psf	-216.95 lb
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Negative -216.95 lb/fastener

Connection (Pull Out)

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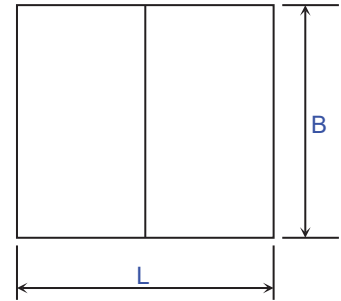
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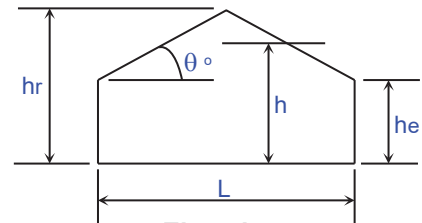
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Kh =	0.93	(Kh = Kz evaluated at z = h)

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qh =	27.11	psf	qh = 0.00256 * Kh * Kzt * Kd * V^2 (qz evaluated at z = h)
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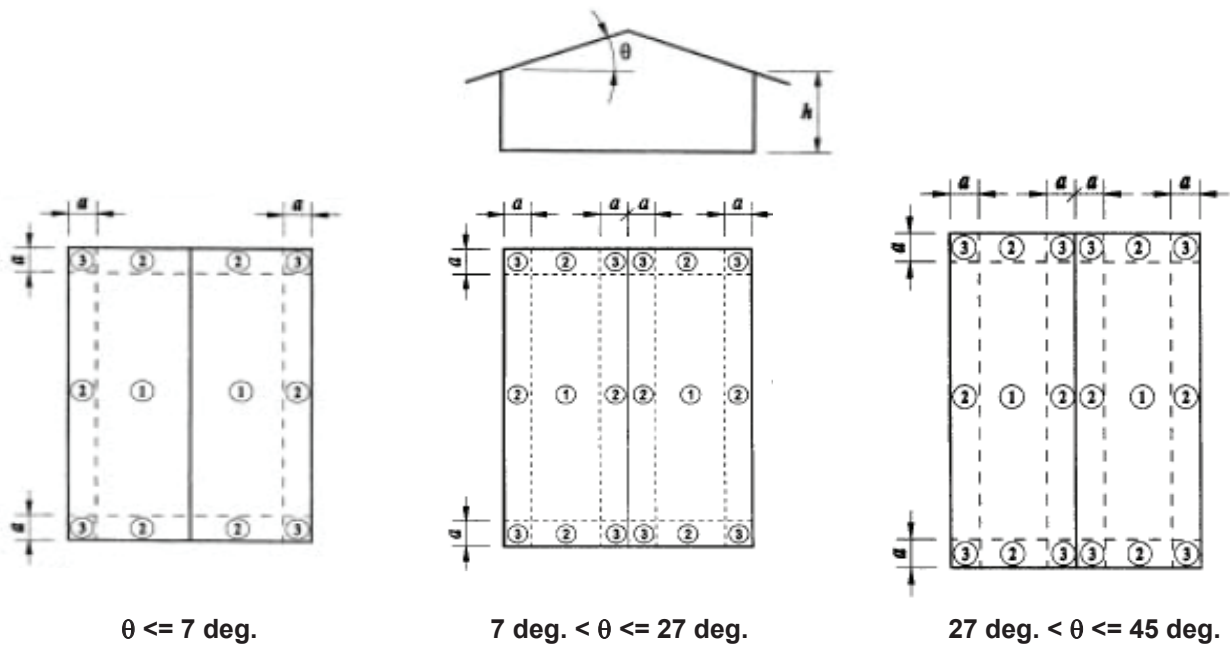
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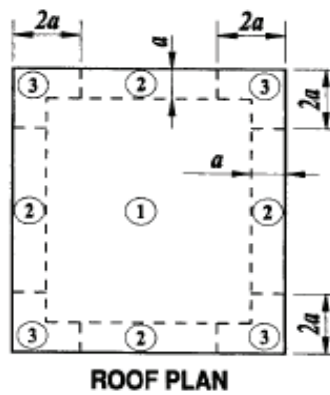
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	20.00	0.93	27.11	24.27	-26.86	-32.28	-32.28
	25.00	0.93	27.11	24.27	-26.86	-32.28	-32.28
For z = he:	20.00	0.93	27.11	24.27	-26.86	-32.28	-32.28
For z = h:	22.65	0.93	27.11	24.27	-26.86	-32.28	-32.28

- Notes: 1. (+) and (-) signs signify wind pressures acting toward & away from respective surfaces.
2. Width of Zone 2 (edge), 'a' = 3.00 ft.
3. Width of Zone 3 (corner), 'a' = 3.00 ft.
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Roof Components and Cladding:



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 (for Gable Roofs $\leq 45^\circ$ and Monoslope Roofs $\leq 3^\circ$)



Roof Zones for Buildings with $h > 60 \text{ ft.}$
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Address:	38 Lone Pine Trail		
City, State:	Sanford, NC 27332		

Roof Rafter

Rafter Size= 2x4 SYP #1
 Trib. Area= 2 ft
 Rafter length= 6.5 ft

Roof Loads

Dead Load= 6 psf
 Live Load= 20 psf
 Snow Load= 15 psf

Load Combination

D+0.75L+0.75S 32.3 psf

w= 64.50 plf

M= 340.64 lb-ft

EI= 8.6E+06 ib-in
 Sx = 3.0625
 C_M= 1.0
 C_r= 1.2
 C_D= 1.15
 C_F= 1.3
 C_L= 1.0
 F_b= 1500 psi

$$fb = \frac{M * 12}{Sx}$$

$$F'b = Fb * Cd * Cr * Cf * Cm * Cl$$

fb= 1334.76 psi
 F'b= 2578.88 psi **OK**

$$\frac{5wl^4}{384EI}$$

ΔL= 0.19 in
 ΔS= 0.14 in
 ΔD+L= 0.24 in

l/120
 Δ_{allow in}= 0.24 < 0.65 **OK**
l/180
 Δ_{allow in}= 0.19 < 0.43 **OK**

2x4 @ 2 o/c OK

Assume rafters are fully braced