January 11, 2022

BES Project Number: 5436 Roneil Swaby

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

Project Location: Roneil Swaby: 402 New Castle Ln., Spring Lake, NC 28390
Solar Array Installation

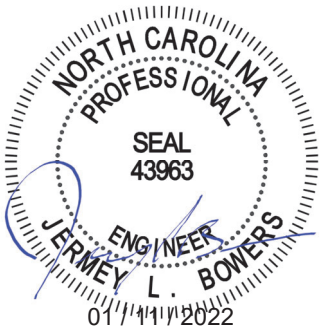
To Whom It May Concern:

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

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Bowers Engineering Services
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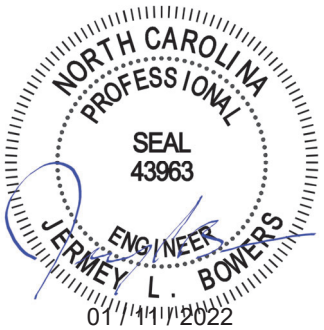
Structural Analysis

Location

402 New Castle Ln
Spring Lake, NC 28390

Roof Mount Solar

1/11/2022



Project: 5436 Rev: -

BES 121 South Main ST Auburn, IN			Date:	1/11/2022	Connections
Cust. Name:	Bowers Engineering Services	Subject:	Roof Mount		
Job Number:	5436	Originator	0	Checker:	

STRUCTURAL SUMMARY

CODE SPEC

IBC 2015
ASCE 7-10

WIND
Speed: 119 MPH
Exp.: C

Risk Cat: II

Wind Load - uplift

			Max lb	
Zone 1	-28.71	psf	-192.93	lb
Zone 2	-34.50	psf	-231.87	lb
Zone 3	-34.50	psf	-231.87	lb
Max trib	11.20	ft2		

Max loading at connection

Negitive	-231.87	lb/fastener

Connection (Pull Out)

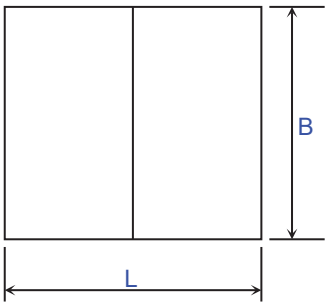
Lag screw	5/16	in			
Cd	1.60	Table 2.3.2			
embedment	2.5	in			
Nominal CapacityPrying	205.00	lbs G=0.42			
Max capacity (lbs)	***533.00***		>	***231.87***	***OK***

Note:
* Lag screws to be diameter 5/16x2.5inches long.
* All fasteners need to be placed at roof rafters.

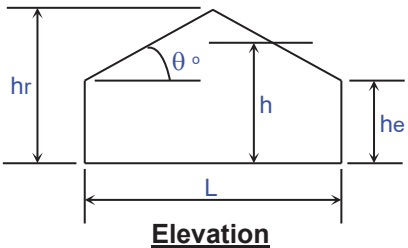
BES 121 South Main ST Auburn, IN			WIND LOADING Per ASCE 7-10		
Cust Name:	Bowers Engineering Services	Subject:	Roof Mount		
Job Number:	5436	Originator:	0	Checker:	

Input Data:

Wind Speed, V =	119	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 =	28.75	ft. (hr >= he)
Eave Height, he =	20.00	ft. (he <= hr)
Building Width =	30.00	ft. (Normal to Building Ridge)
Building Length =	36.00	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 =	24.38	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 <= 15 then: Kz = 2.01*(15/zg)^(2/α) , If z > 15 then: Kz = 2.01*(z/zg)^(2/α) (Table 30.3-1)

α =	9.50	(Table 26.9-1)
zg =	900	(Table 26.9-1)
Kh =	0.94	(Kh = Kz evaluated at z = h)

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

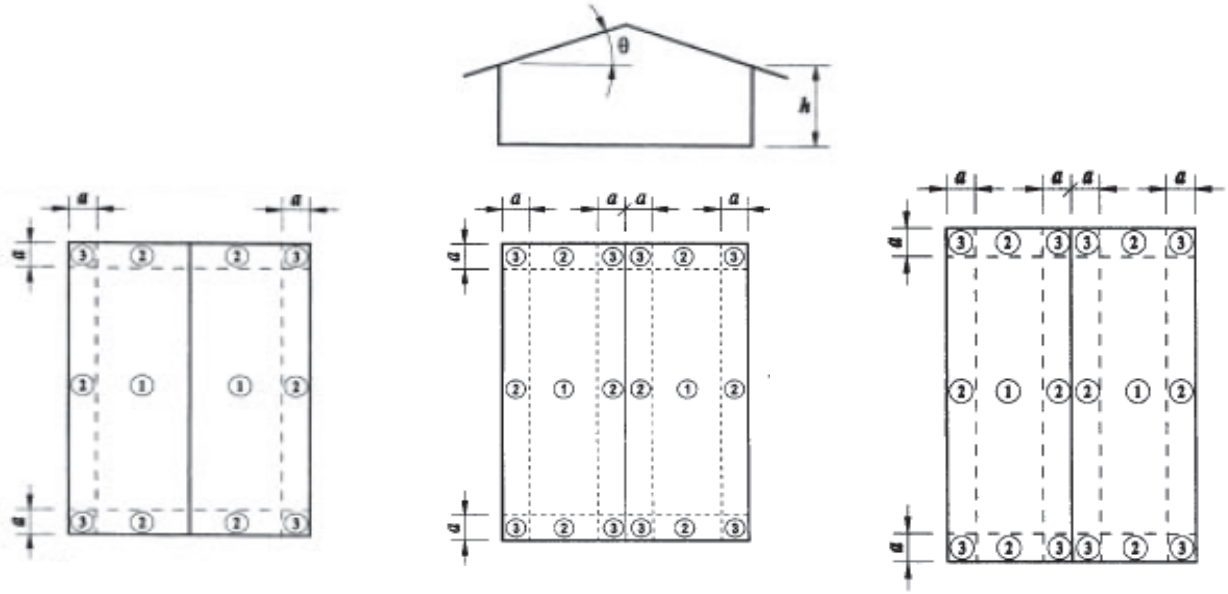
qh = 28.97 psf qh = 0.00256*Kh*Kzt*Kd*V^2 (qz evaluated at z = h)

Design Net External Wind Pressures (Sect. 30.4 & 30.6):
For h <= 60 ft.: p = qh*((GCp) - (+/-GCpi)) (psf)
For h > 60 ft.: p = q*(GCp) - qi*(+/-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	0.94	28.97	25.94	-28.71	-34.50	-34.50
	15.00	0.94	28.97	25.94	-28.71	-34.50	-34.50
	20.00	0.94	28.97	25.94	-28.71	-34.50	-34.50
	25.00	0.94	28.97	25.94	-28.71	-34.50	-34.50
For z = he:	20.00	0.94	28.97	25.94	-28.71	-34.50	-34.50
For z = h:	24.38	0.94	28.97	25.94	-28.71	-34.50	-34.50

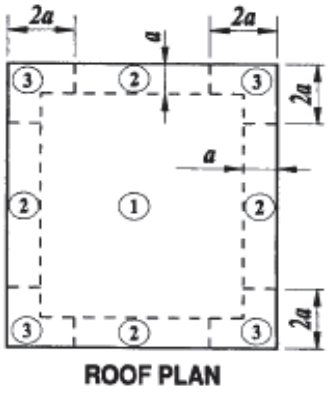
Notes: 1. (+) and (-) signs signify wind pressures acting toward & away from respective surfaces.
2. Width of Zone 2 (edge), 'a' = 3.00 ft.
3. Width of Zone 3 (corner), 'a' = 3.00 ft.
4. For monoslope roofs with θ <= 3 degrees, use Fig. 30.4-2A for 'GCp' values with 'qh'.
5. For buildings with h > 60' and θ > 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 >= 3' in height is provided around perimeter of roof with θ <= 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:



θ <= 7 deg. | 7 deg. < θ <= 27 deg. | 27 deg. < θ <= 45 deg.

Roof Zones for Buildings with h <= 60 ft.
(for Gable Roofs <= 45° and Monoslope Roofs <= 3°)



ROOF PLAN

Roof Zones for Buildings with h > 60 ft.
(for Gable Roofs <= 10° and Monoslope Roofs <= 3°)

Frame Design			General Info		
Cust. Name:	Bowers Engineering Services		Subject:	Roof Mount	
Job Number:	5436		Originator:		Checker:
Date:	1/11/22				
Address	402 New Castle Ln	Rev:	-		
City, State:	Spring Lake, NC 28390				

Roof Rafter

Rafter Size=	2x4	**SYP #1**			
Trib. Area=	2	ft			
Rafter length=	8.5	ft			
w=	61.00	plf			
M=	550.91	lb-ft			

Roof Loads

Dead Load=	8.00	psf
Live Load=	20	psf
Snow Load=	10	psf

Load Combination

D+0.75L+0.75S	30.5	psf
EI=	8.6E+06	ib-in
Sx =	3.0625	
C_M=	1.0	
Cr=	1.2	
C_D=	1.15	
C_F=	1.3	
C_L=	1.0	
Fb=	1500	psi

Dead Load Roof Materials

Sheathing=	2	psf
Aspahlt Shingles=	3	psf
Insulation=	0.50	psf
Solar Panels=	2.50	psf

Assume Light-frame wood roof

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

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

fb=	2158.65	psi	
F'b=	2578.88	psi	**OK**

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

ΔL=	0.55	in			
ΔS=	0.27	in			
ΔD+L=	0.77	in			
				l/120	
$\Delta_{allow\ in}$=	0.77	<		0.85	**OK**
				l/180	
$\Delta_{allow\ in}$=	0.55	<		0.57	**OK**

2x4	***@***	2 o/c	***OK***

Assume rafters are fully braced

BES 121 South Main ST Auburn, IN			Date:	1/11/2022	Connections
Cust. Name:	Bowers Engineering Services	Subject:	Roof Mount		
Job Number:	5436	Originator	0	Checker:	

STRUCTURAL SUMMARY

CODE SPEC

IBC 2015
ASCE 7-10

WIND
Speed: 119 MPH
Exp.: C

Risk Cat: II

Wind Load - uplift

			Max lb	
Zone 1	-28.49	psf	-191.45	lb
Zone 2	-34.24	psf	-230.1	lb
Zone 3	-34.24	psf	-230.1	lb
Max trib	11.20	ft2		

Max loading at connection

Negitive	-230.10	lb/fastener

Connection (Pull Out)

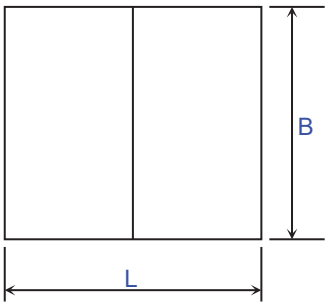
Lag screw	5/16	in			
Cd	1.60	Table 2.3.2			
embedment	2.5	in			
Nominal CapacityPrying	205.00	lbs G=0.42			
Max capacity (lbs)	***533.00***		>	***230.10***	***OK***

Note:
* Lag screws to be diameter 5/16x2.5inches long.
* All fasteners need to be placed at roof rafters.

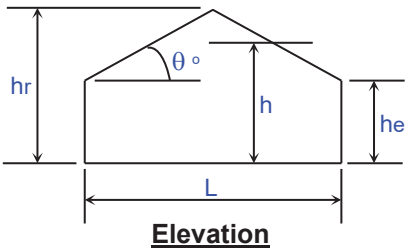
BES 121 South Main ST Auburn, IN			WIND LOADING Per ASCE 7-10		
Cust Name:	Bowers Engineering Services	Subject:	Roof Mount		
Job Number:	5436	Originator:	0	Checker:	

Input Data:

Wind Speed, V =	119	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 =	27.00	ft. (hr >= he)
Eave Height, he =	20.00	ft. (he <= hr)
Building Width =	24.00	ft. (Normal to Building Ridge)
Building Length =	28.00	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 =	23.50	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 <= 15 then: Kz = 2.01*(15/zg)^(2/α) , If z > 15 then: Kz = 2.01*(z/zg)^(2/α) (Table 30.3-1)

α =	9.50	(Table 26.9-1)
zg =	900	(Table 26.9-1)
Kh =	0.93	(Kh = Kz evaluated at z = h)

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

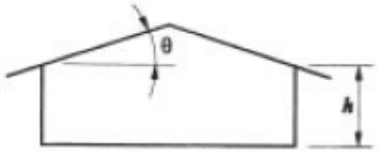
qh = 28.75 psf qh = 0.00256*Kh*Kzt*Kd*V^2 (qz evaluated at z = h)

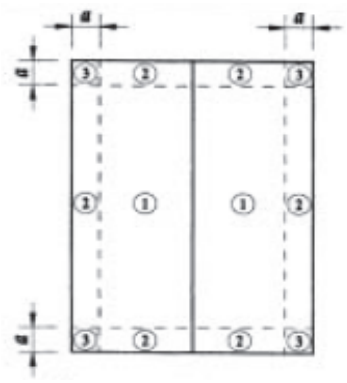
Design Net External Wind Pressures (Sect. 30.4 & 30.6):
For h <= 60 ft.: p = qh*((GCp) - (+/-GCpi)) (psf)
For h > 60 ft.: p = q*(GCp) - qi*(+/-GCpi) (psf)
where: q = qh for roof
qi = qh for roof (conservatively assumed per Sect. 30.6)

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	0.93	28.75	25.75	-28.49	-34.24	-34.24
	15.00	0.93	28.75	25.75	-28.49	-34.24	-34.24
	20.00	0.93	28.75	25.75	-28.49	-34.24	-34.24
	25.00	0.93	28.75	25.75	-28.49	-34.24	-34.24
For z = he:	20.00	0.93	28.75	25.75	-28.49	-34.24	-34.24
For z = h:	23.50	0.93	28.75	25.75	-28.49	-34.24	-34.24

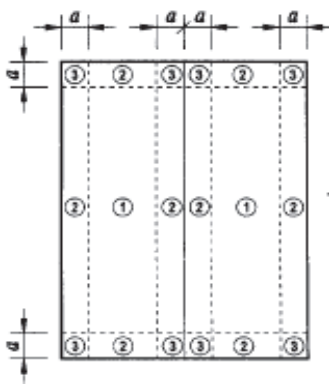
Notes: 1. (+) and (-) signs signify wind pressures acting toward & away from respective surfaces.
2. Width of Zone 2 (edge), 'a' = 3.00 ft.
3. Width of Zone 3 (corner), 'a' = 3.00 ft.
4. For monoslope roofs with θ <= 3 degrees, use Fig. 30.4-2A for 'GCp' values with 'qh'.
5. For buildings with h > 60' and θ > 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 >= 3' in height is provided around perimeter of roof with θ <= 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:

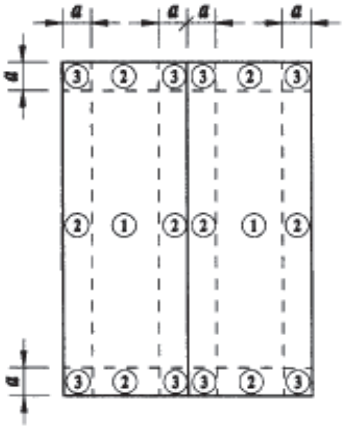




θ <= 7 deg.

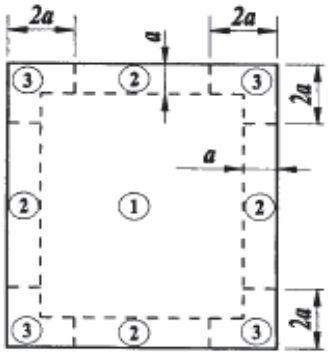


7 deg. < θ <= 27 deg.



27 deg. < θ <= 45 deg.

Roof Zones for Buildings with h <= 60 ft.
(for Gable Roofs <= 45° and Monoslope Roofs <= 3°)



ROOF PLAN

Roof Zones for Buildings with h > 60 ft.
(for Gable Roofs <= 10° and Monoslope Roofs <= 3°)

Frame Design			General Info		
Cust. Name:	Bowers Engineering Services		Subject:	Roof Mount	
Job Number:	5436		Originator:		Checker:
Date:	1/11/22				
Address	402 New Castle Ln	Rev:	-		
City, State:	Spring Lake, NC 28390				

Roof Rafter

Rafter Size=	2x4	**SYP #1**			
Trib. Area=	2	ft			
Rafter length=	8.5	ft			
w=	61.00	plf			
M=	550.91	lb-ft			

Roof Loads

Dead Load=	8.00	psf
Live Load=	20	psf
Snow Load=	10	psf

Load Combination

D+0.75L+0.75S	30.5	psf
EI=	8.6E+06	ib-in
Sx =	3.0625	
C_M=	1.0	
Cr=	1.2	
C_D=	1.15	
C_F=	1.3	
C_L=	1.0	
Fb=	1500	psi

Dead Load Roof Materials

Sheathing=	2	psf
Aspahlt Shingles=	3	psf
Insulation=	0.50	psf
Solar Panels=	2.50	psf

Assume Light-frame wood roof

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

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

fb=	2158.65	psi	
F'b=	2578.88	psi	**OK**

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

ΔL=	0.55	in			
ΔS=	0.27	in			
ΔD+L=	0.77	in			
				l/120	
$\Delta_{allow\ in}$=	0.77	<		0.85	**OK**
				l/180	
$\Delta_{allow\ in}$=	0.55	<		0.57	**OK**

2x4	***@***	2 o/c	***OK***

Assume rafters are fully braced