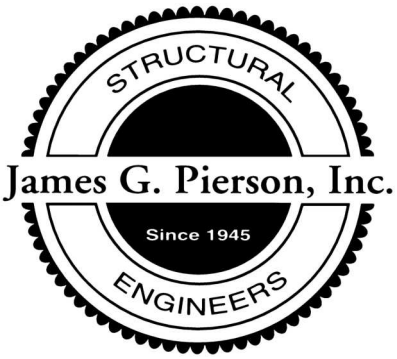
21-088106-REV-01-RS

STRUCTURAL CALCULATIONS
ROOF MOUNTED SOLAR

PROJECT:
Query Residence
1612 NE Going Street
Portland, Oregon 97211

for

Elemental Energy
1339 SE 8th Avenue
Portland, Oregon 97214



REPLACEMENT

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September 15, 2021

SUBMITTED
By tmarshall@elementalenergy.net at 2:48:43 PM, 10/31/2023

Query Residence Roof Mounted Solar

GENERAL DESIGN LOADS:

Project is designed in accord with requirements of the 2019 Oregon Structural Specialty Code. For this location the following design parameters apply:

Roof Snow Load = 20 PSF
Solar Dead Load = 3.0 PSF
Wind: 100 MPH, Exp. B (ASCE 7-16)

Design Summary:

The following calculations are for the proposed roof mounted solar array located at 1612 NE Going St. in Portland, Oregon. The structure where the solar panels are being added is a single-family residence. The proposed solar array will be flush mounted and attached to the roof. For this specific project, the adequacy of the roof to support the rooftop solar panels and the panel to roof connections were analyzed. Some reinforcements are required.

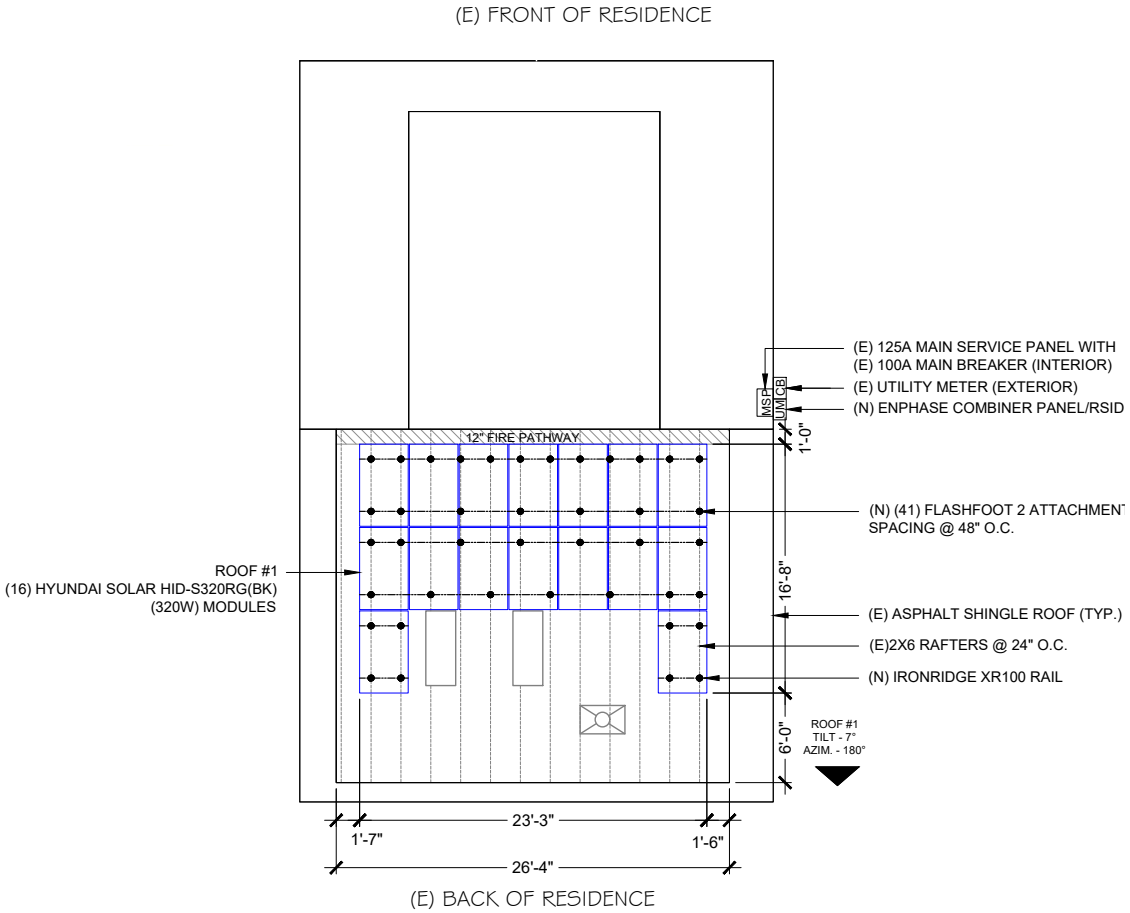
The techniques and principles of structural analysis used for these calculations conform to generally accepted standards of the engineering community. These design calculations have been prepared based upon shop drawings provided by the client.

Solar Panels at Query Residence

Task: Determine the adequacy of roof to support rooftop solar panels and check the panel to roof connections.

References: **SEAOC PV2-2017**
2018 IBC
2019 OSSC
ASCE 7-16

Plans (for reference only):



1 ROOF PLAN WITH MODULES
SCALE: 1/8" = 1'-0"

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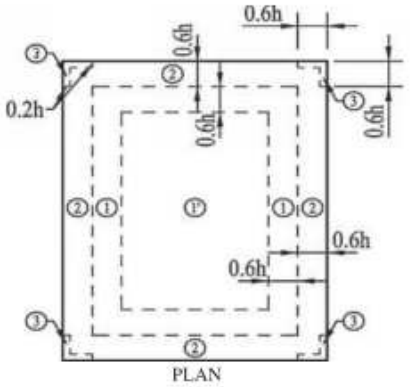
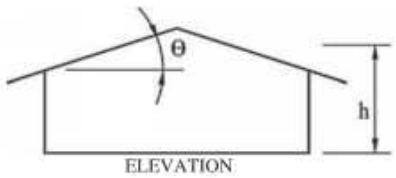
James G. Pierson, Inc. Consulting Structural Engineers 610 S.W. Alder, Suite 918 Portland, Oregon 97205 Tel: (503) 226-1286 Fax: (503) 226-3130	Project: QUERY RESIDENCE - SOLAR	Job no.
	Location: 1612 NE GOING ST, PORTLAND, OR	Date: September, 2021
	Client: ELEMENTAL ENERGY	Sheet no.: Page 3 of 17

Diagrams

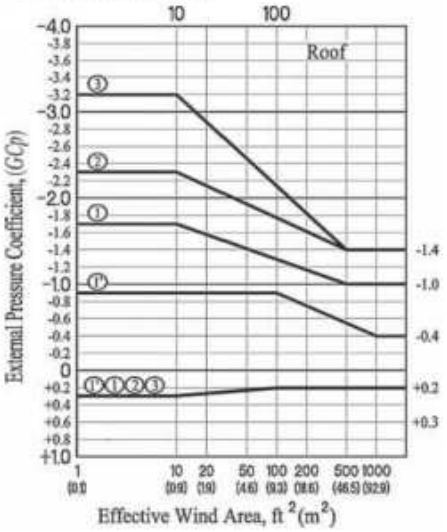


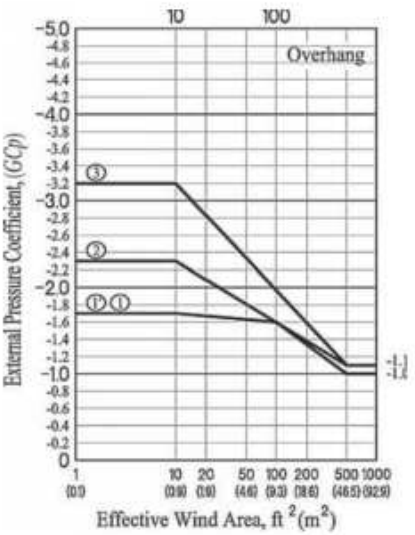


Notation

B = Horizontal dimension of building measured normal to wind direction, in ft (m).
h = Eave height shall be used for $\theta = 10°$.
θ = Angle of plane of roof from horizontal, in degrees.

External Pressure Coefficients





Notes

1. Vertical scale denotes (GC_p) to be used with q_h.
2. Horizontal scale denotes effective wind area, in ft² (m²).
3. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
4. Each component shall be designed for maximum positive and negative pressures.
5. If a parapet equal to or higher than 3 ft (0.9 m) is provided around the perimeter of the roof with $\theta \leq 7°$, the negative values of (GC_p) in Zone 3 shall be equal to those for Zone 2, and positive values of (GC_p) in Zones 2 and 3 shall be set equal to those for wall Zones 4 and 5, respectively, in Fig. 30.3-1.
6. Values of (GC_p) for roof overhangs include pressure contributions from both upper and lower surfaces.
7. If overhangs exist, the lesser horizontal dimension of the building shall not include any overhang dimension, but the edge distance, a, shall be measured from the outside edge of the overhang.

FIGURE 30.3-2A Components and Cladding [$h \leq 60$ ft ($h \leq 18.3$ m)]: External Pressure Coefficients, (GC_p), for Enclosed and Partially Enclosed Buildings—Gable Roofs, $\theta \leq 7°$

Parallel-to-Roof (Flush-Mounted) Modules (per SEAOC PV2-2017):

Roof

K_z = **0.70 psf** Velocity Pressure Coefficient (Table 26.10-1)
K_{zt} = **1.0** Topography Coefficient
K_d = **0.85** Exponent Coefficient (Table 26.6-1)
K_e = **1.0** Ground elevation factor
V = **100 mph** Basic wind speed

$q_h = 0.00256*K_z*K_{zt}*K_d*K_e*V^2$ = **15.23** psf Peak velocity pressure – internal

"GC_p determined from Fig. 30.3-2A of ASCE 7-16 (largest area supported by any clamp is less than 10 ft2, so GCp for clamp design is based on effective wind area A ≤ 10 ft2)" for roof slope = 7 degrees

For Zone 3, GC_{p3} = **-3.2**
For Zone 2, GC_{p2} = **-2.3**
For Zone 1, GC_{p1} = **-1.7**
For Zone 1a GC_{p1a} = **-0.9**
All Zones GC_{pa} = **0.3**

Upward Pressures

Y_E = 1.5 for exposed PV modules located along each outer row, or adjacent to aisles > 4'

Y_a = 0.8 "per ASCE 7-16 Fig. 29.4-8 for A ≤ 10 ft2"

$P_3 = q_h*GC_{p3}*Y_E*Y_a$ = **-58.49** psf
$P_2 = q_h*GC_{p2}*Y_E*Y_a$ = **-42.04** psf
$P_1 = q_h*GC_{p1}*Y_E*Y_a$ = **-31.07** psf$P_{1a} = q_h* GC_{p1a} *Y_E*Y_a$ = **-16.45** psf
$P_{up} = \min(P_3, P_2, P_1, P_{1a})$ = **-58.49** psf

Downward Pressure

q_h = **15.23** psf
GC_{pa} = **0.30**
Y_E = **1.50**
Y_a = **0.80**
$P_{down} = q_h*GC_{pa}*Y_E*Y_a$ = **5.48** psf

Use max wind load case to design solar support rails

P_{up} = **-58.49** psf Upward force on solar panels at corners
P_1 = **-31.07** psf Upward force on solar panels at center sections
P_{down} = **5.48** psf Downward force on upper section of solar panels

Check Rails for critical load combinations

Solar Panels:Hyundai Solar HID-S320RG(BK)**l = 66 in w = 39 in weight = 40.1 lbs**

DL = weight / (w * l) = **2.24** psf

DL = **3.0 psf** Self weight of solar panels

LL = **20 psf**

$Wind_{down} = P_{down}$ $Wind_{down}$ = **5.48** psf

$Wind_{up} = P_{up}$ $Wind_{up}$ = **-58.49** psf

Tributary Load per rail a = l/2 a = **2.75**

Combine Nominal Loads using Allowable Stress Design (ASCE 7-16 2.4.1)

DL_r = DL * a = **8.25** plf

LL_r = LL * a = **55.00** plf

$Wind_{upr} = Wind_{up}$ * a = **-160.85** plf

$Wind_{downr} = Wind_{down}$ * a = **15.08** plf

U_3 = (DL + LL) * l/2 =**63.25** plf - Controls

U_5 = (DL + (0.6 * $Wind_{down}$)) * l/2 =**17.30** plf

U_6 = (DL + .75 * (LL + 0.6 * $Wind_{down}$)) * l/2 =**56.29** plf

U_7 = (0.6 * DL + 0.6 * $Wind_{up}$) * l/2 =**-91.56** plf up - Controls

Try Iron Ridge Rail XR100 Series (Downward)

Check Rails for design loads

L = 4 **ft** span of rails

M = 1/8 * U_3 * L^2 = **1518.00** lb_in

V_x = U_3 * L/2 = **126.50** lbs down each side of support

Try XR100:

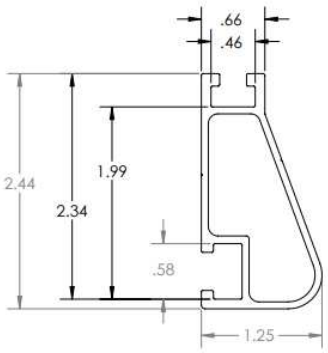
S_{PXR100} = **0.297** in^3

f_b = M / S_{PXR100} = **5111.11** psi

F_b = 21000 psi 6005A-T51

f_b / F_b = **0.24** <1.0 – OK

- Use XR100 Series
  (4 ft or less span between supports)



Rail Section Properties	
Property	Value
Total Cross-Sectional Area	0.582 in^2
Section Modulus (X-axis)	0.297 in^3
Moment of Inertia (X-axis)	0.390 in^4
Moment of Inertia (Y-axis)	0.085 in^4
Torsional Constant	0.214 in^3
Polar Moment of Inertia	0.126 in^4

Try Iron Ridge Rail XR100 Series (Uplift)

Check Rails for design loads

L = 4 **ft** span of rails

M = 1/8 * U_7 * L^2 = **-2197.44** lb_in

V_x = U_7 * L/2 = **-183.12** lbs each side of support

Try XR100:
S_{P6} = **0.297** in^3
$f_b = M / S_{P6}$ = **-7398.78** psi
F_b = 21000 psi 6005A-T51
f_b / F_b = **-0.35** <1.0 – OK

- Use XR100 Series at ends
  (4 ft or less span between supports)

Connections to Structure:

Use L-Foot
L = 2 ft
Uplift on connections $R_{up} = -U_7 * L$ = **183.12** lbs up at supports
Dead Load per Connection $DL_f = DL_r * L$ = **16.50** lbs at supports
Live Load per Connection $LL_f = LL_r * L$ = **110.00** lbs at supports
Wind Load per Connection $L_f = Wind_{downr} * L$ = **30.16** lbs at supports

L = 4 ft
Uplift on connections $R_{up} = -U_7 * L$ = **366.24** lbs up at supports
Dead Load per Connection $DL_f = DL_r * L$ = **33.00** lbs at supports
Live Load per Connection $LL_f = LL_r * L$ = **220.00** lbs at supports
Wind Load per Connection $L_f = Wind_{downr} * L$ = **60.32** lbs at supports

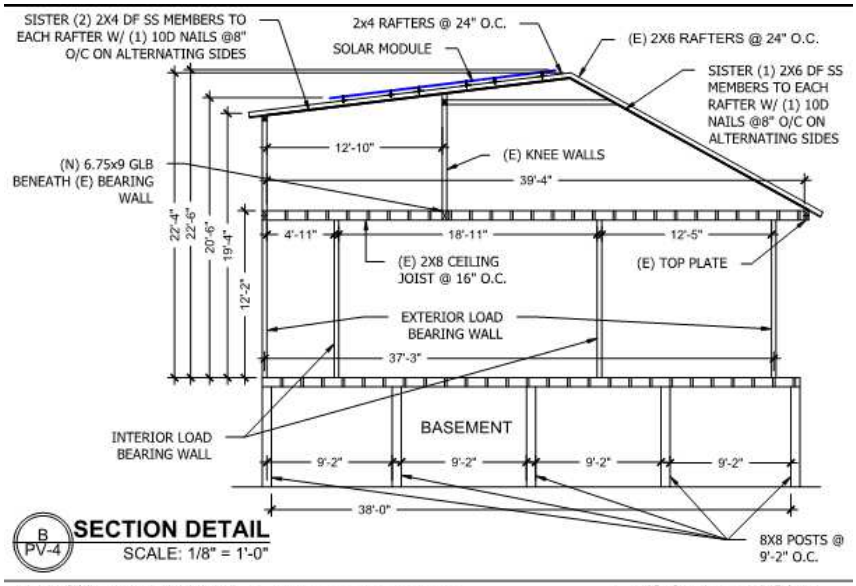
Try (1) 5/16 x 4” Lag Screw
T_{allow} = 1 * 266 lbs/in * 2.3125 in * 1.6 = **984.20** lbs
R_{up} / T_{allow} = **0.37** <1.0 - OK

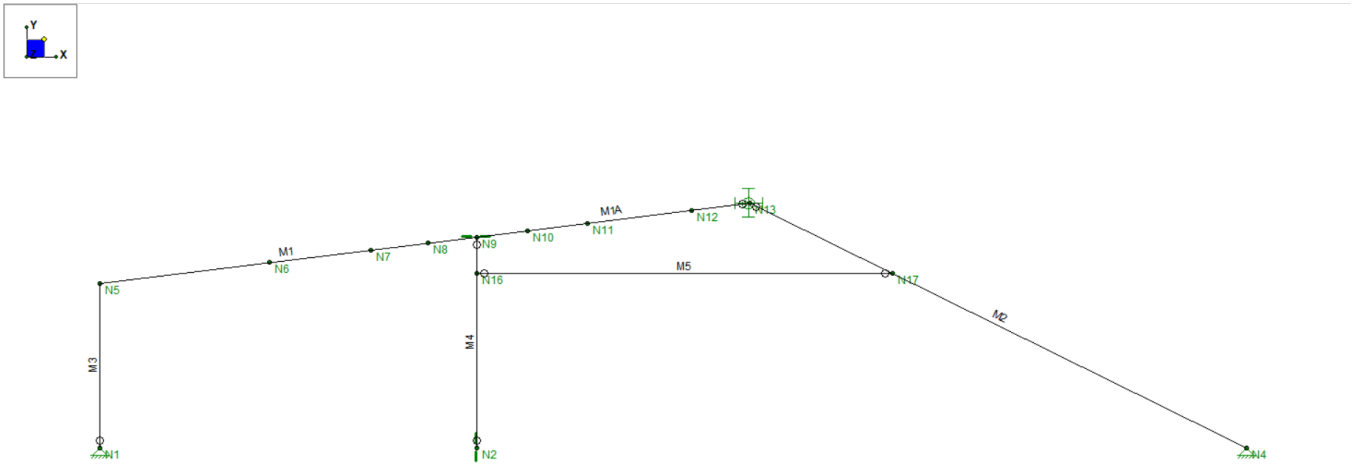
- Use L-Foot W/ 5/16 X 4” lag screw at 4 ft maximum spacing

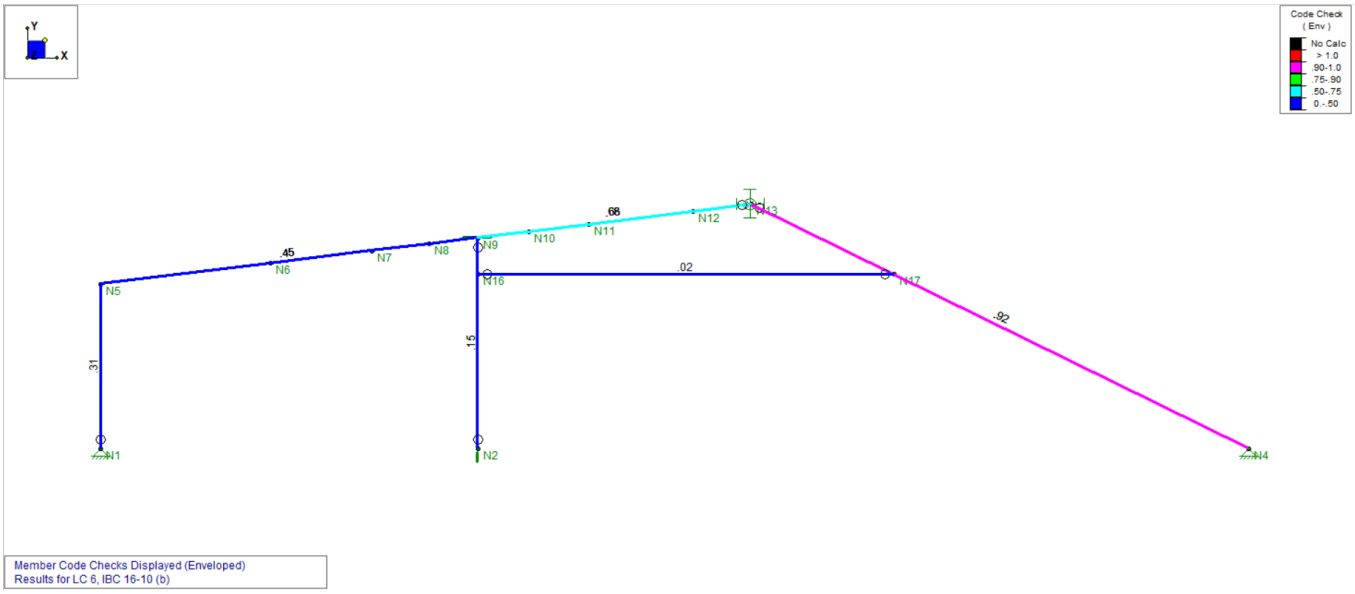
Task: Check roof framing for the added weight of the solar panels.

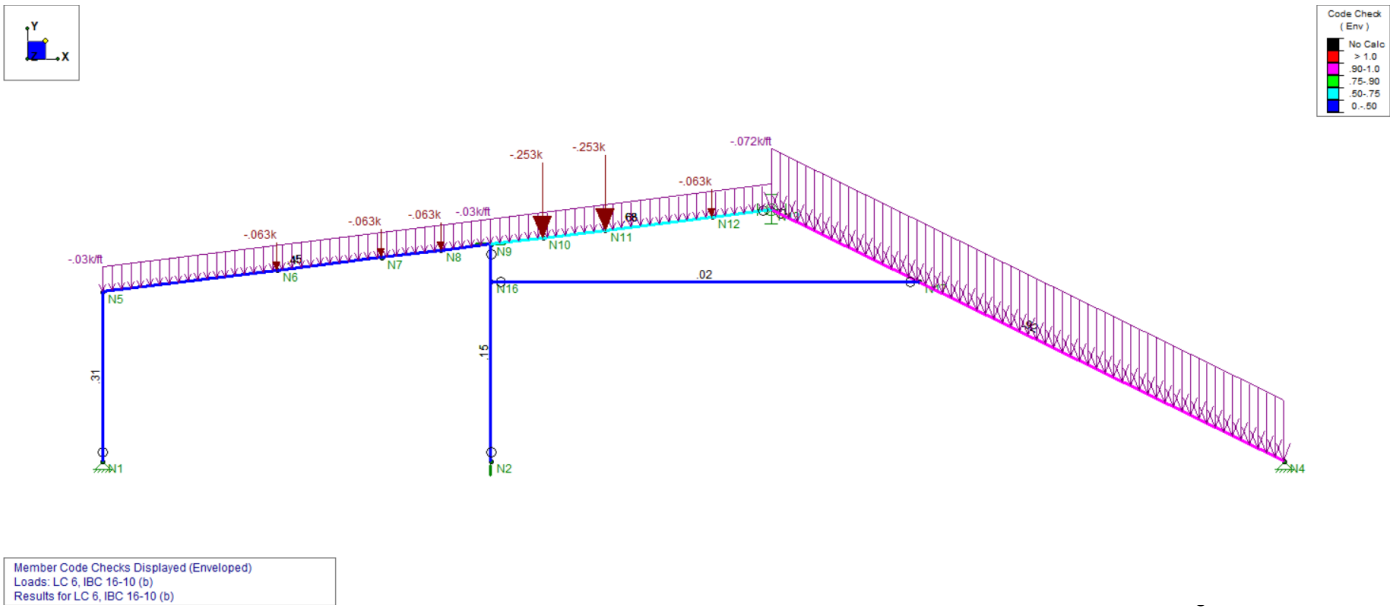
The roof framing plan of the structure was given, as well as the proposed location of the solar panels. The roof will contain 17 total panels.

The current roof at both Section B and Section C is not adequate for the additional loads and requires reinforcement. Sister (2) 2x4 DF Structural Select member to each rafter bearing solar panels, and sister (1) 2x6 DF SS member to each opposing rafter on the north side of the roof. In addition, add a new 6.75x9 GLB beneath each of the 2nd floor bearing walls, as shown below.




Y
X
M1A
M1
M5
M2
M3
M4
N1
N2
N4
N5
N6
N7
N8
N9
N10
N11
N12
N13
N16
N17


Y
X
Code Check
(Env)
No Calc
> 1.0
.90-1.0
.75-.90
.50-.75
0 -.50
.68
.45
.02
.92
.31
.15
N1
N2
N4
N5
N6
N7
N8
N9
N10
N11
N12
N13
N16
N17
Member Code Checks Displayed (Enveloped)
Results for LC 6, IBC 16-10 (b)


Y
X
Code Check
(Env)
No Calc
> 1.0
.90-1.0
.75-.90
.50-.75
0 -.50
-.253k
-.253k
-.072k/ft
-.063k
-.063k
-.063k
-.063k
-.03k/ft
-.03k/ft
.68
.45
.02
.92
.31
.15
N1
N2
N4
N5
N6
N7
N8
N9
N10
N11
N12
N13
N16
N17
Member Code Checks Displayed (Enveloped)
Loads: LC 6, IBC 16-10 (b)
Results for LC 6, IBC 16-10 (b)

Wood Material Properties

	Label	Type	Database	Species	Grade	Cm	Em...	Nu	The...	Dens...
1	DF SS	Solid Sa...	Visually Graded	Douglas Fir-Larch	Select Structural		1	.3	.3	.035
2	DF No.1	Solid Sa...	Visually Graded	Douglas Fir-Larch	No.1		1	.3	.3	.035
3	DF No. 2	Solid Sa...	Visually Graded	Douglas Fir-Larch	No.2		1	.3	.3	.035

Wood Section Sets

	Label	Shape	Type	Design List	Material	Design R...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	Old Rafters	2-2X6	Beam	None	DF SS	Typical	16.5	12.375	41.594	32.615
2	Newer Rafters	3-2X4	Beam	None	DF SS	Typical	15.75	26.578	16.078	39.809
3	Collar Tie	2X4	Beam	None	DF No. 2	Typical	5.25	.984	5.359	2.877
4	Floor Joists	2X6	Beam	None	DF SS	Typical	8.25	1.547	20.797	5.125
5	Verts	2X4	Column	Rectangular	DF SS	Typical	5.25	.984	5.359	2.877

Wood Design Parameters

	Label	Shape	Length[...	le2[ft]	le1[ft]	le-bend to...	le-bend bo...	Kyy	Kzz	CV	Cr	y sway	z sway
1	M1	Newer Raf...	13.098	2	2	Lbyy					Yes		
2	M3	Verts	5.667	2	2						Yes		
3	M4	Verts	7.263	2	2						Yes		
4	M2	Old Rafters	19.12	2	2	Lbyy					Yes		
5	M5	Collar Tie	14.35	2		Lbyy					Yes		
6	M1A	Newer Raf...	9.487			Lbyy							

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diaphragm
1	N1	0	0	0	0	
2	N2	13	0	0	0	
3	N4	39.58333	0	0	0	
4	N5	0	5.6667	0	0	
5	N6	5.83333	6.382939	0	0	
6	N7	9.3333	6.812655	0	0	
7	N8	11.3333	7.058221	0	0	
8	N9	12.999967	7.262865	0	0	
9	N10	14.74996	7.477737	0	0	
10	N11	16.833293	7.733538	0	0	
11	N12	20.416623	8.173516	0	0	
12	N13	22.416623	8.419085	0	0	
13	N16	13	6	0	0	
14	N17	27.35	6	0	0	

Joint Loads and Enforced Displacements (BLC 3 : Solar Dead)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N6	L	Y	-.008
2	N7	L	Y	-.008
3	N8	L	Y	-.008
4	N10	L	Y	-.033
5	N11	L	Y	-.033
6	N12	L	Y	-.008

Joint Loads and Enforced Displacements (BLC 4 : Solar Snow)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N6	L	Y	-.055
2	N7	L	Y	-.055

Joint Loads and Enforced Displacements (BLC 4 : Solar Snow) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
3	N8	L	Y	-.055
4	N10	L	Y	-.22
5	N11	L	Y	-.22
6	N12	L	Y	-.055

Joint Loads and Enforced Displacements (BLC 5 : Solar Wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N6	L	Y	-.015
2	N7	L	Y	-.015
3	N8	L	Y	-.015
4	N10	L	Y	-.06
5	N11	L	Y	-.06
6	N12	L	Y	-.015

Member Distributed Loads (BLC 1 : Dead)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M1	PY	-.03	-.03	0	0
2	M2	PY	-.03	-.03	0	0
3	M1A	PY	-.03	-.03	0	0

Member Distributed Loads (BLC 2 : Snow)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M2	PY	-.05	-.05	0	0

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribut...	Area(Me...	Surface(...
1	Dead	DL						3		
2	Snow	SL						1		
3	Solar Dead	DL				6				
4	Solar Snow	SL				6				
5	Solar Wind	WL				6				

Load Combinations

	Description	Sol...	PDelta	SR..	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...
1	Deflection 1	Yes	Y		DL	1																		
2	Deflection 2	Yes	Y		LL	1																		
3	Deflection 3	Yes	Y		DL	1	LL	1																
4	IBC 16-8	Yes			DL	1																		
5	IBC 16-9	Yes			DL	1	LL	1	LLS	1														
6	IBC 16-10...	Yes			DL	1	SL	1	SLN	1														
7	IBC 16-11...	Yes			DL	1	LL	.75	LLS	.75	SL	.75	SLN	.75										
8	IBC 16-12...	Yes			DL	1	WL	.6																
9	IBC 16-13...	Yes			DL	1	WL	.45	LL	.75	LLS	.75												
10	IBC 16-13...	Yes			DL	1	WL	.45	LL	.75	LLS	.75	SL	.75	SLN	.75								
11	IBC 16-15	Yes			DL	.6	WL	.6																

Envelope Maximum Member Section Forces

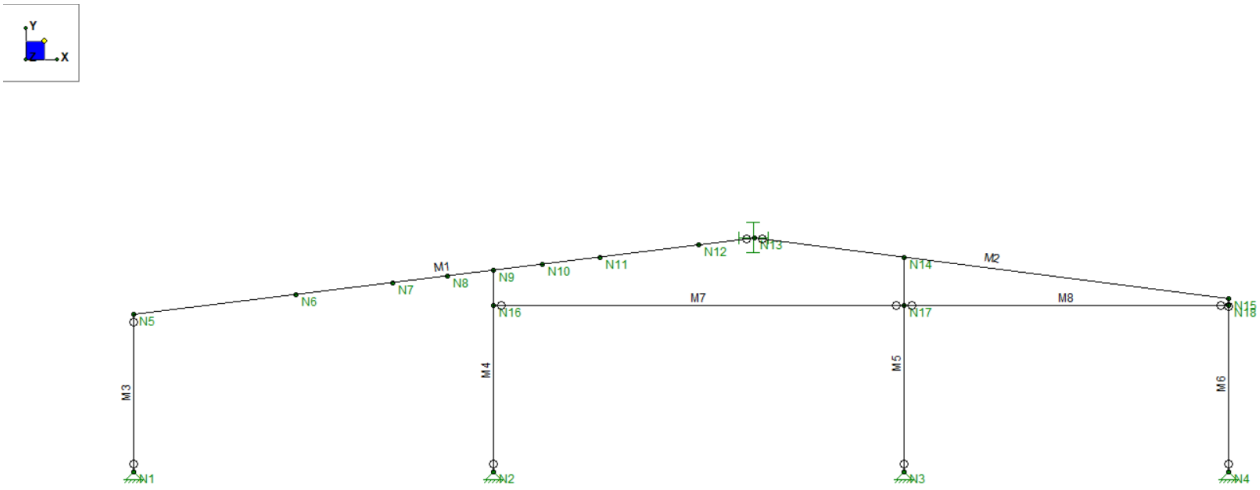
	Member		Axial[k]	Loc[ft]	LC	y Shear...	Loc[ft]	LC	z Shear...	Loc[ft]	LC	Torque[...	Loc[ft]	LC	y-y Mome...	Loc[ft]	LC	z-z Mome...	Loc[ft]	LC
1	M1	m...	.057	0	6	.19	0	6	0	0	11	0	0	11	0	0	11	1.028	13.0...	6
2		min	-.013	13.0...	6	-.385	13.0...	6	0	0	1	0	0	1	0	0	1	-.414	5.867	6
3	M3	m...	.195	0	6	.034	0	6	0	0	11	0	0	11	0	0	11	.191	0	6

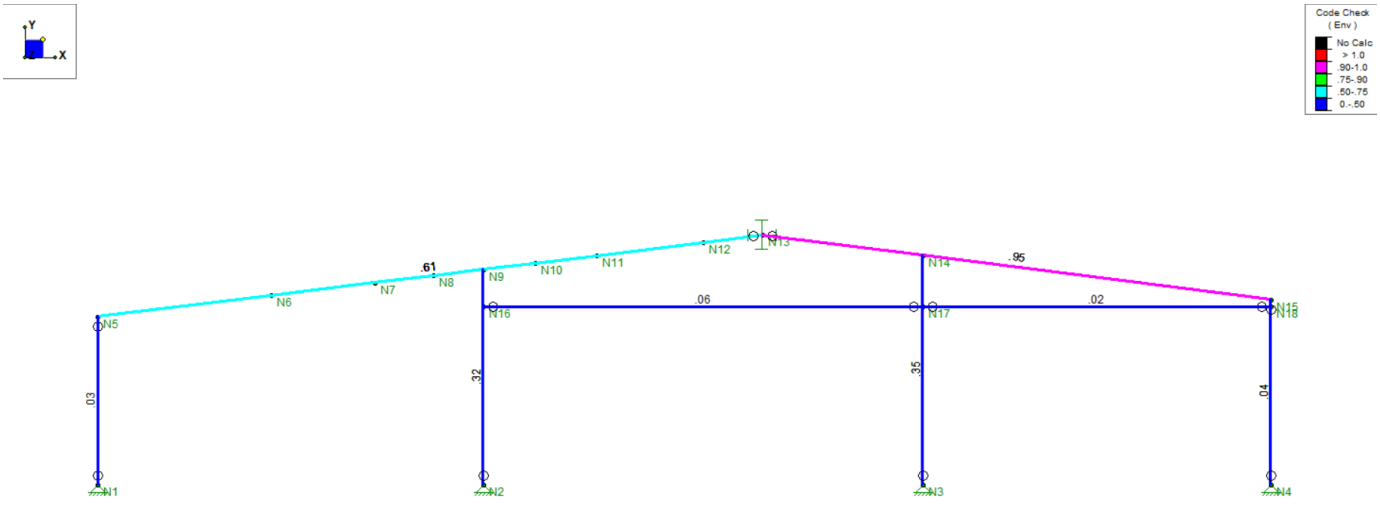
Envelope Maximum Member Section Forces (Continued)

	Member		Axial[k]	Loc[ft]	LC	y Shear...	Loc[ft]	LC	z Shear...	Loc[ft]	LC	Torque[...	Loc[ft]	LC	y-y Mome...	Loc[ft]	LC	z-z Mome...	Loc[ft]	LC
4		min	0	0	2	0	0	2	0	0	1	0	0	1	0	0	1	0	5.667	1
5	M4	m...	1.187	0	6	.073	0	3	0	0	11	0	0	11	0	0	11	0	0	11
6		min	0	0	2	-.015	1.286	1	0	0	1	0	0	1	0	0	1	-.092	1.286	1
7	M2	m...	1.97	19.12	6	.617	0	6	0	0	11	0	0	11	0	0	11	0	0	11
8		min	0	0	2	-.617	19.12	6	0	0	1	0	0	1	0	0	1	-2.947	9.56	6
9	M5	m...	0	0	11	0	0	11	0	0	11	0	0	11	0	0	11	0	0	11
10		min	-.087	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1
11	M1A	m...	1.584	0	6	.615	0	6	0	0	11	0	0	11	0	0	11	1.028	0	6
12		min	0	0	2	-.23	9.487	6	0	0	1	0	0	1	0	0	1	-.6	3.953	6

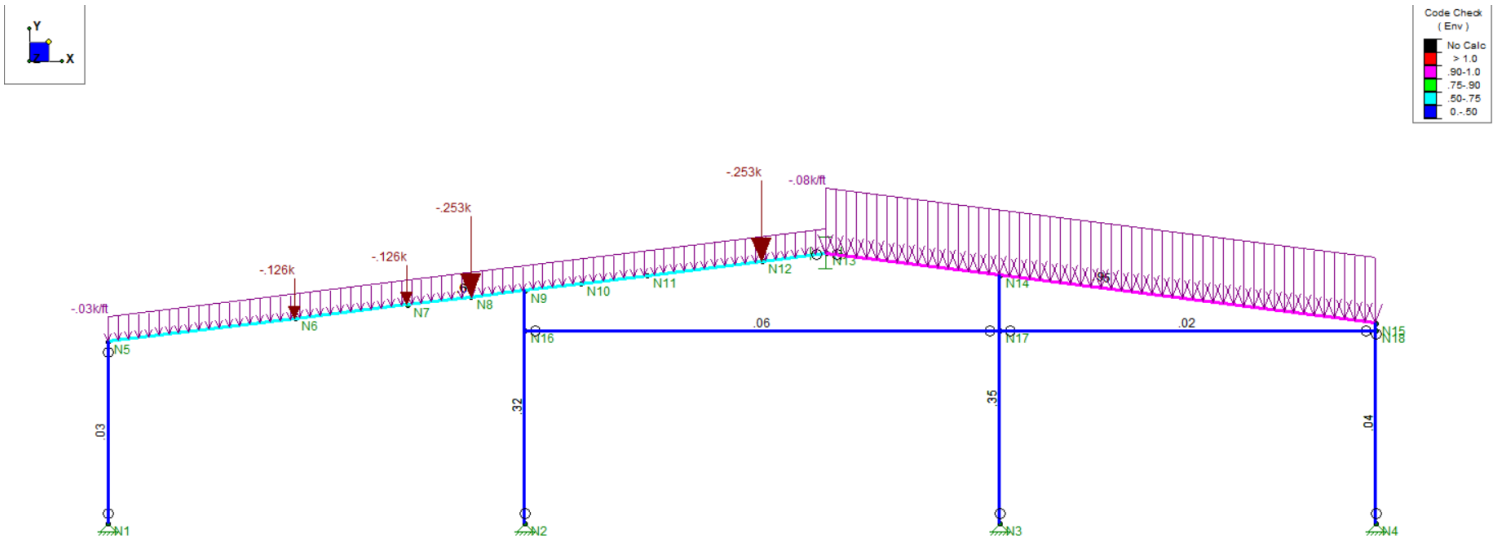
Envelope Wood Code Checks

	Mem...	Shape	Code Check	Loc[ft]	LC	Shear ...	Lo...	Dir	LC	Fc' [...	Ft' [...	Fb1'...	Fb2'...	Fv' [...	RB	CL	CP	Eqn
1	M1	3-2X4	.454	13.0...	6	.177	13...	y	6	1.317	1.725	2.96	3.273	.207	5.212	.995	.586	3.9-3
2	M3	2X4	.307	0	4	.055	0	y	4	1.347	1.35	2.282	2.562	.162	10.2...	.98	.766	3.9-3
3	M4	2X4	.151	1.286	3	.116	0	y	3	1.435	1.5	2.502	2.846	.18	11.6...	.967	.734	3.9-3
4	M2	2-2X6	.919	9.56	6	.271	19...	y	6	1.218	1.495	2.573	2.966	.207	3.83	.998	.567	3.9-3
5	M5	2X4	.019	0	3	.000	0	z	11	.193	.863	1.46	1.708	.288	16.3...	.941	.124	3.9-1
6	M1A	3-2X4	.684	0	6	.283	0	y	6	.481	1.725	2.579	2.846	.207	4.436	.997	.214	3.9-3





Member Code Checks Displayed (Enveloped)
Results for LC 6, IBC 16-10 (b)



Member Code Checks Displayed (Enveloped)
Loads: LC 6, IBC 16-10 (b)
Results for LC 6, IBC 16-10 (b)

Wood Material Properties

	Label	Type	Database	Species	Grade	Cm	Em...	Nu	The...	Dens...
1	DF SS	Solid Sa...	Visually Graded	Douglas Fir-Larch	Select Structural		1	.3	.3	.035
2	DF No.1	Solid Sa...	Visually Graded	Douglas Fir-Larch	No.1		1	.3	.3	.035
3	DF No. 2	Solid Sa...	Visually Graded	Douglas Fir-Larch	No.2		1	.3	.3	.035

Wood Section Sets

	Label	Shape	Type	Design List	Material	Design R...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	Old Rafters	2-2X6	Beam	None	DF No. 2	Typical	16.5	12.375	41.594	32.615
2	Newer Rafters	3-2X4	Beam	None	DF SS	Typical	15.75	26.578	16.078	39.809
3	Collar Tie	2X4	Beam	None	DF No. 2	Typical	5.25	.984	5.359	2.877
4	Floor Joists	2X6	Beam	None	DF SS	Typical	8.25	1.547	20.797	5.125
5	Verts	2X4	Column	Rectangular	DF SS	Typical	5.25	.984	5.359	2.877

Wood Design Parameters

	Label	Shape	Length[...	le2[ft]	le1[ft]	le-bend to...	le-bend bo...	Kyy	Kzz	CV	Cr	y sway	z sway
1	M1	Newer Raf...	22.585	2	2	Lbyy					Yes		
2	M2	Old Rafters	17.303	2	2	Lbyy					Yes		
3	M3	Verts	5.667	2	2						Yes		
4	M4	Verts	7.263	2	2						Yes		
5	M5	Verts	7.735	2	2						Yes		
6	M6	Verts	6.25	2	2						Yes		
7	M7	Collar Tie	14.833	2	2	Lbyy					Yes		
8	M8	Collar Tie	11.75	2		Lbyy					Yes		

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diaphragm
1	N1	0	0	0	0	
2	N2	13	0	0	0	
3	N3	27.8333	0	0	0	
4	N4	39.58333	0	0	0	
5	N5	0	5.6667	0	0	
6	N6	5.83333	6.382939	0	0	
7	N7	9.3333	6.812655	0	0	
8	N8	11.3333	7.058221	0	0	
9	N9	12.999967	7.262865	0	0	
10	N10	14.74996	7.477737	0	0	
11	N11	16.833293	7.733538	0	0	
12	N12	20.416623	8.173516	0	0	
13	N13	22.416623	8.419085	0	0	
14	N14	27.8333	7.7351	0	0	
15	N15	39.58333	6.25	0	0	
16	N16	13	6	0	0	
17	N17	27.8333	6	0	0	
18	N18	39.58333	6	0	0	

Joint Loads and Enforced Displacements (BLC 3 : Solar Dead)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N6	L	Y	-.016
2	N7	L	Y	-.016
3	N8	L	Y	-.033
4	N12	L	Y	-.033

Joint Loads and Enforced Displacements (BLC 4 : Solar Snow)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N6	L	Y	-.11
2	N7	L	Y	-.11
3	N8	L	Y	-.22
4	N12	L	Y	-.22

Joint Loads and Enforced Displacements (BLC 5 : Solar Wind)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/f...
1	N6	L	Y	-.03
2	N7	L	Y	-.03
3	N8	L	Y	-.06
4	N12	L	Y	-.06

Member Distributed Loads (BLC 1 : Dead)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M1	Y	-.03	-.03	0	0
2	M2	Y	-.03	-.03	0	0

Member Distributed Loads (BLC 2 : Snow)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,F...	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.05	-.05	0	0

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribut...	Area(Me...	Surface(...
1	Dead	DL						2		
2	Snow	SL						1		
3	Solar Dead	DL				4				
4	Solar Snow	SL				4				
5	Solar Wind	WL				4				

Load Combinations

	Description	Sol...	PDelta	SR...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...	BLC	Fac...
1	Deflection 1	Yes	Y		DL	1																		
2	Deflection 2	Yes	Y		LL	1																		
3	Deflection 3	Yes	Y		DL	1	LL	1																
4	IBC 16-8	Yes			DL	1																		
5	IBC 16-9	Yes			DL	1	LL	1	LLS	1														
6	IBC 16-10...	Yes			DL	1	SL	1	SLN	1														
7	IBC 16-11...	Yes			DL	1	LL	.75	LLS	.75	SL	.75	SLN	.75										
8	IBC 16-12...	Yes			DL	1	WL	.6																
9	IBC 16-13...	Yes			DL	1	WL	.45	LL	.75	LLS	.75												
10	IBC 16-13...	Yes			DL	1	WL	.45	LL	.75	LLS	.75	SL	.75	SLN	.75								
11	IBC 16-15	Yes			DL	.6	WL	.6																

Envelope Maximum Member Section Forces

	Member		Axial[k]	Loc[ft]	LC	y Shear...	Loc[ft]	LC	z Shear...	Loc[ft]	LC	Torque[...	Loc[ft]	LC	y-y Mome...	Loc[ft]	LC	z-z Mome...	Loc[ft]	LC
1	M1	m...	.332	13.1...	6	.34	13.1...	6	0	0	11	0	0	11	0	0	11	1.376	13.1...	6
2		min	-.079	12.9...	6	-.646	12.9...	6	0	0	1	0	0	1	0	0	1	-.902	5.882	6
3	M2	m...	.36	5.407	6	.595	5.587	6	0	0	11	0	0	11	0	0	11	1.809	5.407	6
4		min	-.005	5.587	11	-.549	5.407	6	0	0	1	0	0	1	0	0	1	-.704	13.1...	6
5	M3	m...	.243	0	6	0	0	11	0	0	11	0	0	11	0	0	11	0	0	11
6		min	0	0	2	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1

Envelope Maximum Member Section Forces (Continued)

	Member		Axial[k]	Loc[ft]	LC	y Shear...	Loc[ft]	LC	z Shear...	Loc[ft]	LC	Torque[...	Loc[ft]	LC	y-y Mome...	Loc[ft]	LC	z-z Mome...	Loc[ft]	LC
7	M4	m...	1.035	0	6	.288	0	6	0	0	11	0	0	11	0	0	11	.218	0	6
8		min	0	0	2	-.024	1.286	6	0	0	1	0	0	1	0	0	1	-.145	1.286	6
9	M5	m...	1.194	0	6	.021	1.773	6	0	0	11	0	0	11	0	0	11	.124	1.773	6
10		min	0	0	2	-.205	0	6	0	0	1	0	0	1	0	0	1	-.231	0	6
11	M6	m...	.348	0	6	.003	.26	6	0	0	11	0	0	11	0	0	11	.021	.26	6
12		min	0	0	2	-.083	0	6	0	0	1	0	0	1	0	0	1	0	0	1
13	M7	m...	0	0	2	0	0	11	0	0	11	0	0	11	0	0	11	0	0	11
14		min	-.312	0	6	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1
15	M8	m...	0	0	2	0	0	11	0	0	11	0	0	11	0	0	11	0	0	11
16		min	-.086	0	6	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1

Envelope Wood Code Checks

	Mem...	Shape	Code Check	Loc[ft]	LC	Shear ...	Lo...	Dir	LC	Fc' [...	Ft' [...	Fb1'...	Fb2'...	Fv' [...	RB	CL	CP	Eqn
1	M1	3-2X4	.611	13.1...	6	.297	12....	y	6	1.317	1.725	2.946	3.273	.207	6.844	.99	.586	3.9-3
2	M2	2-2X6	.946	5.407	6	.262	5.5...	y	6	.971	.86	1.519	1.779	.207	11.2...	.981	.569	3.9-3
3	M3	2X4	.030	0	6	.000	0	z	11	1.547	1.725	2.892	3.273	.288	10.2...	.972	.688	3.6.3
4	M4	2X4	.321	0	6	.398	0	y	6	1.547	1.725	2.852	3.273	.207	11.6...	.958	.688	3.9-3
5	M5	2X4	.347	0	6	.283	0	y	6	1.547	1.725	2.838	3.273	.207	12.0...	.954	.688	3.9-3
6	M6	2X4	.043	.26	6	.114	0	y	6	1.547	1.725	2.878	3.273	.207	10.8...	.967	.688	3.6.3
7	M7	2X4	.060	0	6	.000	0	z	11	1.264	.992	1.636	1.964	.288	16.64	.916	.708	3.9-1
8	M8	2X4	.017	0	6	.000	0	z	11	.285	.992	1.691	1.964	.288	14.81	.947	.16	3.9-1

Multiple Simple Beam

Description :

Wood Beam Design : BM1 - Upper Floor Joists

Calculations per NDS 2018, IBC 2018, CBC 2019, ASCE 7-16

BEAM Size : **6.75x9, GLB, Fully Braced**
Using Allowable Stress Design with ASCE 7-16 Load Combinations, Major Axis Bending

Wood Species : DF/DF Wood Grade : 24F-V8

Fb - Tension	2,400.0 psi	Fc - Prll	1,650.0 psi	Fv	265.0 psi	Ebend- xx	1,800.0 ksi	Density	31.210 pcf
Fb - Compr	2,400.0 psi	Fc - Perp	650.0 psi	Ft	1,100.0 psi	Eminbend - xx	950.0 ksi		

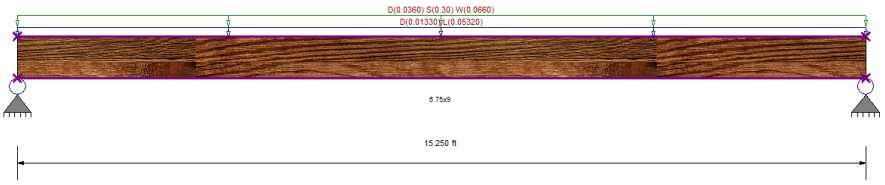
Applied Loads

Unif Load: D = 0.010, L = 0.040 k/ft, Trib= 1.330 ft
Unif Load: D = 0.0030, S = 0.0250, W = 0.00550 k/ft, Trib= 12.0 ft

Design Summary

Max fb/Fb Ratio = **0.484** : 1
fb : Actual : 1,337.19 psi at 7.625 ft in Span # 1
Fb : Allowable : 2,760.00 psi
Load Comb : +D+S+H

Max fv/FvRatio = **0.196** : 1
fv : Actual : 59.63 psi at 14.538 ft in Span # 1
Fv : Allowable : 304.75 psi
Load Comb : +D+S+H



Max Reactions (k)

	D	L	Lr	S	W	E	H
Left Support	0.38	0.41		2.29	0.50		
Right Support	0.38	0.41		2.29	0.50		

Max Deflections

Transient Downward	0.497 in	Total Downward	0.579 in
Ratio	368	Ratio	316
	LC: S Only		LC: +D+S+H
Transient Upward	0.000 in	Total Upward	0.000 in
Ratio	9999	Ratio	9999
	LC:		LC: