21-097268 REV 01 RS

STRUCTURAL CALCULATIONS
Residential Improvement

PROJECT:

Steve Erickson - Solar
3033 Northeast 44th Avenue
Portland, OR 97213

for

Elemental Energy
1339 SE 8th Ave.
Portland, OR 97214

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Erickson 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 Roof Dead Load = 15 PSF
Solar Dead Load = 3.5 PSF
Wind: 98 MPH, EXP B (ASCE 7-16, Risk Category II)

Design Summary:

The following calculations are for the proposed roof mounted solar array located at 3033 Northeast 44th Avenue in Portland, OR. The structure is a wood framed residence. For this specific project, the gravity loads were checked for the new loads associated with the solar racking on the existing roof system. The panel to roof connections were also checked. The lateral system of the house is existing and will remain as there is no increase in lateral loads for this upgrade.

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 architectural drawings furnished by the client.

Design

Goal: Install Solar panels at Residence

Authority having Juristiction

Governing Code	City of Portland	
	State of Oregon	OSSC
	Country of U.S.A.	IBC / ASCE

ASCE Loading			**Building Properties**		
Dead Load:	15	PSF	W, Least:	30	ft.
Snow Load:	20	PSF	W, Most:	33	ft.
			H, Height:	14	ft.
			Roof angle:	45	deg.

Generate Wind Load Per ASCE 7-16

Wind Load parameters per ASCE 7-16 chap 26

Design Cat:	II	
Exposure:	B	
H= 14 ft., Kz =	0.57	Velocity Pressure Coefficient (Table 26.10-1)
Kzt =	1	Topography Coefficient
Kd =	0.85	Directionality(Building config) (Table 26.6-1)
Elevation =	100	ft.
Ke =	1	Ground elevation factor
V =	98	mph
qh =	0.00256*Kz*Kzt*Kd*Ke*V^2	
qh =	**11.9**	**psf**
Wind zone edge distance, A =	3	ft.

Design Check Summary, solar hardware

Iron Ridge XR100 downward:	0.77	< 1.0 – rail okay
Iron Ridge XR100 upward:	0.21	< 1.0 – rail okay
Iron Ridge Flashfoot 2 Attachment capacity:	0.17	< 1.0 - foot okay

Wind Loads to PV System Calculated per SEAOC PV2-2017

Roof Angle:	Φ =	45	deg.
Panel flush with roof	W =	0	deg.
Net area Calc	Panel Length =	6.53	ft. Portrait / panel
	Footing OC Spacing =	4	ft. OC
	A = Area = Panel Length/2 * OC =	13.1	ft.^2
	Lb =	=MIN(0.4*(14*33)^0.5,14,30)	
	Lb =	8.6	
	An =	1000 / (MAX(8.6,15))*A	
	An =	66.7	(ft^-2)*A
Effective Wind Area	An =	874	sq. ft.

Design with C&C (GCp) from ASCE 7-16 Table 30.3-5 27-45 degrees gable

Pressure Equalization Factor	Ya =	0.8	
Edge Factor	YE =	1	Interior, All
	YE =	1.5	Edge, uplift factor

		Interior	Exterior
Roof Wind Zone	GCp	p - Wind Pressure (psf)	p - Wind Pressure (psf)
All Zones	0.50	4.8	4.8
1, 2e, 2r	-0.80	-7.6	-11.4
2n, 3r	-1.00	-9.5	-14.3
3e	-1.00	-9.5	-14.3

p = qh * GCp * Ya * Ye

qh = 11.9

For conservative uplift design use zone 3e

Design wind pressure is 4.8 psf (down)

Design wind pressure is -14.3 psf (uplift)

PV System Design

Panel: Silfab SIL-380

Panel orientation to slope: Portrait

Panel Properties: Silfab SIL-380 in Portrait orientation.

Lp:	78.4	in.	-->	6.53	ft.
W:	39.1	in.	-->	3.26	ft.
Weight:	48	lbs.		2.3	psf

For purposes of calculation "W" is parallel to railing

Check Rail Capacity for Design Loads

Rail: Iron Ridge XR100

Applied Loads to Rail

Solar DL =	3.5	psf	Includes rails, inverters, and misc.
Snow =	20	psf	
Wind Down =	4.8	psf	
Wind Uplift =	-14.3	psf	
Panel Length Lp =	6.53	ft.	
Lp/2=	3.27	ft.	
DL+SL =	23.5	psf	<- Controls
DL+.75*.6WL+.75SL =	20.7	psf	

Try Iron Ridge XR100 Racking - Downward

Load Down =	77	plf	Load = (Lp/2) * LF = LF(PSF)=3.27*23.5		
L = span of rails =	5.5	ft.	=	66	in.
M = 1/8 * PLF * L^2 =	291	lb-ft.	=	3487	lb.-in.
S_P =	0.297	in^3			
$f_b = M / S_P$ =	11740	psi			
F_b =	15200	psi			
f_b / F_b =	0.77	< 1.0 – rail okay			

Try Iron Ridge XR100 Racking - Upward

.6DL+.6WL =	-6.5	psf			
Load Up =	-21.2	plf			
L = span of rails =	5.5	ft.			
M = 1/8 * PLF * L^2 =	-80	lb.-ft.	=	-961	lb.-in.
S_P =	0.30	in.^3			
$f_b = M / S_P$ =	-3237	psi			
F_b =	15200	psi			
f_b / F_b =	0.21	< 1.0 – rail okay			

Generate Design Loads to Roof

Roof properties and loading

Rafter Spacing:	16	in. OC			
DL:	15	PSF	Rafter DL:	20.0	plf
SL:	20	PSF	Rafter SL:	25.0	plf

Solar Panel Dimensions: Portrait Orientation

Lp	78.4	in. =	6.53	ft.	*spans rail to rail
W	39.1	in. =	3.26	ft.	*along rail

Point load to roof: Portrait Orientation

Trib length (in)	area trib per leg (sq. ft.)	Solar DL (#)	Snow (#)	Wind Down (#)	Wind Uplift Zone	Uplift Pressure, (PSF)	Wind Uplift (#)
24.0	6.5	22.9	130.7	31.4	3e	-14.3	-93.4
48.0	13.1	45.7	261.3	62.7	2n, 3r	-9.5	-124.1
48.0	13.1	45.7	261.3	62.7	2n, 3r	-14.3	-186.9
	area = Trib length* Lp /2					Max	-186.9

Check Connection to Structure W/ Iron Ridge Flashfoot 2

Footing Load Calculations

Maximum Uplift Load

Solar DL:	3.5	PSF		
Wind Uplift:	-14.3	PSF, exterior		
Ftg Spacing				
Trib length:	48.0	in. =	4.00	ft.

13.07 sq. ft. per leg (area = Trib* L /2)

Point Load To roof

Solar DL:	45.7	lbs
Wind Uplift:	-186.9	lbs

Uplift Load: 0.6*DL+0.6*WL

Rup = Demand = L(span) * Load up = Uplift: -85 lbs

Try (1) 5/16" lag bolt

T_{allow} = 1 bolt * 3 in. embed * 266 lbs/in. * (2/3) * 1.6 = 851 lbs

Rup / Tallow = 85# / 851# = 0.1 < 1.0 - foot okay

Use L-Foot W/ (1) 5/16" lag bolt (with minimum embedment of 3 in.) at 4 ft. maximum spacing

Wind Loads to PV System Calculated per SEAOC PV2-2017

Roof Angle:	Φ =	21	deg.
Panel flush with roof	W =	0	deg.
Net area Calc	Panel Length =	5.32	ft. Portrait / panel
	Footing OC Spacing =	4	ft. OC
	A = Area = Panel Length/2 * OC =	10.6	ft.^2
	Lb =	=MIN(0.4*(18.5*33)^0.5,18.5,30)	
	Lb =	9.9	
	An =	1000 / (MAX(9.9,15))*A	
	An =	66.7	(ft^-2)*A
Effective Wind Area	An =	707	sq. ft.

Design with C&C (GCp) from ASCE 7-16 Table 30.3-4 20 - 27 degrees gable

Pressure Equalization Factor	Ya =	0.8	
Edge Factor	YE =	1	Interior, All
	YE =	1.5	Edge, uplift factor

		Interior	Exterior
Roof Wind Zone	GCp	p - Wind Pressure (psf)	p - Wind Pressure (psf)
All Zones	0.30	3.0	3.0
1, 2e	-0.80	-8.1	-12.2
2n, 2r, 3r	-1.20	-12.2	-18.3
3e	-1.80	-18.3	-27.4

p = qh * GCp * Ya * Ye

qh = 12.7

For conservative uplift design use zone 3e

Design wind pressure is 3 psf (down)

Design wind pressure is -27.4 psf (uplift)

PV System Design

Panel: Solaria XT-370R
Panel orientation to slope: Portrait

Panel Properties: Solaria XT-370R in Portrait orientation.

Lp:	63.8	in.	-->	5.32	ft.
W:	43.9	in.	-->	3.66	ft.
Weight:	46	lbs.		2.4	psf

For purposes of calculation "W" is parallel to railing

Check Rail Capacity for Design Loads

Rail: Iron Ridge XR100

Applied Loads to Rail

Solar DL =	3.5	psf	Includes rails, inverters, and misc.
Snow =	20	psf	
Wind Down =	3.0	psf	
Wind Uplift =	-27.4	psf	
Panel Length Lp =	5.32	ft.	
Lp/2=	2.66	ft.	
DL+SL =	23.5	psf	<- Controls
DL+.75*.6WL+.75SL =	19.9	psf	

Try Iron Ridge XR100 Racking - Downward

Load Down =	63	plf	Load = (Lp/2) * LF = LF(PSF)=2.66*23.5		
L = span of rails =	5.5	ft.	=	66	in.
$M = 1/8 * PLF * L^2$ =	236	lb-ft.	=	2836	lb.-in.
S_P =	0.297	in^3			
$f_b = M / S_P$ =	9550	psi			
F_b =	15200	psi			
f_b / F_b =	0.63	< 1.0 – rail okay			

Try Iron Ridge XR100 Racking - Upward

.6DL+.6WL =	-14.3	psf			
Load Up =	-38.1	plf			
L = span of rails =	5.5	ft.			
$M = 1/8 * PLF * L^2$ =	-144	lb.-ft.	=	-1731	lb.-in.
S_P =	0.30	in.^3			
$f_b = M / S_P$ =	-5828	psi			
F_b =	15200	psi			
f_b / F_b =	0.38	< 1.0 – rail okay			

Generate Design Loads to Roof

Roof properties and loading

Rafter Spacing:	16	in. OC			
DL:	15	PSF	Rafter DL:	20.0	plf
SL:	20	PSF	Rafter SL:	25.0	plf

Solar Panel Dimensions: Landscape Orientation

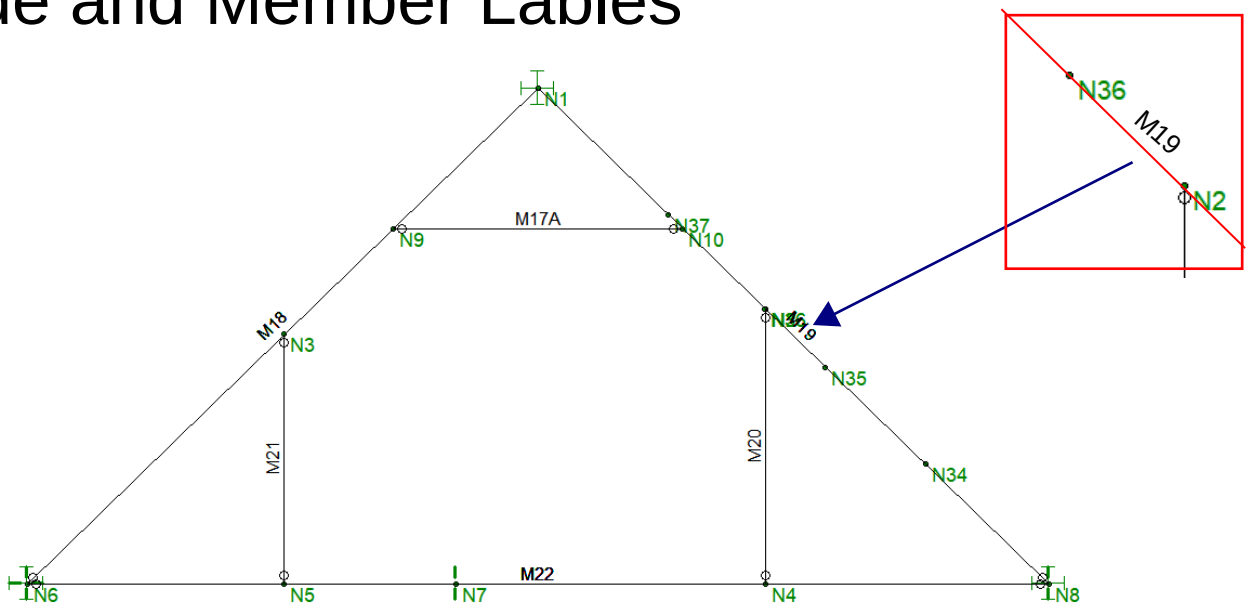
Lp	43.9	in. =	3.66	ft.	*spans rail to rail
W	63.8	in. =	5.32	ft.	*along rail

Point load to roof: Landscape Orientation

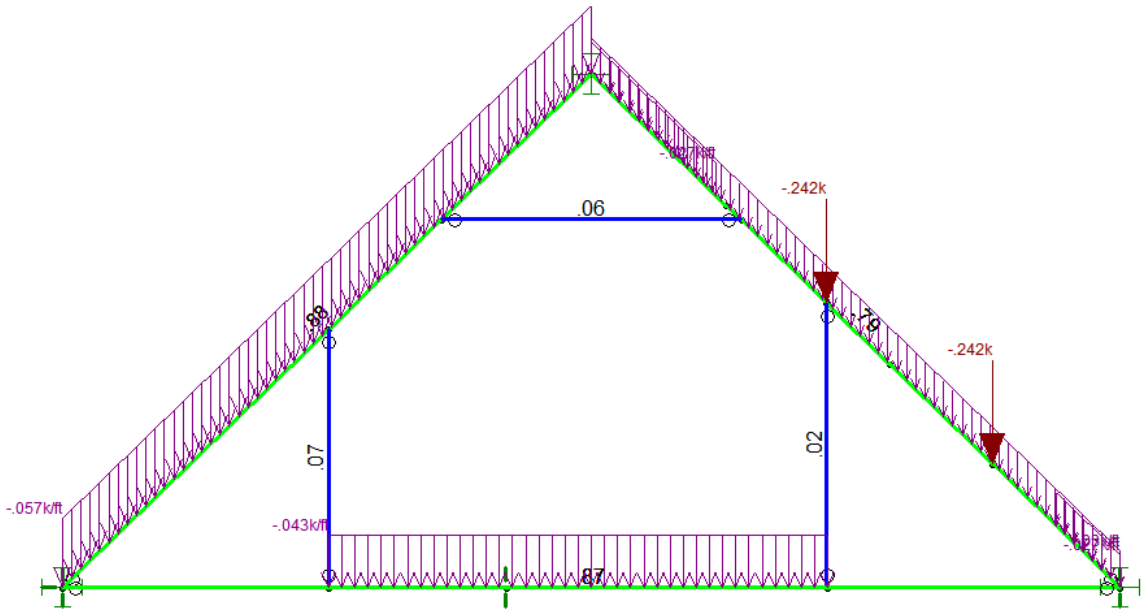
Trib length (in)	area trib per leg (sq. ft.)	Solar DL (#)	Snow (#)	Wind Down (#)	Wind Uplift Zone	Uplift Pressure, PSF	Wind Uplift #
24.0	3.7	12.8	73.2	11.0	3e	-27.4	-100.2
48.0	7.3	25.6	146.3	22.0	2n, 2r, 3r	-18.3	-133.9
48.0	7.3	25.6	146.3	22.0	2n, 2r, 3r	-18.3	-133.9
	area = Trib length* Lp /2					Max	-133.9

Section 1

Node and Member Lables

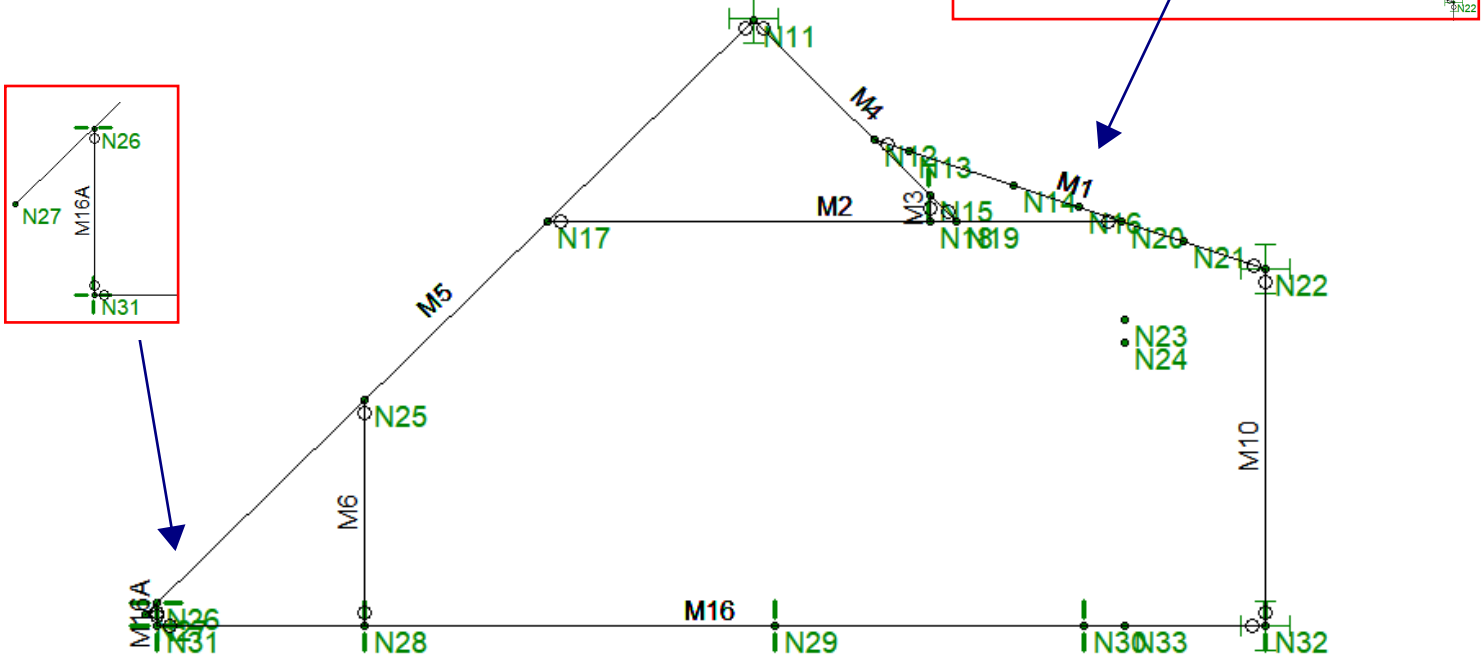


Loading and Design stress ratios

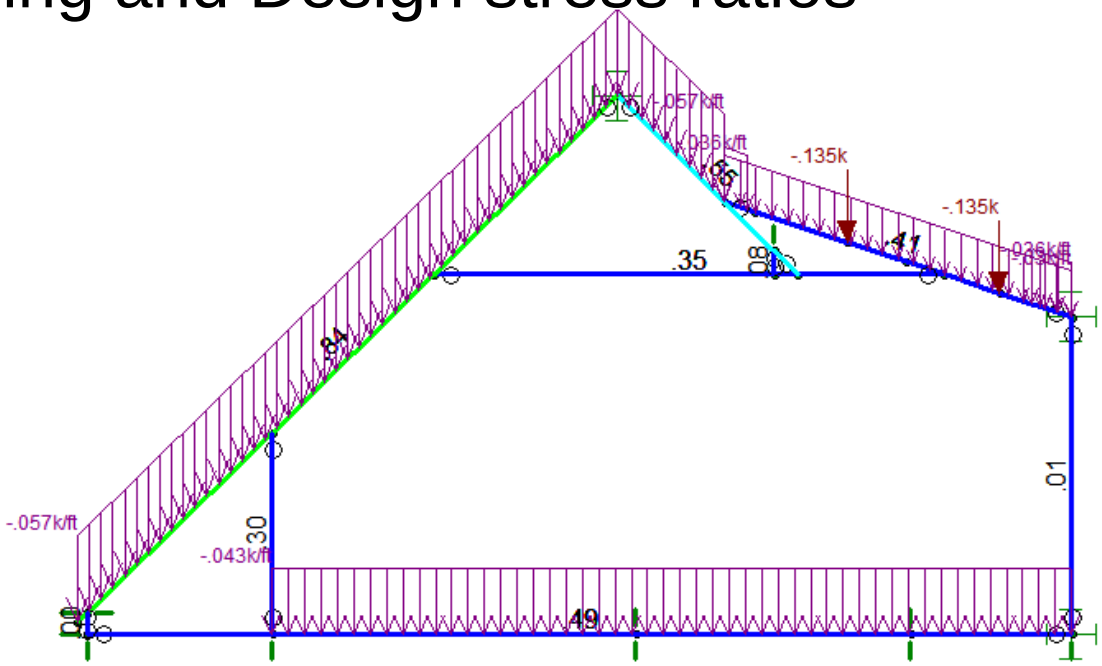


Section 2

Node and Member Lables



Loading and Design stress ratios



Basic Load Cases

	BLC Description	Category	X Gra...	Y Gra...	Z Gra...	Joint	Point	Distrib...	Area(Member)	Surface(Plate/Wall)
1	DL	DL				4		5		
2	SL	SL				4		7		
3	LL	LL						2		

Load Combinations

	Description	Solve	PDel...	S...	B...	Fa...	BLC	Fa...	BLC	F...	BLC	Fa...	BLC	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...
1	IBC 16-8	Yes			DL	1																		
2	IBC 16-9	Yes			DL	1	LL	1	LLS	1														
3	IBC 16-10 (b)	Yes			DL	1	SL	1	SLN	1														
4	IBC 16-11 (b)	Yes			DL	1	LL	.75	LLS	.75	SL	.75	SLN	.75										

Joint Coordinates and Temperatures

	Label	X [in]	Y [in]	Z [in]	Temp [F]	Detach From Di...
1	N1	143	438.45	0	0	
2	N2	206.66	376.793987	0	0	
3	N3	71.99	369.699409	0	0	
4	N4	206.66	300	0	0	
5	N5	71.99	300	0	0	
6	N6	0	300	0	0	
7	N7	120	300	0	0	
8	N8	285.95	300	0	0	
9	N9	102.56338	399.3	0	0	
10	N10	183.422481	399.3	0	0	
11	N11	149.05	151.31	0	0	
12	N12	179.125478	121.448202	0	0	
13	N13	187.54	118.69	0	0	
14	N14	213.66	110.11	0	0	
15	N15	192.97	107.702043	0	0	
16	N16	230.05	104.73	0	0	
17	N17	97.483184	101	0	0	
18	N18	192.97	101	0	0	
19	N19	199.72	101	0	0	
20	N20	240.874843	101	0	0	
21	N21	256.35	95.85	0	0	
22	N22	276.75	89.12	0	0	
23	N25	51.88	56.508283	0	0	
24	N26	0	5.892732	0	0	
25	N27	-2.76	3.2	0	0	
26	N28	51.88	0	0	0	
27	N29	154.29	0	0	0	
28	N30	231.39	0	0	0	
29	N31	0.	-0.	0	0	
30	N32	276.75	-0.	0	0	
31	N34	251.46	333.404271	0	0	
32	N35	223.52	360.464732	0	0	
33	N36	206.51	376.939265	0	0	
34	N37	179.47	403.128059	0	0	

Joint Loads and Enforced Displacements (BLC 1 : DL)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/in, k*s^2*in)]
1	N14	L	Y	-.026

Joint Loads and Enforced Displacements (BLC 1 : DL) (Continued)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/in, k*s^2*in)]
2	N21	L	Y	-.026
3	N34	L	Y	-.046
4	N36	L	Y	-.046

Joint Loads and Enforced Displacements (BLC 2 : SL)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/in, k*s^2*in)]
1	N14	L	Y	-.146
2	N21	L	Y	-.146
3	N34	L	Y	-.261
4	N36	L	Y	-.261

Member Distributed Loads (BLC 1 : DL)

	Member Label	Direction	Start Magnitude[...	End Magnitude[k/ft,F,ksf]	Start Location...	End Location[in,%]
1	M5	Y	-.03	-.03	0	0
2	M4	Y	-.03	-.03	29	0
3	M1	Y	-.03	-.03	0	0
4	M18	Y	-.03	-.03	0	0
5	M19	Y	-.03	-.03	0	0

Member Distributed Loads (BLC 2 : SL)

	Member Label	Direction	Start Magnitude[...	End Magnitude[k/ft,F,ksf]	Start Location...	End Location[in,%]
1	M18	PY	-.05	-.05	0	0
2	M19	PY	-.05	-.05	0	24
3	M19	PY	-.05	-.05	152	0
4	M5	PY	-.05	-.05	0	0
5	M4	PY	-.05	-.05	29	0
6	M1	PY	-.05	-.05	0	12
7	M1	PY	-.05	-.05	96	0

Member Distributed Loads (BLC 3 : LL)

	Member Label	Direction	Start Magnitude[...	End Magnitude[k/ft,F,ksf]	Start Location...	End Location[in,%]
1	M22	Y	-.057	-.057	72	207
2	M16	Y	-.057	-.057	52	0

Wood Material Properties

	Label	Type	Database	Species	Grade	Cm	Emod	Nu	Ther...	Dens[...
1	DF	Solid Sawn	Visually Graded	Douglas Fir-Larch	No.1		1	.3	.3	.035
2	SP	Solid Sawn	Visually Graded	Southern Pine	No.1		1	.3	.3	.035
3	HF	Solid Sawn	Visually Graded	Hem-Fir	No.1		1	.3	.3	.035
4	SPF	Solid Sawn	Visually Graded	Spruce-Pine-fir	No.1		1	.3	.3	.035
5	24F-1.8E...	Glulam	NDS Table 5A	24F-1.8E_DF_BAL	na		1	.3	.3	.035
6	24F-1.8E...	Glulam	NDS Table 5A	24F-1.8E_DF_U...	na		1	.3	.3	.035
7	24F-1.8E...	Glulam	NDS Table 5A	24F-1.8E_SP_BAL	na		1	.3	.3	.035
8	24F-1.8E...	Glulam	NDS Table 5A	24F-1.8E_SP_U...	na		1	.3	.3	.035

Wood Section Sets

	Label	Shape	Type	Design List	Material	Design R...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	WOOD1A	2X6	Beam	None	DF	Typical	8.25	1.547	20.797	5.125
2	Rafter	2X6	Beam	None	DF	Typical	8.25	1.547	20.797	5.125
3	Collar	2X6	Beam	None	DF	Typical	8.25	1.547	20.797	5.125
4	Knee	2X6	Column	Rectangular	DF	Typical	8.25	1.547	20.797	5.125

Wood Section Sets (Continued)

	Label	Shape	Type	Design List	Material	Design R...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
5	Joist1	2X6	Beam	None	DF	Typical	8.25	1.547	20.797	5.125
6	Joist2	2X8	Beam	None	DF	Typical	10.875	2.039	47.635	7.093

Wood Design Parameters

	Label	Shape	Lengt...	le2[in]	le1[in]	le-bend top[in]	le-bend bot[in]	Kyy	Kzz	CV	Cr	y sway	z sway
1	M1	Rafter	102.8...	12	12	Lbyy					Yes		
2	M2	Collar	143.3...	48	12	Lbyy					Yes		
3	M3	Knee	6.702			Lbyy							
4	M4	Rafter	71.404	12	12	Lbyy					Yes		
5	M5	Rafter	212.0...	12	12	Lbyy					Yes		
6	M6	Knee	56.508			Lbyy							
7	M10	Knee	89.12	12	12	Lbyy							
8	M16	Joist1	276.75	12	12	Lbyy					Yes		
9	M18	Rafter	199.0...	12	12	Lbyy					Yes		
10	M19	Rafter	199.0...	12	12	Lbyy					Yes		
11	M20	Knee	76.794	12		Lbyy							
12	M21	Knee	69.699			Lbyy							
13	M22	Joist1	285.95	12	12	Lbyy					Yes		
14	M16A	Knee	5.893			Lbyy							
15	M17A	Collar	80.859	12	12	Lbyy							

Envelope Wood Code Checks

	Me...	Sha...	Code Check	Loc[in]	LC	Shea...	Loc[in]	...	LC	Fc' [ksi]	Ft' [...	Fb...	Fb2' [ksi]	Fv' ...	RB	CL	CP	Eqn
1	M1	2X6	.411	67.16	3	.156	38.827	y	3	1.793	1.009	1.7...	1.977	.207	5.4...	.996	.945	3.9-1
2	M2	2X6	.346	95.107	3	.559	96.57	y	3	.468	1.009	1.5...	1.977	.207	18....	.887	.247	3.9-3
3	M3	2X6	.081	0	3	.000	0	z	4	1.868	1.009	1.4...	1.719	.207	4.0...	.998	.984	3.9-1
4	M4	2X6	.546	28.416	3	.350	0	y	3	1.793	1.009	1.6...	1.977	.207	13....	.969	.945	3.9-3
5	M5	2X6	.840	75.747	3	.301	77.911	y	3	1.793	1.009	1.2...	1.977	.207	22....	.734	.945	3.9-3
6	M6	2X6	.297	0	3	.000	0	z	4	.344	1.009	1.4...	1.719	.207	11....	.982	.182	3.6.3
7	M10	2X6	.010	0	3	.000	0	z	4	1.793	1.009	1.4...	1.719	.207	14....	.965	.945	3.6.3
8	M16	2X6	.493	155....	2	.248	152....	y	2	1.573	.878	1	1.719	.18	26....	.669	.953	3.9-3
9	M18	2X6	.878	142....	4	.253	144....	y	4	1.793	1.009	1.3...	1.977	.207	22....	.766	.945	3.9-3
10	M19	2X6	.787	48.736	3	.300	142....	y	4	1.793	1.009	1.7...	1.977	.207	5.4...	.996	.945	3.9-3
11	M20	2X6	.016	0	3	.000	0	z	4	1.497	1.009	1.4...	1.719	.207	13....	.972	.789	3.6.3
12	M21	2X6	.071	0	3	.000	0	z	4	.23	1.009	1.4...	1.719	.207	13....	.976	.121	3.6.3
13	M22	2X6	.867	119....	4	.291	122.55	y	2	1.793	1.009	.997	1.977	.18	26....	.58	.945	3.9-3
14	M16A	2X6	.004	0	3	.000	0	z	4	1.875	1.009	1.4...	1.719	.207	3.7...	.999	.988	3.6.3
15	M17A	2X6	.056	0	4	.000	0	z	4	1.793	1.009	1.45	1.719	.207	14....	.97	.945	3.6.3

Envelope Joint Reactions

	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
1	N15	max	0	4	1.02	3	0	4	0	4	0	4	0	4
2		min	0	1	.48	1	0	1	0	1	0	1	0	1
3	N32	max	0	4	.178	4	NC	NC	NC	NC	NC	NC	0	4
4		min	0	1	.052	1	NC	NC	NC	NC	NC	NC	0	1
5	N31	max	0	4	.063	3	0	4	0	4	0	4	0	4
6		min	0	1	-.026	2	0	1	0	1	0	1	0	1
7	N6	max	0	4	.991	3	NC	NC	NC	NC	NC	NC	0	4
8		min	0	1	.454	1	NC	NC	NC	NC	NC	NC	0	1
9	N8	max	0	4	1.185	3	NC	NC	NC	NC	NC	NC	0	4
10		min	0	1	.526	1	NC	NC	NC	NC	NC	NC	0	1
11	N29	max	0	4	.47	2	0	4	0	4	0	4	0	4

Envelope Joint Reactions (Continued)

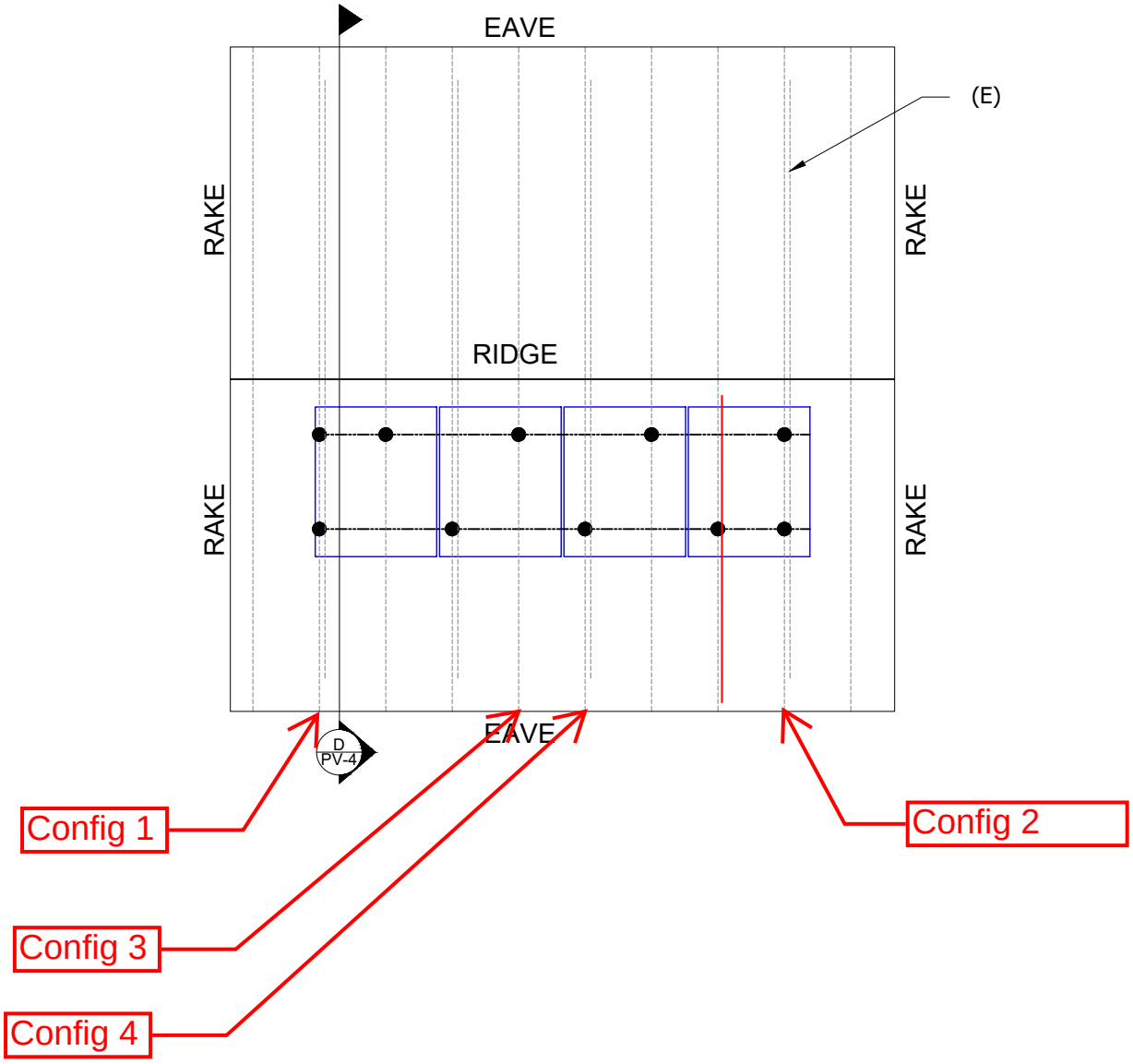
	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
12		min	0	1	0	1	0	1	0	1	0	1	0	1
13	N30	max	0	4	.29	2	0	4	0	4	0	4	0	4
14		min	0	1	0	1	0	1	0	1	0	1	0	1
15	N28	max	0	4	.943	4	0	4	0	4	0	4	0	4
16		min	0	1	.385	1	0	1	0	1	0	1	0	1
17	N7	max	0	4	.512	2	0	4	0	4	0	4	0	4
18		min	0	1	.107	1	0	1	0	1	0	1	0	1
19	N26	max	0	4	0	4	0	4	0	4	0	4	0	4
20		min	0	1	0	1	0	1	0	1	0	1	0	1
21	Totals:	max	0	4	5.155	4	0	4						
22		min	0	1	2.032	1	0	1						

Envelope Joint Displacements

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotatio...	LC	Y Rotatio...	LC	Z Rotation [rad]	LC
1	N1	max	.007	3	-.01	1	0	4	0	4	0	4	-1.337e-3	1
2		min	.003	1	-.022	3	0	1	0	1	0	1	-4.027e-3	4
3	N2	max	-.108	1	-.124	1	0	4	0	4	0	4	-2.828e-3	1
4		min	-.298	4	-.335	4	0	1	0	1	0	1	-6.764e-3	3
5	N3	max	0	1	.043	2	0	4	0	4	0	4	4.546e-3	4
6		min	-.048	2	-.006	1	0	1	0	1	0	1	2.032e-3	1
7	N4	max	.011	3	-.123	1	0	4	0	4	0	4	9.283e-4	2
8		min	.005	1	-.334	4	0	1	0	1	0	1	-6.034e-4	3
9	N5	max	.004	3	.043	2	0	4	0	4	0	4	6.566e-4	3
10		min	.002	1	-.005	1	0	1	0	1	0	1	6.01e-5	2
11	N6	max	0	4	0	4	0	4	0	4	0	4	0	4
12		min	0	1	0	1	0	1	0	1	0	1	0	1
13	N7	max	.006	3	0	4	0	4	0	4	0	4	-7.107e-4	1
14		min	.003	1	0	1	0	1	0	1	0	1	-3.243e-3	4
15	N8	max	.015	3	0	4	0	4	0	4	0	4	0	4
16		min	.007	1	0	1	0	1	0	1	0	1	0	1
17	N9	max	-.043	1	.125	4	0	4	0	4	0	4	2.126e-4	3
18		min	-.134	4	.038	1	0	1	0	1	0	1	-3.538e-4	2
19	N10	max	-.045	1	-.06	1	0	4	0	4	0	4	-2.105e-3	1
20		min	-.139	4	-.173	4	0	1	0	1	0	1	-5.756e-3	4
21	N11	max	.137	3	-.065	2	0	4	0	4	0	4	0	4
22		min	.063	1	-.142	3	0	1	0	1	0	1	0	1
23	N12	max	.27	3	-.003	2	0	4	0	4	0	4	2.051e-3	3
24		min	.123	1	-.007	3	0	1	0	1	0	1	9.389e-4	1
25	N13	max	.264	3	-.013	2	0	4	0	4	0	4	-1.105e-3	2
26		min	.12	1	-.028	3	0	1	0	1	0	1	-2.28e-3	3
27	N14	max	.253	3	-.032	2	0	4	0	4	0	4	-1.459e-4	2
28		min	.115	1	-.067	3	0	1	0	1	0	1	-3.184e-4	3
29	N15	max	.274	3	0	4	0	4	0	4	0	4	-4.094e-4	2
30		min	.125	1	0	1	0	1	0	1	0	1	-8.753e-4	3
31	N16	max	0	4	0	4	0	4	0	4	0	4	0	4
32		min	0	1	0	1	0	1	0	1	0	1	0	1
33	N17	max	.264	3	-.124	2	0	4	0	4	0	4	-1.55e-3	2
34		min	.12	1	-.271	3	0	1	0	1	0	1	-3.396e-3	3
35	N18	max	.265	3	0	2	0	4	0	4	0	4	-3.678e-4	2
36		min	.121	1	0	3	0	1	0	1	0	1	-7.763e-4	3
37	N19	max	.265	3	-.004	2	0	4	0	4	0	4	-5.306e-4	2
38		min	.121	1	-.008	3	0	1	0	1	0	1	-1.131e-3	3
39	N20	max	.262	3	-.023	2	0	4	0	4	0	4	9.824e-4	3
40		min	.119	1	-.05	3	0	1	0	1	0	1	5.092e-4	1
41	N21	max	.267	3	-.015	2	0	4	0	4	0	4	1.243e-3	3

Envelope Joint Displacements (Continued)

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotatio...	LC	Y Rotatio...	LC	Z Rotation [rad]	LC
42		min	.122	1	-.035	3	0	1	0	1	0	1	6.021e-4	1
43	N22	max	.278	3	0	2	0	4	0	4	0	4	0	4
44		min	.127	1	0	3	0	1	0	1	0	1	0	1
45	N25	max	.004	3	-.002	2	0	4	0	4	0	4	-1.793e-3	2
46		min	.002	1	-.003	3	0	1	0	1	0	1	-3.931e-3	3
47	N26	max	0	4	0	2	0	4	0	4	0	4	9.544e-4	3
48		min	0	1	0	3	0	1	0	1	0	1	4.353e-4	1
49	N27	max	.003	3	-.001	2	0	4	0	4	0	4	9.555e-4	3
50		min	.001	1	-.003	3	0	1	0	1	0	1	4.358e-4	1
51	N28	max	0	4	0	4	0	4	0	4	0	4	0	3
52		min	0	1	0	1	0	1	0	1	0	1	-1.389e-3	2
53	N29	max	0	4	0	4	0	4	0	4	0	4	8.357e-4	2
54		min	0	1	0	1	0	1	0	1	0	1	0	1
55	N30	max	0	4	0	4	0	4	0	4	0	4	9.272e-5	2
56		min	0	1	0	1	0	1	0	1	0	1	0	1
57	N31	max	0	4	0	4	0	4	0	4	0	4	0	4
58		min	0	1	0	1	0	1	0	1	0	1	0	1
59	N32	max	0	4	0	4	0	4	0	4	0	4	0	4
60		min	0	1	0	1	0	1	0	1	0	1	0	1
61	N34	max	-.139	1	-.154	1	0	4	0	4	0	4	6.217e-3	4
62		min	-.345	4	-.377	4	0	1	0	1	0	1	2.382e-3	1
63	N35	max	-.147	1	-.163	1	0	4	0	4	0	4	-1.256e-3	2
64		min	-.38	4	-.417	4	0	1	0	1	0	1	-3.732e-3	3
65	N36	max	-.108	1	-.123	1	0	4	0	4	0	4	-2.833e-3	1
66		min	-.297	4	-.334	4	0	1	0	1	0	1	-6.779e-3	3
67	N37	max	-.038	1	-.053	1	0	4	0	4	0	4	-1.731e-3	1
68		min	-.119	4	-.152	4	0	1	0	1	0	1	-4.897e-3	4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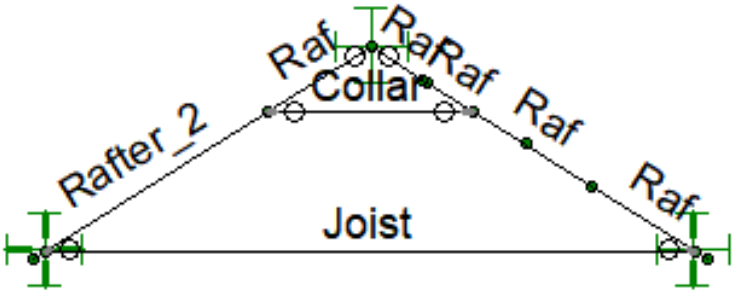
Config 3
Config 4

Config 1



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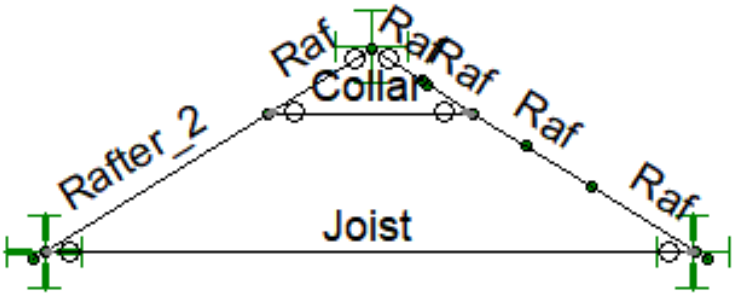

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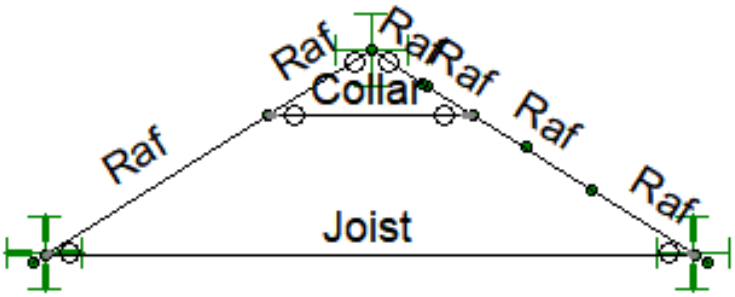

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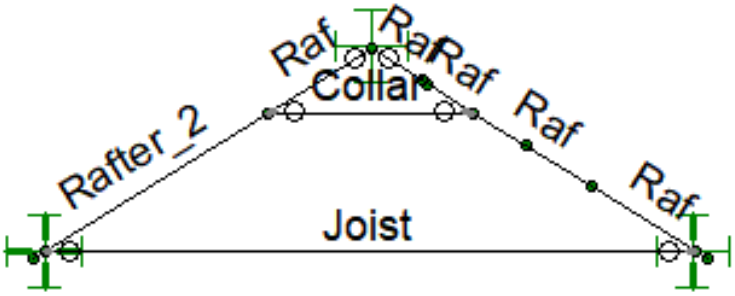
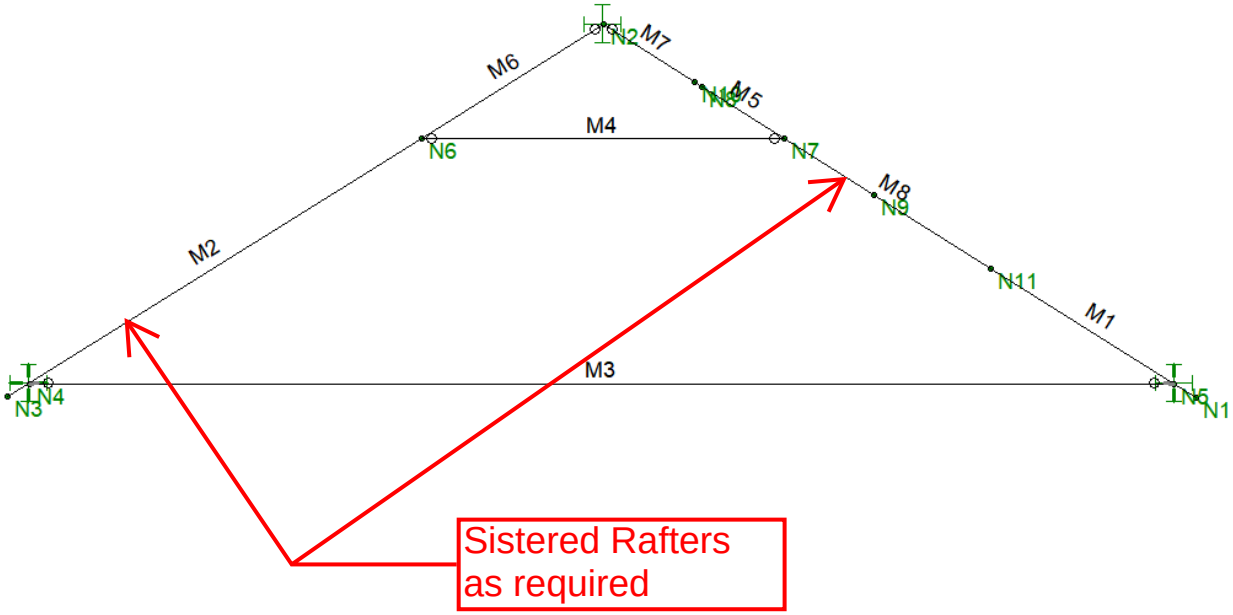
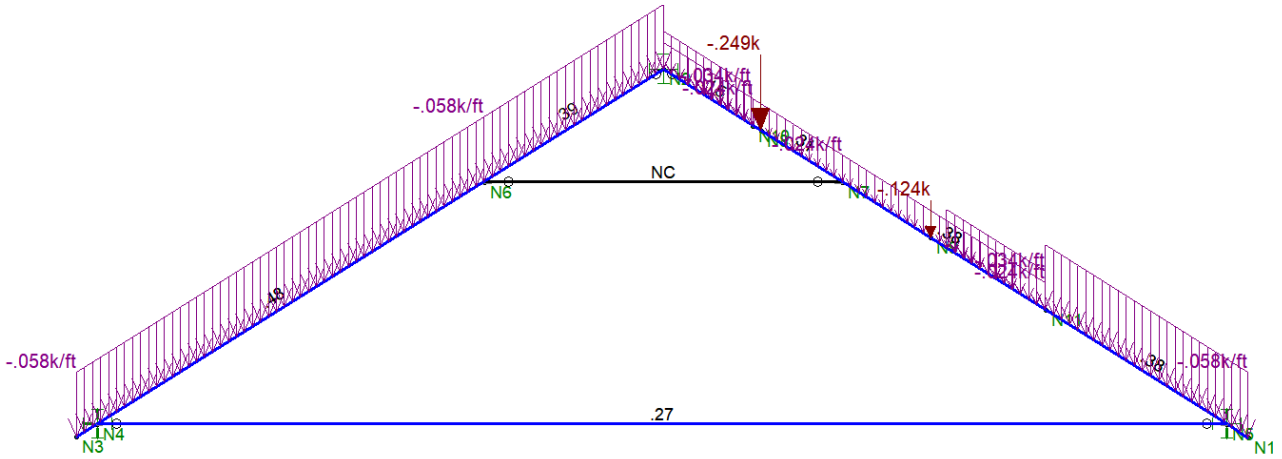


Garage Load config 1

Node and Member Labels



Loading and Design stress ratios



Wood Material Properties

	Label	Type	Database	Species	Grade	Cm	Emod	Nu	Ther...	Dens[k...
1	DF Larch	Solid Sawn	Visually Graded	Douglas Fir-Larch	No.1		1	.3	.3	.035
2	So Pine	Solid Sawn	Visually Graded	Southern Pine	No.1		1	.3	.3	.035

Wood Section Sets

	Label	Shape	Type	Design List	Material	Design Rul...	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	Raf	2X4	Beam	None	DF Larch	Typical	5.25	.984	5.359	2.877
2	Rafter_2	2-2X4	Beam	None	DF Larch	Typical	10.5	7.875	10.719	15.255
3	Joist	2X4	Beam	None	DF Larch	Typical	5.25	.984	5.359	2.877
4	Coll	2X2	Beam	None	DF Larch	Typical	2.25	.422	.422	.713

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
1	N1	19.58	.88	0	0	
2	N2	9.74	7.07	0	0	
3	N3	-.14	.89	0	0	
4	N4	0.211715	1.11	0	0	
5	N5	19.214378	1.11	0	0	
6	N6	6.718447	5.18	0	0	
7	N7	12.744459	5.18	0	0	
8	N8	11.38	6.038333	0	0	
9	N9	14.24	4.239207	0	0	
10	N10	11.242229	6.125	0	0	
11	N11	16.162229	3.03	0	0	
12	N12	19.58	-11.12	0	0	
13	N13	9.74	-4.93	0	0	
14	N14	-.14	-11.11	0	0	
15	N15	0.211715	-10.89	0	0	
16	N16	19.214378	-10.89	0	0	
17	N17	6.718447	-6.82	0	0	
18	N18	12.744459	-6.82	0	0	
19	N19	11.38	-5.961667	0	0	
20	N20	14.24	-7.760793	0	0	
21	N21	11.242229	-5.875	0	0	
22	N22	16.162229	-8.97	0	0	
23	N23	19.58	-23.12	0	0	
24	N24	9.74	-16.93	0	0	
25	N25	-.14	-23.11	0	0	
26	N26	0.211715	-22.89	0	0	
27	N27	19.214378	-22.89	0	0	
28	N28	6.718447	-18.82	0	0	
29	N29	12.744459	-18.82	0	0	
30	N30	11.38	-17.961667	0	0	
31	N31	14.24	-19.760793	0	0	
32	N32	11.242229	-17.875	0	0	
33	N33	16.162229	-20.97	0	0	
34	N34	19.58	-35.12	0	0	
35	N35	9.74	-28.93	0	0	
36	N36	-.14	-35.11	0	0	
37	N37	0.211715	-34.89	0	0	
38	N38	19.214378	-34.89	0	0	
39	N39	6.718447	-30.82	0	0	
40	N40	12.744459	-30.82	0	0	
41	N41	11.38	-29.961667	0	0	

Joint Coordinates and Temperatures (Continued)

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
42	N42	14.24	-31.760793	0	0	
43	N43	11.242229	-29.875	0	0	
44	N44	16.162229	-32.97	0	0	

Joint Boundary Conditions

	Joint Label	X [k/in]	Y [k/in]	Z [k/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]
1	N4	Reaction	Reaction	Fixed	Fixed	Fixed	
2	N5		Reaction	Fixed	Fixed	Fixed	
3	N2			Fixed	Fixed	Fixed	
4	N13			Fixed	Fixed	Fixed	
5	N15	Reaction	Reaction	Fixed	Fixed	Fixed	
6	N16		Reaction	Fixed	Fixed	Fixed	
7	N24			Fixed	Fixed	Fixed	
8	N26	Reaction	Reaction	Fixed	Fixed	Fixed	
9	N27		Reaction	Fixed	Fixed	Fixed	
10	N35			Fixed	Fixed	Fixed	
11	N37	Reaction	Reaction	Fixed	Fixed	Fixed	
12	N38		Reaction	Fixed	Fixed	Fixed	

Wood Design Parameters

	Label	Shape	Length[ft]	le2[ft]	le1[ft]	le-bend to...	le-bend bo...	Kyy	Kzz	CV	Cr	y sway	z sway
1	M1	Raf	4.038	1		Lbyy					Yes		
2	M5	Raf	1.775	1		Lbyy					Yes		
3	M6	Raf	3.564	1		Lbyy					Yes		
4	M7	Raf	1.775	1		Lbyy					Yes		
5	M8	Raf	4.038	1		Lbyy					Yes		
6	M9	Raf	4.038	1		Lbyy					Yes		
7	M13	Raf	1.775	1		Lbyy					Yes		
8	M14	Raf	3.564	1		Lbyy					Yes		
9	M15	Raf	1.775	1		Lbyy					Yes		
10	M16	Raf	4.038	1		Lbyy					Yes		
11	M17	Raf	4.038	1		Lbyy					Yes		
12	M21	Raf	1.775	1		Lbyy					Yes		
13	M22	Raf	3.564	1		Lbyy					Yes		
14	M23	Raf	1.775	1		Lbyy					Yes		
15	M24	Raf	4.038	1		Lbyy					Yes		
16	M25	Raf	4.038	1		Lbyy					Yes		
17	M29	Raf	1.775	1		Lbyy					Yes		
18	M30	Raf	3.564	1		Lbyy					Yes		
19	M31	Raf	1.775	1		Lbyy					Yes		
20	M32	Raf	4.038	1		Lbyy					Yes		
21	M2	Rafter_2	8.09	1		Lbyy					Yes		
22	M10	Rafter_2	8.09	1		Lbyy					Yes		
23	M18	Raf	8.09	1		Lbyy					Yes		
24	M26	Rafter_2	8.09	1		Lbyy					Yes		
25	M3	Joist	19.003			Lbyy					Yes		
26	M11	Joist	19.003			Lbyy					Yes		
27	M19	Joist	19.003			Lbyy					Yes		
28	M27	Joist	19.003			Lbyy					Yes		

Joint Loads and Enforced Displacements (BLC 1 : DL)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N8	L	Y	-.018
2	N9	L	Y	-.037
3	N19	L	Y	-.037
4	N20	L	Y	-.018
5	N30	L	Y	-.037
6	N42	L	Y	-.037

Joint Loads and Enforced Displacements (BLC 2 : SL)

	Joint Label	L,D,M	Direction	Magnitude[(k,k-ft), (in,rad), (k*s^2/ft...
1	N8	L	Y	-.106
2	N9	L	Y	-.212
3	N19	L	Y	-.212
4	N20	L	Y	-.106
5	N30	L	Y	-.212
6	N42	L	Y	-.212

Member Distributed Loads (BLC 1 : DL)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,F,...	Start Location[ft,%]	End Location[ft,%]
1	M2	Y	-.024	-.024	0	0
2	M1	Y	-.024	-.024	0	0
3	M5	Y	-.024	-.024	0	0
4	M6	Y	-.024	-.024	0	0
5	M7	Y	-.024	-.024	0	1.775
6	M8	Y	-.024	-.024	0	4.038
7	M9	Y	-.024	-.024	0	0
8	M10	Y	-.024	-.024	0	0
9	M13	Y	-.024	-.024	0	0
10	M14	Y	-.024	-.024	0	0
11	M15	Y	-.024	-.024	0	1.775
12	M16	Y	-.024	-.024	0	4.038
13	M17	Y	-.024	-.024	0	0
14	M18	Y	-.024	-.024	0	0
15	M21	Y	-.024	-.024	0	0
16	M22	Y	-.024	-.024	0	0
17	M23	Y	-.024	-.024	0	1.775
18	M24	Y	-.024	-.024	0	4.038
19	M25	Y	-.024	-.024	0	0
20	M26	Y	-.024	-.024	0	0
21	M29	Y	-.024	-.024	0	0
22	M30	Y	-.024	-.024	0	0
23	M31	Y	-.024	-.024	0	1.775
24	M32	Y	-.024	-.024	0	4.038

Member Distributed Loads (BLC 2 : SL)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,F,...	Start Location[ft,%]	End Location[ft,%]
1	M2	PY	-.04	-.04	0	0
2	M1	PY	-.04	-.04	0	0
3	M7	PY	-.04	-.04	.025	1.775
4	M6	PY	-.04	-.04	0	0
5	M8	PY	-.04	-.04	0	1.962
6	M9	PY	-.04	-.04	0	0
7	M10	PY	-.04	-.04	0	0
8	M14	PY	-.04	-.04	0	0

Member Distributed Loads (BLC 2 : SL) (Continued)

	Member Label	Direction	Start Magnitude[k/ft,...	End Magnitude[k/ft,F,...	Start Location[ft,%]	End Location[ft,%]
9	M15	PY	-.04	-.04	.025	1.775
10	M16	PY	-.04	-.04	0	1.962
11	M17	PY	-.04	-.04	0	0
12	M18	PY	-.04	-.04	0	0
13	M22	PY	-.04	-.04	0	0
14	M23	PY	-.04	-.04	.025	1.775
15	M24	PY	-.04	-.04	0	1.962
16	M25	PY	-.04	-.04	0	0
17	M26	PY	-.04	-.04	0	0
18	M30	PY	-.04	-.04	0	0
19	M31	PY	-.04	-.04	.025	1.775
20	M32	PY	-.04	-.04	0	1.962

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distributed	Area(Me...	Surface(P...
1	DL	DL		-1		6		24		
2	SL	SL				6		20		

Load Combinations

	Description	Sol...	PD...	SR...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...	BLC	Fact...
1	IBC 16-8	Yes			DL	1																		
2	IBC 16-9	Yes			DL	1	LL	1	LLS	1														
3	IBC 16-10 ..	Yes			DL	1	SL	1	SLN	1														
4	IBC 16-11 ..	Yes			DL	1	LL	.75	LLS	.75	SL	.75	SLN	.75										

Envelope Joint Reactions

	Joint		X [k]	LC	Y [k]	LC	Z [k]	LC	MX [k-ft]	LC	MY [k-ft]	LC	MZ [k-ft]	LC
1	N4	max	0	4	.783	3	NC	NC	NC	NC	NC	NC	0	4
2		min	0	1	.333	1	NC	NC	NC	NC	NC	NC	0	1
3	N5	max	0	4	.874	3	NC	NC	NC	NC	NC	NC	0	4
4		min	0	1	.348	1	NC	NC	NC	NC	NC	NC	0	1
5	N15	max	0	4	.802	3	NC	NC	NC	NC	NC	NC	0	4
6		min	0	1	.336	1	NC	NC	NC	NC	NC	NC	0	1
7	N16	max	0	4	.855	3	NC	NC	NC	NC	NC	NC	0	4
8		min	0	1	.345	1	NC	NC	NC	NC	NC	NC	0	1
9	N26	max	0	4	.76	3	NC	NC	NC	NC	NC	NC	0	4
10		min	0	1	.323	1	NC	NC	NC	NC	NC	NC	0	1
11	N27	max	0	4	.762	3	NC	NC	NC	NC	NC	NC	0	4
12		min	0	1	.33	1	NC	NC	NC	NC	NC	NC	0	1
13	N37	max	0	4	.732	3	NC	NC	NC	NC	NC	NC	0	4
14		min	0	1	.326	1	NC	NC	NC	NC	NC	NC	0	1
15	N38	max	0	4	.801	3	NC	NC	NC	NC	NC	NC	0	4
16		min	0	1	.337	1	NC	NC	NC	NC	NC	NC	0	1
17	Totals:	max	0	4	6.368	3	0	4						
18		min	0	1	2.678	1	0	1						

Envelope Joint Displacements

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation ...	LC	Y Rotation ...	LC	Z Rotation [...	LC
1	N1	max	.082	3	.093	3	0	4	0	4	0	4	2.113e-2	3
2		min	.028	1	.03	1	0	1	0	1	0	1	6.733e-3	1
3	N2	max	.015	3	-.014	2	0	4	0	4	0	4	0	4

Envelope Joint Displacements (Continued)

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation ...	LC	Y Rotation ...	LC	Z Rotation [...	LC
4		min	.006	1	-.035	3	0	1	0	1	0	1	0	1
5	N3	max	0	3	.005	2	0	4	0	4	0	4	3.513e-4	3
6		min	-.003	1	-.001	3	0	1	0	1	0	1	-1.258e-3	1
7	N4	max	0	4	0	4	0	4	0	4	0	4	3.465e-4	3
8		min	0	1	0	1	0	1	0	1	0	1	-1.26e-3	1
9	N5	max	.024	3	0	4	0	4	0	4	0	4	2.114e-2	3
10		min	.009	1	0	1	0	1	0	1	0	1	6.737e-3	1
11	N6	max	-.028	2	.227	3	0	4	0	4	0	4	7.611e-4	2
12		min	-.149	3	.041	1	0	1	0	1	0	1	5.649e-4	3
13	N7	max	-.044	2	-.094	2	0	4	0	4	0	4	-3.049e-3	2
14		min	-.191	3	-.363	3	0	1	0	1	0	1	-1.046e-2	3
15	N8	max	-.02	2	-.056	2	0	4	0	4	0	4	-2.022e-3	2
16		min	-.099	3	-.216	3	0	1	0	1	0	1	-8.551e-3	3
17	N9	max	-.084	2	-.155	2	0	4	0	4	0	4	-2.943e-3	2
18		min	-.314	3	-.554	3	0	1	0	1	0	1	-8.202e-3	3
19	N10	max	-.018	2	-.052	2	0	4	0	4	0	4	-2.023e-3	2
20		min	-.09	3	-.202	3	0	1	0	1	0	1	-8.654e-3	3
21	N11	max	-.098	2	-.176	2	0	4	0	4	0	4	6.261e-3	3
22		min	-.334	3	-.579	3	0	1	0	1	0	1	1.429e-3	1
23	N12	max	.071	3	.074	3	0	4	0	4	0	4	1.692e-2	3
24		min	.026	1	.027	1	0	1	0	1	0	1	6.092e-3	1
25	N13	max	.015	3	-.014	2	0	4	0	4	0	4	0	4
26		min	.006	1	-.037	3	0	1	0	1	0	1	0	1
27	N14	max	-.003	3	.006	2	0	4	0	4	0	4	-1.254e-3	3
28		min	-.004	1	.005	3	0	1	0	1	0	1	-1.502e-3	1
29	N15	max	0	4	0	4	0	4	0	4	0	4	-1.259e-3	3
30		min	0	1	0	1	0	1	0	1	0	1	-1.504e-3	1
31	N16	max	.024	3	0	4	0	4	0	4	0	4	1.693e-2	3
32		min	.009	1	0	1	0	1	0	1	0	1	6.097e-3	1
33	N17	max	-.021	2	.158	3	0	4	0	4	0	4	1.113e-3	3
34		min	-.105	3	.03	1	0	1	0	1	0	1	8.445e-4	1
35	N18	max	-.037	2	-.083	2	0	4	0	4	0	4	-2.497e-3	2
36		min	-.145	3	-.291	3	0	1	0	1	0	1	-6.824e-3	3
37	N19	max	-.018	2	-.052	2	0	4	0	4	0	4	-1.692e-3	2
38		min	-.085	3	-.195	3	0	1	0	1	0	1	-6.378e-3	3
39	N20	max	-.072	2	-.135	2	0	4	0	4	0	4	-2.644e-3	2
40		min	-.232	3	-.425	3	0	1	0	1	0	1	-6.235e-3	3
41	N21	max	-.016	2	-.05	2	0	4	0	4	0	4	-1.73e-3	2
42		min	-.078	3	-.184	3	0	1	0	1	0	1	-6.729e-3	3
43	N22	max	-.086	2	-.156	2	0	4	0	4	0	4	4.373e-3	3
44		min	-.254	3	-.453	3	0	1	0	1	0	1	1.142e-3	1
45	N23	max	.05	3	.045	3	0	4	0	4	0	4	1.015e-2	3
46		min	.023	1	.023	1	0	1	0	1	0	1	5.192e-3	1
47	N24	max	.011	3	-.016	2	0	4	0	4	0	4	0	4
48		min	.004	1	-.038	3	0	1	0	1	0	1	0	1
49	N25	max	-.01	2	.04	3	0	4	0	4	0	4	-3.675e-3	2
50		min	-.025	3	.016	1	0	1	0	1	0	1	-9.425e-3	3
51	N26	max	0	4	0	4	0	4	0	4	0	4	-3.679e-3	2
52		min	0	1	0	1	0	1	0	1	0	1	-9.435e-3	3
53	N27	max	.022	3	0	4	0	4	0	4	0	4	1.016e-2	3
54		min	.009	1	0	1	0	1	0	1	0	1	5.197e-3	1
55	N28	max	.002	3	.005	2	0	4	0	4	0	4	3.357e-3	3
56		min	-.008	1	-.023	3	0	1	0	1	0	1	1.231e-3	1
57	N29	max	-.023	2	-.059	2	0	4	0	4	0	4	-1.888e-3	2
58		min	-.032	3	-.105	3	0	1	0	1	0	1	-2.425e-3	3
59	N30	max	-.011	2	-.04	2	0	4	0	4	0	4	-9.986e-4	2
60		min	-.021	3	-.089	3	0	1	0	1	0	1	-1.145e-3	3

Envelope Joint Displacements (Continued)

	Joint		X [in]	LC	Y [in]	LC	Z [in]	LC	X Rotation ...	LC	Y Rotation ...	LC	Z Rotation [...	LC
61	N31	max	-.052	2	-.104	2	0	4	0	4	0	4	-2.43e-3	2
62		min	-.083	3	-.181	3	0	1	0	1	0	1	-4.872e-3	3
63	N32	max	-.01	2	-.038	2	0	4	0	4	0	4	-1.031e-3	2
64		min	-.02	3	-.087	3	0	1	0	1	0	1	-1.439e-3	3
65	N33	max	-.069	2	-.128	2	0	4	0	4	0	4	6.658e-4	3
66		min	-.124	3	-.242	3	0	1	0	1	0	1	6.617e-4	1
67	N34	max	.073	3	.083	3	0	4	0	4	0	4	1.894e-2	3
68		min	.027	1	.028	1	0	1	0	1	0	1	6.415e-3	1
69	N35	max	.013	3	-.013	2	0	4	0	4	0	4	0	4
70		min	.006	1	-.031	3	0	1	0	1	0	1	0	1
71	N36	max	-.004	2	.007	3	0	4	0	4	0	4	-1.561e-3	2
72		min	-.005	3	.007	1	0	1	0	1	0	1	-1.734e-3	3
73	N37	max	0	4	0	4	0	4	0	4	0	4	-1.563e-3	2
74		min	0	1	0	1	0	1	0	1	0	1	-1.739e-3	3
75	N38	max	.021	3	0	4	0	4	0	4	0	4	1.895e-2	3
76		min	.009	1	0	1	0	1	0	1	0	1	6.42e-3	1
77	N39	max	-.02	2	.139	3	0	4	0	4	0	4	1.337e-3	3
78		min	-.093	3	.028	1	0	1	0	1	0	1	8.731e-4	1
79	N40	max	-.036	2	-.079	2	0	4	0	4	0	4	-2.975e-3	2
80		min	-.132	3	-.262	3	0	1	0	1	0	1	-9.947e-3	3
81	N41	max	-.014	2	-.044	2	0	4	0	4	0	4	-1.65e-3	2
82		min	-.054	3	-.138	3	0	1	0	1	0	1	-5.987e-3	3
83	N42	max	-.075	2	-.14	2	0	4	0	4	0	4	-3.029e-3	2
84		min	-.255	3	-.454	3	0	1	0	1	0	1	-8.795e-3	3
85	N43	max	-.012	2	-.041	2	0	4	0	4	0	4	-1.609e-3	2
86		min	-.048	3	-.128	3	0	1	0	1	0	1	-5.802e-3	3
87	N44	max	-.092	2	-.165	2	0	4	0	4	0	4	4.673e-3	3
88		min	-.291	3	-.506	3	0	1	0	1	0	1	1.199e-3	1

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...	1.242	.463	3	.205	.463	3	0	0	4	0	0	4	0	0	4	.004	.421	3
2		min	-.013	.421	3	-.021	.421	3	0	0	1	0	0	1	0	0	1	-.416	4.038	3
3	M5	m...	.124	0	3	.163	0	3	0	0	4	0	0	4	0	0	4	.197	0	3
4		min	.028	1.775	1	.018	1.775	1	0	0	1	0	0	1	0	0	1	-.042	1.775	3
5	M6	m...	.164	0	3	.228	0	3	0	0	4	0	0	4	0	0	4	.493	0	3
6		min	.02	3.564	1	.005	3.564	1	0	0	1	0	0	1	0	0	1	0	3.564	1
7	M7	m...	.034	0	3	.02	0	3	0	0	4	0	0	4	0	0	4	0	1.775	4
8		min	-.022	1.775	3	-.068	1.775	3	0	0	1	0	0	1	0	0	1	-.046	.425	3
9	M8	m...	1.129	0	3	.026	0	3	0	0	4	0	0	4	0	0	4	.197	4.038	3
10		min	.365	4.038	1	-.327	4.038	3	0	0	1	0	0	1	0	0	1	-.423	.505	3
11	M9	m...	1.242	.463	3	.182	.463	3	0	0	4	0	0	4	0	0	4	.004	.421	3
12		min	-.013	.421	3	-.021	.421	3	0	0	1	0	0	1	0	0	1	-.335	4.038	3
13	M13	m...	.238	0	3	.217	0	3	0	0	4	0	0	4	0	0	4	.183	0	3
14		min	.035	1.775	1	-.032	1.775	3	0	0	1	0	0	1	0	0	1	-.138	1.627	3
15	M14	m...	.231	0	3	.208	0	3	0	0	4	0	0	4	0	0	4	.422	0	3
16		min	.03	3.564	1	.002	3.564	1	0	0	1	0	0	1	0	0	1	0	3.564	1
17	M15	m...	.081	0	3	.01	0	2	0	0	4	0	0	4	0	0	4	0	1.775	4
18		min	.011	1.775	1	-.12	1.775	3	0	0	1	0	0	1	0	0	1	-.134	0	3
19	M16	m...	1.13	0	3	.003	0	3	0	0	4	0	0	4	0	0	4	.184	4.038	3
20		min	.375	4.038	1	-.244	4.038	3	0	0	1	0	0	1	0	0	1	-.335	.084	3
21	M17	m...	1.115	.463	3	.152	.463	3	0	0	4	0	0	4	0	0	4	.004	.421	3
22		min	-.013	.421	3	-.026	4.038	3	0	0	1	0	0	1	0	0	1	-.234	3.491	3
23	M21	m...	.276	0	3	.229	0	3	0	0	4	0	0	4	0	0	4	.225	0	3
24		min	.039	1.775	1	-.02	1.775	3	0	0	1	0	0	1	0	0	1	-.115	1.627	3

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
25	M22	m...	.237	0	3	.168	0	3	0	0	4	0	0	4	0	0	4	.279	0	3
26		min	.031	3.564	1	-.011	3.564	3	0	0	1	0	0	1	0	0	1	-.001	3.341	3
27	M23	m...	.12	0	3	.011	0	2	0	0	4	0	0	4	0	0	4	0	1.775	4
28		min	.015	1.775	1	-.108	1.775	3	0	0	1	0	0	1	0	0	1	-.113	0	3
29	M24	m...	1.002	0	3	-.007	0	2	0	0	4	0	0	4	0	0	4	.226	4.038	3
30		min	.363	4.038	1	-.169	4.038	3	0	0	1	0	0	1	0	0	1	-.227	0	3
31	M25	m...	1.114	.463	3	.199	.463	3	0	0	4	0	0	4	0	0	4	.004	.421	3
32		min	-.013	.421	3	-.021	.421	3	0	0	1	0	0	1	0	0	1	-.395	4.038	3
33	M29	m...	.058	0	3	.118	0	3	0	0	4	0	0	4	0	0	4	.242	0	3
34		min	.028	1.775	1	.027	1.775	1	0	0	1	0	0	1	0	0	1	.014	1.775	1
35	M30	m...	.11	0	3	.201	0	3	0	0	4	0	0	4	0	0	4	.399	0	3
36		min	-.002	3.564	3	.001	3.564	1	0	0	1	0	0	1	0	0	1	0	3.564	1
37	M31	m...	.034	0	3	.08	0	3	0	0	4	0	0	4	0	0	4	.065	0	3
38		min	-.021	1.775	3	-.011	1.775	1	0	0	1	0	0	1	0	0	1	-.003	1.257	1
39	M32	m...	1.002	0	3	.02	0	3	0	0	4	0	0	4	0	0	4	.242	4.038	3
40		min	.346	4.038	1	-.333	4.038	3	0	0	1	0	0	1	0	0	1	-.399	.421	3
41	M2	m...	1.194	.421	3	.132	.421	3	0	0	4	0	0	4	0	0	4	.494	8.09	3
42		min	-.011	.337	3	-.261	8.09	3	0	0	1	0	0	1	0	0	1	-.169	3.034	3
43	M10	m...	1.215	.421	3	.142	.421	3	0	0	4	0	0	4	0	0	4	.423	8.09	3
44		min	-.011	.337	3	-.251	8.09	3	0	0	1	0	0	1	0	0	1	-.194	3.202	3
45	M18	m...	1.115	.421	3	.156	.421	3	0	0	4	0	0	4	0	0	4	.279	8.09	3
46		min	-.011	.337	3	-.229	8.09	3	0	0	1	0	0	1	0	0	1	-.242	3.539	3
47	M26	m...	1.078	.421	3	.145	.421	3	0	0	4	0	0	4	0	0	4	.399	8.09	3
48		min	-.011	.337	3	-.248	8.09	3	0	0	1	0	0	1	0	0	1	-.203	3.286	3
49	M3	m...	-.371	0	2	.012	0	4	0	0	4	0	0	4	0	0	4	0	0	4
50		min	-.942	0	3	-.012	18.6...	1	0	0	1	0	0	1	0	0	1	-.056	9.335	1
51	M11	m...	-.373	0	2	.012	0	4	0	0	4	0	0	4	0	0	4	0	0	4
52		min	-.955	0	3	-.012	18.6...	1	0	0	1	0	0	1	0	0	1	-.056	9.335	1
53	M19	m...	-.357	0	2	.012	0	4	0	0	4	0	0	4	0	0	4	0	0	4
54		min	-.862	0	3	-.012	18.6...	1	0	0	1	0	0	1	0	0	1	-.056	9.335	1
55	M27	m...	-.356	0	2	.012	0	4	0	0	4	0	0	4	0	0	4	0	0	4
56		min	-.837	0	3	-.012	18.6...	1	0	0	1	0	0	1	0	0	1	-.056	9.335	1
57	M4	m...	.924	0	3	.002	0	4	0	0	4	0	0	4	0	0	4	0	0	4
58		min	.357	0	1	-.002	5.526	1	0	0	1	0	0	1	0	0	1	-.002	2.763	1
59	M12	m...	.869	0	3	.002	0	4	0	0	4	0	0	4	0	0	4	0	0	4
60		min	.349	0	1	-.002	5.526	1	0	0	1	0	0	1	0	0	1	-.002	2.763	1
61	M20	m...	.75	0	3	.002	0	4	0	0	4	0	0	4	0	0	4	0	0	4
62		min	.33	0	1	-.002	5.526	1	0	0	1	0	0	1	0	0	1	-.002	2.763	1
63	M28	m...	.851	0	3	.002	0	4	0	0	4	0	0	4	0	0	4	0	0	4
64		min	.347	0	1	-.002	5.526	1	0	0	1	0	0	1	0	0	1	-.002	2.763	1

Envelope Wood Code Checks

	Member	Shape	Code ...	Loc[ft]	LC	Shear...	Loc[ft]	Dir	LC	Fc' [ksi]	Ft' [ksi]	Fb1' [...	Fb2' [...	Fv' [ksi]	RB	CL	CP	Eqn
1	M1	2X4	.916	4.038	3	.283	.463	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
2	M5	2X4	.392	0	3	.225	0	y	3	1.869	1.164	1.974	2.182	.207	5.756	.995	.942	3.9-3
3	M6	2X4	.994	0	3	.314	0	y	3	1.667	1.164	1.963	2.182	.207	8.156	.989	.84	3.9-3
4	M7	2X4	.091	.425	3	.094	1.775	y	3	1.869	1.164	1.979	2.182	.207	4.32	.997	.942	3.9-3
5	M8	2X4	.929	.505	3	.452	4.038	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
6	M9	2X4	.740	4.038	3	.252	.463	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
7	M13	2X4	.365	0	3	.299	0	y	3	1.869	1.164	1.974	2.182	.207	5.756	.995	.942	3.9-3
8	M14	2X4	.854	0	3	.287	0	y	3	1.667	1.164	1.963	2.182	.207	8.156	.989	.84	3.9-3
9	M15	2X4	.266	0	3	.165	1.775	y	3	1.869	1.164	1.979	2.182	.207	4.32	.997	.942	3.9-3
10	M16	2X4	.741	.042	3	.337	4.038	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
11	M17	2X4	.516	3.491	3	.210	.463	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
12	M21	2X4	.450	0	3	.316	0	y	3	1.869	1.164	1.974	2.182	.207	5.756	.995	.942	3.9-3

Envelope Wood Code Checks (Continued)

	Member	Shape	Code ...	Loc[ft]	LC	Shear...	Loc[ft]	Dir	LC	Fc' [ksi]	Ft' [ksi]	Fb1' [...	Fb2' [...	Fv' [ksi]	RB	CL	CP	Eqn
13	M22	2X4	.565	0	3	.231	0	y	3	1.667	1.164	1.963	2.182	.207	8.156	.989	.84	3.9-3
14	M23	2X4	.224	0	3	.149	1.775	y	3	1.869	1.164	1.979	2.182	.207	4.32	.997	.942	3.9-3
15	M24	2X4	.500	0	3	.233	4.038	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
16	M25	2X4	.858	4.038	3	.275	.463	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
17	M29	2X4	.480	0	3	.163	0	y	3	1.869	1.164	1.974	2.182	.207	5.756	.995	.942	3.9-3
18	M30	2X4	.801	0	3	.278	0	y	3	1.667	1.164	1.963	2.182	.207	8.156	.989	.84	3.9-3
19	M31	2X4	.129	0	3	.111	0	y	3	1.869	1.164	1.974	2.182	.207	5.756	.995	.942	3.9-3
20	M32	2X4	.866	.379	3	.460	4.038	y	3	1.551	1.164	1.979	2.182	.207	4.32	.997	.782	3.9-3
21	M2	2-2X4	.589	8.09	3	.180	8.09	y	3	.61	1.164	1.973	2.182	.207	6.144	.994	.307	3.9-3
22	M10	2-2X4	.510	8.09	3	.174	8.09	y	3	.61	1.164	1.973	2.182	.207	6.144	.994	.307	3.9-3
23	M18	2X4	.835	8.09	3	.316	8.09	y	3	.61	1.164	1.922	2.182	.207	12.288	.969	.307	3.9-3
24	M26	2-2X4	.467	8.09	3	.171	8.09	y	3	.61	1.164	1.973	2.182	.207	6.144	.994	.307	3.9-3
25	M3	2X4	.264	9.335	3	.021	0	y	1	.023	1.164	1.678	2.182	.162	18.668	.846	.012	3.9-1
26	M11	2X4	.266	9.335	3	.021	0	y	1	.023	1.164	1.678	2.182	.162	18.668	.846	.012	3.9-1
27	M19	2X4	.251	9.335	3	.021	0	y	1	.023	1.164	1.678	2.182	.162	18.668	.846	.012	3.9-1
28	M27	2X4	.247	9.335	3	.021	0	y	1	.023	1.164	1.678	2.182	.162	18.668	.846	.012	3.9-1

STRUCTURAL CALCULATIONS
Residential Improvement

PROJECT:

Steve Erickson - Solar
3033 Northeast 44th Avenue
Portland, OR 97213

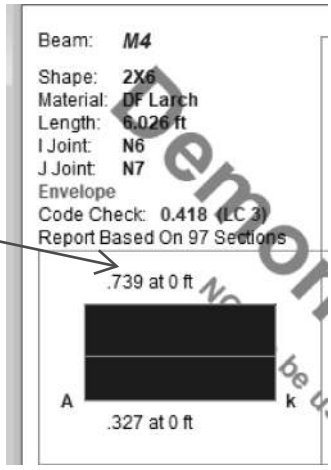
for

Elemental Energy
1339 SE 8th Ave.
Portland, OR 97214

James G. Pierson, Inc.
Consulting Structural Engineers
610 S.W. ALDER SUITE 918 PORTLAND, OR. 97205
(503) 226-1286 FAX 226-3130

June 2, 2022
Supplement September 1, 2022

Initial collar compression force is 739#, assumed resists load at 48" oc, total load applied is 1.48 k



updated collar compression load

Based on the increase in collar load, the roof will recieve a collar at ea row of rafters to recieve compression load. Design load is 924 #. Ea collar requires (6)10d nails to attach, see next page nail capacity calc + following page for detail

NDS 12.3.1A Yield Limit Equations

Collar Tie

Type of Dowel (lag screw,wood screw, bolt,nail):	nail	[-]
Is Dowel threaded?:	no	[-]
Dowel Diameter (D):	0.148	in
Dowel Root Diameter (D_r):	0.148	in
Dowel Root Diameter (non-input) (D_r):	0.148	in
Dowel Bending Yield Strength (F_{yb}):	120800	psi
Main Member Dowel Brg Length (l_m):	1.5	in
Side Member Dowel Brg Length (l_s):	1.5	in
Main Member Dowel Brg Str (F_{em}):	4637	psi
Side Member Dowel Brg Str (F_{es}):	4637	psi

Is the side member made of a non wood material?:	no	[-]
If yes, input material bearing strength	50000	psi
Main Member Bearing Angle (θ_m):	23	deg
Main Member Specific Gravity (G_m):	0.5	[-]
Side Member Bearing Angle (θ_s):	0	deg
Side Member Specific Gravity (G_s):	0.50	[-]
Main Member Dowel Brg Str ∥ grain ($F_{em\parallel}$):	4637	psi
Main Member Dowel Brg Str ⊥ grain ($F_{em\perp}$):	4637	psi
Side Member Dowel Brg Str ∥ grain ($F_{es\parallel}$):	4637	psi
Side Member Dowel Brg Str ⊥ grain ($F_{es\perp}$):	4637	psi

Reduction Term, R_d

Max angle of load to grain (0° ≤ θ ≤ 90°) for any member in a connection (θ):	23.0	deg
K_θ:	1.06	[-]
Yield Modes I_m, I_s (R_d):	2.2	[-]
Yield Mode II (R_d):	2.2	[-]
Yield Modes III_m, III_s, IV (R_d):	2.2	[-]

R_e:	1.000
R_t:	1.000

k_1:	0.4142
k_2:	1.1230
k_3:	1.1230

Figure 11B Single Shear Bolted Connection

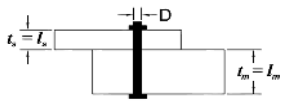
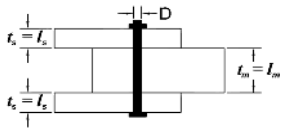


Figure 11C Double Shear Bolted Connection



Yield Modes

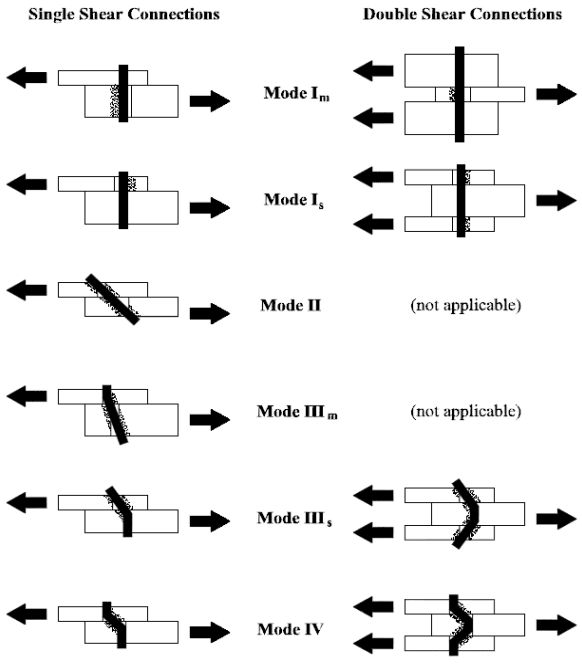
Single Shear		Double Shear	
I_m: Z =	467.9 lbs	**I_m: Z =**	467.9 lbs
I_s: Z =	467.9 lbs	**I_s: Z =**	935.8 lbs
II: Z =	193.8 lbs		N/A
III_m: Z =	175.2 lbs		N/A
III_s: Z =	175.2 lbs	**III_m: Z =**	350.3 lbs
IV: Z =	136.0 lbs	**IV: Z =**	272.1 lbs
Max: Z =	136.0 lbs		272.1 lbs

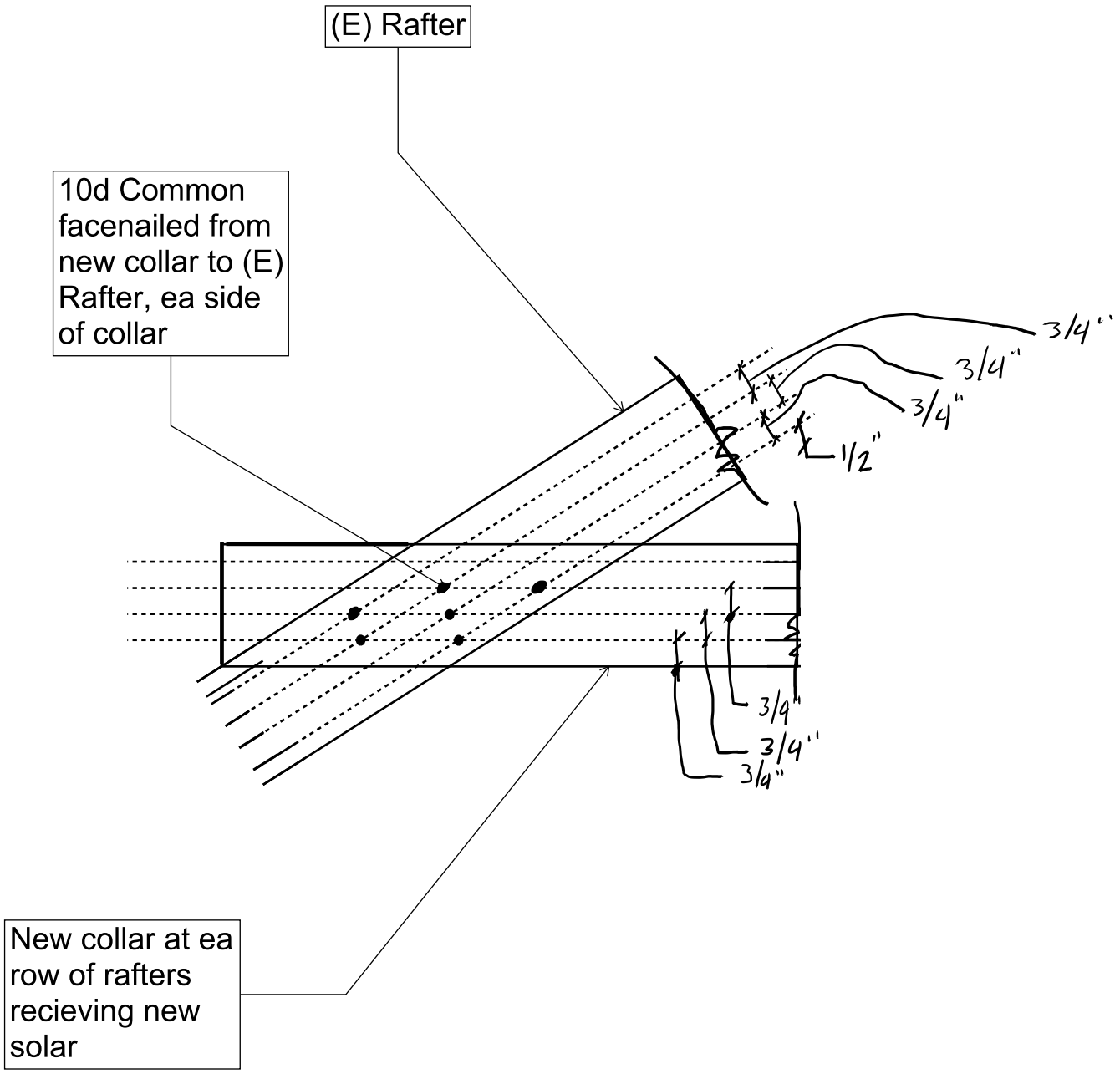
Z' = 1.15

Capacity / nail 156.5 lbs

Load(ASD) 924 lb / ft

5.91 nails required




(E) Rafter
10d Common facenailed from new collar to (E) Rafter, ea side of collar
New collar at ea row of rafters recieving new solar
3/4"
3/4"
3/4"
1/2"
3/4"
3/4"
3/4"

Fastener Nail
Dia 0.148 in

End Distance Requirements, Table 12.5.1A

Perpendicular to Grain							
	2D	0.296	in	4D	0.592	in	5D
Parallel to Grain, Compression							
	2D	0.296	in	4D	0.592	in	10D
Parallel to Grain, Tension							
HARDWOODS	3.5D	0.518	in	7D	1.036	in	10D
SOFTWOODS	2.5D	0.37	in	5D	0.74	in	10D

Spacing Requirements for Fasteners in a Row, Table 12.5.1B

Perpendicular to Grain							
	3D	0.444	in	4D	0.592	in	10D
Parallel to Grain							
	3D	0.444	in				15D

Edge Distance Requirements, Table 12.5.1C

Parallel to grain			
L/d<6	1.5D	0.222	in
L/d>6	max(1.5D, 1/2 x row)	0.222	in
Perp to grain			
Loaded edge	4D	0.592	in
unloaded edge	1.5D	0.222	in

Spacing Requirements Between Rows, Table 12.5.1D

Parallel to grain			
	1.5D	0.222	in
Perp to grain			
l/2<2	2.5D	0.37	in
2<l/d<6	(5l+10D)/8		
l/d>6	5D	0.74	in

Based on required fastener spacing for 10d common nail, use 3/4" oc typ