RIGHT ANGLE *ENGINEERING*

July 07, 2022

Design Criteria:
Wind Speed (V_{ult}) - 116.0 mph
Ground Snow Load - 15.0 psf
Risk Category - 2
Exposure Category - C

Pink Energy
919 North Main Street
Mooresville, North Carolina, 28115

RE: Structural Roof Evaluation for the Thomas Johnson Residence: 48 Day Trading Ct, Broadway, North Carolina

We have evaluated the roof structure under the proposed solar panel array. The information used to evaluate this structure was gathered during a field visit by Pink Energy on behalf of Right Angle Engineering. The design criteria used to analyze this structure are listed above and included with this letter. The adopted building codes in this jurisdiction are: The 2018 North Carolina Residential code and ASCE 7-16.

Array Name	Connection Type	Panel Quantity	Min # Connections	Reinforcements
Array 1	L-Foot	14	28	None
Array 2	L-Foot	2	4	None
Array 3	L-Foot	2	4	None

Solar Panel Anchorage

The solar panel anchorage shall be installed according to the manufactures most current installation manual. For the loads to be evenly distributed, the roof attachments should be staggered and spread evenly throughout the panel array. Attachment points should be spaced at a maximum of 48 inches on center. Roof anchors that are attached to the substructure should have a 5/16” or 18/8 SS lag screw with 2.5” minimum penetration centered on each truss top chord or rafter.

Conclusion

Based on our assessment, we have determined that the existing roof framing is in good condition and will safely and adequately support the additional loads imposed by the solar panels without reinforcement. The equipment will not create a negative impact on the building's structural design, including any additional loads imposed (dead,snow, wind/seismic). A roof evaluation was performed with the required loading in accordance with section 324.4 of the Residential Code

Regards,

07/07/2022

Robert D. Smythe, P.E.
Right Angle Engineering

Scope of work and limitations

The evaluation is based on information provided by the client. All information is verified by the engineer from pictures, video, and third party software. Verification of the field observations is the responsibility of the contractor. The contractor shall verify the framing sizes, spacing, spans, and roof pitch noted in this letter and/or sealed plans. The contractor shall notify the engineer if there are any discrepancies, or if there is any damage to the structure (i.e., fire damage, water damage, dry rot, deflections, broken member, broken connection, etc). The scope of work is strictly limited to the fastener attachments and underlying roof framing directly under each solar array. Right Angle Engineering assumes no responsibility for improper installation of solar panels or their components. Waterproofing around the roof penetrations is the responsibility of others. Alterations to this engineering evaluation and/or sealed plans shall not be made without direct written consent of the engineer of record.

Job Details

Roof Snow Load - ASCE 7-16	
Ground Snow Load (p_g) *Section 7.2*	15.0 psf
Exposure Factor (C_e) *Table 7.3-1*	0.9
Thermal Factor (C_t) *Table 7.3-2*	1.1
Importance Factor (I_s) *Table 1.5-2*	1
Flat Roof Snow Load (p_f) *Equation 7.3-1*	10.4 psf
Slippery Surface Slope Factor (C_s) *Figure 7.4-1*	0.87
Non-Slippery Surface Slope Factor (C_s) *Figure 7.4-1*	1
Roof Snow Load *Equation 7.4-1*	10.4 psf
Reduced Snow Load (Slippery Surface) *Equation 7.4-1*	9.01 psf

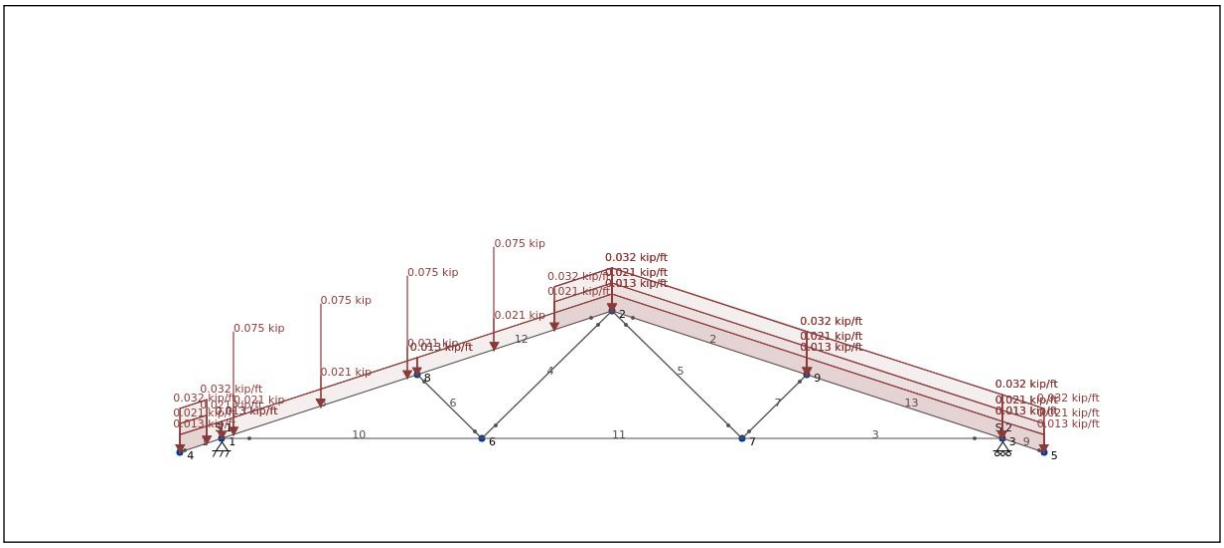
Design Criteria	
Design Wind Speed	116.0mph
Exposure Category	C
Risk Category	2
Mean Roof Height	30 ft
Roof Type	Gable Roof
Building Type	Enclosed

Roof Live Load	
Existing Roof Live Load *ASCE 7-16 Table 4.3-1*	20 psf
Roof Live Load with Solar Panels	0.0 psf

[1]Roof Dead Load			
Asphalt Shingles	2.0 psf	**No Drywall**	0.0 psf
5/8" Plywood Sheathing	2.0 psf	**Solar Panel Array**	2.39 psf
Roof Framing	1.1 psf	**Dead Load Without Panels**	6.3 psf
Insulation	1.2 psf	**Dead Load With Panels**	8.69 psf

[1]Roof Dead Load is taken from the worst case scenario dead load from all arrays of the job in order to provide a more conservative evaluation.

Array 1



Array Details	
Roof Pitch	18.0°
Panel Quantity	14
Panel Area	246.16 ft²

Beam Stresses			
Beam Span	168"	**Panel Orientation**	Landscape
Spacing	24.0"	**# of Panels on Rafter**	4
Roof Framing Type	2x4 Truss DF#2	**Panel Distance From Eave**	12.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 *Figure 30.3-(2A-5B)*	-3.0
GC_{pi} *Table 26.13-1*	-0.18
K_h *Table 26.10-1*	0.98
K_{ht} *Equation 26.8-1*	1
K_d *Table 26.6-1*	0.85
Velocity Pressure *Equation 26.10-1*	28.2 psf
Zone 2 Pressure *Equation 30.7-1*	-79.53 psf

Panel Area	
Shear Capacity *NDS 2015 Table 12k*	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	28
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Design Ratio

Member ID	P	M_z	V_y	C	SI	D	Status
1	0.003	0.103	0.066	0.106	0.035	0.952	Pass
2	0.123	0.553	0.261	0.568	0.035	0.169	Pass
3	0.258	0.026	0.002	0.284	0.076	0.013	Pass
4	0.07	0.0	0.0	0.07	0.064	0.0	Pass
5	0.08	0.0	0.0	0.08	0.064	0.0	Pass
6	0.07	0.0	0.0	0.07	0.045	0.0	Pass
7	0.08	0.0	0.0	0.08	0.045	0.0	Pass
8	0.148	0.449	0.273	0.47	0.035	0.215	Pass
9	0.004	0.115	0.091	0.119	0.035	0.617	Pass
10	0.245	0.023	0.002	0.268	0.076	0.016	Pass
11	0.145	0.026	0.001	0.171	0.076	0.029	Pass
12	0.118	0.449	0.173	0.462	0.035	0.204	Pass
13	0.155	0.553	0.251	0.577	0.035	0.13	Pass

Member Design Capacity (LRFD)

Member ID	F'_b(ksi)	F'_t(ksi)	F'_v(ksi)	F'_c(ksi)	F'_{cp}(ksi)	E'(ksi)	$E_{min}{}'$(ksi)
1	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
2	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
3	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
4	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
5	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
6	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
7	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
8	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
9	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
10	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
11	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
12	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
13	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216

Node Coordinates

ID	X Coordinate	Y Coordinate
1	0.000	0.000
2	14.000	4.549
3	28.000	0.000
4	-1.500	-0.487
5	29.500	-0.487
6	9.333	0.000
7	18.667	0.000
8	7.000	2.274
9	21.000	2.274

Members

ID	Node A	Node B	Section	Node A Fixity	Node B Fixity	Length
1	4	1	1	FFFFRR	FFFFFF	1.577
2	2	9	1	FFFFRR	FFFFFF	7.360
3	3	7	1	FFFFRR	FFFFFF	9.333
4	2	6	1	FFFFRR	FFFFRR	6.517
5	2	7	1	FFFFRR	FFFFRR	6.517
6	6	8	1	FFFFRR	FFFFRR	3.258
7	7	9	1	FFFFRR	FFFFRR	3.258
8	1	8	1	FFFFFF	FFFFFF	7.360
9	3	5	1	FFFFFF	FFFFRR	1.577
10	6	1	1	FFFFFF	FFFFRR	9.333
11	7	6	1	FFFFFF	FFFFFF	9.333
12	8	2	1	FFFFFF	FFFFRR	7.360
13	9	3	1	FFFFFF	FFFFFF	7.360

Supports

ID	Node ID	Restraint Code
1	1	FFFFRR
2	3	RFFRRR

Materials

ID	Name	Young's Modulus	Density	Poisson's Ratio
1	NDS - Table 4A - DOUGLAS FIR-LARCH - No.2 - 2in & wider	1600.000	33.611	0.400

Sections

ID	Name	Depth	Width	Shear Area Z	Shear Area Y	Torsion Radius
1	2 x 4	3.500	1.500	4.375	4.375	1.437

ID	Centroid Y	Centroid Z	Area	Y-Axis MoI	Z-Axis MoI	Torsion Constant
1	0.750	1.750	5.250	0.984	5.359	2.875

Point Loads

ID	Load Group	Member	Position %	Y Magnitude
1	Solar-Snow	8	5.987%	-0.075
2	Solar	8	5.987%	-0.021
3	Solar-Snow	8	50.536%	-0.075
4	Solar	8	50.536%	-0.021
5	Solar-Snow	8	95.086%	-0.075
6	Solar	8	95.086%	-0.021
7	Solar-Snow	12	39.636%	-0.075
8	Solar	12	39.636%	-0.021

Member Distributed Loads

ID	Load Group	Start Position	End Position	Member	Y Magnitude
1	Dead Load	0.000%	100.000%	1	-0.013
2	Dead Load	0.000%	100.000%	2	-0.013
3	Snow Load	0.000%	63.969%	1	-0.021
4	Snow Load	70.478%	100.000%	12	-0.021
5	Snow Load	0.000%	100.000%	2	-0.021
6	Roof Live Load	0.000%	63.969%	1	-0.032
7	Roof Live Load	70.478%	100.000%	12	-0.032
8	Roof Live Load	0.000%	100.000%	2	-0.032
9	Dead Load	0.000%	100.000%	8	-0.013
10	Dead Load	0.000%	100.000%	9	-0.013
11	Snow Load	0.000%	100.000%	9	-0.021
12	Roof Live Load	0.000%	100.000%	9	-0.032
13	Dead Load	0.000%	100.000%	12	-0.013
14	Dead Load	0.000%	100.000%	13	-0.013
15	Snow Load	0.000%	100.000%	13	-0.021
16	Roof Live Load	0.000%	100.000%	13	-0.032

Load Combinations

ID	Name	Dead Load Factor	Snow Load Factor	Solar Factor	Solar-Snow Factor	Roof Live Load Factor
1	1. 1.4D	1.4	0	1.4	0	0
2	3. 1.2D + 1.6Lr	1.2	0	1.2	0	1.6
3	3. 1.2D + 1.6S	1.2	1.6	1.2	1.6	0

Internal Member Forces and Moments

Member	Axial Force (Min/Max)	Shear Force Y (Min/Max)	Shear Force Z (Min/Max)	Torsion (Min/Max)	Bending Moment Y (Min/Max)	Bending Moment Z (Min/Max)
1	-0.023 / 0.000	-0.072 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.071 / 0.000

2	1.587 / 1.738	-0.284 / 0.181	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.379 / 0.258
3	-2.015 / -2.015	0.002 / 0.002	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.018
4	-0.546 / -0.546	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
5	-0.625 / -0.625	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
6	0.549 / 0.549	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
7	0.629 / 0.629	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
8	1.920 / 2.090	-0.298 / 0.224	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.307 / 0.227
9	-0.032 / -0.000	0.000 / 0.099	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.078 / 0.000
10	-1.918 / -1.918	-0.002 / -0.002	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.016
11	-1.134 / -1.134	-0.001 / -0.001	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.010 / 0.018
12	1.563 / 1.665	-0.125 / 0.188	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.307 / 0.183
13	2.031 / 2.181	-0.191 / 0.273	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.379 / 0.209

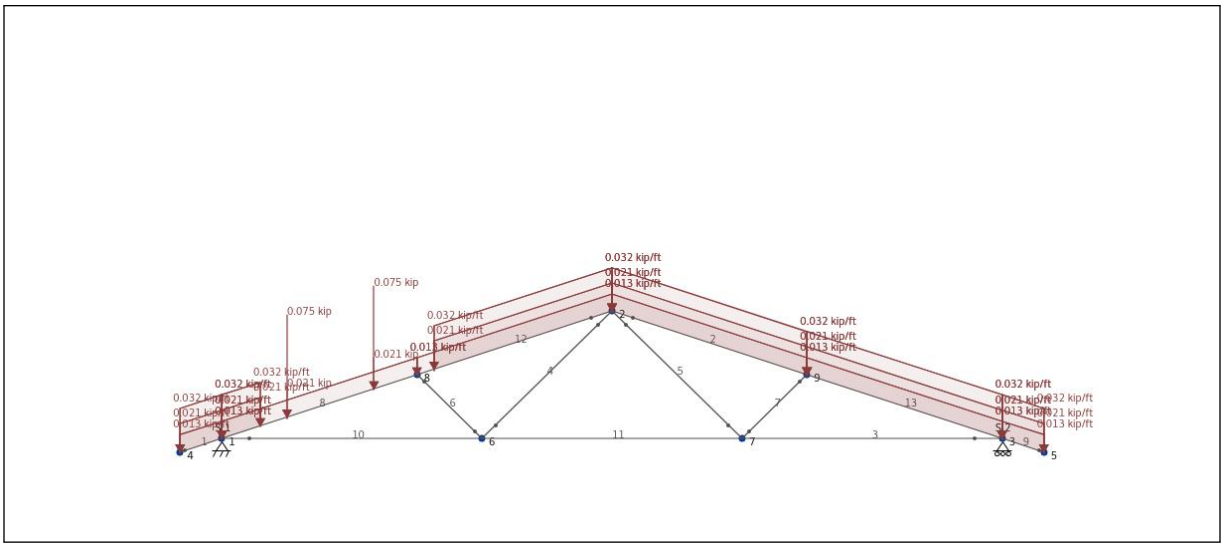
Member Displacement Span Check

Member	Length	Max Relative Displacement	Span Method 1
1	1.577	0.165	L/252
2	7.360	0.228	L/1424
3	9.333	0.020	L/19084
4	6.517	0.000	L/110592782547
5	6.517	0.000	L/116176705273
6	3.258	0.000	L/51425438755
7	3.258	0.000	L/58127670237
8	7.360	0.173	L/1117
9	1.577	0.159	L/389
10	9.333	0.018	L/14622
11	9.333	0.033	L/8408
12	7.360	0.167	L/1174
13	7.360	0.174	L/1849

Member Stresses

Member	Axial Stress (Min/Max)	Torsion Stress (Min/Max)	Shear Stress Y (Min/Max)	Shear Stress Z (Min/Max)	Top Bending Moment Z (Min/Max)	Bottom Bending Moment Z (Min/Max)
1	-0.004 / 0.000	0.000 / 0.000	-0.021 / 0.000	0.000 / 0.000	-0.277 / 0.000	0.000 / 0.277
2	0.302 / 0.331	0.000 / 0.000	-0.081 / 0.052	0.000 / 0.000	-1.484 / 1.013	-1.013 / 1.484
3	-0.384 / -0.384	0.000 / 0.000	0.001 / 0.001	0.000 / 0.000	0.000 / 0.071	-0.071 / 0.000
4	-0.104 / -0.104	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
5	-0.119 / -0.119	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
6	0.105 / 0.105	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
7	0.120 / 0.120	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
8	0.366 / 0.398	0.000 / 0.000	-0.085 / 0.064	0.000 / 0.000	-1.203 / 0.889	-0.889 / 1.203
9	-0.006 / -0.000	0.000 / 0.000	0.000 / 0.028	0.000 / 0.000	-0.307 / 0.000	0.000 / 0.307
10	-0.365 / -0.365	0.000 / 0.000	-0.000 / -0.000	0.000 / 0.000	0.000 / 0.062	-0.062 / 0.000
11	-0.216 / -0.216	0.000 / 0.000	-0.000 / -0.000	0.000 / 0.000	0.039 / 0.071	-0.071 / -0.039
12	0.298 / 0.317	0.000 / 0.000	-0.036 / 0.054	0.000 / 0.000	-1.203 / 0.718	-0.718 / 1.203
13	0.387 / 0.416	0.000 / 0.000	-0.055 / 0.078	0.000 / 0.000	-1.484 / 0.821	-0.821 / 1.484

Array 2



Array Details	
Roof Pitch	18.0°
Panel Quantity	2
Panel Area	35.16 ft²

Beam Stresses			
Beam Span	168"	**Panel Orientation**	Landscape
Spacing	24.0"	**# of Panels on Rafter**	2
Roof Framing Type	2x4 Truss DF#2	**Panel Distance From Eave**	36.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 *Figure 30.3-(2A-5B)*	-3.0
GC_{pi} *Table 26.13-1*	-0.18
K_h *Table 26.10-1*	0.98
K_{ht} *Equation 26.8-1*	1
K_d *Table 26.6-1*	0.85
Velocity Pressure *Equation 26.10-1*	28.2 psf
Zone 2 Pressure *Equation 30.7-1*	-79.53 psf

Panel Area	
Shear Capacity *NDS 2015 Table 12k*	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	4
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Design Ratio

Member ID	P	M_z	V_y	C	SI	D	Status
1	0.004	0.115	0.091	0.119	0.035	1.048	Pass
2	0.14	0.549	0.26	0.568	0.035	0.167	Pass
3	0.286	0.028	0.002	0.313	0.076	0.012	Pass
4	0.063	0.0	0.0	0.063	0.064	0.0	Pass
5	0.08	0.0	0.0	0.08	0.064	0.0	Pass
6	0.064	0.0	0.0	0.064	0.045	0.0	Pass
7	0.08	0.0	0.0	0.08	0.045	0.0	Pass
8	0.144	0.472	0.228	0.493	0.035	0.26	Pass
9	0.004	0.115	0.091	0.119	0.035	0.597	Pass
10	0.242	0.022	0.001	0.264	0.076	0.014	Pass
11	0.171	0.028	0.0	0.199	0.076	0.026	Pass
12	0.126	0.472	0.217	0.488	0.035	0.119	Pass
13	0.171	0.549	0.25	0.578	0.035	0.129	Pass

Member Design Capacity (LRFD)

Member ID	F'_b(ksi)	F'_t(ksi)	F'_v(ksi)	F'_c(ksi)	F'_{cp}(ksi)	E'(ksi)	E'_{min}(ksi)
1	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
2	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
3	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
4	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
5	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
6	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
7	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
8	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
9	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
10	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
11	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
12	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
13	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216

Node Coordinates

ID	X Coordinate	Y Coordinate
1	0.000	0.000
2	14.000	4.549
3	28.000	0.000
4	-1.500	-0.487
5	29.500	-0.487
6	9.333	0.000
7	18.667	0.000
8	7.000	2.274
9	21.000	2.274

Members

ID	Node A	Node B	Section	Node A Fixity	Node B Fixity	Length
1	4	1	1	FFFFRR	FFFFFF	1.577
2	2	9	1	FFFFRR	FFFFFF	7.360
3	3	7	1	FFFFRR	FFFFFF	9.333
4	2	6	1	FFFFRR	FFFFRR	6.517
5	2	7	1	FFFFRR	FFFFRR	6.517
6	6	8	1	FFFFRR	FFFFRR	3.258
7	7	9	1	FFFFRR	FFFFRR	3.258
8	1	8	1	FFFFFF	FFFFFF	7.360
9	3	5	1	FFFFFF	FFFFRR	1.577
10	6	1	1	FFFFFF	FFFFRR	9.333
11	7	6	1	FFFFFF	FFFFFF	9.333
12	8	2	1	FFFFFF	FFFFRR	7.360
13	9	3	1	FFFFFF	FFFFFF	7.360

Supports

ID	Node ID	Restraint Code
1	1	FFFFRR
2	3	RFFRRR

Materials

ID	Name	Young's Modulus	Density	Poisson's Ratio
1	NDS - Table 4A - DOUGLAS FIR-LARCH - No.2 - 2in & wider	1600.000	33.611	0.400

Sections

ID	Name	Depth	Width	Shear Area Z	Shear Area Y	Torsion Radius
1	2 x 4	3.500	1.500	4.375	4.375	1.437

ID	Centroid Y	Centroid Z	Area	Y-Axis MoI	Z-Axis MoI	Torsion Constant
1	0.750	1.750	5.250	0.984	5.359	2.875

Point Loads

ID	Load Group	Member	Position %	Y Magnitude
1	Solar-Snow	8	33.402%	-0.075
2	Solar	8	33.402%	-0.021
3	Solar-Snow	8	77.952%	-0.075
4	Solar	8	77.952%	-0.021

Member Distributed Loads

ID	Load Group	Start Position	End Position	Member	Y Magnitude
1	Dead Load	0.000%	100.000%	1	-0.013
2	Dead Load	0.000%	100.000%	2	-0.013
3	Snow Load	0.000%	100.000%	1	-0.021
4	Snow Load	8.794%	100.000%	12	-0.021
5	Snow Load	0.000%	100.000%	2	-0.021
6	Roof Live Load	0.000%	100.000%	1	-0.032
7	Roof Live Load	8.794%	100.000%	12	-0.032
8	Roof Live Load	0.000%	100.000%	2	-0.032
9	Dead Load	0.000%	100.000%	8	-0.013
10	Snow Load	0.000%	19.694%	8	-0.021
11	Roof Live Load	0.000%	19.694%	8	-0.032
12	Dead Load	0.000%	100.000%	9	-0.013
13	Snow Load	0.000%	100.000%	9	-0.021
14	Roof Live Load	0.000%	100.000%	9	-0.032
15	Dead Load	0.000%	100.000%	12	-0.013
16	Dead Load	0.000%	100.000%	13	-0.013
17	Snow Load	0.000%	100.000%	13	-0.021
18	Roof Live Load	0.000%	100.000%	13	-0.032

Load Combinations

ID	Name	Dead Load Factor	Snow Load Factor	Solar Factor	Solar-Snow Factor	Roof Live Load Factor
1	1. 1.4D	1.4	0	1.4	0	0
2	3. 1.2D + 1.6Lr	1.2	0	1.2	0	1.6
3	3. 1.2D + 1.6S	1.2	1.6	1.2	1.6	0

Internal Member Forces and Moments

Member	Axial Force (Min/Max)	Shear Force Y (Min/Max)	Shear Force Z (Min/Max)	Torsion (Min/Max)	Bending Moment Y (Min/Max)	Bending Moment Z (Min/Max)
1	-0.032 / -0.000	-0.099 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.078 / 0.000
2	1.817 / 1.968	-0.283 / 0.181	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.376 / 0.260
3	-2.233 / -2.233	0.002 / 0.002	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.019

4	-0.496 / -0.496	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
5	-0.624 / -0.624	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
6	0.499 / 0.499	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
7	0.628 / 0.628	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
8	1.957 / 2.030	-0.248 / 0.181	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.323 / 0.265
9	-0.032 / -0.000	0.000 / 0.099	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.078 / 0.000
10	-1.896 / -1.896	-0.002 / -0.002	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.015
11	-1.337 / -1.337	-0.001 / -0.001	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.014 / 0.019
12	1.635 / 1.776	-0.197 / 0.236	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.323 / 0.168
13	2.260 / 2.411	-0.192 / 0.272	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.376 / 0.211

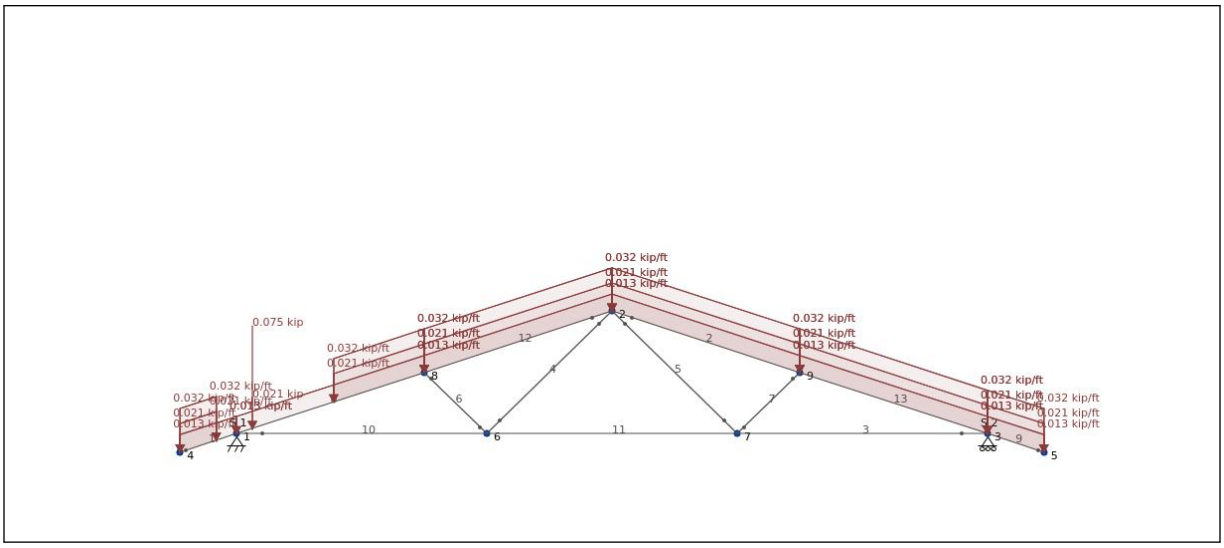
Member Displacement Span Check

Member	Length	Max Relative Displacement	Span Method 1
1	1.577	0.193	L/229
2	7.360	0.229	L/1433
3	9.333	0.021	L/19726
4	6.517	0.000	L/128130634636
5	6.517	0.000	L/110595925817
6	3.258	0.000	L/58853086382
7	3.258	0.000	L/80209842750
8	7.360	0.215	L/922
9	1.577	0.167	L/402
10	9.333	0.016	L/16812
11	9.333	0.037	L/9218
12	7.360	0.308	L/2011
13	7.360	0.176	L/1864

Member Stresses

Member	Axial Stress (Min/Max)	Torsion Stress (Min/Max)	Shear Stress Y (Min/Max)	Shear Stress Z (Min/Max)	Top Bending Moment Z (Min/Max)	Bottom Bending Moment Z (Min/Max)
1	-0.006 / -0.000	0.000 / 0.000	-0.028 / 0.000	0.000 / 0.000	-0.307 / 0.000	0.000 / 0.307
2	0.346 / 0.375	0.000 / 0.000	-0.081 / 0.052	0.000 / 0.000	-1.472 / 1.017	-1.017 / 1.472
3	-0.425 / -0.425	0.000 / 0.000	0.001 / 0.001	0.000 / 0.000	0.000 / 0.075	-0.075 / 0.000
4	-0.095 / -0.095	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
5	-0.119 / -0.119	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
6	0.095 / 0.095	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
7	0.120 / 0.120	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
8	0.373 / 0.387	0.000 / 0.000	-0.071 / 0.052	0.000 / 0.000	-1.266 / 1.037	-1.037 / 1.266
9	-0.006 / -0.000	0.000 / 0.000	0.000 / 0.028	0.000 / 0.000	-0.307 / 0.000	0.000 / 0.307
10	-0.361 / -0.361	0.000 / 0.000	-0.000 / -0.000	0.000 / 0.000	0.000 / 0.058	-0.058 / 0.000
11	-0.255 / -0.255	0.000 / 0.000	-0.000 / -0.000	0.000 / 0.000	0.056 / 0.075	-0.075 / -0.056
12	0.311 / 0.338	0.000 / 0.000	-0.056 / 0.067	0.000 / 0.000	-1.266 / 0.660	-0.660 / 1.266
13	0.430 / 0.459	0.000 / 0.000	-0.055 / 0.078	0.000 / 0.000	-1.472 / 0.825	-0.825 / 1.472

Array 3



Array Details	
Roof Pitch	18.0°
Panel Quantity	2
Panel Area	35.16 ft²

Beam Stresses			
Beam Span	120"	**Panel Orientation**	Landscape
Spacing	24.0"	**# of Panels on Rafter**	1
Roof Framing Type	2x4 Truss DF#2	**Panel Distance From Eave**	12.0"

Wind Calculations - ASCE 7-16	
GC_p Zone 2 *Figure 30.3-(2A-5B)*	-3.0
GC_{pi} *Table 26.13-1*	-0.18
K_h *Table 26.10-1*	0.98
K_{ht} *Equation 26.8-1*	1
K_d *Table 26.6-1*	0.85
Velocity Pressure *Equation 26.10-1*	28.2 psf
Zone 2 Pressure *Equation 30.7-1*	-79.53 psf

Panel Area	
Shear Capacity *NDS 2015 Table 12k*	190.0 lbs
Pullout Capacity	266.0 lbs/in
Minimum # of Connections	4
Lag Screw Embedment	2.5"
Total Pullout Capacity	665.0 lbs

Design Ratio

Member ID	P	M_z	V_y	C	SI	D	Status
1	0.003	0.103	0.066	0.106	0.035	0.275	Pass
2	0.103	0.242	0.181	0.253	0.035	0.07	Pass
3	0.208	0.027	0.003	0.236	0.064	0.008	Pass
4	0.048	0.0	0.0	0.048	0.054	0.0	Pass
5	0.054	0.0	0.0	0.054	0.054	0.0	Pass
6	0.049	0.0	0.0	0.049	0.038	0.0	Pass
7	0.055	0.0	0.0	0.055	0.038	0.0	Pass
8	0.118	0.194	0.158	0.208	0.035	0.055	Pass
9	0.004	0.115	0.091	0.119	0.035	0.208	Pass
10	0.199	0.025	0.002	0.225	0.064	0.009	Pass
11	0.13	0.027	0.0	0.158	0.064	0.017	Pass
12	0.101	0.226	0.176	0.236	0.035	0.066	Pass
13	0.125	0.242	0.168	0.258	0.035	0.042	Pass

Member Design Capacity (LRFD)

Member ID	F'_b(ksi)	F'_t(ksi)	F'_v(ksi)	F'_c(ksi)	F'_{cp}(ksi)	E'(ksi)	$E_{min}{}'$(ksi)
1	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
2	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
3	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
4	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
5	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
6	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
7	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
8	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
9	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
10	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
11	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
12	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216
13	2.681	1.49	0.311	2.683	0.939	1600.0	1041.216

Node Coordinates

ID	X Coordinate	Y Coordinate
1	0.000	0.000
2	10.000	3.249
3	20.000	0.000
4	-1.500	-0.487
5	21.500	-0.487
6	6.667	0.000
7	13.333	0.000
8	5.000	1.625
9	15.000	1.625

Members

ID	Node A	Node B	Section	Node A Fixity	Node B Fixity	Length
1	4	1	1	FFFFRR	FFFFFF	1.577
2	2	9	1	FFFFRR	FFFFFF	5.257
3	3	7	1	FFFFRR	FFFFFF	6.667
4	2	6	1	FFFFRR	FFFFRR	4.655
5	2	7	1	FFFFRR	FFFFRR	4.655
6	6	8	1	FFFFRR	FFFFRR	2.327
7	7	9	1	FFFFRR	FFFFRR	2.327
8	1	8	1	FFFFFF	FFFFFF	5.257
9	3	5	1	FFFFFF	FFFFRR	1.577
10	6	1	1	FFFFFF	FFFFRR	6.667
11	7	6	1	FFFFFF	FFFFFF	6.667
12	8	2	1	FFFFFF	FFFFRR	5.257
13	9	3	1	FFFFFF	FFFFFF	5.257

Supports

ID	Node ID	Restraint Code
1	1	FFFFRR
2	3	RFFRRR

Materials

ID	Name	Young's Modulus	Density	Poisson's Ratio
1	NDS - Table 4A - DOUGLAS FIR-LARCH - No.2 - 2in & wider	1600.000	33.611	0.400

Sections

ID	Name	Depth	Width	Shear Area Z	Shear Area Y	Torsion Radius
1	2 x 4	3.500	1.500	4.375	4.375	1.437

ID	Centroid Y	Centroid Z	Area	Y-Axis MoI	Z-Axis MoI	Torsion Constant
1	0.750	1.750	5.250	0.984	5.359	2.875

Point Loads

ID	Load Group	Member	Position %	Y Magnitude
1	Solar-Snow	8	8.493%	-0.075
2	Solar	8	8.493%	-0.021

Member Distributed Loads

ID	Load Group	Start Position	End Position	Member	Y Magnitude
1	Dead Load	0.000%	100.000%	1	-0.013
2	Dead Load	0.000%	100.000%	2	-0.013
3	Snow Load	0.000%	64.155%	1	-0.021
4	Snow Load	51.798%	100.000%	8	-0.021
5	Snow Load	0.000%	100.000%	2	-0.021
6	Roof Live Load	0.000%	64.155%	1	-0.032
7	Roof Live Load	51.798%	100.000%	8	-0.032
8	Roof Live Load	0.000%	100.000%	2	-0.032
9	Dead Load	0.000%	100.000%	8	-0.013
10	Dead Load	0.000%	100.000%	9	-0.013
11	Snow Load	0.000%	100.000%	9	-0.021
12	Roof Live Load	0.000%	100.000%	9	-0.032
13	Snow Load	0.000%	100.000%	12	-0.021
14	Roof Live Load	0.000%	100.000%	12	-0.032
15	Dead Load	0.000%	100.000%	12	-0.013
16	Dead Load	0.000%	100.000%	13	-0.013
17	Snow Load	0.000%	100.000%	13	-0.021
18	Roof Live Load	0.000%	100.000%	13	-0.032

Load Combinations

ID	Name	Dead Load Factor	Snow Load Factor	Solar Factor	Solar-Snow Factor	Roof Live Load Factor
1	1. 1.4D	1.4	0	1.4	0	0
2	3. 1.2D + 1.6Lr	1.2	0	1.2	0	1.6
3	3. 1.2D + 1.6S	1.2	1.6	1.2	1.6	0

Internal Member Forces and Moments

Member	Axial Force (Min/Max)	Shear Force Y (Min/Max)	Shear Force Z (Min/Max)	Torsion (Min/Max)	Bending Moment Y (Min/Max)	Bending Moment Z (Min/Max)
1	-0.023 / 0.000	-0.072 / -0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.071 / 0.000
2	1.347 / 1.455	-0.197 / 0.134	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.166 / 0.142
3	-1.630 / -1.630	0.003 / 0.003	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.019
4	-0.377 / -0.377	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
5	-0.425 / -0.425	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000

6	0.380 / 0.380	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
7	0.429 / 0.429	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
8	1.593 / 1.666	-0.122 / 0.172	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.133 / 0.033
9	-0.032 / -0.000	0.000 / 0.099	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.078 / 0.000
10	-1.560 / -1.560	-0.003 / -0.003	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.017
11	-1.018 / -1.018	-0.000 / -0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.017 / 0.019
12	1.309 / 1.416	-0.141 / 0.191	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.133 / 0.154
13	1.654 / 1.762	-0.149 / 0.182	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	-0.166 / 0.096

Member Displacement Span Check

Member	Length	Max Relative Displacement	Span Method 1
1	1.577	0.044	L/872
2	5.257	0.069	L/3441
3	6.667	0.011	L/28307
4	4.655	0.000	L/89214161800
5	4.655	0.000	L/1000000000000
6	2.327	0.000	L/37218807310
7	2.327	0.000	L/55582224944
8	5.257	0.023	L/4400
9	1.577	0.060	L/1156
10	6.667	0.010	L/27695
11	6.667	0.020	L/14223
12	5.257	0.080	L/3647
13	5.257	0.041	L/5699

Member Stresses

Member	Axial Stress (Min/Max)	Torsion Stress (Min/Max)	Shear Stress Y (Min/Max)	Shear Stress Z (Min/Max)	Top Bending Moment Z (Min/Max)	Bottom Bending Moment Z (Min/Max)
1	-0.004 / 0.000	0.000 / 0.000	-0.021 / -0.000	0.000 / 0.000	-0.277 / 0.000	0.000 / 0.277
2	0.257 / 0.277	0.000 / 0.000	-0.056 / 0.038	0.000 / 0.000	-0.650 / 0.557	-0.557 / 0.650
3	-0.310 / -0.310	0.000 / 0.000	0.001 / 0.001	0.000 / 0.000	0.000 / 0.073	-0.073 / 0.000
4	-0.072 / -0.072	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
5	-0.081 / -0.081	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
6	0.072 / 0.072	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
7	0.082 / 0.082	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000	0.000 / 0.000
8	0.303 / 0.317	0.000 / 0.000	-0.035 / 0.049	0.000 / 0.000	-0.520 / 0.129	-0.129 / 0.520
9	-0.006 / -0.000	0.000 / 0.000	0.000 / 0.028	0.000 / 0.000	-0.307 / 0.000	0.000 / 0.307
10	-0.297 / -0.297	0.000 / 0.000	-0.001 / -0.001	0.000 / 0.000	0.000 / 0.068	-0.068 / 0.000
11	-0.194 / -0.194	0.000 / 0.000	-0.000 / -0.000	0.000 / 0.000	0.068 / 0.073	-0.073 / -0.068
12	0.249 / 0.270	0.000 / 0.000	-0.040 / 0.055	0.000 / 0.000	-0.520 / 0.605	-0.605 / 0.520
13	0.315 / 0.336	0.000 / 0.000	-0.043 / 0.052	0.000 / 0.000	-0.650 / 0.375	-0.375 / 0.650