

January 07, 2022

Power Home Solar and Roofing
919 North Main Street
Mooresville, North Carolina, 28115

Design Criteria:

Wind Speed (ASD)- 130.0 mph
Ground Snow Load- 10.0 psf
Risk Category- 2
Exposure Category- C

RE: Structural Roof Evaluation for the Dana Lockhart Residence: 118 Hallow Oak St, Spring Lake, 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 Power Home Solar and Roofing 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 Building code and ASCE 7-16.

Array Name	Panel Quantity	Connection Type	Min # Connections	Reinforcements
Roof 1	6	L-Foot	9	None
Roof 2	4	L-Foot	6	None
Roof 3	3	L-Foot	5	None
Roof 4	9	L-Foot	14	None

Solar Panel Anchorage

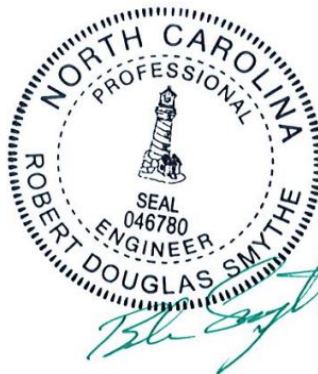
The solar panel anchorage shall be installed according to the manufactures most current installation manual. For the loads to be evenly distributed, the roof attachments should be staggered and spread evenly throughout the panel array. Attachment points should be spaced at a maximum of 48 inches on center. 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 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,

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



01/07/2022

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.

Design Criteria

Design Wind Speed	130.0	mph
Exposure Category	C	
Risk Category	2	
Mean Roof Height	30	ft
Roof Type	Gable Roof	
Building Type	Enclosed	

Roof Dead Load

Asphalt Shingles	2.0	psf
5/8" Plywood Sheathing	2.0	psf
Insulation	1.2	psf
Roof Framing	1.1	psf
1/2" Gypsum Sheathing	2.2	psf
Solar Panel Array	2.39	psf
Dead Load Without Panels	8.5	psf
Dead Load With Panels	10.89	psf

Roof Live Load

Existing Roof Live Load	20	psf	ASCE 7-16 Table 4.3-1
Roof Live Load with Solar Panels	0.0	psf	2018 IBC

Roof Snow Load-ASCE 7-16

Ground Snow Load(pg)	10.0	psf	Section 7.2
Exposure Factor (Ce)	0.9		Table 7.3-1
Thermal Factor (Ct)	1.1		Table 7.3-2
Importance Fator (Is)	1		Table 1.5-2
Flat Roof Snow Load (Pf)	6.93		Equation 7.3-1
Slippery Surface Slope Factor (Cs)	0.6		Figure 7.4-1
Non-Slippery Surface Slope Factor (Cs)	1	psf	Figure 7.4-1
Roof Snow Load	6.93	psf	Equation 7.4-1
Reduced Snow Load (Slippery Surface)	4.16	psf	Equation 7.4-1

Array Name - Roof 1

Roof Slope	34.0	degrees
Number of panels	6	
Panel Area	105.495	ft^2

Wind Calculations - ASCE 7-16

GCp Zone 2	-1.8		Figure 30.3-(2A-5B)
Gcpi	-0.18		Table 26.13-1
kh	0.98		Table 26.10-1
kht	1		Equation 26.8-1
kd	0.85		Table 26.6-1
Velocity Pressure	28.2	psf	Equation 26.10-1
Zone 2 Pressure	-45.69	psf	Equation 30.7-1

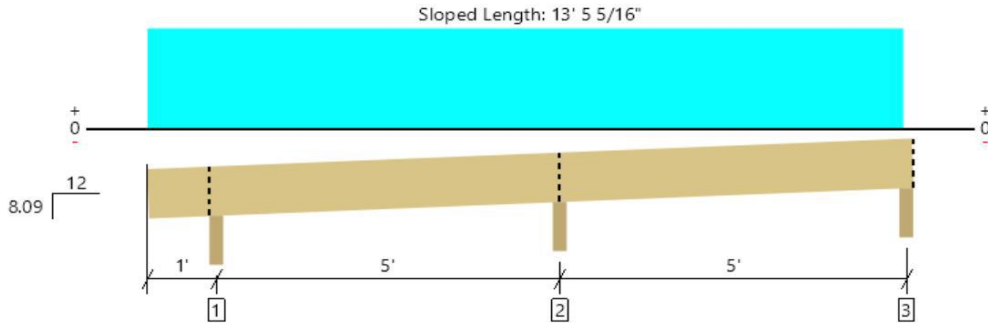
Roof Connection

Shear Capacity	190.0	lbs	NDS 2015 Table 12k
Pullout capacity	266.0	lbs/in	
Minimum # of connections	9		
Lag screw embedment	2.5	in	
Total pullout capacity	665.0	in	

Beam Stress

Beam Span	60, 60	in	
Spacing	24.0	in	
Roof Framing type	2x4 Trusses DF#2		
Panel orientation	Portrait		
Number of panels per rafter	1		
Panel distance from eave	24.0	in	
Shear without Panels	163	lbs	see attached analysis
Shear with Panels	165	lbs	see attached analysis
Shear percent increase	101.0		
Bending Moment without Panels	182	ft-lbs	see attached analysis
Bending Moment with Panels	150	ft-lbs	see attached analysis
Bending percent increase	82.0		

Roof, roof: Joist before panels
1 piece(s) 2 x 4 DF No.2 @ 24" OC



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Member Length : 13' 7 11/16"

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	370 @ 6"	3957 (3.50")	Passed (9%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	163 @ 6' 4 5/8"	788	Passed (21%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	-182 @ 6"	495	Passed (37%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.052 @ 8' 8 5/16"	0.298	Passed (L/999+)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.072 @ 8' 8 13/16"	0.397	Passed (L/986)	--	1.0 D + 1.0 Lr (Alt Spans)

System : Roof
 Member Type : Joist
 Building Use : Residential
 Building Code : IBC 2018
 Design Methodology : ASD
 Member Pitch : 8.09/12

- Deflection criteria: LL (L/240) and TL (L/180).
- Overhang deflection criteria: LL (2L/240) and TL (2L/180).
- Allowed moment does not reflect the adjustment for the beam stability factor.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	62	126	44	232	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	124	245	85	454	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	40	84	29	153	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	13' 5" o/c	
Bottom Edge (Lu)	13' 5" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Load	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 11'	24"	8.5	20.0	6.9	Dead load and snow load on roof before panels are added

Member Notes
 Roof joist before solar panels are added

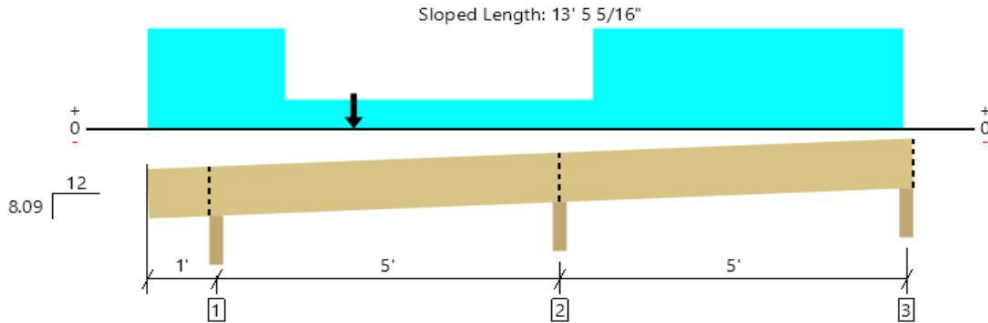
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 The product application, input design loads, dimensions and support information have been provided by Imported test Software Operator

Forteweb Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof joist before and after solar panels are added



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Roof, roof: Joist with solar panels
1 piece(s) 2 x 4 DF No.2 @ 24" OC



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Member Length : 13' 7 11/16"

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	282 @ 6'	3957 (3.50")	Passed (7%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	165 @ 6' 4 5/8"	788	Passed (21%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	-150 @ 6'	495	Passed (30%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.064 @ 8' 7 1/8"	0.298	Passed (L/999+)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.084 @ 8' 8 7/16"	0.397	Passed (L/847)	--	1.0 D + 1.0 Lr (Alt Spans)

System : Roof
 Member Type : Joist
 Building Use : Residential
 Building Code : IBC 2018
 Design Methodology : ASD
 Member Pitch : 8.09/12

- Deflection criteria: LL (L/240) and TL (L/180).
- Overhang deflection criteria: LL (2L/240) and TL (2L/180).
- Allowed moment does not reflect the adjustment for the beam stability factor.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	93	74	47	214	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	175	107	60	342	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	48	89	29	166	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	13' 5" o/c	
Bottom Edge (Lu)	13' 5" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Loads	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 11'	24"	10.9	-	-	DL
2 - Uniform (PSF)	0 to 2'	24"	-	20.0	6.9	DL+SL below panels
3 - Point (lb)	3'	N/A	28	-	40	solar and SL
4 - Uniform (PSF)	6' 5 13/16" to 11'	24"	-	20.0	6.9	DL+SL above panels

Member Notes
 Roof joist with solar panels

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ForTEWEB Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof Joist before and after solar panels are added



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Array Name - Roof 2

Roof Slope	30.0	degrees
Number of panels	4	
Panel Area	70.33	ft^2

Wind Calculations - ASCE 7-16

GCp Zone 2	-1.8		Figure 30.3-(2A-5B)
Gcpi	-0.18		Table 26.13-1
kh	0.98		Table 26.10-1
kht	1		Equation 26.8-1
kd	0.85		Table 26.6-1
Velocity Pressure	28.2	psf	Equation 26.10-1
Zone 2 Pressure	-45.69	psf	Equation 30.7-1

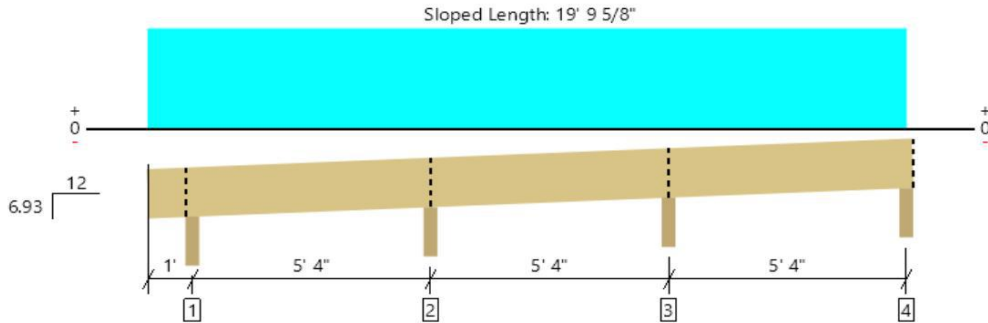
Roof Connection

Shear Capacity	190.0	lbs	NDS 2015 Table 12k
Pullout capacity	266.0	lbs/in	
Minimum # of connections	6		
Lag screw embedment	2.5	in	
Total pullout capacity	665.0	in	

Beam Stress

Beam Span	64, 64, 64	in	
Spacing	24.0	in	
Roof Framing type	2x4 Trusses DF#2		
Panel orientation	Portrait		
Number of panels per rafter	2		
Panel distance from eave	24.0	in	
Shear without Panels	167	lbs	see attached analysis
Shear with Panels	174	lbs	see attached analysis
Shear percent increase	104.0		
Bending Moment without Panels	178	ft-lbs	see attached analysis
Bending Moment with Panels	158	ft-lbs	see attached analysis
Bending percent increase	89.0		

Roof, roof: Joist before panels
1 piece(s) 2 x 4 DF No.2 @ 24" OC



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Member Length : 19' 11 5/8"

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	360 @ 11' 8"	3789 (3.50")	Passed (10%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	167 @ 12' 3/4"	788	Passed (21%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	-178 @ 11' 8"	495	Passed (36%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.069 @ 14' 5 15/16"	0.304	Passed (L/999+)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.097 @ 14' 6 5/16"	0.406	Passed (L/754)	--	1.0 D + 1.0 Lr (Alt Spans)

System : Roof
 Member Type : Joist
 Building Use : Residential
 Building Code : IBC 2018
 Design Methodology : ASD
 Member Pitch : 6.93/12

- Deflection criteria: LL (L/240) and TL (L/180).
- Overhang deflection criteria: LL (2L/240) and TL (2L/180).
- Allowed moment does not reflect the adjustment for the beam stability factor.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	64	135	47	246	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	112	243	84	439	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	115	245	85	445	Blocking
4 - Beveled Plate - DF	3.50"	3.50"	1.50"	42	92	32	166	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	19' 10" o/c	
Bottom Edge (Lu)	19' 10" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Load	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 17'	24"	8.5	20.0	6.9	Dead load and snow load on roof before panels are added

Member Notes
Roof joist before solar panels are added

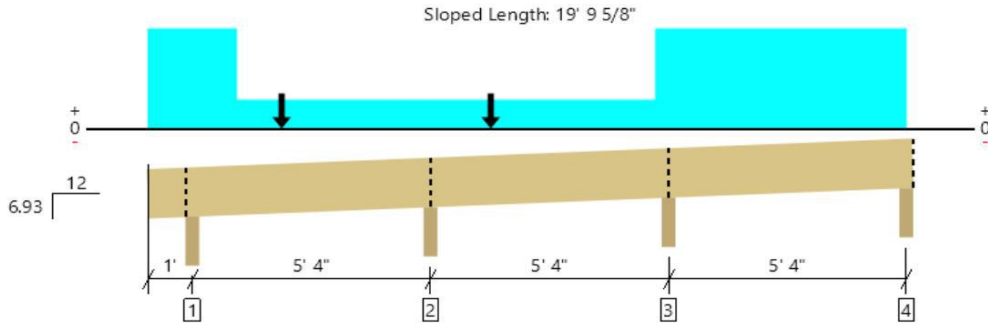
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FortewEB Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof joist before and after solar panels are added



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Roof, roof: Joist with solar panels
1 piece(s) 2 x 4 DF No.2 @ 24" OC



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Member Length : 19' 11 5/8"

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	300 @ 11' 8"	3789 (3.50")	Passed (8%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	174 @ 12' 3/4"	788	Passed (22%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	158 @ 14' 8 3/4"	495	Passed (32%)	1.25	1.0 D + 1.0 Lr (Alt Spans)
Live Load Defl. (in)	0.074 @ 14' 5 9/16"	0.304	Passed (L/986)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.108 @ 14' 6 3/16"	0.406	Passed (L/676)	--	1.0 D + 1.0 Lr (Alt Spans)

System : Roof
 Member Type : Joist
 Building Use : Residential
 Building Code : IBC 2018
 Design Methodology : ASD
 Member Pitch : 6.93/12

- Deflection criteria: LL (L/240) and TL (L/180).
- Overhang deflection criteria: LL (2L/240) and TL (2L/180).
- Allowed moment does not reflect the adjustment for the beam stability factor.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	95	83	50	228	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	184	-23	57	241/-23	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	151	149	60	360	Blocking
4 - Beveled Plate - DF	3.50"	3.50"	1.50"	54	94	33	181	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	19' 10" o/c	
Bottom Edge (Lu)	19' 10" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Loads	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 17'	24"	10.9	-	-	DL
2 - Uniform (PSF)	0 to 2'	24"	-	20.0	6.9	DL+SL below panels
3 - Point (lb)	3'	N/A	28	-	42	solar and SL
4 - Point (lb)	7' 8 1/4"	N/A	28	-	42	solar and SL
5 - Uniform (PSF)	11' 4 7/16" to 17'	24"	-	20.0	6.9	DL+SL above panels

Member Notes
Roof joist with solar panels

Forteweb Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof joist before and after solar panels are added



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Array Name - Roof 3

Roof Slope	34.0	degrees
Number of panels	3	
Panel Area	52.7475	ft^2

Wind Calculations - ASCE 7-16

GCp Zone 2	-1.8		Figure 30.3-(2A-5B)
Gcpi	-0.18		Table 26.13-1
kh	0.98		Table 26.10-1
kht	1		Equation 26.8-1
kd	0.85		Table 26.6-1
Velocity Pressure	28.2	psf	Equation 26.10-1
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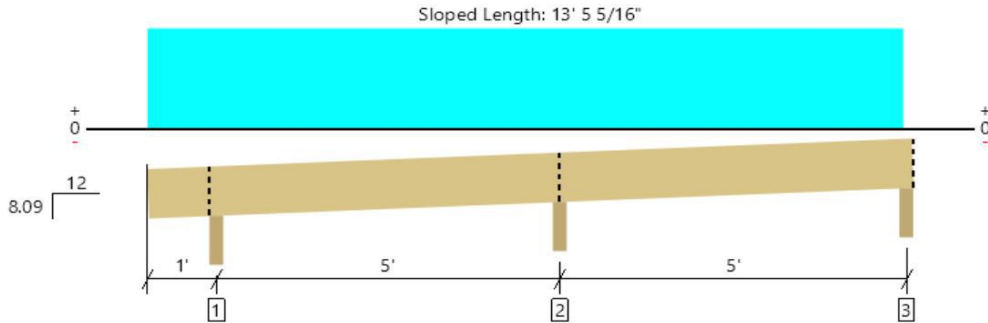
Roof Connection

Shear Capacity	190.0	lbs	NDS 2015 Table 12k
Pullout capacity	266.0	lbs/in	
Minimum # of connections	5		
Lag screw embedment	2.5	in	
Total pullout capacity	665.0	in	

Beam Stress

Beam Span	60, 60	in	
Spacing	24.0	in	
Roof Framing type	2x4 Trusses DF#2		
Panel orientation	Portrait		
Number of panels per rafter	1		
Panel distance from eave	24.0	in	
Shear without Panels	163	lbs	see attached analysis
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Shear percent increase	101.0		
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Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	62	126	44	232	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	124	245	85	454	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	40	84	29	153	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	13' 5" o/c	
Bottom Edge (Lu)	13' 5" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Load	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 11'	24"	8.5	20.0	6.9	Dead load and snow load on roof before panels are added

Member Notes
 Roof joist before solar panels are added

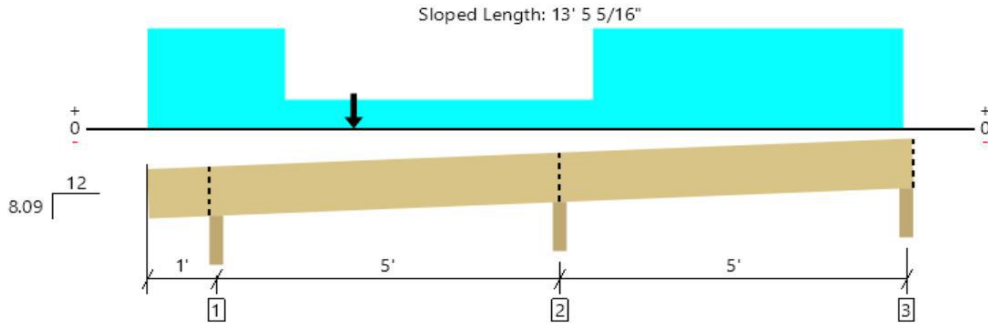
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 The product application, input design loads, dimensions and support information have been provided by Imported test Software Operator

ForteWEB Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof joist before and after solar panels are added



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Roof, roof: Joist with solar panels
1 piece(s) 2 x 4 DF No.2 @ 24" OC



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Member Length : 13' 7 11/16"

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	280 @ 6'	3957 (3.50")	Passed (7%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	165 @ 6' 4 5/8"	788	Passed (21%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	-149 @ 6'	495	Passed (30%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.064 @ 8' 7 1/8"	0.298	Passed (L/999+)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.085 @ 8' 8 7/16"	0.397	Passed (L/842)	--	1.0 D + 1.0 Lr (Alt Spans)

System : Roof
 Member Type : Joist
 Building Use : Residential
 Building Code : IBC 2018
 Design Methodology : ASD
 Member Pitch : 8.09/12

- Deflection criteria: LL (L/240) and TL (L/180).
- Overhang deflection criteria: LL (2L/240) and TL (2L/180).
- Allowed moment does not reflect the adjustment for the beam stability factor.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	92	74	44	210	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	174	107	58	339	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	49	89	29	167	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	13' 5" o/c	
Bottom Edge (Lu)	13' 5" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Loads	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 11'	24"	10.9	-	-	DL
2 - Uniform (PSF)	0 to 2'	24"	-	20.0	6.9	DL+SL below panels
3 - Point (lb)	3'	N/A	25	-	36	solar and SL
4 - Uniform (PSF)	6' 5 13/16" to 11'	24"	-	20.0	6.9	DL+SL above panels

Member Notes
 Roof joist with solar panels

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ForTEWEB Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof Joist before and after solar panels are added



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Array Name - Roof 4

Roof Slope	30.0	degrees
Number of panels	9	
Panel Area	158.2425	ft^2

Wind Calculations - ASCE 7-16

GCp Zone 2	-1.8		Figure 30.3-(2A-5B)
Gcpi	-0.18		Table 26.13-1
kh	0.98		Table 26.10-1
kht	1		Equation 26.8-1
kd	0.85		Table 26.6-1
Velocity Pressure	28.2	psf	Equation 26.10-1
Zone 2 Pressure	-45.69	psf	Equation 30.7-1

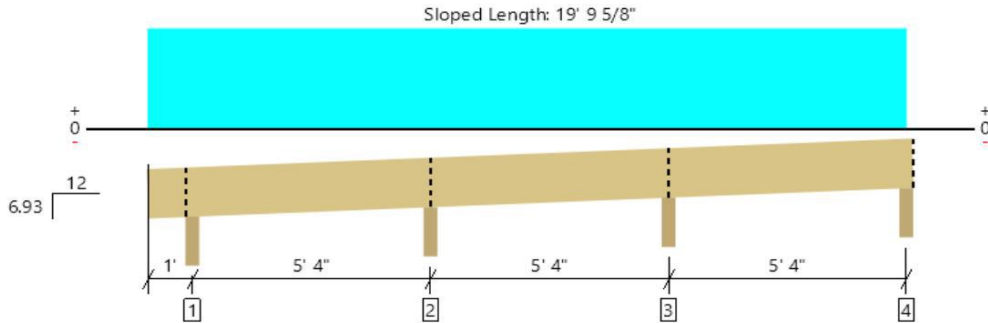
Roof Connection

Shear Capacity	190.0	lbs	NDS 2015 Table 12k
Pullout capacity	266.0	lbs/in	
Minimum # of connections	14		
Lag screw embedment	2.5	in	
Total pullout capacity	665.0	in	

Beam Stress

Beam Span	64, 64, 64	in	
Spacing	24.0	in	
Roof Framing type	2x4 Trusses DF#2		
Panel orientation	Portrait		
Number of panels per rafter	2		
Panel distance from eave	6.0	in	
Shear without Panels	167	lbs	see attached analysis
Shear with Panels	177	lbs	see attached analysis
Shear percent increase	106.0		
Bending Moment without Panels	178	ft-lbs	see attached analysis
Bending Moment with Panels	165	ft-lbs	see attached analysis
Bending percent increase	93.0		

Roof, roof: Joist before panels
1 piece(s) 2 x 4 DF No.2 @ 24" OC



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Member Length : 19' 11 5/8"

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	360 @ 11' 8"	3789 (3.50")	Passed (10%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	167 @ 12' 3/4"	788	Passed (21%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	-178 @ 11' 8"	495	Passed (36%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.069 @ 14' 5 15/16"	0.304	Passed (L/999+)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.097 @ 14' 6 5/16"	0.406	Passed (L/754)	--	1.0 D + 1.0 Lr (Alt Spans)

System : Roof
 Member Type : Joist
 Building Use : Residential
 Building Code : IBC 2018
 Design Methodology : ASD
 Member Pitch : 6.93/12

- Deflection criteria: LL (L/240) and TL (L/180).
- Overhang deflection criteria: LL (2L/240) and TL (2L/180).
- Allowed moment does not reflect the adjustment for the beam stability factor.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	64	135	47	246	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	112	243	84	439	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	115	245	85	445	Blocking
4 - Beveled Plate - DF	3.50"	3.50"	1.50"	42	92	32	166	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	19' 10" o/c	
Bottom Edge (Lu)	19' 10" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Load	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 17'	24"	8.5	20.0	6.9	Dead load and snow load on roof before panels are added

Member Notes
 Roof joist before solar panels are added

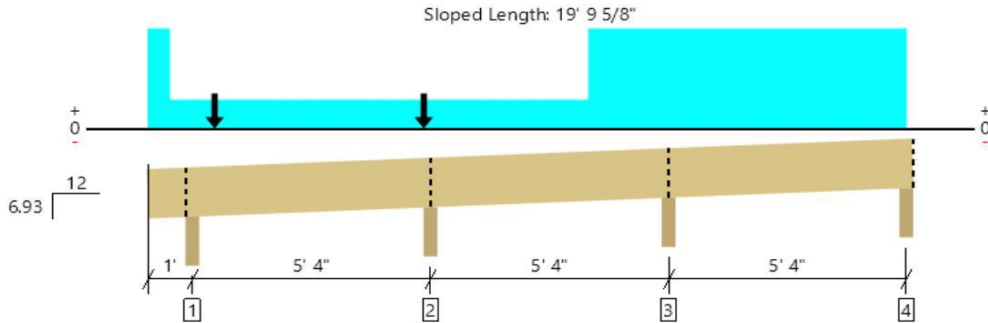
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FortewEB Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof joist before and after solar panels are added



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Roof, roof: Joist with solar panels
1 piece(s) 2 x 4 DF No.2 @ 24" OC



All locations are measured from the outside face of left support (or left cantilever end). All dimensions are horizontal.

Member Length : 19' 11 5/8"

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	349 @ 11' 8"	3789 (3.50")	Passed (9%)	--	1.0 D + 1.0 Lr (All Spans)
Shear (lbs)	177 @ 12' 3/4"	788	Passed (22%)	1.25	1.0 D + 1.0 Lr (All Spans)
Moment (Ft-lbs)	-165 @ 11' 8"	495	Passed (33%)	1.25	1.0 D + 1.0 Lr (All Spans)
Live Load Defl. (in)	0.069 @ 14' 5 15/16"	0.304	Passed (L/999+)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.105 @ 14' 6 3/8"	0.406	Passed (L/696)	--	1.0 D + 1.0 Lr (Alt Spans)

System : Roof
 Member Type : Joist
 Building Use : Residential
 Building Code : IBC 2018
 Design Methodology : ASD
 Member Pitch : 6.93/12

- Deflection criteria: LL (L/240) and TL (L/180).
- Overhang deflection criteria: LL (2L/240) and TL (2L/180).
- Allowed moment does not reflect the adjustment for the beam stability factor.
- A 15% increase in the moment capacity has been added to account for repetitive member usage.
- Applicable calculations are based on NDS.

Supports	Bearing Length			Loads to Supports (lbs)				Accessories
	Total	Available	Required	Dead	Roof Live	Snow	Total	
1 - Beveled Plate - DF	3.50"	3.50"	1.50"	106	26	45	177	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	175	-19	47	222/-19	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	146	203	70	419	Blocking
4 - Beveled Plate - DF	3.50"	3.50"	1.50"	55	92	32	179	Blocking

• Blocking Panels are assumed to carry no loads applied directly above them and the full load is applied to the member being designed.

Lateral Bracing	Bracing Intervals	Comments
Top Edge (Lu)	19' 10" o/c	
Bottom Edge (Lu)	19' 10" o/c	

•Maximum allowable bracing intervals based on applied load.

Vertical Loads	Location (Side)	Spacing	Dead (0.90)	Roof Live (non-snow: 1.25)	Snow (1.15)	Comments
1 - Uniform (PSF)	0 to 17'	24"	10.9	-	-	DL
2 - Uniform (PSF)	0 to 6"	24"	-	20.0	6.9	DL+SL below panels
3 - Point (lb)	1' 6"	N/A	27	-	41	solar and SL
4 - Point (lb)	6' 2 1/4"	N/A	27	-	41	solar and SL
5 - Uniform (PSF)	9' 10 7/16" to 17'	24"	-	20.0	6.9	DL+SL above panels

Member Notes
Roof joist with solar panels

ForteWEB Software Operator	Job Notes
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof joist before and after solar panels are added



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