

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

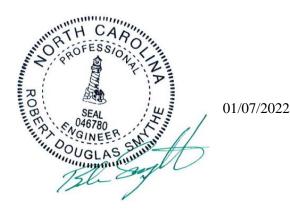
Solar Panel Anchorage

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

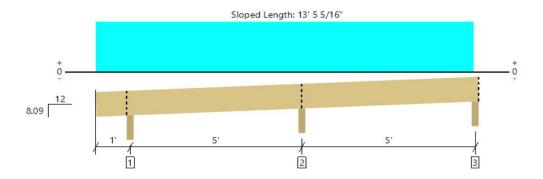
Scope of work and limitations

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 Wind Speed130.0mphExposure CategoryCRisk Category2Mean Roof Height30ftRoof TypeGable RoofBuilding TypeEnclosedRoof Dead Load20Asphalt Shingles2.05/8" Plywood Sheathing2.0Insulation1.2Roof Framing1.11/2" Gypsum Sheathing2.2Dead Load Without Panels8.5Dead Load Without Panels8.5Dead Load Without Panels10.89Pord Live Load20Roof Live Load20Roof Live Load with Solar Panels0.0psf2018 IBCRoof Live Load with Solar Panels0.0psf2018 IBCRoof Live Load with Solar Panels0.0psf2018 IBCRoof Live Load with Solar Panels0.0psfSection 7.2Ground Snow Load(pg)10.0PsfTable 7.3-1				
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	Roof Snow Load-ASCE 7-16			
Exposure Factor (Ce)0.9Table 7.3-1	Ground Snow Load(pg)	10.0	psf	Section 7.2
	Exposure Factor (Ce)	0.9		Table 7.3-1
Thermal Factor (Ct)1.1Table 7.3-2	Thermal Factor (Ct)	1.1		Table 7.3-2
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Flat Roof Snow Load (Pf)6.93Equation 7.3-1	Flat Poof Snow Load (Pf)	6.93		Equation 7.3-1
Slippery Surface Slope Factor (Cs)0.6Figure 7.4-1		0.0		Figure 7.4-1
Non-Slippery Surface Slope Factor (Cs) 1 psf Figure 7.4-1		0.6		
Roof Snow Load 6.93 psf Equation 7.4-1	Slippery Surface Slope Factor (Cs)		psf	Figure 7.4-1
Reduced Snow Load (Slippery Surface) 4.16 psf Equation 7.4-1	Slippery Surface Slope Factor (Cs) Non-Slippery Surface Slope Factor (Cs)	1	-	-

Array Name - Roof 1			
Roof Slope	34.0	degrees	
Number of panels	6		
Panel Area	105.495	ft^2	
Wind Calculations - ASCE 7-1	6		
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	
Minumum # 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	
	24.0 163	in Ibs	see attached analysis
Panel distance from eave			see attached analysis see attached analysis
Panel distance from eave Shear without Panels	163	lbs	•
Panel distance from eave Shear without Panels Shear with Panels	163 165 101.0	lbs	•
Panel distance from eave Shear without Panels Shear with Panels Shear percent increase	163 165 101.0	lbs Ibs	see attached analysis

MEMBER REPORT 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.

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)	

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.

	Bearing Length			Loads to Supports (lbs)				
Supports	Total	Available	Required	Dead	Roof Live	Snow	Total	Accessories
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

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

lowable bracing intervals based on applied lo

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

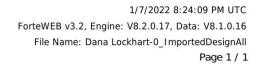
Roof joist before solar panels are added

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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	J ob Notes	
Taylor Smythe Right Angle Engineering (925) 787-3067 taylor@rightangleeng.com	Roof J oist before and after solar panels are added	Weyerhaeuse

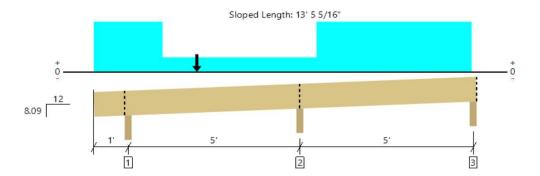


Member Length : 13' 7 11/16"

n : Roof er Type : Joist ng Use : Residential ng Code : IBC 2018 Methodology : ASD er Pitch : 8.09/12



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.

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)	

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.

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

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.

			Dead	Roof Live	Snow	
Vertical Loads	Location (Side)	Spacing	(0.90)	(non-snow: 1.25)	(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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The product application, input design loads, dimensions and support information have been provided by Imported test Software Operator

ForteWEB Software Operator	J ob 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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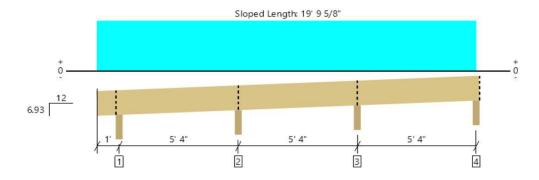
Member Length : 13' 7 11/16"

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

Roof Slope			
	30.0	degrees	
Number of panels	4	-	
Panel Area	70.33	ft^2	
Wind Calculations - ASCE 7-1	6		
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	
Minumum # 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
	101.0		
Shear percent increase	104.0		
Shear percent increase Bending Moment without Pan		ft-lbs	see attached analysis
·		ft-lbs ft-lbs	see attached analysis see attached analysis

MEMBER REPORT

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.

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)	2
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)	

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.

	B	Bearing Length			Loads to Supports (lbs)			
Supports	Total	Available	Required	Dead	Roof Live	Snow	Total	Accessories
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

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

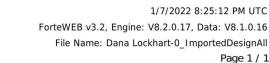
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Weverhaeuser

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

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



Member Length : 19' 11 5/8"

n : Roof er Type : Joist ng Use : Residential ng Code : IBC 2018 Methodology : ASD er Pitch : 6.93/12

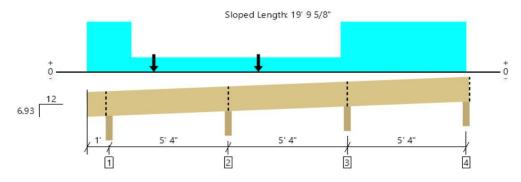
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Page 8 letter of approval



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.

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)	

• 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.

	Bearing Length			I	oads to Sup			
Supports	Total	Available	Required	Dead	Roof Live	Snow	Total	Accessories
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 log 	ads applied dire	ectly above the	m and the ful	l load is appli	ed to the mem	ber being de	signed.	

Bracing Intervals	Comments
19'10" o/c	
19' 10" o/c	
	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	2	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"	H	20.0	6.9	DL+SL above panels

Member Notes

Roof joist with solar panels

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

Member Length : 19' 11 5/8"

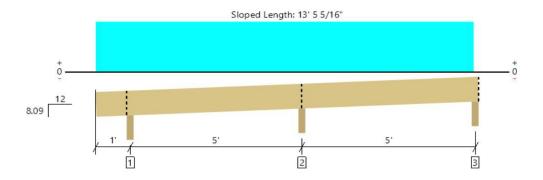
System : Roof Member Type : Joist Building Use : Residential Building Code : IBC 2018 Design Methodology : ASD Member Pitch : 6.93/12

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Roof Slope34.0degreesNumber of panels3Panel Area52.7475ft^2Wind Calculations - ASCE 7-16Figure 30.3-(2A-5B)GCp Zone 2-1.8Figure 30.3-(2A-5B)Gcpi-0.18Table 26.13-1kh0.98Table 26.10-1kht1Equation 26.8-1kd0.85Table 26.6-1Velocity Pressure28.2psfEquation 26.10-1Zone 2 PressureShear Capacity190.0lbsNDS 2015 Table 12kPullout capacityPullout capacity266.0Minumum # of connections5Lag screw embedment2.5Beam Span60, 60Spacing24.0Roof Framing type2x4 Trusses DF#2Panel orientationPortraitNumber st panels per pafer1	Array Name - Roof 3			
Panel Area 52.7475 ft^2 Wind Calculations - ASCE 7-16 Figure 30.3-(2A-5B) Gcpi -1.8 Table 26.13-1 Gcpi -0.18 Table 26.10-1 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 - Minumum # of connections 5 - - Lag screw embedment 2.5 in - Total pullout capacity 665.0 in - Beam Span 60, 60 in - Spacing 2x4 Trusses DF#2 - - Panel orientation Portrait - -	Roof Slope	34.0	degrees	
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 Velocity Pressure 2.5 in Shear Capacity 190.0 lbs NDS 2015 Table 12k Pullout capacity 266.0 lbs/in Velocity Table 26.5 Minumum # of connections 5 In Velocity Table 26.5 Lag screw embedment 2.5 in Velocity Table 26.5 Beam Span 60, 60 in Velocity Table 26.5 Beam Span 60, 60 in Spacing 24.0 in Roof Framing type 2x4 Trusses DF#2 Velocitation Portrait Velocitation Velocitation	Number of panels	3		
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 Stear Capacity 190.0 lbs NDS 2015 Table 12k Pullout capacity 266.0 lbs/in Image: Second Secon	Panel Area	52.7475	ft^2	
Gcpi-0.18Table 26.13-1kh0.98Table 26.10-1kht1Equation 26.8-1kd0.85Table 26.6-1Velocity Pressure28.2psfEquation 26.10-1Zone 2 Pressure-45.69psfEquation 30.7-1Roof ConnectionShear Capacity190.0lbsNDS 2015 Table 12kPullout capacity266.0lbs/inIteration 1000000000000000000000000000000000000	Wind Calculations - ASCE 7-1	6		
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kd0.85Table 26.6-1Velocity Pressure28.2psfEquation 26.10-1Zone 2 Pressure-45.69psfEquation 30.7-1Roof ConnectionShear Capacity190.0lbsNDS 2015 Table 12kPullout capacity266.0lbs/inImage: ConnectionMinumum # of connections5Image: ConnectionImage: ConnectionLag screw embedment2.5inImage: ConnectionTotal pullout capacity665.0inImage: ConnectionBeam Span60, 60inImage: ConnectionSpacing24.0inImage: ConnectionRoof Framing type2x4 Trusses DF#2Image: ConnectionImage: ConnectionPanel orientationPortraitImage: ConnectionImage: Connection	kh	0.98		Table 26.10-1
Velocity Pressure28.2psfEquation 26.10-1Zone 2 Pressure-45.69psfEquation 30.7-1Roof ConnectionShear Capacity190.0lbsNDS 2015 Table 12kPullout capacity266.0lbs/inImage: Connection 100 (Destine)Minumum # of connections5Image: Connection 100 (Destine)Lag screw embedment2.5inTotal pullout capacity665.0inBeam Span60, 60inSpacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	kht	1		Equation 26.8-1
Zone 2 Pressure-45.69psfEquation 30.7-1Roof ConnectionIbsNDS 2015 Table 12kShear Capacity190.0IbsNDS 2015 Table 12kPullout capacity266.0Ibs/inIbs/inMinumum # of connections5Ibs/inIbs/inLag screw embedment2.5inIbs/inTotal pullout capacity665.0inIbs/inBeam StressIbs/inIbs/inIbs/inBeam Span60, 60inIbs/inSpacing24.0inIbs/inRoof Framing type2x4 Trusses DF#2Ibs/inPanel orientationPortraitIbs/in	kd	0.85		Table 26.6-1
Roof ConnectionShear Capacity190.0lbsNDS 2015 Table 12kPullout capacity266.0lbs/inMinumum # of connections5Lag screw embedment2.5inTotal pullout capacity665.0inBeam StressBeam Span60, 60inSpacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Velocity Pressure	28.2	psf	Equation 26.10-1
Shear Capacity190.0IbsNDS 2015 Table 12kPullout capacity266.0Ibs/inMinumum # of connections5Lag screw embedment2.5inTotal pullout capacity665.0inBeam Stress5Beam Span60, 60inSpacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Zone 2 Pressure	-45.69	psf	Equation 30.7-1
Pullout capacity266.0Ibs/inMinumum # of connections5Lag screw embedment2.5Total pullout capacity665.0Beam StressBeam Span60, 60Spacing24.0Roof Framing type2x4 Trusses DF#2Panel orientationPortrait	Roof Connection			
Minumum # of connections5Lag screw embedment2.5inTotal pullout capacity665.0inBeam StressBeam Span60, 60inSpacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Shear Capacity	190.0	lbs	NDS 2015 Table 12k
Lag screw embedment2.5inTotal pullout capacity665.0inBeam Span60, 60Spacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Pullout capacity	266.0	lbs/in	
Total pullout capacity665.0inBeam StressBeam Span60, 60inSpacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Minumum # of connections	5		
Beam StressBeam Span60, 60inSpacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Lag screw embedment	2.5	in	
Beam Span60, 60inSpacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Total pullout capacity	665.0	in	
Spacing24.0inRoof Framing type2x4 Trusses DF#2Panel orientationPortrait	Beam Stress			
Roof Framing type2x4 Trusses DF#2Panel orientationPortrait	Beam Span	60, 60	in	
Panel orientation Portrait	Spacing	24.0	in	
	Roof Framing type	2x4 Trusses DF#2		
Number of papels per rafter 1	Panel orientation	Portrait		
	Number of panels per rafter	1		
Panel distance from eave 24.0 in	Panel distance from eave	24.0	in	
Shear without Panels163Ibssee attached analysis	Shear without Panels	163	lbs	see attached analysis
Shear with Panels165Ibssee attached analysis	Shear with Panels	165	lbs	see attached analysis
Shear percent increase 101.0	Shear percent increase	101.0		
Bending Moment without Panels182ft-lbssee attached analysis	Bending Moment without Pane	els 182	ft-lbs	see attached analysis
Bending Moment with Panels149ft-lbssee attached analysis	Bending Moment with Panels	149	ft-lbs	see attached analysis
Bending percent increase 82.0	Bending percent increase	82.0		

FORTE WEB

MEMBER REPORT 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.

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)	

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.

	B	earing Leng	th	L	oads to Sup	oorts (lbs)		
Supports	Total	Available	Required	Dead	Roof Live	Snow	Total	Accessories
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

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

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

Weyerhaeuser Notes

Weyerhaeuser warrants that the sizing of its products will be in accordance with Weyerhaeuser product design criteria and published design values. Weyerhaeuser expressly disclaims any other warranties related to the software. Use of this software is not intended to circumvent the need for a design professional as determined by the authority having jurisdiction. The designer of record, builder or framer is responsible to assure that this calculation is compatible with the overall project. Accessories (Rim Board, Blocking Panels and Squash Blocks) are not designed by this software. Products manufactured at Weyerhaeuser facilities are third-party certified to sustainable forestry standards. Weyerhaeuser Engineered Lumber Products have been evaluated by ICC-ES under evaluation reports ESR-1153 and ESR-1387 and/or tested in accordance with applicable ASTM standards. For current code evaluation reports, Weyerhaeuser product literature and installation details refer to www.weyerhaeuser.com/woodproducts/document-library.

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

ForteWEB Software Operator	J ob 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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Member Length : 13' 7 11/16"

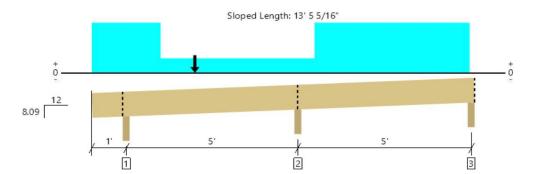
System : Roof Member Type : Joist Building Use : Residential Building Code : IBC 2018 Design Methodology : ASD Member Pitch : 8.09/12

PASSED

Page 11 letter of approval



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.

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)	

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.

Bearing Length		L	oads to Sup				
Total	Available	Required	Dead	Roof Live	Snow	Total	Accessories
3.50"	3.50"	1.50"	92	74	44	210	Blocking
3.50"	3.50"	1.50"	174	107	58	339	Blocking
3.50"	3.50"	1.50"	49	89	29	167	Blocking
	Total 3.50" 3.50"	Total Available 3.50" 3.50" 3.50" 3.50"	Total Available Required 3.50" 3.50" 1.50" 3.50" 3.50" 1.50"	Total Available Required Dead 3.50" 3.50" 1.50" 92 3.50" 3.50" 1.50" 174	Total Available Required Dead Roof Live 3.50" 3.50" 1.50" 92 74 3.50" 3.50" 1.50" 174 107	Total Available Required Dead Roof Live Snow 3.50" 3.50" 1.50" 92 74 44 3.50" 3.50" 1.50" 174 107 58	Total Available Required Dead Roof Live Snow Total 3.50" 3.50" 1.50" 92 74 44 210 3.50" 3.50" 1.50" 174 107 58 339

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

mum 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	6	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

Weyerhaeuser Notes

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Weverhaeuser

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

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



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Member Length : 13' 7 11/16"

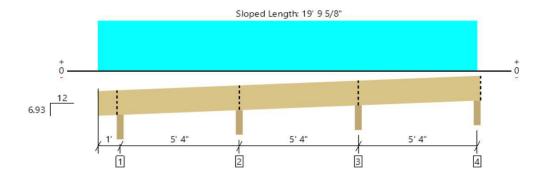
tem : Roof mber Type : Joist ding Use : Residential ding Code : IBC 2018 ign Methodology : ASD nber Pitch : 8.09/12

Array Name - Roof 4			
Roof Slope	30.0	degrees	
Number of panels	9	-	
Panel Area	158.2425	ft^2	
Wind Calculations - ASCE 7-1	6		
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	
Minumum # 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 Pane	els 178	ft-lbs	see attached analysis
Bending Moment with Panels	165	ft-lbs	see attached analysis
Bending memorie man anole			,

FORTE WEB

MEMBER REPORT

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.

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)	2
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)	

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.

	B	Bearing Length			Loads to Supports (lbs)				
Supports	Total	Available	Required	Dead	Roof Live	Snow	Total	Accessories	
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	

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

Weyerhaeuser Notes

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Weverhaeuser

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

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

1/7/2022 8:26:57 PM UTC ForteWEB v3.2, Engine: V8.2.0.17, Data: V8.1.0.16 File Name: Dana Lockhart-0_ImportedDesignAll

Member Length : 19' 11 5/8"

n : Roof er Type : Joist ng Use : Residential ng Code : IBC 2018 Methodology : ASD er Pitch : 6.93/12

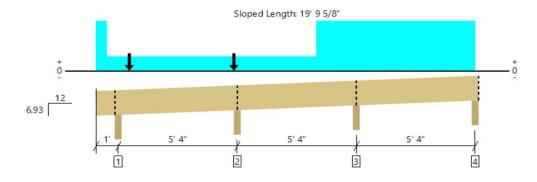
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Roof, roof: Joist with solar panels 1 piece(s) 2 x 4 DF No.2 @ 24" OC



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

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)	2
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)	

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.

	В	Bearing Length			oads to Sup			
Supports	Total	Available	Required	Dead	Roof Live	Snow	Total	Accessories
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 dire	ctly above the	m and the ful	I load is appli	ed to the mem	ber being de	signed.	•

Bracing Intervals	Comments
19'10" o/c	
19' 10" o/c	
	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	2	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"	H	20.0	6.9	DL+SL above panels

Member Notes

Roof joist with solar panels

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



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