RIGHT ANGLE *ENGINEERING*

January 28, 2022

Advance Solar Solutions
2372 Morse Avenue #912
Irvine, California, 92614

Design Criteria:

Wind Speed (ASD)- 115.0 mph
Ground Snow Load- 20.0 psf
Risk Category- 2
Exposure Category- C

RE: Structural Roof Evaluation for the LSCV455-MO Commercial: 455 SW Ward Rd, Lees Summit, Missouri

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 Advance Solar Solutions 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 2015 International Building code and ASCE 7-10.

Array Name	Panel Quantity	Connection Type	Min # Connections	Reinforcements
Array 1	37	RT-Mini Mount	88	None
Array 2	28	RT-Mini Mount	67	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.

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).

Regards,

01/28/2022

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.

Design Criteria			
Design Wind Speed	115.0	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	1.57	psf	
1/2" Gypsum Sheathing	2.2	psf	
Solar Panel Array	2.39	psf	
Dead Load Without Panels	8.97	psf	
Dead Load With Panels	11.36	psf	
Roof Live Load			
Existing Roof Live Load	20	psf	ASCE 7-10 Table 4-1
Roof Live Load with Solar Panels	0.0	psf	1607.12.5
Roof Snow Load-ASCE 7-10			
Ground Snow Load(pg)	20.0	psf	Section 7.2
Exposure Factor (Ce)	0.9		Table 7-2
Thermal Factor (Ct)	1.1		Table 7-3
Importance Fator (Is)	1		Table 1.5-2
Flat Roof Snow Load (Pf)	13.86		Equation 7.3-1
Slippery Surface Slope Factor (Cs)	0.78		Figure 7-2
Non-Slippery Surface Slope Factor (Cs)	1	psf	Figure 7-2
Roof Snow Load	13.86	psf	Equation 7.4-1
Reduced Snow Load (Slippery Surface)	10.86	psf	Equation 7.4-1

Array Name - Array 1			
Roof Slope	23.0	degrees	
Number of panels	37		
Panel Area	650.5525	ft^2	
Wind Calculations - ASCE 7-10			
GCp Zone 2	-2.5		Figure 30.4-(2A-5B)
Gcpi	-0.18		Table 26.11-1
kh	0.98		Table 27.3-1
kht	1		Equation 26.8-1
kd	0.85		Table 26.6-1
Velocity Pressure	28.2	psf	Equation 27.3-1
Zone 2 Pressure	-65.43	psf	Equation 30.8-1
Roof Connection			
Shear Capacity	355.0	lbs	NDS 2015 Table 12k
Pullout capacity	447.0	lbs/in	
Minumum # of connections	88		
Lag screw embedment	0.5	in	
Total pullout capacity	447.0	in	
Beam Stress			
Beam Span	84, 84, 84, 84	in	
Spacing	24.0	in	
Roof Framing type	2x4 Trusses DF#2		
Panel orientation	Landscape		
Number of panels per rafter	5		
Panel distance from eave	0.0	in	
Shear without Panels	228	lbs	see attached analysis
Shear with Panels	234	lbs	see attached analysis
Shear percent increase	103.0		
Bending Moment without Panels	321	ft-lbs	see attached analysis
Bending Moment with Panels	350	ft-lbs	see attached analysis
Bending percent increase	109.0		

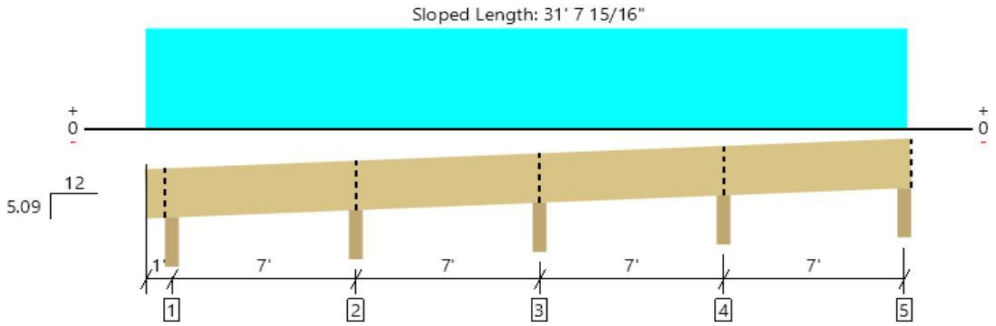
FORTE WEB

MEMBER REPORT

PASSED

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 : 31' 9 3/8"

System : Roof
Member Type : Joist
Building Use : Residential
Building Code : IBC 2018
Design Methodology : ASD
Member Pitch : 5.09/12

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	484 @ 22'	3564 (3.50")	Passed (14%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	228 @ 22' 5"	788	Passed (29%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	-321 @ 22'	495	Passed (65%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.178 @ 25' 8 9/16"	0.377	Passed (L/508)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.247 @ 25' 9 1/16"	0.502	Passed (L/366)	--	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.

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"	75	161	112	348	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	154	329	228	711	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	128	291	202	621	Blocking
4 - Beveled Plate - DF	3.50"	3.50"	1.50"	155	329	228	712	Blocking
5 - Beveled Plate - DF	3.50"	3.50"	1.50"	54	119	82	255	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)	20' 5" o/c	
Bottom Edge (Lu)	14' 9" 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 29'	24"	9.0	20.0	13.9	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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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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1/28/2022 7:42:56 PM UTC
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File Name: LSCV455-MO-0_ImportedDesignAll

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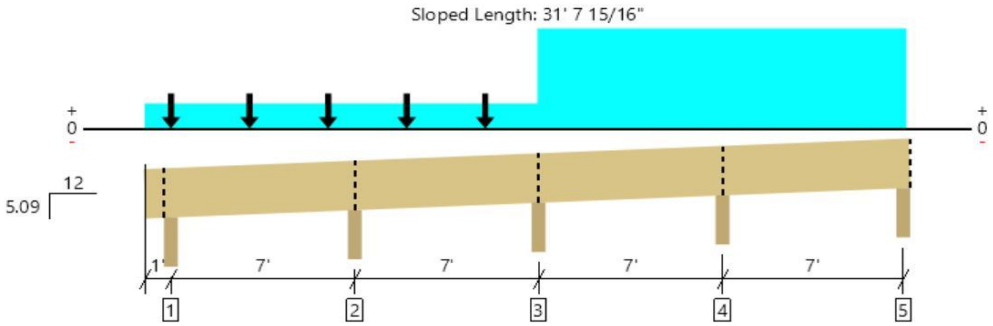
MEMBER REPORT

PASSED

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 : 31' 9 3/8"

System : Roof
Member Type : Joist
Building Use : Residential
Building Code : IBC 2018
Design Methodology : ASD
Member Pitch : 5.09/12

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	527 @ 22'	3564 (3.50")	Passed (15%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	234 @ 7' 7"	725	Passed (32%)	1.15	1.0 D + 1.0 S (Adj Spans)
Moment (Ft-lbs)	-350 @ 22'	495	Passed (71%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.162 @ 25' 9 1/4"	0.377	Passed (L/557)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.252 @ 25' 9 9/16"	0.502	Passed (L/359)	--	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.

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"	120	7	116	243	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	243	-20	200	443/-20	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	178	145	178	501	Blocking
4 - Beveled Plate - DF	3.50"	3.50"	1.50"	194	333	228	755	Blocking
5 - Beveled Plate - DF	3.50"	3.50"	1.50"	69	116	82	267	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' 5" o/c	
Bottom Edge (Lu)	13' 2" 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 29'	24"	11.4	-	-	DL
2 - Uniform (PSF)	0	24"	-	20.0	13.9	DL+SL below panels
3 - Point (lb)	1'	N/A	18	-	74	solar and SL
4 - Point (lb)	3' 11 7/8"	N/A	18	-	74	solar and SL
5 - Point (lb)	6' 11 13/16"	N/A	18	-	74	solar and SL
6 - Point (lb)	9' 11 11/16"	N/A	18	-	74	solar and SL
7 - Point (lb)	12' 11 5/8"	N/A	18	-	74	solar and SL
8 - Uniform (PSF)	14' 11 1/2" to 29'	24"	-	20.0	13.9	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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File Name: LSCV455-MO-0_ImportedDesignAll

Array Name - Array 2			
Roof Slope	23.0	degrees	
Number of panels	28		
Panel Area	492.31	ft^2	
Wind Calculations - ASCE 7-10			
GCp Zone 2	-2.5		Figure 30.4-(2A-5B)
Gcpi	-0.18		Table 26.11-1
kh	0.98		Table 27.3-1
kht	1		Equation 26.8-1
kd	0.85		Table 26.6-1
Velocity Pressure	28.2	psf	Equation 27.3-1
Zone 2 Pressure	-65.43	psf	Equation 30.8-1
Roof Connection			
Shear Capacity	355.0	lbs	NDS 2015 Table 12k
Pullout capacity	447.0	lbs/in	
Minumum # of connections	67		
Lag screw embedment	0.5	in	
Total pullout capacity	447.0	in	
Beam Stress			
Beam Span	120, 120	in	
Spacing	24.0	in	
Roof Framing type	2x6 Trusses DF#2		
Panel orientation	Portrait		
Number of panels per rafter	4		
Panel distance from eave	0.0	in	
Shear without Panels	336	lbs	see attached analysis
Shear with Panels	204	lbs	see attached analysis
Shear percent increase	61.0		
Bending Moment without Panels	734	ft-lbs	see attached analysis
Bending Moment with Panels	477	ft-lbs	see attached analysis
Bending percent increase	65.0		

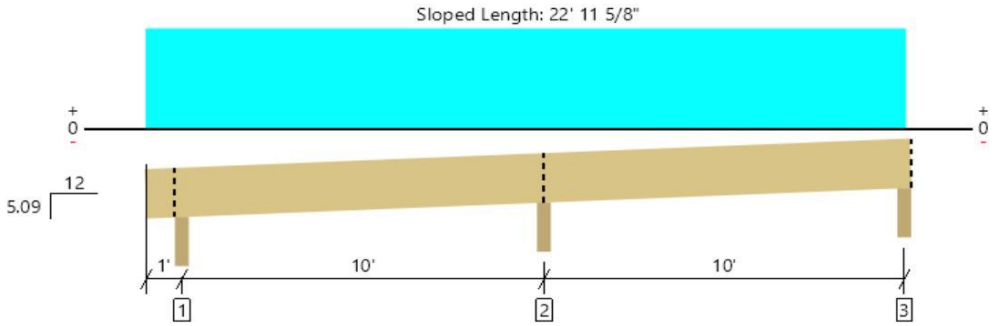
FORTE WEB

MEMBER REPORT

PASSED

Roof, roof: Joist before panels

1 piece(s) 2 x 6 DF No.2 @ 24" OC



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Member Length : 23' 1 15/16"

System : Roof
Member Type : Joist
Building Use : Residential
Building Code : IBC 2018
Design Methodology : ASD
Member Pitch : 5.09/12

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	738 @ 11'	3564 (3.50")	Passed (21%)	--	1.0 D + 1.0 Lr (Adj Spans)
Shear (lbs)	336 @ 11' 6 13/16"	1238	Passed (27%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Moment (Ft-lbs)	-734 @ 11'	1060	Passed (69%)	1.25	1.0 D + 1.0 Lr (Adj Spans)
Live Load Defl. (in)	0.175 @ 16' 5 1/4"	0.540	Passed (L/741)	--	1.0 D + 1.0 Lr (Alt Spans)
Total Load Defl. (in)	0.238 @ 16' 6 1/4"	0.720	Passed (L/544)	--	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.

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"	94	205	142	441	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	241	497	344	1082	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	74	164	114	352	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)	16' 11" o/c	
Bottom Edge (Lu)	9' 11" 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 21'	24"	9.0	20.0	13.9	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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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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1/28/2022 7:44:30 PM UTC
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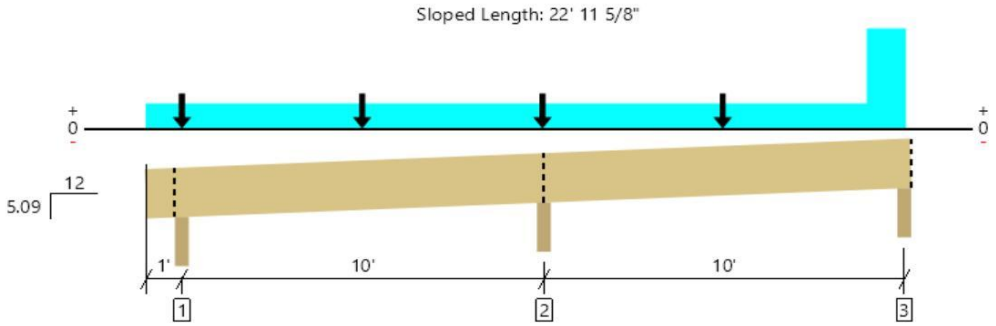
MEMBER REPORT

PASSED

Roof, roof: Joist with solar panels

1 piece(s) 2 x 6 DF No.2 @ 24" OC



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Member Length : 23' 1 15/16"

System : Roof
Member Type : Joist
Building Use : Residential
Building Code : IBC 2018
Design Methodology : ASD
Member Pitch : 5.09/12

Design Results	Actual @ Location	Allowed	Result	LDF	Load: Combination (Pattern)
Member Reaction (lbs)	524 @ 11'	3564 (3.50")	Passed (15%)	--	1.0 D + 1.0 S (Adj Spans)
Shear (lbs)	204 @ 11' 6 13/16"	1139	Passed (18%)	1.15	1.0 D + 1.0 S (Adj Spans)
Moment (Ft-lbs)	-477 @ 11'	975	Passed (49%)	1.15	1.0 D + 1.0 S (Adj Spans)
Live Load Defl. (in)	0.058 @ 16' 4 7/16"	0.540	Passed (L/999+)	--	1.0 D + 1.0 S (Alt Spans)
Total Load Defl. (in)	0.148 @ 16' 6 7/8"	0.720	Passed (L/878)	--	1.0 D + 1.0 S (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.

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"	142	3	102	247	Blocking
2 - Beveled Plate - DF	3.50"	3.50"	1.50"	347	3	176	526	Blocking
3 - Beveled Plate - DF	3.50"	3.50"	1.50"	99	41	54	194	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)	23' o/c	
Bottom Edge (Lu)	16' 3" 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 21'	24"	11.4	-	-	DL
2 - Uniform (PSF)	0	24"	-	20.0	13.9	DL+SL below panels
3 - Point (lb)	1'	N/A	18	-	73	solar and SL
4 - Point (lb)	5' 11 3/4"	N/A	18	-	73	solar and SL
5 - Point (lb)	10' 11 1/2"	N/A	18	-	73	solar and SL
6 - Point (lb)	15' 11 1/4"	N/A	18	-	73	solar and SL
7 - Uniform (PSF)	19' 11 1/16" to 21'	24"	-	20.0	13.9	DL+SL above panels

Member Notes
Roof joist with solar panels

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