

iRooFAtm

Instant Roof Framing Analysis

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STRUCTURAL ANALYSIS

for the

ROOFTOP PV SOLAR INSTALLATION

Project: Lee Osterhout, 42 Oakland Drive Sanford Nc 27332, Sanford, NC 27332

Prepared for:



Freedom Solar, LLC

4801 Freidrich Ln, Ste 100 - Austin, TX 78744

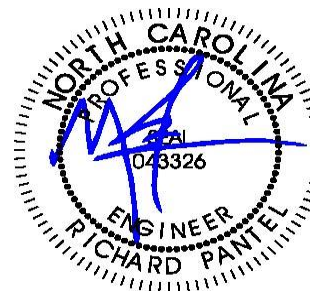
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Project Number: 36.114630, Rev. 0

Report Date: 06/03/2024

Report Prepared by:



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 Date: 2024.06.03 17:06:55 -04'00'

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Loading Summary

Exposure and Occupancy Categories		
B		Exposure Category (ASCE 7-10 Table 26.7.3, Page 266)
II		Building Use Occupancy / Risk Category (ASCE 7-10 Table 1.5-1, Page 4)

Wind Loading:			
v	117	mph	ASCE 7-10, Figure 26.5-1 A, B or C, pp 249-251. [(117 mph, 50 year wind MRI)]
qz	20.76	psf	Velocity qz, calculated at height z [ASD]

Snow Loading			
pg	10.00	psf	Ground Snow Load pg (ASCE 7-10 Table 7.2-1, Page 52-53)
Total Snow Load			
ps	10.00	psf	Effective snow load on roof and modules

Module Data			
Mission Solar: MSE395SX9R			
Dimensions	mm	ft	in
Length	1,907	6.26	75.08
Width	1,054	3.46	41.50
Area (m ² , ft ²)	2.0	21.64	
Weight	kg	lb	
Module	22.00	48.50	

Roof Panel (Cladding) Loading Summary		Module Loading Summary			
Support Point Loads		Upward	Upward	Upward	Downward
Roof Zones		1	2	3	All
Net load per module	lb	-271	-366	-366	295

Positive values indicate net downward force

Stanchion Fastener Pull-out and Spacing Calculations				
Framing spacing	ft			2.00
Rails / Module	ea			2
Max proposed stanchion span	ft			6.00
# fasteners per stanchion				1
Bolt thread embedment depth	in			3
Safety Factor				1.10
Pull-out for 5/16 threaded fasteners	lb/in			220
Factored max fastener uplift capacity	lb			599
Fastener details	Material	Stainless	Size	5/16
Max stanchion uplift capacity	lb			618
Max support point uplift capacity	lb			599

Pre-drill hole 0.16" dia or use self tapping

Roof Zones		1	2	3	
Net lift per module	<i>lb</i>	271	366	366	
Min tot bolt thread embedment depth req'd	<i>in</i>	1.36	1.83	1.83	
Net uplift pressure	7. 0.6D - 0.6W	<i>psf</i>	-7.23	-9.75	-9.75
Allowable lift area / support point		<i>sf</i>	82.85	61.42	61.42
Max rail span per framing spacing		<i>ft</i>	6.00	6.00	6.00
Landscape Modules					
Length along rafter		<i>ft</i>	3.46		
Lift calc'ed max stanchion EW spacing		<i>ft</i>	> 6	> 6	> 6
Max stanchion EW spacing		<i>ft</i>	6.00	6.00	6.00
Maximum module area / support point		<i>sf</i>	10.37	10.37	10.37
Factored lift per support point		<i>lb</i>	-75	-101	-101
Portrait Modules					
Length along rafter		<i>ft</i>	6.26		
Lift calc'ed max stanchion EW spacing		<i>ft</i>	> 6	> 6	> 6
Max stanchion EW spacing		<i>ft</i>	6.00	6.00	6.00
Maximum module area / support point		<i>sf</i>	18.77	18.77	18.77
Factored lift per support point		<i>lb</i>	-136	-183	-183

Stanchion support threaded fastener sizes are indicated in the Module Loading Summary table above. Lift forces were determined from GCP and other coefficients contained in the ASCE nomographs

Conclusions

We were asked to review the roof of Lee Osterhout, located at 42 Oakland Drive Sanford Nc 27332, Sanford, NC, by Freedom Solar, LLC, to determine its suitability to support a PV solar system installation.

The referenced building's roof structure was field measured by Freedom Solar, LLC on 05/16/2024. The attached framing analyses reflect the results of those field measurements combined with the PV solar module locations shown on the PV solar roof layout design prepared by Freedom Solar, LLC. Loads are calculated to combine the existing building and environmental loads with the proposed new PV array loads.

The Pegasus PSR-B Rail racking and Pegasus Solar InstaFlash PIF-RB0 stanchions were selected for this project by Freedom Solar, LLC. The racking and support stanchions shall be placed as shown on their plans, dated 06/03/2024, and shall be fastened to the roof framing using fastener sizes indicated in this report. Rack support spacing shall be no more than that shown above. Note that support points for alternating rows shall share the same truss. Intermediate rows shall move the support points laterally to the next truss. The support rail can be cantilevered up to 1/3 of the maximum span between modules. 1/3 maximum span = 24.00 inches.



Google Location Map

Framing Summary

	<u>Ex. Framing</u>	<u>Total Ex DL</u>
MP 1: Truss @ 24" OC	0.79 psf	5.19 psf
MP 2: Truss @ 24" OC	0.79 psf	5.19 psf

* Wood species used in these calculations assumes spruce, pine or fir, #2 grade.

Based upon the attached calculations, the existing roofs' framing systems are capable of supporting the additional loading for the proposed PV solar system along with the existing building and environmental loads. No supplemental roof framing structural supports are required. Minimum required anchorage fastening is described above.

Wood fastener notes: 1) Fastener threads must be embedded in the side grain of a roof support structural member or other structural member integrated into the building's structure. 2) Fastener must be located in the middle third of the structural member. 3) Install fasteners with head and where required, washer, flush to material surface (no gap). Do not over-torque.

References and Codes:

- 1) ASCE 7-10 Minimum Design Loads for Buildings and Other Structures
- 2) 2015 IBC
- 3) 2018 NC Building Code
- 4) American Wood Council, NDS 2018, Table 12.2A, 12.3.3A.
- 5) American Wood Council, Wood Structural Design, 1992, Figure 6.

Roof Structural Calculations for PV Solar Installation

Array AR-1

Location: MP 1

Member: Truss - Total Length 22.5 ft, Unsupported 22.5 ft

Geometric Data			
Θ	deg.	34.00	Angle of roof plane from horizontal, in degrees
ω	deg.	0.00	Angle the solar panel makes with the roof surface
L	ft.	28.00	Length of roof plane, in feet (meters)
W	ft.	18.50	Plan view width of roof plane, in feet (meters)
h	ft.	18.67	Average height of roof above grade, in feet (meters)

Roof Wind Zone Width			
use, a =	3.00	ft	

Wind Velocity Pressure, q_z evaluated at the height z			
q_z =	20.76	psf	$V_{asd} q_z$ = 12.61 psf Basic wind pressure
V=	117		mph

Framing Data	
Wood type	US Spruce
Wood source, moisture content	White 0.12%
# Framing Members / Support	1
Rafter / Truss OC	in 24.00
Member Total Length	ft 22.50

3	# Rafters / Rack Support Width
6.00	Rack Support Spacing (ft)
72	Max. Rack Support Spacing (in)
3	Max # of mod's / Truss top chord

Member Properties	Member
Name	(1) 2x4
Repetitive Member Factor (Cr)	1.15

* Mem properties based upon field measurements

Truss top chord

Module Physical Data			
Weight	kg	lb	psf load
Module	22.00	48.50	2.24
4 Stanchions	1.36	3.0	0.14

Existing Dead Loads	Units	Value	Description
Roof Deck & Surface	psf	4.40	Truss members' self weight added to FEA analysis

Rack Support Spacing and Loading			
Across rafters	ft	6.0	
Along rafter slope	ft	6.3	
Area / support point	sf	18.8	
Uphill gap between modules	in	1.0	0.08 ft

Member Total Length	ft	22.50	
Maximum member free span	ft	22.50	Truss top chord span
Zones	1	2	3
GCp	-0.93	-1.13	-1.13

Downward, Zones 1, 2 & 3
GCp 0.87

ASCE 7-10 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)

Zones	1	2	3	1, 2 & 3
2.2 SYMBOLS AND NOTATION	<i>Module Upward</i>	<i>Module Upward</i>	<i>Module Upward</i>	<i>Downward</i>
D = dead load of PV Module + Stanchion	2.38	2.38	2.38	2.38
S = snow load	10.00	10.00	10.00	10.00
W = wind load = (Vu Windload) = (Vasd Windload / 0.6)	-19.61	-23.82	-23.82	18.22

2.4 Combining Nominal Loads Using Allowable Stress Design (in psf)

2.4.1 Basic Combinations. Loads listed herein shall be considered to act in the following combinations; whichever produces the most unfavorable effect in the building, foundation, or structural member being considered. Effects of one or more loads not acting shall be considered.

<i>Combination Formulae</i>	<i>Upward</i>	<i>Upward</i>	<i>Upward</i>	<i>Downward</i>
Use this loading combination for DOWNWARD for Proposed PV Dead Load				
6. D + 0.75L - 0.75(0 or 0.7)eE + 0.75S	12.38	12.38	12.38	18.08
Module Support point load (lb)	232	232	232	339
Cr Factored Module Support point load (lb)	202	202	202	295

Use this loading combination for UPWARD for Proposed PV Dead Load

7. 0.6D - 0.6W	-7.23	-9.75	-9.75	4.54
Module Support point load (lb)	-136	-183	-183	85

DOWNWARD

Presume loading directly over member.

Combined Dead and Wind Pressure Downward Loading

Truss top chord span					
PV Module Row	Point load loc's from Left support	Point Load #'s	Module Support Point Load	Comment	Module Orientation
	<i>ft from left</i>		<i>lb</i>		
1	0.25		295		Portrait
1	6.51			Support placed on adjoining truss	Portrait
2	6.59			Support placed on adjoining truss	Portrait
2	12.85		295		Portrait
3	12.93		295		Portrait
3	19.19			Support placed on adjoining truss	Portrait

Truss Data and Loading for MP 1

Roof slope (degrees)	34.00
Top ridge height above floor plane	12.58

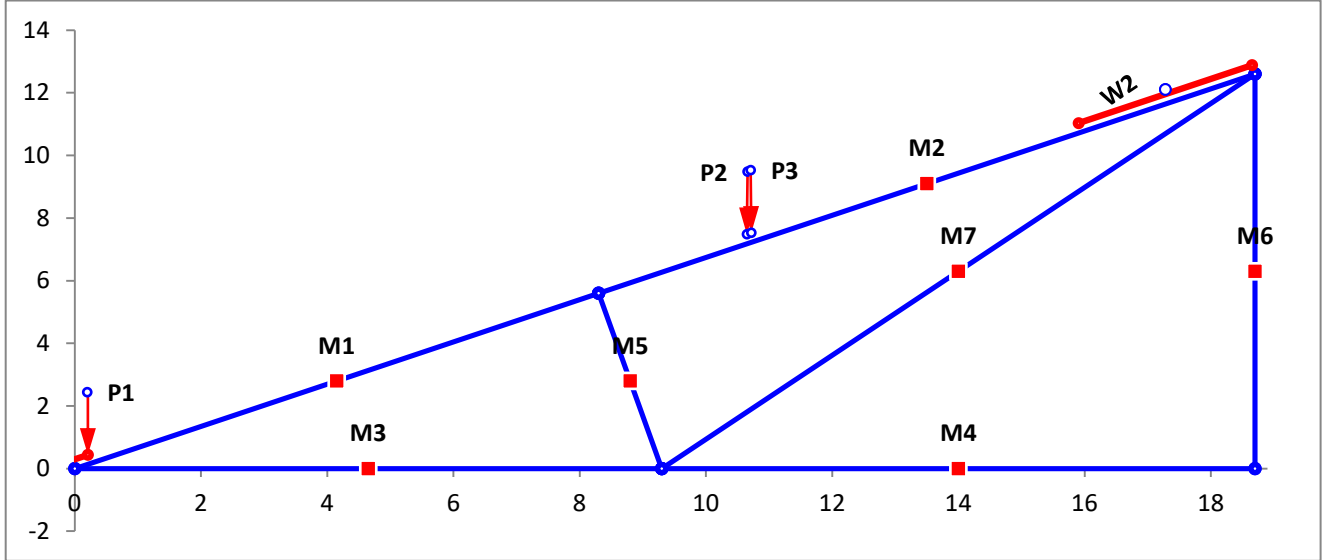
Length of roof plane	22.50
Length of floor plane	18.50

Truss Segments

Roof Plane		Floor Plane	
Mem #	Mem Type	Mem #	Mem Type
1	2x4	3	2x4
2	2x4	4	2x4

Diagonals		Diagonals	
Mem #	Mem Type	Mem #	Mem Type
5	2x4	7	2x4
6	2x4		

* Loading includes member self weight & roofing materials. *w* loading = wind & snow on exposed areas



Roof Structural Calculations for PV Solar Installation

Array AR-2

Location: MP 2

Member: Truss - Total Length 11 ft, Unsupported 11 ft

Geometric Data			
Θ	deg.	34.00	Angle of roof plane from horizontal, in degrees
ω	deg.	0.00	Angle the solar panel makes with the roof surface
L	ft.	24.00	Length of roof plane, in feet (meters)
W	ft.	9.00	Plan view width of roof plane, in feet (meters)
h	ft.	18.67	Average height of roof above grade, in feet (meters)

Roof Wind Zone Width			
use, a =	3.00	ft	

Wind Velocity Pressure, q_z evaluated at the height z			
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V=	117		mph

Framing Data	
Wood type	US Spruce
Wood source, moisture content	White 0.12%
# Framing Members / Support	1
Rafter / Truss OC	in 24.00
Member Total Length	ft 11.00

3	# Rafters / Rack Support Width
6.00	Rack Support Spacing (ft)
72	Max. Rack Support Spacing (in)
1	Max # of mod's / Truss top chord

Member Properties	Member
Name	(1) 2x4
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Truss top chord

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Weight	kg	lb	psf load
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Existing Dead Loads	Units	Value	Description
Roof Deck & Surface	psf	4.40	Truss members' self weight added to FEA analysis

Rack Support Spacing and Loading			
Across rafters	ft	6.0	
Along rafter slope	ft	6.3	
Area / support point	sf	18.8	
Uphill gap between modules	in	1.0	0.08 ft

Member Total Length	ft	11.00	
Maximum member free span	ft	11.00	Truss top chord span
Zones	1	2	3
GCp	-0.93	-1.13	-1.13

Downward, Zones 1, 2 & 3
GCp 0.87

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6. $D + 0.75L - 0.75(0 \text{ or } 0.7)eE + 0.75S$	12.38	12.38	12.38	18.08
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Cr Factored Module Support point load (lb)	202	202	202	295

Use this loading combination for UPWARD for Proposed PV Dead Load

7. $0.6D - 0.6W$	-7.23	-9.75	-9.75	4.54
Module Support point load (lb)	-136	-183	-183	85

DOWNWARD

Presume loading directly over member.

Combined Dead and Wind Pressure Downward Loading

Truss top chord span					
PV Module Row	Point load loc's from Left support	Point Load #'s	Module Support Point Load	Comment	Module Orientation
	<i>ft from left</i>		<i>lb</i>		
1	2.15		295		Portrait
1	8.41			Support placed on adjoining truss	Portrait

Truss Data and Loading for MP 2

Roof slope (degrees)	34.00
Top ridge height above floor plane	6.15

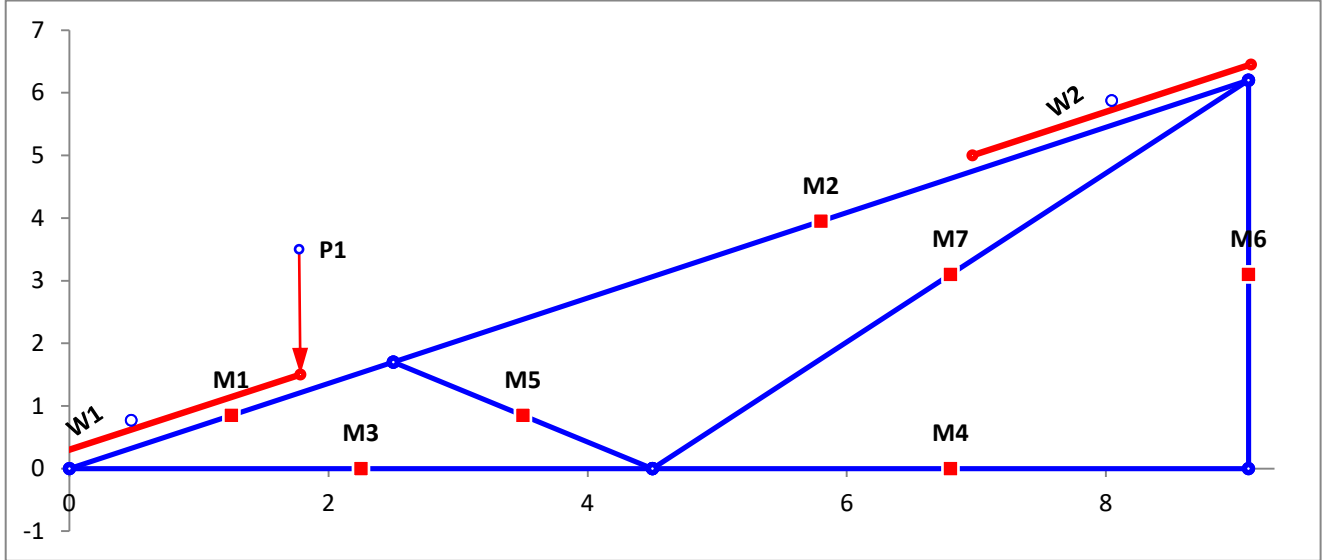
Length of roof plane	11.00
Length of floor plane	9.00

Truss Segments

Roof Plane		Floor Plane	
Mem #	Mem Type	Mem #	Mem Type
1	2x4	3	2x4
2	2x4	4	2x4

Diagonals		Diagonals	
Mem #	Mem Type	Mem #	Mem Type
5	2x4	7	2x4
6	2x4		

* Loading includes member self weight & roofing materials. w loading = wind & snow on exposed areas



Snow Loading Analysis

where:

- | | | |
|------------------------|--|---|
| | Fully Exposed | Exposure category |
| C_e = | 0.9 | Exposure Factor, C _e (ASCE 7-10 Table 7.3-1, Page 58) |
| C_t = | 1.0 | Thermal Factor, C _t (ASCE 7-10 Table 7.3-2, Page 58) |
| I_s = | 1.0 | Snow Importance Factor, I _s (ASCE 7-10 Table 1.5-2, Page 5) |
| p_g = | 10.00 | Ground Snow Load p _g (ASCE 7-10 Table 7.2-1, Page 52-53) |
| p_f = | 0.7C_eC_tI_sP_g | Flat Roof Snow Load, p _f (ASCE 7-10 Table 7.3-1, Page 58) |
| p_f = | 6.30 | psf |
| | | but where P _f is not less than the following: |
| | | Minimum Snow Load p _m (ASCE 7-10 Table 7.3.4, Page 53) |
| p_m = | 10.00 | When P _g <=20 psf, then use P _f = P _g x I _s |
| p_f = | 10.00 | psf. Resultant Snow pressure to be used with Roof slope factor below |
| p_s = | C_sp_f | Sloped Roof Snow Load p _s (ASCE 7-10 Table 7.4, Page 54) |
| | | Roof Type Warm Roofs |

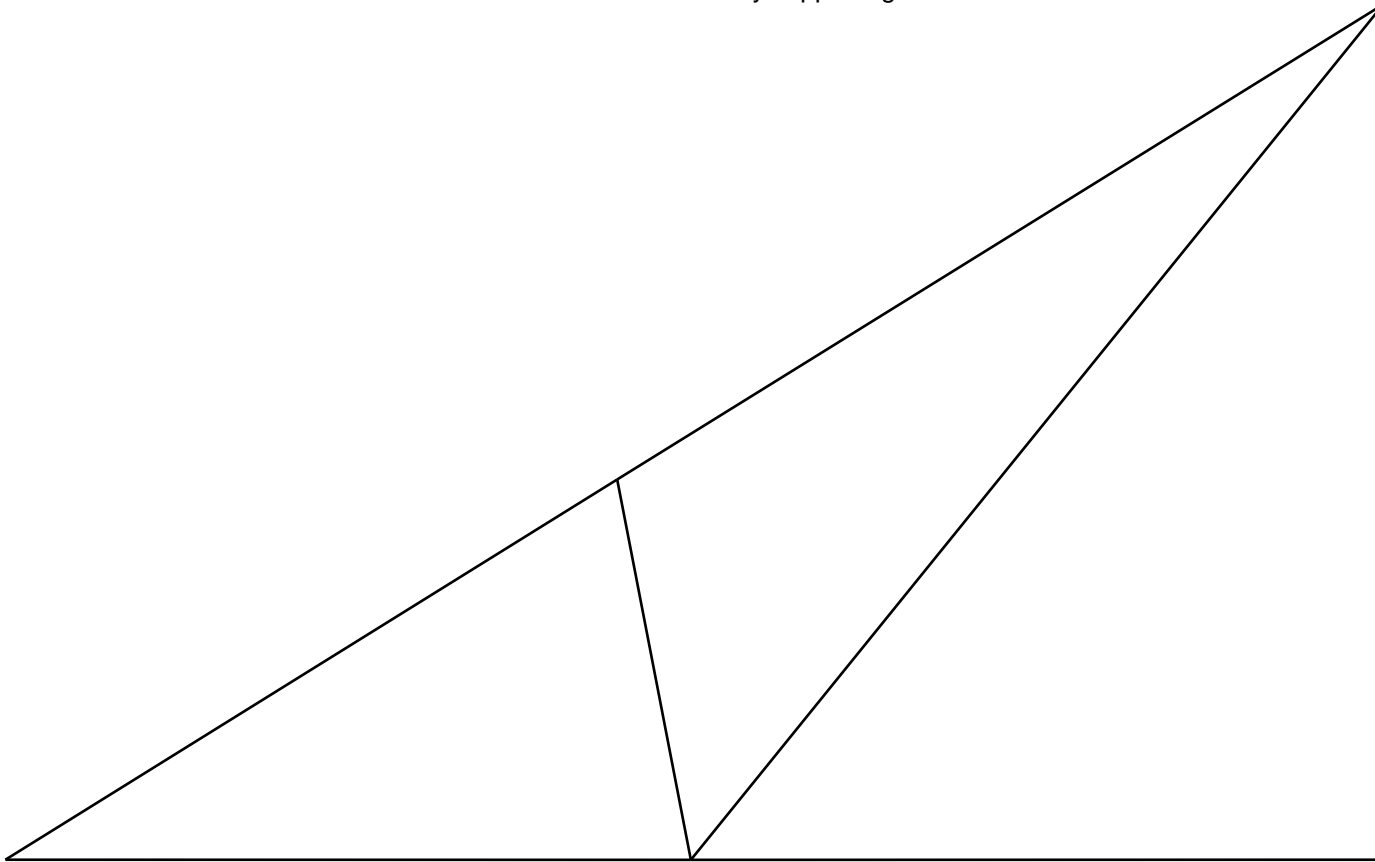
Roof slope factor C_s for Warm Roofs, where C_t = 1.0
 Roof surface condition = Slippery Roof

C_s = 1.00 Roof Slope Factor, C_s (ASCE 7-10 Table 7-2a, Page 59)

Total Snow Load

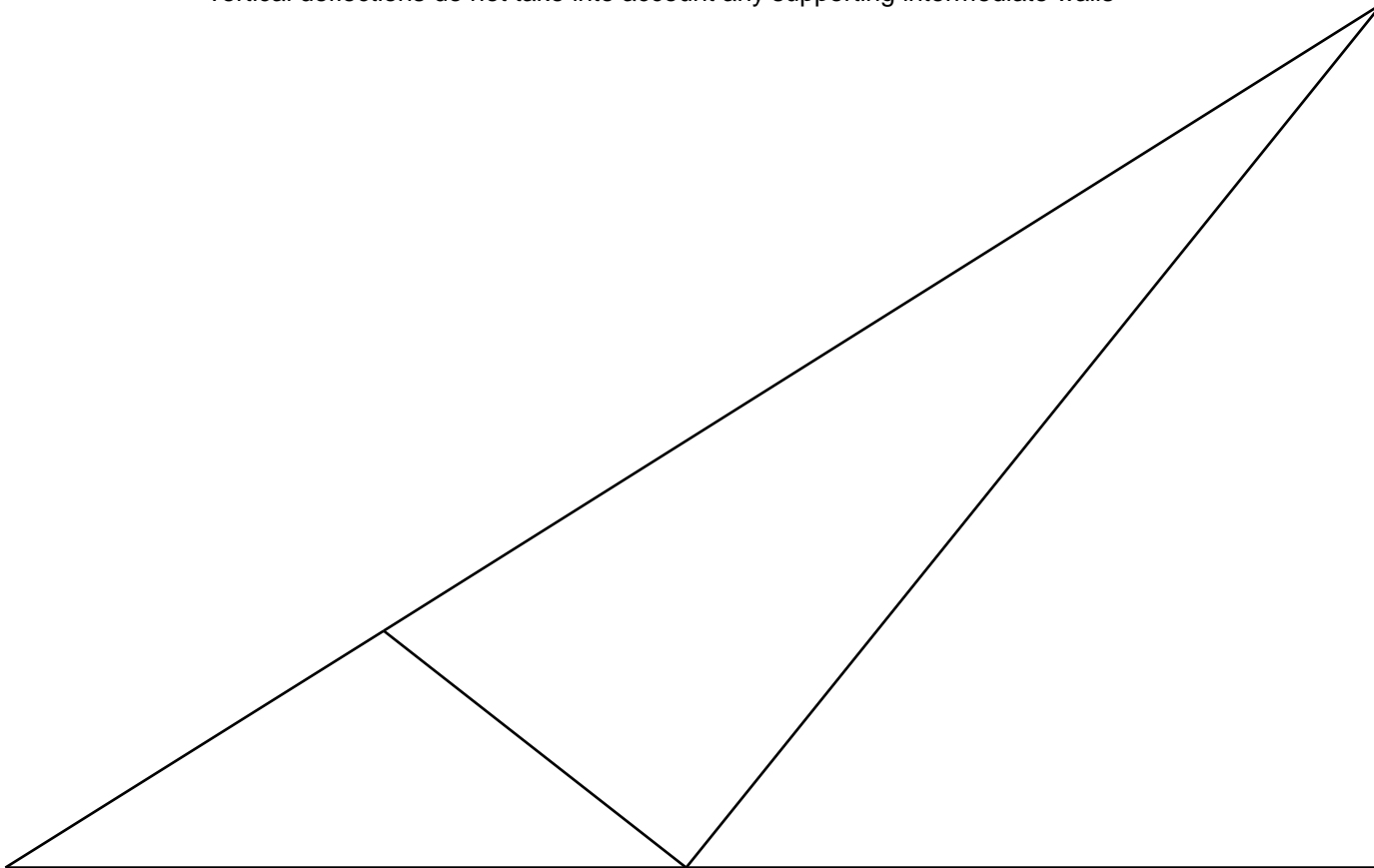
p_s =	10.00 psf	Roof snow load
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* vertical deflections do not take into account any supporting intermediate walls



Scaled 2X Deflected Truss Plot
Roof Plane MP 1 for Freedom Solar, LLC Client Lee Osterhout

* vertical deflections do not take into account any supporting intermediate walls



Scaled 2X Deflected Truss Plot
Roof Plane MP 2 for Freedom Solar, LLC Client Lee Osterhout