

iRooFAtm
Instant Roof Framing Analysis
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STRUCTURAL ANALYSIS
for the
ROOFTOP PV SOLAR INSTALLATION

Project: Abdelrahman Abuayyash, 223 Se Victoria Glen, Lake City, FL 32025

Prepared for:



sunergy

Sunergy

7625 Little Rd Ste 200a - New Port Richey, FL 34654

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Project Number: 66.400399.1, Rev. 0

Report Date: 11/08/2023

Report Prepared by:

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Cover

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Loading Summary

Exposure and Occupancy Categories		
B		Exposure Category (ASCE 7-16 Table 26.7.3, Page 266)
II		Building Use Occupancy / Risk Category (ASCE 7-16 Table 1.5-1, Page 4)

Wind Loading:			
v	165	mph	Over-ridden per client request. Original data from Municipality provided wind / snow loadings.
qz	41.47	psf	Velocity qz, calculated at height z [ASD]

Snow Loading			
pg	0	psf	Ground Snow Load pg (Over-ridden per client request. Original data from Municipality provided wind / snow loadings.)

Module Data			
Mission Solar Energy LLC: MSE385SX5R			
Dimensions	mm	ft	in
Length	1,905	6.25	75.00
Width	1,041	3.42	41.00
Area (m^2, ft^2)	2.0	21.35	
Weight	kg	lb	
Module	22.23	49.00	

Roof Panel (Cladding) Loading Summary		Module Loading Summary			
Support Point Loads		Upward	Upward	Upward	Downward
Roof Zones		1,2e	2n,2r,3e	3r	All
Net load per module	lb	-442	-688	-788	100

Positive values indicate net downward force

Stanchion Fastener Pull-out and Spacing Calculations				
Framing spacing	<i>ft</i>	2.00		
Rails / Module	<i>ea</i>	2		
Max proposed stanchion span	<i>ft</i>	4.00		
# fasteners per stanchion		2		
Screw thread embedment depth	<i>in</i>	2		
Safety Factor		1.10		
Pull-out for M5 threaded fasteners	<i>lb/in</i>	103		
Factored max fastener uplift capacity	<i>lb</i>	376		
Fastener details	<i>Material</i>	Stainless	<i>Size</i>	M5
Max stanchion uplift capacity	<i>lb</i>	400		
Max support point uplift capacity	<i>lb</i>	376		

Roof Zones			1,2e	2n,2r,3e	3r
Net lift per module		<i>lb</i>	442	688	788
Min tot screw thread embedment depth req'd		<i>in</i>	2.35	3.66	4.19
Net uplift pressure	7. 0.60D - 0.6W	<i>psf</i>	-17.69	-27.53	-31.51
Allowable lift area / support point		<i>sf</i>	21.27	13.67	11.94
Max rail span per framing spacing		<i>ft</i>	4.00	4.00	4.00
Landscape Modules					
Length along rafter		<i>ft</i>	3.42		
Lift calc'ed max stanchion EW spacing		<i>ft</i>	> 6	6.00	6.00
Max stanchion EW spacing		<i>ft</i>	4.00	4.00	4.00
Maximum module area / support point		<i>sf</i>	6.83	6.83	6.83
Factored lift per support point		<i>lb</i>	-121	-188	-215
Portrait Modules					
Length along rafter		<i>ft</i>	6.25		
Lift calc'ed max stanchion EW spacing		<i>ft</i>	6.00	4.00	2.00
Max stanchion EW spacing		<i>ft</i>	4.00	4.00	2.00
Maximum module area / support point		<i>sf</i>	12.50	12.50	6.25
Factored lift per support point		<i>lb</i>	-221	-344	-197

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

Princeton Engineering was asked to review the roof of Abdelrahman Abuayyash, located at 223 Se Victoria Glen, Lake City, FL, by Sunergy, to determine its suitability to support a PV solar system installation.

The referenced building's roof structure was field measured by Sunergy. 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 Sunergy. Loads are calculated to combine the existing building and environmental loads with the proposed new PV array loads.

Sunergy selected the K2-Systems CrossRail 44-X racking with K2-Systems Splice Foot XL w/2 bolts stanchions for this project. The racking and support stanchions shall be placed as shown on their plans, dated 11/08/2023, 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.



Google Location Map

Framing Summary

Based upon the attached calculations and in accordance with the FBC 2020 Section R324.4 and the FBC's reference to IRC 2018 Section 1607.12.5.2, 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 7-16 Minimum Design Loads for Buildings and Other Structures
- 2) IBC 2018
- 3) FBC 2020
- 4) 2022 Florida Statutes and 2023 Florida Administrative Codes
- 5) American Wood Council, NDS 2018, Table 12.2A, 12.3.3A.
- 6) 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 19.67 ft, Unsupported 19.67 ft

Geometric Data			
Θ	deg.	22.00	Angle of roof plane from horizontal, in degrees
ω	deg.	0.00	Angle the solar panel makes with the roof surface
L	ft.	51.67	Length of roof plane, in feet (meters)
W	ft.	18.67	Plan view width of roof plane, in feet (meters)
h	ft.	15.00	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 =	41.47	psf	$V_{as} q_z$ =	24.96	psf
V=	165				mph
					Basic wind pressure

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	19.67

2	# Rafters / Rack Support Width
4.00	Rack Support Spacing (ft)
48	Max. Rack Support Spacing (in)
3	Max # of mod's / Top truss chord

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

* Mem properties based upon field measurements

Top truss chord

Module Physical Data			
Weight	kg	lb	psf load
Module	22.23	49.00	2.29
4 Stanchions	1.27	2.8	0.13

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	4.0		
Along rafter slope	ft	6.3		
Area / support point	sf	12.5		
Uphill gap between modules	in	1.0	0.08	ft

Member Total Length	ft	19.67	
Maximum member free span	ft	19.67	Top truss chord span

Notation

L_p = Panel chord length.

p = uplift wind pressure

γ_a = Solar panel pressure equalization factor, defined in Fig. 29.4-8.

γ_E = Array edge factor as defined in Section 29.4.4.

θ = Angle of plane of roof from horizontal, in degrees.

29.4.4 Rooftop Solar Panels Parallel to the Roof Surface on Buildings of All Heights and Roof Slopes.

$\theta \geq 7$ deg

TRUE

Min.d1: Exposed **FALSE**

Max.d1: Exposed **TRUE**

Use EXPOSED for uplift calculations

$1.5(L_p) =$

5.13

$\gamma_E =$

1.5

$\gamma_a =$

0.67

$p = qh(GC_p) (\gamma_E) (\gamma_a) \text{ (lb/ft}^2\text{)} \quad (29.4-7)$

Zones	1,2e	2n,2r,3e	3r
p, Windload (psf)	-37.09	-53.49	-60.12

ASCE 7-16 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)				
Zones	1,2e	2n,2r,3e	3r	All Zones
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	2.43	2.43	2.43	2.43
W = wind load	-37.09	-53.49	-60.12	11.32

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				
5. D - 0.6W	2.43	2.43	2.43	9.22
Module Support point load (lb)	30	30	30	115
Cr Factored Module Support point load (lb)	26	26	26	100

Use this loading combination for UPWARD for Proposed PV Dead Load				
7. 0.60D - 0.6W	-17.69	-27.53	-31.51	7.61
Module Support point load (lb)	-221	-344	-394	95

DOWNWARD

Presume loading directly over member.

Combined Dead and Wind Pressure Downward Loading					
Top truss 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	0.42		100		Portrait
1	6.67			Support placed on adjoining truss	Portrait
2	6.75			Support placed on adjoining truss	Portrait
2	13.00		100		Portrait
3	13.09		100		Portrait
3	19.34			Support placed on adjoining truss	Portrait

Truss Data and Loading for MP 1

Roof slope (degrees)	22.00
Top ridge height above floor plane	7.37

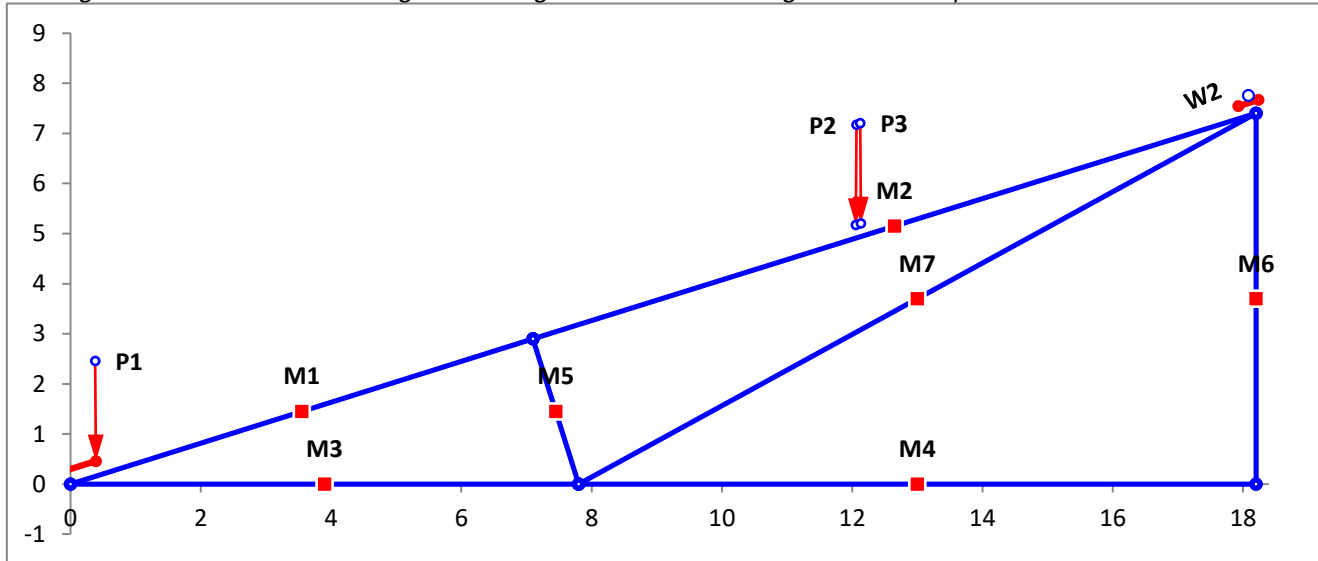
Length of roof plane	19.67
Length of floor plane	18.25

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 on exposed areas



Roof Structural Calculations for PV Solar Installation

Array AR-2

Location: MP 2

Member: Truss - Total Length 15.25 ft, Unsupported 15.25 ft

Geometric Data			
Θ	deg.	22.00	Angle of roof plane from horizontal, in degrees
ω	deg.	0.00	Angle the solar panel makes with the roof surface
L	ft.	49.92	Length of roof plane, in feet (meters)
W	ft.	16.25	Plan view width of roof plane, in feet (meters)
h	ft.	15.00	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 =	41.47	psf	$V_{asd} q_z$ =	24.96	psf
V=	165				mph
					Basic wind pressure

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	15.25

2	# Rafters / Rack Support Width
4.00	Rack Support Spacing (ft)
48	Max. Rack Support Spacing (in)
2	Max # of mod's / Top truss chord

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

* Mem properties based upon field measurements

Top truss chord

Module Physical Data			
Weight	kg	lb	psf load
Module	22.23	49.00	2.29
4 Stanchions	1.27	2.8	0.13

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	4.0		
Along rafter slope	ft	6.3		
Area / support point	sf	12.5		
Uphill gap between modules	in	1.0	0.08	ft

Member Total Length	ft	15.25	
Maximum member free span	ft	15.25	Top truss chord span

Notation

L_p = Panel chord length.

p = uplift wind pressure

γ_a = Solar panel pressure equalization factor, defined in Fig. 29.4-8.

γ_E = Array edge factor as defined in Section 29.4.4.

θ = Angle of plane of roof from horizontal, in degrees.

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TRUE

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$1.5(L_p) =$

5.13

$\gamma_E =$

1.5

$\gamma_a =$

0.67

$p = qh(GC_p) (\gamma_E) (\gamma_a) \text{ (lb/ft}^2\text{)} \quad (29.4-7)$

Zones	1,2e	2n,2r,3e	3r
p, Windload (psf)	-37.09	-53.49	-60.12

ASCE 7-16 Chapter 2 Combinations of Loads, Table 2.4, Page 8 (in psf)				
Zones	1,2e	2n,2r,3e	3r	All Zones
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	2.43	2.43	2.43	2.43
W = wind load	-37.09	-53.49	-60.12	11.32

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.				
Combination Formulae	<i>Upward</i>	<i>Upward</i>	<i>Upward</i>	<i>Downward</i>
Use this loading combination for DOWNWARD for Proposed PV Dead Load				
5. D - 0.6W	2.43	2.43	2.43	9.22
Module Support point load (lb)	30	30	30	115
Cr Factored Module Support point load (lb)	26	26	26	100

Use this loading combination for UPWARD for Proposed PV Dead Load				
7. 0.60D - 0.6W	-17.69	-27.53	-31.51	7.61
Module Support point load (lb)	-221	-344	-394	95

DOWNWARD

Presume loading directly over member.

Combined Dead and Wind Pressure Downward Loading					
Top truss 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	0.42		100		Portrait
1	6.67			Support placed on adjoining truss	Portrait
2	6.75			Support placed on adjoining truss	Portrait
2	13.00		100		Portrait

Truss Data and Loading for MP 2

Roof slope (degrees)	22.00
Top ridge height above floor plane	5.71

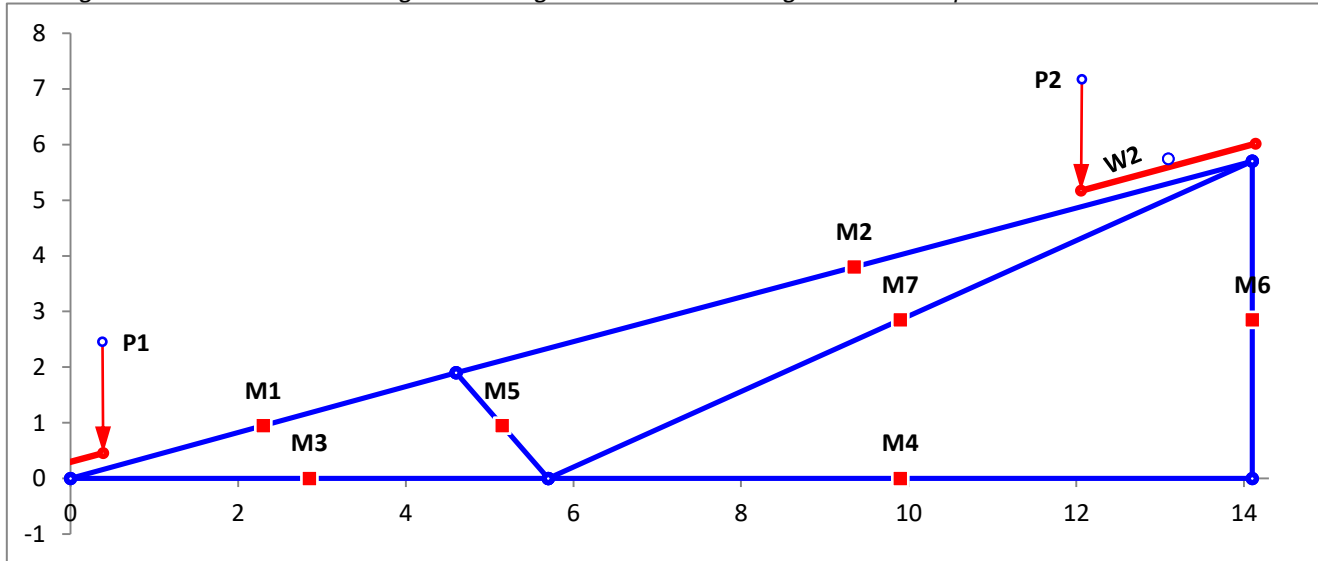
Length of roof plane	15.25
Length of floor plane	14.17

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 on exposed areas



FEA Calculation Results for Roof Plane MP 1 for Sunergy Client ABDELRAHMAN ABUAYYASH

IDSPL - 2D Frame Analysis of a 2D frame subject to distributed loads, point loads and moments

Equilibrium check	FX	FY	1.6E-05
Total applied forces	0.00	1416	
Total output reactions	0.00	-1416	
Output error	1.07E-14	-6.82E-13	

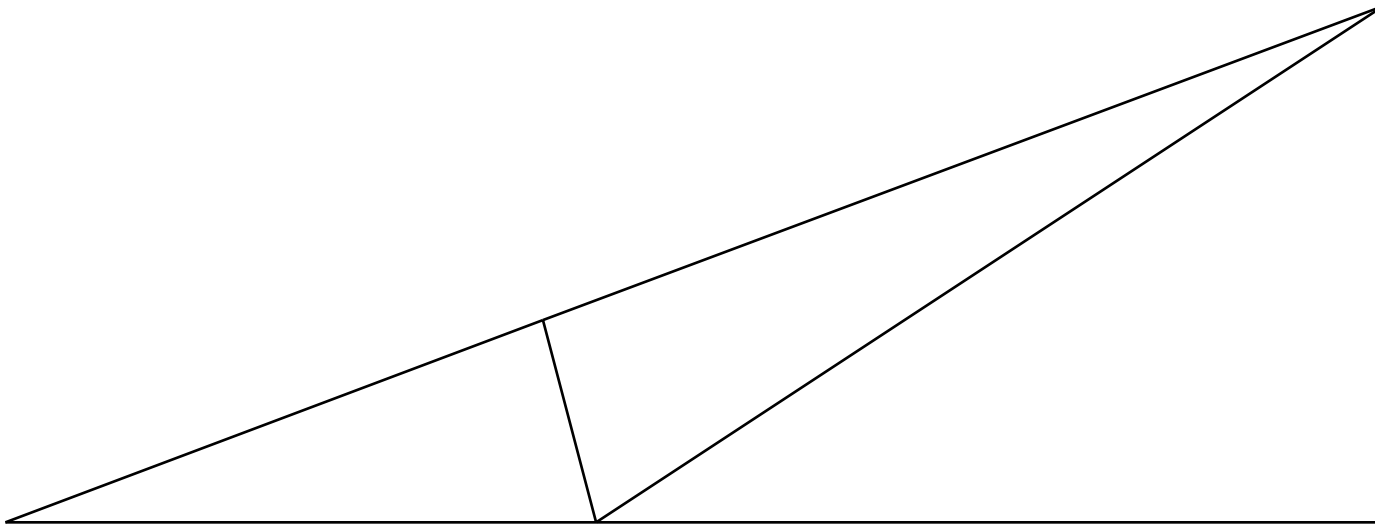
Node Results			Beam End Results			
Direction	Deflection	Reaction	Beam	Shear	Ax	BM
DX1	0.00E+00	-39	1-1	-480	238	1235
DY1	0.00E+00	-583	1-2	-290	160	-1841
RZ1	-1.55E-04	0	2-1	-523	105	-2528
DX2	1.37E-04	0	2-2	281	-221	-4899
DY2	1.07E-04	0	3-1	-49	0	-1235
RZ2	-1.73E-04	0	3-2	158	0	-250
DX3	1.45E-04	0	4-1	0	0	0
DY3	0.00E+00	-387	4-2	0	0	0
RZ3	0.00E+00	-4705	5-1	-86	229	-429
DX4	0.00E+00	64	5-2	-88	222	-687
DY4	0.00E+00	-435	6-1	25	10	-92
RZ4	0.00E+00	145	6-2	25	-25	92
DX5	0.00E+00	-25	7-1	-18	104	34
DY5	0.00E+00	-10	7-2	58	49	102
RZ5	0.00E+00	92				

# of segments/beam	1	Maximum Deflections	
		1.45E-04	-1.07E-04

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

Beam	X	Shear	Mom	Ax	DX	DY	RZ
1	0.00	-480	1235	238	0.00E+00	0.00E+00	-1.55E-04
1	7.67	-347	-1541	184	1.25E-04	-1.02E-04	-4.11E-04
2	0.00	-523	-2528	105	1.37E-04	-1.07E-04	-1.73E-04
2	11.98	-15	-2538	-101	5.04E-05	3.83E-05	-1.79E-03
3	0.00	-49	-1235	0	0.00E+00	0.00E+00	-1.55E-04
3	7.80	95	80	0	0.00E+00	-4.91E-20	-2.41E-05
4	0.00	0	0	0	0.00E+00	0.00E+00	0.00E+00
4	10.40	0	0	0	0.00E+00	0.00E+00	0.00E+00
5	0.00	-86	-429	229	0.00E+00	0.00E+00	0.00E+00
5	2.98	-87	-687	224	1.37E-04	-1.07E-04	-1.29E-04
6	0.00	25	-92	10	0.00E+00	0.00E+00	0.00E+00
6	7.40	25	92	-18	1.45E-04	3.81E-07	3.85E-06
7	0.00	-18	34	104	0.00E+00	0.00E+00	0.00E+00
7	12.76	48	107	56	1.44E-04	2.24E-07	-4.35E-07

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



Scaled 2X Deflected Truss Plot
Roof Plane MP 1 for Sunergy Client ABDELRAHMAN ABUAYYASH

FEA Calculation Results for Roof Plane MP 2 for Sunergy Client ABDELRAHMAN ABUAYYASH

IDSPL - 2D Frame Analysis of a 2D frame subject to distributed loads, point loads and moments

Equilibrium check	FX	FY	1.7E-05
Total applied forces	0.00	1004	
Total output reactions	0.00	-1004	
Output error	-4.97E-14	-3.41E-13	

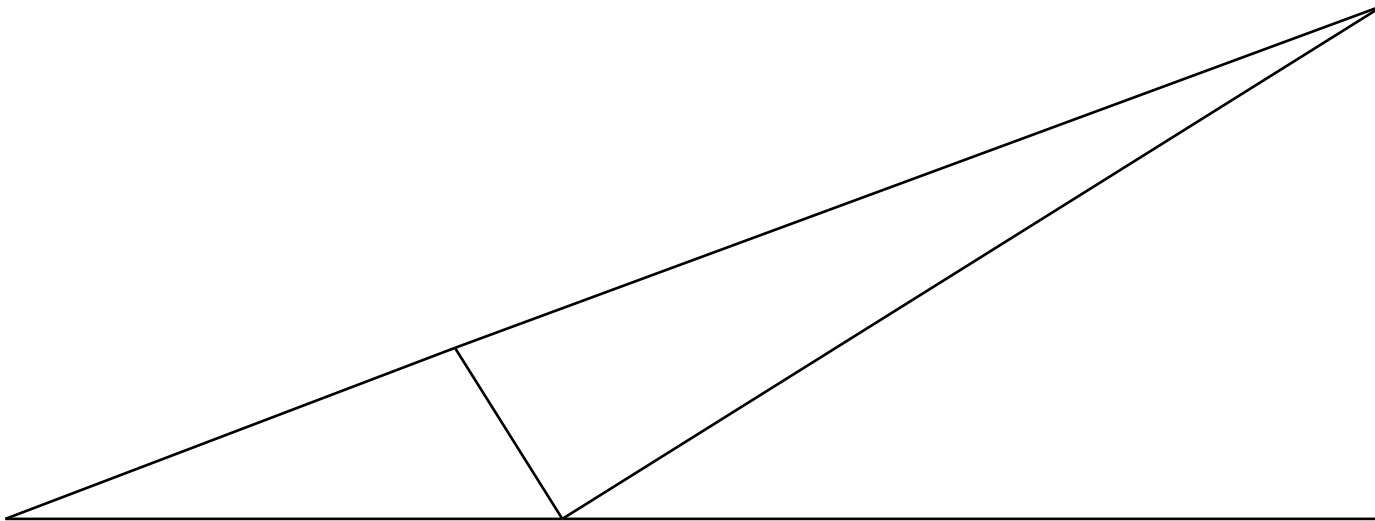
Node Results			Beam End Results			
Direction	Deflection	Reaction	Beam	Shear	Ax	BM
DX1	0.00E+00	-32	1-1	-335	173	59
DY1	0.00E+00	-524	1-2	-186	112	-1277
RZ1	1.45E-04	0	2-1	-547	101	-1446
DX2	3.49E-05	0	2-2	87	-153	-5154
DY2	1.17E-04	0	3-1	-148	0	-59
RZ2	-4.99E-05	0	3-2	-76	0	-1003
DX3	1.14E-04	0	4-1	0	0	0
DY3	0.00E+00	-153	4-2	0	0	0
RZ3	0.00E+00	-4994	5-1	46	361	-267
DX4	0.00E+00	66	5-2	43	357	-168
DY4	0.00E+00	-322	6-1	34	6	-96
RZ4	0.00E+00	-739	6-2	34	-16	96
DX5	0.00E+00	-34	7-1	-9	98	4
DY5	0.00E+00	-6	7-2	42	63	64
RZ5	0.00E+00	96				

# of segments/beam	1	Maximum Deflections	
		1.14E-04	-1.17E-04

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

Beam	X	Shear	Mom	Ax	DX	DY	RZ
1	0.00	-335	59	173	0.00E+00	0.00E+00	1.45E-04
1	4.98	-222	-1086	126	2.72E-05	-1.14E-04	-2.43E-04
2	0.00	-547	-1446	101	3.49E-05	-1.17E-04	-4.99E-05
2	10.23	-158	-3177	-54	3.57E-05	3.13E-05	-1.66E-03
3	0.00	-148	-59	0	0.00E+00	0.00E+00	1.45E-04
3	5.70	-121	-764	0	0.00E+00	7.62E-21	-1.94E-04
4	0.00	0	0	0	0.00E+00	0.00E+00	0.00E+00
4	8.40	0	0	0	0.00E+00	0.00E+00	0.00E+00
5	0.00	46	-267	361	0.00E+00	0.00E+00	0.00E+00
5	2.20	44	-169	359	3.50E-05	-1.17E-04	-1.23E-05
6	0.00	34	-96	6	0.00E+00	0.00E+00	0.00E+00
6	5.70	34	96	-11	1.14E-04	2.91E-07	5.21E-06
7	0.00	-9	4	98	0.00E+00	0.00E+00	0.00E+00
7	10.15	34	68	68	1.14E-04	1.66E-07	8.65E-08

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



Scaled 2X Deflected Truss Plot
Roof Plane MP 2 for Sunergy Client ABDELRAHMAN ABUAYYASH