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MEGCHEM

Design of Solar Panel Structure

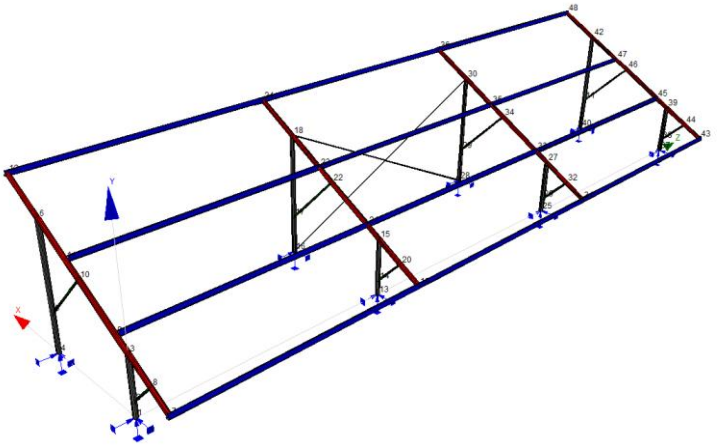
Design Certificate No: COD25AA93-Rev.02 Issue date: 10 February 2025

1. Objective

On behalf of Solar Bracket Industries, Mr. G. van Rooyen requested Megchem to conduct design checks on the provided drawing and suggest modifications to enhance the structural safety. This report presents the recommended modifications and design calculations for the solar panel structure.

2. Recommendations

The following structural modifications are recommended to ensure the structure can safely withstand the loads imposed by wind and the mass of the solar panels:



- The structural drawing of the solar panel structure is updated as shown in the above figure.
- According to drawing of the solar panel structure, the wall thickness of the tubes is 2mm. However, as discussed with the client, a 3 mm wall thickness of the tubes will be used. The structural analysis was conducted on 3 mm wall thickness.
- PS-UE components should be welded all around with a 3 mm weld.
- A foundation analysis was not conducted for the structure. Therefore, a field engineer should inspect the foundation where the structure will be anchored.

3. Conclusion

Megchem has conducted design calculations to ensure the structural integrity of the system. The design calculations are attached below. The structure is designed to support a maximum of eight solar panels, each measuring 2280 mm x 1136 mm and weighing 28 kg per panel. The structural member is approved for use, provided that all conditions outlined in Section 2 are strictly adhered to. If any condition in Section 2 is not met, a certified design review request must be submitted to a Megchem Structural Engineer.

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PrTechEng

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DESIGN CALCULATIONS

Client: Solar Bracket Industries	Equipment Description: Solar Structure

Our Ref. Number: MCP2750045	Prepared By: W Mavimbela	Date: 2025-02-10

Wind Load Calculation

Table 5 — Calculation procedure

1	2	3
Description	**Symbol**	**Reference**
Fundamental basic wind speed	$v_{b,0}$	Figure 1
Basic wind speed	v_b	Equation (1)
Terrain category	A, B, C, D	Table 2
Reference height	z_e	7.5.2.2
Topography coefficient	$c_o(z)$	7.3.3
Roughness/Height coefficient	$c_r(z)$	7.3.2
Peak wind speed	$v_p(z)$	Equations (3) and (4)
Peak wind speed pressure	$q_p(z)$	Equation (6)
Internal pressure coefficient	c_{pi}	8.3.9
External pressure coefficient	c_{pe}	8.3.2 to 8.3.8
Internal wind pressure	w_i	Equation (7)
External wind pressure	w_e	Equation (8)
Wind force calculated from force coefficient	F_w	Equations (9) and (10)
Internal forces	$F_{w,i}$	Equation (11)
External forces	$F_{w,e}$	Equation (12)
Friction forces	F_{fr}	Equation (13)

1. Fundamental Wind Speed ($v_{b.0}$)

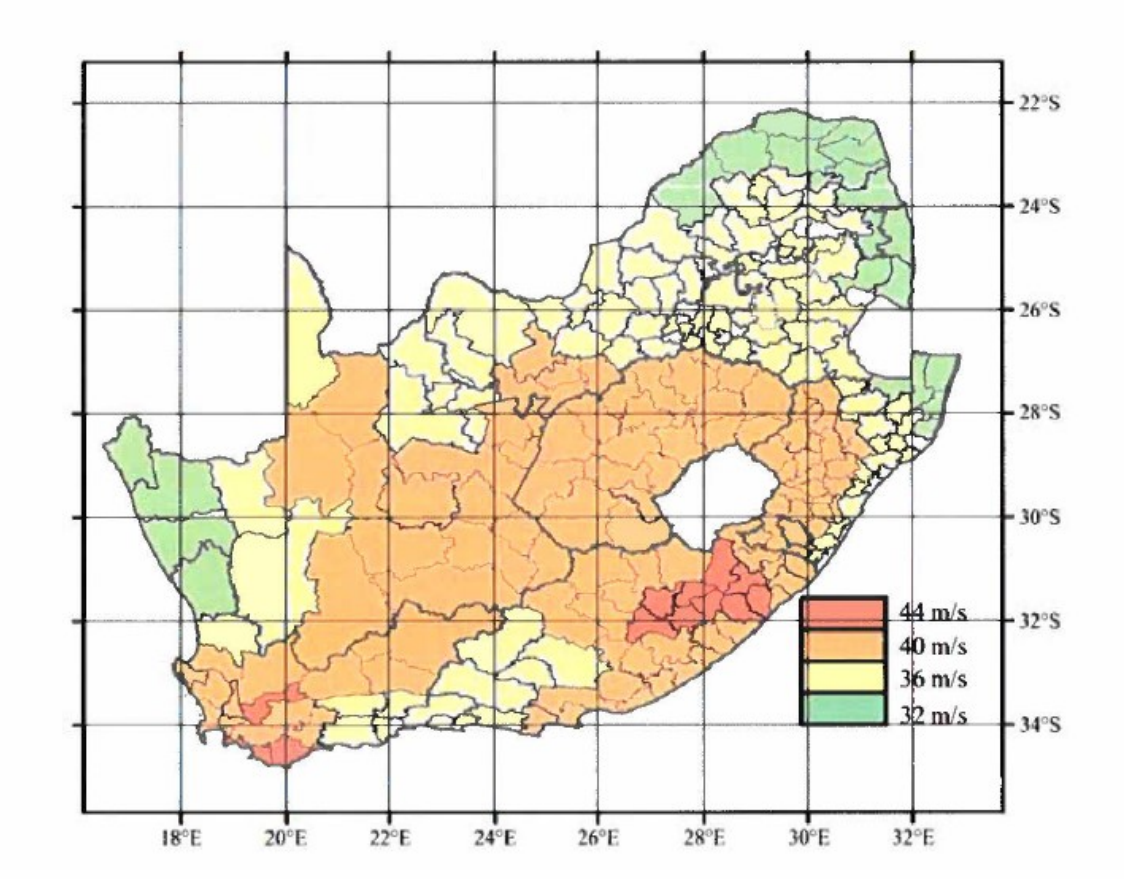


Figure 1 - Map of the fundamental value of the basic wind speed [7.2.3]
Location: Bloemfountein, Free State

$$v_{b.0} := 40 \cdot \frac{m}{s}$$

2. Basic Wind Speed ($v_{b.0}$)

$$c_{prob} := \left(\frac{1 - 0.2 \cdot \ln\left(-\ln\left(1 - 0.02\right)\right)}{1 - 0.2 \cdot \ln\left(-\ln\left(0.98\right)\right)} \right)^{0.5} = 1 \qquad [7.2.3]$$

$$v_b := c_{prob} \cdot v_{b.0} = 40 \ \frac{m}{s} \qquad [7.2.2]$$

3. Topography coefficient

Assume the topograph of the site is flat. There are no hills or cliffs nearby the site. As the topograph of the site is flat, the effect of topograph may be neglected.

$c_0 := 1$ [7.3.3]

4. Terrain Category

Assume the solar panel structure location is not surrounded by building and there is low vegetation. Use terrain category B for the wind design.

$z_g := 300 \cdot m$ $z_0 := 0\ m$ $\alpha := 0.095$ [Table 1 - 7.3.2.1]

Height of the scaffold is 2.6 m

$z := 2.6 \cdot m$

$$c_r := 1.36 \left(\frac{z - z_0}{z_g - z_0} \right)^{\alpha} = 0.866$$

5. Effect of neighbouring structures

Assume the evaluation of the structures under consideration does not need to take into account the effect of the neighbouring structures .

According to SANS 10160-3, 7.3.4., the accelerated wind speed will not be considered in this design calculations because there are no neighbouring structures of significant height adjacent to the evaluated structure.

6. Closely spaced buildings and obstacles

Do not consider the wind displacement due the surrounding building.

For worst case wind loading, assume the structure is a stand alone. [7.3.5]

7. Peak wind speed

$$v_{b.z} := c_r \cdot c_0 \cdot v_b = 34.649\ \frac{m}{s}$$ [7.3.1.1] - Equation 3

8. Peak wind speed pressure

Sasol Secunda altitude level is 1 395 m

$$\rho_{1395m} := 1.115 \cdot \frac{kg}{m^3}$$ [7.4 - Table 4]

$$q_p := \frac{1}{2} \cdot \rho_{1395m} \cdot v_{b.z}^{\ 2} = 669.321\ Pa$$

9. Net force Coefficient

Blockage

Roof angle = 17.69 °

$w := 2 \cdot m$ $l := 13.5 \cdot m$ $h_1 := 2.145 \cdot m$

Area of solar panels

$L := 2.280\ m$ $W := 1.136\ m$

$A_{blockage} := 8 \cdot L \cdot W = 20.721\ m^2$ 8 Solar panels on the structure

$A_{roof} := w \cdot l = 27\ m^2$

$\phi := 1$

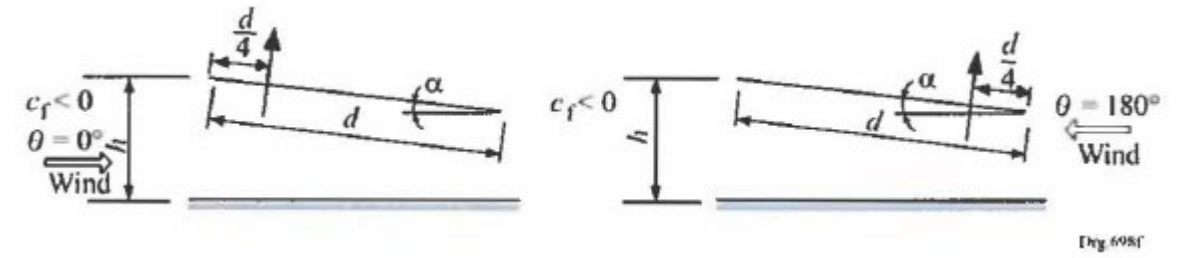
Assume the canopy is fully blocked for a case where the client decides to store objects under the structure

At roof angle 35 degrees

Uplift wind

$c_{f.35U} := -1.4$ SANS 10160-3: Table 13

$c_{f.35} < 0$



$d := 3.8\ m$

$\frac{d}{4} = 0.95\ m$

10. Wind Friction

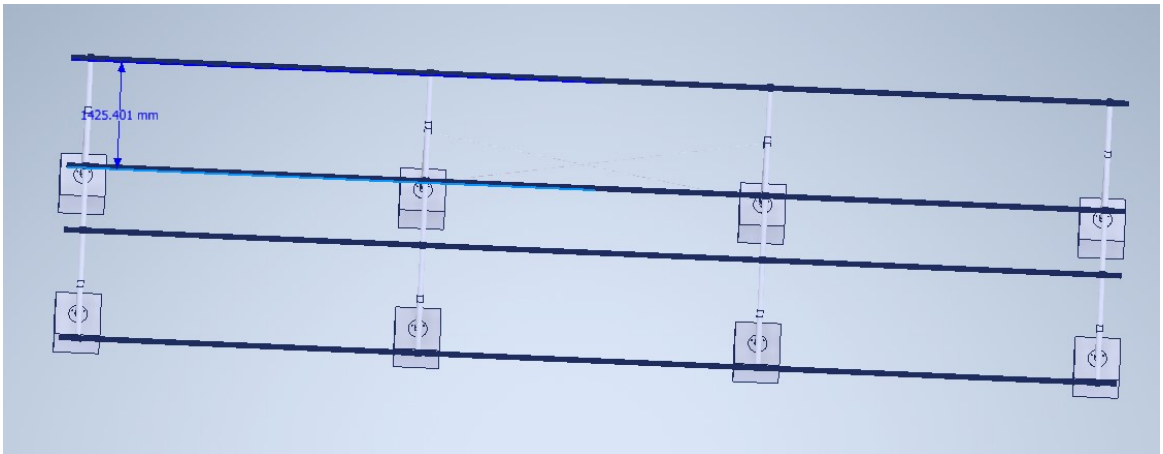
The effect of wind friction can be ignore as there are no parallel surface to the wind.

11. Net wind pressure

$w_{net.U} := c_{f.35U} \cdot q_p = -937.05\ Pa$

Worst Case because the wind and self of the structure in the same direction

12. Loading on solar brackets



Wind Load

$Spacing := 1.425\ m$

$UDL_W := \frac{Spacing}{2} \cdot w_{net.U} = -0.668\ \frac{kN}{m}$

Mass of solar panels

$Mass_{Panel} := 28 \cdot kg$

$W = 1.136\ m$ Mass per panel (provided by client)

$UDL_M := \frac{Mass_{Panel} \cdot g}{W} = 0.242\ \frac{kN}{m}$

13. Design loads

ULS Design

$UDL_{D.M.ULS} := 1.2 \cdot UDL_M = 0.29\ \frac{kN}{m}$

$UDL_{D.W.ULS} := 1.6 \cdot UDL_W = -1.068\ \frac{kN}{m}$

SLS Design

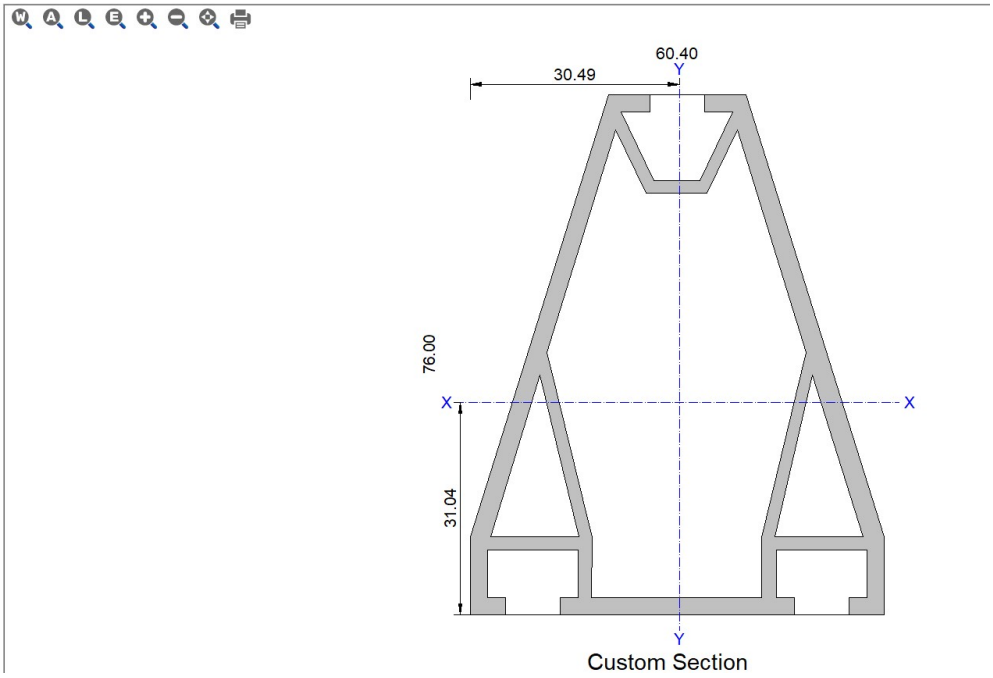
$UDL_{D.M.SLS} := 1.1 \cdot UDL_M = 0.266\ \frac{kN}{m}$

$UDL_{D.W.SLS} := 1 \cdot UDL_W = -0.668\ \frac{kN}{m}$

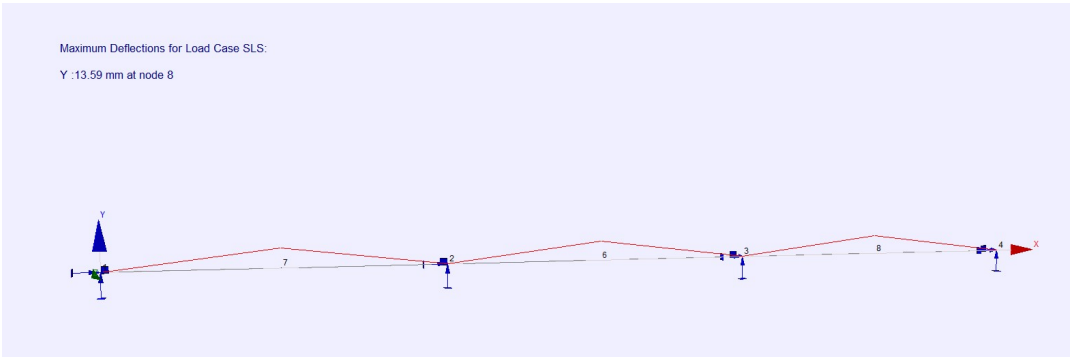
14. Prokon Results

Bracket sectional properties

A	mm²	775.41
Ixx	mm⁴	458.33E3
Iyy	mm⁴	266.47E3
Ixy	mm⁴	997.64
Iuu	mm⁴	458.33E3
Ivv	mm⁴	266.46E3
Ir	mm⁴	724.80E3
Angle	°	-297.91E-3°
Zxx(T)	mm³	10.193E3
Zxx(B)	mm³	14.768E3
Zyy(L)	mm³	8.7407E3
Zyy(R)	mm³	8.9079E3
Zuu	mm³	10.182E3
Zvv	mm³	8.7698E3
Zpx	mm³	16.224E3
Zpy	mm³	13.132E3
Yc	mm	31.036
Xc	mm	30.486
rx	mm	24.312
ry	mm	18.538
ru	mm	24.312
rv	mm	18.538
Xpl	mm	31.734
Ypl	mm	26.106
Perimeter	mm	238.58
J	mm⁴	441.25E3
Zt	mm³	1.1973E3
Cw	mm⁶	128.66E6
A-Shear	mm²	297.86
βx		-11.489
Vr		831.08E-3
Γ		423.56E-3
jx	mm	1.0097
jy	mm	5.7445



Deflection



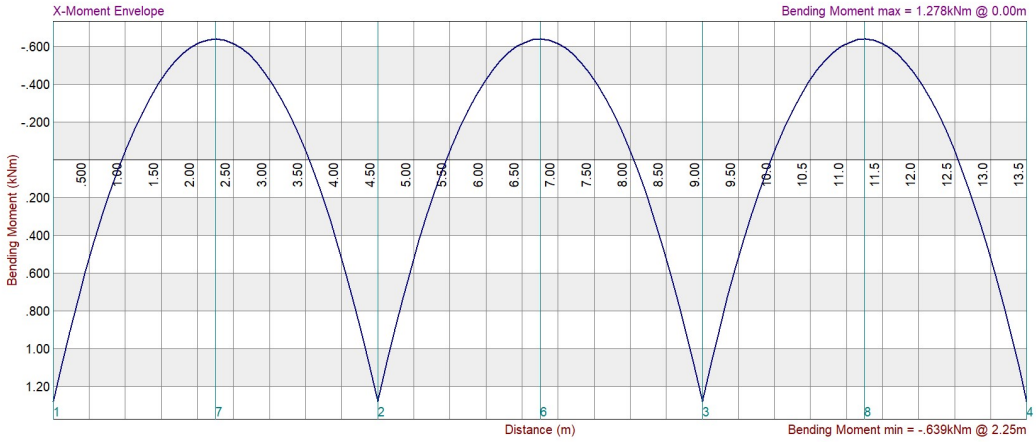
$\delta := 13.59 \cdot mm$

$Span := 4500\ mm$

$\delta_a := \frac{Span}{300} = 15\ mm$

$Check_1 := \mathbf{if}\left(\delta < \delta_a, \text{“Safe”}, \text{“Not Safe”}\right) = \text{“Safe”}$

Bending Stress



$M_u := 1.278 \cdot kN \cdot m$

$I := 458330 \cdot mm^4$

$y := 76\ mm - 31.04\ mm = 44.96\ mm$

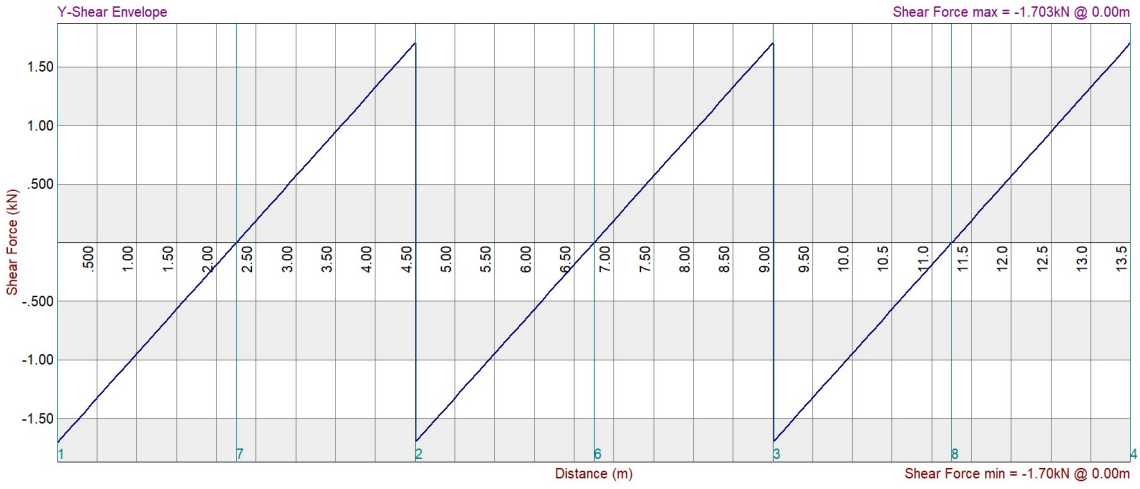
$\sigma := M_u \cdot \frac{y}{I} = 125.366\ MPa$

$f_y := 214 \cdot MPa$ Aluminum 6063-T6

$\sigma_a := 0.66 \cdot f_y = 141.24\ MPa$

$Check_2 := \text{if}\left(\sigma < \sigma_a, \text{“Safe”}, \text{“Not Safe”}\right) = \text{“Safe”}$

Shear Stress



$V_u := 1.703 \cdot kN$

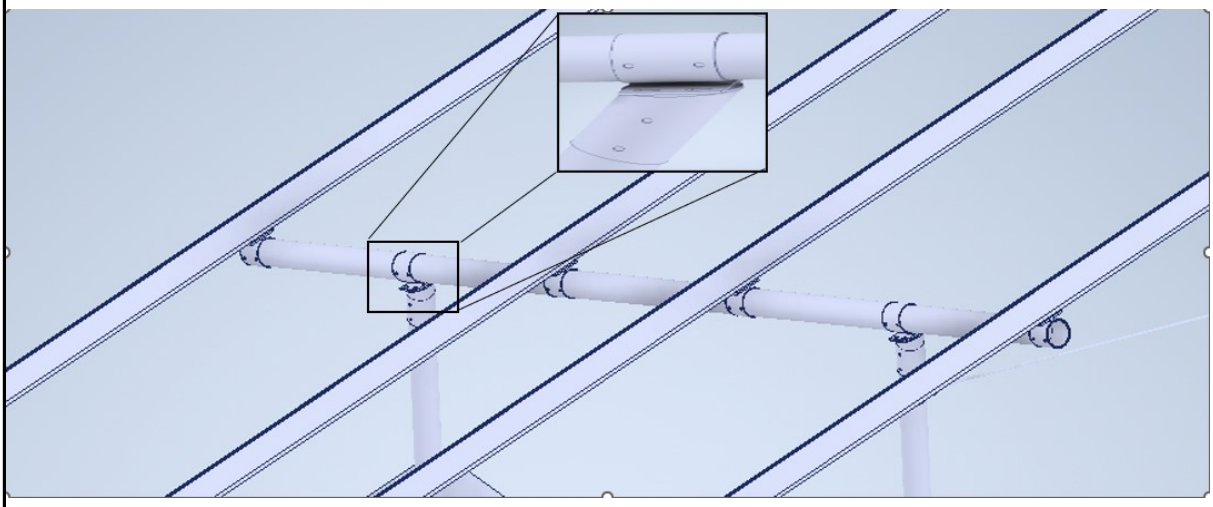
$A := 775.41 \cdot mm^2$

$\tau_{avg} := \frac{V_u}{A} = 2.196\ MPa$

$\sigma_a := 0.66 \cdot f_y = 141.24\ MPa$

$Check_3 := \text{if}\left(\tau_{avg} < \sigma_a, \text{“Safe”}, \text{“Not Safe”}\right) = \text{“Safe”}$

Connection



The maximum bolt hole size is 8 mm. Therefore, 6 mm bolts.

$V_A := 3.926 \cdot kN$

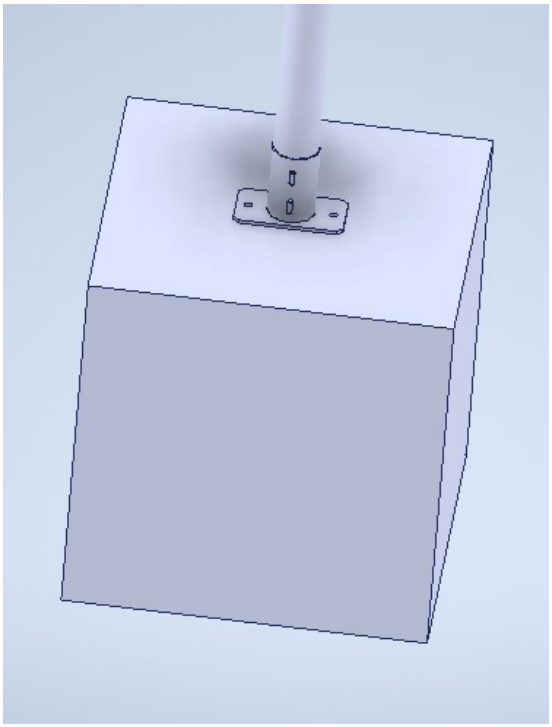
$V_{r.PerBolt} := 11.58 \cdot kN$ ProBolt Brochure

$n := 4$ Number of Bolts

$V_r := V_{r.PerBolt} \cdot n = 46.32\ kN$

$Check_4 := \text{if}\left(V_A < V_r, \text{“Safe”}, \text{“Not Safe”}\right) = \text{“Safe”}$

Base Plate



$V_{u.a} := 1.298 \cdot kN$

$V_{r.PerBolt.2} := 11.58 \cdot kN$ ProBolt Brochure

$n_2 := 2$ Number of Bolts

$V_{r2} := V_{r.PerBolt} \cdot n_2 = 23.16\ kN$

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Civil Engineer

Digitally signed by Johannes Lodewyk Venter
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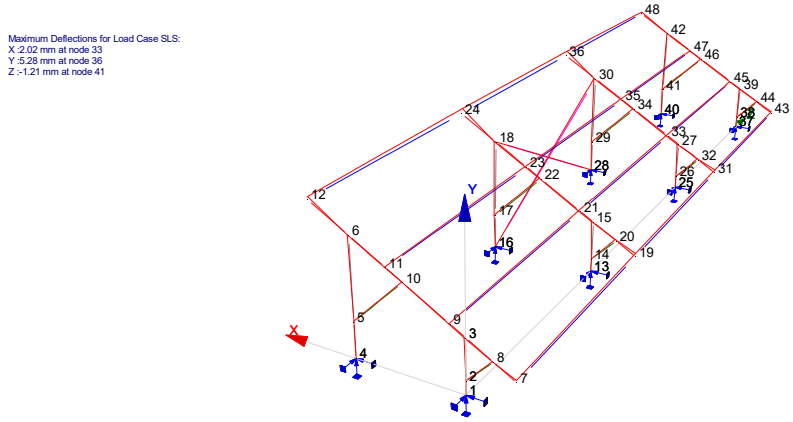
J Venter
Civil Pr Engineer

PROKON	Job Number	MCP2750045		Sheet
Your details here	Job Title	SOLAR PANEL STRUCTURE		
	Client	SOLAR BRACKET INDUSTRIES		
	Calcs by	W MAVIMBELA	Checked by J VENTER	Date 2025/02/10

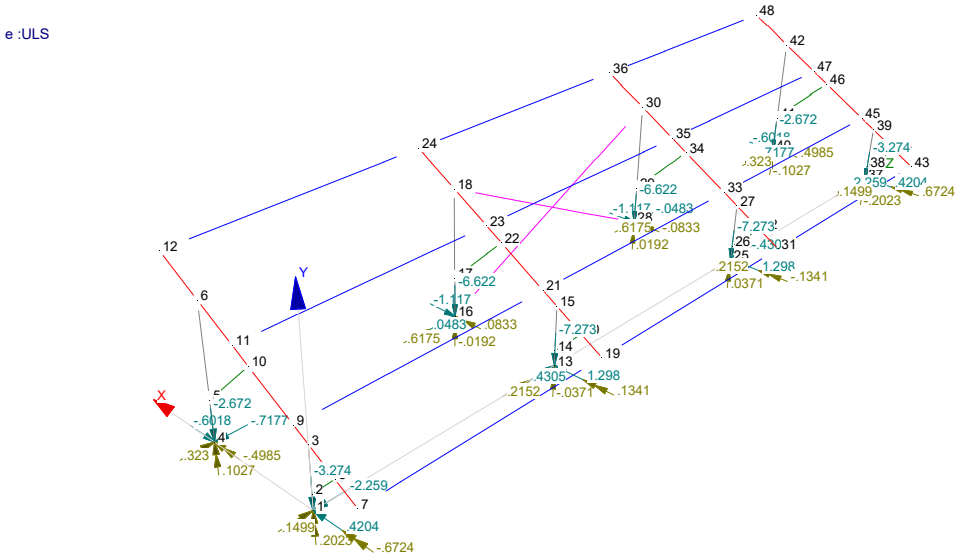
Solar Panel Structure

Deflections for Load Case SLS

Maximum Deflections for Load Case SLS:
X :2.02 mm at node 33
Y :5.28 mm at node 36
Z :-1.21 mm at node 41



Reactions for Load Load Case ULS



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	Client	SOLAR BRACKET INDUSTRIES		
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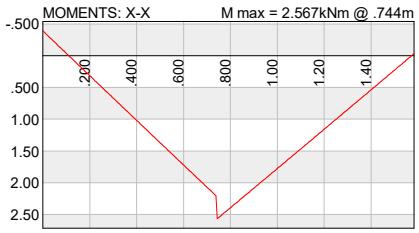
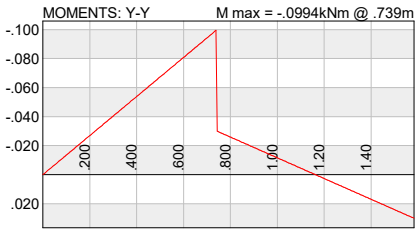
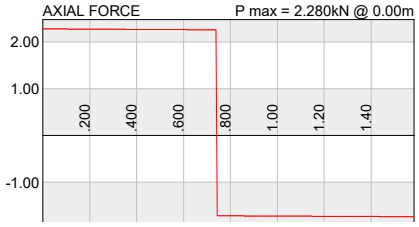
Combine Design







Combine Ver W5.2.12
Element 35-36 Evaluate current sections
Section name RAFTER

Lx Eff = 1.346 m W1x = 1.00
Ly Eff = 1.346 m W1y = 1.00
Le Eff = 1.583 m W2 = 1.00
Fy = 214 MPa Fu = 241 MPa
Tension area factor (Ane/Ag) = 1.00
Section class: 1

Critical load case : ULS

Section 76x3 Round hollow sections

SANS 10162-1:2011 13.8.3 :
a) Cross-sectional strength (Critical position = 0.792 m)

Cu	Mux	Muy	1.72	2.43	.027		
-- +	--- +	--- =	---- +	---- +	---- = 0.81		OK
Cr	Mrx	Mry	133	3.08	3.08		

b) Overall member strength

Cu	U1xMux	U1yMuy	2.28	2.42	.089		
-- +	------ +	------ =	---- +	---- +	---- = 0.84		OK
Cr	Mrx	Mry	109	3.08	3.08		

c) Lateral torsional buckling strength

Cu	U1xMux	U1yMuy	2.28	2.42	.089		
-- +	------ +	------ =	---- +	---- +	---- = 0.83		OK
Cr	Mrx	Mry	116	3.08	3.08		

13.4:Shear

Vux < Vrx	3.5 < 48.6	OK
Vuy < Vry	0.1 < 48.6	OK

Slenderness ratio:

Lx/rx = 52	OK
Ly/ry = 52	OK

PROKON	Job Number	MCP2750045		Sheet
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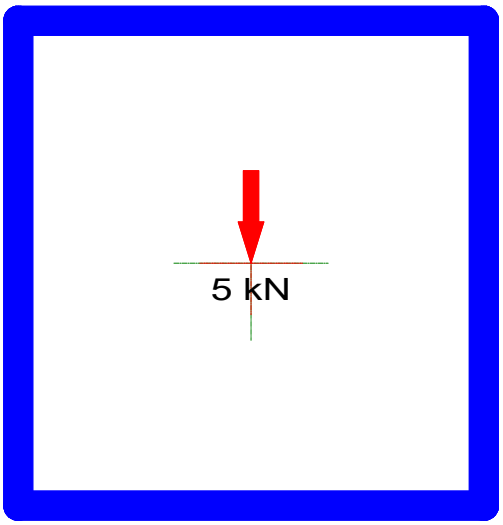
	Calcs by	W MAVIMBELA	Checked by J VENTER	Date 2025/02/10

Weld Group Shear Analysis Ver W5.2.02 - 06 Aug 2024

Title : Default Connection Created on: 2025-02-10 10:09:38

S16



Design Code : SANS 10162-1:2011
Analysis : Non-Linear
Electrode fu : 290 MPa
Parent Metal fu : 241 MPa
Parent Metal fy : 214 MPa

Since unit values are used for the length and size of the weld, the capacity of this layout is given in MPa

The capacity, Vr is the lesser of Vr1 & Vr2 : *13.13.2.2*

$V_{r1} = 0.67 \cdot \phi_w \cdot A_m \cdot f_u$

$= 0.67 \times 0.67 \times 1 \times 241$

$= 108.185$ MPa

$V_{r2} = 0.67 \cdot \phi_w \cdot A_w \cdot X_u$

$= 0.67 \times 0.67 \times 0.707 \times 290$

$= 92.038$ MPa

$V_r = V_{r2} = 92.038$ MPa

The capacity = 0.276 kN/mm of a 3 mm weld

The resistance of the Weld Group is : **50 kN**

The applied ULS force is : **5 kN**

Weld is safe

Weld forces at ultimate load

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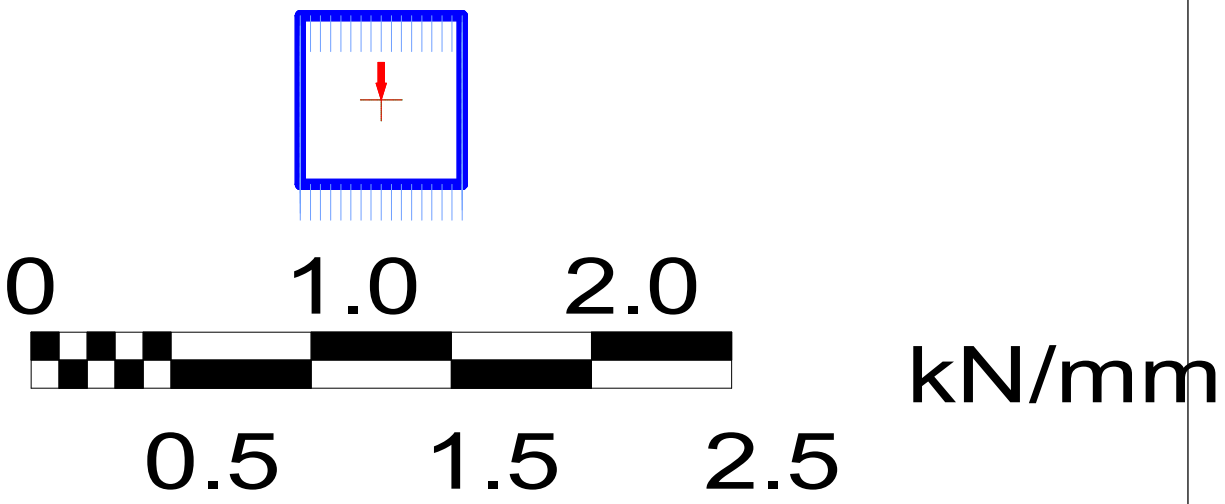

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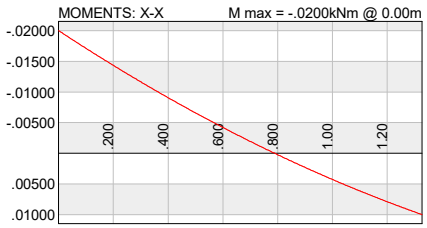
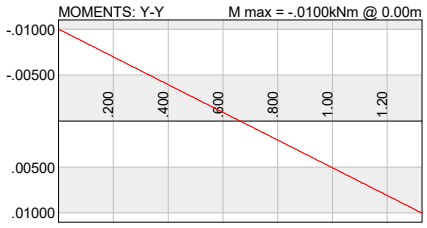
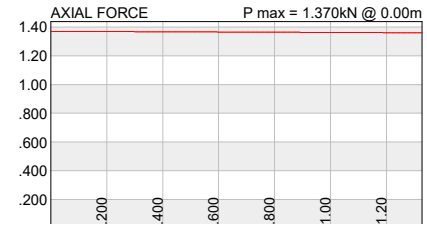
Combine Design







Combine Ver W5.2.12
Element 17-22 Evaluate current sections
Section name BRACING

Lx Eff = 1.128 m W1x = 1.00
Ly Eff = 1.128 m W1y = 0.40
Le Eff = 1.327 m W2 = 2.35
Fy = 214 MPa Fu = 241 MPa
Tension area factor (Ane/Ag) = 1.00
Section class: 1

Critical load case : ULS

Section 32x3 Round hollow sections

SANS 10162-1:2011 13.8.3 :
a) Cross-sectional strength (Critical position = 0.000 m)

Cu	Mux	Muy	1.37	.021	.010		
-- +	--- +	---	= ----	+ ----	+ ----	= 0.13	OK
Cr	Mrx	Mry	36.2	.347	.347		

b) Overall member strength

Cu	U1xMux	U1yMuy	1.37	.020	.010		
-- +	------ +	------	= ----	+ ----	+ ----	= 0.17	OK
Cr	Mrx	Mry	15.8	.347	.347		

c) Lateral torsional buckling strength

Cu	U1xMux	U1yMuy	1.37	.020	.010		
-- +	------ +	------	= ----	+ ----	+ ----	= 0.16	OK
Cr	Mrx	Mry	19.3	.347	.347		

13.4:Shear

Vux < Vrx	0.0 < 13.3	OK
Vuy < Vry	0.0 < 13.3	OK

Slenderness ratio:

Lx/rx = 106	OK
Ly/ry = 106	OK

PROKON	Job Number	MCP2750045		Sheet
	Job Title	SOLAR PANEL STRUCTURE		
Your details here	Client	SOLAR BRACKET INDUSTRIES		
	Calcs by	W MAVIMBELA	Checked by J VENTER	Date 2025/02/10

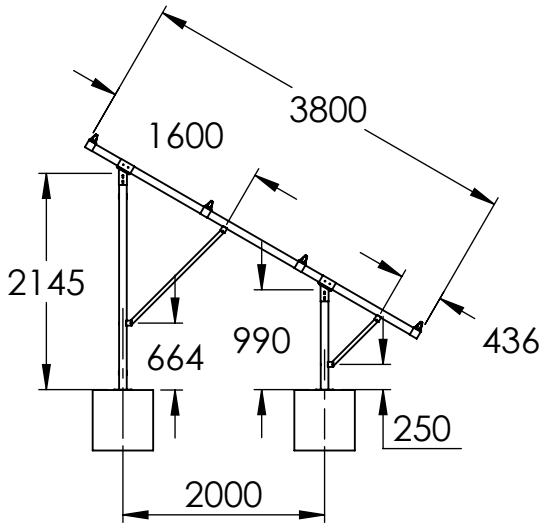
Strut Ver W5.2.14 - 11 December 2024

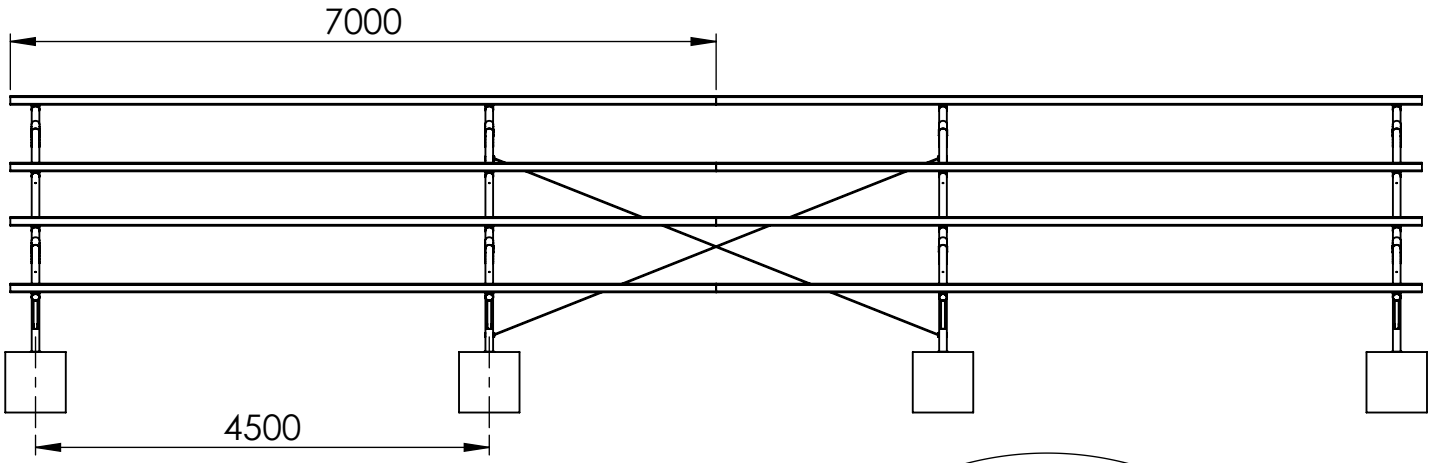
Task: Task 1

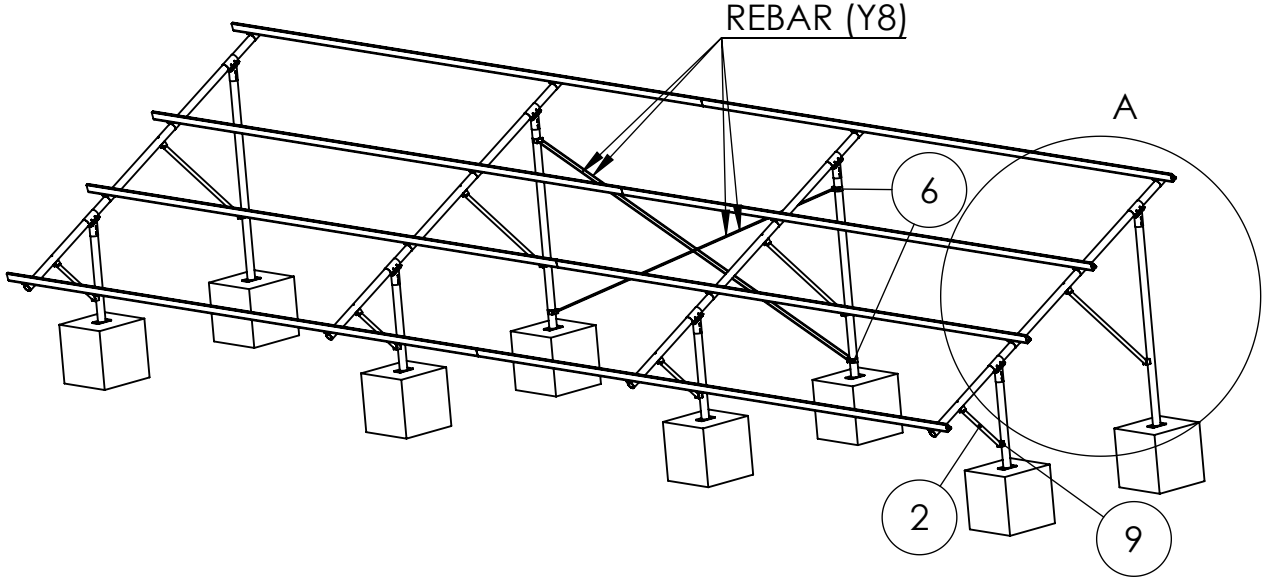
Design parameters		
Kv factor		0.85
Kx factor		0.85
Ky factor		1.00
Kz factor		1.00
Ane/Ag		1.00
Fy	MPa	214.00
Fu	MPa	241.00

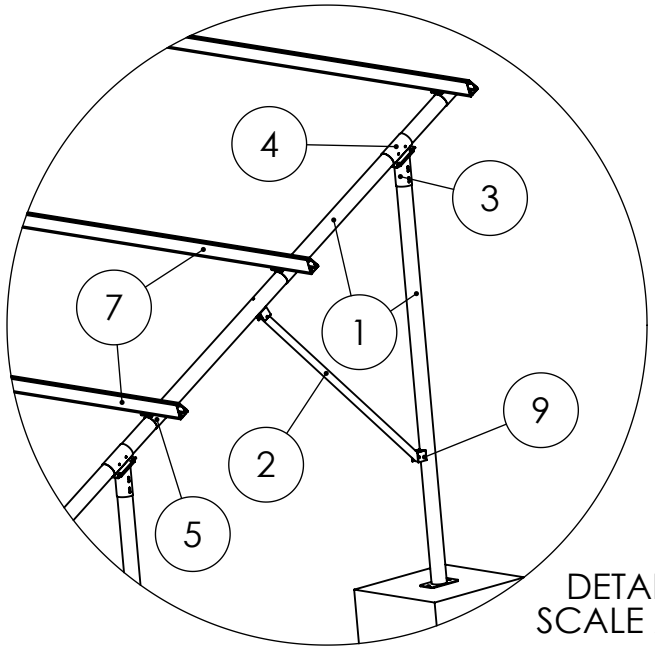
Maximum L/r ratios		
Load case	Compression	Tension
ULS	200	300
SLS	200	300

Element	Length (m)	Load case	L/R	Critical Axis	Section designation	P (kN)	Pr (kN)	Result
16-17	0.664	ULS	83	Y	76.2x3.0	-6.6	-127.2	OK
17-18	1.481	ULS	83	Y	76.2x3.0	-7.6	-127.2	OK
Group mass = 11.6 kg								









DETAIL A
SCALE 2 : 75

1	2	3	4	5	6	7	8
76 x 2 mm Round tubing	32 x 3 mm Round tubing	PAM-30	PMS-PAM	PMS-TE	PMS-Y8R	PS-TE	PS-UE

	CREATED BY: HW HUYSHAMEN DATE: 2025/02/01	SHEET 1OF 1	SIZE A4	SCALE 1:75	REVISION 3.4
ALL DIMENSIONS IN MILLIMETRES DIMENSIONS WITHOUT TOLERANCE TO ISO 2768c	PART CODE: PGMS	DESCRIPTION: PipeGround Mount Structure			
GEOMETRIC TOLERANCE BS:8888		-			