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***Planning documentation for the bearing system
Pitched roof system for solar modules***

***Project: 01-UK-Manchester College ASH
Project-46055460-CCL Components
Ltd-136351_Roof 1_ProLine***

Module type: LR4-72HPH 455M 2094 x 1038 mm



By order

CCL Components Ltd

1 Cairn Court, East Kilbride
UK-G74

March 2022

Project planning and auto-calculation

Version 5.170.8081.28370

Plant details

Date	07/03/2022
Customer	CCL Components Ltd
Order	46055460

Module selection

Manufacturer	Longi Solar,
Module	LR4-72HPH 455M
Peak power	450 W
Height	2,094 mm
Width	1,038 mm
Thickness	35 mm
Framing	Framed



Module arrangement

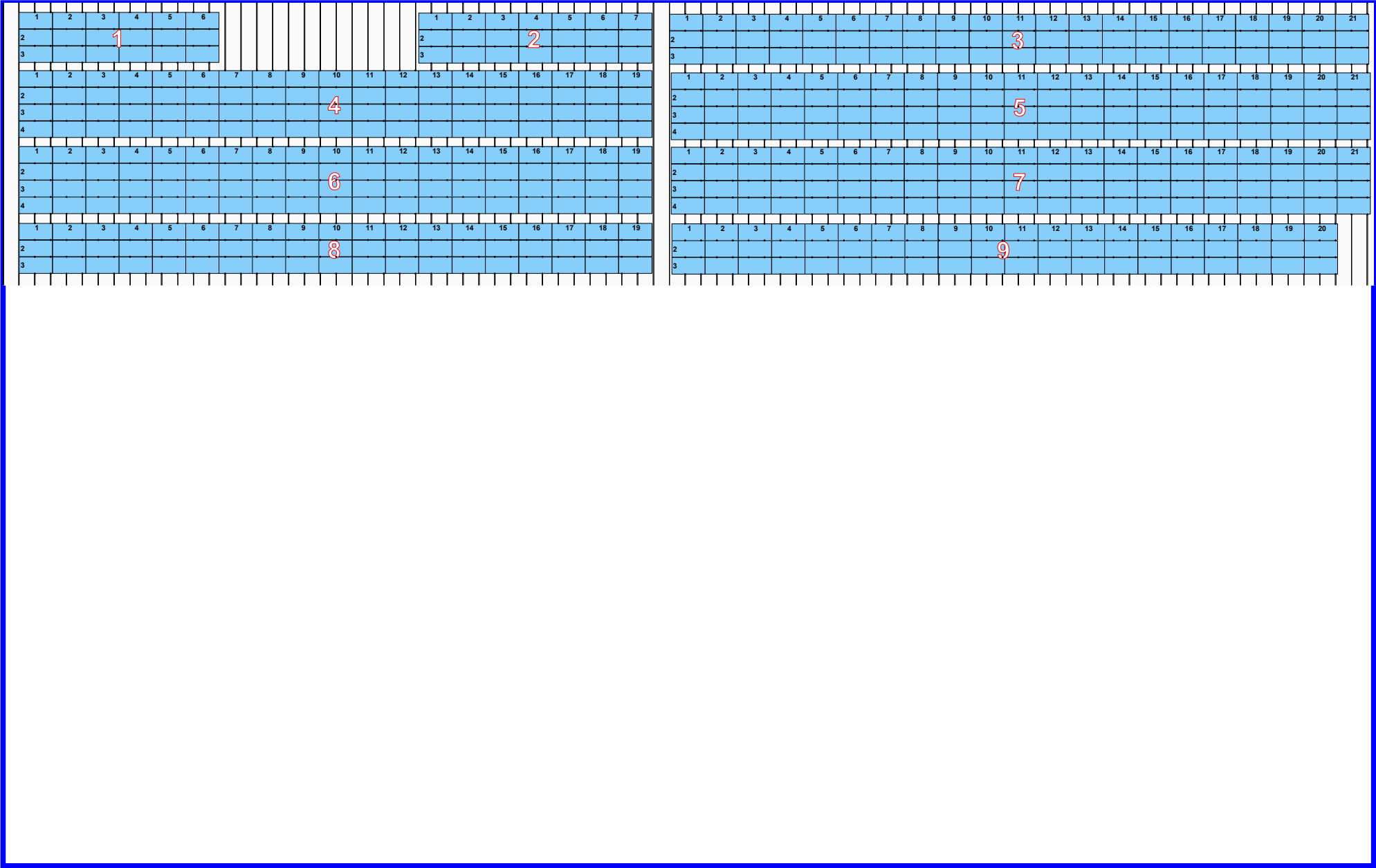
Number of modules	539
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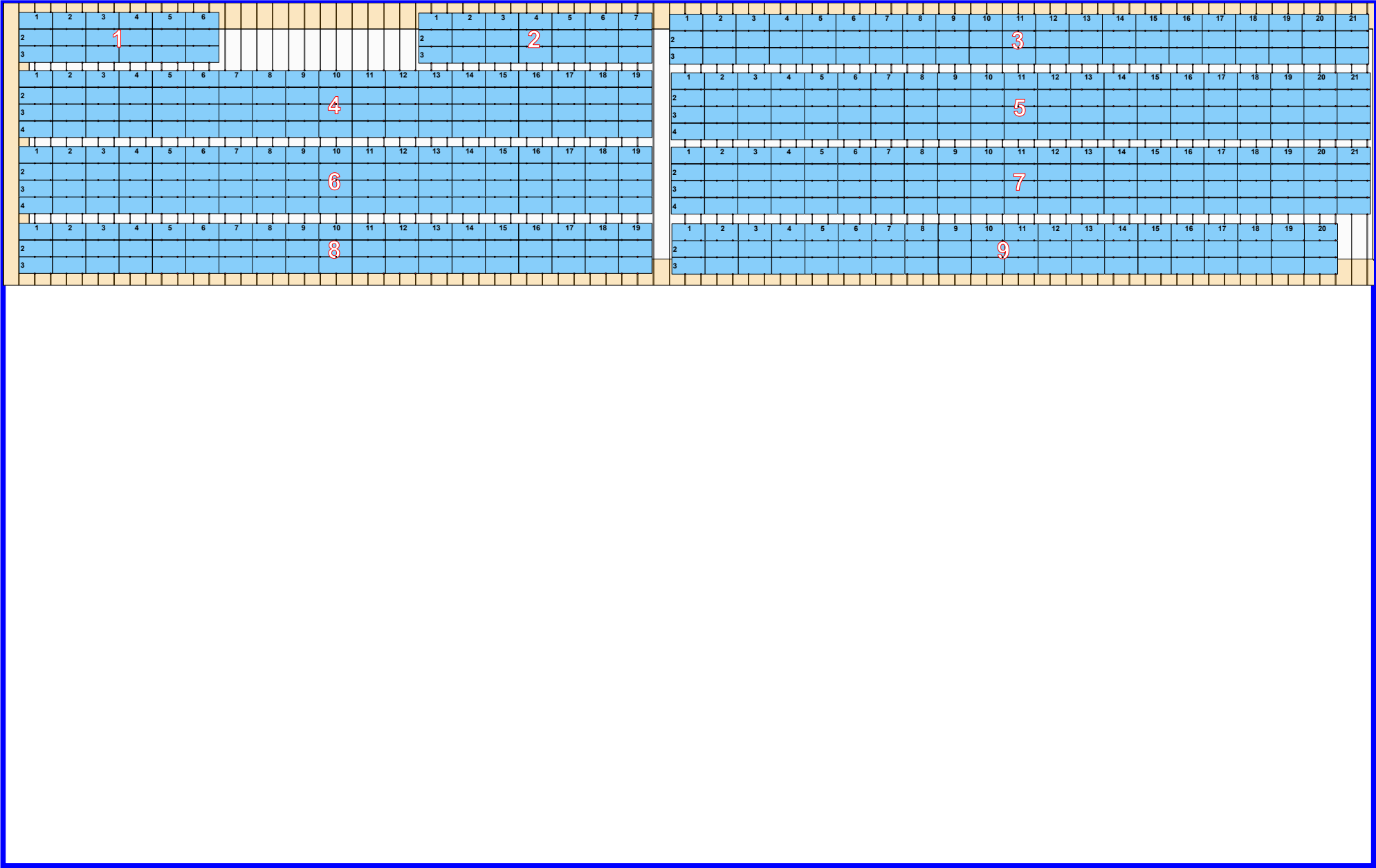
Basic configuration

System selection	
Clamp type	
Fastening	ClampFit Pro

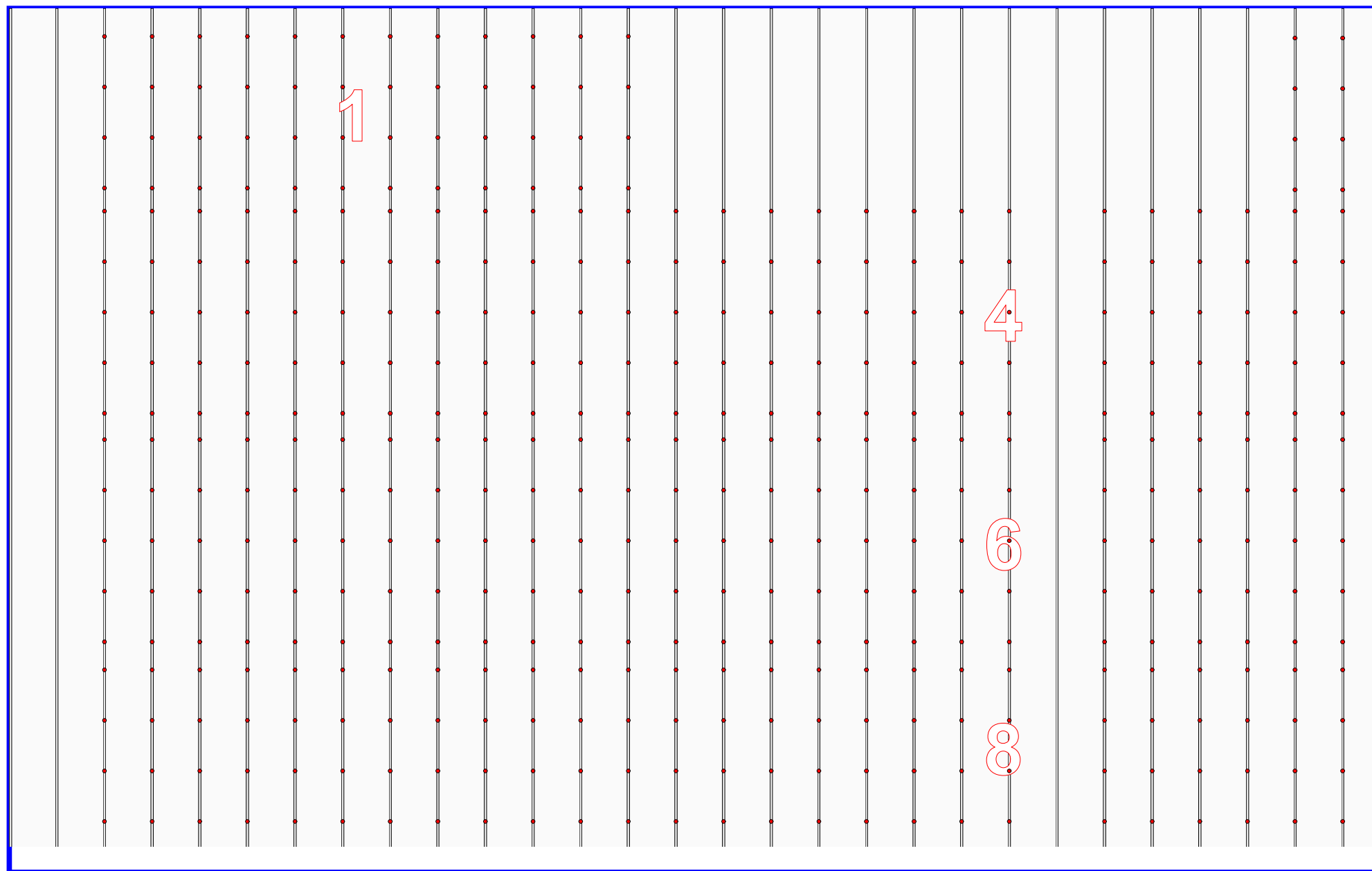
Results: Plant details

Peak power	242.55 kW
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FS calculator 5.170.8081.28370



Customer CCL Components Ltd
Project Manchester College ASH Project

Bill of Materials: Pitched Roof System

Pos	Item number	Item	Total amount	Length mm	Unit	Total weight kg
1	130004-300	ClampFit Pro	1384		ST	127.328
2	943000-360	Drill screw 6.0x25 self-tapping seal A2	2768		ST	19.376
3	131020-000	End clamp RapidPro 30-47mm	612		ST	33.660
4	131020-001	Middle clamp RapidPro 30-47mm	772		ST	40.144
		Total				220.508

Attention! If you want to order directly from Schletter Solar GmbH only complete packing units will be provided!

System configurator Status 5.170.8081.28370
Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (with special terrain formation), the consideration of higher wind loads is required.

Customer CCL Components Ltd
 Order 46055460
 Postal code construction site **M11 Manchester**
 53.4809 ° northern latitude
 2.2374 ° western longitude

Tilt angle	α	3.0	°
Module length	h	2.09	m
Height above sea level	H	61	m
Height above ground	z	5.00	m
Height of roof parapet	h_p	0.00	m

Structural system

Gable roof (double pitch roof)

Load assumptions acc. to BS EN 1991-1

Module weight	g	0.11	kN/m ²
Peak velocity pressure	$q(z)$	0.46	kN/m ²
Snow load	s	0.34	kN/m ²
Terrain category	III		

Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (villages, suburban terrain, permanent forest)

Terrain category III


Verification of the fastening system ClampFit Pro (130004-300)

Applicable for Gable roof (double pitch roof)

Tilt angle	α	3 °
Height above ground	z	5.00 m
Module length	h	2.09 m
Substructure grid size	a	0.80 m
Cantilever	l_{kr}	0.40 m

sin =	0.052	cos =	0.999
Module weight	g	0.11 kN/m ²	
Snow load	s	0.34 kN/m ²	
Peak velocity pressure	$q(z)$	0.46 kN/m ²	

Wind force coefficients			
c _{p1} 0.46	c _{p2} -0.33	H	
	c _{p2} -0.45	G	
	c _{p2} -0.63	F	

Load chart per Square meter of roof area
Dead load Modules

$$\begin{aligned}
 g_v &= 0.11 \cdot 1.00 \cdot 1.000 = 0.11 \text{ kN/m}^2 \\
 g_z &= 0.11 \cdot 0.999 = 0.11 \text{ kN/m}^2 \\
 g_y &= 0.11 \cdot 0.052 = 0.01 \text{ kN/m}^2
 \end{aligned}$$

Snow load

$$\begin{aligned}
 s_v &= 0.34 \cdot 1.00 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_z &= 0.34 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_y &= 0.34 \cdot 0.052 = 0.02 \text{ kN/m}^2
 \end{aligned}$$

Wind pressure

$$\begin{aligned}
 \text{Zone H} \quad w_{dz} &= 0.46 \cdot 0.20 = 0.09 \text{ kN/m}^2 \\
 \text{Zone G} \quad w_{dz} &= 0.46 \cdot 0.46 = 0.21 \text{ kN/m}^2 \\
 \text{Zone F} \quad w_{dz} &= 0.46 \cdot 0.90 = 0.41 \text{ kN/m}^2
 \end{aligned}$$

Wind suction

$$\begin{aligned}
 \text{Zone H} \quad w_{sz} &= 0.46 \cdot -0.33 = -0.15 \text{ kN/m}^2 \\
 \text{Zone G} \quad w_{sz} &= 0.46 \cdot -0.45 = -0.21 \text{ kN/m}^2 \\
 \text{Zone F} \quad w_{sz} &= 0.46 \cdot -0.63 = -0.29 \text{ kN/m}^2
 \end{aligned}$$

Overview load per Square meter Roof area
Section forces factors for single, double or triple-span girders

Force factors				
n	A _{total}	A _{partial}	B _{total}	B _{partial}
1	0.500	0.500	0.000	0.000
2	0.375	0.438	1.250	1.250
3	0.400	0.450	1.100	1.200

Load combinations
Importance/reliability factor: $K_{FI} = 1.00$ (RC2)Load combination 1: $1.35 \cdot g + 1.5 \cdot s + 0.6 \cdot 1.5 \cdot w$ Load combination 2: $1.35 \cdot g + 0.5 \cdot 1.5 \cdot s + 1.5 \cdot w$ Load combination 3: $0.9 \cdot g + 1.5 \cdot w$

Load combination 1					Load combination 2				Load combination 3							
Vertical/portrait		Horizontal/landscape			Vertical/portrait		Horizontal/landscape		Vertical/portrait H		Vertical/portrait G		Vertical/portrait F		Horizontal/landscape	
n	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	0.67	0.67	0.03	0.03	0.49	0.49	0.02	0.02	-0.12	-0.12	-0.22	-0.22	-0.34	-0.34	0.00	0.00
2	0.67	1.33	0.03	0.06	0.49	0.97	0.02	0.04	-0.12	-0.24	-0.22	-0.43	-0.34	-0.68	0.00	0.01
3	0.67	1.33	0.03	0.06	0.49	0.97	0.02	0.04	-0.12	-0.24	-0.22	-0.43	-0.34	-0.68	0.00	0.01

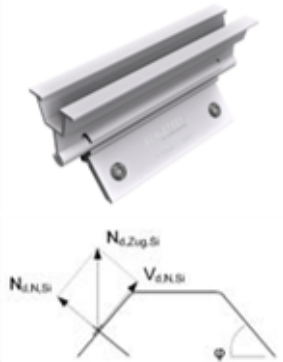
Resume of the relevant combinations (Single-span girder)

	LC1	LC2	LC3			
			H	G	F	
AV	0.67	0.49	-0.12	-0.22	-0.34	kN
AH	0.03	0.02	0.00	0.01	0.01	kN
BV	0.67	0.49	-0.12	-0.22	-0.34	kN
BH	0.03	0.02	0.00	0.01	0.01	kN

	Center	Border	Load distribution
Compressive force	$N_D = 0.67 \text{ kN}$	$N_D = 0.67 \text{ kN}$	$P = 0.67 \text{ kN}$
Perm. shear force	$N_H = 0.03 \text{ kN}$	$N_H = 0.03 \text{ kN}$	$H = 0.03 \text{ kN}$
Tensile force H	$N_Z = -0.12 \text{ kN}$	$N_Z = -0.12 \text{ kN}$	$P = 0.67 \text{ kN}$
Perm. shear force H	$N_H = 0.00 \text{ kN}$	$N_H = 0.00 \text{ kN}$	$H = 0.03 \text{ kN}$
Tensile force G	$N_Z = -0.22 \text{ kN}$	$N_Z = -0.22 \text{ kN}$	$P = 0.85 \text{ kN}$
Perm. shear force G	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.03 \text{ kN}$
Tensile force F	$N_Z = -0.34 \text{ kN}$	$N_Z = -0.34 \text{ kN}$	$P = 1.04 \text{ kN}$
Perm. shear force F	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.03 \text{ kN}$

Verification ClampFit Pro
according to German general technical approval Z 14.4-646

Type of fastening	ClampFit Pro					
Sheet material	Steel					
Sheet metal thickness	t	0.50	mm			
Crest distance	b	1,000	mm			
Crown/beading height	h	30	mm			
Corrugation top (crown)	b _o	50	mm	E	210,000	N/mm ²
Corrugation valley	b _u	900	mm	f _{yb}	280	N/mm ²
Web tilt	φ	50.2	°	r	2	Sheet metal
Rotation	β	0.0	°	γ _{M1}	1.10	Sheet metal
Fix length	S _s	33	mm	γ _{M1}	1.33	Screws/bolts



		LK1	LK2	LK3				Formula
				H	G	F		
Loads	N _{d,Pressure}	0.67	0.49	0.00	0.00	0.00	kN	0.5 · h _b + h _z
	N _{d,Traction}	0.00	0.00	0.12	0.22	0.34	kN	
	V _{d,II}	0.03	0.02	0.00	0.01	0.01	kN	
Geometry	h _b	40					mm	
	h _z	5					mm	
	b	71					mm	
	h	25					mm	
Moments	M _{D,II}	0.77	0.47	0.11	0.13	0.13	kNcm	V _{d,II} · h
Clamps	N _{R,k}	7.05					kN	Z-14.4-646 Chapter 3.2.3.2
	γ _M	1.20					kNcm	
	V _{R,k}	11.22					kN	
	γ _{M1}	1.20					kNcm	
Verification		0.00	0.00	0.02	0.04	0.06		N _{d,Traction} · γ _M / N _{R,k} + V _{d,II} · γ _M / V _{R,k} ≤ 1
Forces	N _{d,s}	0.00	0.00	0.04	0.07	0.11	kN	Z-14.4-646 Chapter 3.2.3.5
	V _{d,s}	0.02	0.01	0.05	0.08	0.13	kN	
	f _i	0.25					-	
Screws/bolts	N _{R,k}	0.41					kN	Z-14.1-537
	V _{R,k}	0.77					kN	
Verification		0.04	0.02	0.20	0.37	0.59	-	N _{d,s} · γ _M / N _{R,k} + V _{d,s} · γ _M / V _{R,k} ≤ 1
Trapezoidal sheet metal	R _{w,Rd,zen}	0.93					kN	α = 0.150 l _a = 10 mm
	R _{w,Rd,lin}	0.32					kN	α = 0.150 l _a = S _s
Verification		0.41	0.30	0.00	0.00	0.00	-	Z-14.4-646 Chapter 3.2.3.4

Verification of connections

Tilt angle	α	3	°	$\sin = 0.052$	$\cos = 0.999$	
Snow load	s	0.34	kN/m ²	Peak velocity pressure 0.46 kN/m ²		
Height above ground	z	5.00	m	Zone F	$c_{p,1} = -0.63$	Pressure coefficients $c_{pe,1}$
Module length	h	2.09		Zone G	$c_{p,1} = -0.45$	
Module weight	g	0.11	kN/m ²	Zone H	$c_{p,1} = -0.33$	

Load overview

Dead load Modules

$$\begin{aligned}
 g_v &= 0.11 \cdot 1.00 \cdot 1.000 = 0.11 \text{ kN/m}^2 \\
 g_z &= 0.11 \cdot 0.999 = 0.11 \text{ kN/m}^2 \\
 g_y &= 0.11 \cdot 0.052 = 0.01 \text{ kN/m}^2
 \end{aligned}$$

Snow load

$$\begin{aligned}
 s_v &= 0.34 \cdot 1.00 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_z &= 0.34 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_y &= 0.34 \cdot 0.052 = 0.02 \text{ kN/m}^2
 \end{aligned}$$

Wind suction

$$\begin{aligned}
 w_{dz} &= 0.46 \cdot 0.20 = 0.09 \text{ kN/m}^2 \\
 w_{sz} &= 0.46 \cdot c_{p,1}
 \end{aligned}$$

Module clamps according to general technical approval Z-14.4-631

Middle clamps		End clamps	
$F_{R,d}$ kN	$V_{R,d}$ kN	$F_{R,d}$ kN	$V_{R,d}$ kN
5.16	1.28	2.27	1.67

Module surface

$$A = 2.17 \text{ m}^2$$

Frictional connection

$$A = 0.22 \text{ kN} (F_{S,d} \cdot \mu)$$

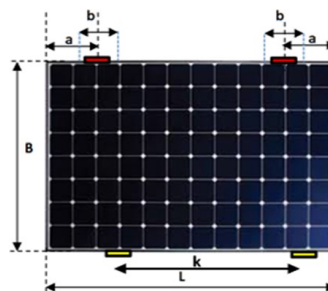
Internal forces at module clamps

$$\text{Middle clamp } |F_{S,d}| = 0.93 \cdot (0.9 \cdot g_v + 1.5 \cdot 0.46 \cdot c_p) \cdot 2.17$$

$$\text{End clamp } |F_{S,d}| = 0.47 \cdot (0.9 \cdot g_v + 1.5 \cdot 0.46 \cdot c_p) \cdot 2.17$$

$$f = \frac{(0.5 \cdot L - x_1) / k}{k} = 0.93$$

$$\begin{aligned}
 L &= 2,094 \text{ mm} \\
 x_1 &= 117 \text{ mm} \\
 x_2 &= 977 \text{ mm} \\
 k &= 1,000 \text{ mm}
 \end{aligned}$$



	$V_{S,d}$ kN	$F_{S,d}$ kN		
		Zone F	Zone G	Zone H
Middle clamps	-0.18	0.59	0.34	0.15
End clamps	-0.09	0.29	0.17	0.08

$$V_{S,d} = V_{S,dy} - F_{S,dz} \cdot \mu (\mu = 0.50)$$

Utilization ratio 2.9%

Utilization ratio 3.3%

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***Planning documentation for the bearing system
Pitched roof system for solar modules***

***Project: 01-UK-Manchester College ASH
Project-46055460-CCL Components
Ltd-136351_Roof 2_Prollne***

Module type: LR4-72HPH 455M. 2094 x 1038 mm



By order

CCL Components Ltd

1 Cairn Court, East Kilbride
UK-G74

March 2022

Project planning and auto-calculation

Version 5.170.8081.28370

Plant details

Date	07/03/2022
Customer	CCL Components Ltd
Order	46055460

Module selection

Manufacturer	Longi Solar,
Module	LR4-72HPH 455M.
Peak power	450 W
Height	2,094 mm
Width	1,038 mm
Thickness	35 mm
Framing	Framed



Module arrangement

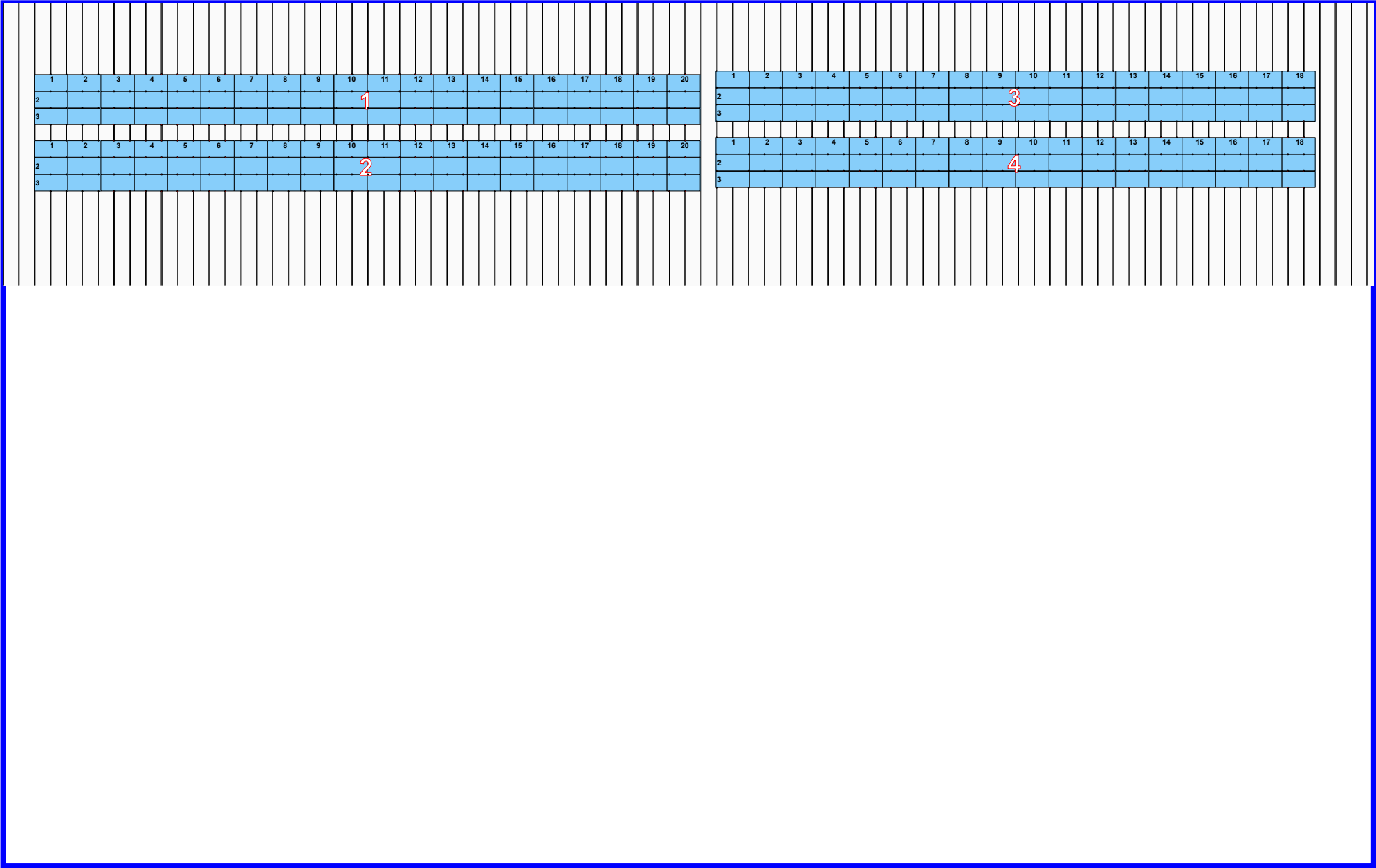
Number of modules	228
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Basic configuration

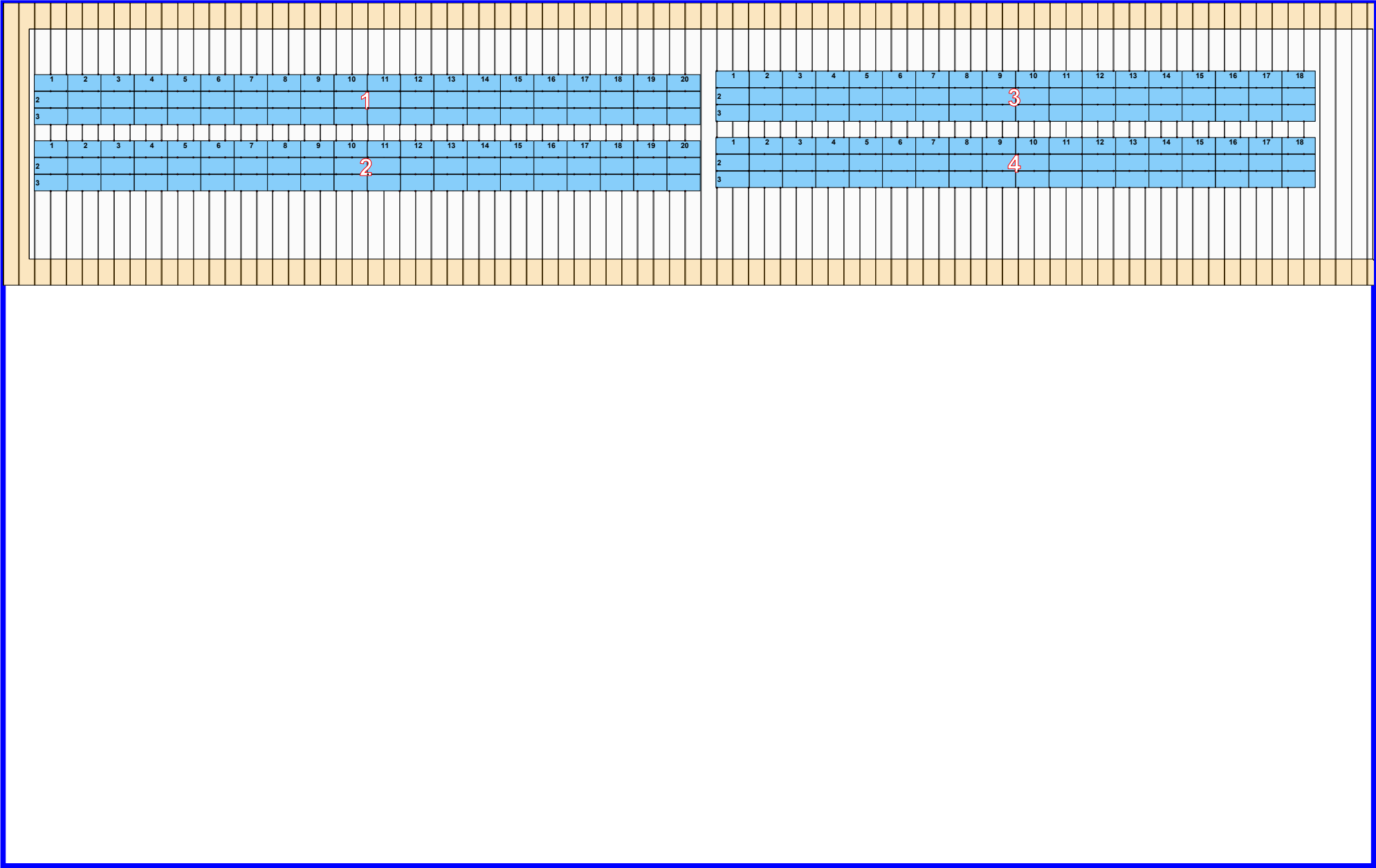
System selection	
Clamp type	
Fastening	ClampFit Pro

Results: Plant details

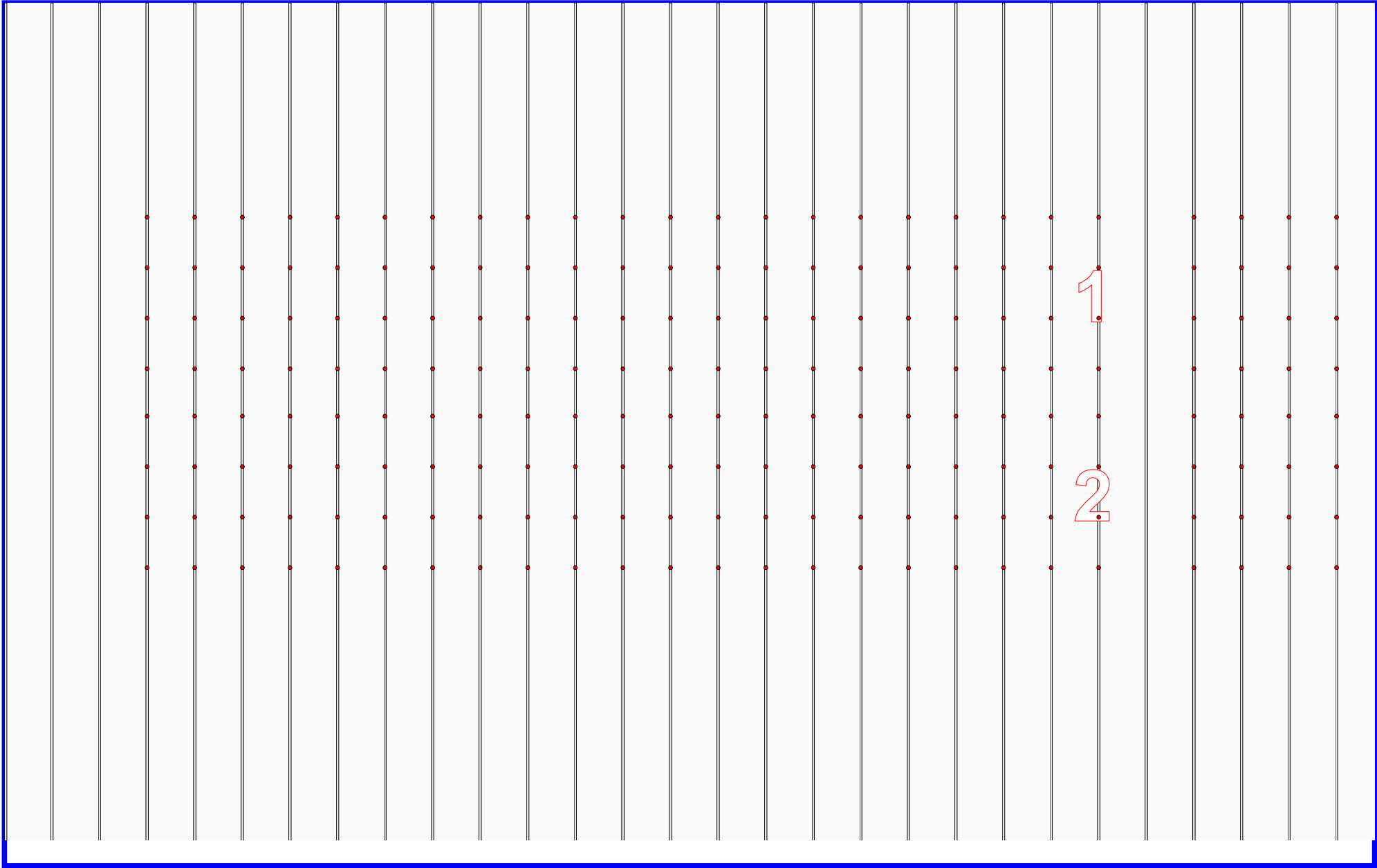
Peak power	102.60 kW
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FS calculator 5.170.8081.28370



FS calculator 5.170.8081.28370



FS calculator 5.170.8081.28370

Customer CCL Components Ltd
Project Manchester College ASH Project

Bill of Materials: Pitched Roof System

Pos	Item number	Item	Total amount	Length mm	Unit	Total weight kg
1	130004-300	ClampFit Pro	608		ST	55.936
2	943000-360	Drill screw 6.0x25 self-tapping seal A2	1216		ST	8.512
3	131020-000	End clamp RapidPro 30-47mm	304		ST	16.720
4	131020-001	Middle clamp RapidPro 30-47mm	304		ST	15.808
		Total				96.976

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System configurator Status 5.170.8081.28370
Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (with special terrain formation), the consideration of higher wind loads is required.

Customer CCL Components Ltd
 Order 46055460
 Postal code construction site **M11 Manchester**
 53.4809 ° northern latitude
 2.2374 ° western longitude

Tilt angle	α	3.0	°
Module length	h	2.09	m
Height above sea level	H	61	m
Height above ground	z	5.00	m
Height of roof parapet	h_p	0.00	m

Structural system

Gable roof (double pitch roof)

Load assumptions acc. to BS EN 1991-1

Module weight	g	0.11	kN/m ²
Peak velocity pressure	$q(z)$	0.46	kN/m ²
Snow load	s	0.34	kN/m ²
Terrain category	III		

Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (villages, suburban terrain, permanent forest)

Terrain category III


Verification of the fastening system ClampFit Pro (130004-300)

Applicable for Gable roof (double pitch roof)

Tilt angle	α	3 °
Height above ground	z	5.00 m
Module length	h	2.09 m
Substructure grid size	a	0.80 m
Cantilever	l_{kr}	0.40 m

sin =	0.052	cos =	0.999
Module weight	g	0.11 kN/m ²	
Snow load	s	0.34 kN/m ²	
Peak velocity pressure	$q(z)$	0.46 kN/m ²	

Wind force coefficients			
c _{p1} 0.46	c _{p2} -0.33	H	
	c _{p2} -0.45	G	
	c _{p2} -0.63	F	

Load chart per Square meter of roof area
Dead load Modules

$$\begin{aligned} g_v &= 0.11 \cdot 1.00 \cdot 1.000 = 0.11 \text{ kN/m}^2 \\ g_z &= 0.11 \cdot 0.999 = 0.11 \text{ kN/m}^2 \\ g_y &= 0.11 \cdot 0.052 = 0.01 \text{ kN/m}^2 \end{aligned}$$

Snow load

$$\begin{aligned} s_v &= 0.34 \cdot 1.00 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\ s_z &= 0.34 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\ s_y &= 0.34 \cdot 0.052 = 0.02 \text{ kN/m}^2 \end{aligned}$$

Wind pressure

$$\begin{aligned} \text{Zone H} \quad w_{dz} &= 0.46 \cdot 0.20 = 0.09 \text{ kN/m}^2 \\ \text{Zone G} \quad w_{dz} &= 0.46 \cdot 0.46 = 0.21 \text{ kN/m}^2 \\ \text{Zone F} \quad w_{dz} &= 0.46 \cdot 0.90 = 0.41 \text{ kN/m}^2 \end{aligned}$$

Wind suction

$$\begin{aligned} \text{Zone H} \quad w_{sz} &= 0.46 \cdot -0.33 = -0.15 \text{ kN/m}^2 \\ \text{Zone G} \quad w_{sz} &= 0.46 \cdot -0.45 = -0.21 \text{ kN/m}^2 \\ \text{Zone F} \quad w_{sz} &= 0.46 \cdot -0.63 = -0.29 \text{ kN/m}^2 \end{aligned}$$

Overview load per Square meter Roof area
Section forces factors for single, double or triple-span girders

Force factors				
n	A _{total}	A _{partial}	B _{total}	B _{partial}
1	0.500	0.500	0.000	0.000
2	0.375	0.438	1.250	1.250
3	0.400	0.450	1.100	1.200

Load combinations
Importance/reliability factor: $K_{FI} = 1.00$ (RC2)Load combination 1: $1.35 \cdot g + 1.5 \cdot s + 0.6 \cdot 1.5 \cdot w$ Load combination 2: $1.35 \cdot g + 0.5 \cdot 1.5 \cdot s + 1.5 \cdot w$ Load combination 3: $0.9 \cdot g + 1.5 \cdot w$

Load combination 1					Load combination 2				Load combination 3							
Vertical/portrait		Horizontal/landscape			Vertical/portrait		Horizontal/landscape		Vertical/portrait H		Vertical/portrait G		Vertical/portrait F		Horizontal/landscape	
n	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	0.78	0.78	0.04	0.04	0.57	0.57	0.02	0.02	-0.14	-0.14	-0.23	-0.23	-0.36	-0.36	0.01	0.01
2	0.78	1.56	0.04	0.07	0.57	1.14	0.02	0.04	-0.14	-0.28	-0.23	-0.46	-0.36	-0.72	0.01	0.01
3	0.78	1.56	0.04	0.07	0.57	1.14	0.02	0.04	-0.14	-0.28	-0.23	-0.46	-0.36	-0.72	0.01	0.01

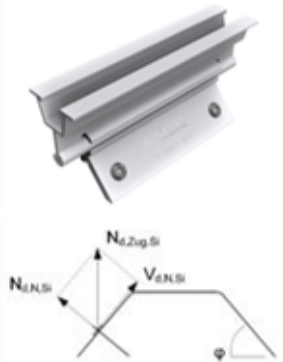
Resume of the relevant combinations (Single-span girder)

	LC1	LC2	LC3			
			H	G	F	
AV	0.78	0.57	-0.14	-0.23	-0.36	kN
AH	0.04	0.02	0.01	0.01	0.01	kN
BV	0.78	0.57	-0.14	-0.23	-0.36	kN
BH	0.04	0.02	0.01	0.01	0.01	kN

	Center	Border	Load distribution
Compressive force	$N_D = 0.78 \text{ kN}$	$N_D = 0.78 \text{ kN}$	$P = 0.78 \text{ kN}$
Perm. shear force	$N_H = 0.04 \text{ kN}$	$N_H = 0.04 \text{ kN}$	$H = 0.04 \text{ kN}$
Tensile force H	$N_Z = -0.14 \text{ kN}$	$N_Z = -0.14 \text{ kN}$	$P = 0.78 \text{ kN}$
Perm. shear force H	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.04 \text{ kN}$
Tensile force G	$N_Z = -0.23 \text{ kN}$	$N_Z = -0.23 \text{ kN}$	$P = 0.90 \text{ kN}$
Perm. shear force G	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.04 \text{ kN}$
Tensile force F	$N_Z = -0.36 \text{ kN}$	$N_Z = -0.36 \text{ kN}$	$P = 1.09 \text{ kN}$
Perm. shear force F	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.04 \text{ kN}$

Verification ClampFit Pro
according to German general technical approval Z 14.4-646

Type of fastening	ClampFit Pro					
Sheet material	Steel					
Sheet metal thickness	t	0.50	mm			
Crest distance	b	1,000	mm			
Crown/beading height	h	30	mm			
Corrugation top (crown)	b _o	50	mm	E	210,000	N/mm ²
Corrugation valley	b _u	900	mm	f _{yb}	280	N/mm ²
Web tilt	φ	50.2	°	r	2	Sheet metal
Rotation	β	0.0	°	γ _{M1}	1.10	Sheet metal
Fix length	S _s	33	mm	γ _{M1}	1.33	Screws/bolts



		LK1	LK2	LK3				Formula
				H	G	F		
Loads	N _{d,Pressure}	0.78	0.57	0.00	0.00	0.00	kN	
	N _{d,Traction}	0.00	0.00	0.14	0.23	0.36	kN	
	V _{d,II}	0.04	0.02	0.01	0.01	0.01	kN	
Geometry	h _b	40					mm	
	h _z	5					mm	
	b	71					mm	
	h	25					mm	
Moments	M _{D,II}	0.91	0.56	0.13	0.13	0.13	kNcm	0.5 · h _b + h _z
Clamps	N _{R,k}	7.05					kN	Z-14.4-646 Chapter 3.2.3.2
	γ _M	1.20					kNcm	
	V _{R,k}	11.22					kN	
	γ _{M1}	1.20					kNcm	
Verification		0.00	0.00	0.02	0.04	0.06		N _{d,Traction} · γ _M / N _{R,k} + V _{d,II} · γ _M / V _{R,k} ≤ 1
Forces	N _{d,s}	0.00	0.00	0.05	0.07	0.12	kN	Z-14.4-646 Chapter 3.2.3.5
	V _{d,s}	0.02	0.01	0.05	0.09	0.14	kN	
	f _i	0.25					-	
Screws/bolts	N _{R,k}	0.41					kN	Z-14.1-537
	V _{R,k}	0.77					kN	
Verification		0.05	0.03	0.24	0.39	0.62	-	N _{d,s} · γ _M / N _{R,k} + V _{d,s} · γ _M / V _{R,k} ≤ 1
Trapezoidal sheet metal	R _{w,Rd,zen}	0.93					kN	α = 0.150 l _a = 10 mm
	R _{w,Rd,lin}	0.32					kN	α = 0.150 l _a = S _s
Verification		0.48	0.35	0.00	0.00	0.00	-	Z-14.4-646 Chapter 3.2.3.4

Verification of connections

Tilt angle	α	3	°	$\sin = 0.052$	$\cos = 0.999$	
Snow load	s	0.34	kN/m ²	Peak velocity pressure 0.46 kN/m ²		
Height above ground	z	5.00	m	Zone F	$c_{p,1} = -0.63$	Pressure coefficients $c_{pe,1}$
Module length	h	2.09		Zone G	$c_{p,1} = -0.45$	
Module weight	g	0.11	kN/m ²	Zone H	$c_{p,1} = -0.33$	

Load overview

Dead load Modules

$$\begin{aligned}
 g_v &= 0.11 \cdot 1.00 \cdot 1.000 = 0.11 \text{ kN/m}^2 \\
 g_z &= 0.11 \cdot 0.999 = 0.11 \text{ kN/m}^2 \\
 g_y &= 0.11 \cdot 0.052 = 0.01 \text{ kN/m}^2
 \end{aligned}$$

Snow load

$$\begin{aligned}
 s_v &= 0.34 \cdot 1.00 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_z &= 0.34 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_y &= 0.34 \cdot 0.052 = 0.02 \text{ kN/m}^2
 \end{aligned}$$

Wind suction

$$\begin{aligned}
 w_{dz} &= 0.46 \cdot 0.20 = 0.09 \text{ kN/m}^2 \\
 w_{sz} &= 0.46 \cdot c_{p,1}
 \end{aligned}$$

Module clamps according to general technical approval Z-14.4-631

Middle clamps		End clamps	
$F_{R,d}$ kN	$V_{R,d}$ kN	$F_{R,d}$ kN	$V_{R,d}$ kN
5.16	1.28	2.27	1.67

Module surface

$$A = 2.17 \text{ m}^2$$

Frictional connection

$$A = 0.22 \text{ kN } (F_{S,d} \cdot \mu)$$

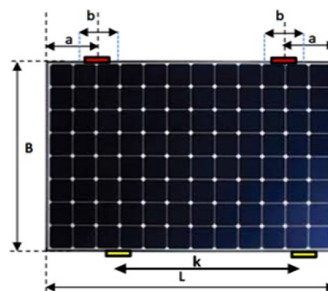
Internal forces at module clamps

$$\text{Middle clamp } |F_{S,d}| = 0.98 \cdot (0.9 \cdot g_v + 1.5 \cdot 0.46 \cdot c_p) \cdot 2.17$$

$$\text{End clamp } |F_{S,d}| = 0.49 \cdot (0.9 \cdot g_v + 1.5 \cdot 0.46 \cdot c_p) \cdot 2.17$$

$$f = \frac{(0.5 \cdot L - x_1) / k}{k} = 0.98$$

$$\begin{aligned}
 L &= 2,094 \text{ mm} \\
 x_1 &= 70 \text{ mm} \\
 x_2 &= 1,024 \text{ mm} \\
 k &= 1,000 \text{ mm}
 \end{aligned}$$



	$V_{S,d}$ kN	$F_{S,d}$ kN		
		Zone F	Zone G	Zone H
Middle clamps	-0.18	0.62	0.35	0.18
End clamps	-0.09	0.31	0.18	0.09

$$V_{S,d} = V_{S,dy} - F_{S,dz} \cdot \mu \quad (\mu = 0.50)$$

Utilization ratio 3.4%

Utilization ratio 3.9%

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***Planning documentation for the bearing system
Pitched roof system for solar modules***

***Project: 01-UK-Manchester College ASH
Project-46055460-CCL Components
Ltd-136351_Roof 3_Proline***

Module type: LR4-72HPH 455M 2094 x 1038 mm



By order

CCL Components Ltd

1 Cairn Court, East Kilbride
UK-G74

March 2022

Project planning and auto-calculation

Version 5.170.8081.28370

Plant details

Date	07/03/2022
Customer	CCL Components Ltd
Order	46055460

Module selection

Manufacturer	Longi Solar,
Module	LR4-72HPH 455M
Peak power	450 W
Height	2,094 mm
Width	1,038 mm
Thickness	35 mm
Framing	Framed



Module arrangement

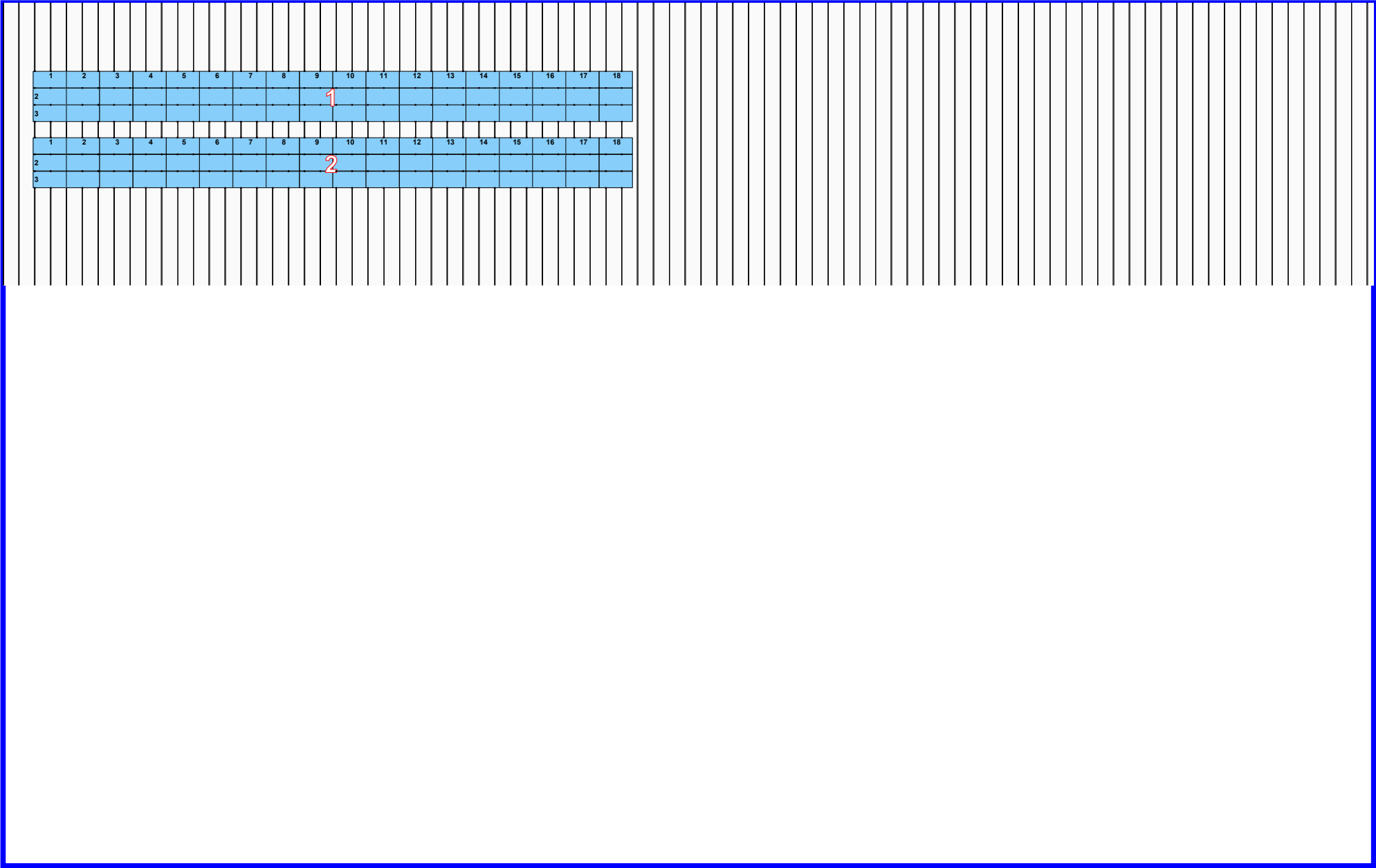
Number of modules	108
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Basic configuration

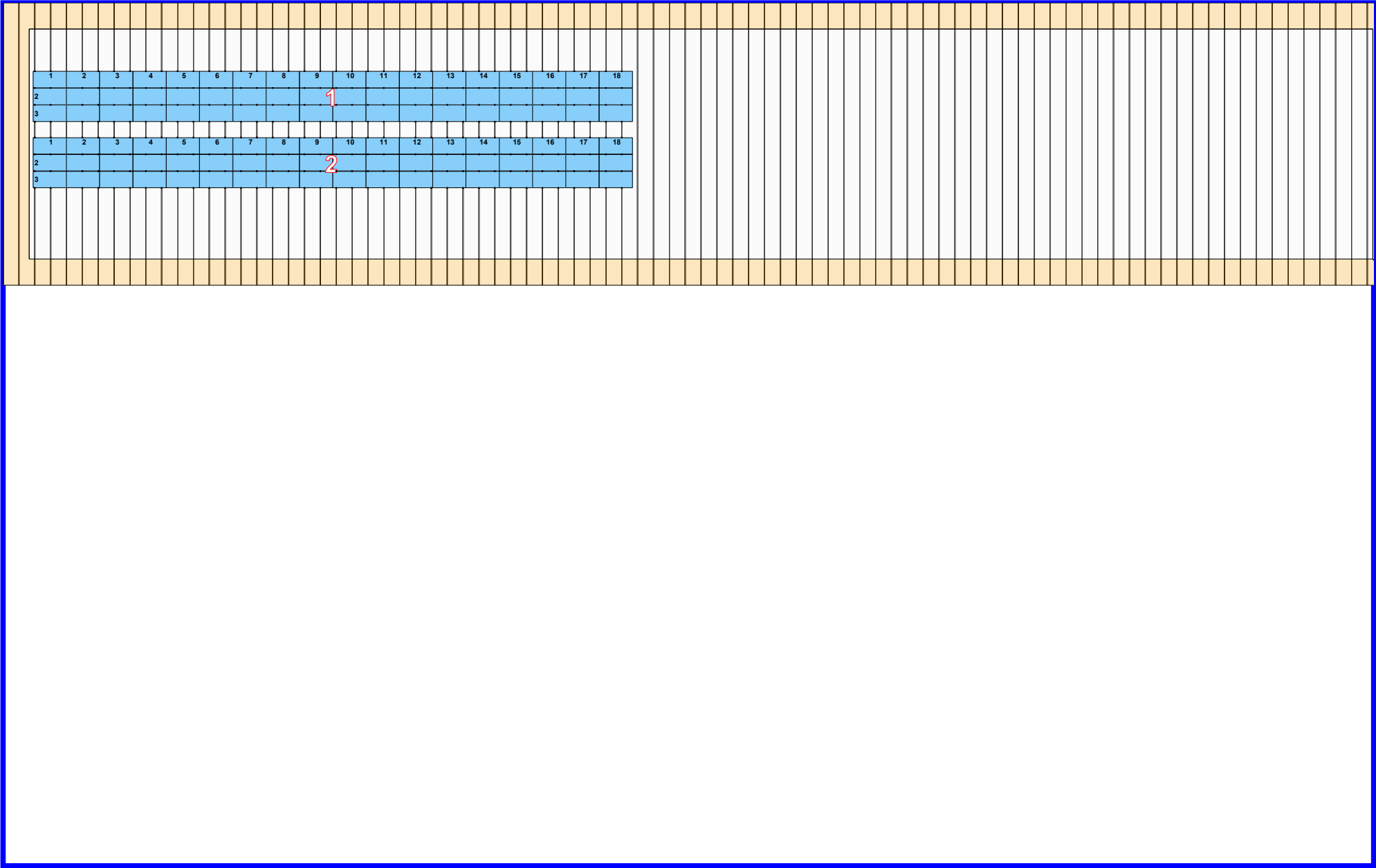
System selection	
Clamp type	
Fastening	ClampFit Pro

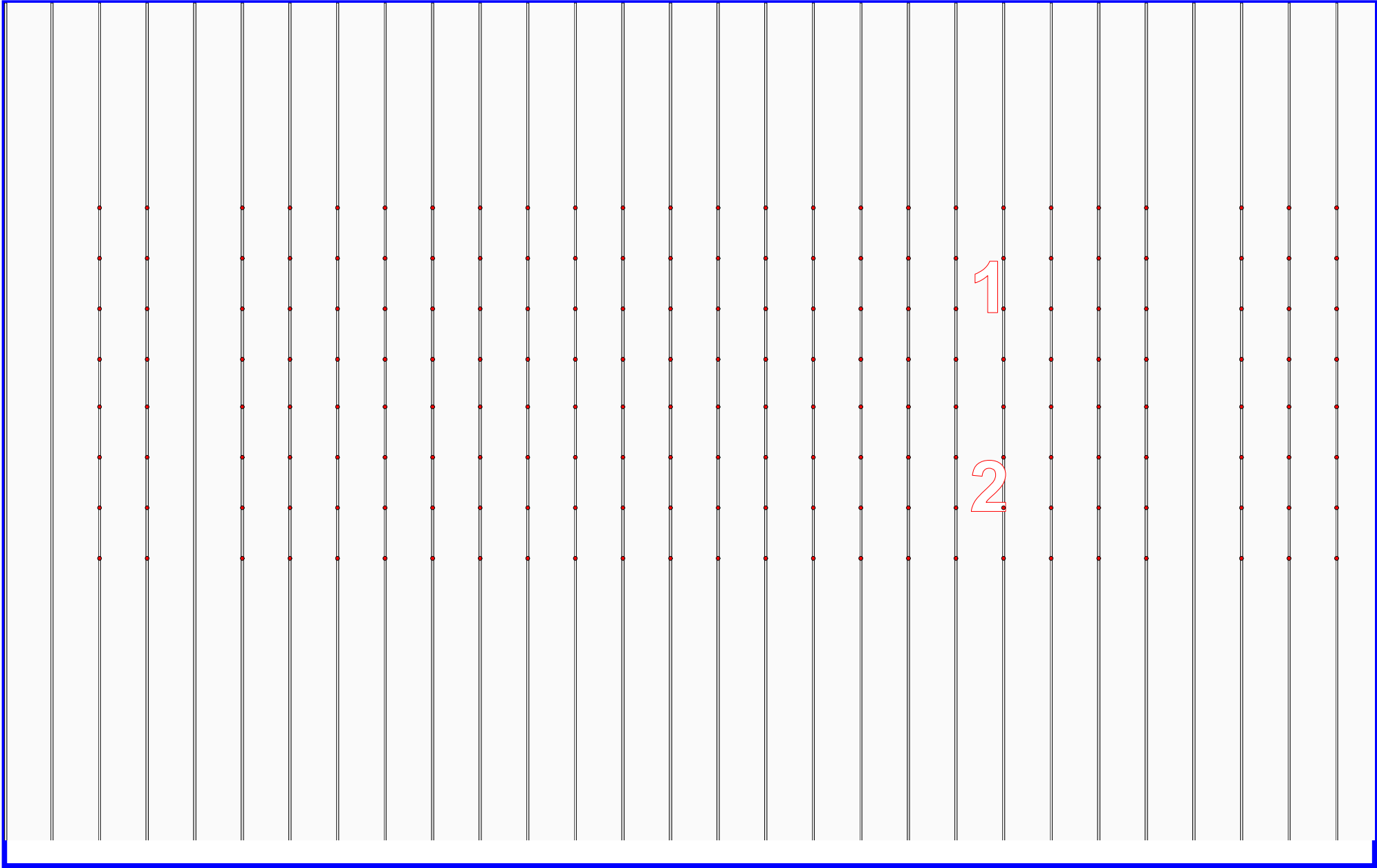
Results: Plant details

Peak power	48.60 kW
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FS calculator 5.170.8081.28370





FS calculator 5.170.8081.28370

Customer CCL Components Ltd
Project Manchester College ASH Project

Bill of Materials: Pitched Roof System

Pos	Item number	Item	Total amount	Length mm	Unit	Total weight kg
1	130004-300	ClampFit Pro	288		ST	26.496
2	943000-360	Drill screw 6.0x25 self-tapping seal A2	576		ST	4.032
3	131020-000	End clamp RapidPro 30-47mm	144		ST	7.920
4	131020-001	Middle clamp RapidPro 30-47mm	144		ST	7.488
		Total				45.936

Attention! If you want to order directly from Schletter Solar GmbH only complete packing units will be provided!

System configurator Status 5.170.8081.28370
Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (with special terrain formation), the consideration of higher wind loads is required.

Customer CCL Components Ltd
 Order 46055460
 Postal code construction site **M11 Manchester**
 53.4809 ° northern latitude
 2.2374 ° western longitude

Tilt angle	α	3.0	°
Module length	h	2.09	m
Height above sea level	H	61	m
Height above ground	z	5.00	m
Height of roof parapet	h_p	0.00	m

Structural system

Gable roof (double pitch roof)

Load assumptions acc. to BS EN 1991-1

Module weight	g	0.11	kN/m ²
Peak velocity pressure	$q(z)$	0.46	kN/m ²
Snow load	s	0.34	kN/m ²
Terrain category	III		

Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (villages, suburban terrain, permanent forest)

Terrain category III


Verification of the fastening system ClampFit Pro (130004-300)

Applicable for Gable roof (double pitch roof)

Tilt angle	α	3 °
Height above ground	z	5.00 m
Module length	h	2.09 m
Substructure grid size	a	0.80 m
Cantilever	l_{kr}	0.40 m

sin =	0.052	cos =	0.999
Module weight	g	0.11 kN/m ²	
Snow load	s	0.34 kN/m ²	
Peak velocity pressure	$q(z)$	0.46 kN/m ²	

Wind force coefficients			
c_{p1}	0.46	c_{p2} -0.33	H
		c_{p2} -0.45	G
		c_{p2} -0.63	F

Load chart per Square meter of roof area
Dead load Modules

$$\begin{aligned} g_v &= 0.11 \cdot 1.00 \cdot 1.000 = 0.11 \text{ kN/m}^2 \\ g_z &= 0.11 \cdot 0.999 = 0.11 \text{ kN/m}^2 \\ g_y &= 0.11 \cdot 0.052 = 0.01 \text{ kN/m}^2 \end{aligned}$$

Snow load

$$\begin{aligned} s_v &= 0.34 \cdot 1.00 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\ s_z &= 0.34 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\ s_y &= 0.34 \cdot 0.052 = 0.02 \text{ kN/m}^2 \end{aligned}$$

Wind pressure

$$\begin{aligned} \text{Zone H} \quad w_{dz} &= 0.46 \cdot 0.20 = 0.09 \text{ kN/m}^2 \\ \text{Zone G} \quad w_{dz} &= 0.46 \cdot 0.46 = 0.21 \text{ kN/m}^2 \\ \text{Zone F} \quad w_{dz} &= 0.46 \cdot 0.90 = 0.41 \text{ kN/m}^2 \end{aligned}$$

Wind suction

$$\begin{aligned} \text{Zone H} \quad w_{sz} &= 0.46 \cdot -0.33 = -0.15 \text{ kN/m}^2 \\ \text{Zone G} \quad w_{sz} &= 0.46 \cdot -0.45 = -0.21 \text{ kN/m}^2 \\ \text{Zone F} \quad w_{sz} &= 0.46 \cdot -0.63 = -0.29 \text{ kN/m}^2 \end{aligned}$$

Overview load per Square meter Roof area
Section forces factors for single, double or triple-span girders

Force factors				
n	A _{total}	A _{partial}	B _{total}	B _{partial}
1	0.500	0.500	0.000	0.000
2	0.375	0.438	1.250	1.250
3	0.400	0.450	1.100	1.200

Load combinations
Importance/reliability factor: $K_{FI} = 1.00$ (RC2)Load combination 1: $1.35 \cdot g + 1.5 \cdot s + 0.6 \cdot 1.5 \cdot w$ Load combination 2: $1.35 \cdot g + 0.5 \cdot 1.5 \cdot s + 1.5 \cdot w$ Load combination 3: $0.9 \cdot g + 1.5 \cdot w$

Load combination 1					Load combination 2				Load combination 3							
Vertical/portrait		Horizontal/landscape			Vertical/portrait		Horizontal/landscape		Vertical/portrait H		Vertical/portrait G		Vertical/portrait F		Horizontal/landscape	
n	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
1	0.78	0.78	0.04	0.04	0.57	0.57	0.02	0.02	-0.14	-0.14	-0.23	-0.23	-0.36	-0.36	0.01	0.01
2	0.78	1.55	0.04	0.07	0.57	1.13	0.02	0.04	-0.14	-0.28	-0.23	-0.45	-0.36	-0.71	0.01	0.01
3	0.78	1.55	0.04	0.07	0.57	1.13	0.02	0.04	-0.14	-0.28	-0.23	-0.45	-0.36	-0.71	0.01	0.01

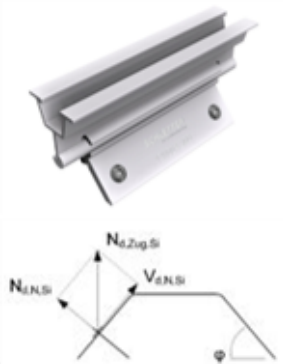
Resume of the relevant combinations (Single-span girder)

	LC1	LC2	LC3			
			H	G	F	
AV	0.78	0.57	-0.14	-0.23	-0.36	kN
AH	0.04	0.02	0.01	0.01	0.01	kN
BV	0.78	0.57	-0.14	-0.23	-0.36	kN
BH	0.04	0.02	0.01	0.01	0.01	kN

	Center	Border	Load distribution
Compressive force	$N_D = 0.78 \text{ kN}$	$N_D = 0.78 \text{ kN}$	$P = 0.78 \text{ kN}$
Perm. shear force	$N_H = 0.04 \text{ kN}$	$N_H = 0.04 \text{ kN}$	$H = 0.04 \text{ kN}$
Tensile force H	$N_Z = -0.14 \text{ kN}$	$N_Z = -0.14 \text{ kN}$	$P = 0.78 \text{ kN}$
Perm. shear force H	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.04 \text{ kN}$
Tensile force G	$N_Z = -0.23 \text{ kN}$	$N_Z = -0.23 \text{ kN}$	$P = 0.89 \text{ kN}$
Perm. shear force G	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.04 \text{ kN}$
Tensile force F	$N_Z = -0.36 \text{ kN}$	$N_Z = -0.36 \text{ kN}$	$P = 1.08 \text{ kN}$
Perm. shear force F	$N_H = 0.01 \text{ kN}$	$N_H = 0.01 \text{ kN}$	$H = 0.04 \text{ kN}$

Verification ClampFit Pro
according to German general technical approval Z 14.4-646

Type of fastening	ClampFit Pro					
Sheet material	Steel					
Sheet metal thickness	t	0.50	mm			
Crest distance	b	1,000	mm			
Crown/beading height	h	30	mm			
Corrugation top (crown)	b _o	50	mm	E	210,000	N/mm ²
Corrugation valley	b _u	900	mm	f _{yb}	280	N/mm ²
Web tilt	φ	50.2	°	r	2	Sheet metal
Rotation	β	0.0	°	γ _{M1}	1.10	Sheet metal
Fix length	S _s	33	mm	γ _{M1}	1.33	Screws/bolts



		LK1	LK2	LK3				Formula
				H	G	F		
Loads	N _{d,Pressure}	0.78	0.57	0.00	0.00	0.00	kN	
	N _{d,Traction}	0.00	0.00	0.14	0.23	0.36	kN	
	V _{d,II}	0.04	0.02	0.01	0.01	0.01	kN	
Geometry	h _b	40					mm	
	h _z	5					mm	
	b	71					mm	
	h	25					mm	0.5 · h _b + h _z
Moments	M _{D,II}	0.90	0.55	0.13	0.13	0.13	kNcm	V _{d,II} · h
Clamps	N _{R,k}	7.05					kN	Z-14.4-646 Chapter 3.2.3.2
	γ _M	1.20					kNcm	
	V _{R,k}	11.22					kN	
	γ _{M1}	1.20					kNcm	
Verification		0.00	0.00	0.02	0.04	0.06		N _{d,Traction} · γ _M / N _{R,k} + V _{d,II} · γ _M / V _{R,k} ≤ 1
Forces	N _{d,s}	0.00	0.00	0.04	0.07	0.11	kN	Z-14.4-646 Chapter 3.2.3.5
	V _{d,s}	0.02	0.01	0.05	0.09	0.14	kN	
	f _i	0.25					-	
Screws/bolts	N _{R,k}	0.41					kN	Z-14.1-537
	V _{R,k}	0.77					kN	
Verification		0.05	0.03	0.24	0.39	0.61	-	N _{d,s} · γ _M / N _{R,k} + V _{d,s} · γ _M / V _{R,k} ≤ 1
Trapezoidal sheet metal	R _{w,Rd,zen}	0.93					kN	α = 0.150 l _a = 10 mm
	R _{w,Rd,lin}	0.32					kN	α = 0.150 l _a = S _s
Verification		0.48	0.35	0.00	0.00	0.00	-	Z-14.4-646 Chapter 3.2.3.4

Verification of connections

Tilt angle	α	3	°	$\sin = 0.052$	$\cos = 0.999$	
Snow load	s	0.34	kN/m ²	Peak velocity pressure 0.46 kN/m ²		
Height above ground	z	5.00	m	Zone F	$c_{p,1} = -0.63$	Pressure coefficients $c_{pe,1}$
Module length	h	2.09		Zone G	$c_{p,1} = -0.45$	
Module weight	g	0.11	kN/m ²	Zone H	$c_{p,1} = -0.33$	

Load overview

Dead load Modules

$$\begin{aligned}
 g_v &= 0.11 \cdot 1.00 \cdot 1.000 = 0.11 \text{ kN/m}^2 \\
 g_z &= 0.11 \cdot 0.999 = 0.11 \text{ kN/m}^2 \\
 g_y &= 0.11 \cdot 0.052 = 0.01 \text{ kN/m}^2
 \end{aligned}$$

Snow load

$$\begin{aligned}
 s_v &= 0.34 \cdot 1.00 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_z &= 0.34 \cdot 0.999 = 0.34 \text{ kN/m}^2 \\
 s_y &= 0.34 \cdot 0.052 = 0.02 \text{ kN/m}^2
 \end{aligned}$$

Wind suction

$$\begin{aligned}
 w_{dz} &= 0.46 \cdot 0.20 = 0.09 \text{ kN/m}^2 \\
 w_{sz} &= 0.46 \cdot c_{p,1}
 \end{aligned}$$

Module clamps according to general technical approval Z-14.4-631

Middle clamps		End clamps	
$F_{R,d}$ kN	$V_{R,d}$ kN	$F_{R,d}$ kN	$V_{R,d}$ kN
5.16	1.28	2.27	1.67

Module surface

$$A = 2.17 \text{ m}^2$$

Frictional connection

$$A = 0.22 \text{ kN } (F_{S,d} \cdot \mu)$$

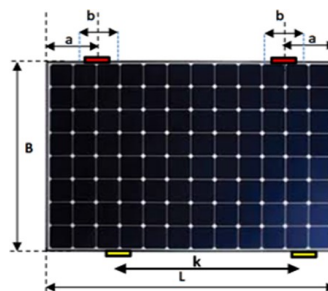
Internal forces at module clamps

$$\text{Middle clamp } |F_{S,d}| = 0.97 \cdot (0.9 \cdot g_v + 1.5 \cdot 0.46 \cdot c_p) \cdot 2.17$$

$$\text{End clamp } |F_{S,d}| = 0.48 \cdot (0.9 \cdot g_v + 1.5 \cdot 0.46 \cdot c_p) \cdot 2.17$$

$$f = \frac{(0.5 \cdot L - x_1) / k}{k} = 0.97$$

$$\begin{aligned}
 L &= 2,094 \text{ mm} \\
 x_1 &= 79 \text{ mm} \\
 x_2 &= 1,015 \text{ mm} \\
 k &= 1,000 \text{ mm}
 \end{aligned}$$



	$V_{S,d}$ kN	$F_{S,d}$ kN		
		Zone F	Zone G	Zone H
Middle clamps	-0.18	0.61	0.35	0.18
End clamps	-0.09	0.31	0.17	0.09

$$V_{S,d} = V_{S,dy} - F_{S,dz} \cdot \mu \quad (\mu = 0.50)$$

Utilization ratio 3.4%

Utilization ratio 3.9%