| Connecting Strength

K2 Base Report

Collins shed 5

Project address	Industrial Estate, Unit 1 Coldingham Rd, Eyemouth TD14 5AN, UK
Company	Maden Eco
Author	Conor Maden
Issue date & version	30/11/2023 | K2 Base Version 3.1.107.0

About us

K2 Systems. Innovative mounting system from a strong team.

Since 2004 we have been developing pioneering and highly functional mounting system solutions for photovoltaic installations around the world. Our systems are designed in our own product development department where we continually optimize and adapt mounting systems to the ever-changing market.

A knowledgeable and friendly team

Just like a mountain climbing team, K2 Systems is built on mutual trust. This applies to our customer service as well as within the company itself, because we believe a trusting partnership leads to successful photovoltaic projects.

Our employees place total focus on the needs and wishes of our customer. This is true in all company departments.

10 locations and worldwide sales network

In our international team, everyone works together to provide customers with competent, comprehensive and entirely personalized service.

This is especially true in the constant training our employees undergo with regards to product optimization, quality assurance, or innovations in construction techniques.

Quality management and certificates

K2 Systems stands for Connecting Strength, the highest quality, and precision-crafted and customized components. Our customers and business partners deeply appreciate all of these factors. Three independent authorities have tested, confirmed, and certified our skills and components. External authorities are not the only ones to have put K2 Systems to the test. Our internal quality control ensures that all our products are subject to a constant review process.

These measures all ensure the outstanding quality standards that exemplify products from K2 Systems, and which we maintain through largely exclusive "Made in Germany" or "Made in Europe" practices.

Product guarantee

K2 Systems offers a 12-year product warranty on all products in its integrated range. The use of high quality materials and a three-level quality inspection ensure these standards.

In a nutshell

As roof-top specialists, we offer effective and economical solutions for roofs all around the world and provide professional, fast and reliable support for our customers in the solar industry.

Contents

Project overview

Project information

Name	**Collins shed 5**
Address	**Industrial Estate, Unit 1 Coldingham Rd, Eyemouth TD14 5AN, UK**
Ground elevation	**37.25 m**
Author	**Conor Maden**

Load settings

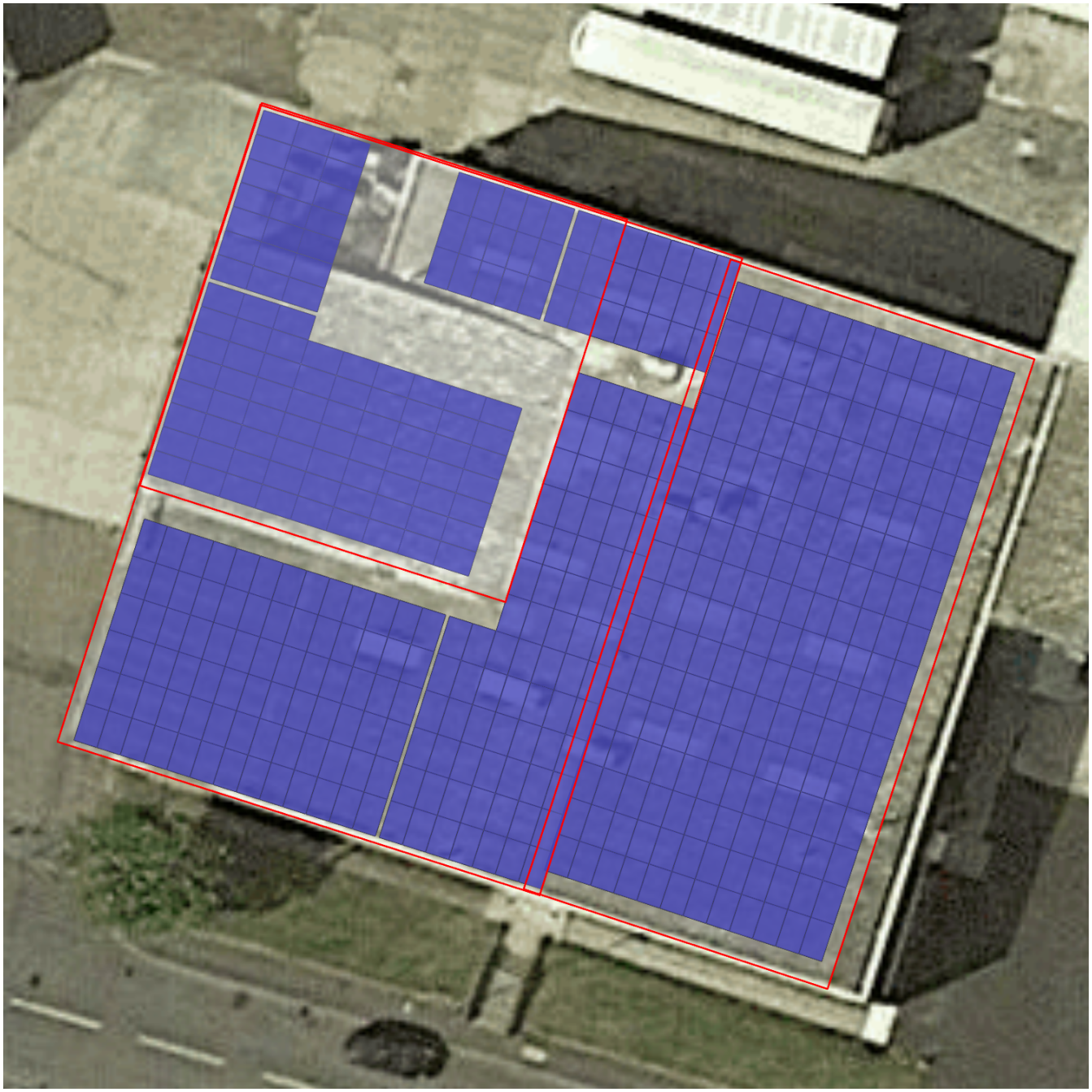
Design method	**BS EN**
Failure consequence class (CC)	**CC1**
Design working life	**25 years**
Terrain category	**Sea**
Environment	**Normal area**
Basic wind speed	**24.5 m/s**
Snow load zone	**3**
Snow load on ground level	**0.50 kN/m²**

Roofs

Roof	System	Module	Power	Quantity	Total power
Roof 1 	SolidRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	192	84.48 kWp
Roof 2 	SolidRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	191	84.04 kWp
Roof 3 	K2 BasicRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	87	38.28 kWp
Total				**470**	**206.80 kWp**

THE PROJECT CONTAINS ERROR(S)
Refer to the notes for more information.

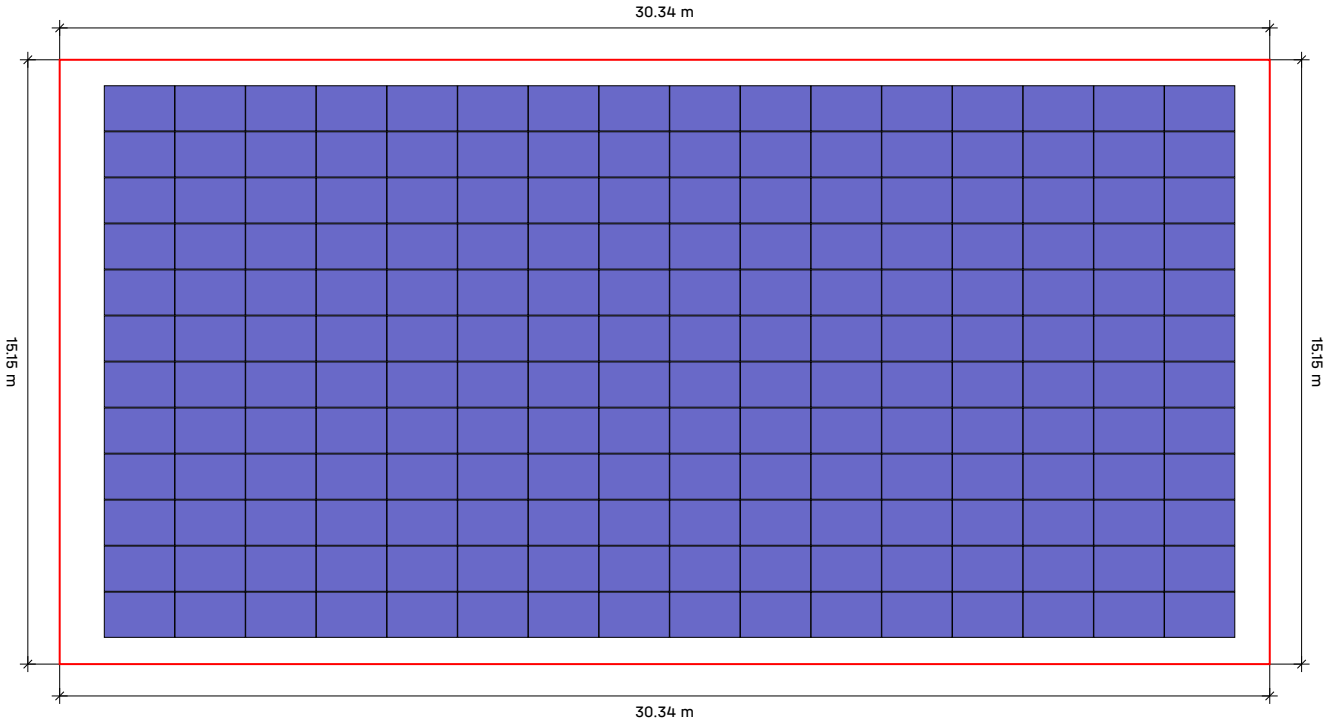
Roofs



Project information

Name	**Collins shed 5**
Address	**Industrial Estate, Unit 1 Coldingham Rd, Eyemouth TD14 5AN, UK**
Ground elevation	**37.25 m**
Author	**Conor Maden**

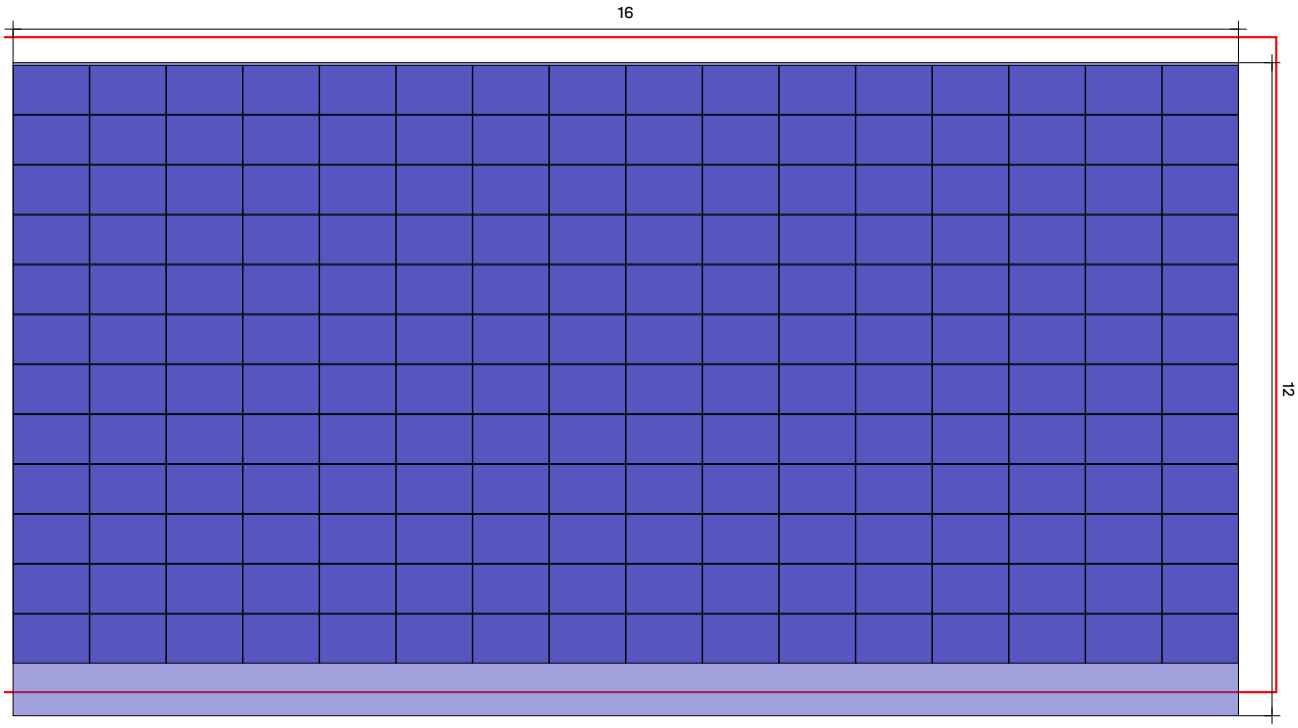
Roofs | Roof 1



Roof	System	Module	Power	Quantity	Total power
Roof 1	SolidRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	192	84.48 kWp

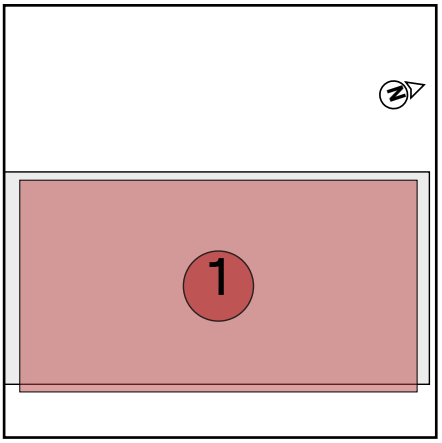
Roofs | Roof 1

Roofs | Roof 1 | Module array 1

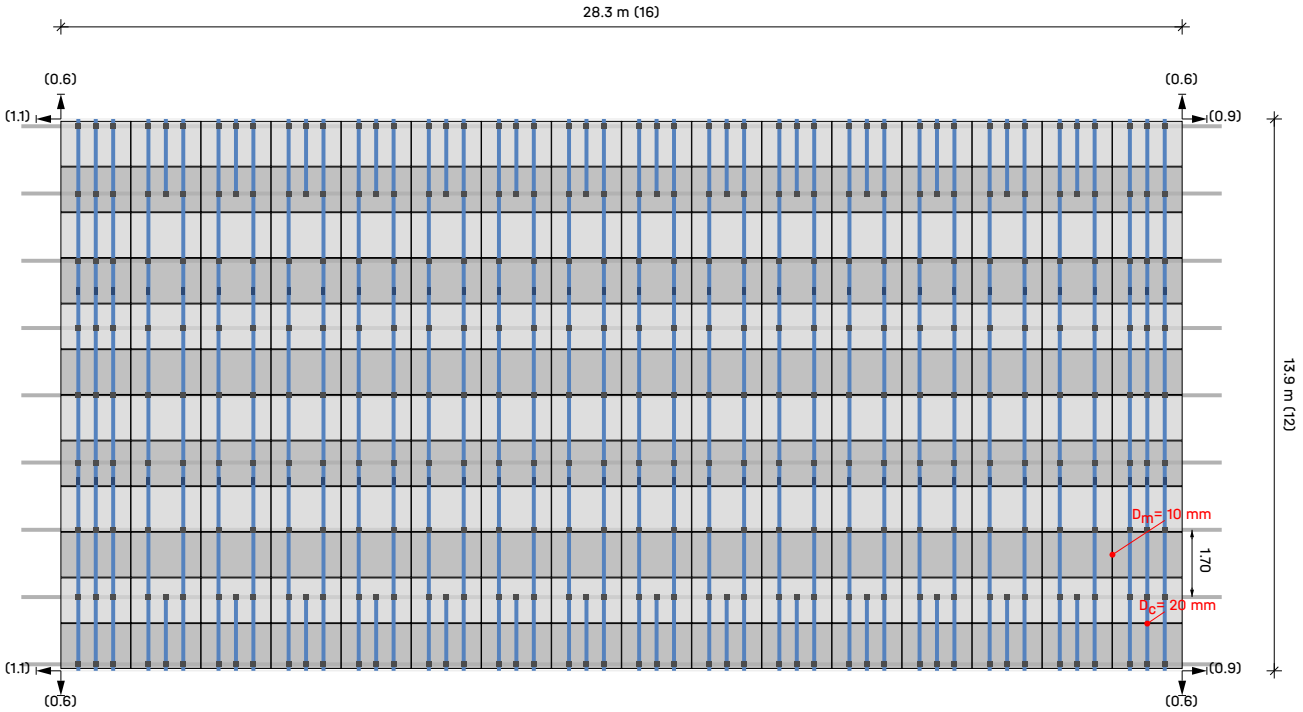


Roof (1) Module array 1

Mounting System	SolidRail
Module	192(84.48 kWp) x TSM-440NEG9R.28 (Vertex S+)
Row spacing	1.77 m



Roofs | Roof 1 | Module array 1 | Module blocks

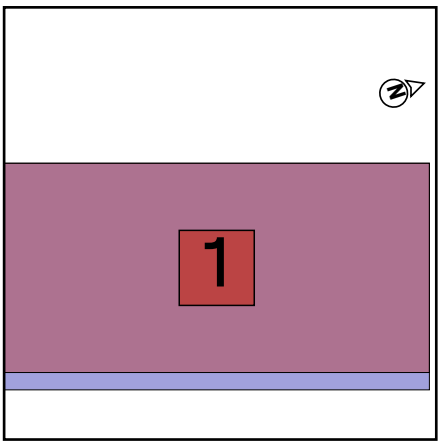


Roof (1) Module array 1 Module block 1

Modules 16 × 12 = **192**

Legend

- Fastener
- Distance to Roof Edge [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



Results | Roof 1

Roof	System	Module	Power	Quantity	Total power
Roof 1 	SolidRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	192	84.48 kWp

Module

Name	TSM-440NEG9R.28 (Vertex S+)
Manufacturer	Trina Solar Energy
Output power	440 Wp
Dimensions	1,762×1,134×30 mm
Weight	21.1 kg

Components

Fastener	Solarfastener 8×85/50 - FZD
Base rails	K2 SolidRail Light 37
Screw-In Depth	-3.00 mm
L2 (Height Adapter plate)	31.00 mm
Type Rail Adaptor	Adaptor Plate
Direction adapter plate	up

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	2.00	742.7	156.9	-668.0	31.6	588.1	124.5	-498.5	31.6
ridge	2.00	742.7	156.9	-1,585.1	31.6	588.1	124.5	-1,217.7	31.6
gableboard	2.00	742.7	156.9	-1,847.1	31.6	588.1	124.5	-1,423.2	31.6
corner region (eave)	2.00	742.7	156.9	-1,978.1	31.6	588.1	124.5	-1,526.0	31.6
eaves	2.00	742.7	156.9	-930.0	31.6	588.1	124.5	-704.0	31.6

Results | Roof 1

Utilisation result

No. Module Array	roof areas	ultimate limit state Pr σ[%]	CL σ[%]	Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	BR [m]	maximum values CL L_{max}[m]	Fst Fst D_{max}[m]
1	field area	46.6	0.0	81.7	64.3	1.700	---	0.531	1.899
1	ridge	74.1	4.3	138.3	99.8	1.700	---	0.468	1.229
1	gableboard	86.3	5.1	160.4	116.7	1.700	---	0.448	1.060
1	corner region (eave)	92.4	4.3	171.4	125.1	1.700	---	0.439	0.992
1	eaves	43.5	2.0	83.3	57.7	1.700	---	0.548	1.950

Pr	**Profile**	Fst D_{max}	**maximum fastener spacing**
Fst	**Fastener**	BR	**Base Rail**
σ	**Stress**	Usab.	**serviceability limit state**
f	**Deflection**	CL	**Cantilever**
F	**Force**		
CL/L_{max}	**maximum cantilever length**		

Results | Roof 1

Notes

- The structural design complies with BS EN 1990 - Basis of Structural Design.
- Snow loads are determined in accordance with National Annex BS NA EN 1991-1-3 (2018) - UK National Annex to EC1 - Action on structures - general actions - snow loads.
- Wind loads are determined in accordance with National Annex BS NA EN 1991-1-4 - UK National Annex to EC1 - Action on structures, general actions - wind actions.
- Service life is recognised according to 'Eurocode EN 1991 – Action on structures, Snow loads' and 'Eurocode EN 1991 – Actions on structures, Wind actions'. Subject to the Building Regulations and for security-relevant reasons the installation has to be dismantled at the end of its service life.
- Failure consequence class is considered according to 'Eurocode EN 1990 – Basis of structural design'.
- Data and results must be verified with regard to local conditions and checked by a suitably qualified person. Please see our TCU under https://k2-systems.com/en/base-tcu , in particular § 2 (''technical and specialist requirements for the customer''), § 7 (''warranty provisions'') and § 8 (''limitation of liability'').
- One or more components are overloaded. Please check and adjust the system utilisation and your input parameters.

Structural analysis report | Roof 1

General information

Name	Collins shed 5
Mounting System	SolidRail
Author	Conor Maden

Location information

Address	Industrial Estate, Unit 1 Coldingham Rd, Eyemouth TD14 5AN, UK
Ground elevation	37.25 m

Roof information

Building height	10.00 m
Roof type	Gable roof
Roof pitch	15°
Fastening method	Roof construction
Roof covering	Corrugated
Min. roof edge distance	0.00 m
Wave distance	150.0 mm
Wave height	51.0 mm
Purlin Distance	1.70 m
Purlin Material	Steel
Purlin Width	80.00 mm
set eaves purlin	No
Distance to the eaves	775.0 mm
set ridge purlin	No
Distance to the ridge	775.0 mm

Loads

Design method	BS EN
Failure consequence class (CC)	CC1
Design working life	25 years
Terrain category	Sea

Wind load

Velocity pressure	$q_{p,50}$ = 1.116 kN/m²
Adjustment factor for service life	f_w = 0.921
Velocity pressure	$q_{p,25}$ = 1.028 kN/m²

Roof areas

Structural analysis report | Roof 1

Array	load impact area [m²]	maxCpe_{10}	minCpe_{10}	wind pressure [kN/m²]	wind suction [kN/m²]
field area	10.00	0.200	-0.600	0.206	-0.617
ridge	10.00	0.200	-1.300	0.206	-1.336
gableboard	10.00	0.200	-1.500	0.206	-1.541
corner region (eave)	10.00	0.200	-1.600	0.206	-1.644
eaves	10.00	0.200	-0.800	0.206	-0.822

Snow load

Snow load zone		3
Environment		Normal terrain
Snow guard		No
Snow load on ground level	s_k	= 0.500 kN/m²
Shape Coefficient for Snow	μ_i	= 0.800
Factor for roof pitch	d_i	= 0.966
Snow load on roof	$s_{i,50}$	= 0.386 kN/m²
Adjustment factor for service life	f_s	= 0.929
Snow load on roof	$s_{i,25}$	= 0.359 kN/m²

Dead Load

Weight of module	G_M	= 21.1 kg
Weight of mounting system per module		= 3.8 kg
Module area	A_M	= 2.00 m²
Dead weight of module per m²		= 10.56 kg/m²
Dead weight of mounting system per m²		= 1.90 kg/m²
Total Dead Load (excl. ballast) per m²		= 0.12 kN/m²

Structural analysis report | Roof 1

Load Combinations

Ultimate limit state

Partial safety factor unfavourable permanent load	$\gamma_{G,sup}$ = 1.35
Partial safety factor favourable permanent load	$\gamma_{G,inf}$ = 1.00
Partial safety factor destabilising permanent load	$\gamma_{G,dst}$ = 1.10
Partial safety factor stabilising permanent load	$\gamma_{G,stb}$ = 0.90
Partial safety factor first variable load	γ_{Q} = 1.50
Partial safety factor variable loads	γ_{Q} = 1.50
Combination coefficient with regards to wind	$\psi_{0,W}$ = 0.60
Combination coefficient with regards to wind (additional varying influences)	$\psi_{1,W}$ = 0.20
Combination coefficient with regards to Snow	$\psi_{0,S}$ = 0.50
Importance factor permanent	$\kappa_{Fl,G}$ = 0.90
Importance factor variable	$\kappa_{Fl,Q}$ = 0.85
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

Load case combination 01	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * S_{i,n}$
Load case combination 02	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Pressure}$
Load case combination 03	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * (W_{k,Pressure} + \psi_{0,S} * S_{i,n})$
Load case combination 04	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * (S_{i,n} + \psi_{0,W} * W_{k,Pressure})$
Load case combination 06	$E_d = \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Uplift}$

Serviceability limit state

Combination coefficient with regards to wind	$\psi_{0,W}$ = 0.60
Combination coefficient with regards to Snow	$\psi_{0,S}$ = 0.50

Load case combination 01	$E_d = G_k + S_{i,n}$
Load case combination 02	$E_d = G_k + W_{k,Pressure}$
Load case combination 03	$E_d = G_k + W_{k,Pressure} + \psi_{0,S} * S_{i,n}$
Load case combination 04	$E_d = G_k + S_{i,n} + \psi_{0,W} * W_{k,Pressure}$
Load case combination 06	$E_d = G_k + W_{k,Uplift}$

Structural analysis report | Roof 1

Maximum load on modules (Mounting system dimensioning)

Array	A-TrA [m²]	ultimate state [kN/m²]				Serviceability [kN/m²]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	10.00	0.743	0.157	-0.668	0.032	0.588	0.125	-0.498	0.032
ridge	10.00	0.743	0.157	-1.585	0.032	0.588	0.125	-1.218	0.032
gableboard	10.00	0.743	0.157	-1.847	0.032	0.588	0.125	-1.423	0.032
corner region (eave)	10.00	0.743	0.157	-1.978	0.032	0.588	0.125	-1.526	0.032
eaves	10.00	0.743	0.157	-0.930	0.032	0.588	0.125	-0.704	0.032

Max. load on fastener

Array	A-TrA [m²]	ultimate state [kN]				Serviceability [kN]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	10.00	1.224	0.258	-1.101	0.052	0.969	0.205	-0.821	0.052
ridge	10.00	0.918	0.194	-1.959	0.039	0.727	0.154	-1.505	0.039
gableboard	10.00	0.918	0.194	-2.282	0.039	0.727	0.154	-1.759	0.039
corner region (eave)	10.00	0.918	0.194	-2.444	0.039	0.727	0.154	-1.886	0.039
eaves	10.00	0.918	0.194	-1.149	0.039	0.727	0.154	-0.870	0.039

Resistance Values of Components

Base Rails

Base Rails	A [cm²]	I_y [cm^4]	I_z [cm^4]	W_y [cm³]	W_z [cm³]
K2 SolidRail Light 37	3.150	4.36	6.98	2.25	3.54

Fastener

Fastener	$R_{D,Uplift,Perpendicular}$ [kN]	$R_{D,Pressure,Perpendicular}$ [kN]	$R_{D,Pressure,Parallel}$ [kN]
Solarfastener 8×85/50 - FZD	1.79	1.79	0.31

Structural analysis report | Roof 1

Utilisation result

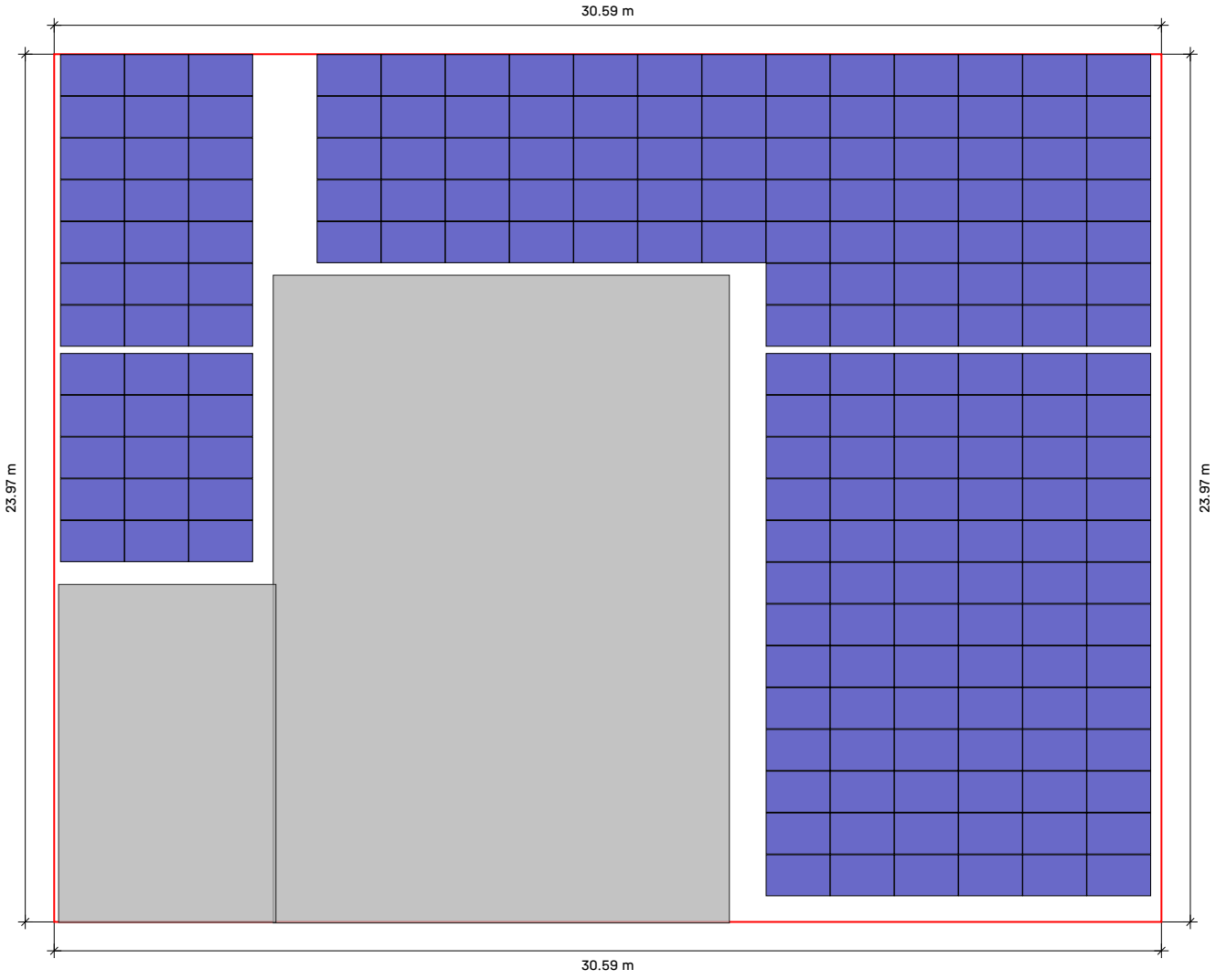
No. Module Array	roof areas	ultimate limit state Pr σ[%]	CL σ[%]	Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	BR [m]	maximum values CL L_{max}[m]	Fst Fst D_{max}[m]
1	field area	46.6	0.0	81.7	64.3	1.700	---	0.531	1.899
1	ridge	74.1	4.3	138.3	99.8	1.700	---	0.468	1.229
1	gableboard	86.3	5.1	160.4	116.7	1.700	---	0.448	1.060
1	corner region (eave)	92.4	4.3	171.4	125.1	1.700	---	0.439	0.992
1	eaves	43.5	2.0	83.3	57.7	1.700	---	0.548	1.950

Pr	**Profile**	Fst D_{max}	**maximum fastener spacing**
Fst	**Fastener**	BR	**Base Rail**
σ	**Stress**	Usab.	**serviceability limit state**
f	**Deflection**	CL	**Cantilever**
F	**Force**		
CL/L_{max}	**maximum cantilever length**		

Roofs | Roof 1 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003013	Solarfastener 8×85/50 - FZD	362	34.0 kg
2	1000041	T-Bolt 28/15 M10×30	362	8.5 kg
3	1000042	Hexagon flange nut M10	362	4.0 kg
4	2002544	Adapterplate M10	362	16.3 kg
5	2002589	OneEnd Black Set 30-42	96	8.4 kg
6	2003072	OneMid Black Set 30-42	402	31.8 kg
7	1004765	SolidRail Light End Cap	124	0.7 kg
8	2002870	K2 Solar Cable Manager	192	0.5 kg
9	2004395	SolidRail Light; 4.80 m	116	475.5 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	68	15.3 kg
Total				**594.9 kg**

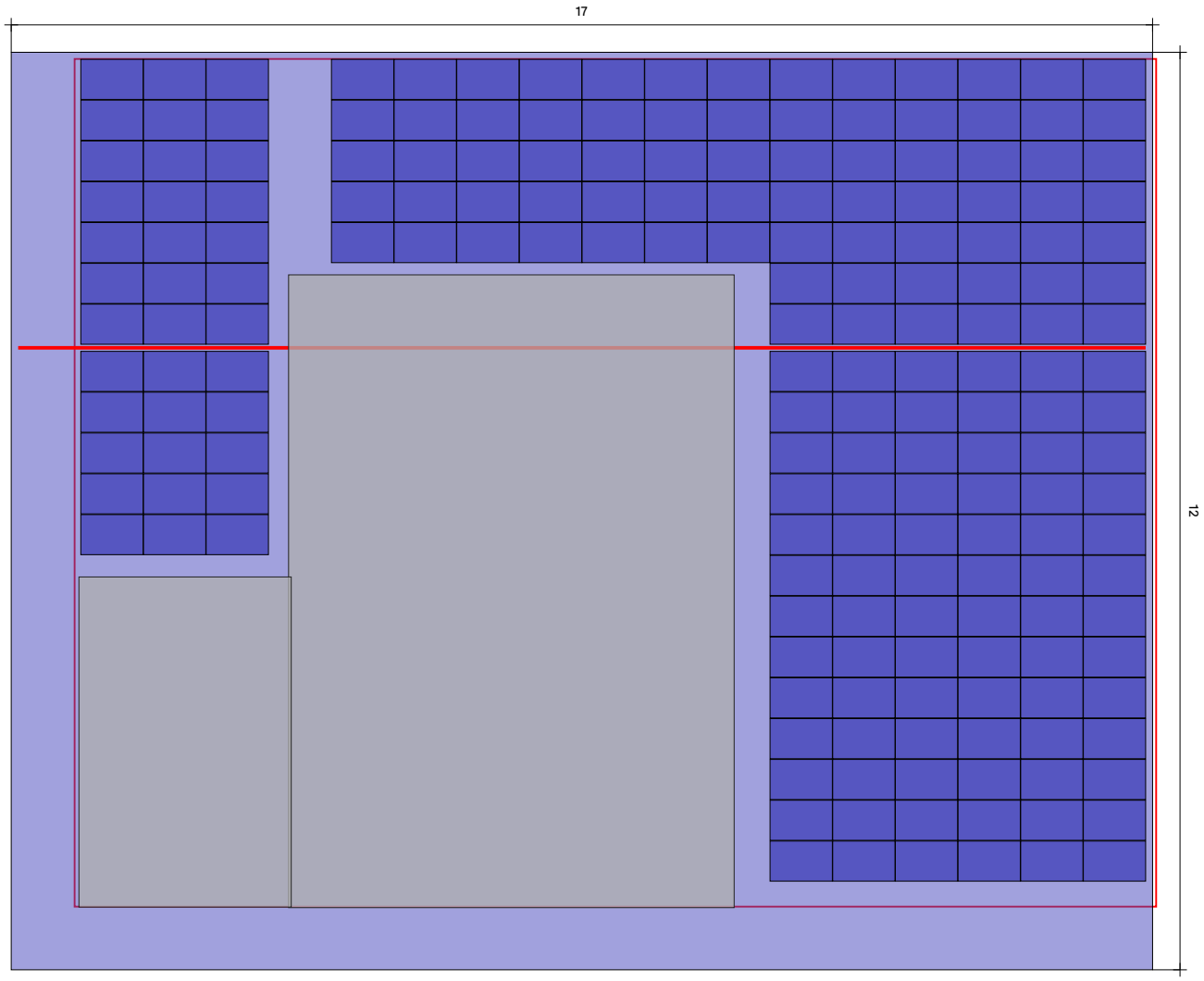
Roofs | Roof 2



Roof	System	Module	Power	Quantity	Total power
Roof 2	SolidRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	191	84.04 kWp

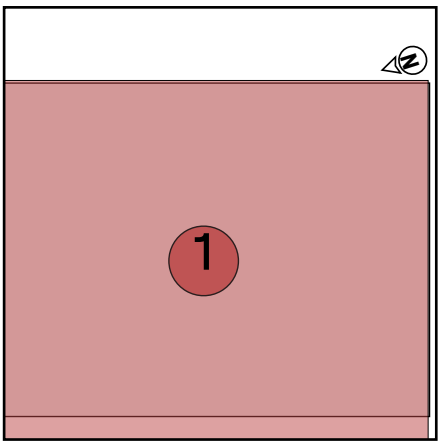
Roofs | Roof 2

Roofs | Roof 2 | Module array 1

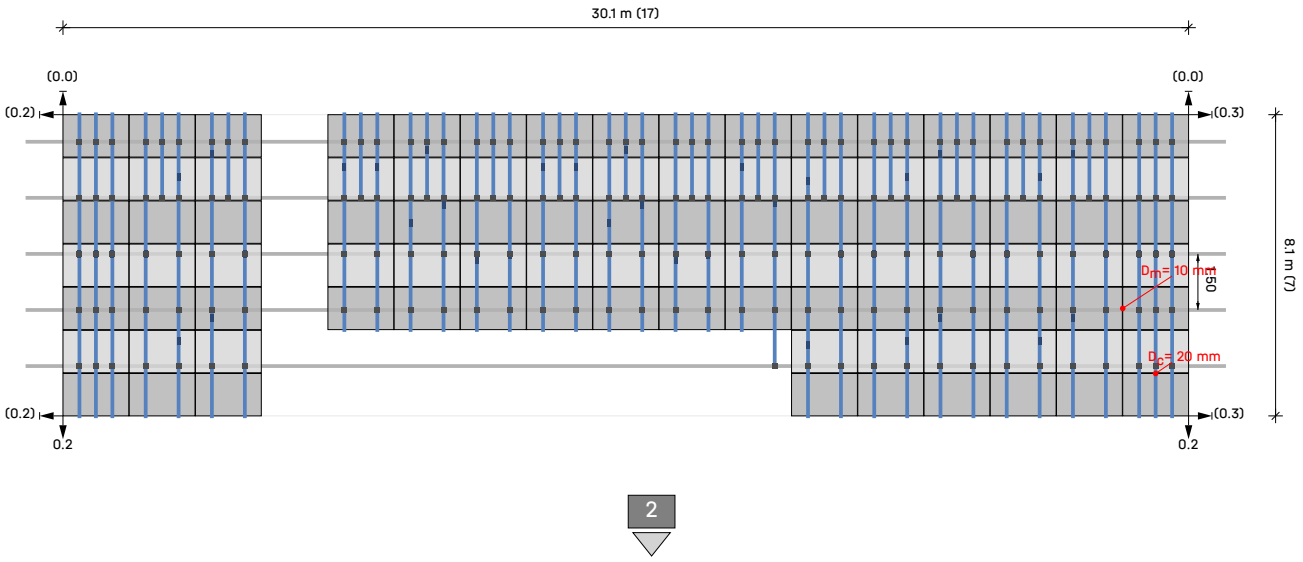


Roof (2) Module array (1)

Mounting System	SolidRail
Module	191(84.04 kWp) x TSM-440NEG9R.28 (Vertex S+)
Row spacing	1.77 m



Roofs | Roof 2 | Module array 1 | Module blocks

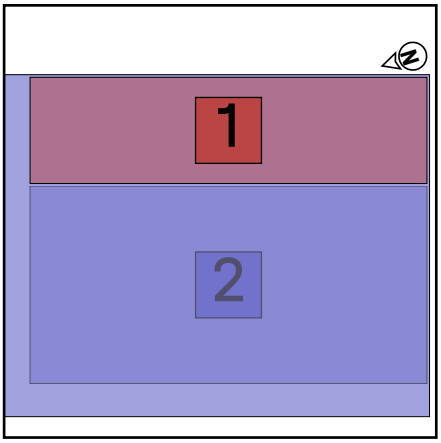


Roof (2) Module array (1) Module block 1

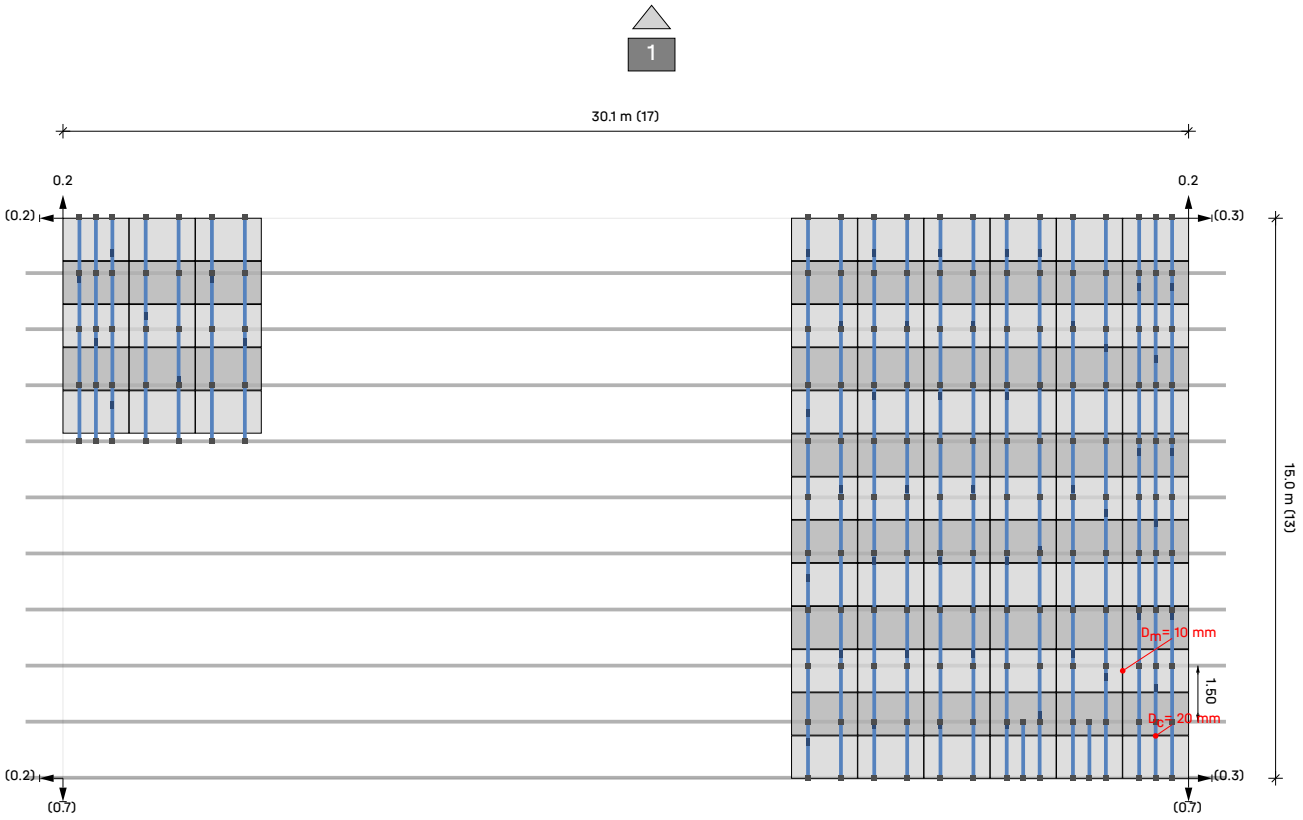
Modules (17 × 7) - 21 = **98**

Legend

- 1 Next block indicator
- Fastener
- Distance to Roof Edge [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



Roofs | Roof 2 | Module array 1 | Module blocks

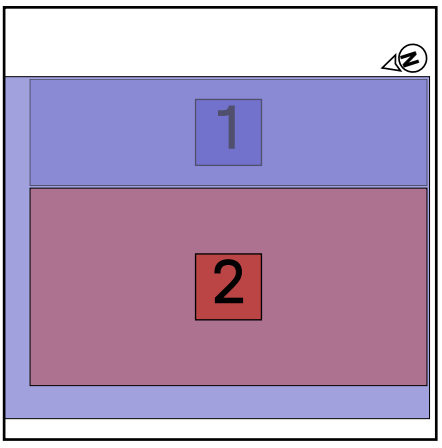


Roof (2) Module array (1) Module block 2

Modules (17 × 13) - 128 = **93**

Legend

- 1 Next block indicator
- Fastener
- Distance to Roof Edge [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



Results | Roof 2

Roof	System	Module	Power	Quantity	Total power
Roof 2 	SolidRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	191	84.04 kWp

Module

Name	TSM-440NEG9R.28 (Vertex S+)
Manufacturer	Trina Solar Energy
Output power	440 Wp
Dimensions	1,762×1,134×30 mm
Weight	21.1 kg

Components

Fastener	Solarfastener 8×85/70 - FZD
Base rails	K2 SolidRail Light 37
Screw-In Depth	-3.00 mm
L2 (Height Adapter plate)	31.00 mm
Type Rail Adaptor	Adaptor Plate
Direction adapter plate	up

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	2.00	742.7	156.9	-668.0	31.6	588.1	124.5	-498.5	31.6
ridge	2.00	742.7	156.9	-1,585.1	31.6	588.1	124.5	-1,217.7	31.6
gableboard	2.00	742.7	156.9	-1,847.1	31.6	588.1	124.5	-1,423.2	31.6
corner region (eave)	2.00	742.7	156.9	-1,978.1	31.6	588.1	124.5	-1,526.0	31.6
eaves	2.00	742.7	156.9	-930.0	31.6	588.1	124.5	-704.0	31.6

Results | Roof 2

Utilisation result

No. Module Array	roof areas	ultimate limit state Pr σ[%]	ultimate limit state CL σ[%]	ultimate limit state Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	Distances BR [m]	maximum values CL L_{max}[m]	maximum values Fst Fst D_{max}[m]
1	field area	36.3	155.6	72.1	39.0	1.500	---	0.546	1.899
1	ridge	57.7	78.8	122.1	60.5	1.500	---	0.482	1.229
1	gableboard	67.2	289.6	141.5	70.7	1.500	---	0.461	1.060
1	corner region (eave)	71.9	0.9	151.2	75.8	1.500	---	0.452	0.992
1	eaves	33.9	0.5	98.0	35.0	1.500	---	0.563	1.531

Pr	**Profile**	Fst D_{max}	**maximum fastener spacing**
Fst	**Fastener**	BR	**Base Rail**
σ	**Stress**	Usab.	**serviceability limit state**
f	**Deflection**	CL	**Cantilever**
F	**Force**		
CL/L_{max}	**maximum cantilever length**		

Results | Roof 2

Notes

- The structural design complies with BS EN 1990 - Basis of Structural Design.
- Snow loads are determined in accordance with National Annex BS NA EN 1991-1-3 (2018) - UK National Annex to EC1 - Action on structures - general actions - snow loads.
- Wind loads are determined in accordance with National Annex BS NA EN 1991-1-4 - UK National Annex to EC1 - Action on structures, general actions - wind actions.
- Service life is recognised according to 'Eurocode EN 1991 – Action on structures, Snow loads' and 'Eurocode EN 1991 – Actions on structures, Wind actions'. Subject to the Building Regulations and for security-relevant reasons the installation has to be dismantled at the end of its service life.
- Failure consequence class is considered according to 'Eurocode EN 1990 – Basis of structural design'.
- Data and results must be verified with regard to local conditions and checked by a suitably qualified person. Please see our TCU under https://k2-systems.com/en/base-tcu , in particular § 2 (''technical and specialist requirements for the customer''), § 7 (''warranty provisions'') and § 8 (''limitation of liability'').
- One or more components are overloaded. Please check and adjust the system utilisation and your input parameters.

Structural analysis report | Roof 2

General information

Name	Collins shed 5
Mounting System	SolidRail
Author	Conor Maden

Location information

Address	Industrial Estate, Unit 1 Coldingham Rd, Eyemouth TD14 5AN, UK
Ground elevation	37.25 m

Roof information

Building height	10.00 m
Roof type	Gable roof
Roof pitch	15°
Fastening method	Roof construction
Roof covering	Corrugated
Min. roof edge distance	0.00 m
Wave distance	150.0 mm
Wave height	51.0 mm
Purlin Distance	1.50 m
Purlin Material	Steel
Purlin Width	80.00 mm
Purlin Height	215.00 mm
set eaves purlin	No
Distance to the eaves	735.0 mm
set ridge purlin	No
Distance to the ridge	735.0 mm

Loads

Design method	BS EN
Failure consequence class (CC)	CC1
Design working life	25 years
Terrain category	Sea

Wind load

Velocity pressure	$q_{p,50}$ = 1.116 kN/m²
Adjustment factor for service life	f_w = 0.921
Velocity pressure	$q_{p,25}$ = 1.028 kN/m²

Structural analysis report | Roof 2

Roof areas

Array	load impact area [m²]	maxCpe$_{10}$	minCpe$_{10}$	wind pressure [kN/m²]	wind suction [kN/m²]
field area	10.00	0.200	-0.600	0.206	-0.617
ridge	10.00	0.200	-1.300	0.206	-1.336
gableboard	10.00	0.200	-1.500	0.206	-1.541
corner region (eave)	10.00	0.200	-1.600	0.206	-1.644
eaves	10.00	0.200	-0.800	0.206	-0.822

Snow load

Snow load zone	3	
Environment	Normal terrain	
Snow guard	No	
Snow load on ground level	s_k	= 0.500 kN/m²
Shape Coefficient for Snow	μ_i	= 0.800
Factor for roof pitch	d_i	= 0.966
Snow load on roof	$s_{i,50}$	= 0.386 kN/m²
Adjustment factor for service life	f_s	= 0.929
Snow load on roof	$s_{i,25}$	= 0.359 kN/m²

Dead Load

Weight of module	G_M	= 21.1 kg
Weight of mounting system per module		= 3.8 kg
Module area	A_M	= 2.00 m²
Dead weight of module per m²		= 10.56 kg/m²
Dead weight of mounting system per m²		= 1.90 kg/m²
Total Dead Load (excl. ballast) per m²		= 0.12 kN/m²

Structural analysis report | Roof 2

Load Combinations

Ultimate limit state

Partial safety factor unfavourable permanent load	$\gamma_{G,sup}$ = 1.35
Partial safety factor favourable permanent load	$\gamma_{G,inf}$ = 1.00
Partial safety factor destabilising permanent load	$\gamma_{G,dst}$ = 1.10
Partial safety factor stabilising permanent load	$\gamma_{G,stb}$ = 0.90
Partial safety factor first variable load	γ_{Q} = 1.50
Partial safety factor variable loads	γ_{Q} = 1.50
Combination coefficient with regards to wind	$\psi_{0,W}$ = 0.60
Combination coefficient with regards to wind (additional varying influences)	$\psi_{1,W}$ = 0.20
Combination coefficient with regards to Snow	$\psi_{0,S}$ = 0.50
Importance factor permanent	$\kappa_{Fl,G}$ = 0.90
Importance factor variable	$\kappa_{Fl,Q}$ = 0.85
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

Load case combination 01	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * S_{i,n}$
Load case combination 02	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Pressure}$
Load case combination 03	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * (W_{k,Pressure} + \psi_{0,S} * S_{i,n})$
Load case combination 04	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * (S_{i,n} + \psi_{0,W} * W_{k,Pressure})$
Load case combination 06	$E_d = \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Uplift}$

Serviceability limit state

Combination coefficient with regards to wind	$\psi_{0,W}$ = 0.60
Combination coefficient with regards to Snow	$\psi_{0,S}$ = 0.50

Load case combination 01	$E_d = G_k + S_{i,n}$
Load case combination 02	$E_d = G_k + W_{k,Pressure}$
Load case combination 03	$E_d = G_k + W_{k,Pressure} + \psi_{0,S} * S_{i,n}$
Load case combination 04	$E_d = G_k + S_{i,n} + \psi_{0,W} * W_{k,Pressure}$
Load case combination 06	$E_d = G_k + W_{k,Uplift}$

Structural analysis report | Roof 2

Maximum load on modules (Mounting system dimensioning)

Array	A-TrA [m²]	ultimate state [kN/m²]				Serviceability [kN/m²]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	10.00	0.743	0.157	-0.668	0.032	0.588	0.125	-0.498	0.032
ridge	10.00	0.743	0.157	-1.585	0.032	0.588	0.125	-1.218	0.032
gableboard	10.00	0.743	0.157	-1.847	0.032	0.588	0.125	-1.423	0.032
corner region (eave)	10.00	0.743	0.157	-1.978	0.032	0.588	0.125	-1.526	0.032
eaves	10.00	0.743	0.157	-0.930	0.032	0.588	0.125	-0.704	0.032

Max. load on fastener

Array	A-TrA [m²]	ultimate state [kN]				Serviceability [kN]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	10.00	1.080	0.228	-0.971	0.046	0.855	0.181	-0.725	0.046
ridge	10.00	0.810	0.171	-1.728	0.034	0.641	0.136	-1.328	0.034
gableboard	10.00	0.810	0.171	-2.014	0.034	0.641	0.136	-1.552	0.034
corner region (eave)	10.00	0.810	0.171	-2.157	0.034	0.641	0.136	-1.664	0.034
eaves	10.00	1.080	0.228	-1.352	0.046	0.855	0.181	-1.023	0.046

Resistance Values of Components

Base Rails

Base Rails	A [cm²]	I_y [cm^4]	I_z [cm^4]	W_y [cm³]	W_z [cm³]
K2 SolidRail Light 37	3.150	4.36	6.98	2.25	3.54

Fastener

Fastener	$R_{D,Uplift,Perpendicular}$ [kN]	$R_{D,Pressure,Perpendicular}$ [kN]	$R_{D,Pressure,Parallel}$ [kN]
Solarfastener 8×85/70 - FZD	2.56	2.56	0.31

Structural analysis report | Roof 2

Utilisation result

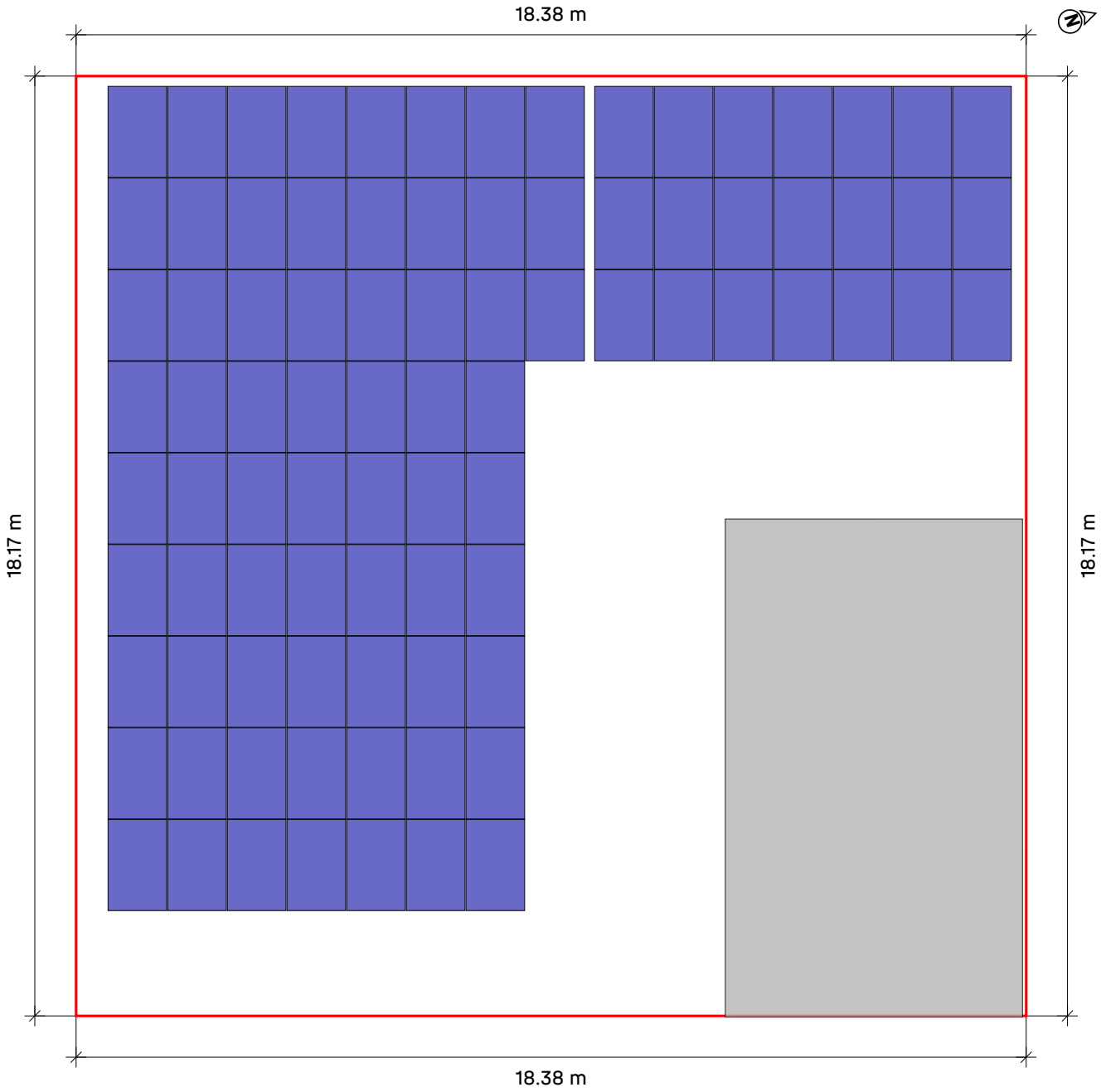
No. Module Array	roof areas	ultimate limit state Pr σ[%]	ultimate limit state CL σ[%]	ultimate limit state Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	Distances BR [m]	maximum values CL L_{max}[m]	maximum values Fst Fst D_{max}[m]
1	field area	36.3	155.6	72.1	39.0	1.500	---	0.546	1.899
1	ridge	57.7	78.8	122.1	60.5	1.500	---	0.482	1.229
1	gableboard	67.2	289.6	141.5	70.7	1.500	---	0.461	1.060
1	corner region (eave)	71.9	0.9	151.2	75.8	1.500	---	0.452	0.992
1	eaves	33.9	0.5	98.0	35.0	1.500	---	0.563	1.531

Pr	**Profile**	Fst D_{max}	**maximum fastener spacing**
Fst	**Fastener**	BR	**Base Rail**
σ	**Stress**	Usab.	**serviceability limit state**
f	**Deflection**	CL	**Cantilever**
F	**Force**		
CL/L_{max}	**maximum cantilever length**		

Roofs | Roof 2 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003028	Solarfastener 8×85/70 - FZD	367	37.4 kg
2	1000041	T-Bolt 28/15 M10×30	367	8.6 kg
3	1000042	Hexagon flange nut M10	367	4.0 kg
4	2002544	Adapterplate M10	367	16.5 kg
5	2002589	OneEnd Black Set 30-42	124	10.8 kg
6	2003072	OneMid Black Set 30-42	376	29.7 kg
7	1004765	SolidRail Light End Cap	140	0.8 kg
8	2002870	K2 Solar Cable Manager	191	0.5 kg
9	2003233	SolidRail Light; 4.40 m	124	462.9 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	95	21.4 kg
Total				**592.7 kg**

Roofs | Roof 3



Roof	System	Module	Power	Quantity	Total power
Roof 3	K2 BasicRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	87	38.28 kWp

Roofs | Roof 3 | Assembly plan

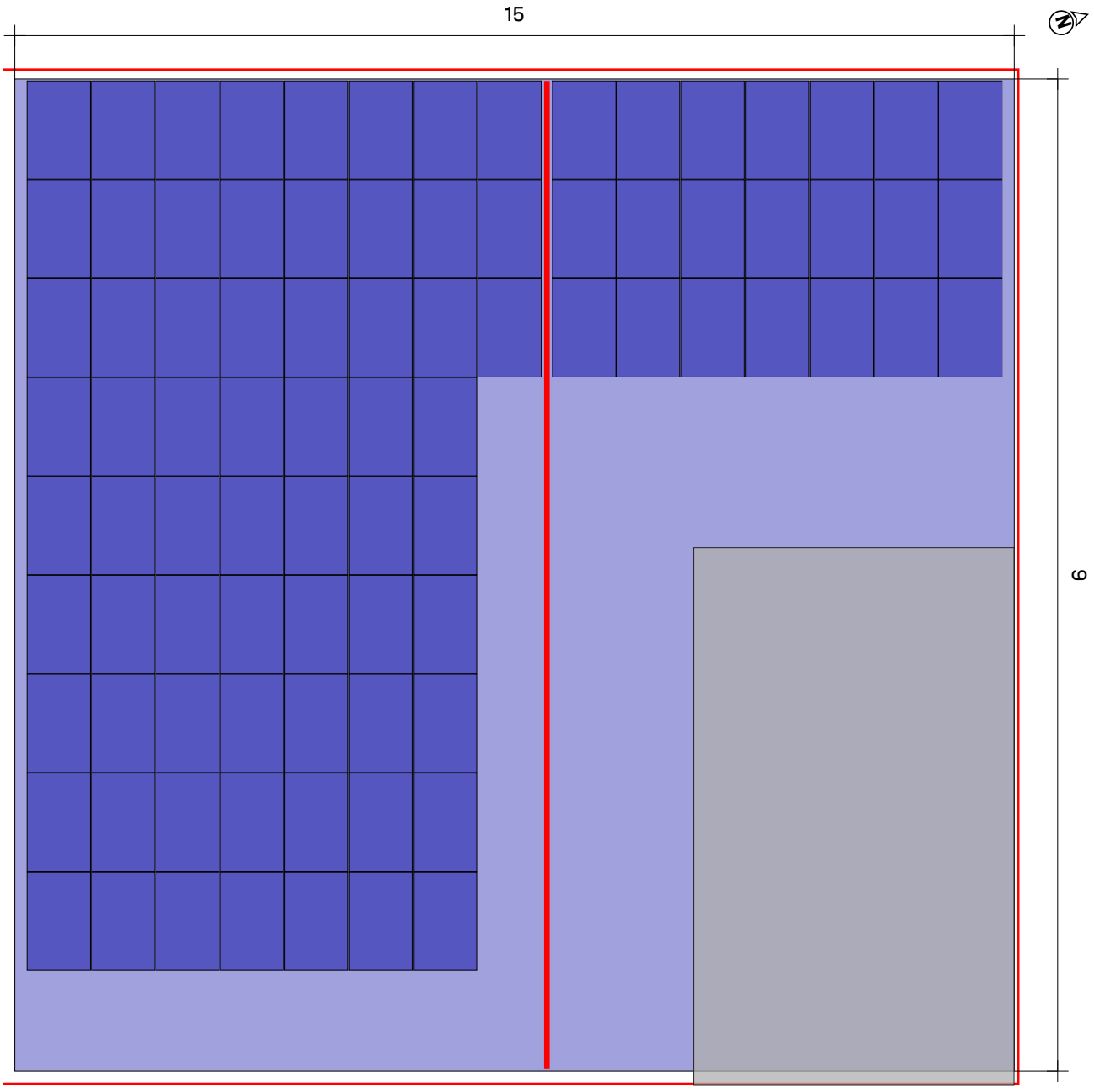
Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 4.40 m	Part of Rail	Length	Rest
A	8.178	1	4.400	3.778	0.612
B	9.332	2	4.400	0.700	3.690
C	9.332	2	3.690	0.700	2.980
D	9.332	2	2.980	0.700	2.270
E	9.332	2	2.270	0.700	1.560
F	9.332	2	1.560	0.700	0.850
G	9.332	2	0.850	0.700	0.140

Module arrays

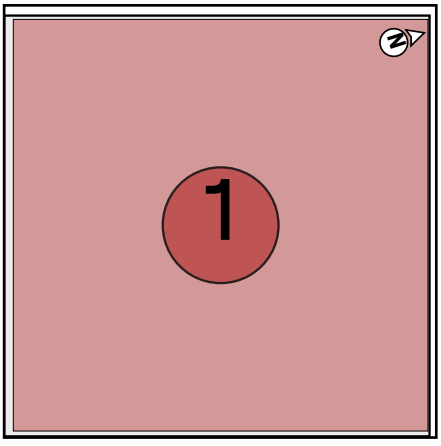
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	17.47	17.71	15	9

Roofs | Roof 3 | Module array 1

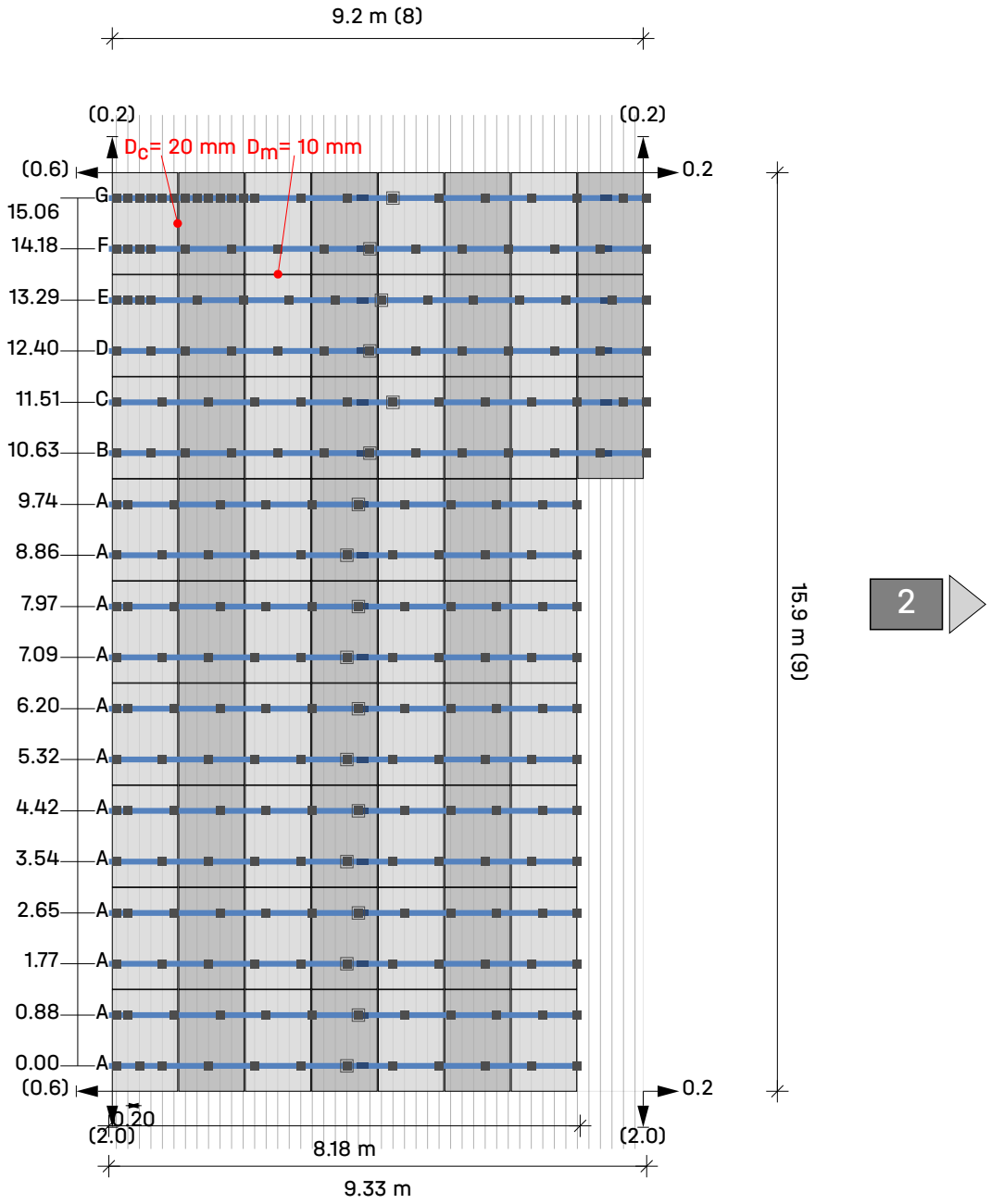


Roof 3 Module array 1

Mounting System	K2 BasicRail
Module	87(38.28 kWp) x TSM-440NEG9R.28 (Vertex S+)
Row spacing	1.77 m



Roofs | Roof 3 | Module array 1 | Module blocks

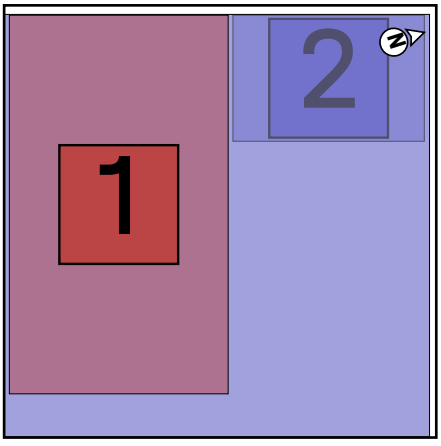


Roof 3 Module array 1 Module block 1

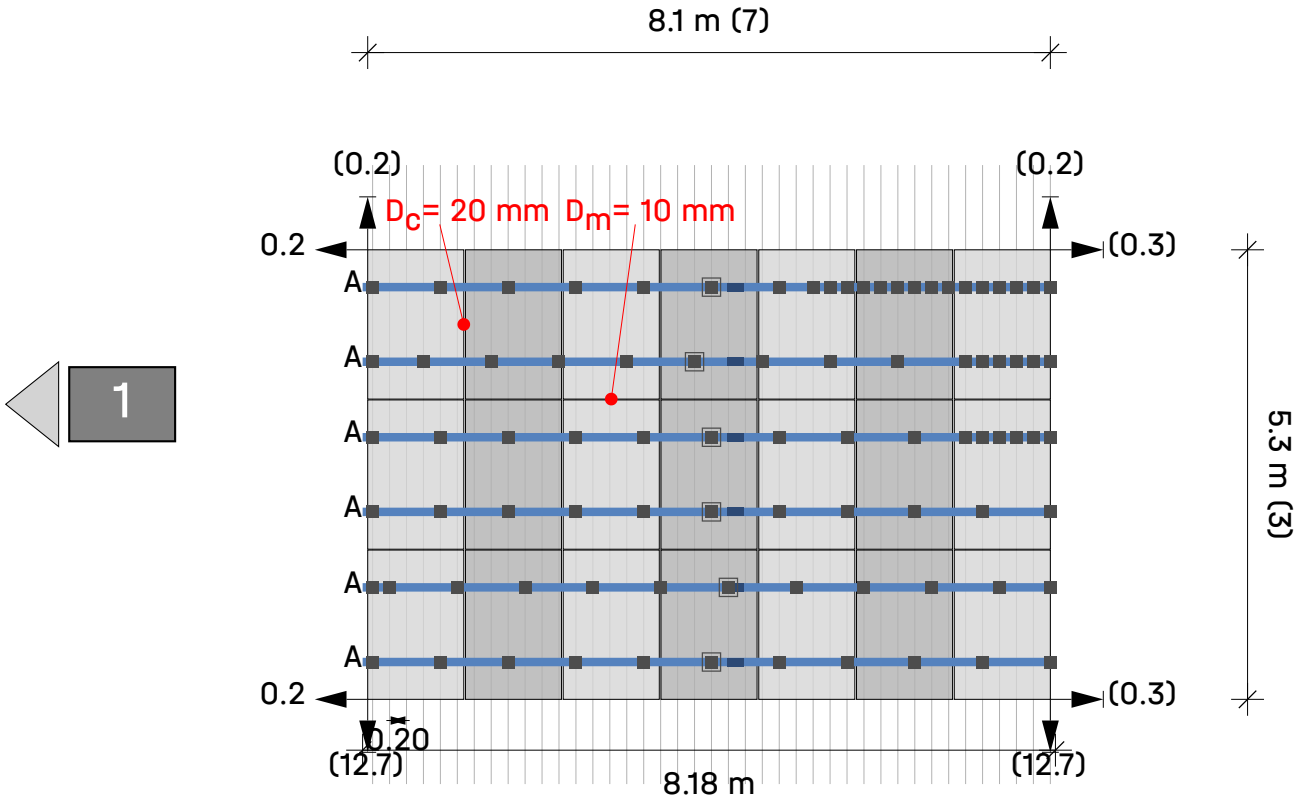
Modules (8 × 9) - 6 = **66**

Legend

- Next block indicator
- Fastener
- BasicLocks
- Mounting rail: K2 BasicRail 22
- Distance to Roof Edge [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



Roofs | Roof 3 | Module array 1 | Module blocks

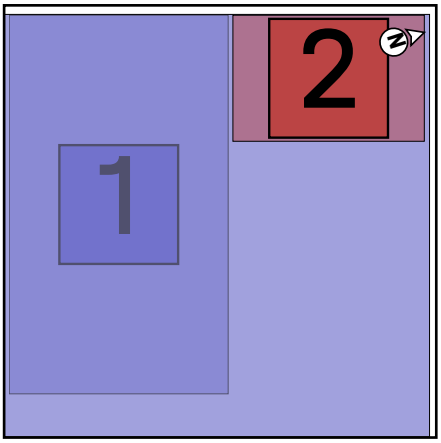


Roof 3 Module array 1 Module block 2

Modules 7 × 3 = **21**

Legend

- Next block indicator
- Fastener
- BasicLocks
- Mounting rail: K2 BasicRail 22
- Distance to Roof Edge [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



Results | Roof 3

Roof	System	Module	Power	Quantity	Total power
Roof 3 	K2 BasicRail	TSM-440NEG9R.28 (Vertex S+)	440 Wp	87	38.28 kWp

Module

Name	TSM-440NEG9R.28 (Vertex S+)
Manufacturer	Trina Solar Energy
Output power	440 Wp
Dimensions	1,762×1,134×30 mm
Weight	21.1 kg

Components

Fastener	K2 BasicClip
Base rails	K2 BasicRail 22
Metal screw	Thread-forming metal screw 6.0×38

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	2.00	713.5	153.3	-952.1	28.7	564.6	121.6	-723.6	28.7
corner region (eave)	2.00	713.5	153.3	-1,775.9	28.7	564.6	121.6	-1,369.8	28.7
gableboard	2.00	713.5	153.3	-1,187.5	28.7	564.6	121.6	-908.2	28.7
corner region (ridge)	2.00	713.5	153.3	-2,952.8	28.7	564.6	121.6	-2,292.8	28.7
ridge	2.00	713.5	153.3	-1,069.8	28.7	564.6	121.6	-815.9	28.7

Utilisation result

No. Module Array	roof areas	ultimate limit state			Usab.	Distances		maximum values	
		Pr σ[%]	CL σ[%]	Fst F[%]	Pr f[%]	Fst [m]	BR [m]	CL L_{max}[m]	Fst Fst D_{max}[m]
1	field area	27.7	3.0	74.5	41.7	0.800	---	0.436	0.850
1	corner region (eave)	12.8	6.8	68.5	4.9	0.400	---	0.400	0.584
1	gableboard	34.5	4.5	92.3	52.4	0.800	---	0.410	0.850
1	corner region (ridge)	5.3	11.2	56.5	1.0	0.200	---	0.200	0.354
1	ridge	31.1	3.4	83.4	47.0	0.800	---	0.422	0.850

Results | Roof 3

Pr	**Profile**
Fst	**Fastener**
σ	**Stress**
f	**Deflection**
F	**Force**
CL/L_{max}	**maximum cantilever length**
Fst D_{max}	**maximum fastener spacing**
BR	**Base Rail**
Usab.	**serviceability limit state**
CL	**Cantilever**

Results | Roof 3

Notes

- The quantity for K2 BasicRail BasicClips is calculated in such a way, that - according to the Assembly Instructions - a BasicClip can be installed on the crest to the left and right of a Rail Connector Set.
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- Snow loads are determined in accordance with National Annex BS NA EN 1991-1-3 (2018) - UK National Annex to EC1 - Action on structures - general actions - snow loads.
- Wind loads are determined in accordance with National Annex BS NA EN 1991-1-4 - UK National Annex to EC1 - Action on structures, general actions - wind actions.
- Service life is recognised according to 'Eurocode EN 1991 – Action on structures, Snow loads' and 'Eurocode EN 1991 – Actions on structures, Wind actions'. Subject to the Building Regulations and for security-relevant reasons the installation has to be dismantled at the end of its service life.
- Failure consequence class is considered according to 'Eurocode EN 1990 – Basis of structural design'.
- Data and results must be verified with regard to local conditions and checked by a suitably qualified person. Please see our TCU under https://k2-systems.com/en/base-tcu , in particular § 2 (''technical and specialist requirements for the customer''), § 7 (''warranty provisions'') and § 8 (''limitation of liability'').

Structural analysis report | Roof 3

General information

Name	Collins shed 5
Mounting System	K2 BasicRail
Author	Conor Maden

Location information

Address	Industrial Estate, Unit 1 Coldingham Rd, Eyemouth TD14 5AN, UK
Ground elevation	37.25 m

Roof information

Building height	6.00 m
Roof type	Monopitch roof
Roof pitch	15°
Fastening method	Roof cover
Roof covering	Trapezoidal
Min. roof edge distance	0.00 m
Crest distance	200.0 mm
Crest width	22.0 mm
Crest height	40.0 mm
Roof material	Steel
Sheet quality	S235
Sheet thickness	0.500 mm

Loads

Design method	BS EN
Failure consequence class (CC)	CC1
Design working life	25 years
Terrain category	Sea

Wind load

Velocity pressure	$q_{p,50}$ = 1.002 kN/m²
Adjustment factor for service life	f_w = 0.921
Velocity pressure	$q_{p,25}$ = 0.923 kN/m²

Structural analysis report | Roof 3

Roof areas

Array	load impact area [m²]	maxCpe$_{10}$	minCpe$_{10}$	wind pressure [kN/m²]	wind suction [kN/m²]
field area	10.00	0.200	-0.900	0.185	-0.831
corner region (eave)	10.00	0.200	-1.600	0.185	-1.477
gableboard	10.00	0.200	-1.100	0.185	-1.015
corner region (ridge)	10.00	0.200	-2.600	0.185	-2.400
ridge	10.00	0.200	-1.000	0.185	-0.923

Snow load

Snow load zone		3
Environment		Normal terrain
Snow guard		No
Snow load on ground level	s_k	= 0.500 kN/m²
Shape Coefficient for Snow	μ_i	= 0.800
Factor for roof pitch	d_i	= 0.966
Snow load on roof	$s_{i,50}$	= 0.386 kN/m²
Adjustment factor for service life	f_s	= 0.929
Snow load on roof	$s_{i,25}$	= 0.359 kN/m²

Dead Load

Weight of module	G_M	= 21.1 kg
Weight of mounting system per module		= 1.5 kg
Module area	A_M	= 2.00 m²
Dead weight of module per m²		= 10.56 kg/m²
Dead weight of mounting system per m²		= 0.75 kg/m²
Total Dead Load (excl. ballast) per m²		= 0.11 kN/m²

Structural analysis report | Roof 3

Load Combinations

Ultimate limit state

Partial safety factor unfavourable permanent load	$\gamma_{G,sup}$ = 1.35
Partial safety factor favourable permanent load	$\gamma_{G,inf}$ = 1.00
Partial safety factor destabilising permanent load	$\gamma_{G,dst}$ = 1.10
Partial safety factor stabilising permanent load	$\gamma_{G,stb}$ = 0.90
Partial safety factor first variable load	γ_{Q} = 1.50
Partial safety factor variable loads	γ_{Q} = 1.50
Combination coefficient with regards to wind	$\psi_{0,W}$ = 0.60
Combination coefficient with regards to wind (additional varying influences)	$\psi_{1,W}$ = 0.20
Combination coefficient with regards to Snow	$\psi_{0,S}$ = 0.50
Importance factor permanent	$\kappa_{Fl,G}$ = 0.90
Importance factor variable	$\kappa_{Fl,Q}$ = 0.85
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

Load case combination 01	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * S_{i,n}$
Load case combination 02	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Pressure}$
Load case combination 03	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * (W_{k,Pressure} + \psi_{0,S} * S_{i,n})$
Load case combination 04	$E_d = \gamma_{G,sup} * \kappa_{Fl,G} * G_k + \gamma_Q * \kappa_{Fl,Q} * (S_{i,n} + \psi_{0,W} * W_{k,Pressure})$
Load case combination 06	$E_d = \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Uplift}$

Serviceability limit state

Combination coefficient with regards to wind	$\psi_{0,W}$ = 0.60
Combination coefficient with regards to Snow	$\psi_{0,S}$ = 0.50

Load case combination 01	$E_d = G_k + S_{i,n}$
Load case combination 02	$E_d = G_k + W_{k,Pressure}$
Load case combination 03	$E_d = G_k + W_{k,Pressure} + \psi_{0,S} * S_{i,n}$
Load case combination 04	$E_d = G_k + S_{i,n} + \psi_{0,W} * W_{k,Pressure}$
Load case combination 06	$E_d = G_k + W_{k,Uplift}$

Structural analysis report | Roof 3

Maximum load on modules (Mounting system dimensioning)

Array	A-TrA [m²]	ultimate state [kN/m²]				Serviceability [kN/m²]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	10.00	0.713	0.153	-0.952	0.029	0.565	0.122	-0.724	0.029
corner region (eave)	10.00	0.713	0.153	-1.776	0.029	0.565	0.122	-1.370	0.029
gableboard	10.00	0.713	0.153	-1.187	0.029	0.565	0.122	-0.908	0.029
corner region (ridge)	10.00	0.713	0.153	-2.953	0.029	0.565	0.122	-2.293	0.029
ridge	10.00	0.713	0.153	-1.070	0.029	0.565	0.122	-0.816	0.029

Max. load on fastener

Array	A-TrA [m²]	ultimate state [kN]				Serviceability [kN]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	10.00	0.553	0.119	-0.738	0.022	0.438	0.094	-0.561	0.022
corner region (eave)	10.00	0.277	0.059	-0.688	0.011	0.219	0.047	-0.531	0.011
gableboard	10.00	0.553	0.119	-0.921	0.022	0.438	0.094	-0.704	0.022
corner region (ridge)	10.00	0.138	0.030	-0.572	0.006	0.109	0.024	-0.444	0.006
ridge	10.00	0.553	0.119	-0.829	0.022	0.438	0.094	-0.633	0.022

Resistance Values of Components

Base Rails

Base Rails	A [cm²]	I_y [cm^4]	I_z [cm^4]	W_y [cm³]	W_z [cm³]
K2 BasicRail 22	2.380	1.52	7.74	1.08	2.46

Fastener

Fastener	$R_{D,Uplift,Perpendicular}$ [kN]	$R_{D,Pressure,Perpendicular}$ [kN]	$R_{D,Pressure,Parallel}$ [kN]
K2 BasicClip	1.02	-	0.96
Thread-forming metal screw 6.0×38	0.65	-	0.62

Structural analysis report | Roof 3

Utilisation result

No. Module Array	roof areas	ultimate limit state Pr σ[%]	ultimate limit state CL σ[%]	ultimate limit state Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	Distances BR [m]	maximum values CL L_{max}[m]	maximum values Fst D_{max}[m]
1	field area	27.7	3.0	74.5	41.7	0.800	---	0.436	0.850
1	corner region (eave)	12.8	6.8	68.5	4.9	0.400	---	0.400	0.584
1	gableboard	34.5	4.5	92.3	52.4	0.800	---	0.410	0.850
1	corner region (ridge)	5.3	11.2	56.5	1.0	0.200	---	0.200	0.354
1	ridge	31.1	3.4	83.4	47.0	0.800	---	0.422	0.850

Pr	**Profile**
Fst	**Fastener**
σ	**Stress**
f	**Deflection**
F	**Force**
CL/L_{max}	**maximum cantilever length**
Fst D_{max}	**maximum fastener spacing**
BR	**Base Rail**
Usab.	**serviceability limit state**
CL	**Cantilever**

Roofs | Roof 3 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	1001164	K2 BasicClip	346	10.4 kg
2	1005193	Thread-forming metal screw 6.0×38	692	4.8 kg
3	2003071	OneMid Set 30-42	150	11.9 kg
4	2002514	OneEnd Set 30-42	48	4.2 kg
5	2003240	K2 BasicRail 22; 4.40m	49	138.6 kg
6	1003571	K2 BasicRail BasicConnector Set	30	1.5 kg
7	1003558	K2 BasicRail BasicLock 22 Set	24	1.2 kg
Total				**172.5 kg**

Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003013	Solarfastener 8×85/50 - FZD	362	34.0 kg
2	1000041	T-Bolt 28/15 M10×30	729	17.1 kg
3	1000042	Hexagon flange nut M10	729	8.0 kg
4	2002544	Adapterplate M10	729	32.8 kg
5	2002589	OneEnd Black Set 30-42	220	19.1 kg
6	2003072	OneMid Black Set 30-42	778	61.5 kg
7	1004765	SolidRail Light End Cap	264	1.6 kg
8	2002870	K2 Solar Cable Manager	383	1.1 kg
9	2004395	SolidRail Light; 4.80 m	116	475.5 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	163	36.7 kg
11	2003028	Solarfastener 8×85/70 - FZD	367	37.4 kg
12	2003233	SolidRail Light; 4.40 m	124	462.9 kg
13	1001164	K2 BasicClip	346	10.4 kg
14	1005193	Thread-forming metal screw 6.0×38	692	4.8 kg
15	2003071	OneMid Set 30-42	150	11.9 kg
16	2002514	OneEnd Set 30-42	48	4.2 kg
17	2003240	K2 BasicRail 22; 4.40m	49	138.6 kg
18	1003571	K2 BasicRail BasicConnector Set	30	1.5 kg
19	1003558	K2 BasicRail BasicLock 22 Set	24	1.2 kg
Total				**1,360.2 kg**

Thank you for choosing a K2 mounting system.

Systems from K2 Systems are quick and easy to install.
We hope these instructions have helped.
Please contact us with any questions or suggestions for improvement.

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Our General Terms of Business apply. Please refer to k2-systems.com

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