| Connecting Strength

K2 Base Report

Lincoln College - Museum Road - PV - Final

Project address	9 Museum Rd, Oxford OX1 3PX, UK
Customer	Lincoln College
Company	Renewable Energy Co-operative
Author	Daniel Tempest
Issue date & version	11/04/2024 | K2 Base Version 3.1.123.1

Contents

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.

The static report is not including module and building verification.

Project overview

Roofs

Roof	System	Module	Height	Quantity	Total power
Roof 1 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	9.00 m	26	12.22 kWp
Roof 2 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	8.32 m	26	12.22 kWp
Roof 3 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	9.00 m	6	2.82 kWp
Roof 4 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	8.50 m	14	6.58 kWp
Roof 5 Tile	SolidRail	REC 420 AA Pure-R (Alpha) 1,730×1,118×30 mm 420 Wp	9.32 m	8	3.36 kWp
Total				**80**	**37.20 kWp**

Project information

Address	9 Museum Rd, Oxford OX1 3PX, UK
Customer	Lincoln College
Contact person	Peter Nitsche-Whitfield
Author	Daniel Tempest

Load settings

Design method	BS EN
Failure consequence class (CC)	CC2
Design working life	25 years
Terrain category	Town Terrain
Basic wind speed	21.5 m/s
Distance to shoreline	100.00 km
Distance inside town terrain	0.20 km
Snow load zone	2
Snow load on ground level	0.40 kN/m²

Material values

Aluminium EM-AW 6063 (EP, ET, ER/B) T66

Project overview

Elastic module	E	= 70.000 N/mm²
Shear module	G	= 26.923 N/mm²
Density	g	= 2.700 kg/m³
Thermal coefficient	α_T	= 2.3e-5
Yielding strength	$f_{o,k}$	= 200 N/mm²
Ultimate strength	$f_{u,k}$	= 245 N/mm²

THE PROJECT IS VERIFIED.
please check the warning(s)!

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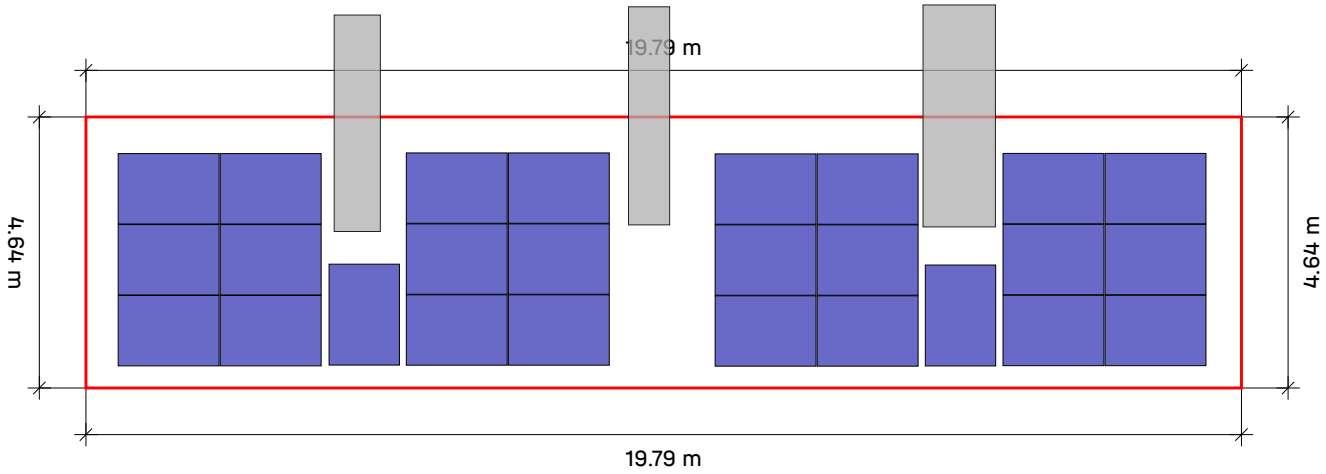
Project information

Address	**9 Museum Rd, Oxford OX1 3PX, UK**
Customer	**Lincoln College**
Contact person	**Peter Nitsche-Whitfield**
Author	**Daniel Tempest**

Roofs | Roof 1



Roof	System	Module	Height	Quantity	Total power
Roof 1 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	9.00 m	26	12.22 kWp

Roofs | Roof 1 | Assembly plan

Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 3.30 m	Part of Rail	Length	Rest
2*A	1.305		3.300	1.305 from 3.300	1.985
2*B	1.305		1.985	1.305 from 1.985	0.670
2*C	3.576	1*3.30 m	3.300	0.700 from 3.300	2.590
2*D	3.576	1*3.30 m	2.590	0.700 from 2.590	1.880
2*E	3.576	1*3.30 m	1.880	0.700 from 1.880	1.170
2*F	3.576	1*3.30 m	1.170	0.700 from 1.170	0.460
4*G	3.576	1*3.30 m	3.300	0.700 from 3.300	2.590
4*H	3.576	1*3.30 m	2.590	0.700 from 2.590	1.880
4*I	3.576	1*3.30 m	1.880	0.700 from 1.880	1.170
4*J	3.576	1*3.30 m	1.170	0.700 from 1.170	0.460

1 cm is viewed as lost for each cutting

Red numbers are leftover rails which will not be used any longer

Fastener Spacing

Module	Array	Distance	maximum cantilever length	maximum fastener spacing
1	ridge	1.80 m	0.573	1.803
1	gableboard	1.80 m	0.542	1.803
1	corner region (eave)	1.35 m	0.563	1.598
2	ridge	1.80 m	0.573	1.803
2	eaves	1.35 m	0.626	1.747
3	ridge	1.80 m	0.573	1.803
3	eaves	1.35 m	0.626	1.747
4	ridge	1.80 m	0.573	1.803
4	gableboard	1.80 m	0.542	1.803

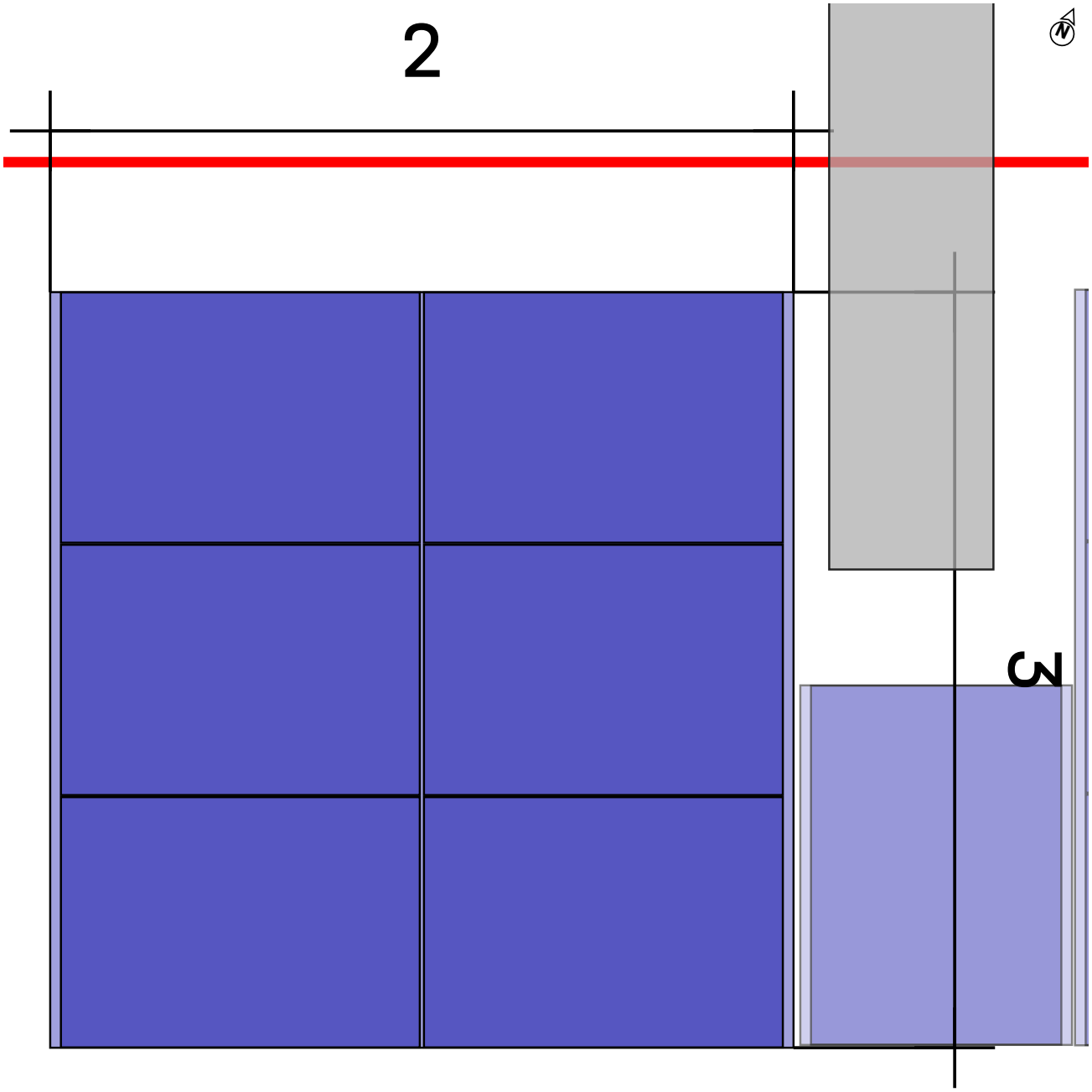
Roofs | Roof 1 | Assembly plan

4	corner region (eave)	1.35 m	0.563	1.598
5	field area	0.90 m	0.616	1.257
5	corner region (eave)	0.90 m	0.550	1.115
5	eaves	0.90 m	0.610	1.218
6	field area	0.90 m	0.616	1.257
6	corner region (eave)	0.90 m	0.550	1.115
6	eaves	0.90 m	0.610	1.218

Module arrays

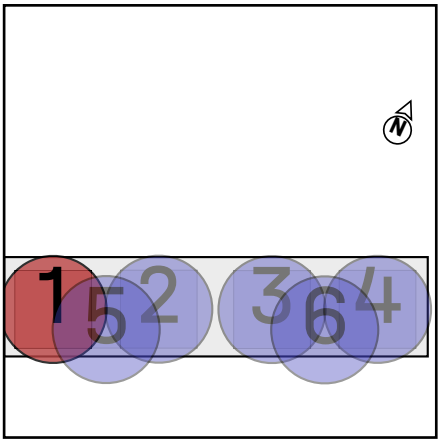
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	3.48	3.64	2	3
2	3.48	3.64	2	3
3	3.48	3.63	2	3
4	3.48	3.64	2	3
5	1.21	1.73	1	1
6	1.21	1.73	1	1

Roofs | Roof 1 | Module array 1

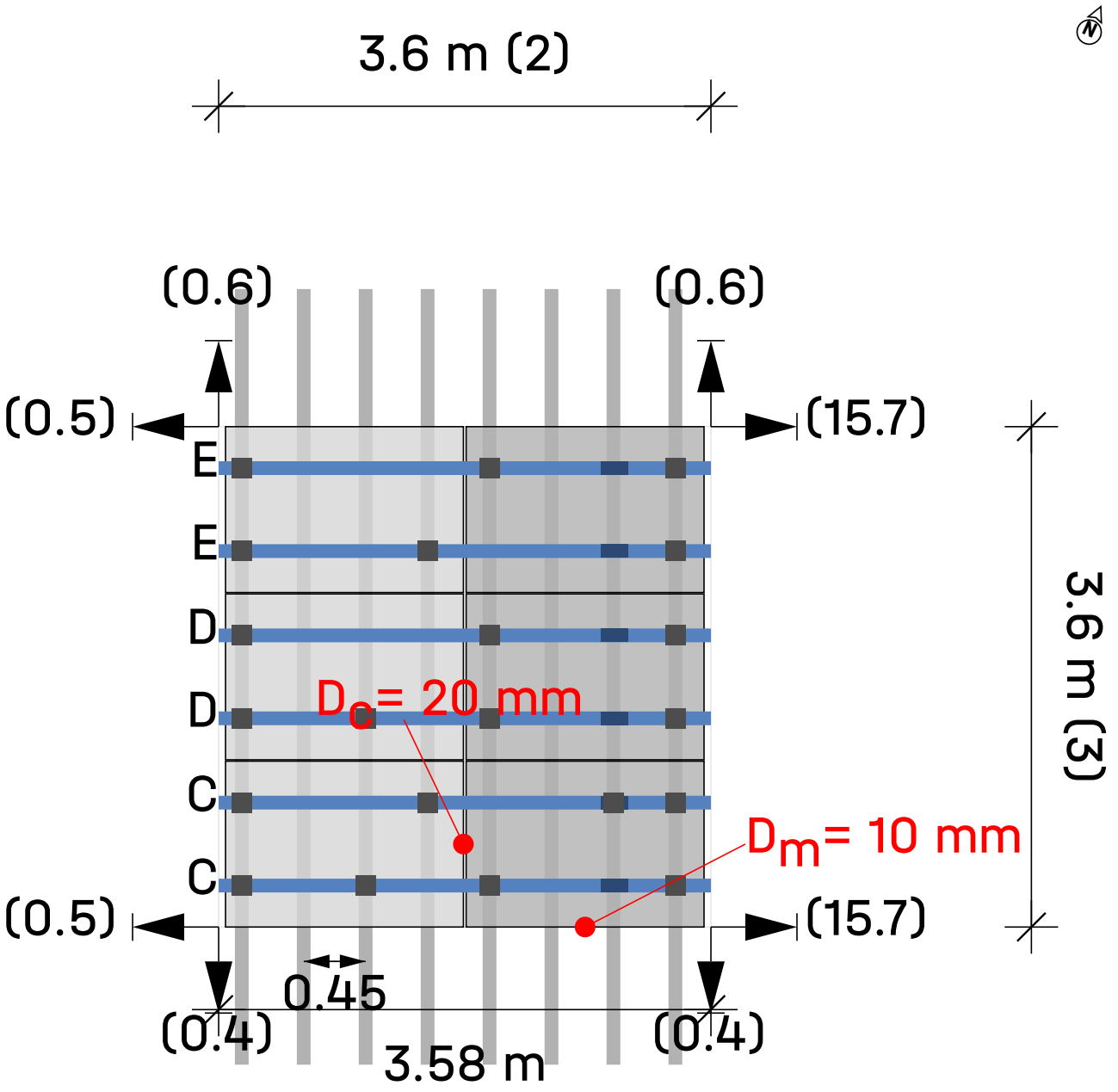


Roof (1) Module array 1

Mounting System	SolidRail
Module	6(2.82 kWp) x Alpha Pure-RX
Row spacing	1.22 m



Roofs | Roof 1 | Module array 1 | Module blocks



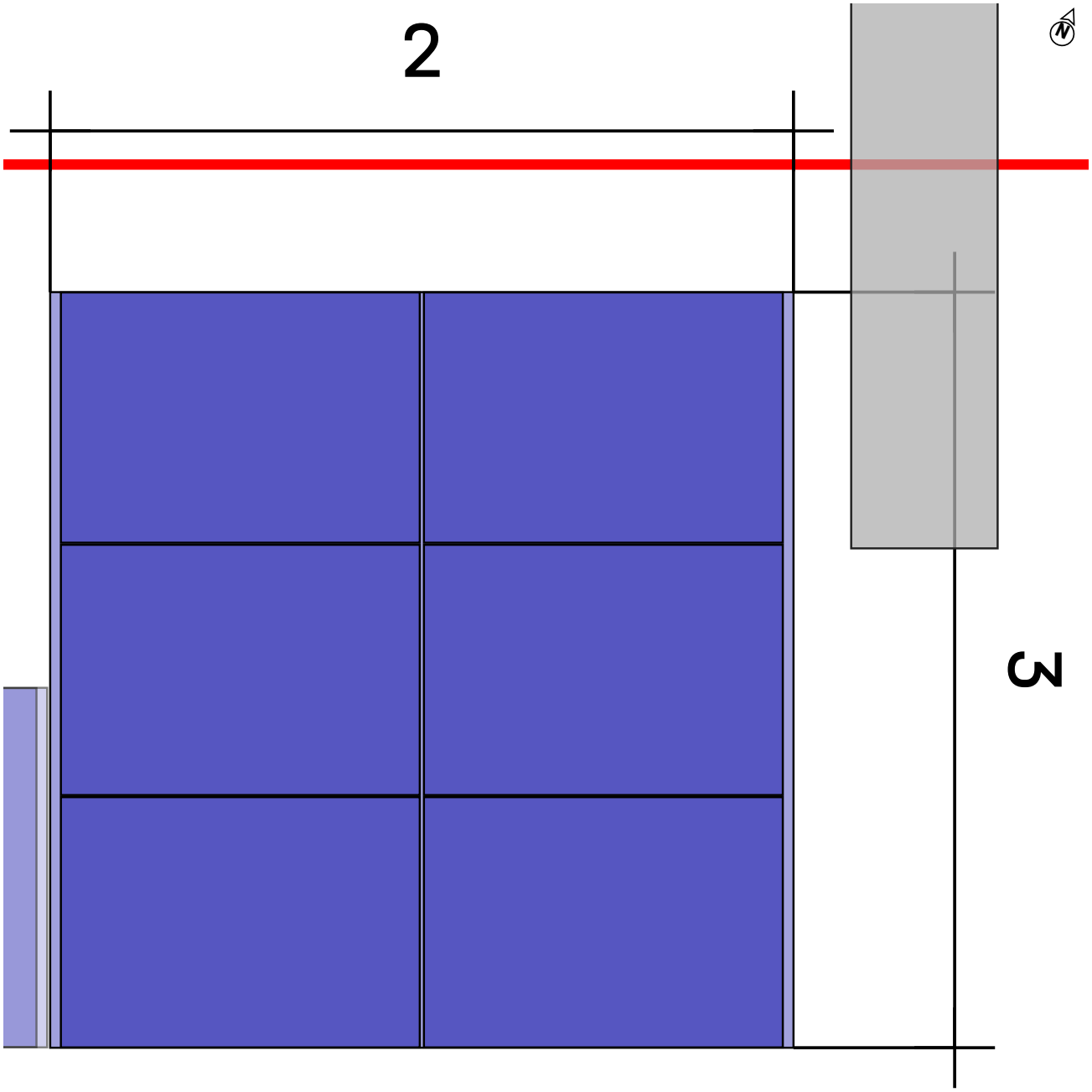
Roof (1) Module array (1) Module block 1

Modules 2 × 3 = **6**

Legend

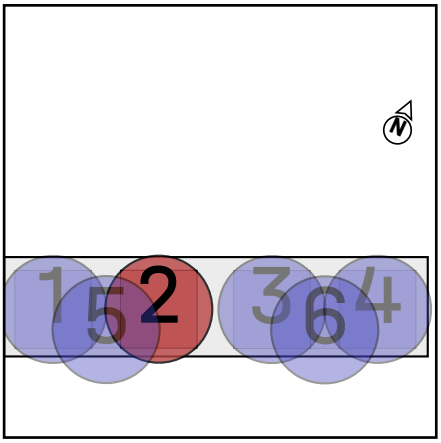
- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_c Distance for clamping between modules
- D_m Distance between modules

Roofs | Roof 1 | Module array 2

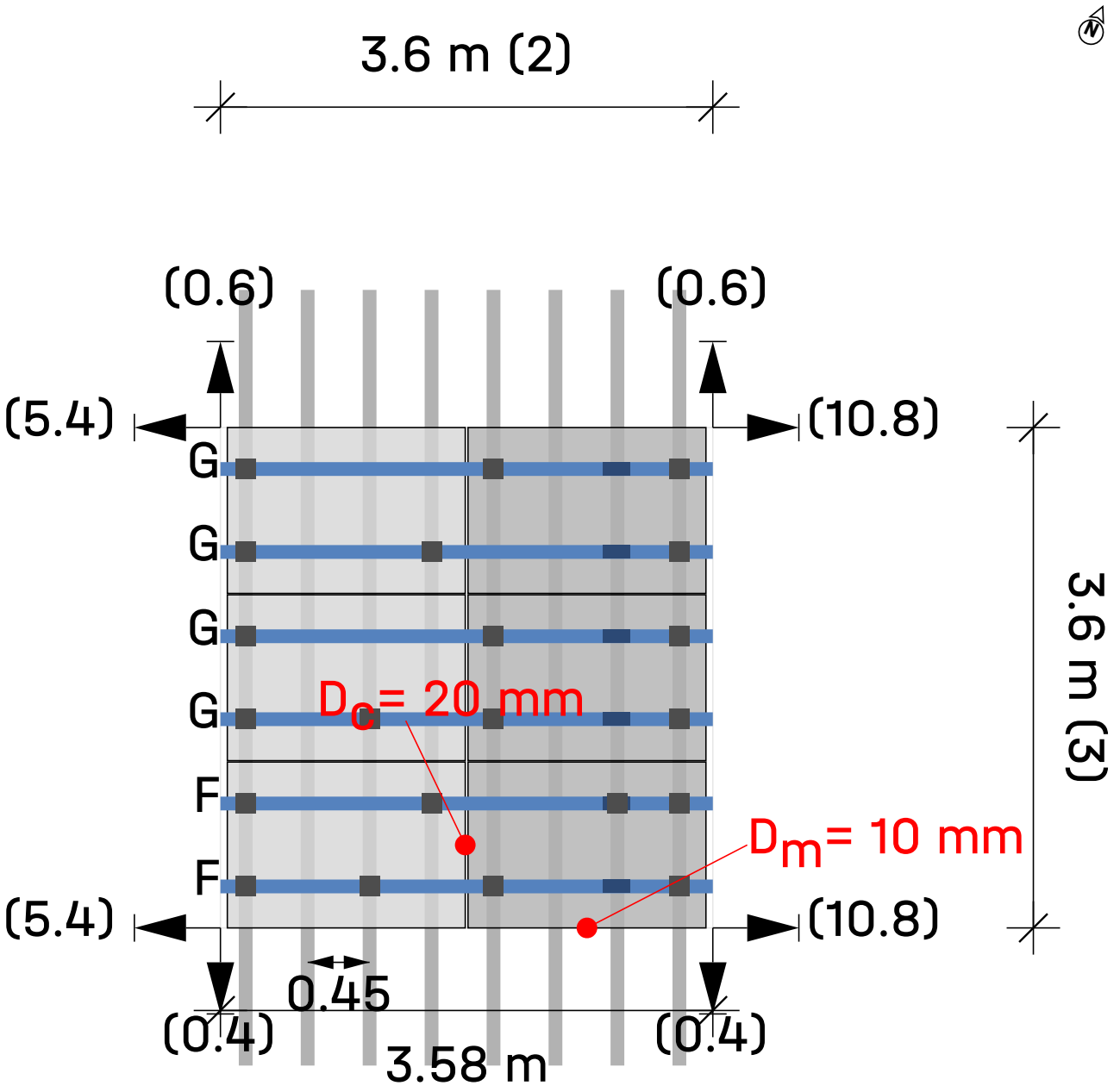


Roof (1) Module array (2)

Mounting System	SolidRail
Module	6(2.82 kWp) x Alpha Pure-RX
Row spacing	1.22 m



Roofs | Roof 1 | Module array 2 | Module blocks



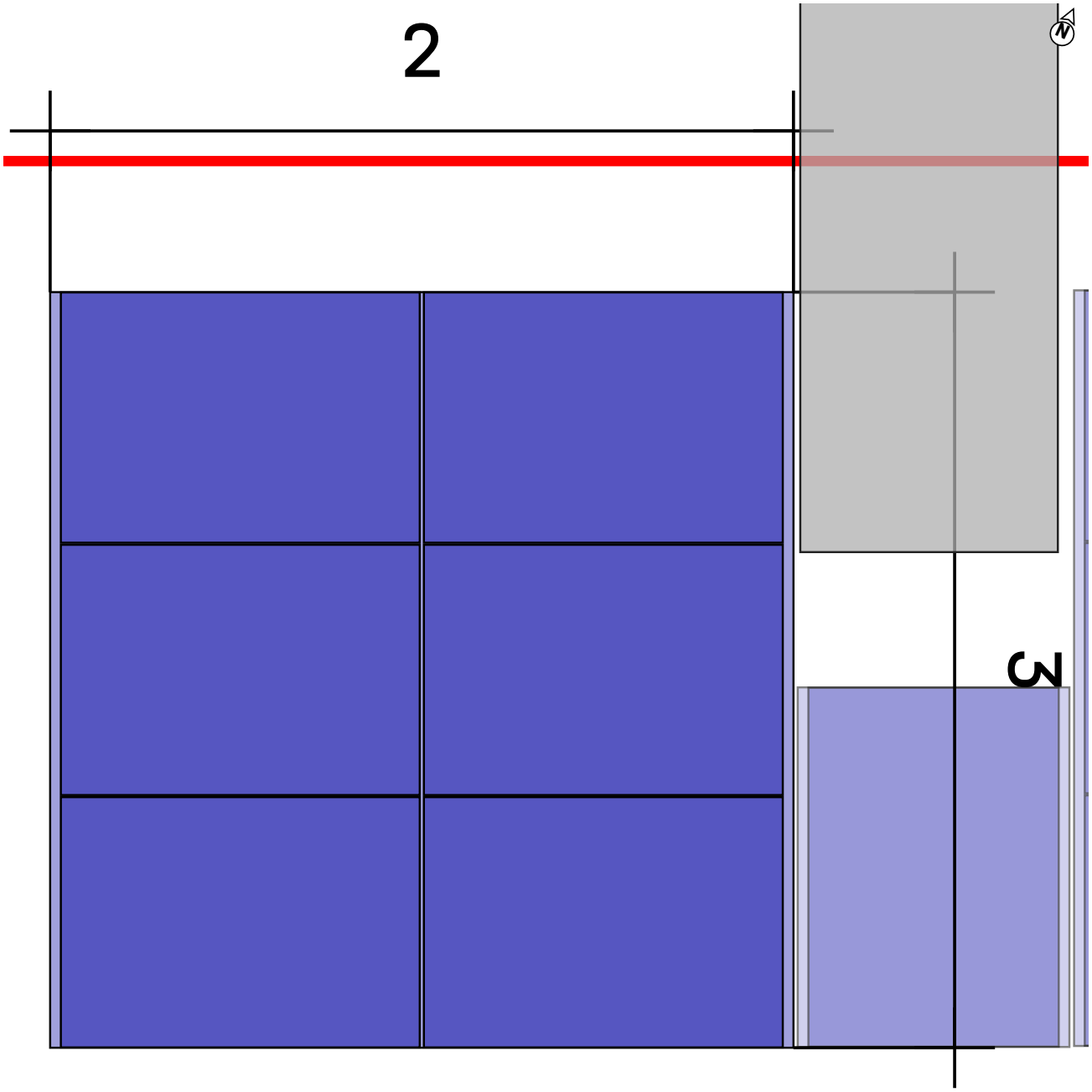
Roof (1) Module array (2) Module block 2

Modules 2 × 3 = **6**

Legend

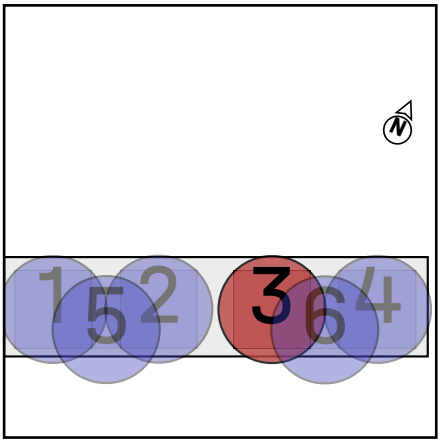
- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_c Distance for clamping between modules
- D_m Distance between modules

Roofs | Roof 1 | Module array 3

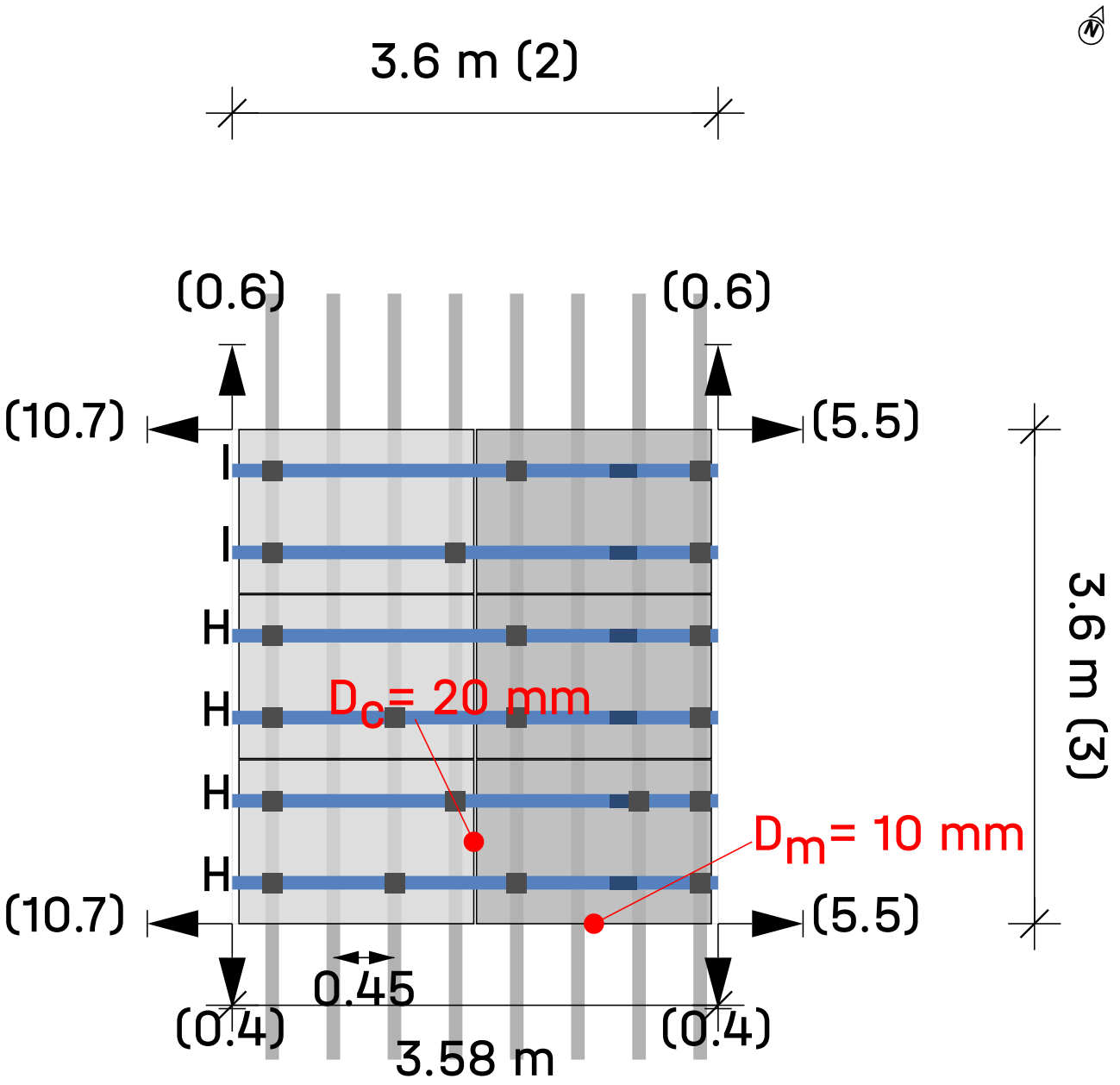


Roof (1) Module array (3)

Mounting System	SolidRail
Module	6(2.82 kWp) x Alpha Pure-RX
Row spacing	1.22 m



Roofs | Roof 1 | Module array 3 | Module blocks



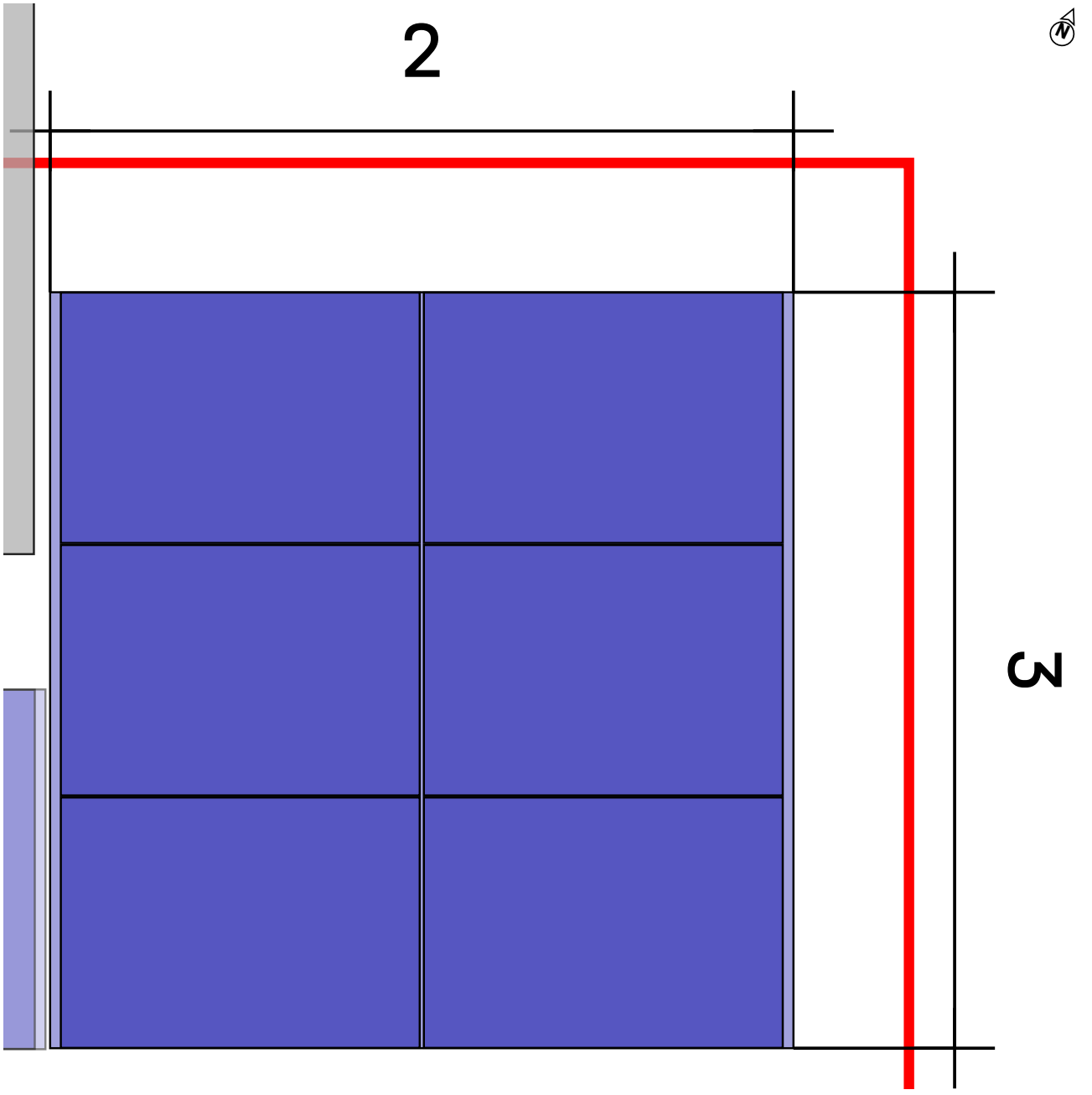
Roof (1) Module array (3) Module block 3

Modules 2 × 3 = **6**

Legend

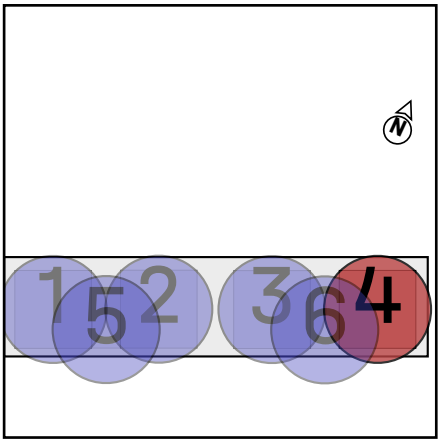
- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_c Distance for clamping between modules
- D_m Distance between modules

Roofs | Roof 1 | Module array 4

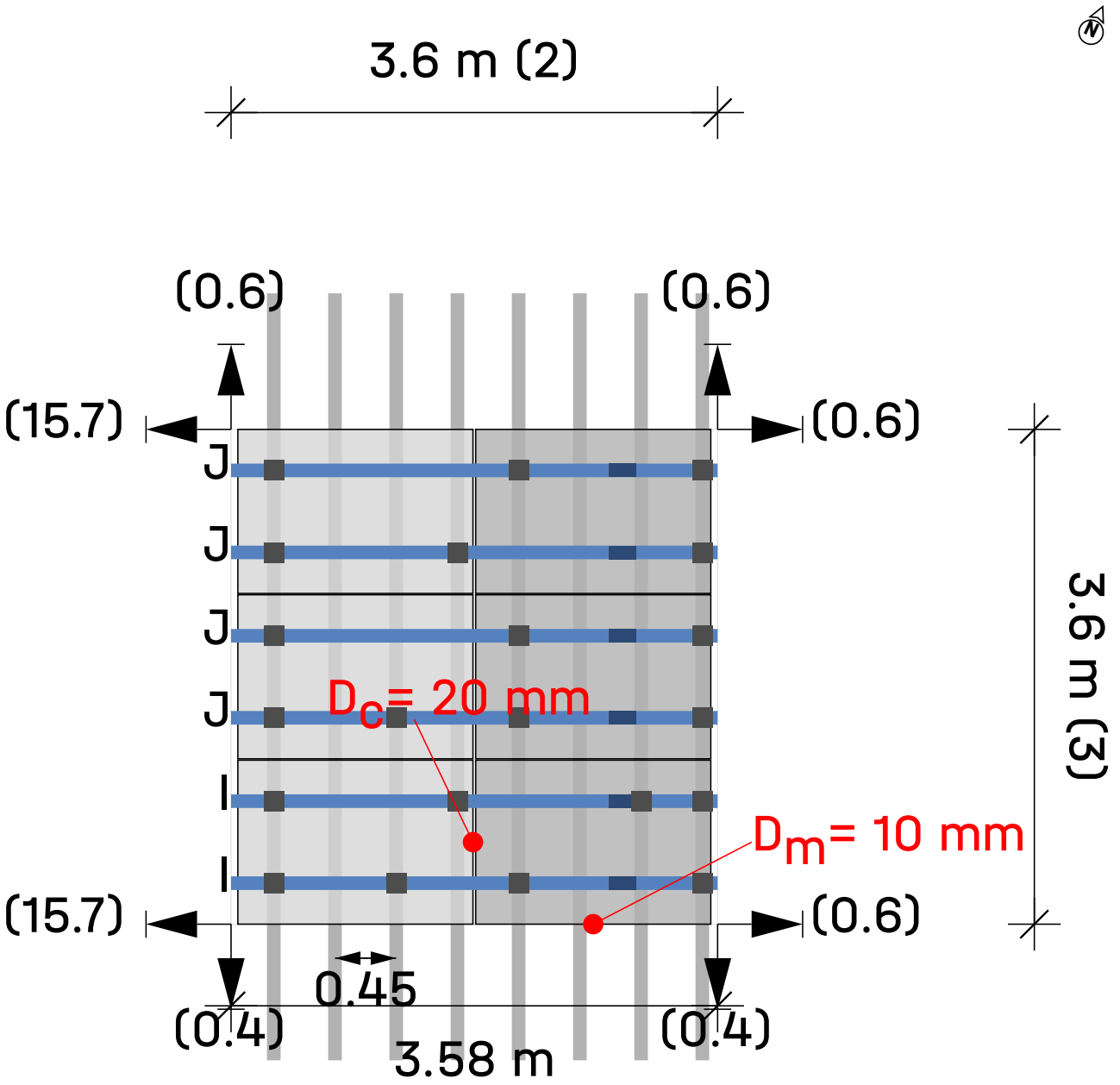


Roof 1 Module array 4

Mounting System	SolidRail
Module	6(2.82 kWp) x Alpha Pure-RX
Row spacing	1.22 m



Roofs | Roof 1 | Module array 4 | Module blocks



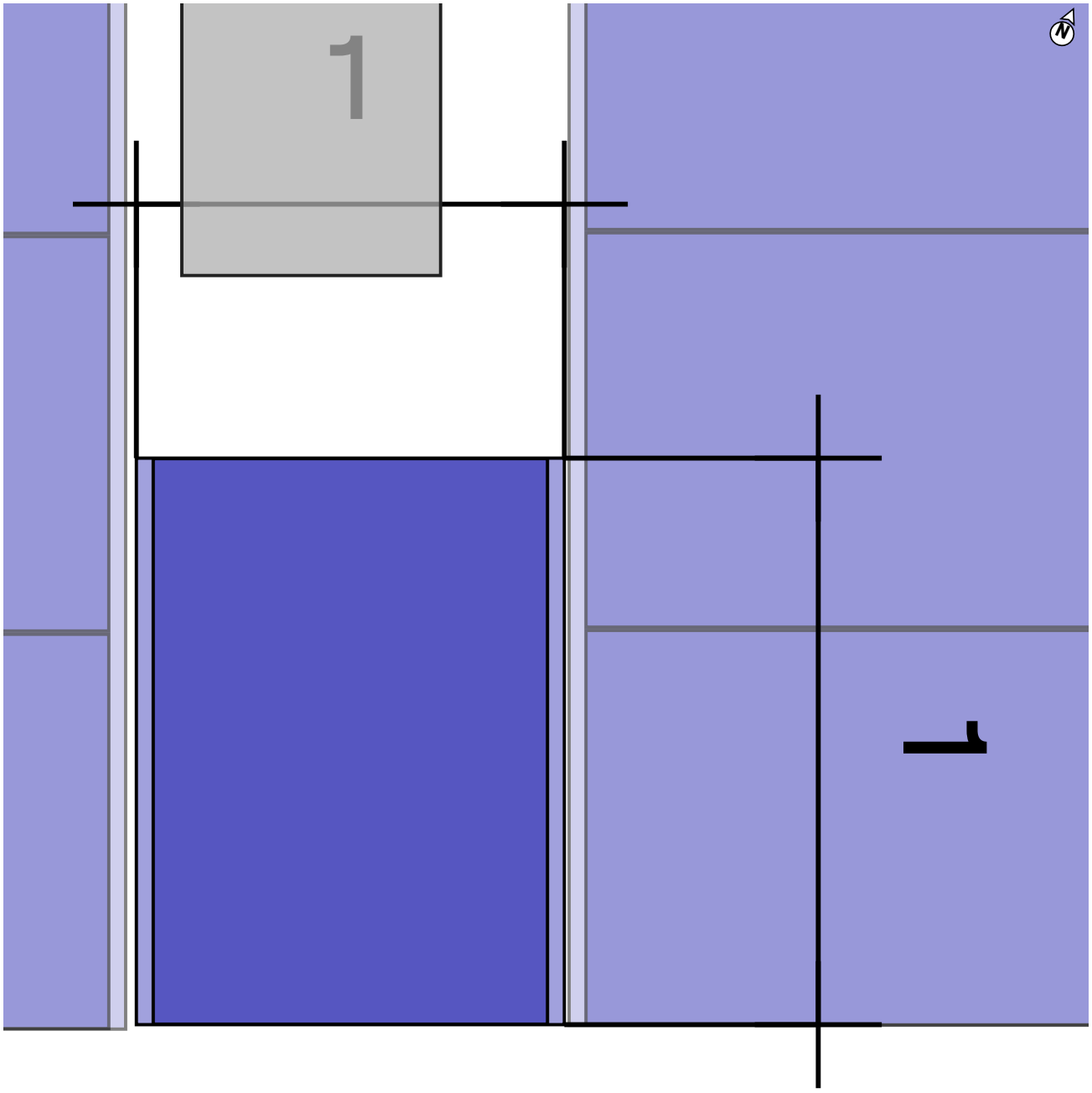
Roof (1) Module array (4) Module block 4

Modules 2 × 3 = **6**

Legend

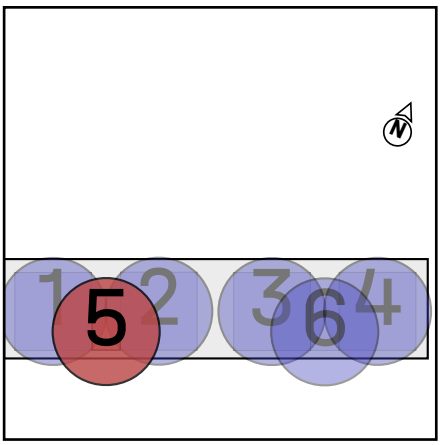
- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_c Distance for clamping between modules
- D_m Distance between modules

Roofs | Roof 1 | Module array 5

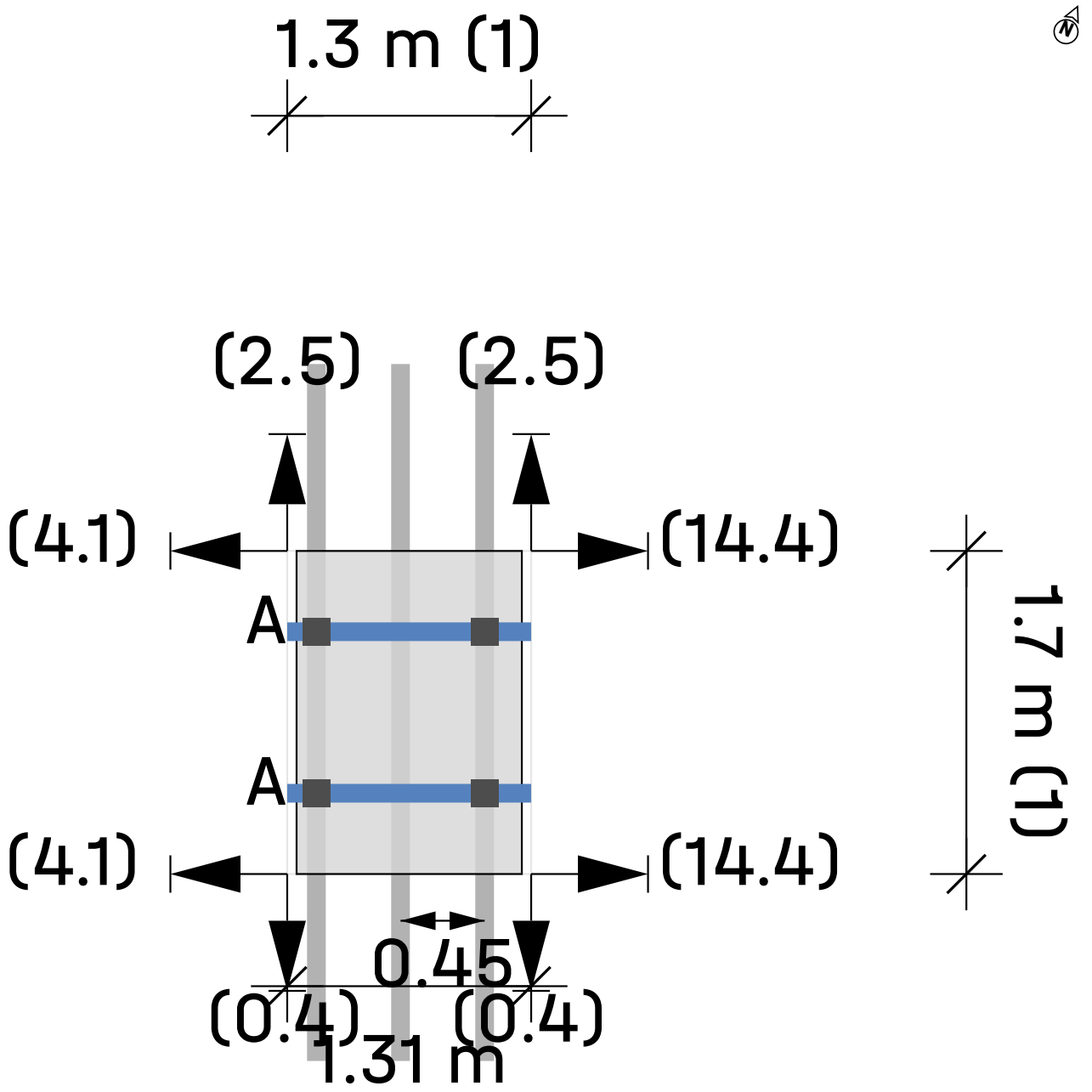


Roof (1) Module array (5)

Mounting System	SolidRail
Module	1(0.47 kWp) x Alpha Pure-RX
Row spacing	1.74 m



Roofs | Roof 1 | Module array 5 | Module blocks

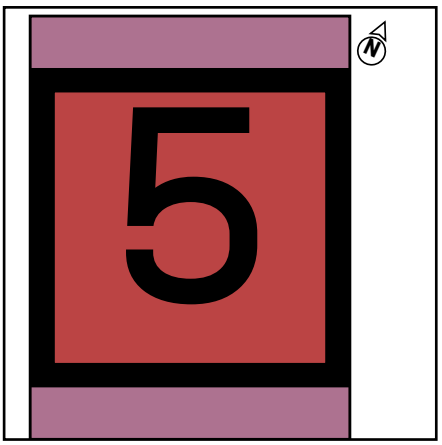


Roof (1) Module array (5) Module block 5

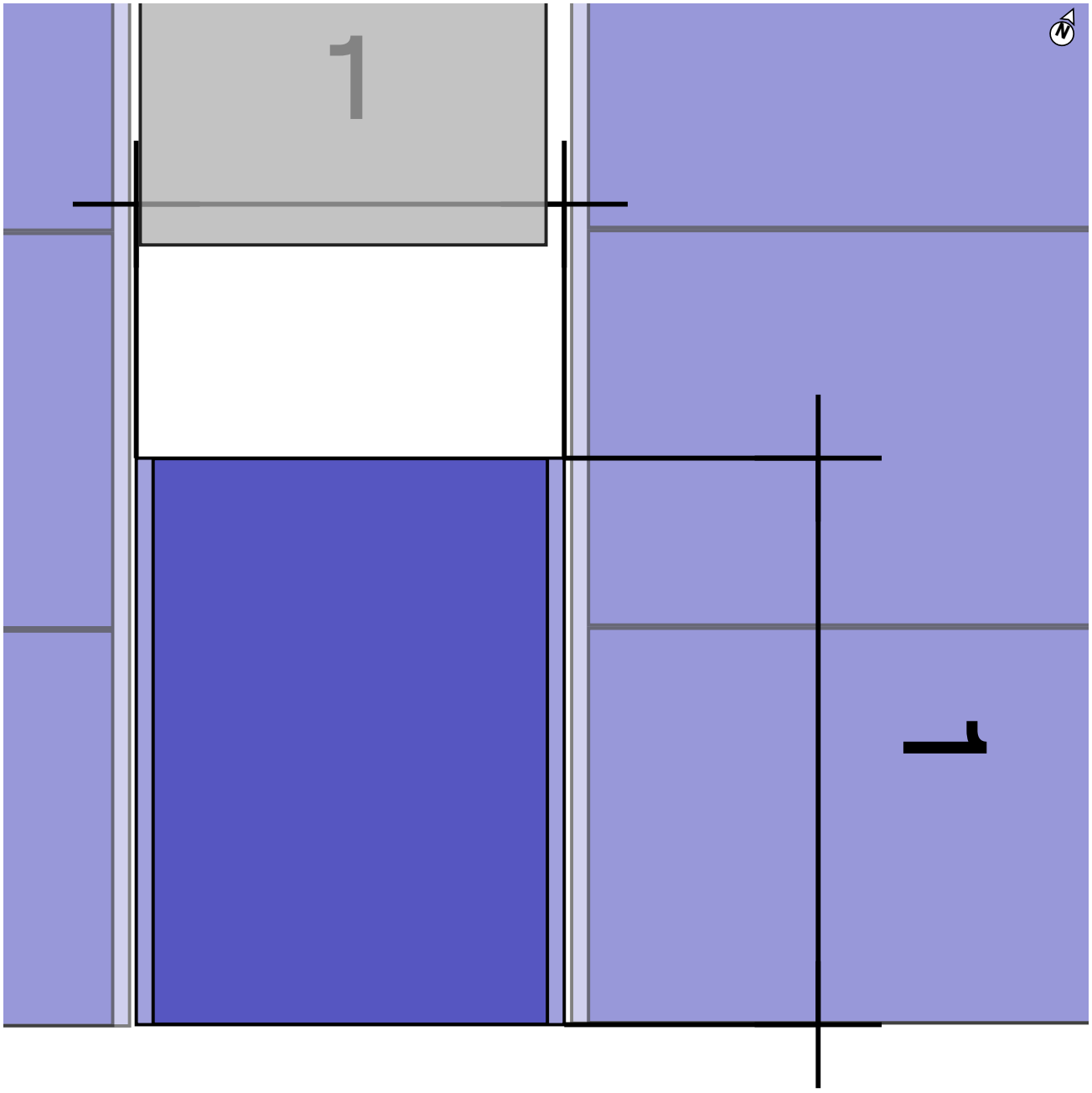
Modules 1 × 1 = 1

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_c Distance for clamping between modules
- D_m Distance between modules

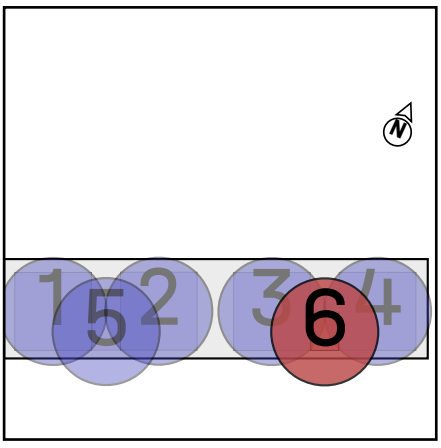


Roofs | Roof 1 | Module array 6

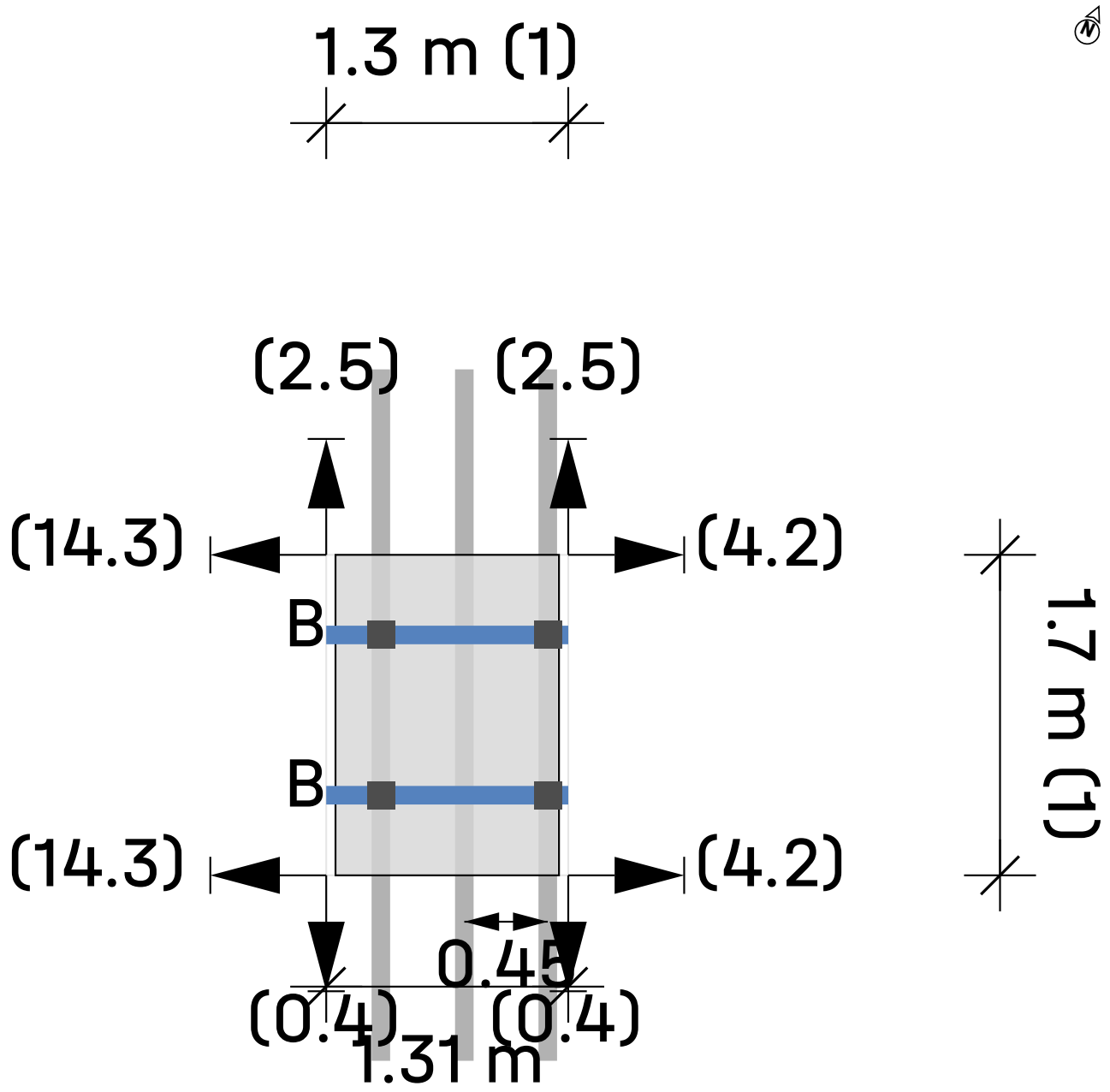


Roof (1) Module array (6)

Mounting System	SolidRail
Module	1(0.47 kWp) x Alpha Pure-RX
Row spacing	1.74 m



Roofs | Roof 1 | Module array 6 | Module blocks

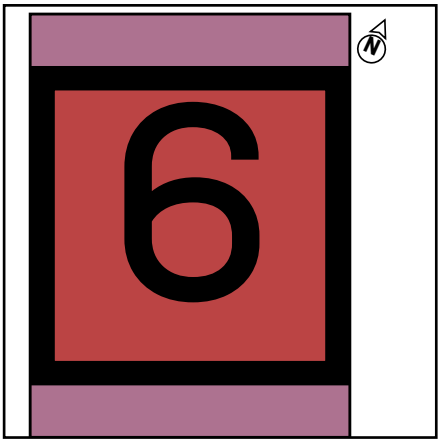


Roof (1) Module array (6) Module block 6

Modules 1 × 1 = 1

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_c Distance for clamping between modules
- D_m Distance between modules



Results | Roof 1

Roof	System	Module	Height	Quantity	Total power
Roof 1 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	9.00 m	26	12.22 kWp

Module

Name	Alpha Pure-RX
Manufacturer	REC
Output power	470 Wp
Dimensions	1,728×1,205×30 mm
Weight	23.4 kg

Components

Fastener	SolidHook Pan Tile Vario 1
Base rails	K2 SolidRail Light 37

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
ridge	2.08	802.3	252.7	-1,005.7	45.7	546.2	173.0	-632.8	45.7
gableboard	2.08	802.3	252.7	-1,206.7	45.7	546.2	173.0	-766.8	45.7
corner region (eave)	2.08	914.9	252.7	-1,307.2	45.7	621.2	173.0	-833.8	45.7
ridge	2.08	802.3	252.7	-1,005.7	45.7	546.2	173.0	-632.8	45.7
eaves	2.08	830.5	252.7	-550.2	45.7	565.0	173.0	-329.1	45.7
ridge	2.08	802.3	252.7	-1,005.7	45.7	546.2	173.0	-632.8	45.7
eaves	2.08	830.5	252.7	-550.2	45.7	565.0	173.0	-329.1	45.7
ridge	2.08	802.3	252.7	-1,005.7	45.7	546.2	173.0	-632.8	45.7
gableboard	2.08	802.3	252.7	-1,206.7	45.7	546.2	173.0	-766.8	45.7
corner region (eave)	2.08	914.9	252.7	-1,307.2	45.7	621.2	173.0	-833.8	45.7
field area	2.08	802.3	252.7	-489.9	45.7	546.2	173.0	-288.9	45.7
corner region (eave)	2.08	914.9	252.7	-1,307.2	45.7	621.2	173.0	-833.8	45.7
eaves	2.08	830.5	252.7	-550.2	45.7	565.0	173.0	-329.1	45.7
field area	2.08	802.3	252.7	-489.9	45.7	546.2	173.0	-288.9	45.7
corner region (eave)	2.08	914.9	252.7	-1,307.2	45.7	621.2	173.0	-833.8	45.7

Results | Roof 1

eaves	2.08	830.5	252.7	-550.2	45.7	565.0	173.0	-329.1	45.7

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	ridge	49.4	5.1	99.8	59.5	1.800	---	0.573	1.803
1	gableboard	59.0	2.6	99.8	72.1	1.800	---	0.542	1.803
1	corner region (eave)	35.9	6.6	84.5	27.6	1.350	---	0.563	1.598
2	ridge	49.4	4.5	99.8	59.5	1.800	---	0.573	1.803
2	eaves	26.6	4.3	77.3	19.0	1.350	---	0.626	1.747
3	ridge	49.4	6.6	99.8	59.5	1.800	---	0.573	1.803
3	eaves	26.6	6.3	77.3	19.0	1.350	---	0.626	1.747
4	ridge	49.4	7.5	99.8	59.5	1.800	---	0.573	1.803
4	gableboard	59.0	1.1	99.8	72.1	1.800	---	0.542	1.803
4	corner region (eave)	35.9	9.7	84.5	27.6	1.350	---	0.563	1.598
5	field area	16.5	0.0	71.6	7.8	0.900	---	0.616	1.257
5	corner region (eave)	22.9	3.4	80.8	11.7	0.900	---	0.550	1.115
5	eaves	17.0	6.5	73.9	8.1	0.900	---	0.610	1.218
6	field area	16.5	0.0	71.6	7.8	0.900	---	0.616	1.257
6	corner region (eave)	22.9	1.7	80.8	11.7	0.900	---	0.550	1.115
6	eaves	17.0	9.1	73.9	8.1	0.900	---	0.610	1.218

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 dimensioning of the timber construction screws is not part of this structural analysis. The dimensioning and positioning of the timber construction screws to be used must be carried out in accordance with the respective applicable codes of practice.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminum structures (DIN EN 1999-1-1:2021) and offers sufficient load-bearing capacity and stability for the loads specified in the chapter 'Maximum actions on the components'.
- Adjustment factor for wind load regarding servise life periond, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding servise life periond, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- 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'').
- The clamping range of the module may not comply with for this installation variant, as the rail spacing depends on the laying of the tiles and thus the batten length. Please ensure that the clamping range specified by the module manufacturer is observed.

Structural analysis report | Roof 1

General information

Name	**Lincoln College - Museum Road - PV - Final**
Mounting System	**SolidRail**
Author	**Daniel Tempest**

Location information

Address	**9 Museum Rd, Oxford OX1 3PX, UK**
Ground elevation	**65.14 m**

Roof information

Building height	**9.00 m**
Roof type	**Gable roof**
Roof pitch	**22°**
Roof covering	**Tile**
Min. roof edge distance	**0.00 m**
Rafter Spacing	**0.450 m**
Rafter width	**50.0 mm**
set edge rafter left	**No**
Rafter spacing left	**220.0 mm**
Rafter spacing right	**No**
Rafter Spacing	**220.0 mm**
Batten spacing	**340.0 mm**

Loads

Design method	**BS EN**
Failure consequence class (CC)	**CC2**
Design working life	**25 years**
Terrain category	**Town Terrain**
Distance to shoreline	**100.00 km**
Distance inside town terrain	**0.20 km**

Wind load

Velocity pressure, 50	$q_{p,50}$ = **0.727 kN/m²**
Adjustment factor for service life	f_w = **1.000**
Velocity pressure, 25	$q_{p,25}$ = **0.670 kN/m²**

Structural analysis report | Roof 1

Roof areas

Array	load impact area [m²]	maxCpe$_{10}$	minCpe$_{10}$	wind pressure [kN/m²]	wind suction [kN/m²]
ridge	10.00	0.293	-1.113	0.197	-0.746
gableboard	10.00	0.293	-1.313	0.197	-0.880
corner region (eave)	10.00	0.480	-1.413	0.322	-0.947
ridge	10.00	0.293	-1.113	0.197	-0.746
eaves	10.00	0.340	-0.660	0.228	-0.442
ridge	10.00	0.293	-1.113	0.197	-0.746
eaves	10.00	0.340	-0.660	0.228	-0.442
ridge	10.00	0.293	-1.113	0.197	-0.746
gableboard	10.00	0.293	-1.313	0.197	-0.880
corner region (eave)	10.00	0.480	-1.413	0.322	-0.947
field area	10.00	0.293	-0.600	0.197	-0.402
corner region (eave)	10.00	0.480	-1.413	0.322	-0.947
eaves	10.00	0.340	-0.660	0.228	-0.442
field area	10.00	0.293	-0.600	0.197	-0.402
corner region (eave)	10.00	0.480	-1.413	0.322	-0.947
eaves	10.00	0.340	-0.660	0.228	-0.442

Snow load

Snow load zone		2
Snow guard		No
Snow load on ground level	s_k	= 0.400 kN/m²
Shape Coefficient for Snow	μ_i	= 0.800
Factor for roof pitch	d_i	= 0.927
Snow load on roof, 50	$s_{i,50}$	= 0.297 kN/m²
Adjustment factor for service life	f_s	= 1.000
Snow load on roof, 25	$s_{i,25}$	= 0.276 kN/m²

Structural analysis report | Roof 1

Dead Load

Weight of module	G_M	= 23.4 kg
Weight of mounting system per module		= 2.5 kg
Module area	A_M	= 2.08 m²
Dead weight of module per m²		= 11.24 kg/m²
Dead weight of mounting system per m²		= 1.20 kg/m²
Total Dead Load (excl. ballast) per m²		= 0.12 kN/m²

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 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	$\kappa_{Fl,G}$	= 1.00
Importance factor variable	$\kappa_{Fl,Q}$	= 1.00
Characteristic dead weight	G_k	
Characteristic snow load on the roof	$S_{i,n}$	
Characteristic wind load	W_k	

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

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	LCC 01_sls	= $G_k + S_{i,n}$
Load case combination 02	LCC 02_sls	= $G_k + W_{k,Pressure}$
Load case combination 03	LCC 03_sls	= $G_k + W_{k,Pressure} + \psi_{0,S} * S_{i,n}$

Structural analysis report | Roof 1

Load case combination 04 $LCC\ 04\_sls = G_k + S_{i,n} + \psi_{0,W} * W_{k,Pressure}$

Load case combination 06 $LCC\ 06\_sls = G_k + W_{k,Suction}$

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 ∥
ridge	10.00	0.802	0.253	-1.006	0.046	0.546	0.173	-0.633	0.046
gableboard	10.00	0.802	0.253	-1.207	0.046	0.546	0.173	-0.767	0.046
corner region (eave)	10.00	0.915	0.253	-1.307	0.046	0.621	0.173	-0.834	0.046
ridge	10.00	0.802	0.253	-1.006	0.046	0.546	0.173	-0.633	0.046
eaves	10.00	0.830	0.253	-0.550	0.046	0.565	0.173	-0.329	0.046
ridge	10.00	0.802	0.253	-1.006	0.046	0.546	0.173	-0.633	0.046
eaves	10.00	0.830	0.253	-0.550	0.046	0.565	0.173	-0.329	0.046
ridge	10.00	0.802	0.253	-1.006	0.046	0.546	0.173	-0.633	0.046
gableboard	10.00	0.802	0.253	-1.207	0.046	0.546	0.173	-0.767	0.046
corner region (eave)	10.00	0.915	0.253	-1.307	0.046	0.621	0.173	-0.834	0.046
field area	10.00	0.802	0.253	-0.490	0.046	0.546	0.173	-0.289	0.046
corner region (eave)	10.00	0.915	0.253	-1.307	0.046	0.621	0.173	-0.834	0.046
eaves	10.00	0.830	0.253	-0.550	0.046	0.565	0.173	-0.329	0.046
field area	10.00	0.802	0.253	-0.490	0.046	0.546	0.173	-0.289	0.046
corner region (eave)	10.00	0.915	0.253	-1.307	0.046	0.621	0.173	-0.834	0.046
eaves	10.00	0.830	0.253	-0.550	0.046	0.565	0.173	-0.329	0.046

Max. load on fastener

Array	A-TrA [m²]	ultimate state [kN]				Serviceability [kN]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
ridge	10.00	0.957	0.301	-1.200	0.055	0.652	0.206	-0.755	0.055
gableboard	10.00	0.957	0.301	-1.440	0.055	0.652	0.206	-0.915	0.055
corner region (eave)	10.00	0.819	0.226	-1.170	0.041	0.556	0.155	-0.746	0.041
ridge	10.00	0.957	0.301	-1.200	0.055	0.652	0.206	-0.755	0.055
eaves	10.00	0.743	0.226	-0.492	0.041	0.505	0.155	-0.294	0.041
ridge	10.00	0.957	0.301	-1.200	0.055	0.652	0.206	-0.755	0.055
eaves	10.00	0.743	0.226	-0.492	0.041	0.505	0.155	-0.294	0.041

Structural analysis report | Roof 1

ridge	10.00	0.957	0.301	-1.200	0.055	0.652	0.206	-0.755	0.055
gableboard	10.00	0.957	0.301	-1.440	0.055	0.652	0.206	-0.915	0.055
corner region (eave)	10.00	0.819	0.226	-1.170	0.041	0.556	0.155	-0.746	0.041
field area	10.00	0.686	0.216	-0.419	0.039	0.467	0.148	-0.247	0.039
corner region (eave)	10.00	0.783	0.216	-1.118	0.039	0.531	0.148	-0.713	0.039
eaves	10.00	0.710	0.216	-0.471	0.039	0.483	0.148	-0.281	0.039
field area	10.00	0.686	0.216	-0.419	0.039	0.467	0.148	-0.247	0.039
corner region (eave)	10.00	0.783	0.216	-1.118	0.039	0.531	0.148	-0.713	0.039
eaves	10.00	0.710	0.216	-0.471	0.039	0.483	0.148	-0.281	0.039

Resistance Values of Components

Base Rails

Base Rails	A [cm^2]	I_y [cm^4]	I_z [cm^4]	W_y [cm^3]	W_z [cm^3]
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]
SolidHook Pan Tile Vario 1	2.21	1.05	1.93

Utilisation result

		ultimate limit state			Usab.	Distances		maximum values	
No. Module Array	roof areas	Pr σ[%]	CL σ[%]	Fst F[%]	Pr f[%]	Fst [m]	BR [m]	CL L_{max}[m]	Fst Fst D_{max}[m]
1	ridge	49.4	5.1	99.8	59.5	1.800	---	0.573	1.803
1	gableboard	59.0	2.6	99.8	72.1	1.800	---	0.542	1.803
1	corner region (eave)	35.9	6.6	84.5	27.6	1.350	---	0.563	1.598
2	ridge	49.4	4.5	99.8	59.5	1.800	---	0.573	1.803
2	eaves	26.6	4.3	77.3	19.0	1.350	---	0.626	1.747
3	ridge	49.4	6.6	99.8	59.5	1.800	---	0.573	1.803
3	eaves	26.6	6.3	77.3	19.0	1.350	---	0.626	1.747
4	ridge	49.4	7.5	99.8	59.5	1.800	---	0.573	1.803
4	gableboard	59.0	1.1	99.8	72.1	1.800	---	0.542	1.803
4	corner region (eave)	35.9	9.7	84.5	27.6	1.350	---	0.563	1.598

Structural analysis report | Roof 1

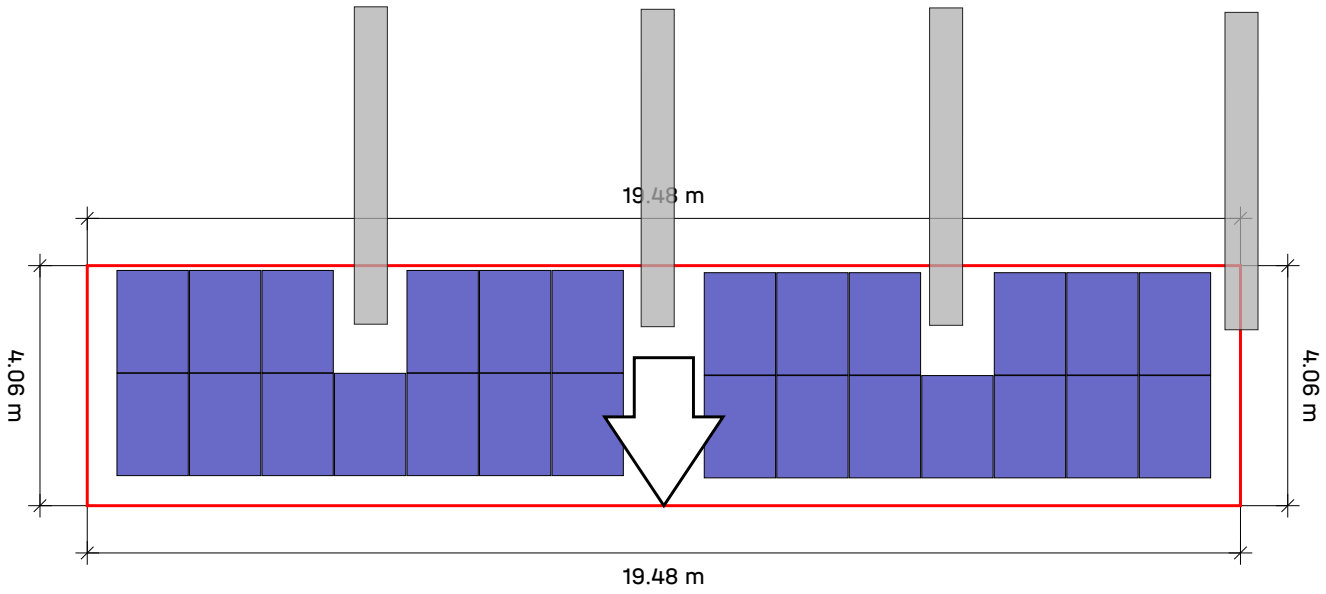
5	field area	16.5	0.0	71.6	7.8	0.900	---	0.616	1.257
5	corner region (eave)	22.9	3.4	80.8	11.7	0.900	---	0.550	1.115
5	eaves	17.0	6.5	73.9	8.1	0.900	---	0.610	1.218
6	field area	16.5	0.0	71.6	7.8	0.900	---	0.616	1.257
6	corner region (eave)	22.9	1.7	80.8	11.7	0.900	---	0.550	1.115
6	eaves	17.0	9.1	73.9	8.1	0.900	---	0.610	1.218

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	2004112	Wood screw 8×100	184	5.0 kg
2	2002589	OneEnd Black Set 30-42	56	4.9 kg
3	1000125	SolidHook Pan Tile Vario 1	92	65.5 kg
4	1000637	T-Bolt 28/15 M10×20	92	1.7 kg
5	1000042	Hexagon flange nut M10	92	1.0 kg
6	2003072	OneMid Black Set 30-42	24	1.9 kg
7	1004765	SolidRail Light End Cap	56	0.3 kg
8	2002870	K2 Solar Cable Manager	26	0.1 kg
9	2003232	SolidRail Light; 3.30 m	32	89.6 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	24	5.4 kg
Total				**175.3 kg**

Roofs | Roof 2



Roof	System	Module	Height	Quantity	Total power
Roof 2 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	8.32 m	26	12.22 kWp

Roofs | Roof 2 | Assembly plan

Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 3.30 m	Part of Rail	Length	Rest
4*A	8.655	2*3.30 m	3.300	2.055 from 3.300	1.235
4*B	3.755	1*3.30 m	1.235	0.700 from 1.235	0.525
1*C	3.755	1*3.30 m	3.300	0.700 from 3.300	2.590
1*D	3.755	1*3.30 m	2.590	0.700 from 2.590	1.880
1*E	3.755	1*3.30 m	1.880	0.700 from 1.880	1.170
1*F	3.755	1*3.30 m	1.170	0.700 from 1.170	0.460

1 cm is viewed as lost for each cutting

Red numbers are leftover rails which will not be used any longer

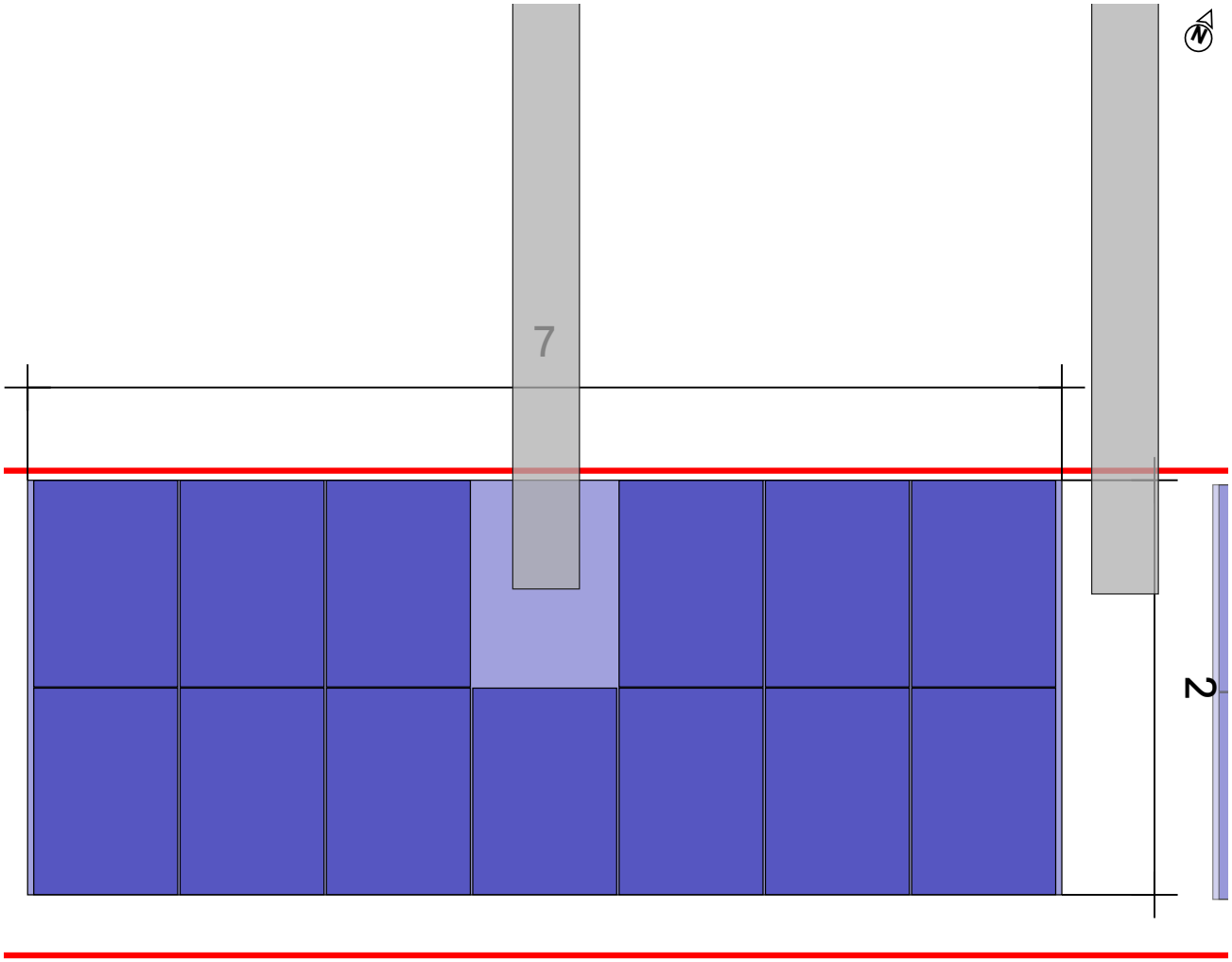
Fastener Spacing

Module	Array	Distance	maximum cantilever length	maximum fastener spacing
1	ridge	0.90 m	0.598	1.113
1	gableboard	0.90 m	0.598	1.113
1	corner region (eave)	0.45 m	0.450	0.885
1	eaves	0.90 m	0.588	1.051
2	ridge	0.90 m	0.598	1.113
2	gableboard	0.90 m	0.598	1.113
2	corner region (eave)	0.45 m	0.450	0.885
2	eaves	0.90 m	0.588	1.051

Module arrays

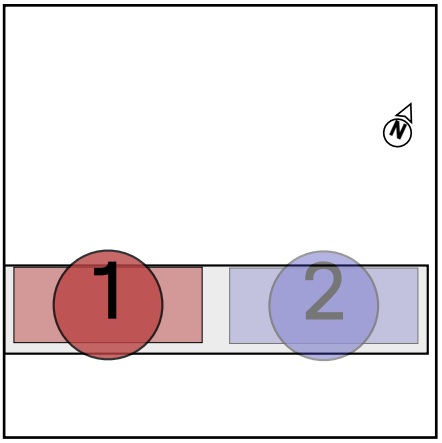
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	8.56	3.47	7	2
2	8.56	3.47	7	2

Roofs | Roof 2 | Module array 1

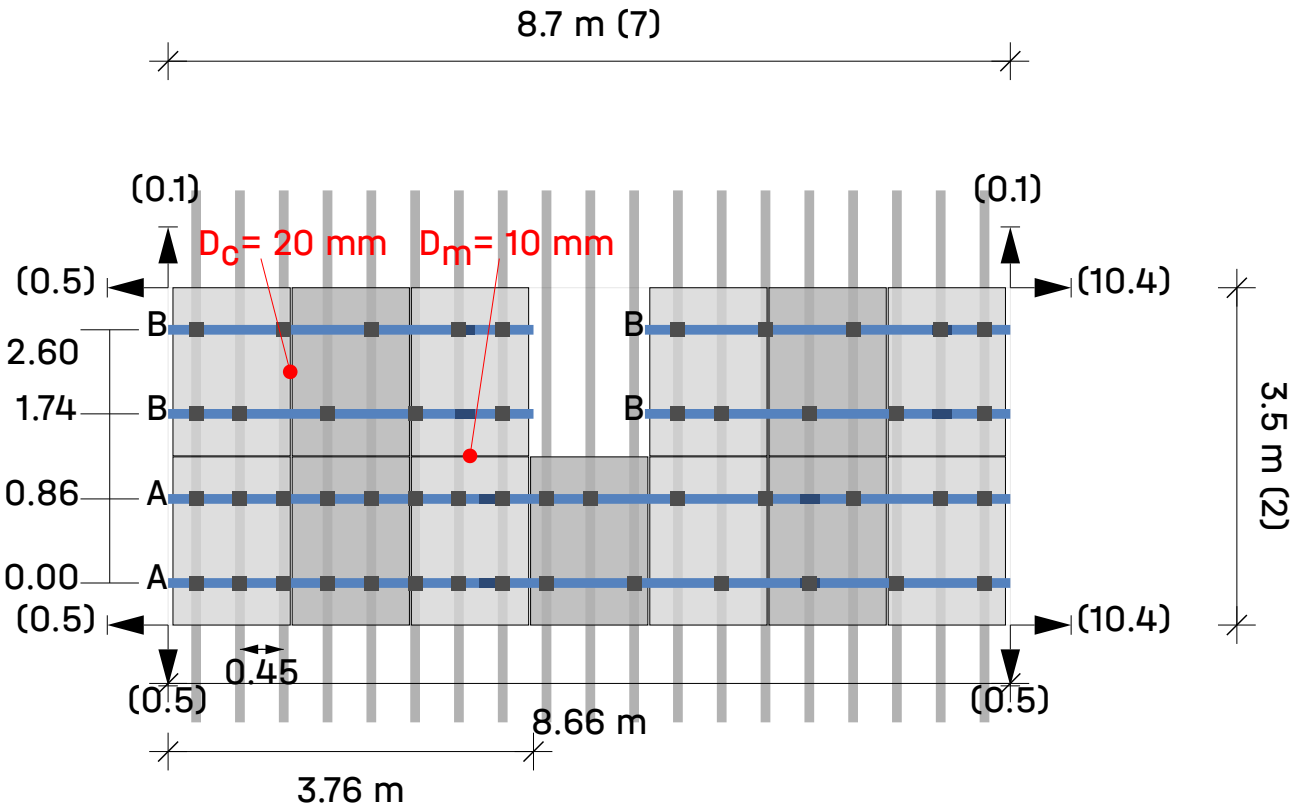


Roof (2) Module array (1)

Mounting System	SolidRail
Module	13(6.11 kWp) x Alpha Pure-RX
Row spacing	1.74 m



Roofs | Roof 2 | Module array 1 | Module blocks

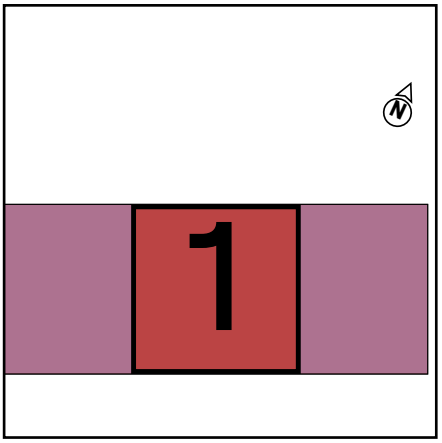


Roof (2) Module array (1) Module block 1

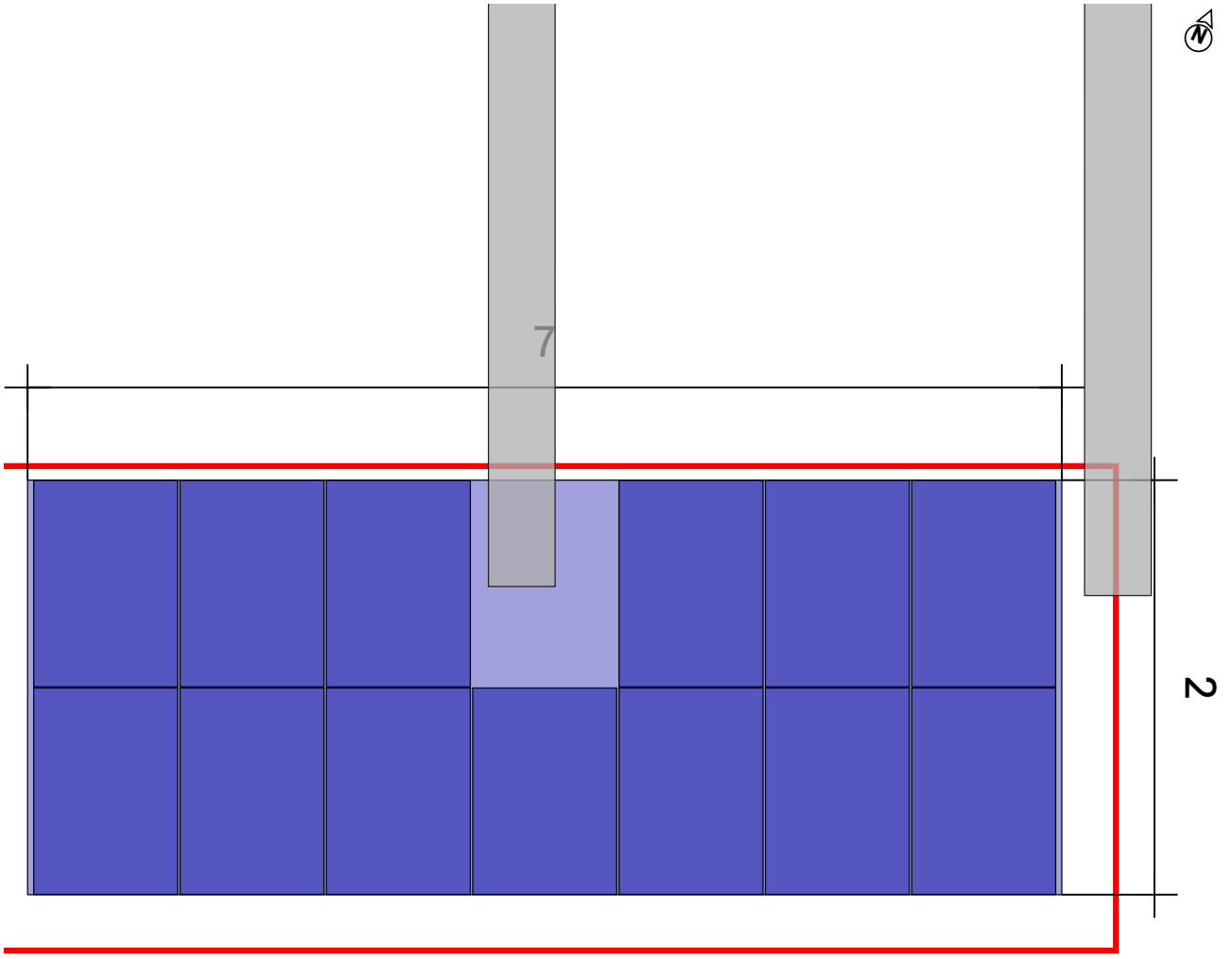
Modules (7 × 2) - 1 = **13**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules

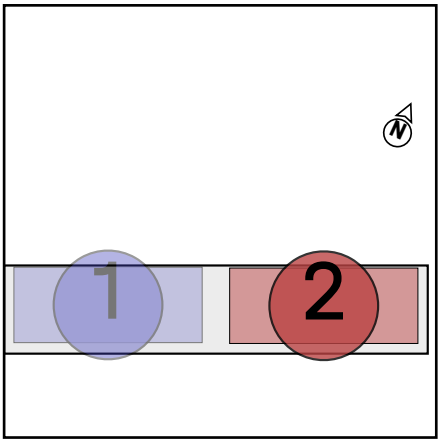


Roofs | Roof 2 | Module array 2

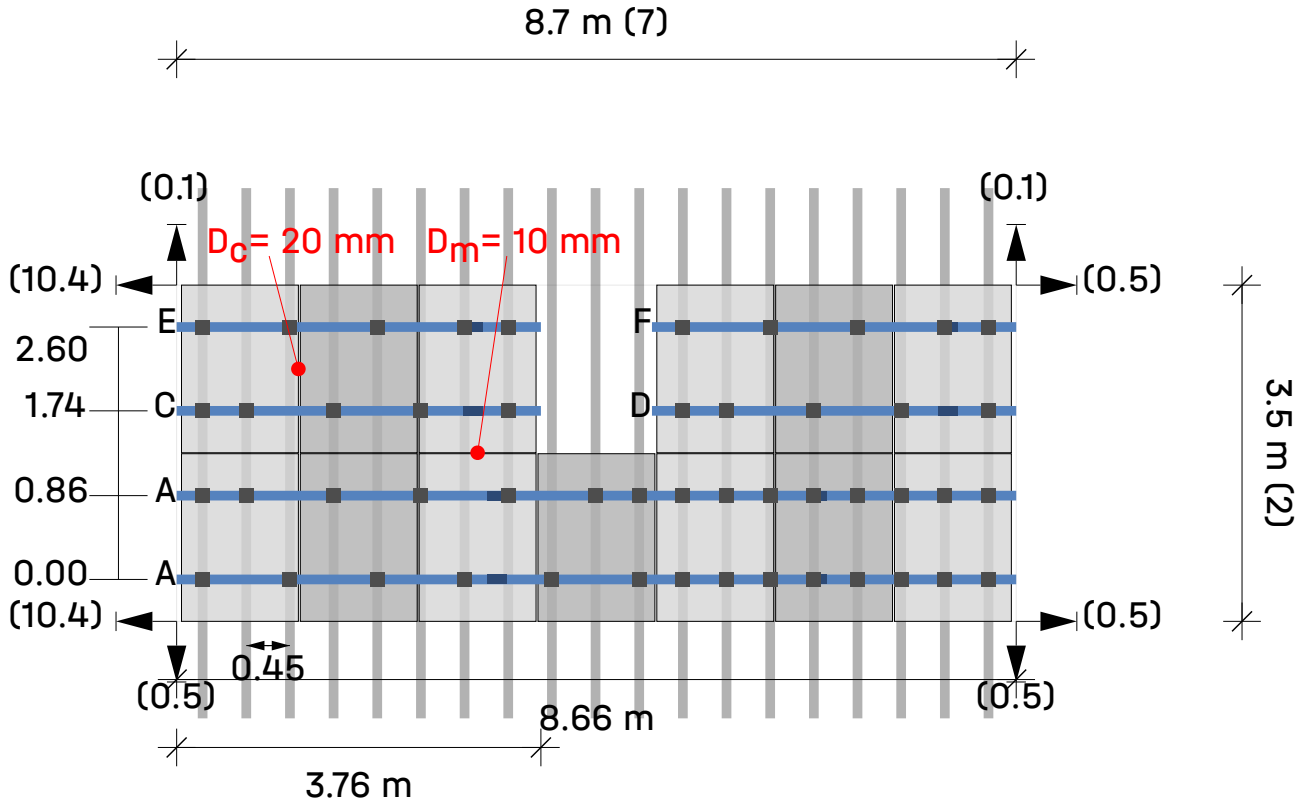


Roof (2) Module array 2

Mounting System	SolidRail
Module	13(6.11 kWp) x Alpha Pure-RX
Row spacing	1.74 m



Roofs | Roof 2 | Module array 2 | Module blocks

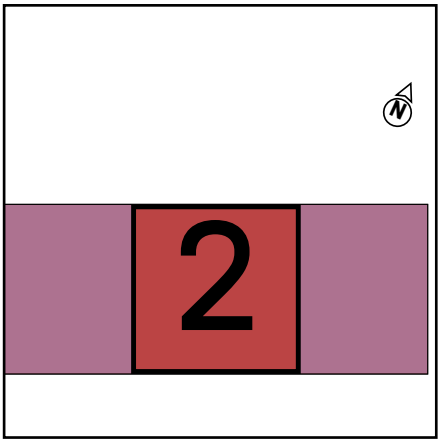


Roof (2) Module array 2 Module block 2

Modules (7 × 2) - 1 = **13**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules



Results | Roof 2

Roof	System	Module	Height	Quantity	Total power
Roof 2 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	8.32 m	26	12.22 kWp

Module

Name	Alpha Pure-RX
Manufacturer	REC
Output power	470 Wp
Dimensions	1,728×1,205×30 mm
Weight	23.4 kg

Components

Fastener	SolidHook Pan Tile Vario 1
Base rails	K2 SolidRail Light 37

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
ridge	2.08	880.2	372.0	-779.2	61.0	597.4	254.1	-484.2	61.0
gableboard	2.08	880.2	372.0	-975.8	61.0	597.4	254.1	-615.3	61.0
corner region (eave)	2.08	1,180.0	372.0	-1,074.1	61.0	797.2	254.1	-680.9	61.0
eaves	2.08	939.2	372.0	-484.2	61.0	636.7	254.1	-287.6	61.0
ridge	2.08	880.2	372.0	-779.2	61.0	597.4	254.1	-484.2	61.0
gableboard	2.08	880.2	372.0	-975.8	61.0	597.4	254.1	-615.3	61.0
corner region (eave)	2.08	1,180.0	372.0	-1,074.1	61.0	797.2	254.1	-680.9	61.0
eaves	2.08	939.2	372.0	-484.2	61.0	636.7	254.1	-287.6	61.0

Results | Roof 2

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	ridge	19.1	13.6	80.9	8.7	0.900	---	0.598	1.113
1	gableboard	19.1	9.8	80.9	8.7	0.900	---	0.598	1.113
1	corner region (eave)	6.1	12.4	50.9	1.4	0.450	---	0.450	0.885
1	eaves	20.1	8.7	85.7	9.2	0.900	---	0.588	1.051
2	ridge	19.1	13.4	80.9	8.7	0.900	---	0.598	1.113
2	gableboard	19.1	9.6	80.9	8.7	0.900	---	0.598	1.113
2	corner region (eave)	6.1	12.2	50.9	1.4	0.450	---	0.450	0.885
2	eaves	20.1	8.9	85.7	9.2	0.900	---	0.588	1.051

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 dimensioning of the timber construction screws is not part of this structural analysis. The dimensioning and positioning of the timber construction screws to be used must be carried out in accordance with the respective applicable codes of practice.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminum structures (DIN EN 1999-1-1:2021) and offers sufficient load-bearing capacity and stability for the loads specified in the chapter 'Maximum actions on the components'.
- Adjustment factor for wind load regarding servise life periond, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding servise life periond, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- 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 2

General information

Name	**Lincoln College - Museum Road - PV - Final**
Mounting System	**SolidRail**
Author	**Daniel Tempest**

Location information

Address	**9 Museum Rd, Oxford OX1 3PX, UK**
Ground elevation	**65.14 m**

Roof information

Building height	**8.32 m**
Roof type	**Gable roof**
Roof pitch	**30°**
Roof covering	**Tile**
Min. roof edge distance	**0.00 m**
Rafter Spacing	**0.450 m**
Rafter width	**50.0 mm**
set edge rafter left	**No**
Rafter spacing left	**290.0 mm**
Rafter spacing right	**No**
Rafter Spacing	**290.0 mm**
Batten spacing	**340.0 mm**

Loads

Design method	**BS EN**
Failure consequence class (CC)	**CC2**
Design working life	**25 years**
Terrain category	**Town Terrain**
Distance to shoreline	**100.00 km**
Distance inside town terrain	**0.20 km**

Wind load

Velocity pressure, 50	$q_{p,50}$ **= 0.712 kN/m²**
Adjustment factor for service life	f_w **= 1.000**
Velocity pressure, 25	$q_{p,25}$ **= 0.655 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]
ridge	10.00	0.400	-0.900	0.262	-0.590
gableboard	10.00	0.400	-1.100	0.262	-0.721
corner region (eave)	10.00	0.800	-1.200	0.524	-0.787
eaves	10.00	0.500	-0.600	0.328	-0.393
ridge	10.00	0.400	-0.900	0.262	-0.590
gableboard	10.00	0.400	-1.100	0.262	-0.721
corner region (eave)	10.00	0.800	-1.200	0.524	-0.787
eaves	10.00	0.500	-0.600	0.328	-0.393

Snow load

Snow load zone		2
Snow guard		No
Snow load on ground level	s_k	= 0.400 kN/m²
Shape Coefficient for Snow	μ_i	= 1.200
Factor for roof pitch	d_i	= 0.866
Snow load on roof, 50	$s_{i,50}$	= 0.416 kN/m²
Adjustment factor for service life	f_s	= 1.000
Snow load on roof, 25	$s_{i,25}$	= 0.386 kN/m²

Dead Load

Weight of module	G_M	= 23.4 kg
Weight of mounting system per module		= 2.5 kg
Module area	A_M	= 2.08 m²
Dead weight of module per m²		= 11.24 kg/m²
Dead weight of mounting system per m²		= 1.20 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 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	$\kappa_{Fl,G}$ = 1.00
Importance factor variable	$\kappa_{Fl,Q}$ = 1.00
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

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

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

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 ∥
ridge	10.00	0.880	0.372	-0.779	0.061	0.597	0.254	-0.484	0.061
gableboard	10.00	0.880	0.372	-0.976	0.061	0.597	0.254	-0.615	0.061
corner region (eave)	10.00	1.180	0.372	-1.074	0.061	0.797	0.254	-0.681	0.061
eaves	10.00	0.939	0.372	-0.484	0.061	0.637	0.254	-0.288	0.061
ridge	10.00	0.880	0.372	-0.779	0.061	0.597	0.254	-0.484	0.061
gableboard	10.00	0.880	0.372	-0.976	0.061	0.597	0.254	-0.615	0.061
corner region (eave)	10.00	1.180	0.372	-1.074	0.061	0.797	0.254	-0.681	0.061
eaves	10.00	0.939	0.372	-0.484	0.061	0.637	0.254	-0.288	0.061

Max. load on fastener

Array	A-TrA [m²]	ultimate state [kN]				Serviceability [kN]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
ridge	10.00	0.753	0.318	-0.666	0.052	0.511	0.217	-0.414	0.052
gableboard	10.00	0.753	0.318	-0.835	0.052	0.511	0.217	-0.526	0.052
corner region (eave)	10.00	0.505	0.159	-0.459	0.026	0.341	0.109	-0.291	0.026
eaves	10.00	0.803	0.318	-0.414	0.052	0.545	0.217	-0.246	0.052
ridge	10.00	0.753	0.318	-0.666	0.052	0.511	0.217	-0.414	0.052
gableboard	10.00	0.753	0.318	-0.835	0.052	0.511	0.217	-0.526	0.052
corner region (eave)	10.00	0.505	0.159	-0.459	0.026	0.341	0.109	-0.291	0.026
eaves	10.00	0.803	0.318	-0.414	0.052	0.545	0.217	-0.246	0.052

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

Structural analysis report | Roof 2

Fastener	$R_{D,Uplift,Perpendicular}$ [kN]	$R_{D,Pressure,Perpendicular}$ [kN]	$R_{D,Pressure,Parallel}$ [kN]
SolidHook Pan Tile Vario 1	2.21	1.05	1.93

Utilisation result

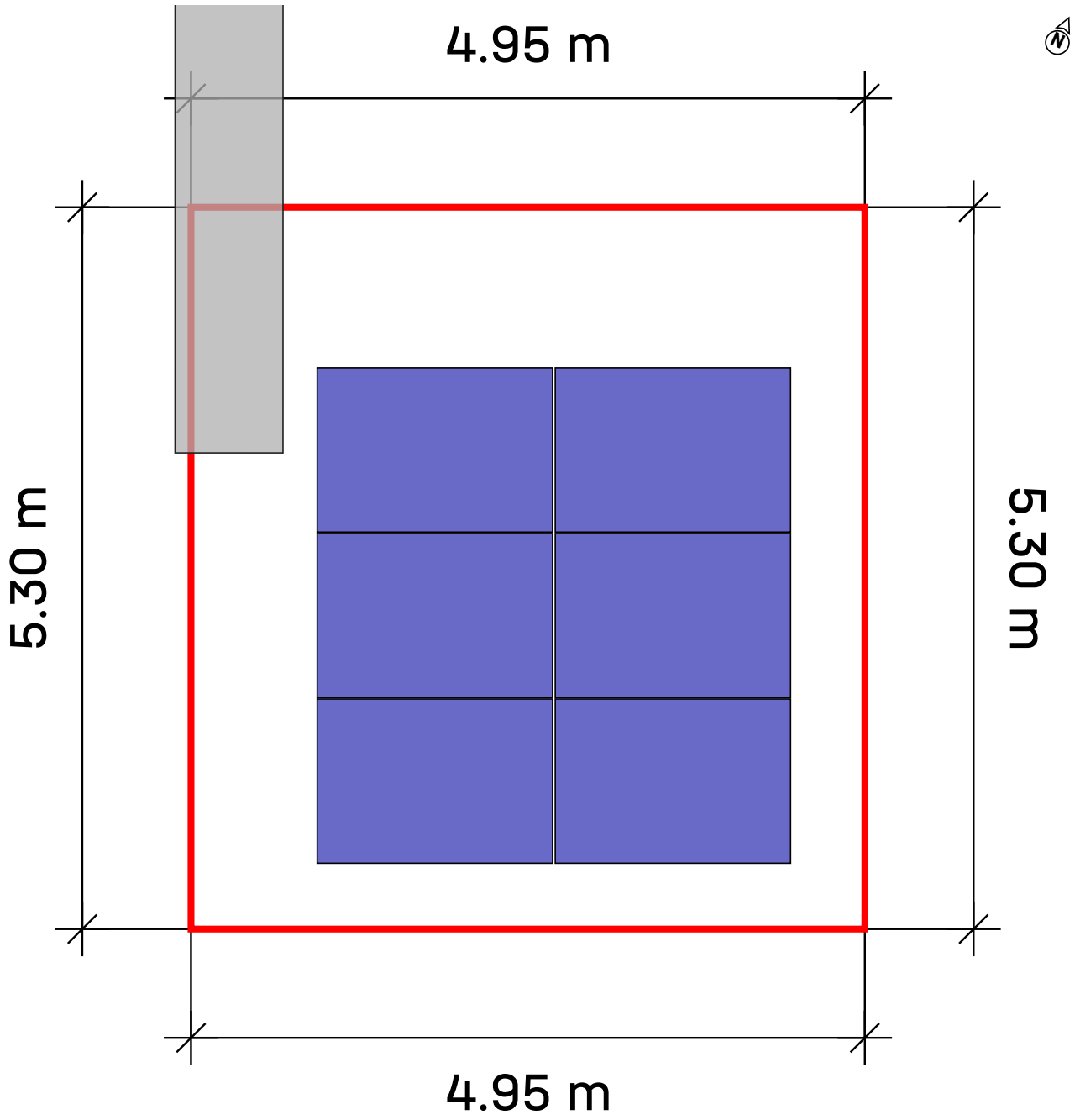
No. Module Array	roof areas	ultimate limit state Pr σ[%]	ultimate limit state CL σ[%]	ultimate limit state Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	Distances BR [m]	maximum values CL L_{max}[m]	maximum values Fst Fst D_{max}[m]
1	ridge	19.1	13.6	80.9	8.7	0.900	---	0.598	1.113
1	gableboard	19.1	9.8	80.9	8.7	0.900	---	0.598	1.113
1	corner region (eave)	6.1	12.4	50.9	1.4	0.450	---	0.450	0.885
1	eaves	20.1	8.7	85.7	9.2	0.900	---	0.588	1.051
2	ridge	19.1	13.4	80.9	8.7	0.900	---	0.598	1.113
2	gableboard	19.1	9.6	80.9	8.7	0.900	---	0.598	1.113
2	corner region (eave)	6.1	12.2	50.9	1.4	0.450	---	0.450	0.885
2	eaves	20.1	8.9	85.7	9.2	0.900	---	0.588	1.051

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	2004112	Wood screw 8×100	196	5.3 kg
2	2002589	OneEnd Black Set 30-42	24	2.1 kg
3	1000125	SolidHook Pan Tile Vario 1	98	69.8 kg
4	1000637	T-Bolt 28/15 M10×20	98	1.8 kg
5	1000042	Hexagon flange nut M10	98	1.1 kg
6	2003072	OneMid Black Set 30-42	40	3.2 kg
7	1004765	SolidRail Light End Cap	24	0.1 kg
8	2002870	K2 Solar Cable Manager	26	0.1 kg
9	2003232	SolidRail Light; 3.30 m	21	58.8 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	16	3.6 kg
Total				**145.8 kg**

Roofs | Roof 3



Roof	System	Module	Height	Quantity	Total power
Roof 3 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	9.00 m	6	2.82 kWp

Roofs | Roof 3 | Assembly plan

Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 3.30 m	Part of Rail	Length	Rest
2*A	3.576	1*3.30 m	3.300	0.700 from 3.300	2.590
2*B	3.576	1*3.30 m	2.590	0.700 from 2.590	1.880
1*C	3.576	1*3.30 m	1.880	0.700 from 1.880	1.170
1*D	3.576	1*3.30 m	1.170	0.700 from 1.170	0.460

1 cm is viewed as lost for each cutting

Red numbers are leftover rails which will not be used any longer

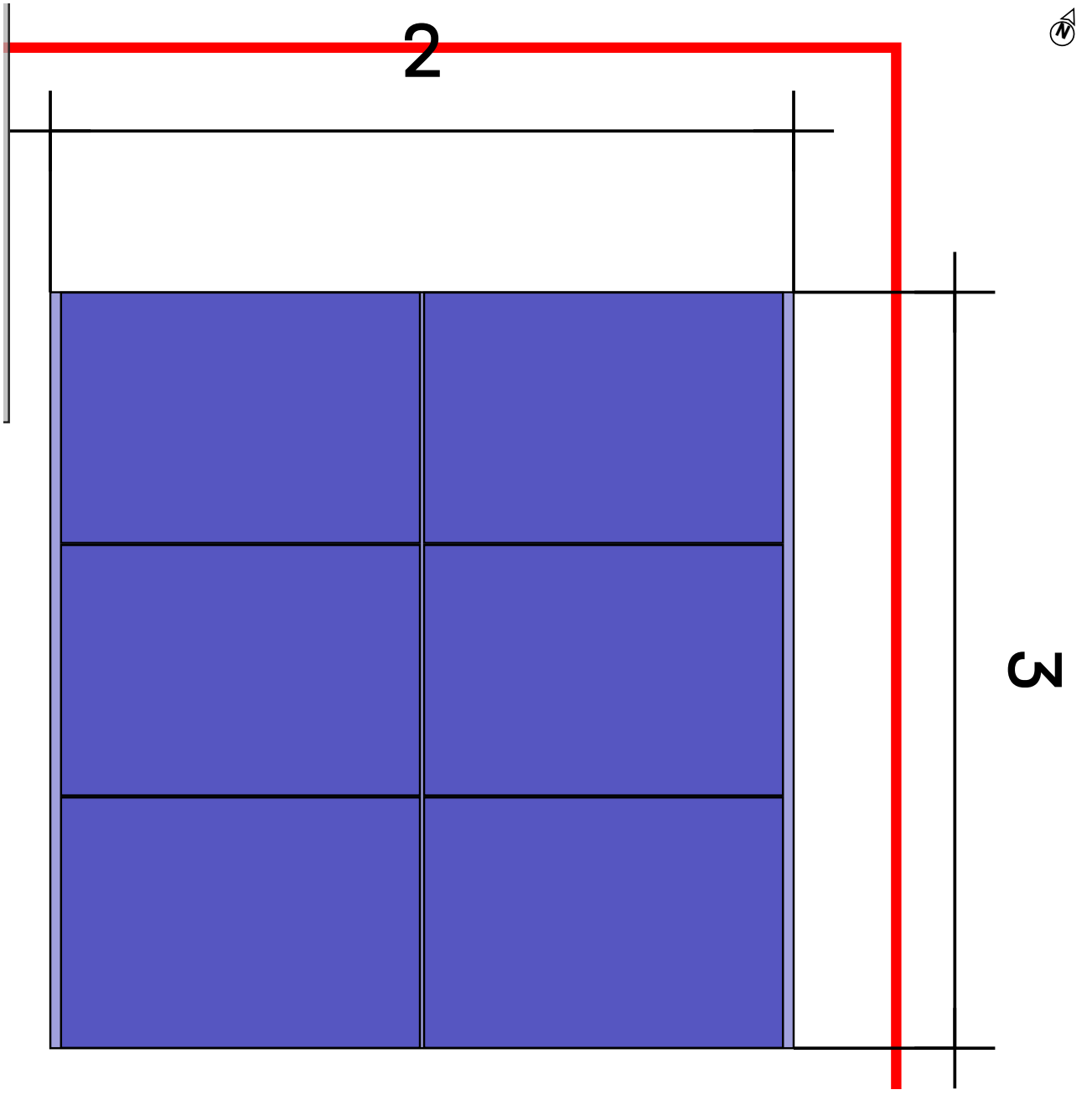
Fastener Spacing

Module	Array	Distance	maximum cantilever length	maximum fastener spacing
1	field area	1.80 m	0.594	1.803
1	gableboard	1.80 m	0.542	1.803
1	corner region (eave)	1.35 m	0.563	1.598
1	eaves	1.35 m	0.626	1.747

Module arrays

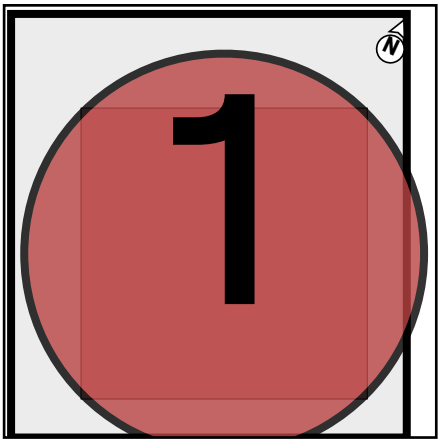
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	3.48	3.64	2	3

Roofs | Roof 3 | Module array 1

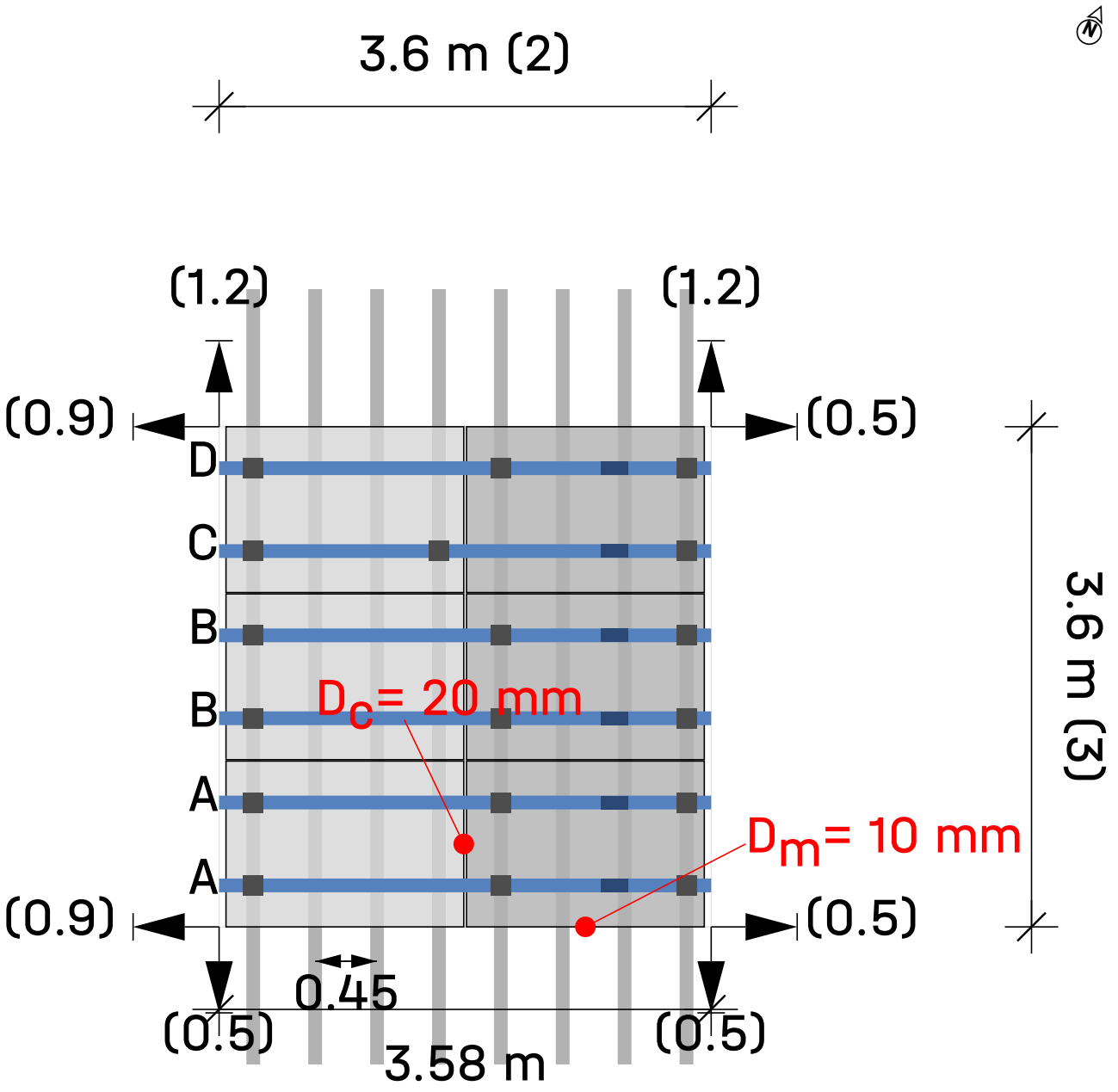


Roof (3) Module array (1)

Mounting System	SolidRail
Module	6(2.82 kWp) x Alpha Pure-RX
Row spacing	1.22 m



Roofs | Roof 3 | Module array 1 | Module blocks



Roof (3) Module array (1) Module block 1

Modules 2 × 3 = **6**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_c Distance for clamping between modules
- D_m Distance between modules

Results | Roof 3

Roof	System	Module	Height	Quantity	Total power
Roof 3 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	9.00 m	6	2.82 kWp

Module

Name	Alpha Pure-RX
Manufacturer	REC
Output power	470 Wp
Dimensions	1,728×1,205×30 mm
Weight	23.4 kg

Components

Fastener	SolidHook Pan Tile Vario 1
Base rails	K2 SolidRail Light 37

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	2.08	802.3	252.7	-489.9	45.7	546.2	173.0	-288.9	45.7
gableboard	2.08	802.3	252.7	-1,206.7	45.7	546.2	173.0	-766.8	45.7
corner region (eave)	2.08	914.9	252.7	-1,307.2	45.7	621.2	173.0	-833.8	45.7
eaves	2.08	830.5	252.7	-550.2	45.7	565.0	173.0	-329.1	45.7

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	46.0	0.0	99.8	52.3	1.800	---	0.594	1.803
1	gableboard	59.0	5.6	99.8	72.1	1.800	---	0.542	1.803
1	corner region (eave)	35.9	6.1	84.5	27.6	1.350	---	0.563	1.598
1	eaves	26.6	0.0	77.3	19.0	1.350	---	0.626	1.747

Pr	Profile	Fst D_{max}	maximum fastener spacing
Fst	Fastener	BR	Base Rail
σ	Stress	Usab.	serviceability limit state

Results | Roof 3

f	**Deflection**
F	**Force**
CL/L_{max}	**maximum cantilever length**
CL	**Cantilever**

Results | Roof 3

Notes

- The dimensioning of the timber construction screws is not part of this structural analysis. The dimensioning and positioning of the timber construction screws to be used must be carried out in accordance with the respective applicable codes of practice.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminum structures (DIN EN 1999-1-1:2021) and offers sufficient load-bearing capacity and stability for the loads specified in the chapter 'Maximum actions on the components'.
- Adjustment factor for wind load regarding servise life periond, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding servise life periond, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- 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'').
- The clamping range of the module may not comply with for this installation variant, as the rail spacing depends on the laying of the tiles and thus the batten length. Please ensure that the clamping range specified by the module manufacturer is observed.

Structural analysis report | Roof 3

General information

Name	**Lincoln College - Museum Road - PV - Final**
Mounting System	**SolidRail**
Author	**Daniel Tempest**

Location information

Address	**9 Museum Rd, Oxford OX1 3PX, UK**
Ground elevation	**65.14 m**

Roof information

Building height	**9.00 m**
Roof type	**Gable roof**
Roof pitch	**22°**
Roof covering	**Tile**
Min. roof edge distance	**0.00 m**
Rafter Spacing	**0.450 m**
Rafter width	**50.0 mm**
set edge rafter left	**No**
Rafter spacing left	**225.0 mm**
Rafter spacing right	**No**
Rafter Spacing	**225.0 mm**
Batten spacing	**340.0 mm**

Loads

Design method	**BS EN**
Failure consequence class (CC)	**CC2**
Design working life	**25 years**
Terrain category	**Town Terrain**
Distance to shoreline	**100.00 km**
Distance inside town terrain	**0.20 km**

Wind load

Velocity pressure, 50	$q_{p,50}$ = **0.727 kN/m²**
Adjustment factor for service life	f_w = **1.000**
Velocity pressure, 25	$q_{p,25}$ = **0.670 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	0.293	-0.600	0.197	-0.402
gableboard	10.00	0.293	-1.313	0.197	-0.880
corner region (eave)	10.00	0.480	-1.413	0.322	-0.947
eaves	10.00	0.340	-0.660	0.228	-0.442

Snow load

Snow load zone		2
Snow guard		No
Snow load on ground level	s_k	= 0.400 kN/m²
Shape Coefficient for Snow	μ_i	= 0.800
Factor for roof pitch	d_i	= 0.927
Snow load on roof, 50	$s_{i,50}$	= 0.297 kN/m²
Adjustment factor for service life	f_s	= 1.000
Snow load on roof, 25	$s_{i,25}$	= 0.276 kN/m²

Dead Load

Weight of module	G_M	= 23.4 kg
Weight of mounting system per module		= 2.5 kg
Module area	A_M	= 2.08 m²
Dead weight of module per m²		= 11.24 kg/m²
Dead weight of mounting system per m²		= 1.20 kg/m²
Total Dead Load (excl. ballast) per m²		= 0.12 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 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	$\kappa_{Fl,G}$	= 1.00
Importance factor variable	$\kappa_{Fl,Q}$	= 1.00
Characteristic dead weight	G_k	
Characteristic snow load on the roof	$S_{i,n}$	
Characteristic wind load	W_k	

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

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

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	0.802	0.253	-0.490	0.046	0.546	0.173	-0.289	0.046
gableboard	10.00	0.802	0.253	-1.207	0.046	0.546	0.173	-0.767	0.046
corner region (eave)	10.00	0.915	0.253	-1.307	0.046	0.621	0.173	-0.834	0.046
eaves	10.00	0.830	0.253	-0.550	0.046	0.565	0.173	-0.329	0.046

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	0.957	0.301	-0.584	0.055	0.652	0.206	-0.345	0.055
gableboard	10.00	0.957	0.301	-1.440	0.055	0.652	0.206	-0.915	0.055
corner region (eave)	10.00	0.819	0.226	-1.170	0.041	0.556	0.155	-0.746	0.041
eaves	10.00	0.743	0.226	-0.492	0.041	0.505	0.155	-0.294	0.041

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]
SolidHook Pan Tile Vario 1	2.21	1.05	1.93

Structural analysis report | Roof 3

Utilisation result

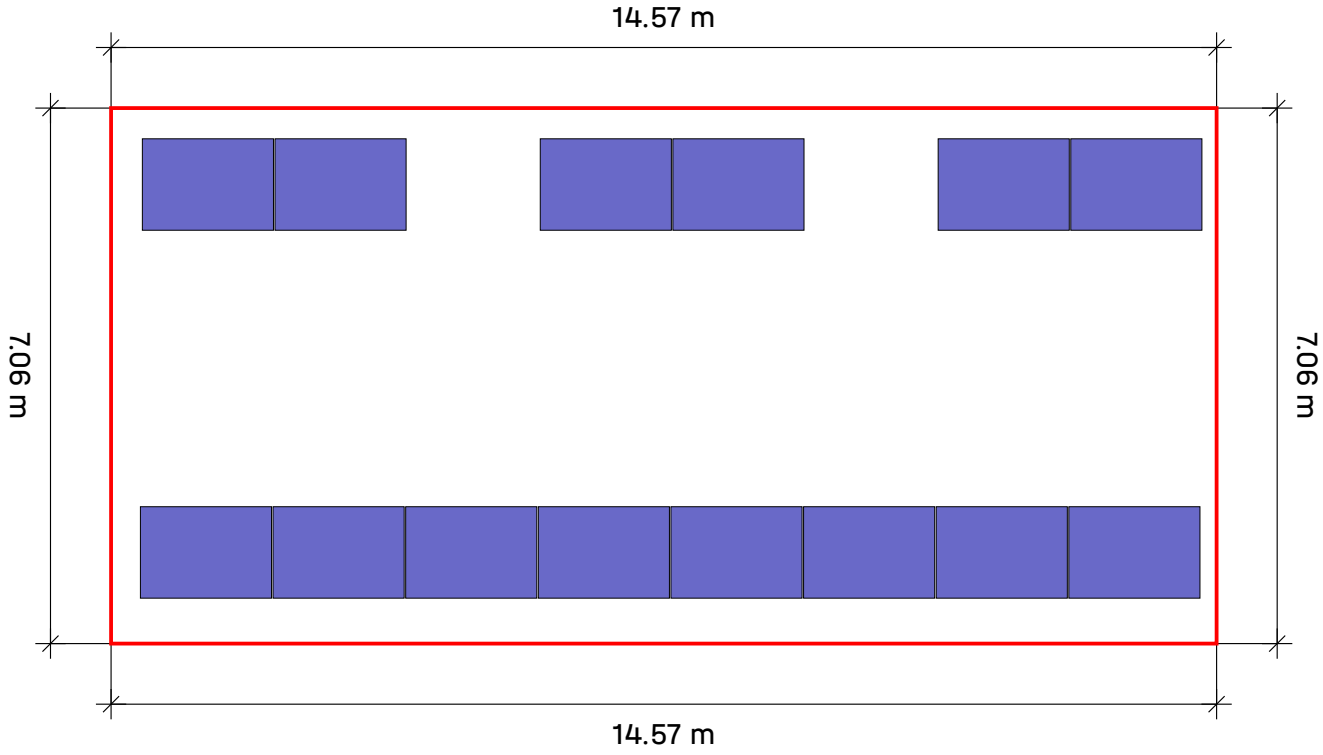
No. Module	Array	roof areas	ultimate limit state Pr σ[%]	CL σ[%]	Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	BR [m]	maximum values CL L_{max}[m]	Fst Fst D_{max}[m]
1		field area	46.0	0.0	99.8	52.3	1.800	---	0.594	1.803
1		gableboard	59.0	5.6	99.8	72.1	1.800	---	0.542	1.803
1		corner region (eave)	35.9	6.1	84.5	27.6	1.350	---	0.563	1.598
1		eaves	26.6	0.0	77.3	19.0	1.350	---	0.626	1.747

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 3 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	1000125	SolidHook Pan Tile Vario 1	18	12.8 kg
2	1000637	T-Bolt 28/15 M10×20	18	0.3 kg
3	1000042	Hexagon flange nut M10	18	0.2 kg
4	2004112	Wood screw 8×100	36	1.0 kg
5	2002589	OneEnd Black Set 30-42	12	1.0 kg
6	2003072	OneMid Black Set 30-42	6	0.5 kg
7	1004765	SolidRail Light End Cap	12	0.1 kg
8	2002870	K2 Solar Cable Manager	6	0.0 kg
9	2003232	SolidRail Light; 3.30 m	8	22.4 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	6	1.4 kg
Total				**39.7 kg**

Roofs | Roof 4



Roof	System	Module	Height	Quantity	Total power
Roof 4 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	8.50 m	14	6.58 kWp

Roofs | Roof 4 | Assembly plan

Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 3.30 m	Part of Rail	Length	Rest
1*A	14.064	4*3.30 m	3.300	0.864 from 3.300	2.426
1*B	14.064	4*3.30 m	2.426	0.864 from 2.426	1.552
1*C	3.576	1*3.30 m	1.552	0.700 from 1.552	0.842
1*D	3.576	1*3.30 m	0.842	0.700 from 0.842	0.132
1*E	3.576	1*3.30 m	3.300	0.700 from 3.300	2.590
1*F	3.576	1*3.30 m	2.590	0.700 from 2.590	1.880
1*G	3.576	1*3.30 m	1.880	0.700 from 1.880	1.170
1*H	3.576	1*3.30 m	1.170	0.700 from 1.170	0.460

1 cm is viewed as lost for each cutting

Red numbers are leftover rails which will not be used any longer

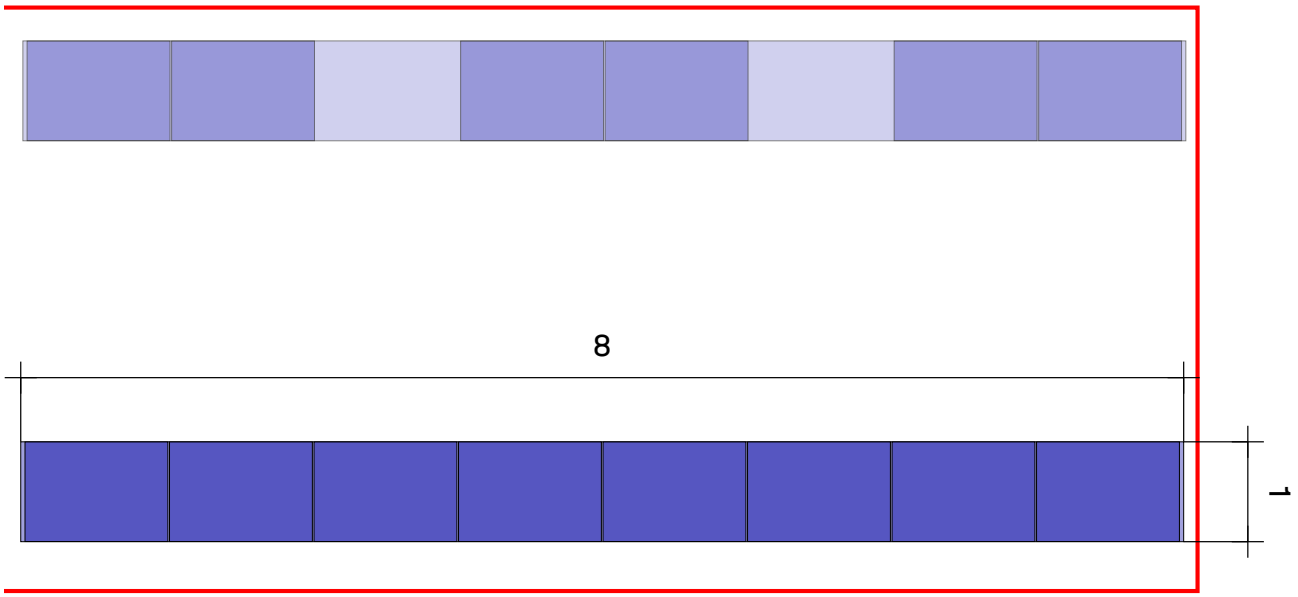
Fastener Spacing

Module	Array	Distance	maximum cantilever length	maximum fastener spacing
1	field area	1.80 m	0.595	1.809
1	corner region (eave)	1.35 m	0.566	1.606
1	eaves	1.35 m	0.627	1.753
2	field area	1.80 m	0.595	1.809
2	ridge	1.80 m	0.576	1.809
2	gableboard	1.80 m	0.545	1.809

Module arrays

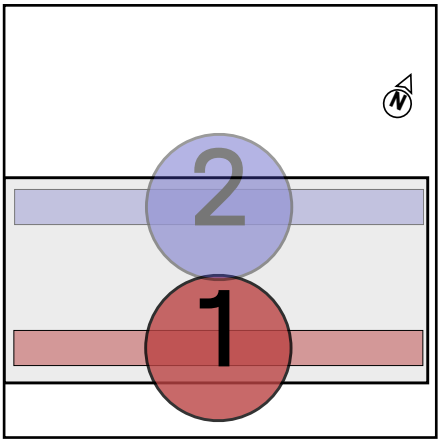
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	13.96	1.21	8	1
2	13.96	1.21	8	1

Roofs | Roof 4 | Module array 1

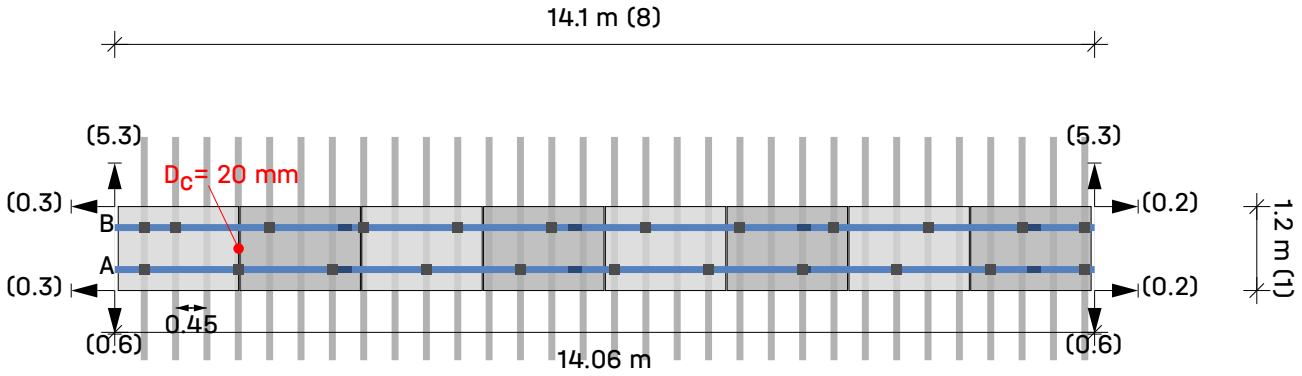


Roof 4 Module array 1

Mounting System	SolidRail
Module	8(3.76 kWp) x Alpha Pure-RX
Row spacing	1.22 m



Roofs | Roof 4 | Module array 1 | Module blocks

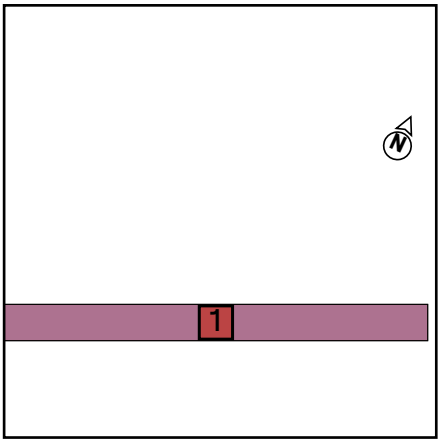


Roof 4 Module array 1 Module block 1

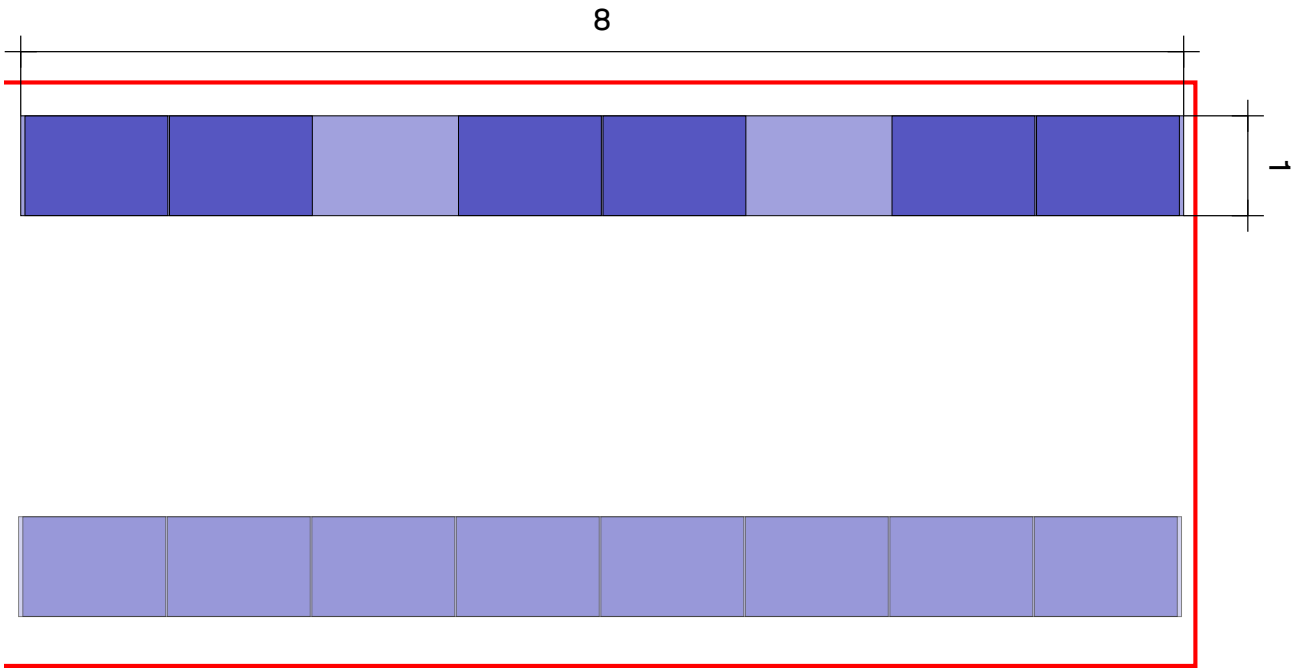
Modules 8 × 1 = **8**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules

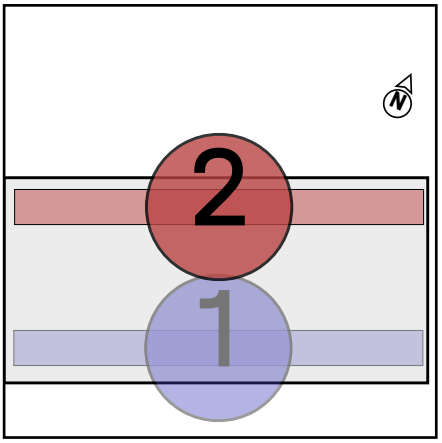


Roofs | Roof 4 | Module array 2

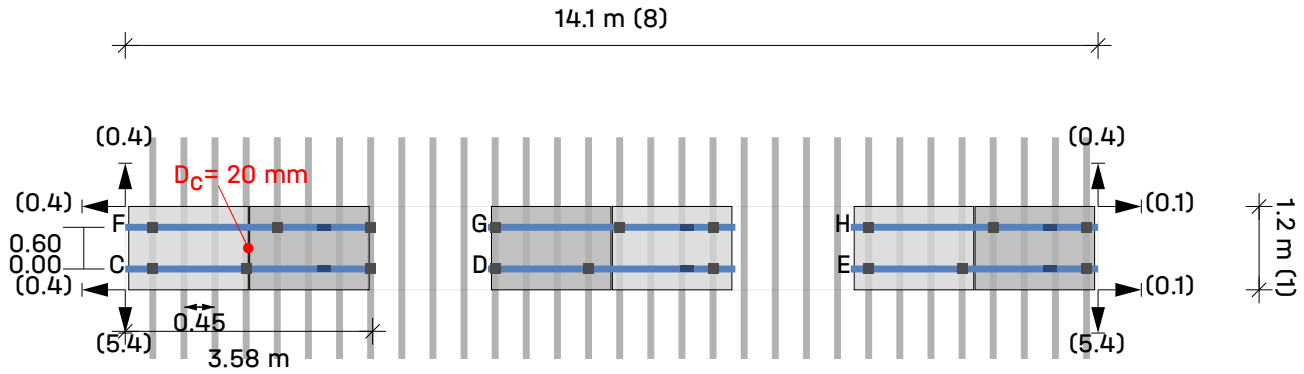


Roof 4 Module array 2

Mounting System	SolidRail
Module	6(2.82 kWp) x Alpha Pure-RX
Row spacing	1.22 m



Roofs | Roof 4 | Module array 2 | Module blocks

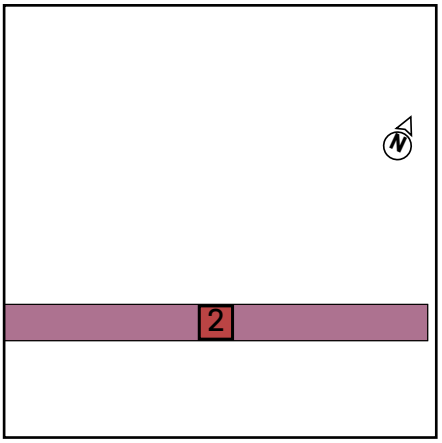


Roof (4) Module array (2) Module block 2

Modules (8 × 1) - 2 = **6**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules



Results | Roof 4

Roof	System	Module	Height	Quantity	Total power
Roof 4 Tile	SolidRail	Alpha Pure-RX 1,728×1,205×30 mm 470 Wp	8.50 m	14	6.58 kWp

Module

Name	Alpha Pure-RX
Manufacturer	REC
Output power	470 Wp
Dimensions	1,728×1,205×30 mm
Weight	23.4 kg

Components

Fastener	SolidHook Pan Tile Vario 1
Base rails	K2 SolidRail Light 37

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	2.08	799.6	252.7	-480.3	45.7	544.3	173.0	-282.5	45.7
corner region (eave)	2.08	910.3	252.7	-1,284.8	45.7	618.2	173.0	-818.8	45.7
eaves	2.08	827.2	252.7	-539.7	45.7	562.8	173.0	-322.1	45.7
field area	2.08	799.6	252.7	-480.3	45.7	544.3	173.0	-282.5	45.7
ridge	2.08	799.6	252.7	-988.1	45.7	544.3	173.0	-621.0	45.7
gableboard	2.08	799.6	252.7	-1,185.9	45.7	544.3	173.0	-752.9	45.7

Results | Roof 4

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	45.8	0.0	99.5	52.1	1.800	---	0.595	1.809
1	corner region (eave)	35.3	17.3	84.1	27.1	1.350	---	0.566	1.606
1	eaves	26.5	0.0	77.0	18.9	1.350	---	0.627	1.753
2	field area	45.8	0.0	99.5	52.1	1.800	---	0.595	1.809
2	ridge	48.5	7.8	99.5	58.4	1.800	---	0.576	1.809
2	gableboard	58.0	14.2	99.5	70.8	1.800	---	0.545	1.809

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 4

Notes

- The dimensioning of the timber construction screws is not part of this structural analysis. The dimensioning and positioning of the timber construction screws to be used must be carried out in accordance with the respective applicable codes of practice.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminum structures (DIN EN 1999-1-1:2021) and offers sufficient load-bearing capacity and stability for the loads specified in the chapter 'Maximum actions on the components'.
- Adjustment factor for wind load regarding servise life periond, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding servise life periond, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- 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'').
- The clamping range of the module may not comply with for this installation variant, as the rail spacing depends on the laying of the tiles and thus the batten length. Please ensure that the clamping range specified by the module manufacturer is observed.

Structural analysis report | Roof 4

General information

Name	**Lincoln College - Museum Road - PV - Final**
Mounting System	**SolidRail**
Author	**Daniel Tempest**

Location information

Address	**9 Museum Rd, Oxford OX1 3PX, UK**
Ground elevation	**65.14 m**

Roof information

Building height	**8.50 m**
Roof type	**Gable roof**
Roof pitch	**22°**
Roof covering	**Tile**
Min. roof edge distance	**0.00 m**
Rafter Spacing	**0.450 m**
Rafter width	**50.0 mm**
set edge rafter left	**No**
Rafter spacing left	**310.0 mm**
Rafter spacing right	**No**
Rafter Spacing	**310.0 mm**
Batten spacing	**340.0 mm**

Loads

Design method	**BS EN**
Failure consequence class (CC)	**CC2**
Design working life	**25 years**
Terrain category	**Town Terrain**
Distance to shoreline	**100.00 km**
Distance inside town terrain	**0.20 km**

Wind load

Velocity pressure, 50	$q_{p,50}$ = **0.716 kN/m²**
Adjustment factor for service life	f_w = **1.000**
Velocity pressure, 25	$q_{p,25}$ = **0.659 kN/m²**

Structural analysis report | Roof 4

Roof areas

Array	load impact area [m²]	maxCpe$_{10}$	minCpe$_{10}$	wind pressure [kN/m²]	wind suction [kN/m²]
field area	10.00	0.293	-0.600	0.193	-0.396
corner region (eave)	10.00	0.480	-1.413	0.317	-0.932
eaves	10.00	0.340	-0.660	0.224	-0.435
field area	10.00	0.293	-0.600	0.193	-0.396
ridge	10.00	0.293	-1.113	0.193	-0.734
gableboard	10.00	0.293	-1.313	0.193	-0.866

Snow load

Snow load zone		2
Snow guard		No
Snow load on ground level	s_k	= 0.400 kN/m²
Shape Coefficient for Snow	μ_i	= 0.800
Factor for roof pitch	d_i	= 0.927
Snow load on roof, 50	$s_{i,50}$	= 0.297 kN/m²
Adjustment factor for service life	f_s	= 1.000
Snow load on roof, 25	$s_{i,25}$	= 0.276 kN/m²

Dead Load

Weight of module	G_M	= 23.4 kg
Weight of mounting system per module		= 2.5 kg
Module area	A_M	= 2.08 m²
Dead weight of module per m²		= 11.24 kg/m²
Dead weight of mounting system per m²		= 1.20 kg/m²
Total Dead Load (excl. ballast) per m²		= 0.12 kN/m²

Structural analysis report | Roof 4

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 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	$\kappa_{Fl,G}$	= 1.00
Importance factor variable	$\kappa_{Fl,Q}$	= 1.00
Characteristic dead weight	G_k	
Characteristic snow load on the roof	$S_{i,n}$	
Characteristic wind load	W_k	

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

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

Structural analysis report | Roof 4

Maximum load on modules (Mounting system dimensioning)

Array	A-TrA [m²]	ultimate state [kN/m²]				Serviceability [kN/m²]			
		Pressure ⊥	Pressure II	Uplift ⊥	Uplift II	Pressure ⊥	Pressure II	Uplift ⊥	Uplift II
field area	10.00	0.800	0.253	-0.480	0.046	0.544	0.173	-0.283	0.046
corner region (eave)	10.00	0.910	0.253	-1.285	0.046	0.618	0.173	-0.819	0.046
eaves	10.00	0.827	0.253	-0.540	0.046	0.563	0.173	-0.322	0.046
field area	10.00	0.800	0.253	-0.480	0.046	0.544	0.173	-0.283	0.046
ridge	10.00	0.800	0.253	-0.988	0.046	0.544	0.173	-0.621	0.046
gableboard	10.00	0.800	0.253	-1.186	0.046	0.544	0.173	-0.753	0.046

Max. load on fastener

Array	A-TrA [m²]	ultimate state [kN]				Serviceability [kN]			
		Pressure ⊥	Pressure II	Uplift ⊥	Uplift II	Pressure ⊥	Pressure II	Uplift ⊥	Uplift II
field area	10.00	0.954	0.301	-0.573	0.055	0.649	0.206	-0.337	0.055
corner region (eave)	10.00	0.814	0.226	-1.150	0.041	0.553	0.155	-0.733	0.041
eaves	10.00	0.740	0.226	-0.483	0.041	0.504	0.155	-0.288	0.041
field area	10.00	0.954	0.301	-0.573	0.055	0.649	0.206	-0.337	0.055
ridge	10.00	0.954	0.301	-1.179	0.055	0.649	0.206	-0.741	0.055
gableboard	10.00	0.954	0.301	-1.415	0.055	0.649	0.206	-0.898	0.055

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]
SolidHook Pan Tile Vario 1	2.21	1.05	1.93

Structural analysis report | Roof 4

Utilisation result

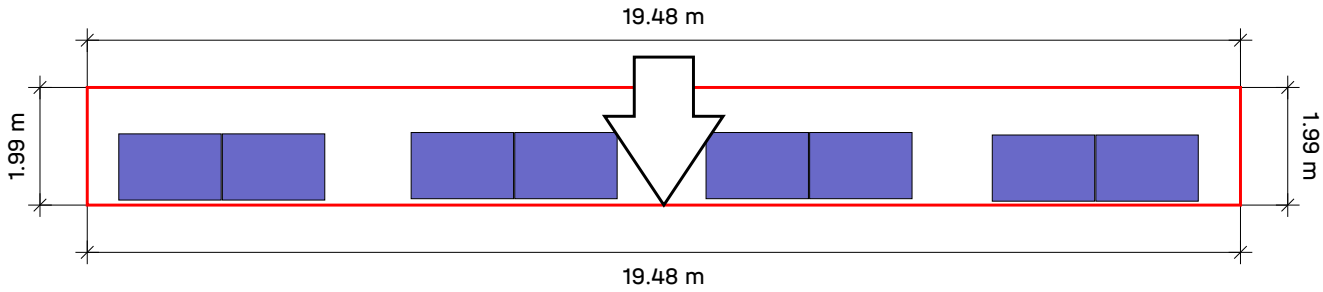
No. Module Array	roof areas	ultimate limit state Pr σ[%]	ultimate limit state CL σ[%]	ultimate limit state Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	Distances BR [m]	maximum values CL L_{max}[m]	maximum values Fst Fst D_{max}[m]
1	field area	45.8	0.0	99.5	52.1	1.800	---	0.595	1.809
1	corner region (eave)	35.3	17.3	84.1	27.1	1.350	---	0.566	1.606
1	eaves	26.5	0.0	77.0	18.9	1.350	---	0.627	1.753
2	field area	45.8	0.0	99.5	52.1	1.800	---	0.595	1.809
2	ridge	48.5	7.8	99.5	58.4	1.800	---	0.576	1.809
2	gableboard	58.0	14.2	99.5	70.8	1.800	---	0.545	1.809

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 4 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	1000125	SolidHook Pan Tile Vario 1	41	29.2 kg
2	1000637	T-Bolt 28/15 M10×20	41	0.8 kg
3	1000042	Hexagon flange nut M10	41	0.5 kg
4	2004112	Wood screw 8×100	82	2.2 kg
5	2002589	OneEnd Black Set 30-42	16	1.4 kg
6	2003072	OneMid Black Set 30-42	20	1.6 kg
7	1004765	SolidRail Light End Cap	16	0.1 kg
8	2002870	K2 Solar Cable Manager	14	0.0 kg
9	2003232	SolidRail Light; 3.30 m	16	44.8 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	14	3.2 kg
Total				**83.7 kg**

Roofs | Roof 5



Roof	System	Module	Height	Quantity	Total power
Roof 5 Tile	SolidRail	REC 420 AA Pure-R (Alpha) 1,730×1,118×30 mm 420 Wp	9.32 m	8	3.36 kWp

Roofs | Roof 5 | Assembly plan

Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 3.30 m	Part of Rail	Length	Rest
2*A	3.580	1*3.30 m	3.300	0.700 from 3.300	2.590
2*B	3.580	1*3.30 m	2.590	0.700 from 2.590	1.880
2*C	3.580	1*3.30 m	1.880	0.700 from 1.880	1.170
2*D	3.580	1*3.30 m	1.170	0.700 from 1.170	0.460

1 cm is viewed as lost for each cutting

Red numbers are leftover rails which will not be used any longer

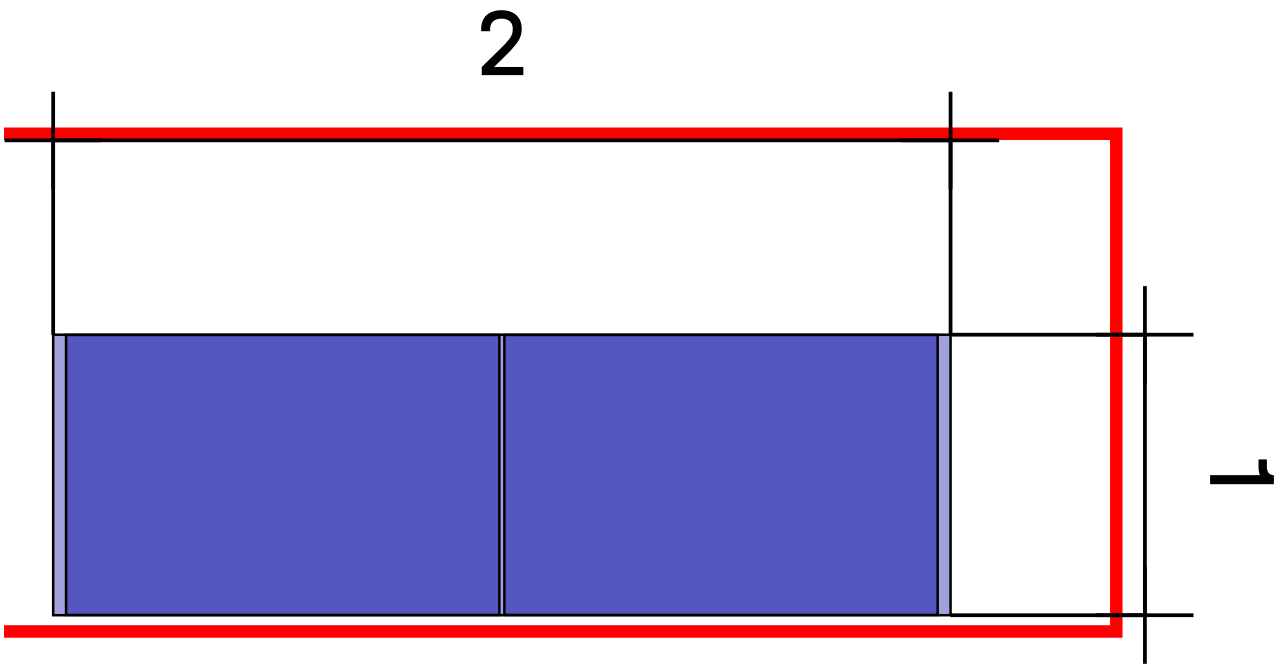
Fastener Spacing

Module	Array	Distance	maximum cantilever length	maximum fastener spacing
1	field area	1.35 m	0.625	1.708
2	field area	1.35 m	0.625	1.708
3	field area	1.35 m	0.625	1.708
4	field area	1.35 m	0.625	1.708

Module arrays

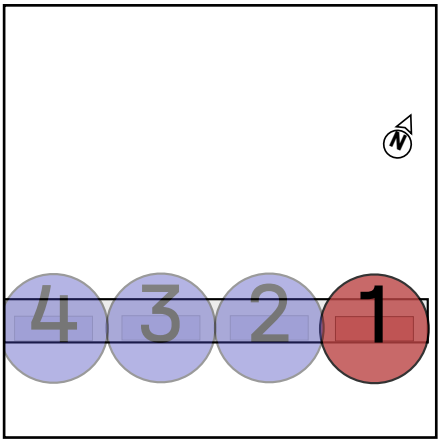
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	3.48	1.12	2	1
2	3.48	1.12	2	1
3	3.48	1.12	2	1
4	3.48	1.12	2	1

Roofs | Roof 5 | Module array 1

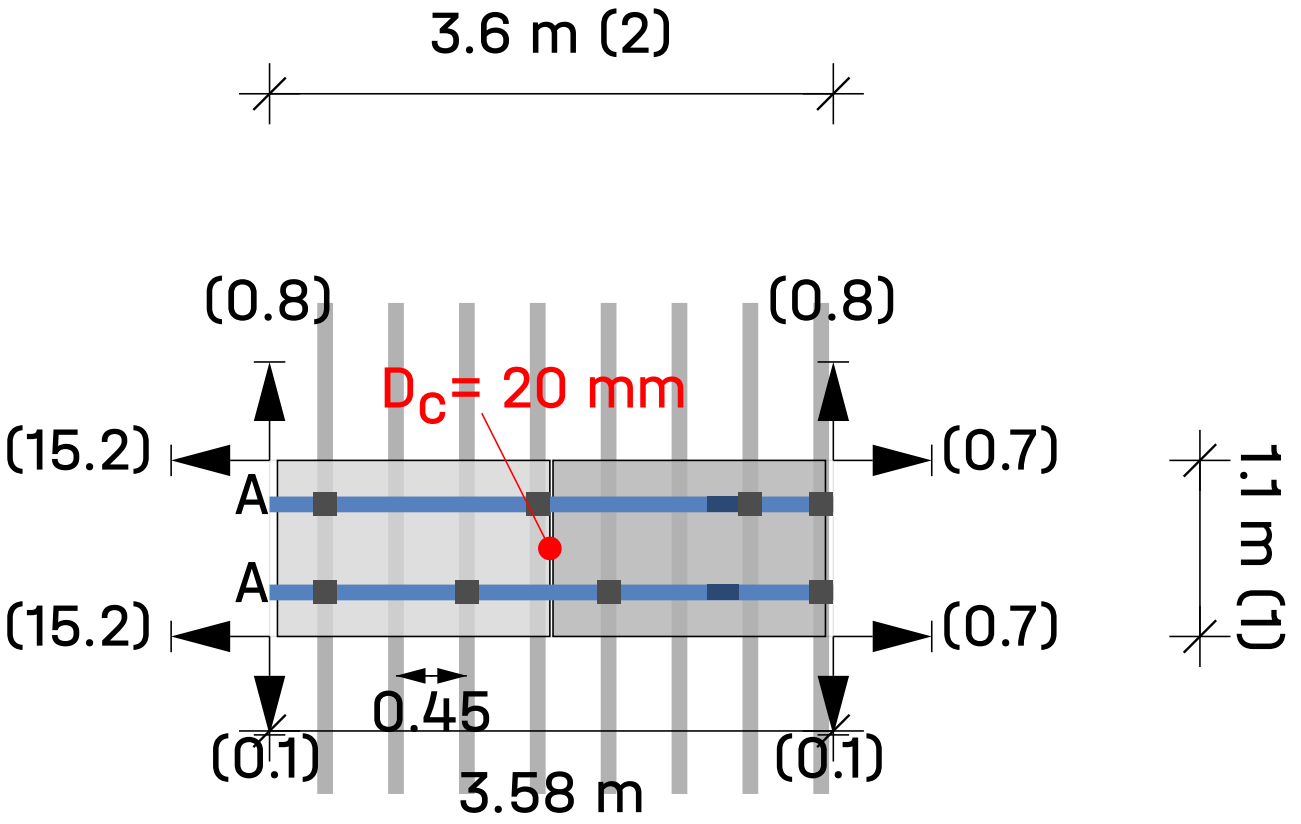


Roof (5) Module array (1)

Mounting System	SolidRail
Module	2(0.84 kWp) x REC 420 AA Pure-R (Alpha)
Row spacing	1.13 m



Roofs | Roof 5 | Module array 1 | Module blocks

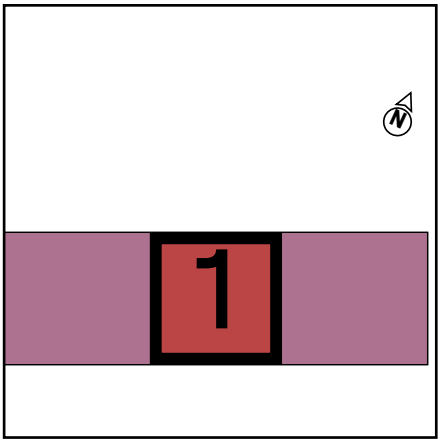


Roof (5) Module array (1) Module block 1

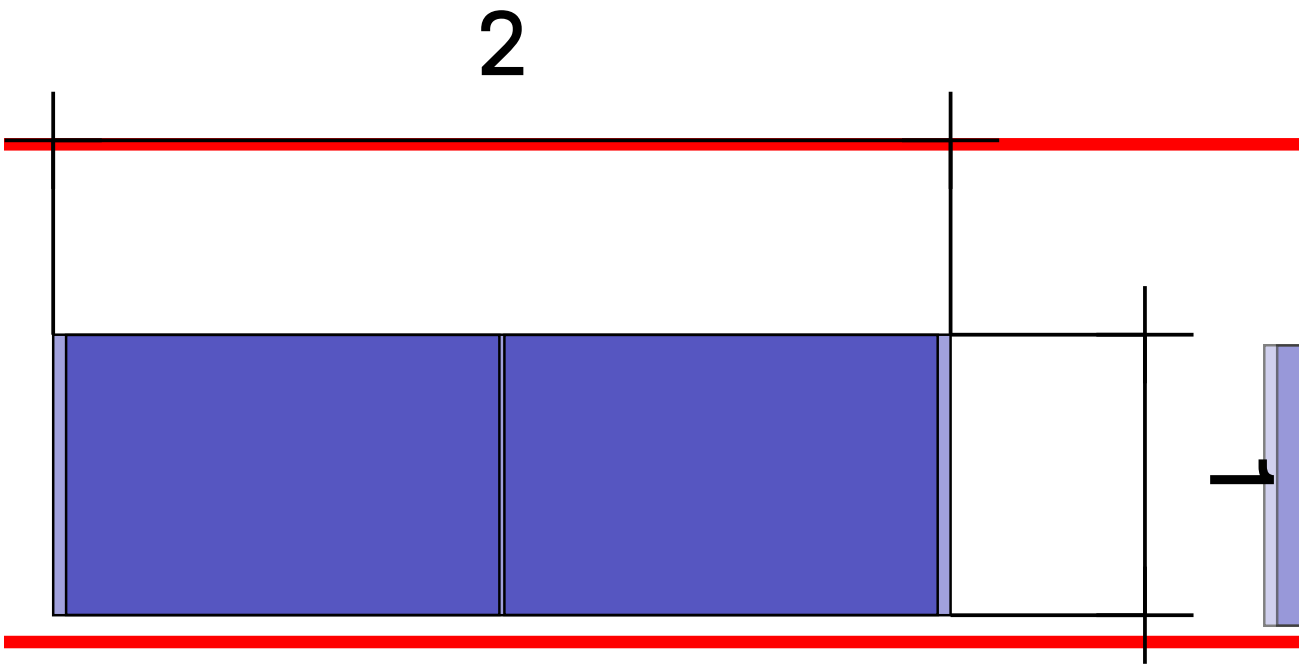
Modules 2 × 1 = **2**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules

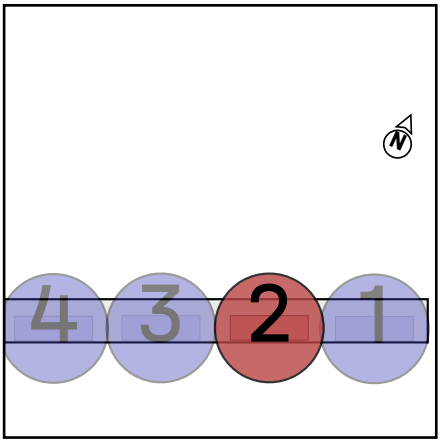


Roofs | Roof 5 | Module array 2

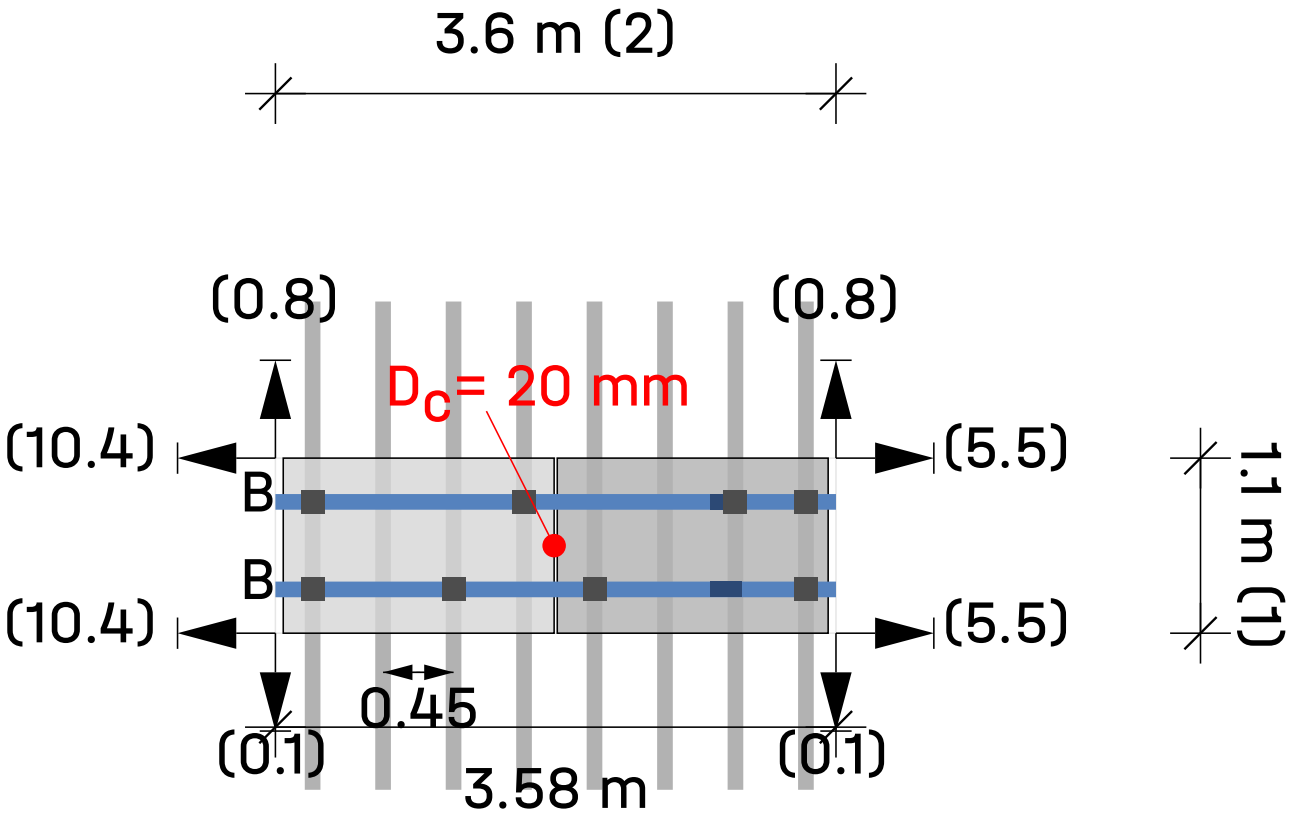


Roof 5 Module array 2

Mounting System	SolidRail
Module	2(0.84 kWp) x REC 420 AA Pure-R (Alpha)
Row spacing	1.13 m



Roofs | Roof 5 | Module array 2 | Module blocks

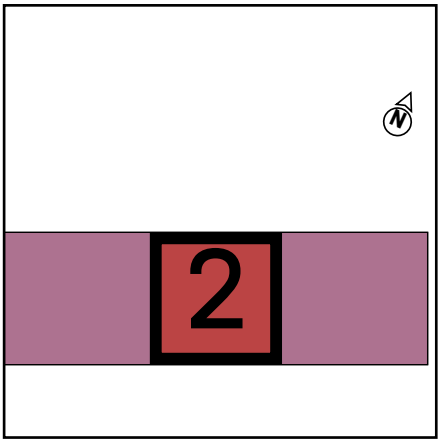


Roof (5) Module array (2) Module block 2

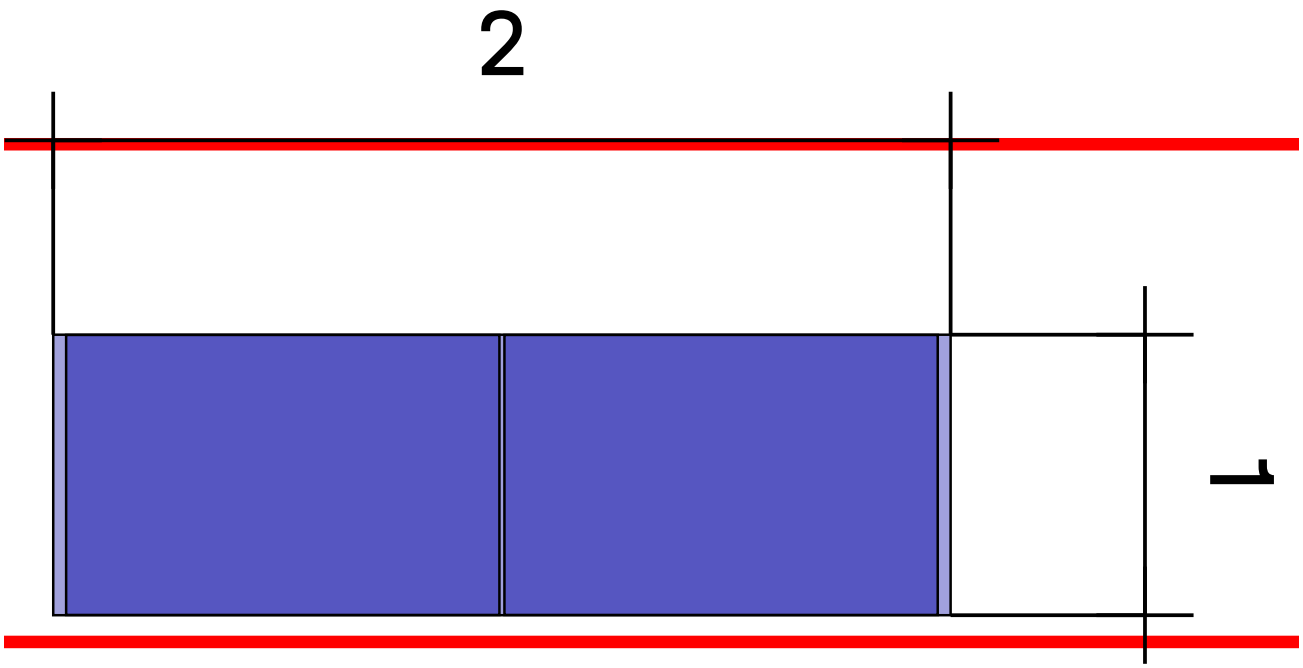
Modules 2 × 1 = **2**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules

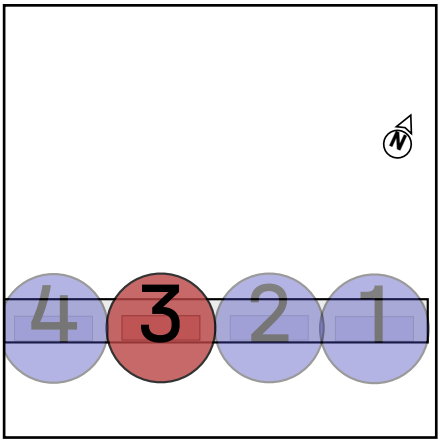


Roofs | Roof 5 | Module array 3

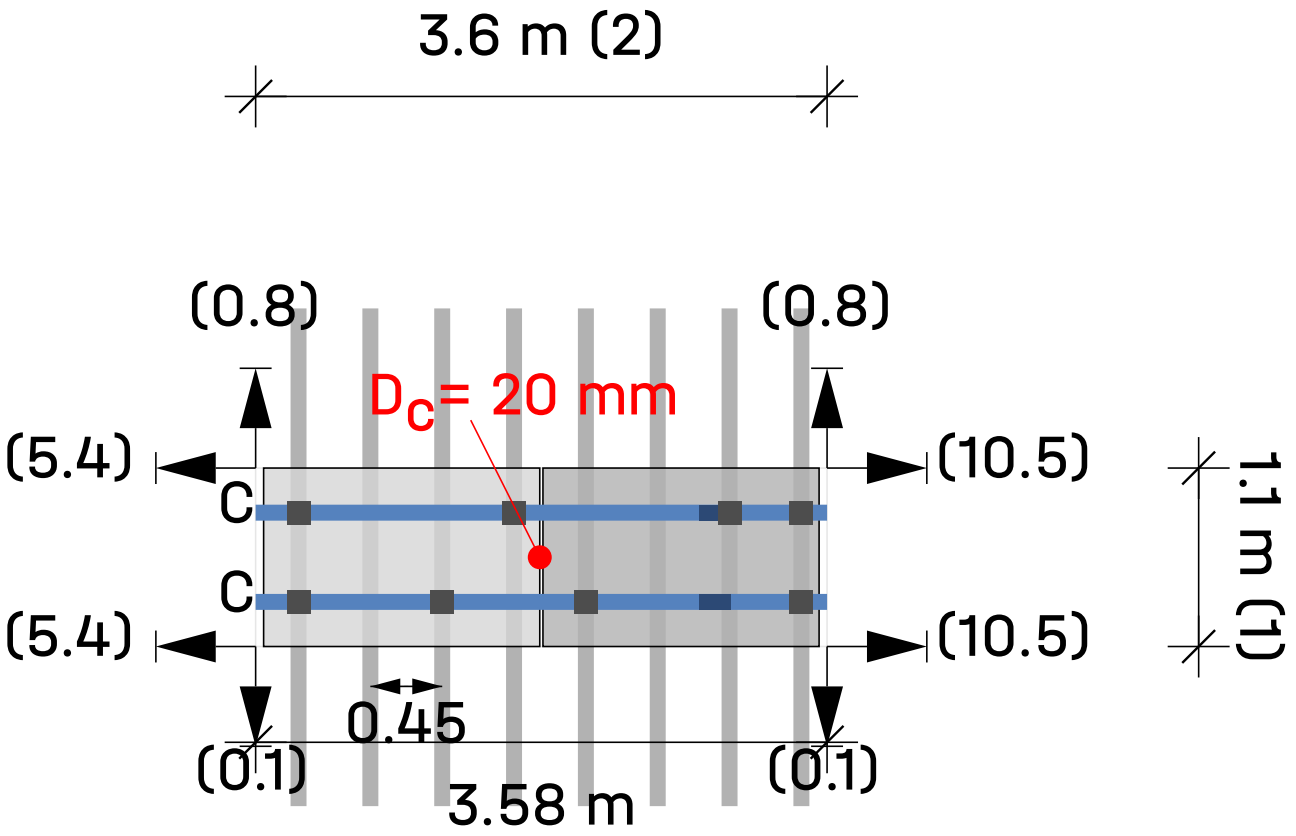


Roof 5 Module array 3

Mounting System	SolidRail
Module	2(0.84 kWp) x REC 420 AA Pure-R (Alpha)
Row spacing	1.13 m



Roofs | Roof 5 | Module array 3 | Module blocks

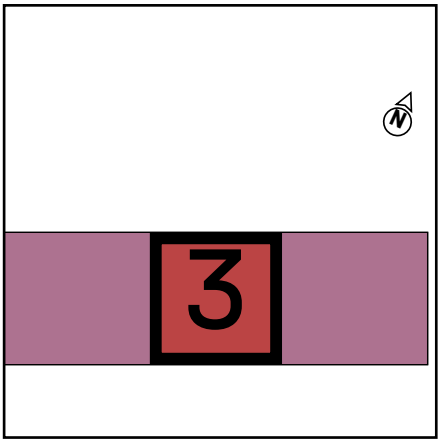


Roof (5) Module array (3) Module block 3

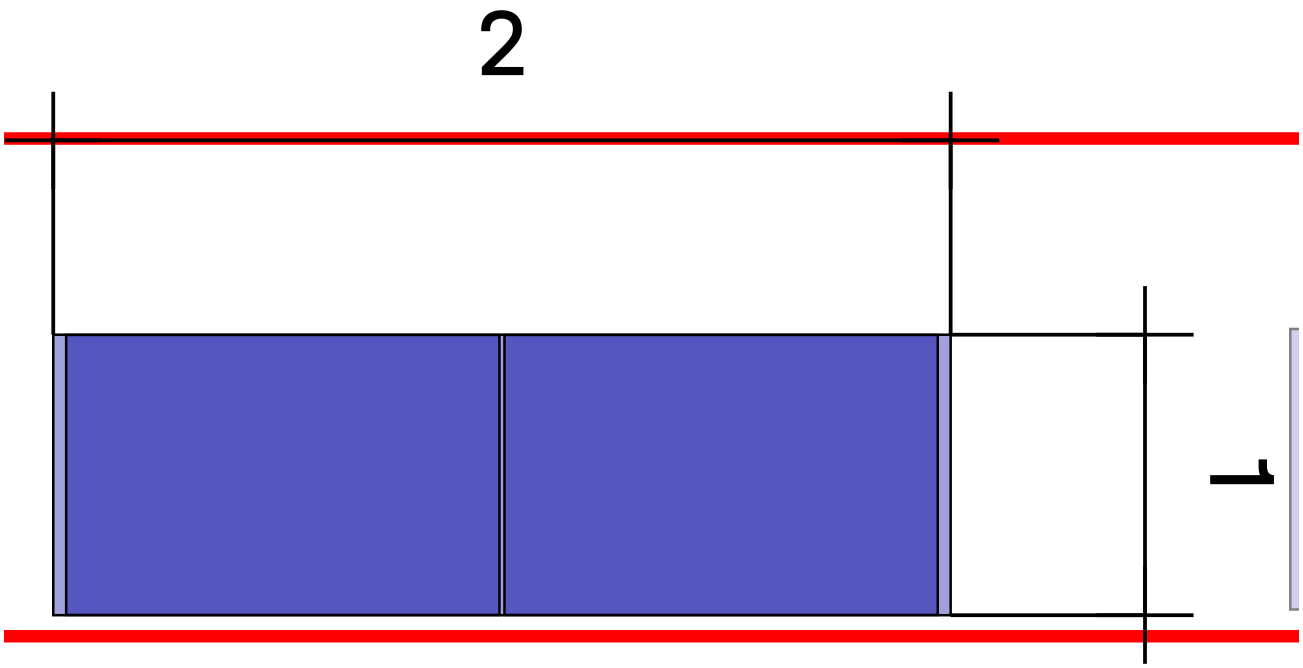
Modules 2 × 1 = **2**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules

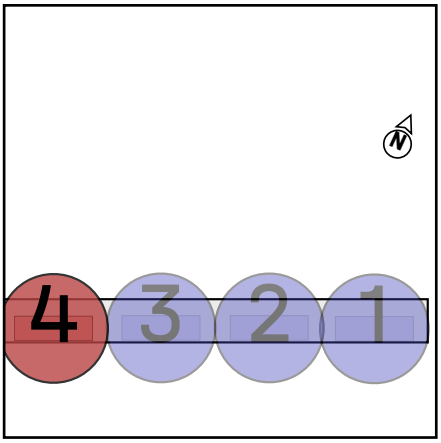


Roofs | Roof 5 | Module array 4

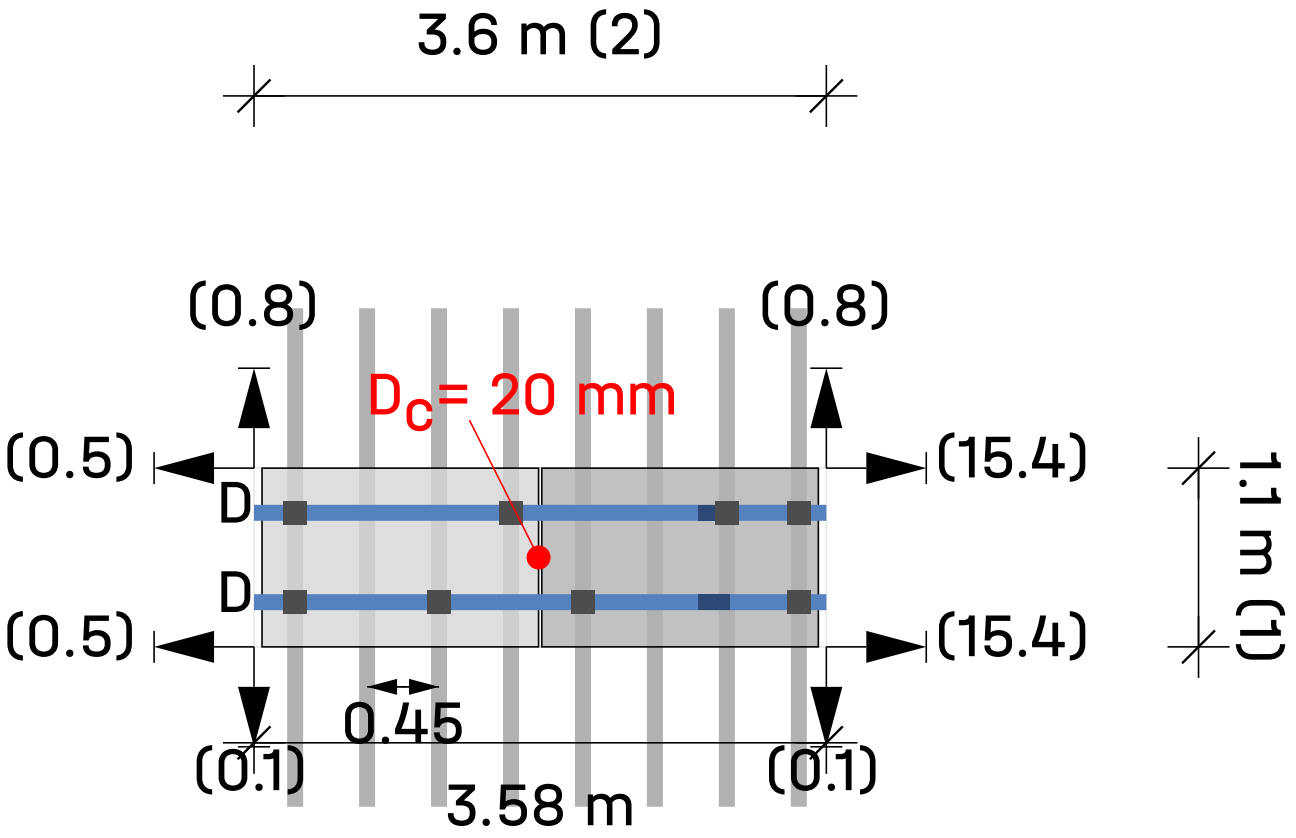


Roof 5 Module array 4

Mounting System	SolidRail
Module	2(0.84 kWp) x REC 420 AA Pure-R (Alpha)
Row spacing	1.13 m



Roofs | Roof 5 | Module array 4 | Module blocks

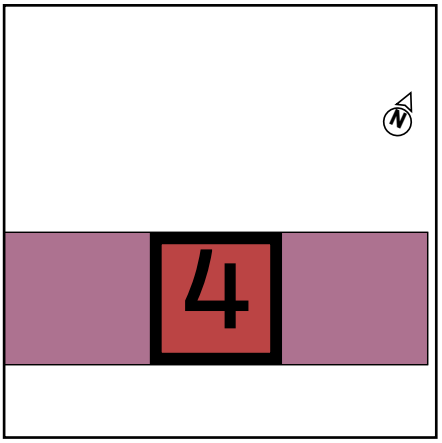


Roof (5) Module array (4) Module block 4

Modules 2 × 1 = **2**

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules



Results | Roof 5

Roof	System	Module	Height	Quantity	Total power
Roof 5 Tile	SolidRail	REC 420 AA Pure-R (Alpha) 1,730×1,118×30 mm 420 Wp	9.32 m	8	3.36 kWp

Module

Name	REC 420 AA Pure-R (Alpha)
Manufacturer	REC Solar AS
Output power	420 Wp
Dimensions	1,730×1,118×30 mm
Weight	21.5 kg

Components

Fastener	SolidHook Pan Tile Vario 1
Base rails	K2 SolidRail Light 37

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure II	Uplift ⊥	Uplift II	Pressure ⊥	Pressure II	Uplift ⊥	Uplift II
field area	1.93	887.4	371.8	-503.4	60.8	602.2	253.9	-300.5	60.8
field area	1.93	887.4	371.8	-503.4	60.8	602.2	253.9	-300.5	60.8
field area	1.93	887.4	371.8	-503.4	60.8	602.2	253.9	-300.5	60.8
field area	1.93	887.4	371.8	-503.4	60.8	602.2	253.9	-300.5	60.8

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	28.0	9.6	79.0	19.1	1.350	---	0.625	1.708
2	field area	28.0	4.3	79.0	19.1	1.350	---	0.625	1.708
3	field area	28.0	5.5	79.0	19.1	1.350	---	0.625	1.708
4	field area	28.0	5.1	79.0	19.1	1.350	---	0.625	1.708

Pr	Profile	Fst D_{max}	maximum fastener spacing
Fst	Fastener	BR	Base Rail
σ	Stress	Usab.	serviceability limit state
f	Deflection	CL	Cantilever

Results | Roof 5

F **Force**

CL/L_{max} **maximum cantilever length**

Results | Roof 5

Notes

- The dimensioning of the timber construction screws is not part of this structural analysis. The dimensioning and positioning of the timber construction screws to be used must be carried out in accordance with the respective applicable codes of practice.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminum structures (DIN EN 1999-1-1:2021) and offers sufficient load-bearing capacity and stability for the loads specified in the chapter 'Maximum actions on the components'.
- Adjustment factor for wind load regarding servise life periond, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding servise life periond, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- 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'').
- The clamping range of the module may not comply with for this installation variant, as the rail spacing depends on the laying of the tiles and thus the batten length. Please ensure that the clamping range specified by the module manufacturer is observed.

Structural analysis report | Roof 5

General information

Name	**Lincoln College - Museum Road - PV - Final**
Mounting System	**SolidRail**
Author	**Daniel Tempest**

Location information

Address	**9 Museum Rd, Oxford OX1 3PX, UK**
Ground elevation	**65.14 m**

Roof information

Building height	**9.32 m**
Roof type	**Gable roof**
Roof pitch	**30°**
Roof covering	**Tile**
Min. roof edge distance	**0.00 m**
Rafter Spacing	**0.450 m**
Rafter width	**50.0 mm**
set edge rafter left	**No**
Rafter spacing left	**290.0 mm**
Rafter spacing right	**No**
Rafter Spacing	**290.0 mm**
Batten spacing	**340.0 mm**

Loads

Design method	**BS EN**
Failure consequence class (CC)	**CC2**
Design working life	**25 years**
Terrain category	**Town Terrain**
Distance to shoreline	**100.00 km**
Distance inside town terrain	**0.20 km**

Wind load

Velocity pressure, 50	$q_{p,50}$ = **0.734 kN/m²**
Adjustment factor for service life	f_w = **0.921**
Velocity pressure, 25	$q_{p,25}$ = **0.676 kN/m²**

Structural analysis report | Roof 5

Roof areas

Array	load impact area [m²]	maxCpe$_{10}$	minCpe$_{10}$	wind pressure [kN/m²]	wind suction [kN/m²]
field area	10.00	0.400	-0.600	0.271	-0.406
field area	10.00	0.400	-0.600	0.271	-0.406
field area	10.00	0.400	-0.600	0.271	-0.406
field area	10.00	0.400	-0.600	0.271	-0.406

Snow load

Snow load zone	2	
Snow guard	No	
Snow load on ground level	s_k	= 0.400 kN/m²
Shape Coefficient for Snow	μ_i	= 1.200
Factor for roof pitch	d_i	= 0.866
Snow load on roof, 50	$s_{i,50}$	= 0.416 kN/m²
Adjustment factor for service life	f_s	= 0.929
Snow load on roof, 25	$s_{i,25}$	= 0.386 kN/m²

Dead Load

Weight of module	G_M	= 21.5 kg
Weight of mounting system per module		= 2.5 kg
Module area	A_M	= 1.93 m²
Dead weight of module per m²		= 11.12 kg/m²
Dead weight of mounting system per m²		= 1.29 kg/m²
Total Dead Load (excl. ballast) per m²		= 0.12 kN/m²

Structural analysis report | Roof 5

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 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	$\kappa_{Fl,G}$ = 1.00
Importance factor variable	$\kappa_{Fl,Q}$ = 1.00
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

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

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

Maximum load on modules (Mounting system dimensioning)

Array	A-TrA [m²]	ultimate state [kN/m²]				Serviceability [kN/m²]			
		Pressure ⊥	Pressure II	Uplift ⊥	Uplift II	Pressure ⊥	Pressure II	Uplift ⊥	Uplift II
field area	10.00	0.887	0.372	-0.503	0.061	0.602	0.254	-0.300	0.061
field area	10.00	0.887	0.372	-0.503	0.061	0.602	0.254	-0.300	0.061
field area	10.00	0.887	0.372	-0.503	0.061	0.602	0.254	-0.300	0.061
field area	10.00	0.887	0.372	-0.503	0.061	0.602	0.254	-0.300	0.061

Structural analysis report | Roof 5

Max. load on fastener

Array	A-TrA [m²]	ultimate state [kN]				Serviceability [kN]			
		Pressure ⊥	Pressure II	Uplift ⊥	Uplift II	Pressure ⊥	Pressure II	Uplift ⊥	Uplift II
field area	10.00	0.737	0.309	-0.418	0.051	0.500	0.211	-0.249	0.051
field area	10.00	0.737	0.309	-0.418	0.051	0.500	0.211	-0.249	0.051
field area	10.00	0.737	0.309	-0.418	0.051	0.500	0.211	-0.249	0.051
field area	10.00	0.737	0.309	-0.418	0.051	0.500	0.211	-0.249	0.051

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]
SolidHook Pan Tile Vario 1	2.21	1.05	1.93

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	28.0	9.6	79.0	19.1	1.350	---	0.625	1.708
2	field area	28.0	4.3	79.0	19.1	1.350	---	0.625	1.708
3	field area	28.0	5.5	79.0	19.1	1.350	---	0.625	1.708
4	field area	28.0	5.1	79.0	19.1	1.350	---	0.625	1.708

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 5 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2004112	Wood screw 8×100	64	1.7 kg
2	2002589	OneEnd Black Set 30-42	16	1.4 kg
3	1000125	SolidHook Pan Tile Vario 1	32	22.8 kg
4	1000637	T-Bolt 28/15 M10×20	32	0.6 kg
5	1000042	Hexagon flange nut M10	32	0.4 kg
6	2003072	OneMid Black Set 30-42	8	0.6 kg
7	1004765	SolidRail Light End Cap	16	0.1 kg
8	2002870	K2 Solar Cable Manager	8	0.0 kg
9	2003232	SolidRail Light; 3.30 m	10	28.0 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	8	1.8 kg
Total				**57.4 kg**

Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2004112	Wood screw 8×100	562	15.2 kg
2	2002589	OneEnd Black Set 30-42	124	10.8 kg
3	1000125	SolidHook Pan Tile Vario 1	281	200.1 kg
4	1000637	T-Bolt 28/15 M10×20	281	5.1 kg
5	1000042	Hexagon flange nut M10	281	3.1 kg
6	2003072	OneMid Black Set 30-42	98	7.7 kg
7	1004765	SolidRail Light End Cap	124	0.7 kg
8	2002870	K2 Solar Cable Manager	80	0.2 kg
9	2003232	SolidRail Light; 3.30 m	87	243.6 kg
10	1004107	SolidRail UtraLight+Light RailConnector Set	68	15.3 kg
Total				**501.9 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.

Our contact data:

k2-systems.com/en/contact

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

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