| Connecting Strength

K2 Base Report

Iron Acton CE vc Primary School

Planned installation date	28/10/2023
Project address	Wotton Rd, Iron Acton, Bristol BS37 9UZ, UK
Customer	Iron Acton Primary School
Company	Source Electrical Services Ltd
Author	Adam Tyers
Issue date & version	14/11/2023 | K2 Base Version 3.1.104.0

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	**Iron Acton CE vc Primary School**
Address	**Wotton Rd, Iron Acton, Bristol BS37 9UZ, UK**
Ground elevation	**64.12 m**
Planned installation date	**28/10/2023**
Customer	**Iron Acton Primary School**
Author	**Adam Tyers**

Load settings

Design method	**BS EN**
Failure consequence class (CC)	**CC1**
Design working life	**25 years**
Terrain category	**Country Terrain**
Environment	**Normal area**
Basic wind speed	**21.5 m/s**
distance to shoreline	**30.00 km**
Snow load zone	**2**
Snow load on ground level	**0.40 kN/m²**

Roofs

Roof	System	Module	Power	Quantity	Total power
Roof 1	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	22	8.8 kWp
Roof 2	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	16	6.4 kWp
Roof 3	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	6	2.4 kWp
Total				**44**	**17.60 kWp**

THE PROJECT IS VERIFIED.
The selected mounting system can be installed as planned
Thank you for choosing a K2 mounting system.

Roofs

Project information

Name	**Iron Acton CE vc Primary School**
Address	**Wotton Rd, Iron Acton, Bristol BS37 9UZ, UK**
Ground elevation	**64.12 m**
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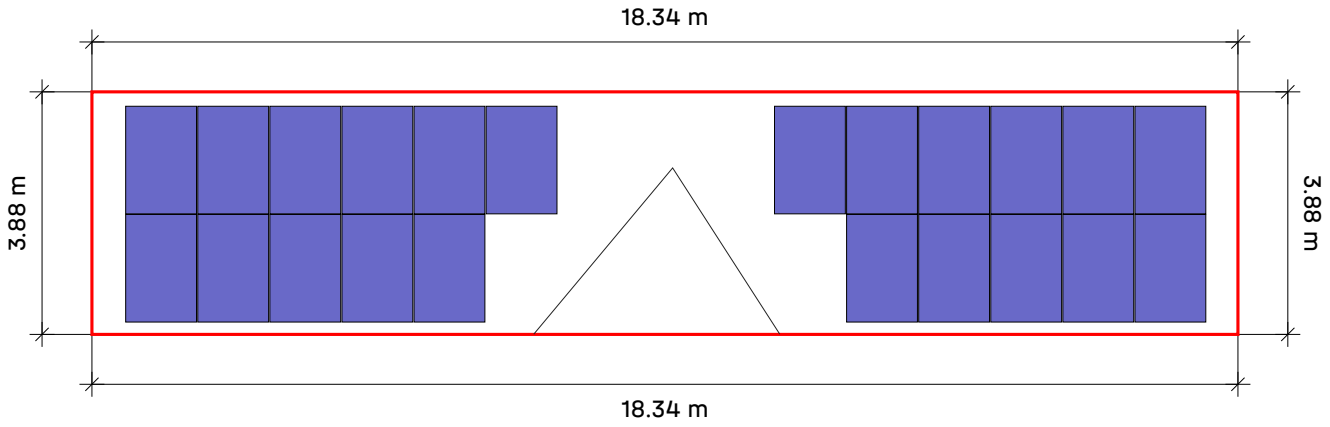
Roofs | Roof 1



Roof	System	Module	Power	Quantity	Total power
Roof 1	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	22	8.8 kWp

Roofs | Roof 1 | Assembly plan

Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 4.40 m	Part of Rail	Length	Rest
A	7.004	1	4.400	2.604	1.786
B	5.850	1	1.786	1.450	0.326

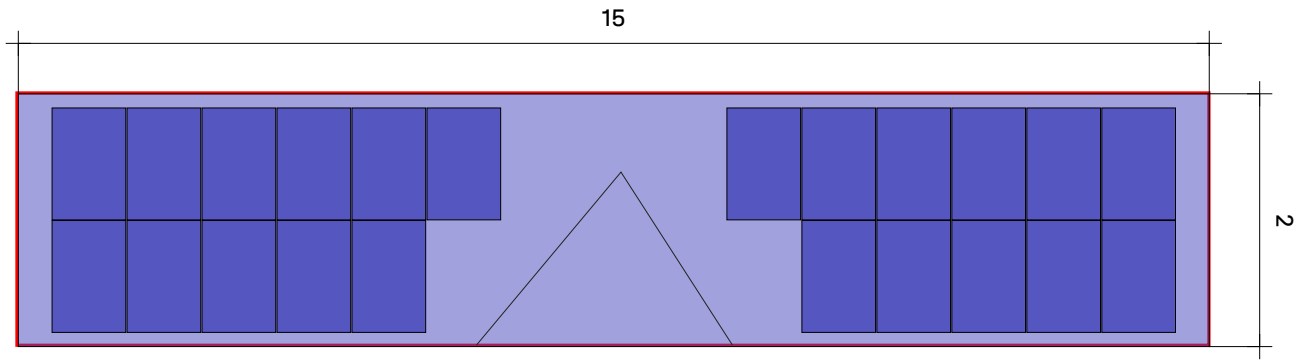
Fastener Spacing

Module	Array	Distance
1	field area	1.50 m
1	eaves	1.50 m
1	corner region (eave)	1.50 m
1	corner region (ridge)	1.50 m
1	ridge	1.50 m

Module arrays

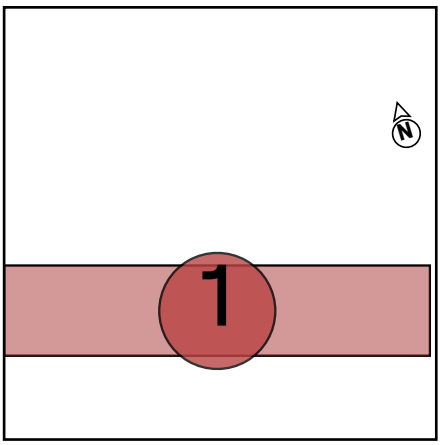
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	17.29	3.45	15	2

Roofs | Roof 1 | Module array 1

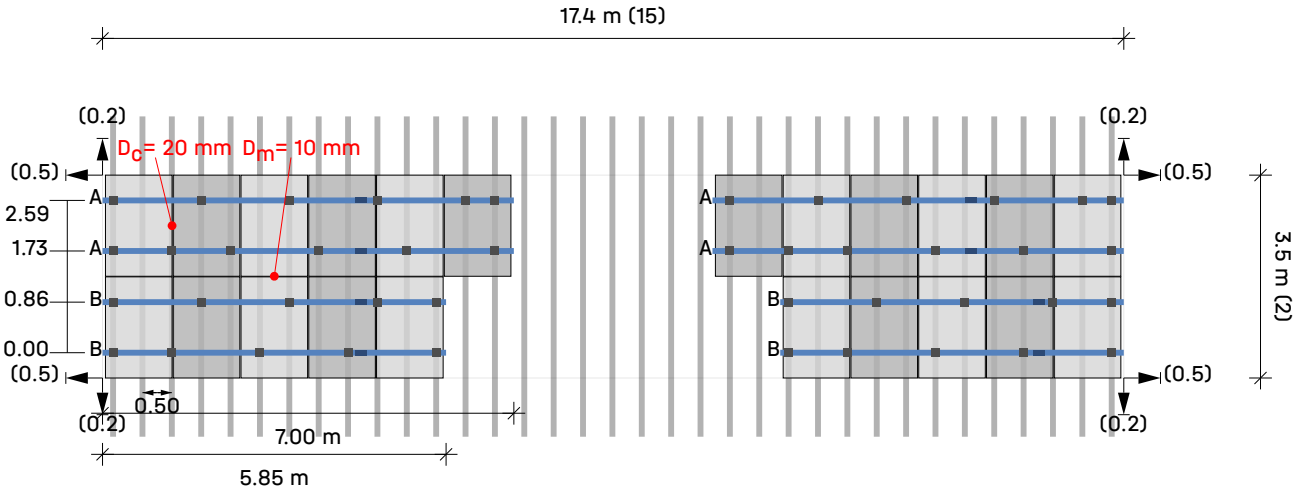


Roof (1) Module array 1

Mounting System	SingleRail
Module	22(8.8 kWp) x JAM54S31-400/MR (1000V)
Row spacing	1.73 m



Roofs | Roof 1 | Module array 1 | Module blocks

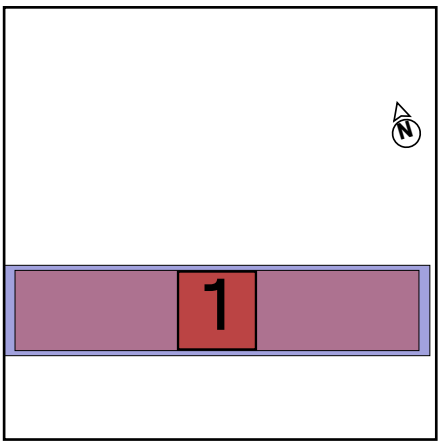


Roof (1) Module array (1) Module block 1

Modules (15 × 2) - 8 = **22**

Legend

- Fastener
- Mounting rail: K2 SingleRail 36
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules



Results | Roof 1

Roof	System	Module	Power	Quantity	Total power
Roof 1 	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	22	8.8 kWp

Module

Name	JAM54S31-400/MR (1000V)
Manufacturer	Shanghai JA Solar Technology Co. Ltd.
Output power	400 Wp
Dimensions	1,722×1,134×30 mm
Weight	21.5 kg

Components

Fastener	SingleHook 3S
Base rails	K2 SingleRail 36

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	1.95	631.2	237.3	-801.2	60.3	499.9	189.0	-605.8	60.3
eaves	1.95	721.7	237.3	-801.2	60.3	571.0	189.0	-605.8	60.3
corner region (eave)	1.95	993.4	237.3	-1,072.8	60.3	784.0	189.0	-818.9	60.3
corner region (ridge)	1.95	721.7	237.3	-1,435.0	60.3	571.0	189.0	-1,103.0	60.3
ridge	1.95	631.2	237.3	-801.2	60.3	499.9	189.0	-605.8	60.3

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	42.0	0.0	56.0	42.6	1.500	---	0.532	1.856
1	eaves	44.1	2.8	56.0	42.6	1.500	---	0.532	1.856
1	corner region (eave)	57.6	5.4	73.8	57.6	1.500	---	0.488	1.722
1	corner region (ridge)	73.5	6.9	97.5	77.5	1.500	---	0.449	1.538
1	ridge	42.0	9.7	56.0	42.6	1.500	---	0.532	1.856

Pr **Profile** Fst D_{max} **maximum fastener spacing**

Results | Roof 1

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

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'').

Structural analysis report | Roof 1

General information

Name	Iron Acton CE vc Primary School
Mounting System	SingleRail
Author	Adam Tyers

Location information

Address	Wotton Rd, Iron Acton, Bristol BS37 9UZ, UK
Ground elevation	64.12 m

Roof information

Building height	10.00 m
Roof type	Monopitch roof
Roof pitch	30°
Fastening method	Roof construction
Roof covering	Tile
Min. roof edge distance	0.00 m
Rafter Spacing	0.500 m
Rafter width	40.0 mm
set edge rafter left	No
Rafter spacing left	170.0 mm
Rafter spacing right	No
Rafter Spacing	170.0 mm
Batten spacing	340.0 mm

Loads

Design method	BS EN
Failure consequence class (CC)	CC1
Design working life	25 years
Terrain category	Country Terrain
distance to shoreline	30.00 km

Wind load

Velocity pressure	$q_{p,50}$ = 0.771 kN/m²
Adjustment factor for service life	f_w = 1.000
Velocity pressure	$q_{p,25}$ = 0.710 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]
field area	10.00	0.400	-1.000	0.284	-0.710
eaves	10.00	0.500	-1.000	0.355	-0.710
corner region (eave)	10.00	0.800	-1.300	0.568	-0.923
corner region (ridge)	10.00	0.500	-1.700	0.355	-1.207
ridge	10.00	0.400	-1.000	0.284	-0.710

Snow load

Snow load zone		2
Environment		Normal terrain
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	= 0.866
Snow load on roof	$s_{i,50}$	= 0.277 kN/m²
Adjustment factor for service life	f_s	= 1.000
Snow load on roof	$s_{i,25}$	= 0.257 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	= 1.95 m²
Dead weight of module per m²		= 11.01 kg/m²
Dead weight of mounting system per m²		= 1.28 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	0.631	0.237	-0.801	0.060	0.500	0.189	-0.606	0.060
eaves	10.00	0.722	0.237	-0.801	0.060	0.571	0.189	-0.606	0.060
corner region (eave)	10.00	0.993	0.237	-1.073	0.060	0.784	0.189	-0.819	0.060
corner region (ridge)	10.00	0.722	0.237	-1.435	0.060	0.571	0.189	-1.103	0.060
ridge	10.00	0.631	0.237	-0.801	0.060	0.500	0.189	-0.606	0.060

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	0.897	0.337	-1.138	0.086	0.710	0.268	-0.861	0.086
eaves	10.00	1.025	0.337	-1.138	0.086	0.811	0.268	-0.861	0.086
corner region (eave)	10.00	1.411	0.337	-1.524	0.086	1.114	0.268	-1.163	0.086
corner region (ridge)	10.00	1.025	0.337	-2.039	0.086	0.811	0.268	-1.567	0.086
ridge	10.00	0.897	0.337	-1.138	0.086	0.710	0.268	-0.861	0.086

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 SingleRail 36	2.850	4.02	6.37	2.14	3.09

Fastener

Fastener	$R_{D,Uplift,Perpendicular}$ [kN]	$R_{D,Pressure,Perpendicular}$ [kN]	$R_{D,Pressure,Parallel}$ [kN]
SingleHook 3S	2.17	2.67	2.40

Structural analysis report | Roof 1

Utilisation result

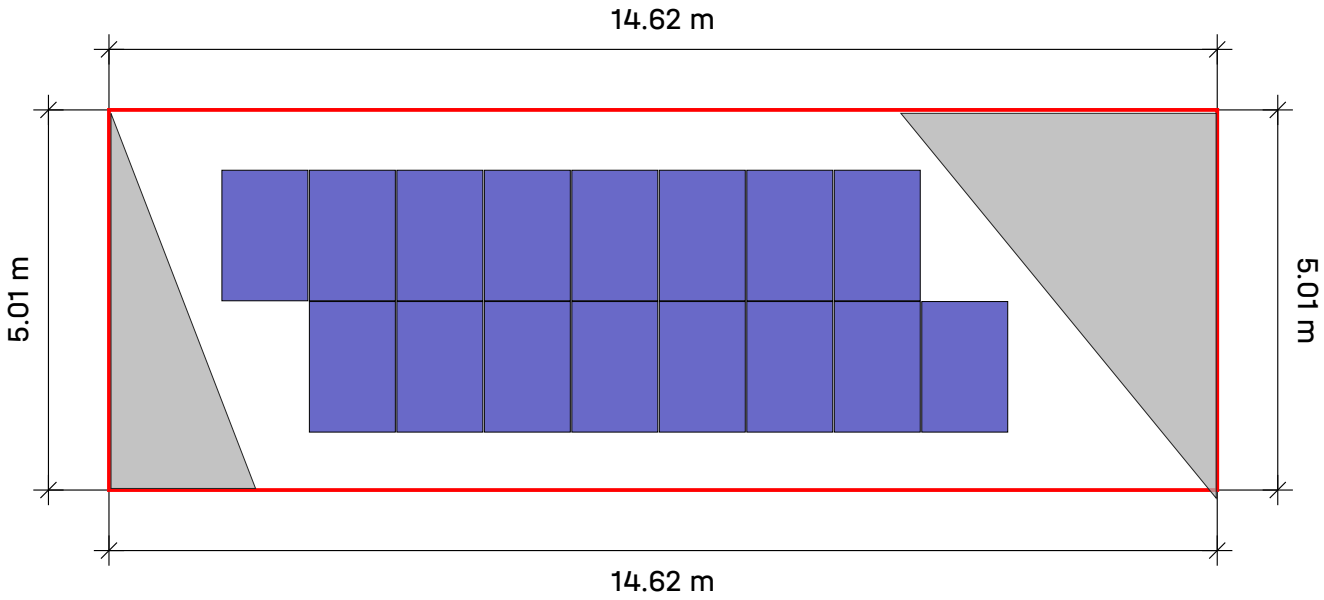
No. Module Array	roof areas	ultimate limit state Pr σ[%]	ultimate limit state CL σ[%]	ultimate limit state Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	Distances BR [m]	maximum values CL L_{max}[m]	maximum values Fst Fst D_{max}[m]
1	field area	42.0	0.0	56.0	42.6	1.500	---	0.532	1.856
1	eaves	44.1	2.8	56.0	42.6	1.500	---	0.532	1.856
1	corner region (eave)	57.6	5.4	73.8	57.6	1.500	---	0.488	1.722
1	corner region (ridge)	73.5	6.9	97.5	77.5	1.500	---	0.449	1.538
1	ridge	42.0	9.7	56.0	42.6	1.500	---	0.532	1.856

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	2003215	SingleHook 3S	44	23.3 kg
2	2004112	Wood screw 8×100	88	2.4 kg
3	2002514	OneEnd Set 30-42	16	1.4 kg
4	2003071	OneMid Set 30-42	36	2.8 kg
5	1004767	SingleRail 36 End Cap	16	0.1 kg
6	2002870	K2 Solar Cable Manager	22	0.1 kg
7	2003222	SingleRail 36; 4.40 m	12	40.7 kg
8	2001976	SingleRail 36 RailConnector Set	8	3.0 kg
Total				**73.8 kg**

Roofs | Roof 2



Roof	System	Module	Power	Quantity	Total power
Roof 2	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	16	6.4 kWp

Roofs | Roof 2 | Assembly plan

Base Rails

	Whole Rails		Rail cutting		
Type	Total Rail Length	Quantity 4.40 m	Part of Rail	Length	Rest
A	9.312	2	4.400	0.700	3.690
B	9.312	2	3.690	0.700	2.980
C	9.312	2	2.980	0.700	2.270
D	9.312	2	2.270	0.700	1.560

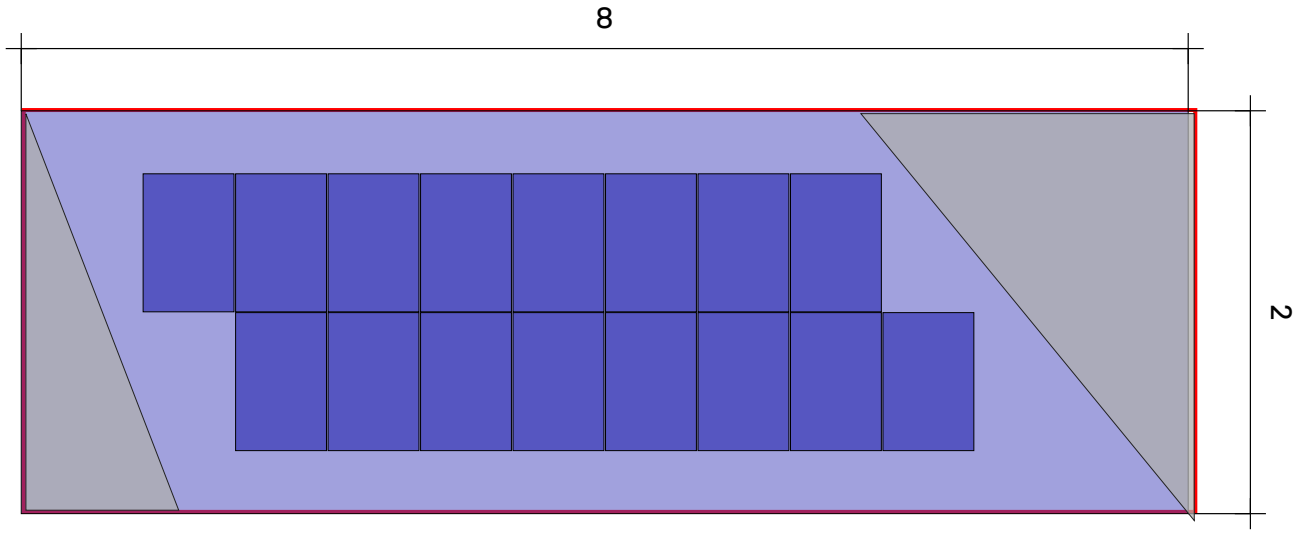
Fastener Spacing

Module	Array	Distance
1	field area	1.50 m
1	eaves	1.50 m
1	corner region (eave)	1.50 m
1	corner region (ridge)	1.50 m
1	ridge	1.50 m

Module arrays

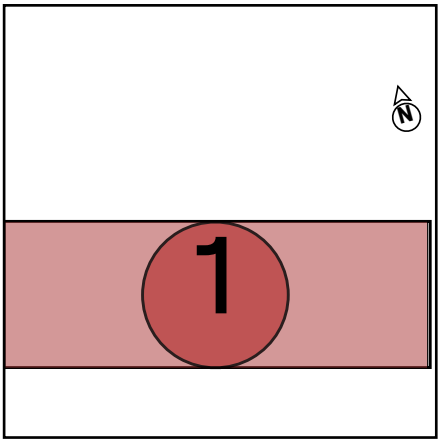
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	13.83	3.45	8	2

Roofs | Roof 2 | Module array 1

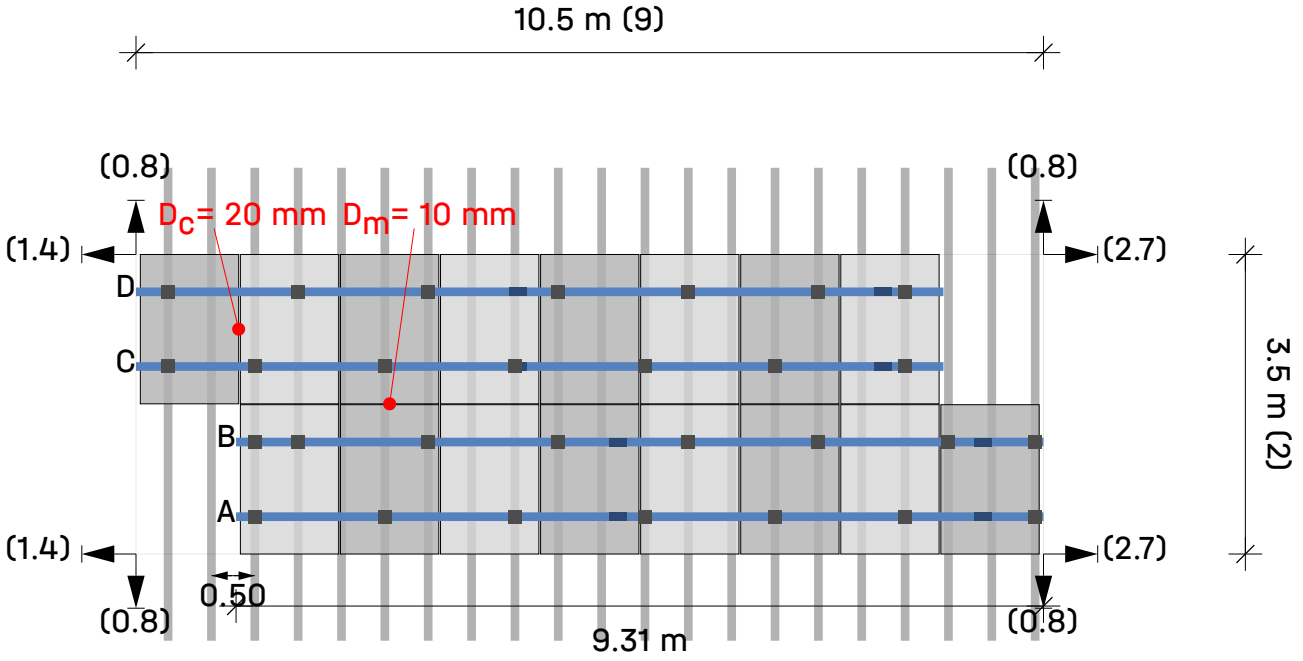


Roof (2) Module array (1)

Mounting System	SingleRail
Module	16(6.4 kWp) x JAM54S31-400/MR (1000V)
Row spacing	1.73 m



Roofs | Roof 2 | Module array 1 | Module blocks

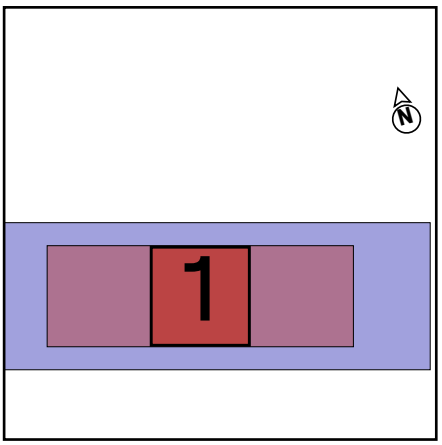


Roof (2) Module array (1) Module block 1

Modules (9 × 2) - 2 = **16**

Legend

- Fastener
- Mounting rail: K2 SingleRail 36
- Distance to Roof Edge [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



Results | Roof 2

Roof	System	Module	Power	Quantity	Total power
Roof 2 	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	16	6.4 kWp

Module

Name	JAM54S31-400/MR (1000V)
Manufacturer	Shanghai JA Solar Technology Co. Ltd.
Output power	400 Wp
Dimensions	1,722×1,134×30 mm
Weight	21.5 kg

Components

Fastener	SingleHook 3S
Base rails	K2 SingleRail 36

Loads on modules (module dimensioning)

Array	A-TrA [m²]	ultimate state [Pa]				Serviceability [Pa]			
		Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥	Pressure ⊥	Pressure ∥	Uplift ⊥	Uplift ∥
field area	1.95	599.0	237.3	-678.7	60.3	474.7	189.0	-509.8	60.3
eaves	1.95	660.5	237.3	-678.7	60.3	522.9	189.0	-509.8	60.3
corner region (eave)	1.95	895.4	237.3	-913.6	60.3	707.2	189.0	-694.0	60.3
corner region (ridge)	1.95	660.5	237.3	-1,226.8	60.3	522.9	189.0	-939.7	60.3
ridge	1.95	599.0	237.3	-678.7	60.3	474.7	189.0	-509.8	60.3

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	38.0	16.5	48.0	35.9	1.500	---	0.559	1.938
1	eaves	41.1	0.0	48.0	37.7	1.500	---	0.551	1.915
1	corner region (eave)	52.8	5.5	63.4	50.4	1.500	---	0.507	1.781
1	corner region (ridge)	63.2	19.2	83.9	66.0	1.500	---	0.470	1.664
1	ridge	38.0	16.5	48.0	35.9	1.500	---	0.559	1.938

Pr **Profile** Fst D_{max} **maximum fastener spacing**

Results | Roof 2

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

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'').

Structural analysis report | Roof 2

General information

Name	Iron Acton CE vc Primary School
Mounting System	SingleRail
Author	Adam Tyers

Location information

Address	Wotton Rd, Iron Acton, Bristol BS37 9UZ, UK
Ground elevation	64.12 m

Roof information

Building height	6.00 m
Roof type	Monopitch roof
Roof pitch	30°
Fastening method	Roof construction
Roof covering	Tile
Min. roof edge distance	0.00 m
Rafter Spacing	0.500 m
Rafter width	40.0 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)	CC1
Design working life	25 years
Terrain category	Country Terrain
distance to shoreline	30.00 km

Wind load

Velocity pressure	$q_{p,50}$ = 0.667 kN/m²
Adjustment factor for service life	f_w = 1.000
Velocity pressure	$q_{p,25}$ = 0.614 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	0.400	-1.000	0.246	-0.614
eaves	10.00	0.500	-1.000	0.307	-0.614
corner region (eave)	10.00	0.800	-1.300	0.491	-0.798
corner region (ridge)	10.00	0.500	-1.700	0.307	-1.044
ridge	10.00	0.400	-1.000	0.246	-0.614

Snow load

Snow load zone		2
Environment		Normal terrain
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	= 0.866
Snow load on roof	$s_{i,50}$	= 0.277 kN/m²
Adjustment factor for service life	f_s	= 1.000
Snow load on roof	$s_{i,25}$	= 0.257 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	= 1.95 m²
Dead weight of module per m²		= 11.01 kg/m²
Dead weight of mounting system per m²		= 1.28 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	0.599	0.237	-0.679	0.060	0.475	0.189	-0.510	0.060
eaves	10.00	0.660	0.237	-0.679	0.060	0.523	0.189	-0.510	0.060
corner region (eave)	10.00	0.895	0.237	-0.914	0.060	0.707	0.189	-0.694	0.060
corner region (ridge)	10.00	0.660	0.237	-1.227	0.060	0.523	0.189	-0.940	0.060
ridge	10.00	0.599	0.237	-0.679	0.060	0.475	0.189	-0.510	0.060

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	0.851	0.337	-0.964	0.086	0.674	0.268	-0.724	0.086
eaves	10.00	0.938	0.337	-0.964	0.086	0.743	0.268	-0.724	0.086
corner region (eave)	10.00	1.272	0.337	-1.298	0.086	1.005	0.268	-0.986	0.086
corner region (ridge)	10.00	0.938	0.337	-1.743	0.086	0.743	0.268	-1.335	0.086
ridge	10.00	0.851	0.337	-0.964	0.086	0.674	0.268	-0.724	0.086

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 SingleRail 36	2.850	4.02	6.37	2.14	3.09

Fastener

Fastener	$R_{D,Uplift,Perpendicular}$ [kN]	$R_{D,Pressure,Perpendicular}$ [kN]	$R_{D,Pressure,Parallel}$ [kN]
SingleHook 3S	2.17	2.67	2.40

Structural analysis report | Roof 2

Utilisation result

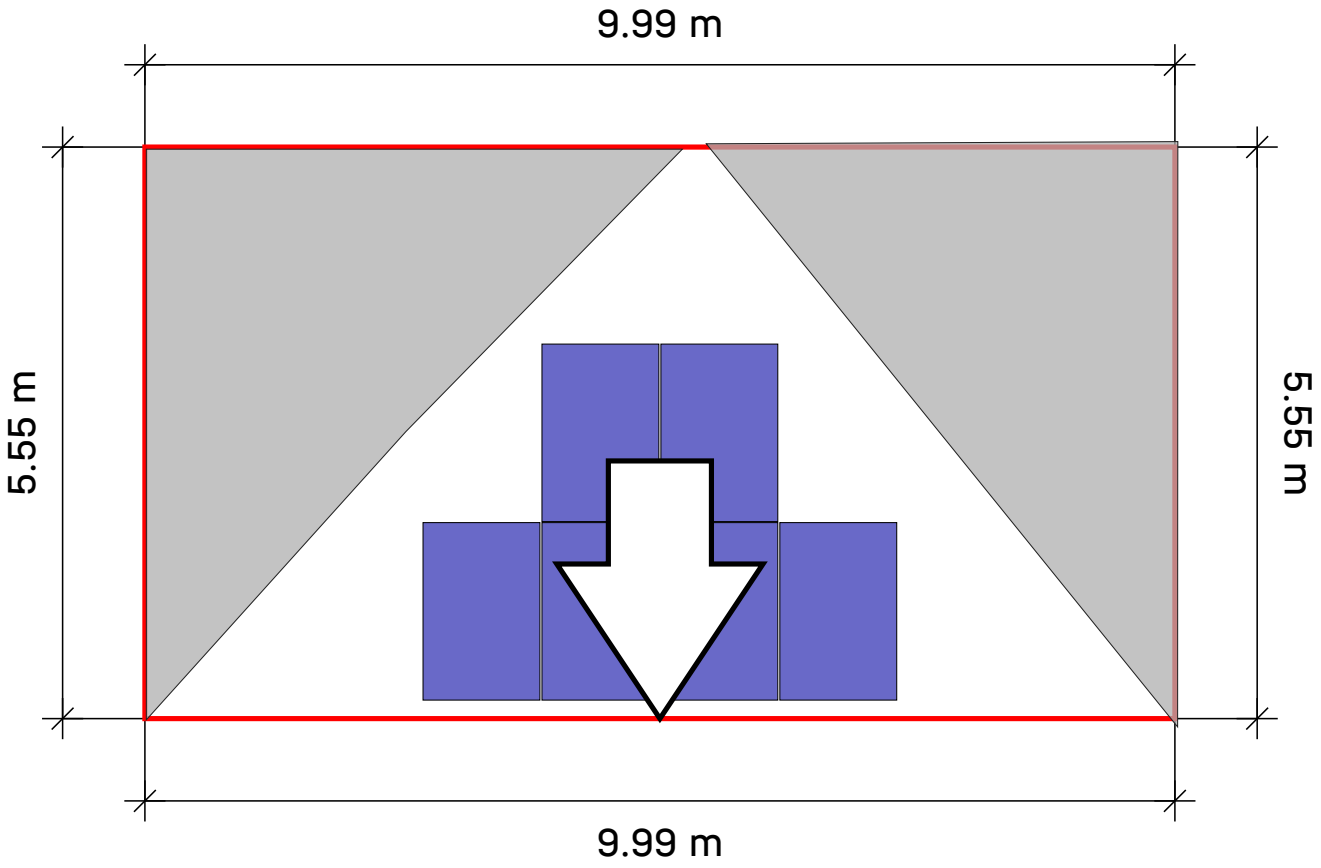
No. Module Array	roof areas	ultimate limit state Pr σ[%]	ultimate limit state CL σ[%]	ultimate limit state Fst F[%]	Usab. Pr f[%]	Distances Fst [m]	Distances BR [m]	maximum values CL L_{max}[m]	maximum values Fst Fst D_{max}[m]
1	field area	38.0	16.5	48.0	35.9	1.500	---	0.559	1.938
1	eaves	41.1	0.0	48.0	37.7	1.500	---	0.551	1.915
1	corner region (eave)	52.8	5.5	63.4	50.4	1.500	---	0.507	1.781
1	corner region (ridge)	63.2	19.2	83.9	66.0	1.500	---	0.470	1.664
1	ridge	38.0	16.5	48.0	35.9	1.500	---	0.559	1.938

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	2003215	SingleHook 3S	29	15.4 kg
2	2004112	Wood screw 8×100	58	1.6 kg
3	2002514	OneEnd Set 30-42	8	0.7 kg
4	2003071	OneMid Set 30-42	28	2.2 kg
5	1004767	SingleRail 36 End Cap	8	0.1 kg
6	2002870	K2 Solar Cable Manager	16	0.0 kg
7	2003222	SingleRail 36; 4.40 m	9	30.5 kg
8	2001976	SingleRail 36 RailConnector Set	8	3.0 kg
Total				**53.5 kg**

Roofs | Roof 3



Roof	System	Module	Power	Quantity	Total power
Roof 3	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	6	2.4 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	2.388		4.400	2.388	2.002
B	4.696	1	2.002	0.700	1.292
C	4.696	1	1.292	0.700	0.582

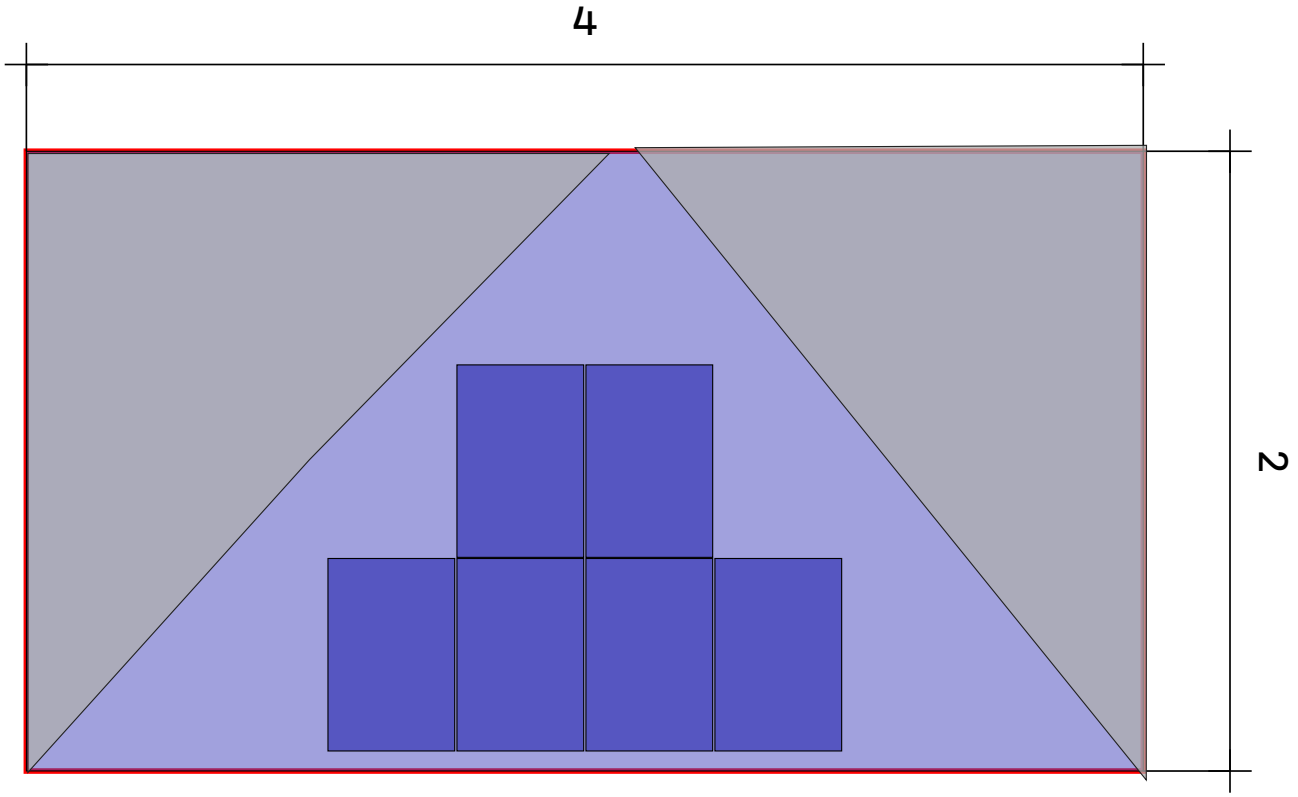
Fastener Spacing

Module	Array	Distance
1	field area	1.50 m
1	eaves	1.50 m

Module arrays

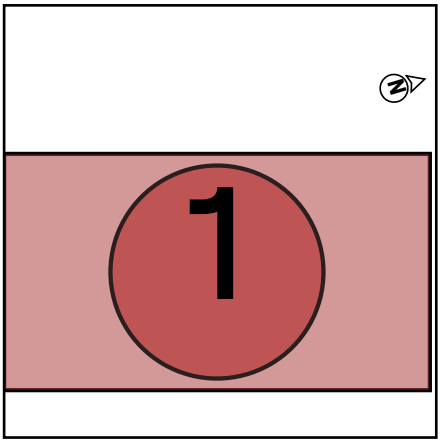
Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	9.21	5.19	4	2

Roofs | Roof 3 | Module array 1

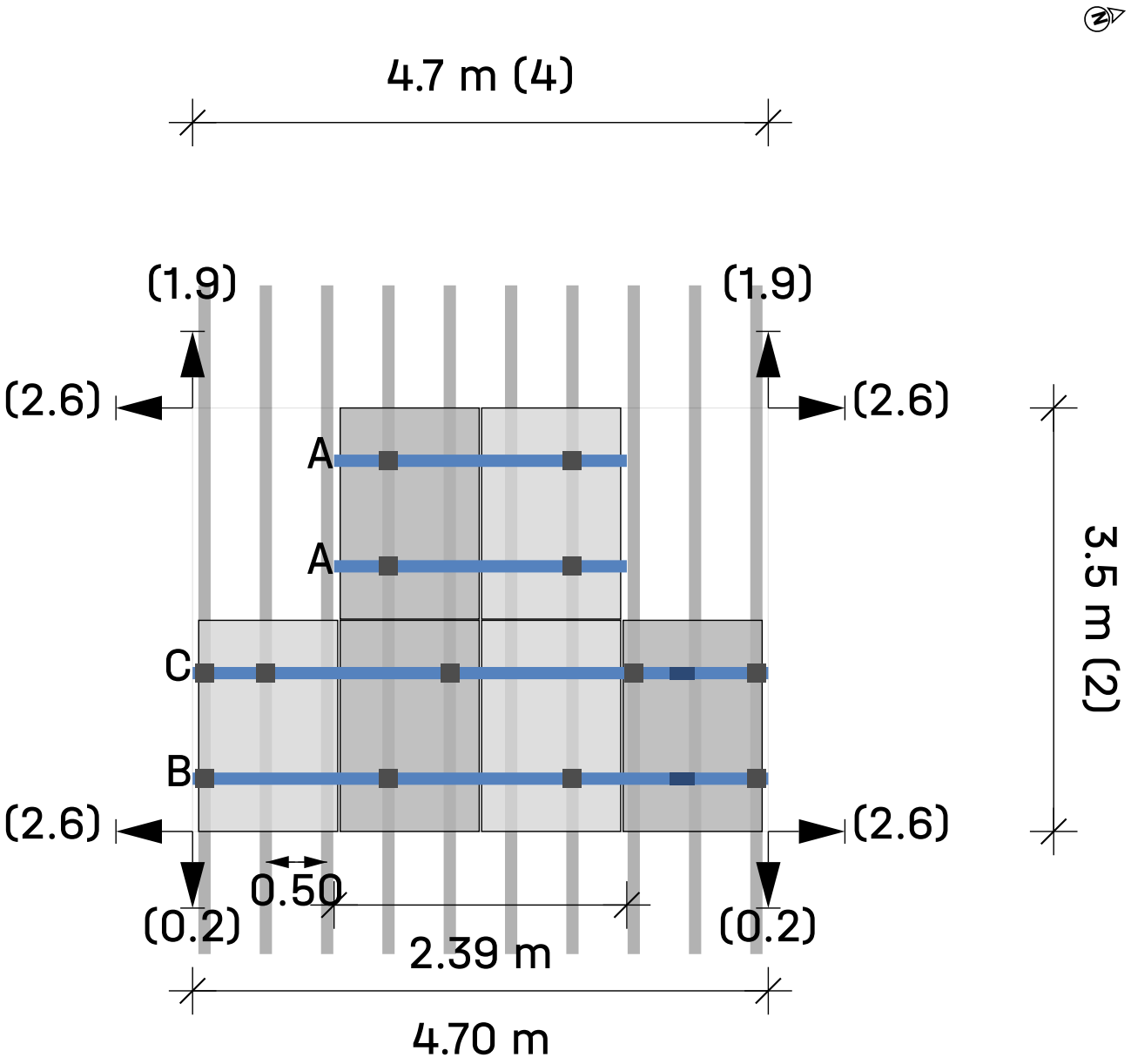


Roof (3) Module array (1)

Mounting System	SingleRail
Module	6(2.4 kWp) x JAM54S31-400/MR (1000V)
Row spacing	1.73 m



Roofs | Roof 3 | Module array 1 | Module blocks

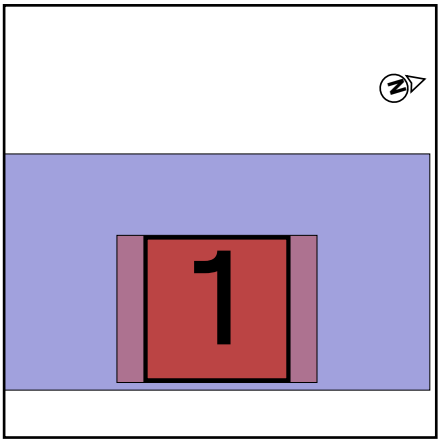


Roof (3) Module array (1) Module block 1

Modules (4 × 2) - 2 = **6**

Legend

- Fastener
- Mounting rail: K2 SingleRail 36
- Distance to Roof Edge [m]
- D_C Distance for clamping between modules
- D_m Distance between modules



Results | Roof 3

Roof	System	Module	Power	Quantity	Total power
Roof 3 	SingleRail	JAM54S31-400/MR (1000V)	400 Wp	6	2.4 kWp

Module

Name	JAM54S31-400/MR (1000V)
Manufacturer	Shanghai JA Solar Technology Co. Ltd.
Output power	400 Wp
Dimensions	1,722×1,134×30 mm
Weight	21.5 kg

Components

Fastener	SingleHook 3S
Base rails	K2 SingleRail 36

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	1.95	599.0	237.3	-678.7	60.3	474.7	189.0	-509.8	60.3
eaves	1.95	660.5	237.3	-678.7	60.3	522.9	189.0	-509.8	60.3

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	38.0	16.6	48.0	35.9	1.500	---	0.559	1.938
1	eaves	41.1	0.9	48.0	37.7	1.500	---	0.551	1.915

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 3

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'').

Structural analysis report | Roof 3

General information

Name	Iron Acton CE vc Primary School
Mounting System	SingleRail
Author	Adam Tyers

Location information

Address	Wotton Rd, Iron Acton, Bristol BS37 9UZ, UK
Ground elevation	64.12 m

Roof information

Building height	6.00 m
Roof type	Monopitch roof
Roof pitch	30°
Fastening method	Roof construction
Roof covering	Tile
Min. roof edge distance	0.00 m
Rafter Spacing	0.500 m
Rafter width	40.0 mm
set edge rafter left	No
Rafter spacing left	245.0 mm
Rafter spacing right	No
Rafter Spacing	245.0 mm
Batten spacing	340.0 mm

Loads

Design method	BS EN
Failure consequence class (CC)	CC1
Design working life	25 years
Terrain category	Country Terrain
distance to shoreline	30.00 km

Wind load

Velocity pressure	$q_{p,50}$ = 0.667 kN/m²
Adjustment factor for service life	f_w = 0.921
Velocity pressure	$q_{p,25}$ = 0.614 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	0.400	-1.000	0.246	-0.614
eaves	10.00	0.500	-1.000	0.307	-0.614

Snow load

Snow load zone		2
Environment		Normal terrain
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	= 0.866
Snow load on roof	$s_{i,50}$	= 0.277 kN/m²
Adjustment factor for service life	f_s	= 0.929
Snow load on roof	$s_{i,25}$	= 0.257 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	= 1.95 m²
Dead weight of module per m²		= 11.01 kg/m²
Dead weight of mounting system per m²		= 1.28 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 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	$E_d = G_k + W_{k,Uplift}$

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	0.599	0.237	-0.679	0.060	0.475	0.189	-0.510	0.060
eaves	10.00	0.660	0.237	-0.679	0.060	0.523	0.189	-0.510	0.060

Structural analysis report | Roof 3

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	0.851	0.337	-0.964	0.086	0.674	0.268	-0.724	0.086
eaves	10.00	0.938	0.337	-0.964	0.086	0.743	0.268	-0.724	0.086

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 SingleRail 36	2.850	4.02	6.37	2.14	3.09

Fastener

Fastener	$R_{D,Uplift,Perpendicular}$ [kN]	$R_{D,Pressure,Perpendicular}$ [kN]	$R_{D,Pressure,Parallel}$ [kN]
SingleHook 3S	2.17	2.67	2.40

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	38.0	16.6	48.0	35.9	1.500	---	0.559	1.938
1	eaves	41.1	0.9	48.0	37.7	1.500	---	0.551	1.915

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	2003215	SingleHook 3S	13	6.9 kg
2	2004112	Wood screw 8×100	26	0.7 kg
3	2002514	OneEnd Set 30-42	8	0.7 kg
4	2003071	OneMid Set 30-42	8	0.6 kg
5	1004767	SingleRail 36 End Cap	8	0.1 kg
6	2002870	K2 Solar Cable Manager	6	0.0 kg
7	2003222	SingleRail 36; 4.40 m	4	13.6 kg
8	2001976	SingleRail 36 RailConnector Set	2	0.8 kg
Total				**23.3 kg**

Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003215	SingleHook 3S	86	45.6 kg
2	2004112	Wood screw 8×100	172	4.6 kg
3	2002514	OneEnd Set 30-42	32	2.8 kg
4	2003071	OneMid Set 30-42	72	5.7 kg
5	1004767	SingleRail 36 End Cap	32	0.2 kg
6	2002870	K2 Solar Cable Manager	44	0.1 kg
7	2003222	SingleRail 36; 4.40 m	25	84.8 kg
8	2001976	SingleRail 36 RailConnector Set	18	6.8 kg
Total				**150.6 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:

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

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