



| Connecting Strength

K2 Base Report

BUCCLEUCH LODGE

Project address	31 Moorfield Rd, West Didsbury, Manchester M20 2UZ, UK
Address	,
Planner	Tyler Adams
Issue date	06/08/2025
Version	K2 Base Version 3.2.49.0



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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  Flat	S-Dome 6.10 Xpress	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	3.00 m	70	37.1 kWp
Roof 2  Tile	SolidRail	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	5.00 m	42	22.26 kWp
Roof 2 (1)  Tile	SolidRail	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	5.00 m	42	22.26 kWp
Total				154	81.62 kWp

Project information

Address	31 Moorfield Rd, West Didsbury, Manchester M20 2UZ, UK
Author	Tyler Adams

Load settings

Design method	BS EN
Failure consequence class (CC)	CC2
Design working life	25 years
Terrain category	Country Terrain
Basic wind speed	22.5 m/s
Distance to shoreline	51.29 km
Snow load zone	3
Snow load on ground level	0.50 kN/m ²

Material values

For material information refer to the product catalogue:

[K2 Catalogue \(k2-systems.com\)](https://k2-systems.com)



THE PROJECT IS VERIFIED.

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

BUCCLEUCH LODGE



Project information

Address

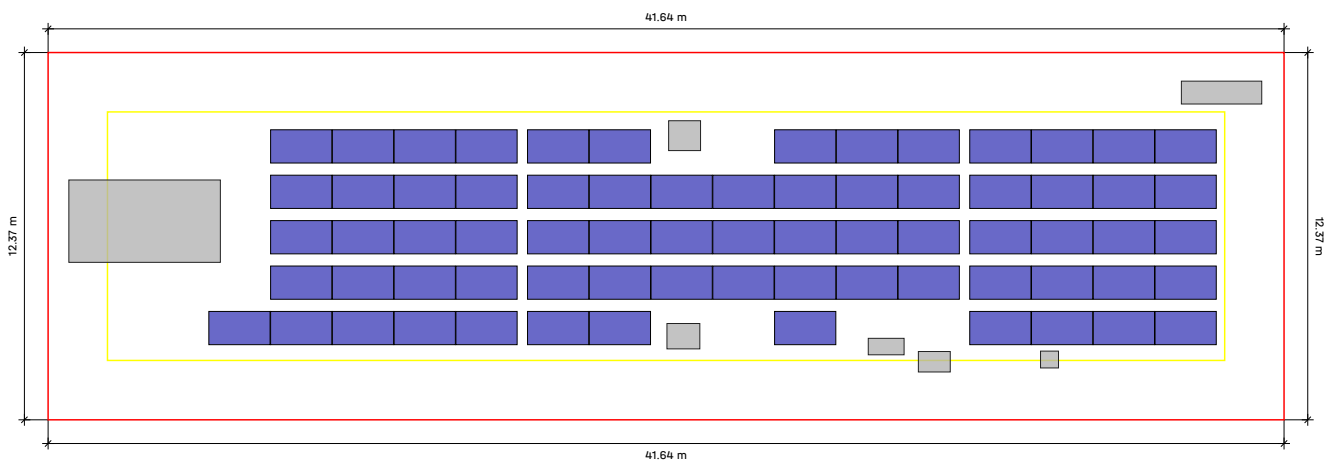
31 Moorfield Rd, West Didsbury, Manchester M20 2UZ, UK

Author

Tyler Adams



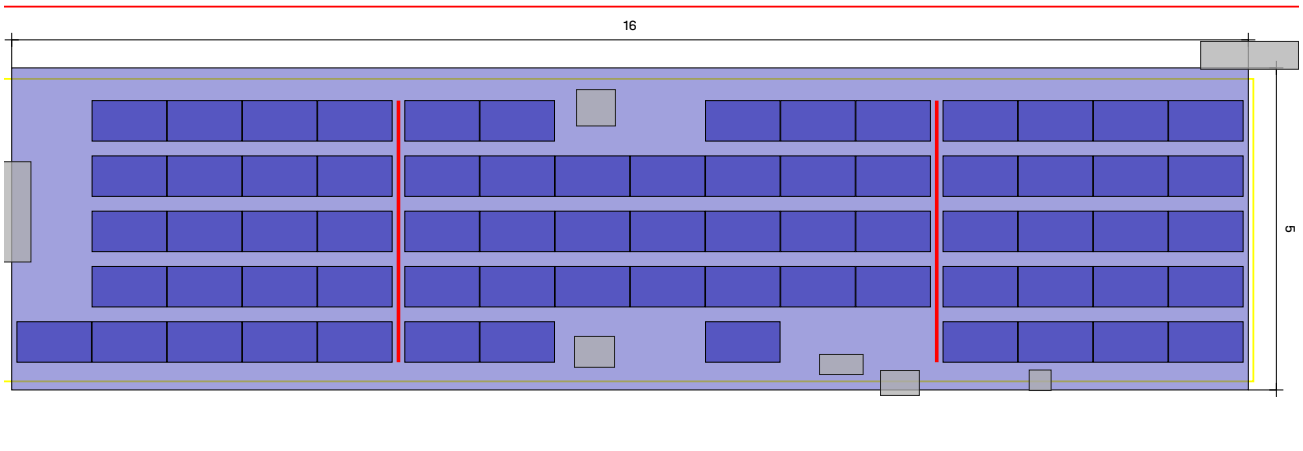
Roof 1



Roof	System	Module	Height	Quantity	Total power
<u>Roof 1</u>	<u>S-Dome 6.10</u>	JAM60D-42-530-LB-TS-BF	3.00 m	70	37.1 kWp
 Flat	<u>Xpress</u>	2,063×1,134×30 mm 530 Wp			



Roof 1 | Module array 1



Roof ① Module array ①

Mounting System

[S-Dome 6.10 Xpress](#)

Module

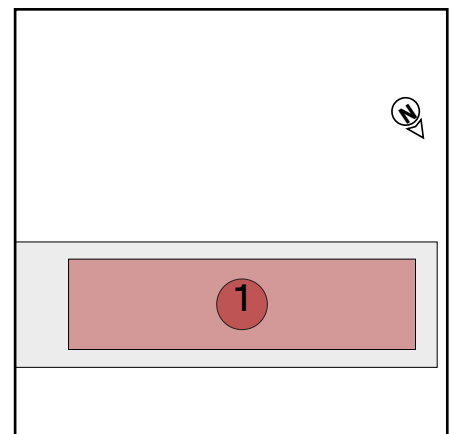
70(37.1 kWp) x
JAM60D-42-530-LB-TS-BF

Row spacing

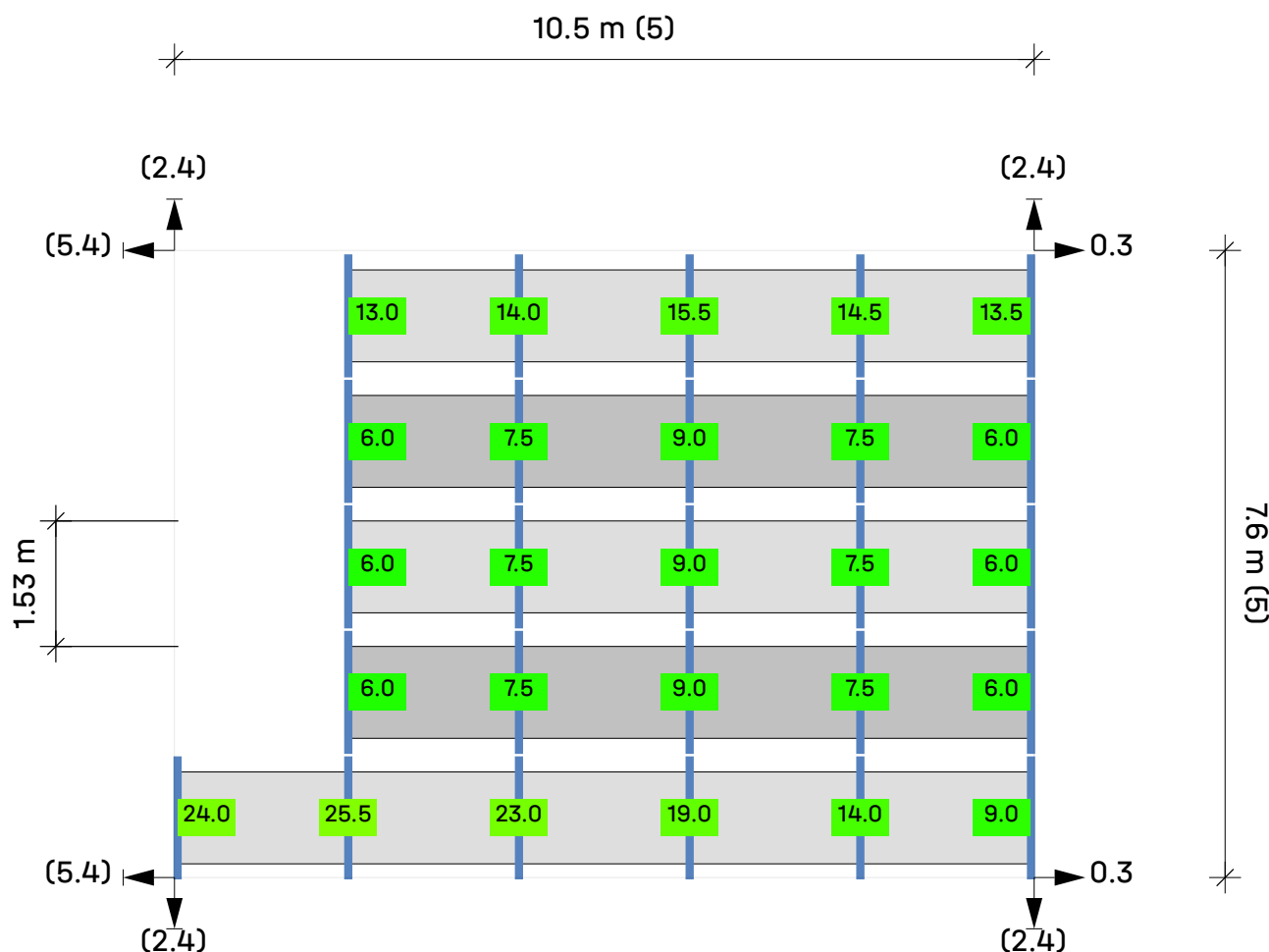
1.53 m

service corridor

0.41 m



Roof 1 | Module array 1 | Module block 1

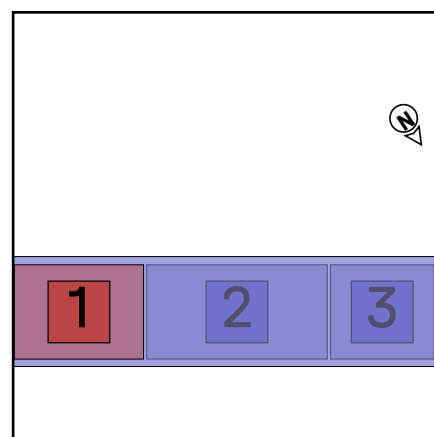


Roof ① Module array ① Module block ①

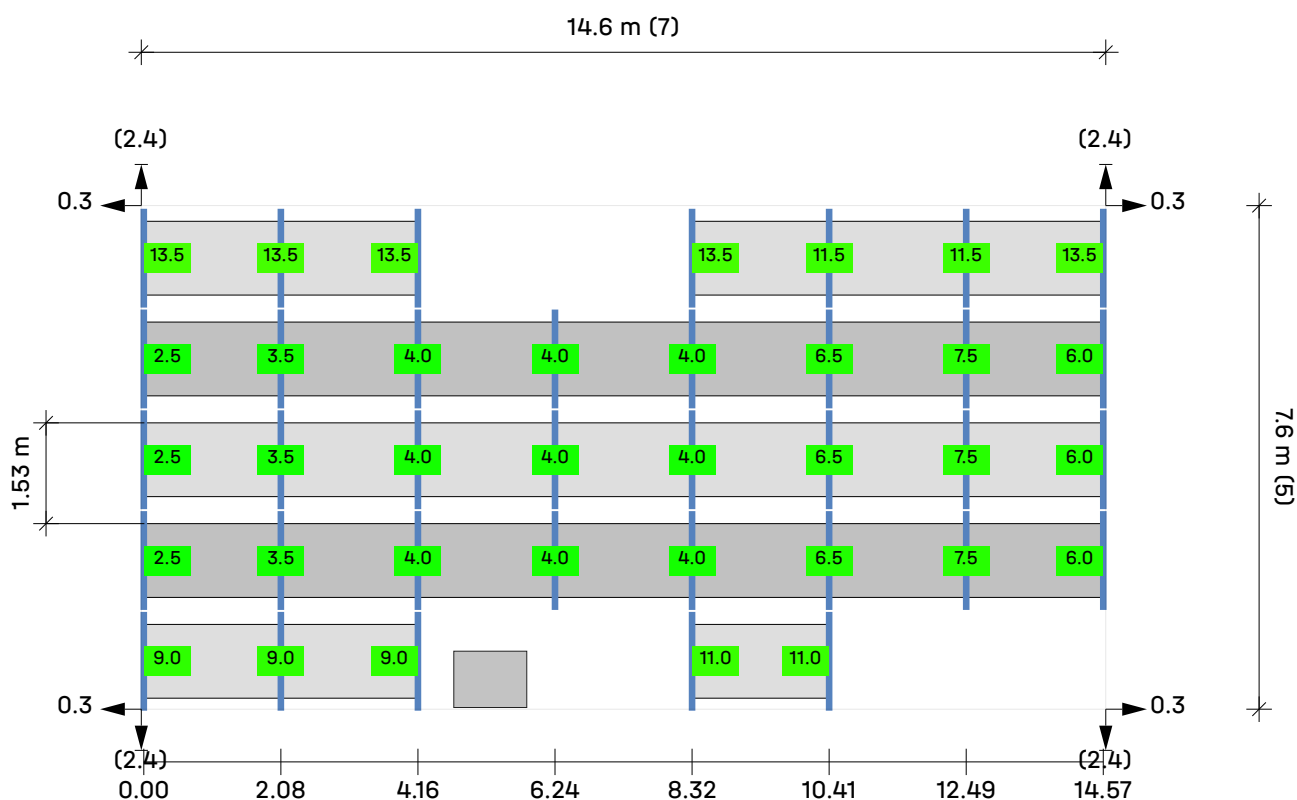
Modules (5 × 5) - 4 = 21

Legend

- Mounting rail
- Row distance [m]
- Distance to Roof Edge [m]
- Dist. to neighbour module block/array [m]
- 25 Ballast in kilogram (kg)
- Porter Ballast



Roof 1 | Module array 1 | Module block 2

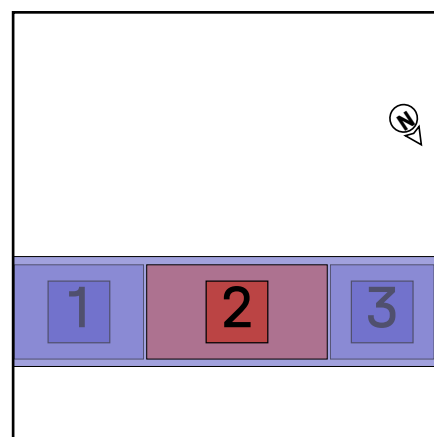


Roof ① Module array ① Module block ②

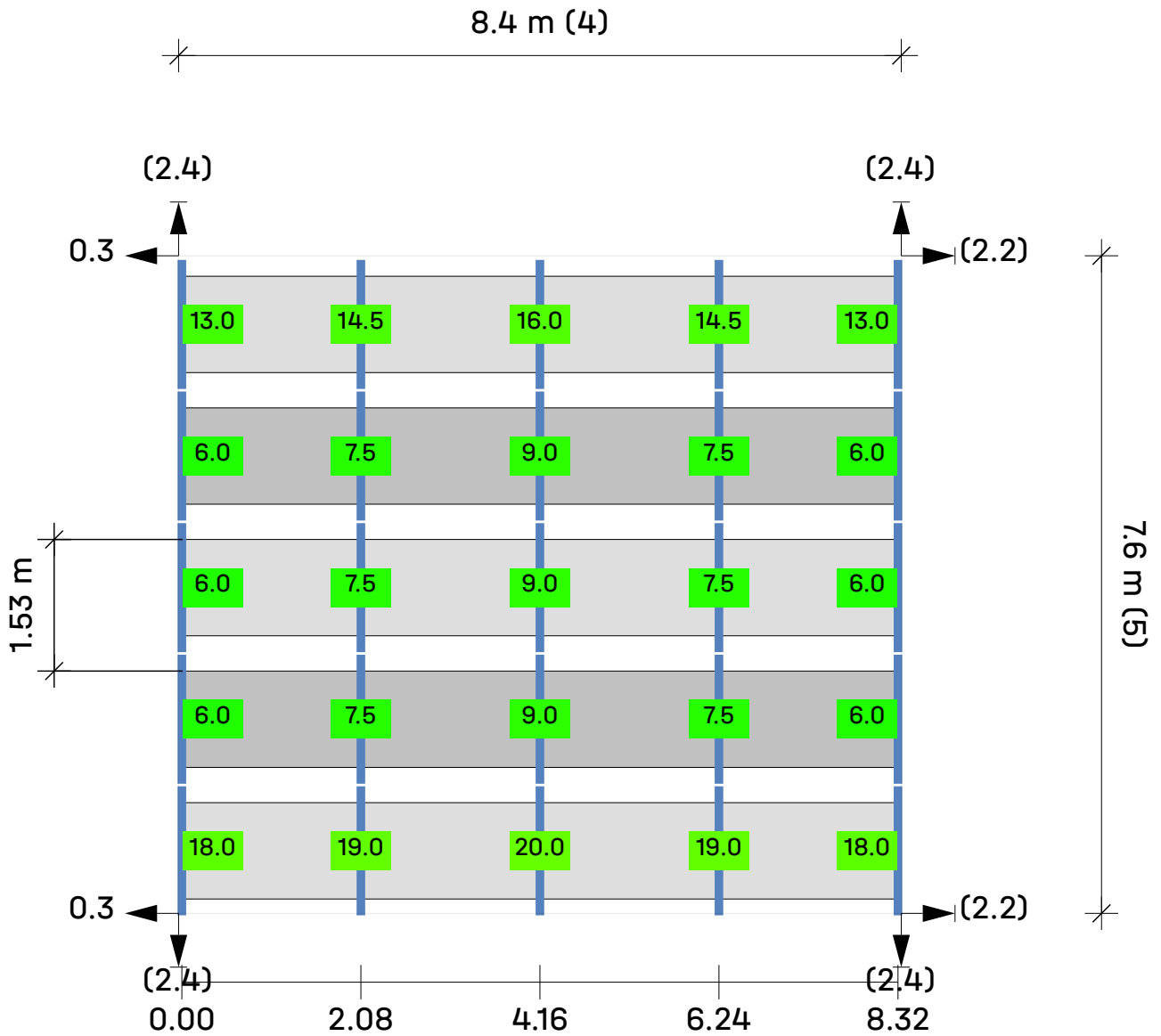
Modules (7 × 5) - 6 = 29

Legend

- Mounting rail
- Row distance [m]
- Distance to Roof Edge [m]
- Dist. to neighbour module block/array [m]
- 25 Ballast in kilogram (kg)
- Porter Ballast



Roof 1 | Module array 1 | Module block 3

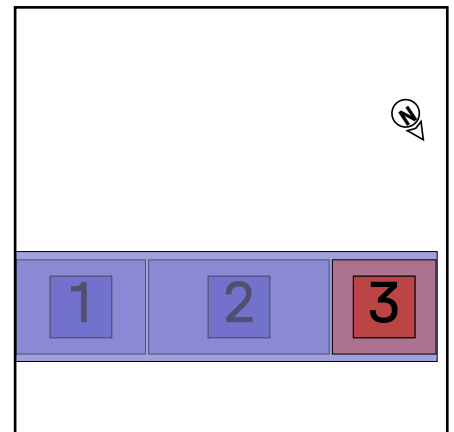


Roof ① Module array ① Module block ③

Modules $4 \times 5 = 20$

Legend

- Mounting rail
- Row distance [m]
- Distance to Roof Edge [m]
- Dist. to neighbour module block/array [m]
- 25 Ballast in kilogram (kg)
- Porter Ballast



Results | Roof 1

Roof	System	Module	Height	Quantity	Total power
Roof 1  Flat	S-Dome 6.10 Xpress	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	3.00 m	70	37.1 kWp

Module

Name	JAM60D-42-530-LB-TS-BF
Manufacturer	JA Solar
Output power	530 Wp
Dimensions	2,063×1,134×30 mm
Weight	28.8 kg

Module clamps

module clamp	DomeClamp Black MC Set 30-50
end clamp	DomeClamp Black EC Set 30-50

Ballast capacity

Speed Porter	40.0 kg
Porter	108.0 kg

Verification system utilisation

Type	pressure	suction
Verification system utilisation	29.73%	44.83%
Loads on modules (ultimate state)	1.34 kN/m ²	-0.79 kN/m ²
Loads on modules (Serviceability)	0.91 kN/m ²	-0.49 kN/m ²

Specific loads

Module block	No. of modules	Ballast [kg]	Dead weight [kg]	Module block area [m ²] (incl. service corridor)	Dead Load [kN/m ²]	Dead load (roof surface area) [kN/m ²]
Block 1	21	293.0	1,023.80	67.39 m ²	0.15	
Block 2	29	253.5	1,262.70	93.08 m ²	0.13	
Block 3	20	273.0	969.00	64.22 m ²	0.15	
Total	70	819.5	3,255.50			0.06



Results | Roof 1

Note

- The proof of static equilibrium and load capacity of the system are carried out by checking the load cases uplift and sliding by wind according to wind tunnel expertise from IFI institute
- You will find a short version of the wind tunnel report and a certificate for the further static calculations on our homepage.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminium 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 service life period, f_W , is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, f_S , is according to DIN EN 1991-1-3/ annex D, table 4
- All resistance values of components are determined from an extern static engineering office.
- 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'.
- The person responsible for the execution of the work must check the load assumptions made with the conditions on site. If deviations are found, the person who prepared the static calculation must be consulted immediately. , 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	BUCCLEUCH LODGE
Mounting System	S-Dome 6.10 Xpress
Author	Tyler Adams

Location information

Address	31 Moorfield Rd, West Didsbury, Manchester M20 2UZ, UK
Ground elevation	36.04 m

Roof information

Building height	3.00 m
Roof type	Flat roof
Roof pitch	1°
Fastening method	with Ballast
Roof covering	Flat
Min. roof edge distance	2.00 m
Parapet wall height	0.00 m
Material	Bitumen
Friction coefficient	0.6

The friction coefficients given here must be checked onsite. If a lower value is found, this must be specified here for the ballast calculation!

Loads

Design method	BS EN
Failure consequence class (CC)	CC2
Design working life	25 years
Terrain category	Country Terrain
Distance to shoreline	51.29 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 0.548 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 0.921$
Velocity pressure, 25 years	$q_{p,25} = 0.505 \text{ kN/m}^2$



Structural analysis report | Roof 1

Snow load

Snow load zone	3
Snow guard	No
Snow load on ground level	$s_k = 0.500 \text{ kN/m}^2$
Shape Coefficient for Snow	$\mu_i = 0.800$
Factor for roof pitch	$d_i = 1.000$
Snow load on roof, 50 year	$s_{i,50} = 0.400 \text{ kN/m}^2$
Adjustment factor for service life	$f_s = 0.929$
Snow load on roof, 25 years	$s_{i,25} = 0.372 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 28.8 \text{ kg}$
Weight of mounting system per module	$= 6.0 \text{ kg}$
Module area	$A_M = 2.34 \text{ m}^2$
Dead weight of module per m^2	$= 12.31 \text{ kg/m}^2$
Dead weight of mounting system per m^2	$= 2.56 \text{ kg/m}^2$
Total Dead Load (excl. ballast) per m^2	$= 0.15 \text{ kN/m}^2$

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	$\gamma_{G,stab} = 0.90$
Partial safety factor variable loads	$\gamma_Q = 1.50$
Combination coefficient with regards to wind	$\psi_{0,W} = 0.60$
Combination coefficient with regards to Snow	$\psi_{0,S} = 0.50$
Importance factor permanent	$\kappa_{FI,G} = 1.00$
Importance factor variable	$\kappa_{FI,Q} = 1.00$
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

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



Structural analysis report | Roof 1

Static equilibrium

Uplift Verification

$$\text{LCC up} = \gamma_{G, \text{stb}} * G_k + \gamma_Q * \kappa_{F1, Q} * W_{k, n, \text{Uplift}}$$

Displacement verification

$$\text{LCC displ} = \gamma_{G, \text{stb}} * G_k + \gamma_Q * \kappa_{F1, Q} * W_{k, n, \text{Displacement}}$$

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

$$\text{LCC 01_sls} = G_k + S_{i, n}$$

Load case combination 02

$$\text{LCC 02_sls} = G_k + W_{k, \text{Pressure}}$$

Load case combination 03

$$\text{LCC 03_sls} = G_k + W_{k, \text{Pressure}} + \psi_{0, S} * S_{i, n}$$

Load case combination 04

$$\text{LCC 04_sls} = G_k + S_{i, n} + \psi_{0, w} * W_{k, \text{Pressure}}$$

Load case combination 06

$$\text{LCC 06_sls} = G_k + W_{k, \text{Suction}}$$

Max. Pressure on insulation

General information

dead load system

$$g_{\text{System}} = 0.15 \text{ kN/m}^2$$

aerodynamic coefficient

$$c_{p, \text{Pressure}} = 0.20$$

Load distribution underneath the building protection mat under Peak

Dimensions

$$75.3 \times 380.0 \times 23.1 \text{ mm}$$

$$A_{\text{eff}} = 28,614.00 \text{ mm}^2$$

$$A_{\text{load range area}} = 1.17 \text{ m}^2$$

maximum ballast

$$G_{\text{ballast required}} = 16.8 \text{ kg}$$

Load distribution underneath the building protection mat under SD

Dimensions

$$75.3 \times 380.0 \times 23.1 \text{ mm}$$

$$A_{\text{eff}} = 28,614.00 \text{ mm}^2$$

$$A_{\text{load range area}} = 1.17 \text{ m}^2$$

maximum ballast

$$G_{\text{ballast required}} = 8.7 \text{ kg}$$

Load Combinations

	$\sigma_{\text{Ek, heat insulation, Peak}} [\text{Pa}]$	$\sigma_{\text{Ek, heat insulation, SD}} [\text{Pa}]$
Load case combination 00	11,731	8,935
Load case combination 01	26,735	23,938

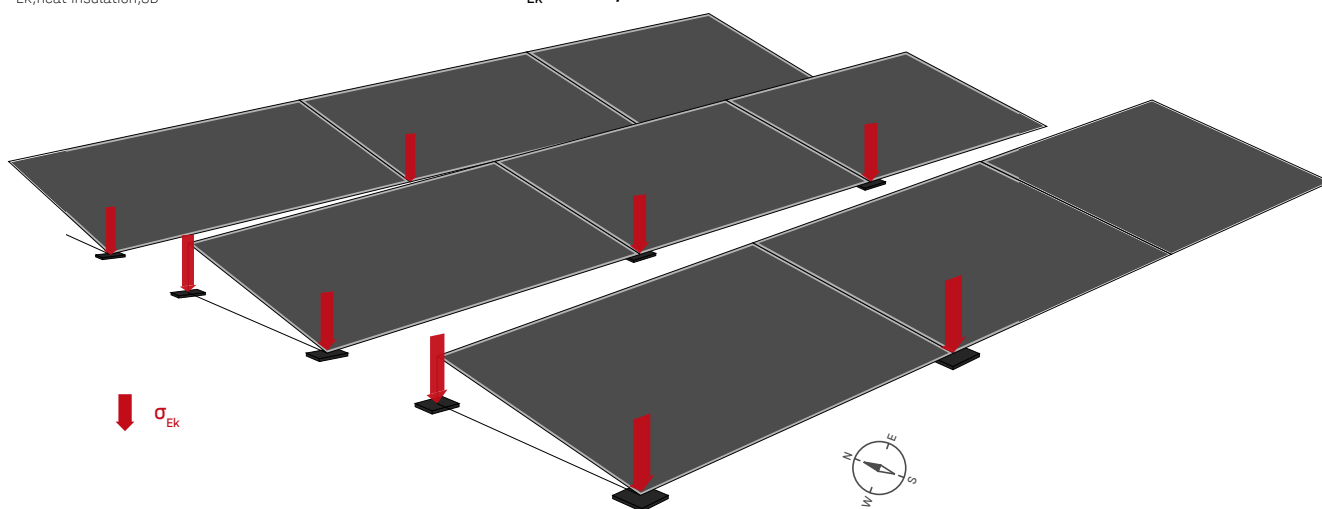
Structural analysis report | Roof 1

Dead loads (PV system + ballast)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\sigma_{\text{Ek}} = 11,731 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\sigma_{\text{Ek}} = 8,935 \text{ Pa}$

Maximum actions (sum of dead loads and snow)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\max \sigma_{\text{Ek}} = 26,735 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\max \sigma_{\text{Ek}} = 23,938 \text{ Pa}$



Structural analysis report | Roof 1

Ballast Calculation

Ballast Calculation Uplift

Force per module perpendicular to the roof

$$F_z = q_p \cdot (-c_{pD} \cos(\delta) A_D - c_{pM} \cos(\alpha) A_M)$$

F_z	uplift force per module unit in z-direction
q_p	local peak velocity pressure at roof height z
A_D	deflector area
A_M	module area
δ	deflector tilt angle
α	module tilt angle
c_{pD}	deflector pressure coefficient
c_{pM}	module pressure coefficient

Ballast against uplift

$$m_{B,uplift} = \frac{\gamma_Q \cdot \kappa_{Fl,Q} \cdot F_z}{\gamma_{G,stab} \cdot \cos(\beta) \cdot g} \cdot \prod_i k_i - m_{DL}$$

m_{DL}	weight of module(s) and mounting system
β	roof pitch angle
k_a	correction factor for roof pitch
k_d	correction factor for wind direction
k_A	correction factor for module blocks with more than 60 modules
k_c	correction factor for module cantilever over windbreaker
k_p	correction factor for parapet walls
k_s	correction factor for large modules
k_R	correction factor for large row spacings
k_{RWS}	correction factor for the gap between windbreaker and module

Structural analysis report | Roof 1

Ballast Calculation Sliding

Force per module parallel to the roof

$$F_x = q_p \cdot (c_{pD} \sin(\delta) A_D - c_{pM} \sin(\alpha) A_M)$$

$$F_y \approx 0$$

- F_x sliding force per module unit in x-direction
- F_y sliding force per module unit in y-direction
- q_p local peak velocity pressure at roof height z
- c_{pD} deflector pressure coefficient
- c_{pM} module pressure coefficient
- A_D deflector area
- A_M module area
- δ deflector tilt angle
- α module tilt angle

Ballast against sliding

$$m_{B,sliding} = \frac{\gamma_Q \cdot \kappa_{Fl,Q} \cdot \left(\frac{\sqrt{F_x^2 + F_y^2}}{\mu_{R,0}} + F_z \right)}{\gamma_{G,stab} \cdot g} \cdot \prod_i k_i - m_{DL}$$

- m_{DL} weight of module(s) and mounting system
- $\mu_{R,0}$ Friction coefficient
- k_a correction factor for roof pitch
- k_d correction factor for wind direction
- k_A correction factor for module blocks with more than 60 modules
- k_c correction factor for module cantilever over windbreaker
- k_p correction factor for parapet walls
- k_s correction factor for large modules
- k_R correction factor for large row spacings
- k_{RWS} correction factor for the gap between windbreaker and module

Case	Highest ballast		Lowest ballast	
	Sliding	Uplift	Sliding	Uplift
c_{pM}	-0.155		-0.361	-0.130
c_{pD}	0.302		0.317	0.144
k_a	1.03		1.00	1.03
k_d	0.90		0.90	0.90

Structural analysis report | Roof 1

k_A	1.00	1.00	1.00	1.00
k_C	1.05	1.05	1.05	1.05
k_p	1.00	1.00	1.00	1.00
k_s	1.03	1.03	1.03	1.03
k_R	1.00	1.00	1.00	1.00
k_{RWS}	1.03	1.03	1.03	1.03
A_M [m ²]	2.34	2.34	2.34	2.34
A_D [m ²]	0.25	0.25	0.25	0.25
delta [°]	81.0	81.0	81.0	81.0
alpha [°]	9.0	9.0	9.0	9.0
qp [kN/m ²]	0.51	0.51	0.51	0.51
μ	0.6	-	0.6	-
Fx [kN]	0.067	-	0.042	-
Fz [kN]	0.175	0.415	0.149	0.167
$m_{ballast}$ [kg]	15.4	35.9	3.7	0.0
m_{DL} [kg]	34.8	34.8	34.8	34.8

Structural analysis report | Roof 1

H-V-loads

According to wind tunnel report by I.F.I. Institut für Industrieaerodynamik GmbH

General information

Total number of modules	70	
Roof areas covered with modules	A	= ca. 224.69 m ²
Dead Load	$g_{k, \text{System incl. ballast}}$	= 0.14 kN/m ²

Aerodynamic coefficients

	$C_{p, \text{Pressure}}$	= according to EN 1991-1-4
	$C_{F, x, \text{average}}$	= 0.01
	$C_{F, y, \text{average}}$	= -0.02
edge distance correction	$k_{s, xy}$	= 1.00
Parapet wall- correction coefficient	k_p	= 1.00
Factor building height		= 1.00

Horizontal pressure

$$W_{k, F, x} = 0.005 \text{ kN/m}^2$$

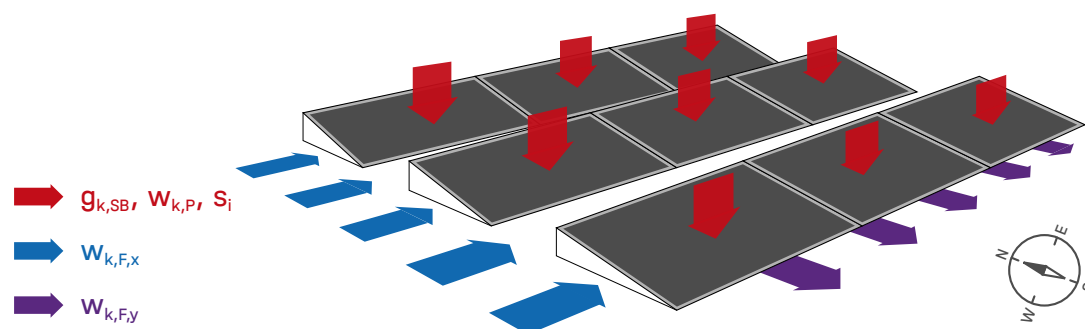
$$W_{k, F, y} = -0.010 \text{ kN/m}^2$$

Vertical pressure

$$g_{k, \text{System incl. ballast}} = 0.14 \text{ kN/m}^2$$

$$W_{k, \text{Pressure}} - \text{according to EN 1991-1-4}$$

$$S_i - \text{according to EN 1991-1-3}$$



Comment:

Flat roof vertical wind loads are essentially determined by its displacement effect and remain unchanged even with a flat pv structure. We advise using the aerodynamic coefficients according to DIN EN 1991-1-4 to calculate flat roofs.

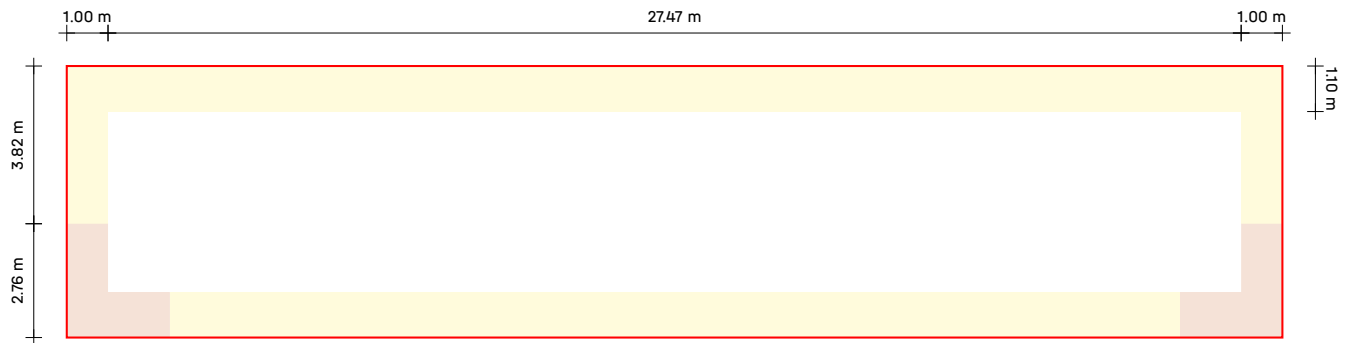


Roof 1 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2004096	S-Dome 6.10 Base Set L	87	163.6 kg
2	2004125	Dome 6.10 Peak	87	26.1 kg
3	2004123	Dome 6 Connector 195 Set	68	14.7 kg
4	2003250	S-Dome 6.10 Windbreaker long	70	150.3 kg
5	2002937	Thread-forming metal screw 6×25	174	1.2 kg
6	2002870	K2 Solar Cable Manager	70	0.2 kg
7	2002609	DomeClamp Black MC Set 30-50	106	6.1 kg
8	2002610	DomeClamp Black EC Set 30-50	68	4.5 kg
9	2002300	Dome SpeedPorter	174	13.2 kg
Total				379.9 kg

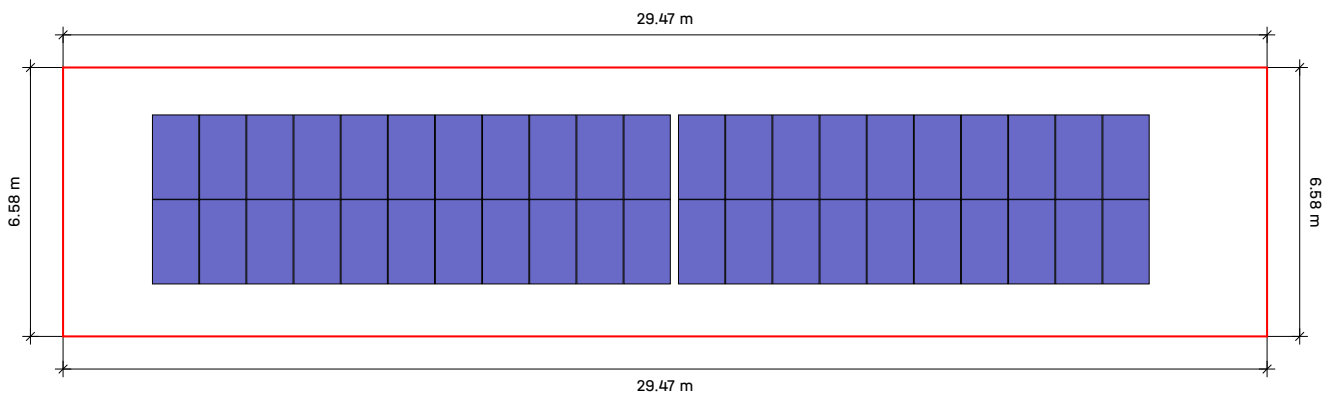


Roof 2





Roof 2



Roof	System	Module	Height	Quantity	Total power
<u>Roof 2</u>	<u>SolidRail</u>	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	5.00 m	42	22.26 kWp
 Tile					



Roof 2 | Assembly plan

Base Rails

Type	Whole Rails		Rail cutting		
	Total Rail Length	Quantity 4.40 m	Part of Rail / Rest	Length	Rest
4*A	12.827 m	2*4.40 m	4.400	4.027 from 4.400	0.363
4*B	11.620 m	2*4.40 m	4.400	2.820 from 4.400	1.570

1 cm is viewed as lost for each cutting

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

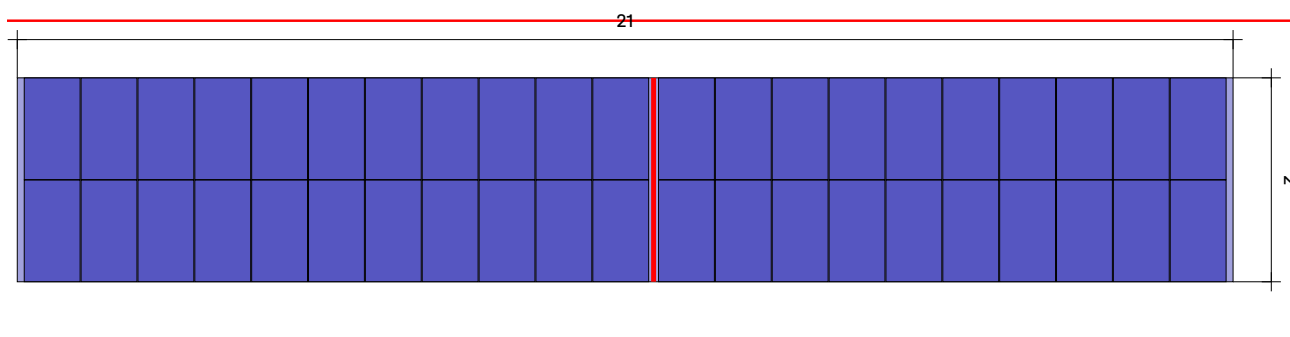
Fastener Spacing

Module	Array	Distance	maximum cantilever length [m]	maximum fastener spacing [m]
1	field area	1.20 m	0.528	1.770

Module arrays

Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	24.39	4.14	21	2

Roof 2 | Module array 1



Roof ② Module array ①

Mounting System

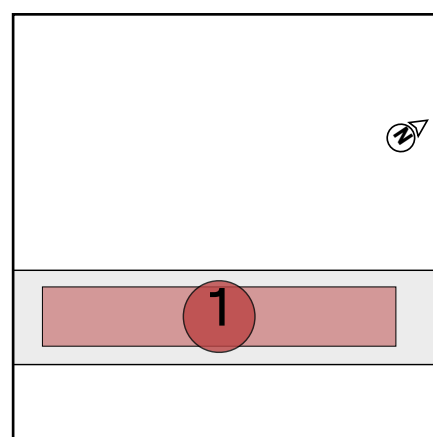
[SolidRail](#)

Module

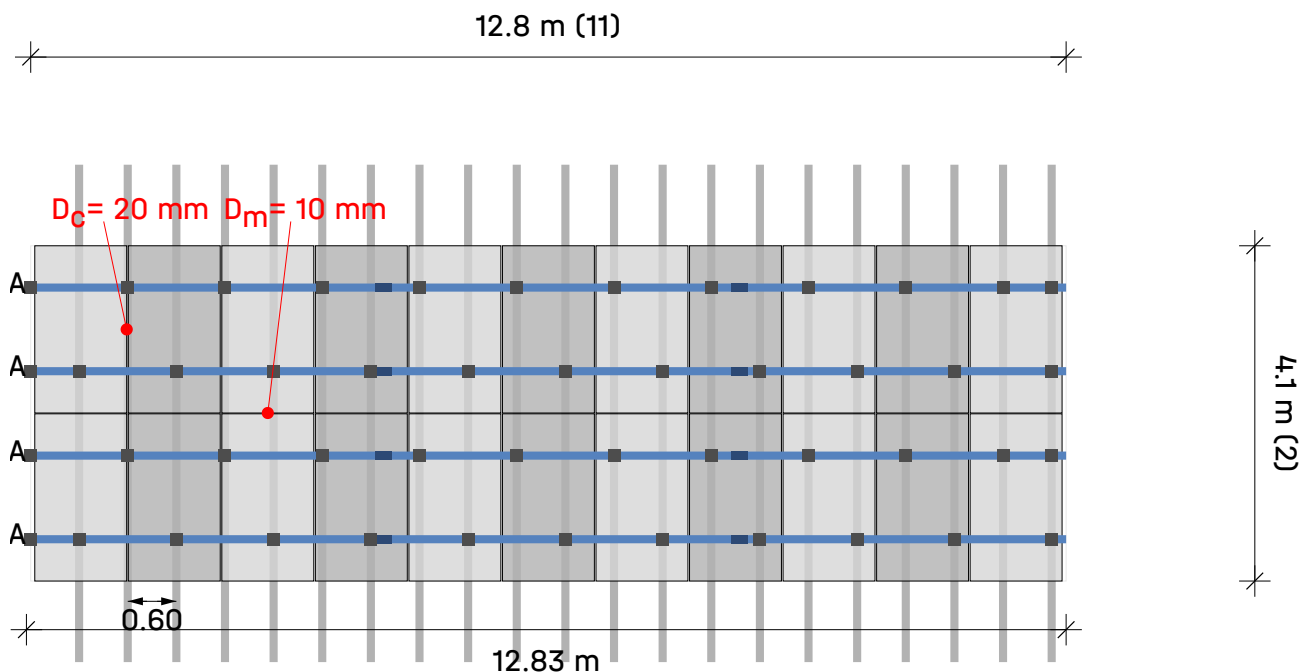
42(22.26 kWp) x
JAM60D-42-530-LB-TS-BF

Row spacing

2.07 m



Roof 2 | Module array 1 | Module block 1

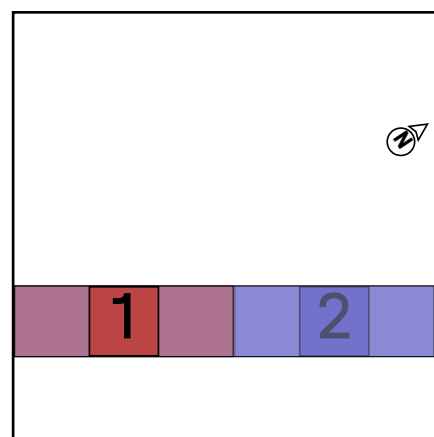


Roof ② Module array ① Module block 1

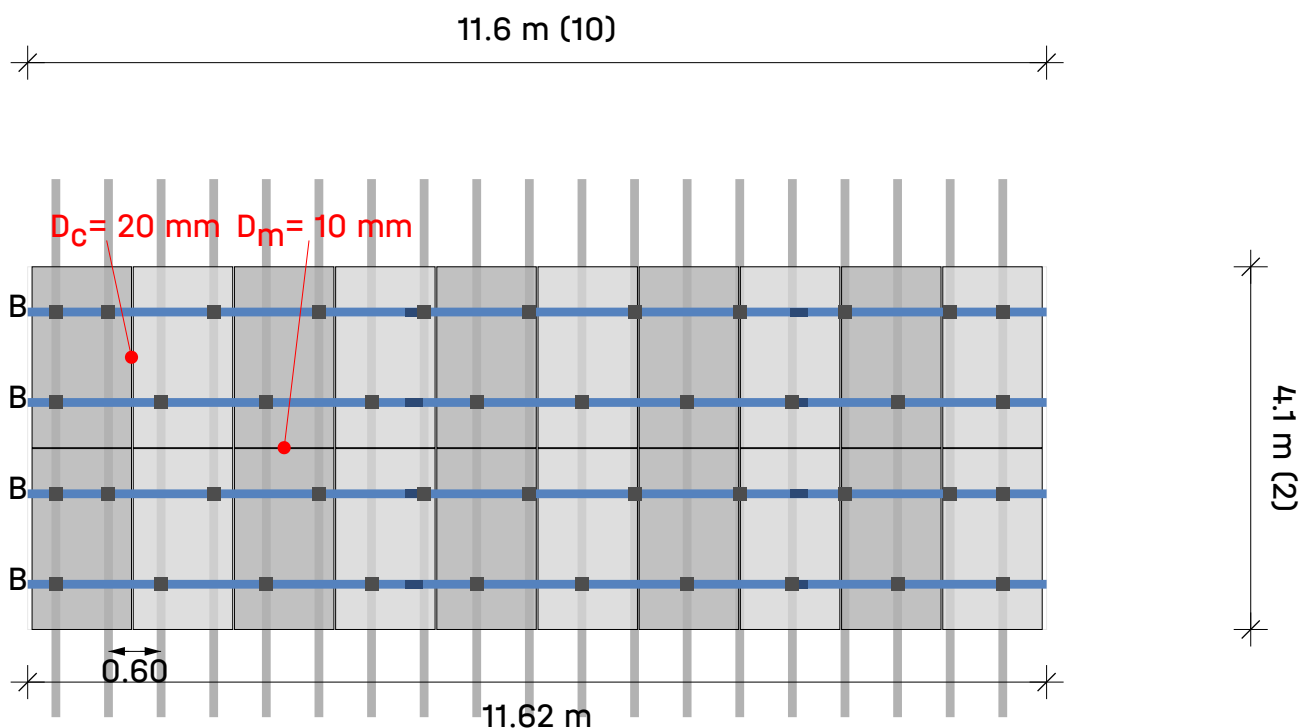
Modules $11 \times 2 = 22$

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- ➔ Dist. to neighbour module block/array [m]
- D_c Distance for clamping between modules
- D_m Distance between modules



Roof 2 | Module array 1 | Module block 2

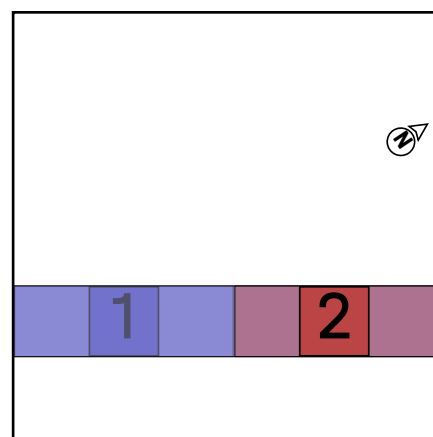


Roof ② Module array ① Module block 2

Modules $10 \times 2 = 20$

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- ➔ Dist. to neighbour module block/array [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	SolidRail	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	5.00 m	42	22.26 kWp
 Tile					

Module

Name	JAM60D-42-530-LB-TS-BF
Manufacturer	JA Solar
Output power	530 Wp
Dimensions	2,063×1,134×30 mm
Weight	28.8 kg

Components

Fastener	SolidHook 3S+
Base rails	K2 SolidRail Light 37

Loads on modules (module dimensioning)

No. Module Array	Array	A-TrA [m ²]	ultimate state [Pa]				Serviceability [Pa]			
			Pressure ⊥	Pressure 	Uplift ⊥	Uplift 	Pressure ⊥	Pressure 	Uplift ⊥	Uplift
1	field area	2.34	952.9	361.2	-413.5	56.7	647.4	246.5	-235.1	56.7

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	42.9	37.2	57.5	26.4	1.200	---	0.528	1.770

Pr	Profile	Fst D _{max}	maximum fastener spacing [m]
Fst	Fastener	BR	Base Rail
σ	Stress	Usab.	serviceability limit state
f	Deflection	CL	Cantilever
F	Force		
CL/L _{max}	maximum cantilever length [m]		



Results | Roof 2

Note

- The dimensioning of the timber construction screws is not part of this structural analysis. This must be done on site. If the rafters are made of solid wood, glued laminated timber, cross laminated timber and laminated veneer lumber, assembly with 2 timber construction screws is usually sufficient. The edge distances must be uphold in accordance with the manufacturer's specifications.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminium 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 service life period, f_W , is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, f_S , 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'.
- The person responsible for the execution of the work must check the load assumptions made with the conditions on site. If deviations are found, the person who prepared the static calculation must be consulted immediately. , 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	BUCCLEUCH LODGE
Mounting System	SolidRail
Author	Tyler Adams

Location information

Address	31 Moorfield Rd, West Didsbury, Manchester M20 2UZ, UK
Ground elevation	36.04 m

Roof information

Building height	5.00 m
Roof type	Gable roof
Roof pitch	25°
Roof covering	Tile
Min. roof edge distance	0.00 m
Rafter Spacing	0.600 m
Rafter width	50.0 mm
set edge rafter left	No
Rafter spacing left	335.0 mm
set edge rafter right	No
Rafter spacing right	335.0 mm
Batten spacing	350.0 mm

Loads

Design method	BS EN
Failure consequence class (CC)	CC2
Design working life	25 years
Terrain category	Country Terrain
Distance to shoreline	51.29 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 0.645 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 0.921$
Velocity pressure, 25 years	$q_{p,25} = 0.594 \text{ kN/m}^2$



Structural analysis report | Roof 2

Roof areas

No. Module Array	Array	load impact area [m ²]	maxCpe	minCpe	wind pressure [kN/m ²]	wind suction [kN/m ²]
1	field area	10.00	0.333	-0.600	0.198	-0.357

Snow load

Snow load zone	3
Snow guard	No
Snow load on ground level	$s_k = 0.500 \text{ kN/m}^2$
Shape Coefficient for Snow	$\mu_i = 1.067$
Factor for roof pitch	$d_i = 0.906$
Snow load on roof, 50 year	$s_{i,50} = 0.483 \text{ kN/m}^2$
Adjustment factor for service life	$f_s = 0.929$
Snow load on roof, 25 years	$s_{i,25} = 0.449 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 28.8 \text{ kg}$
Weight of mounting system per module	$= 3.2 \text{ kg}$
Module area	$A_M = 2.34 \text{ m}^2$
Dead weight of module per m ²	$= 12.31 \text{ kg/m}^2$
Dead weight of mounting system per m ²	$= 1.37 \text{ kg/m}^2$
Total Dead Load (excl. ballast) per m ²	$= 0.13 \text{ kN/m}^2$

Load Combinations

Ultimate limit state

Partial safety factor unfavourable permanent load	$V_{G,sup} = 1.35$
Partial safety factor favourable permanent load	$V_{G,inf} = 1.00$
Partial safety factor destabilising permanent load	$V_{G,dst} = 1.10$
Partial safety factor stabilising permanent load	$V_{G,stb} = 0.90$
Partial safety factor variable loads	$V_Q = 1.50$
Combination coefficient with regards to wind	$\psi_{0,w} = 0.60$
Combination coefficient with regards to Snow	$\psi_{0,s} = 0.50$
Importance factor permanent	$K_{Fl,G} = 1.00$
Importance factor variable	$K_{Fl,Q} = 1.00$
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

Structural analysis report | Roof 2

Load case combination 01	$LCC\ 01_{uls} = Y_{G,sup} * K_{FI,G} * G_k + Y_Q * K_{FI,Q} * S_{i,n}$
Load case combination 02	$LCC\ 02_{uls} = Y_{G,sup} * K_{FI,G} * G_k + Y_Q * K_{FI,Q} * W_{k,Pressure}$
Load case combination 03	$LCC\ 03_{uls} = Y_{G,sup} * K_{FI,G} * G_k + Y_Q * K_{FI,Q} * (W_{k,Pressure} + \psi_{0,S} * S_{i,n})$
Load case combination 04	$LCC\ 04_{uls} = Y_{G,sup} * K_{FI,G} * G_k + Y_Q * K_{FI,Q} * (S_{i,n} + \psi_{0,W} * W_{k,Pressure})$
Load case combination 06	$LCC\ 06_{uls} = Y_{G,inf} * G_k + Y_Q * K_{FI,Q} * W_{k,Suction}$

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)

No. Module Array	Array	A-TrA [m ²]	ultimate state [kN/m ²]				Serviceability [kN/m ²]			
			Pressure ⊥	Pressure 	Uplift ⊥	Uplift 	Pressure ⊥	Pressure 	Uplift ⊥	Uplift
1	field area	10.00	0.953	0.361	-0.413	0.057	0.647	0.246	-0.235	0.057

Max. load on fastener

No. Module Array	Array	A-TrA [m ²]	ultimate state [kN]				Serviceability [kN]			
			Pressure ⊥	Pressure 	Uplift ⊥	Uplift 	Pressure ⊥	Pressure 	Uplift ⊥	Uplift
1	field area	10.00	1.297	0.492	-0.563	0.077	0.882	0.336	-0.320	0.077

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 3S+	2.17	2.67	2.40



Structural analysis report | Roof 2

Utilisation result

No.	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	42.9	37.2	57.5	26.4	1.200	---	0.528	1.770

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

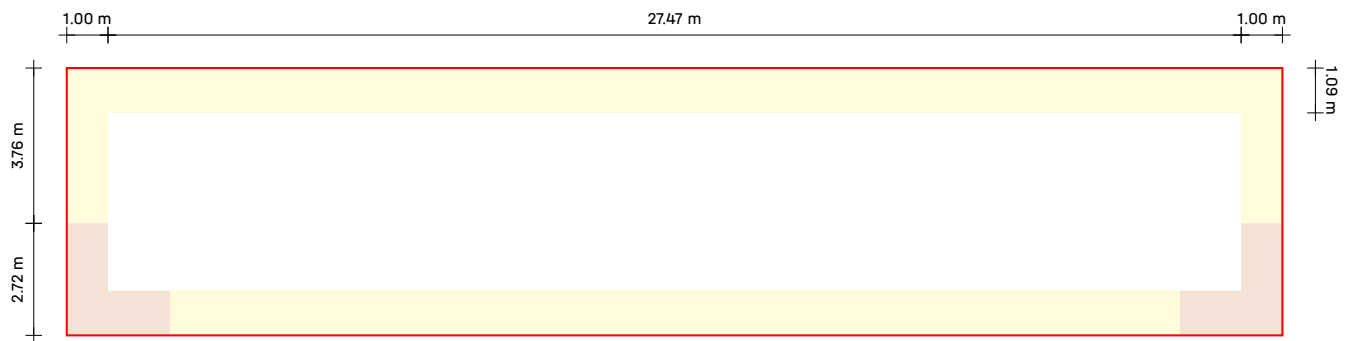


Roof 2 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2004112	Wood screw 8×100	180	4.9 kg
2	2004545	K2 Clamp EC 25-40 Black	16	1.1 kg
3	2002390	SolidHook 3S+	90	46.8 kg
4	1000041	T-Bolt 28/15 M10×30	90	2.1 kg
5	1000042	Hexagon flange nut M10	90	1.0 kg
6	2003072	OneMid Black Set 30-42	76	6.0 kg
7	1004765	SolidRail Light End Cap	16	0.1 kg
8	2002870	K2 Solar Cable Manager	42	0.1 kg
9	2003233	SolidRail Light; 4.40 m	24	89.6 kg
10	1004107	SolidRail UltraLight+Light RailConnector Set	16	3.6 kg
Total				155.3 kg

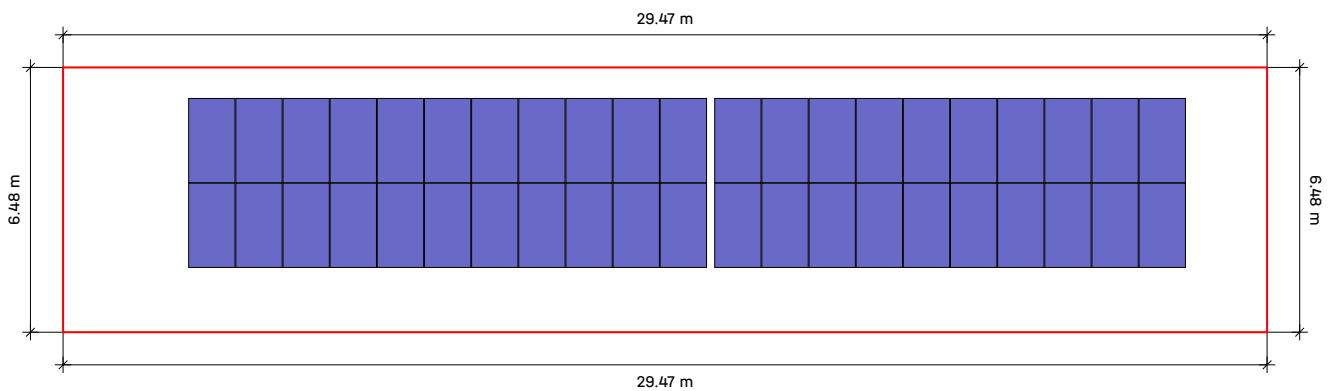


Roof 2 (1)





Roof 2 (1)



Roof	System	Module	Height	Quantity	Total power
<u>Roof 2 (1)</u>	<u>SolidRail</u>	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	5.00 m	42	22.26 kWp
 Tile					



Roof 2 (1) | Assembly plan

Base Rails

Type	Whole Rails		Rail cutting		
	Total Rail Length	Quantity 4.40 m	Part of Rail / Rest	Length	Rest
4*A	12.774 m	2*4.40 m	4.400	3.974 from 4.400	0.416
4*B	11.620 m	2*4.40 m	4.400	2.820 from 4.400	1.570

1 cm is viewed as lost for each cutting

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

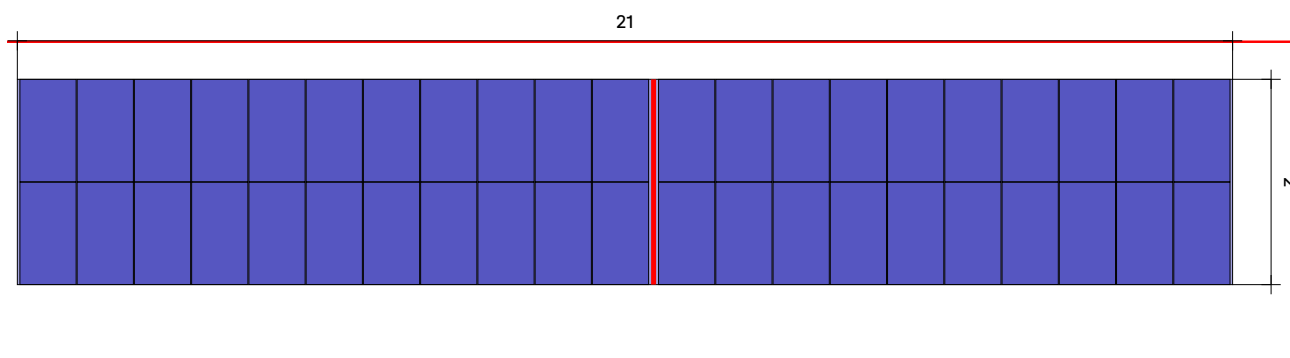
Fastener Spacing

Module	Array	Distance	maximum cantilever length [m]	maximum fastener spacing [m]
1	field area	1.20 m	0.533	1.782
1	ridge	1.20 m	0.533	1.782

Module arrays

Module array	Width[m]	Length[m]	Width in modules	Length in modules
1	24.39	4.14	21	2

Roof 2 (1) | Module array 1



Roof ③ Module array ①

Mounting System

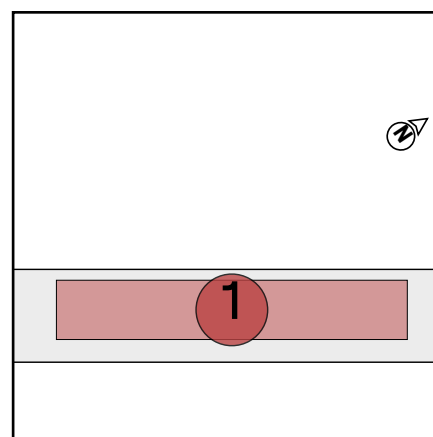
[SolidRail](#)

Module

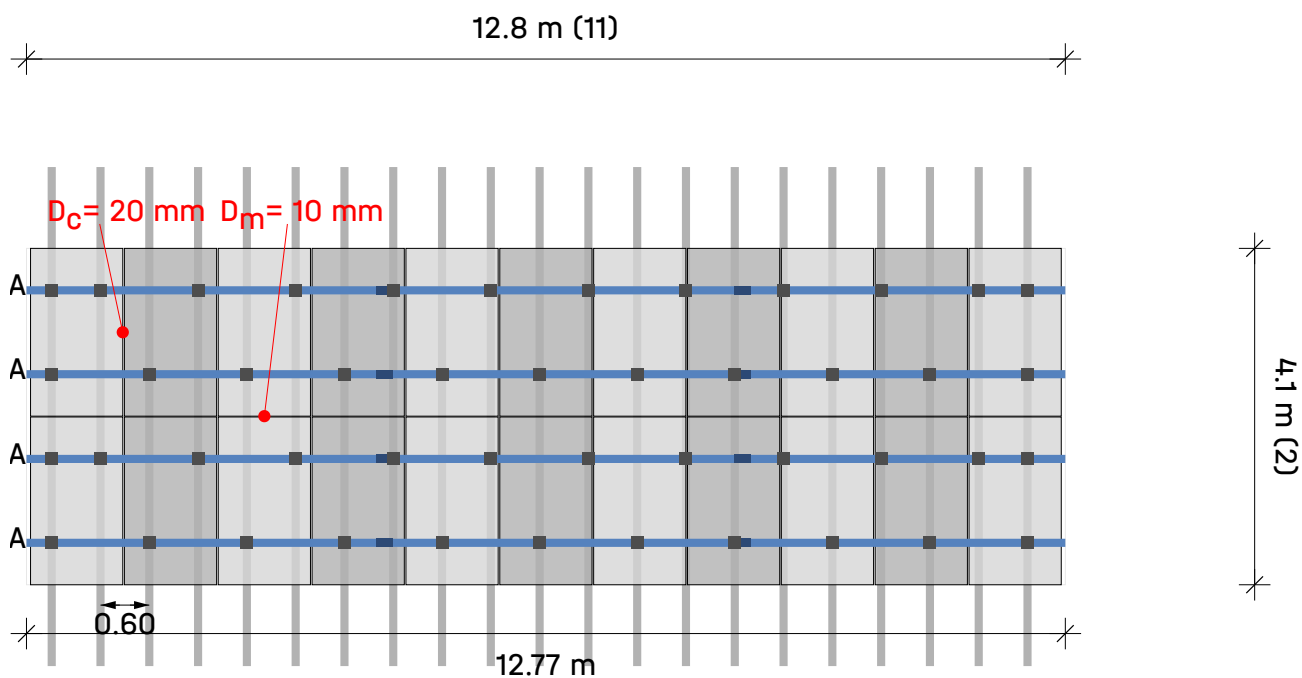
42(22.26 kWp) x
JAM60D-42-530-LB-TS-BF

Row spacing

2.07 m



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

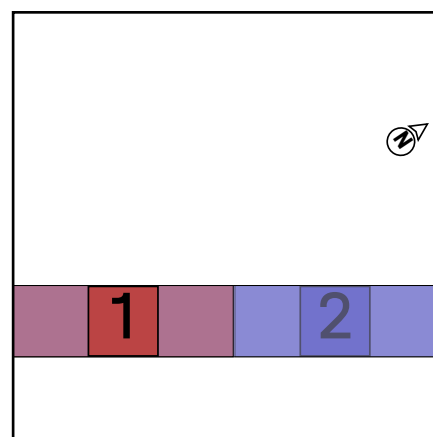


Roof ③ Module array ① Module block 1

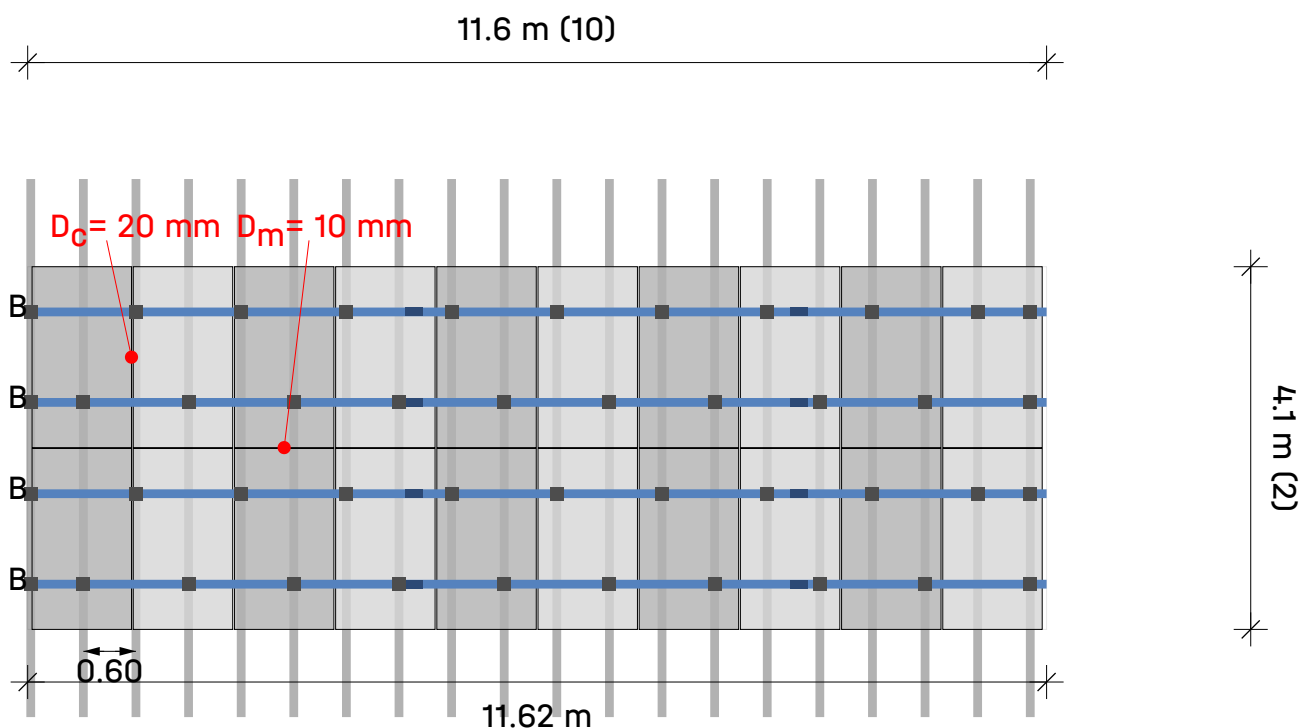
Modules $11 \times 2 = 22$

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- ➔ Dist. to neighbour module block/array [m]
- D_c Distance for clamping between modules
- D_m Distance between modules



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

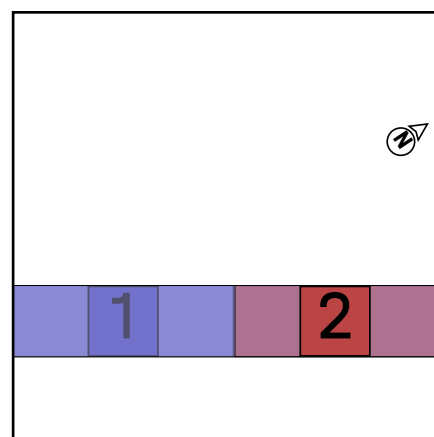


Roof ③ Module array ① Module block ②

Modules $10 \times 2 = 20$

Legend

- Fastener
- Mounting rail: K2 SolidRail Light 37
- ➔ Dist. to neighbour module block/array [m]
- D_c Distance for clamping between modules
- D_m Distance between modules





Results | Roof 2 (1)

Roof	System	Module	Height	Quantity	Total power
Roof 2 (1)	SolidRail	JAM60D-42-530-LB-TS-BF 2,063×1,134×30 mm 530 Wp	5.00 m	42	22.26 kWp
 Tile					

Module

Name	JAM60D-42-530-LB-TS-BF
Manufacturer	JA Solar
Output power	530 Wp
Dimensions	2,063×1,134×30 mm
Weight	28.8 kg

Components

Fastener	SolidHook 3S+
Base rails	K2 SolidRail Light 37

Loads on modules (module dimensioning)

No. Module Array	Array	A-TrA [m ²]	ultimate state [Pa]				Serviceability [Pa]			
			Pressure ⊥	Pressure 	Uplift ⊥	Uplift 	Pressure ⊥	Pressure 	Uplift ⊥	Uplift
1	field area	2.34	929.0	324.7	-411.6	52.4	631.7	221.7	-233.2	52.4
1	ridge	2.34	929.0	324.7	-845.5	52.4	631.7	221.7	-522.5	52.4

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 D _{max} [m]
1	field area	41.2	30.9	55.4	25.7	1.200	---	0.533	1.782
1	ridge	41.2	0.0	56.0	25.7	1.200	---	0.533	1.782

Pr	Profile	Fst D _{max}	maximum fastener spacing [m]
Fst	Fastener	BR	Base Rail
σ	Stress	Usab.	serviceability limit state
f	Deflection	CL	Cantilever
F	Force		
CL/L _{max}	maximum cantilever length [m]		



Results | Roof 2 (1)

Note

- The dimensioning of the timber construction screws is not part of this structural analysis. This must be done on site. If the rafters are made of solid wood, glued laminated timber, cross laminated timber and laminated veneer lumber, assembly with 2 timber construction screws is usually sufficient. The edge distances must be uphold in accordance with the manufacturer's specifications.
- The structure was statically verified in accordance with Eurocode 9: Design of aluminium 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 service life period, f_W , is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, f_S , 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'.
- The person responsible for the execution of the work must check the load assumptions made with the conditions on site. If deviations are found, the person who prepared the static calculation must be consulted immediately. , in particular § 2 ("technical and specialist requirements for the customer"), § 7 ("warranty provisions") and § 8 ("limitation of liability").



Structural analysis report | Roof 2 (1)

General information

Name	BUCCLEUCH LODGE
Mounting System	SolidRail
Author	Tyler Adams

Location information

Address	31 Moorfield Rd, West Didsbury, Manchester M20 2UZ, UK
Ground elevation	36.04 m

Roof information

Building height	5.00 m
Roof type	Gable roof
Roof pitch	23°
Roof covering	Tile
Min. roof edge distance	0.00 m
Rafter Spacing	0.600 m
Rafter width	50.0 mm
set edge rafter left	No
Rafter spacing left	335.0 mm
set edge rafter right	No
Rafter spacing right	335.0 mm
Batten spacing	340.0 mm

Loads

Design method	BS EN
Failure consequence class (CC)	CC2
Design working life	25 years
Terrain category	Country Terrain
Distance to shoreline	51.29 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 0.645 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 0.921$
Velocity pressure, 25 years	$q_{p,25} = 0.594 \text{ kN/m}^2$



Structural analysis report | Roof 2 (1)

Roof areas

No. Module Array	Array	load impact area [m ²]	maxCpe	minCpe	wind pressure [kN/m ²]	wind suction [kN/m ²]
1	field area	10.00	0.307	-0.600	0.182	-0.357
1	ridge	10.00	0.307	-1.087	0.182	-0.646

Snow load

Snow load zone	3
Snow guard	No
Snow load on ground level	$s_k = 0.500 \text{ kN/m}^2$
Shape Coefficient for Snow	$\mu_i = 1.013$
Factor for roof pitch	$d_i = 0.921$
Snow load on roof, 50 year	$s_{i,50} = 0.466 \text{ kN/m}^2$
Adjustment factor for service life	$f_s = 0.929$
Snow load on roof, 25 years	$s_{i,25} = 0.433 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 28.8 \text{ kg}$
Weight of mounting system per module	$= 3.2 \text{ kg}$
Module area	$A_M = 2.34 \text{ m}^2$
Dead weight of module per m ²	$= 12.31 \text{ kg/m}^2$
Dead weight of mounting system per m ²	$= 1.37 \text{ kg/m}^2$
Total Dead Load (excl. ballast) per m ²	$= 0.13 \text{ kN/m}^2$

Load Combinations



Structural analysis report | Roof 2 (1)

Ultimate limit state

Partial safety factor unfavourable permanent load	$V_{G,sup} = 1.35$
Partial safety factor favourable permanent load	$V_{G,inf} = 1.00$
Partial safety factor destabilising permanent load	$V_{G,dst} = 1.10$
Partial safety factor stabilising permanent load	$V_{G,stab} = 0.90$
Partial safety factor variable loads	$V_Q = 1.50$
Combination coefficient with regards to wind	$\psi_{0,W} = 0.60$
Combination coefficient with regards to Snow	$\psi_{0,S} = 0.50$
Importance factor permanent	$K_{Fl,G} = 1.00$
Importance factor variable	$K_{Fl,Q} = 1.00$
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k

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

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)

No. Module Array	Array	A-TrA [m ²]	ultimate state [kN/m ²]				Serviceability [kN/m ²]			
			Pressure ⊥	Pressure 	Uplift ⊥	Uplift 	Pressure ⊥	Pressure 	Uplift ⊥	Uplift
1	field area	10.00	0.929	0.325	-0.412	0.052	0.632	0.222	-0.233	0.052
1	ridge	10.00	0.929	0.325	-0.846	0.052	0.632	0.222	-0.523	0.052

Structural analysis report | Roof 2 (1)

Max. load on fastener

No. Module Array	Array	A-TrA [m ²]	ultimate state [kN]				Serviceability [kN]			
			Pressure ⊥	Pressure 	Uplift ⊥	Uplift 	Pressure ⊥	Pressure 	Uplift ⊥	Uplift
1	field area	10.00	1.265	0.442	-0.560	0.071	0.860	0.302	-0.318	0.071
1	ridge	10.00	1.265	0.442	-1.151	0.071	0.860	0.302	-0.711	0.071

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 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 D _{max} [m]
1	field area	41.2	30.9	55.4	25.7	1.200	---	0.533	1.782
1	ridge	41.2	0.0	56.0	25.7	1.200	---	0.533	1.782

Pr	Profile	Fst D _{max}	maximum fastener spacing [m]
Fst	Fastener	BR	Base Rail
σ	Stress	Usab.	serviceability limit state
f	Deflection	CL	Cantilever
F	Force		
CL/L _{max}	maximum cantilever length [m]		



Roof 2 (1) | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2004112	Wood screw 8×100	180	4.9 kg
2	2004545	K2 Clamp EC 25-40 Black	16	1.1 kg
3	2002390	SolidHook 3S+	90	46.8 kg
4	1000041	T-Bolt 28/15 M10×30	90	2.1 kg
5	1000042	Hexagon flange nut M10	90	1.0 kg
6	2003072	OneMid Black Set 30-42	76	6.0 kg
7	1004765	SolidRail Light End Cap	16	0.1 kg
8	2002870	K2 Solar Cable Manager	42	0.1 kg
9	2003233	SolidRail Light; 4.40 m	24	89.6 kg
10	1004107	SolidRail UltraLight+Light RailConnector Set	16	3.6 kg
Total				155.3 kg



Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2004096	S-Dome 6.10 Base Set L	87	163.6 kg
2	2004125	Dome 6.10 Peak	87	26.1 kg
3	2004123	Dome 6 Connector 195 Set	68	14.7 kg
4	2003250	S-Dome 6.10 Windbreaker long	70	150.3 kg
5	2002937	Thread-forming metal screw 6×25	174	1.2 kg
6	2002870	K2 Solar Cable Manager	154	0.4 kg
7	2002609	DomeClamp Black MC Set 30-50	106	6.1 kg
8	2002610	DomeClamp Black EC Set 30-50	68	4.5 kg
9	2002300	Dome SpeedPorter	174	13.2 kg
10	2004112	Wood screw 8×100	360	9.7 kg
11	2004545	K2 Clamp EC 25-40 Black	32	2.3 kg
12	2002390	SolidHook 3S+	180	93.6 kg
13	1000041	T-Bolt 28/15 M10×30	180	4.2 kg
14	1000042	Hexagon flange nut M10	180	2.0 kg
15	2003072	OneMid Black Set 30-42	152	12.0 kg
16	1004765	SolidRail Light End Cap	32	0.2 kg
17	2003233	SolidRail Light; 4.40 m	48	179.2 kg
18	1004107	SolidRail UltraLight+Light RailConnector Set	32	7.2 kg
Total				690.5 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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