



| Connecting Strength

K2 Base Report

New project

Project address	Warrington Rd, Rainhill, UK
Planner	james wyne
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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	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	111	47.73 kWp
Roof 3  Flat	D-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	112	48.16 kWp
Roof 3 (1)  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	99	42.57 kWp
Roof 3 (2)  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	99	42.57 kWp
roof 4  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	15.00 m	102	43.86 kWp
Total				523	224.89 kWp

Project information

Address Warrington Rd, Rainhill, UK
 Author james wynne

Load settings

Design method BS EN
 Failure consequence class (CC) CC3
 Design working life 25 years
 Terrain category Town Terrain
 Basic wind speed 23.0 m/s
 Distance to shoreline 17.00 km
 Distance inside town terrain 1.00 km
 Snow load zone 3
 Snow load on ground level 0.50 kN/m²

Material values

For material information refer to the product catalogue:
[K2 Catalogue \(k2-systems.com\)](https://k2-systems.com)



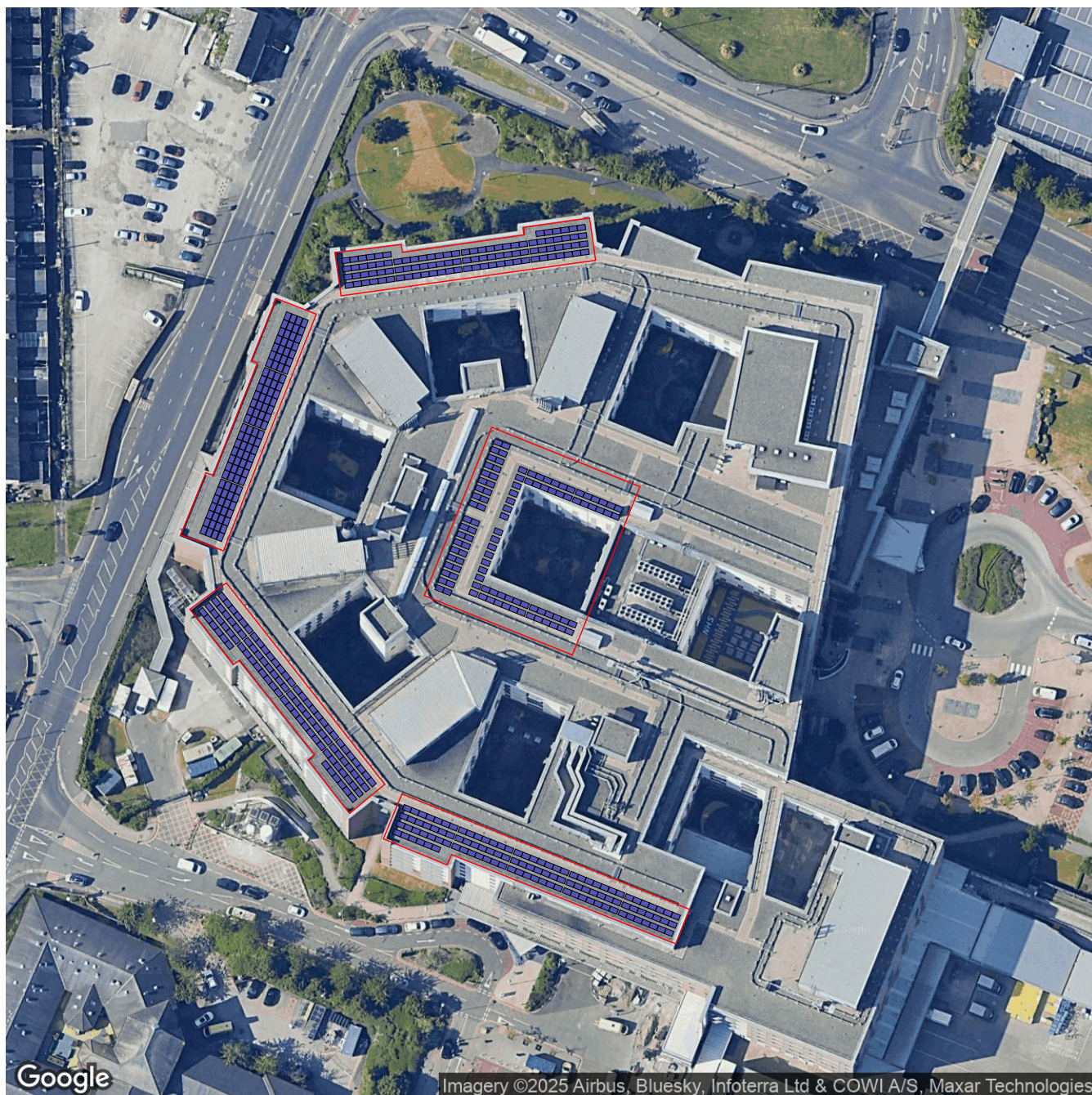
Project overview



THE PROJECT CONTAINS ERROR(S)

Refer to the notes for more information.

New project

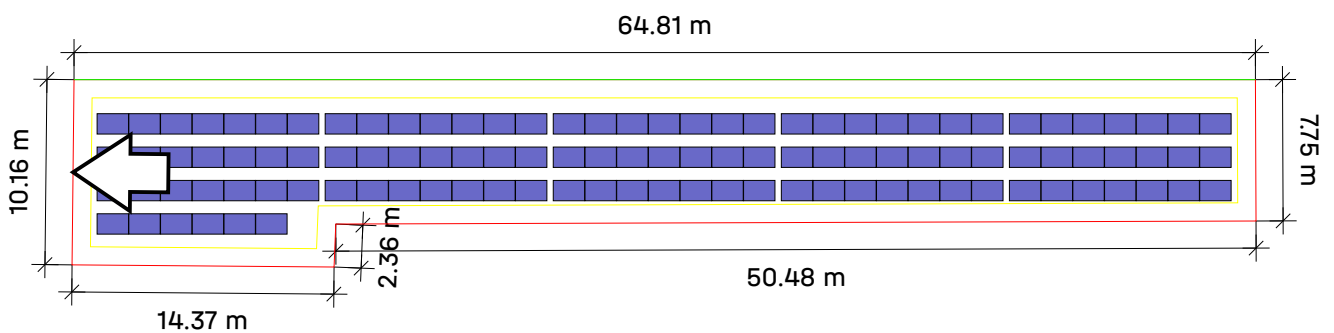


Project information

Address	Warrington Rd, Rainhill, UK
Author	james wyne



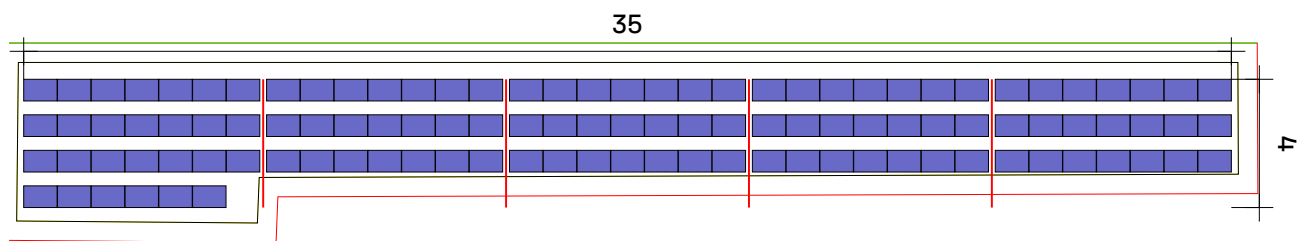
Roof 1



Roof	System	Module	Height	Quantity	Total power
<u>Roof 1</u>  Flat	<u>S-Dome 6.10</u> <u>Xpress</u>	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	111	47.73 kWp



Roof 1 | Module array 1



Roof ① Module array ①

Mounting System

[S-Dome 6.10 Xpress](#)

Module

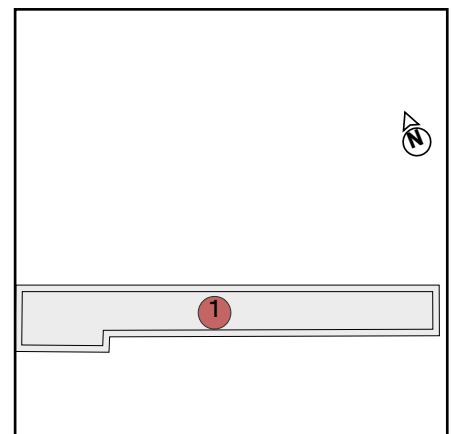
111(47.73 kWp) x DAS-DH108NA-430 (SchwarzThru)

Row spacing

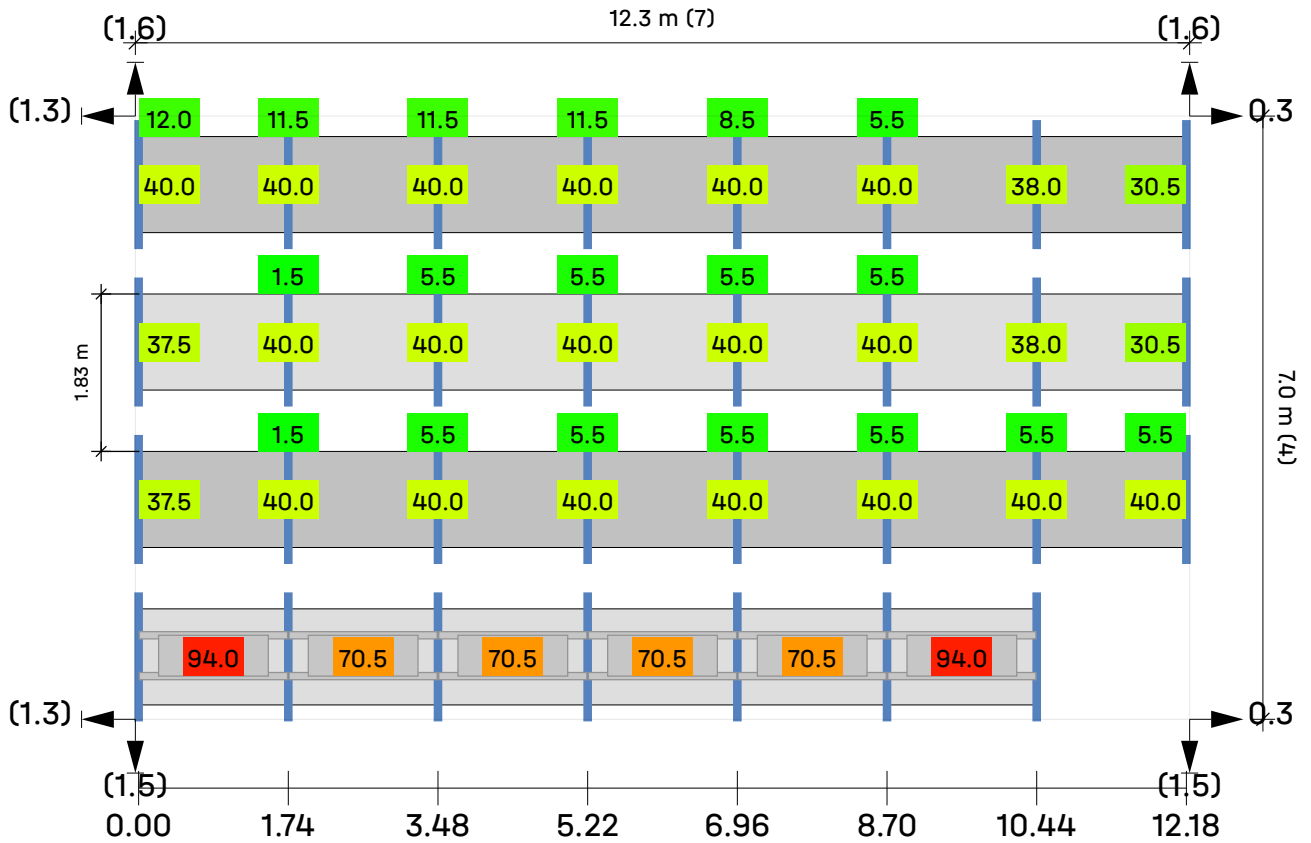
1.83 m

service corridor

0.71 m



Roof 1 | Module array 1 | Module block 1

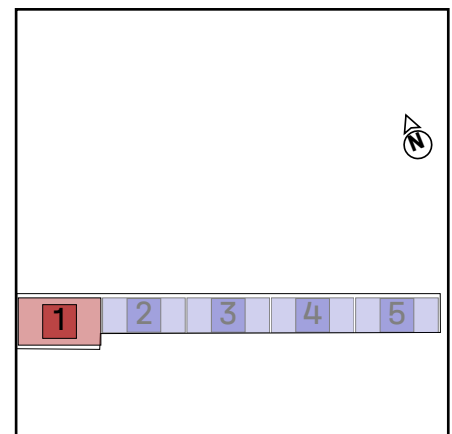


Roof ① Module array ① Module block ①

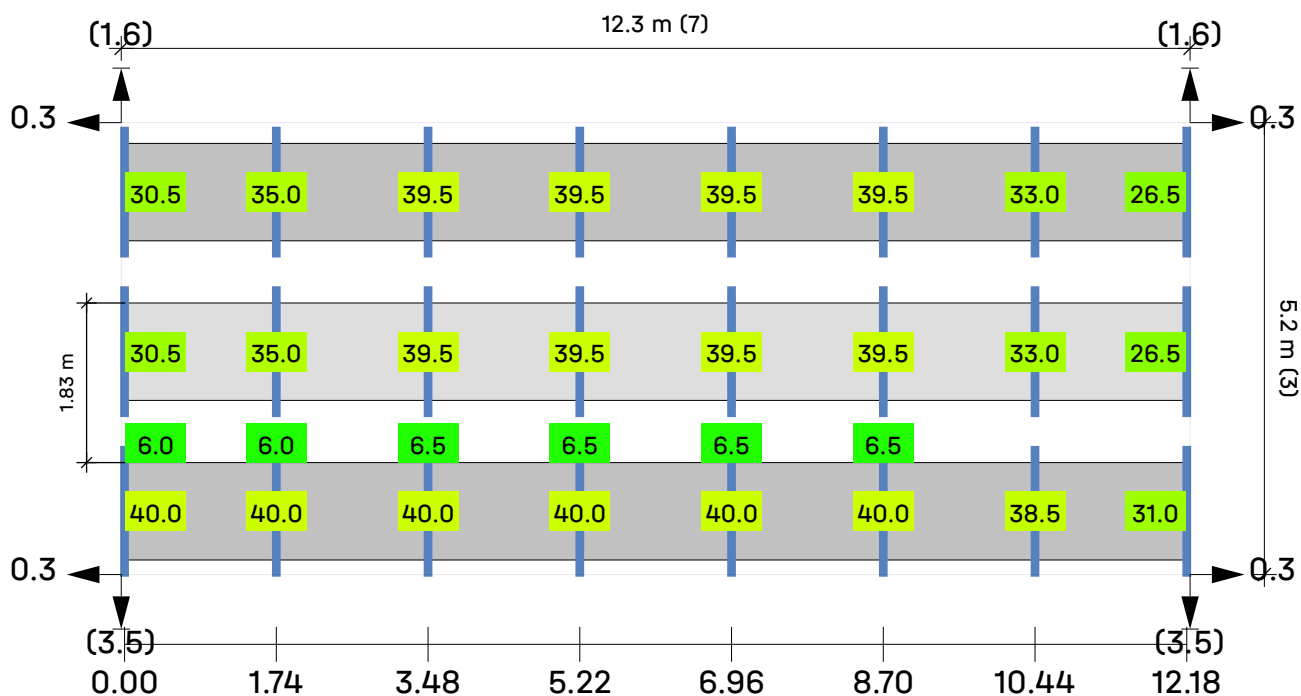
Modules (7 × 4) - 1 = 27

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

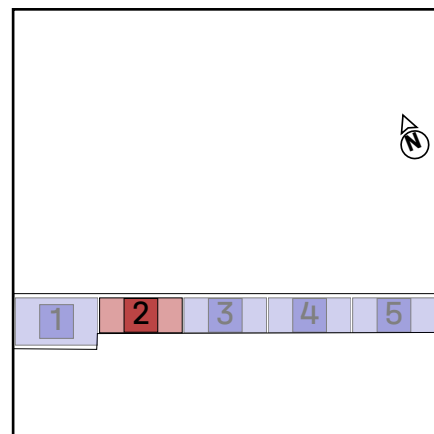


Roof **1** Module array **1** Module block **2**

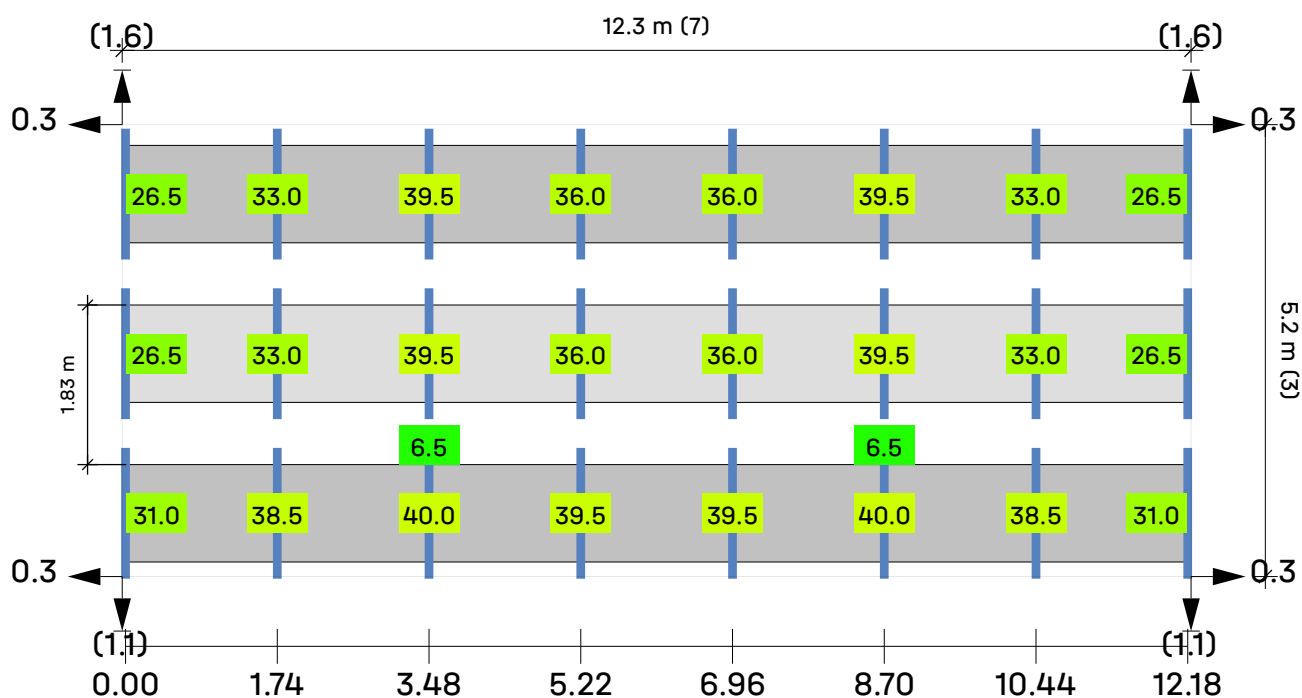
Modules $7 \times 3 = 21$

Legend

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



Roof 1 | Module array 1 | Module block 3

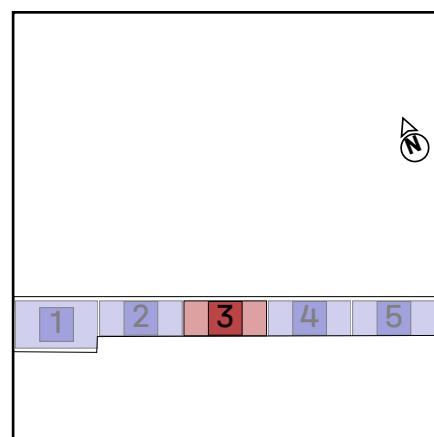


Roof **1** Module array **1** Module block **3**

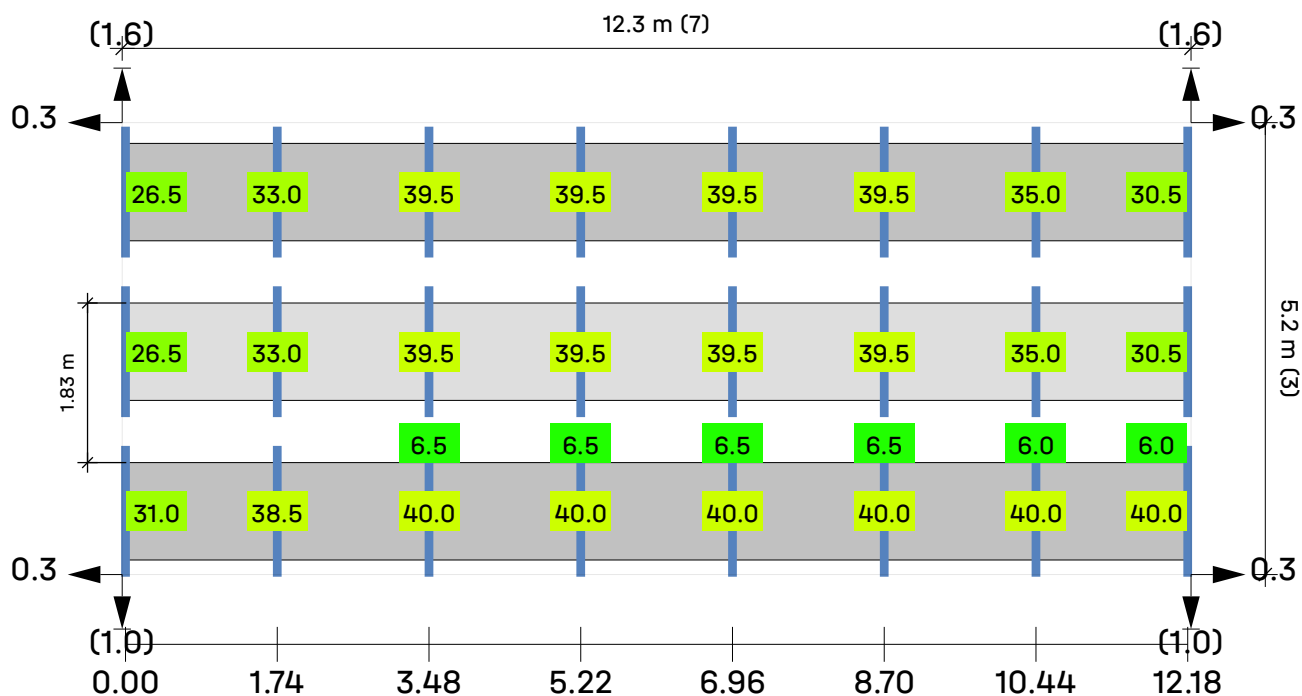
Modules $7 \times 3 = 21$

Legend

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



Roof 1 | Module array 1 | Module block 4

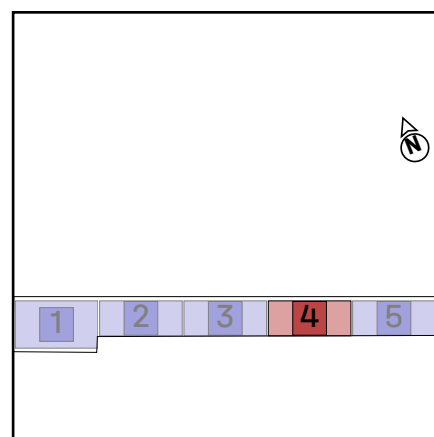


Roof **1** Module array **1** Module block **4**

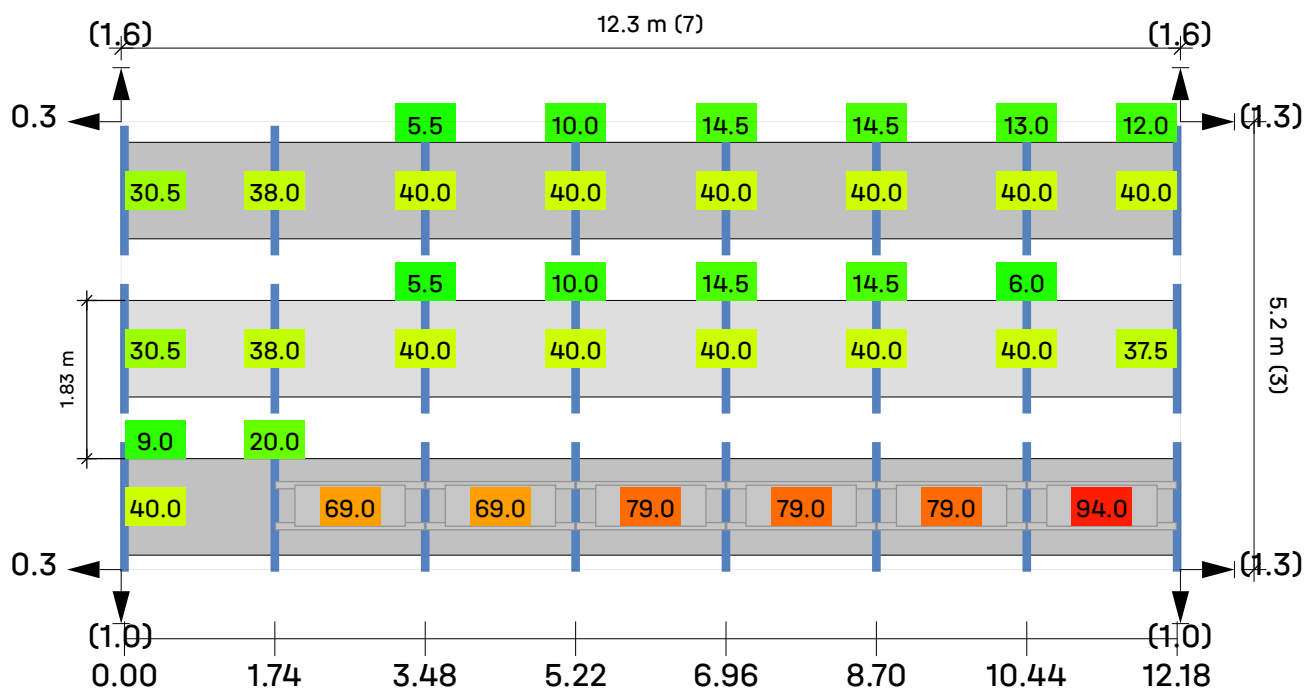
Modules $7 \times 3 = 21$

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 5

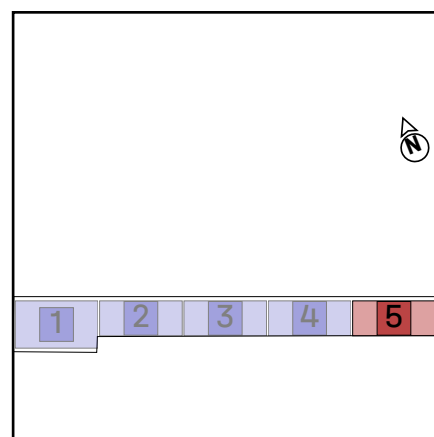


Roof **1** Module array **1** Module block **5**

Modules $7 \times 3 = 21$

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





Results | Roof 1

Roof	System	Module	Height	Quantity	Total power
Roof 1  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	111	47.73 kWp

Module

Name	DAS-DH108NA-430 (SchwarzThru)
Manufacturer	DAS Solar (Quzhou) Co., Ltd.
Output power	430 Wp
Dimensions	1,722×1,134×30 mm
Weight	20.5 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

pressure	67.58%
suction	90.33%

Loads on modules

Type	pressure	suction
ultimate limit state	2.46 kPa	-1.90 kPa
Serviceability	1.50 kPa	-1.12 kPa



Results | Roof 1

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	27	1,520.5	2,236.00	82.75 m ²	0.26	
Block 2	21	913.5	1,470.00	63.51 m ²	0.23	
Block 3	21	851.0	1,407.50	63.51 m ²	0.22	
Block 4	21	913.5	1,470.00	63.51 m ²	0.23	
Block 5	21	1,272.5	1,829.00	63.51 m ²	0.28	
Total	111	5,471.0	8,412.50			0.15



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.
- Please note our General Terms and Conditions of Use (TCU-E) in their currently valid version, available at: <https://k2-systems.com/en/digital-services/general-terms-and-conditions-of-use-for-entrepreneurs-tcu-e/>

Please note in particular § 1, Special provisions for K2 Base, clause 3 ("Technical and specialist requirements on the Customer's premises."), § 6 ("Limitation of warranty") and § 7 ("Limitation of liability").



Structural analysis report | Roof 1

General information

Name	New project
Mounting System	S-Dome 6.10 Xpress
Author	james wynne

Location information

Address	Warrington Rd, Rainhill, UK
Ground elevation	64.60 m

Roof information

Building height	22.00 m
Roof type	Flat roof
Roof pitch	2°
Fastening method	with Ballast
Roof covering	Flat
Min. roof edge distance	1.00 m
Parapet wall height	0.50 m
Material	Concrete
Friction coefficient	1

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)	CC3
Design working life	25 years
Terrain category	Town Terrain
Distance to shoreline	17.00 km
Distance inside town terrain	1.00 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 1.080 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 1.000$
Velocity pressure, 25 years	$q_{p,25} = 0.994 \text{ kN/m}^2$



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	$d_i = 0.999$
Snow load on roof, 50 year	$s_{i,50} = 0.400 \text{ kN/m}^2$
Adjustment factor for service life	$f_s = 1.000$
Snow load on roof, 25 years	$s_{i,25} = 0.371 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 20.5 \text{ kg}$
Weight of mounting system per module	$= 6.00 \text{ kg}$
Module area	$A_M = 1.95 \text{ m}^2$
Dead weight of module per m^2	$= 10.50 \text{ kg/m}^2$
Dead weight of mounting system per m^2	$= 3.07 \text{ kg/m}^2$
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	$\gamma_{G,sup} = 1.35$
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	$\kappa_{FI,G} = 1.10$
Importance factor variable	$\kappa_{FI,Q} = 1.10$
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	$LCC_{up} = \gamma_{G,stab} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,n,Uplift}$
Displacement verification	$LCC_{displ} = \gamma_{G,stab} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,n,Displacement}$

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	$LCC_{01_sls} = G_k + S_{i,n}$
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	$LCC_{06_sls} = G_k + W_{k,Suction}$

Max. Pressure on insulation

General information

dead load system	$g_{System} = 0.13 \text{ kN/m}^2$
aerodynamic coefficient	$C_{p,Pressure} = 0.20$

Load distribution underneath the building protection mat under Peak

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 57.1 \text{ kg}$

Load distribution underneath the building protection mat under SD

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 29.4 \text{ kg}$

Load Combinations

	$\sigma_{Ek,heat \text{ insulation,Peak}} [\text{Pa}]$	$\sigma_{Ek,heat \text{ insulation,SD}} [\text{Pa}]$
Load case combination 00	24,107	14,621
Load case combination 01	37,549	28,062

Structural analysis report | Roof 1

Actions from dead loads (PV system + ballast)

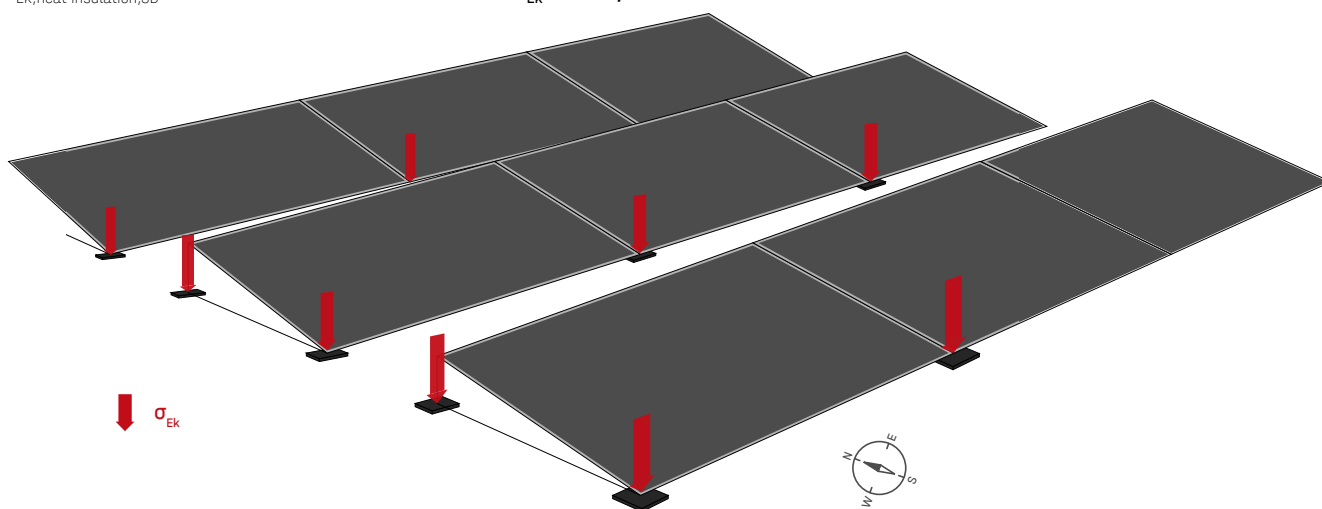
$$\sigma_{\text{Ek,heat insulation,Peak}} = 24,107 \text{ Pa}$$

$$\sigma_{\text{Ek,heat insulation,SD}} = 14,621 \text{ Pa}$$

Maximum actions (PV system + ballast + snow)

$$\sigma_{\text{Ek,heat insulation,Peak}} = \max \sigma_{\text{Ek}} = 37,549 \text{ Pa}$$

$$\sigma_{\text{Ek,heat insulation,SD}} = \max \sigma_{\text{Ek}} = 28,062 \text{ Pa}$$



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}	-0.191		-0.326	-0.123
c_{pD}	0.278		0.276	0.102
k_a	1.04		1.00	1.04
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	1.02	1.02	1.01	1.02
k_s	1.03	1.03	1.03	1.03
k_R	1.02	1.02	1.02	1.02
k_{RWS}	1.03	1.03	1.03	1.03
A_M [m ²]	1.95	1.95	1.95	1.95
A_D [m ²]	0.21	0.21	0.21	0.21
delta [°]	80.0	80.0	80.0	80.0
alpha [°]	10.0	10.0	10.0	10.0
qp [kN/m ²]	0.99	0.99	0.99	0.99
μ	1.0	-	1.0	-
Fx [kN]	0.122	-	0.063	-
Fz [kN]	0.355	0.613	0.231	0.252
$m_{ballast}$ [kg]	70.3	94.0	32.7	23.2
m_{DL} [kg]	26.5	26.5	26.5	26.5

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	111	
Roof areas covered with modules	A	= ca. 336.78 m ²
Dead Load	$g_{k, \text{System incl. ballast}}$	= 0.24 kN/m ²

Aerodynamic coefficients

	$C_{p, \text{Pressure}}$	= according to EN 1991-1-4
	$C_{F, x, \text{average}}$	= 0.01
	$C_{F, y, \text{averaged}}$	= -0.03
edge distance correction	$k_{s, xy}$	= 1.00
Parapet wall- correction coefficient	k_p	= 1.03
Factor building height		= 1.00

Horizontal pressure

$$W_{k, F, x} = 0.009 \text{ kN/m}^2$$

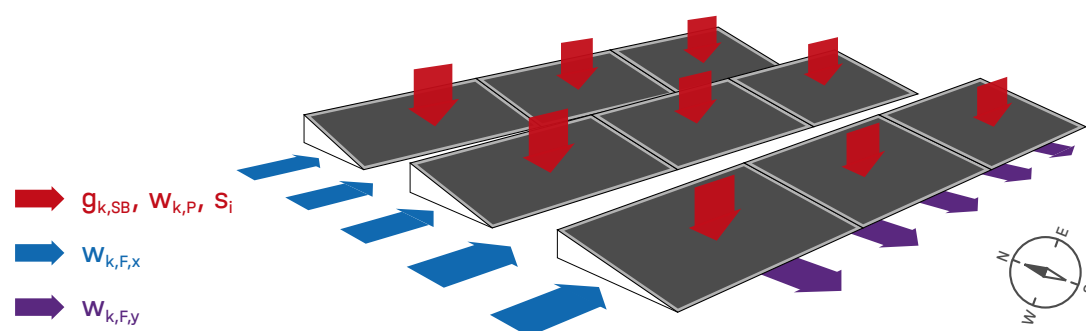
$$W_{k, F, y} = -0.023 \text{ kN/m}^2$$

Vertical pressure

$$g_{k, \text{System incl. ballast}} = 0.24 \text{ kN/m}^2$$

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

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



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.



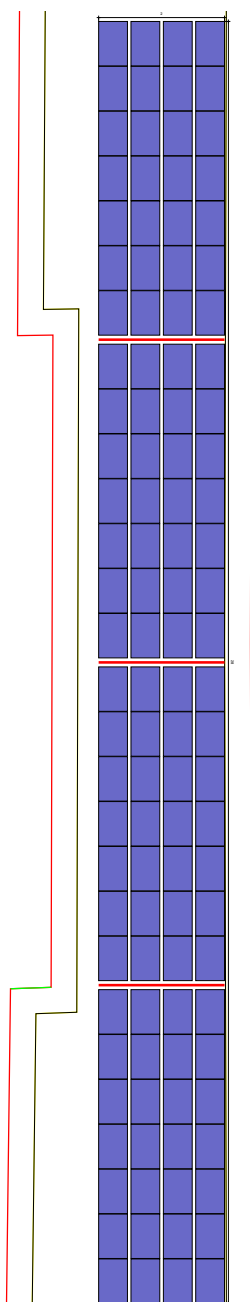
Roof 1 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003621	S-Dome 6.10 Base Set	127	244.7 kg
2	2004125	Dome 6.10 Peak	127	38.1 kg
3	2004178	Dome 6 Connector 495mm Set	87	35.9 kg
4	2003249	S-Dome 6.10 Windbreaker short	111	199.8 kg
5	2002937	Thread-forming metal screw 6×25	254	1.8 kg
6	2002870	K2 Solar Cable Manager	111	0.3 kg
7	2002609	DomeClamp Black MC Set 30-50	190	11.0 kg
8	2002610	DomeClamp Black EC Set 30-50	64	4.2 kg
9	2003150	Dome Porter short	24	35.5 kg
10	1001643	MK2	48	0.8 kg
11	2001729	Socket Head Bolt serrated M8×20	48	0.6 kg
12	2002300	Dome SpeedPorter	316	24.0 kg
Total				596.8 kg





Roof 3 | Module array 1



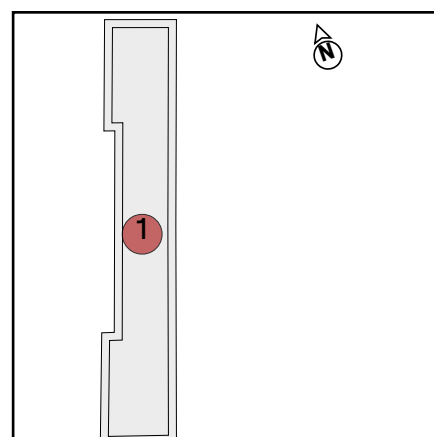
Roof ② Module array ①

Mounting System
Module

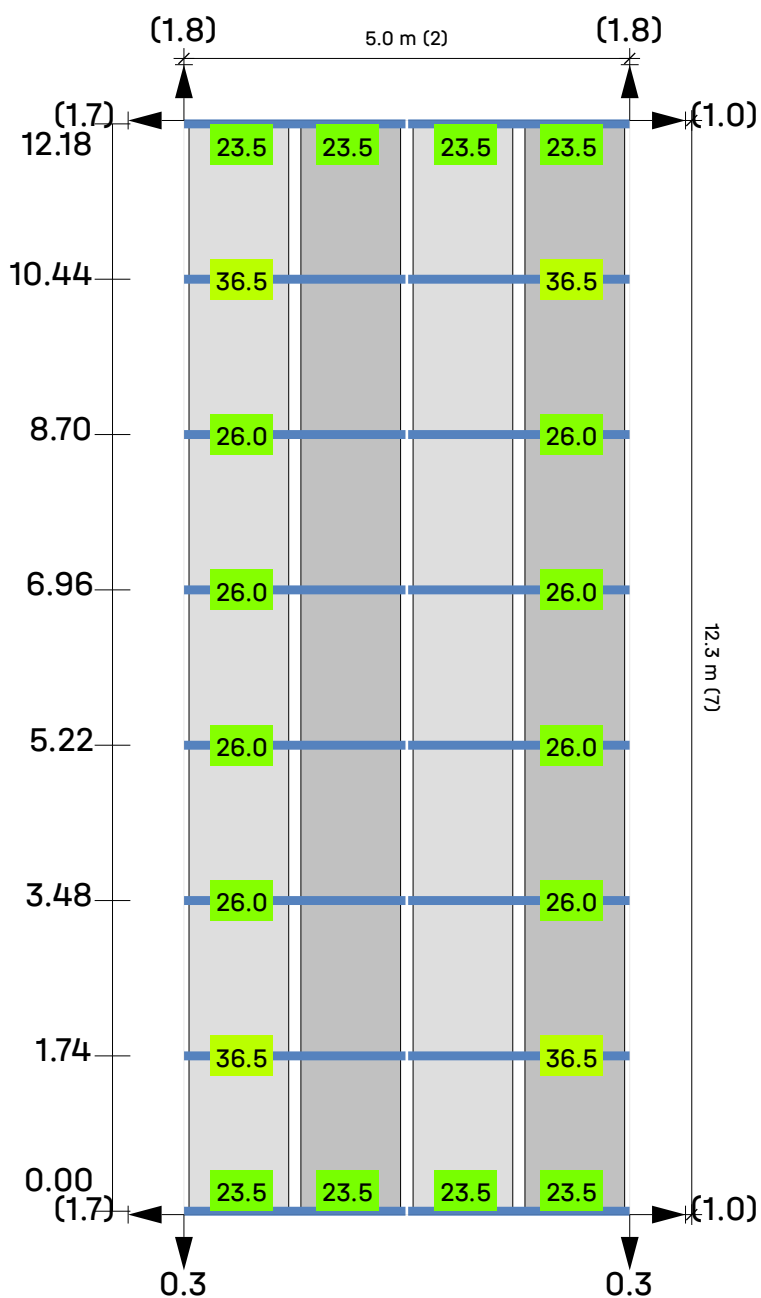
D-Dome 6.10 Xpress
112(48.16 kWp) x DAS-
DH108NA-430
(SchwarzThru)

Row spacing
service corridor

2.51 m
0.14 m



Roof 3 | Module array 1 | Module block 1

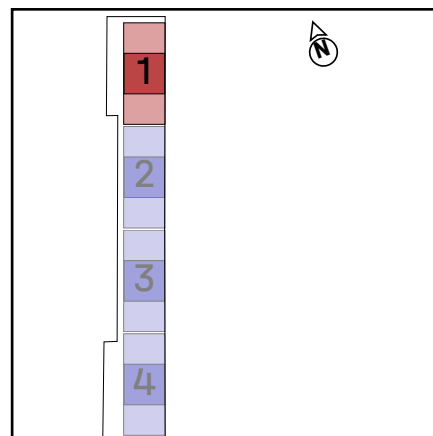


Roof ② Module array ① Module block 1

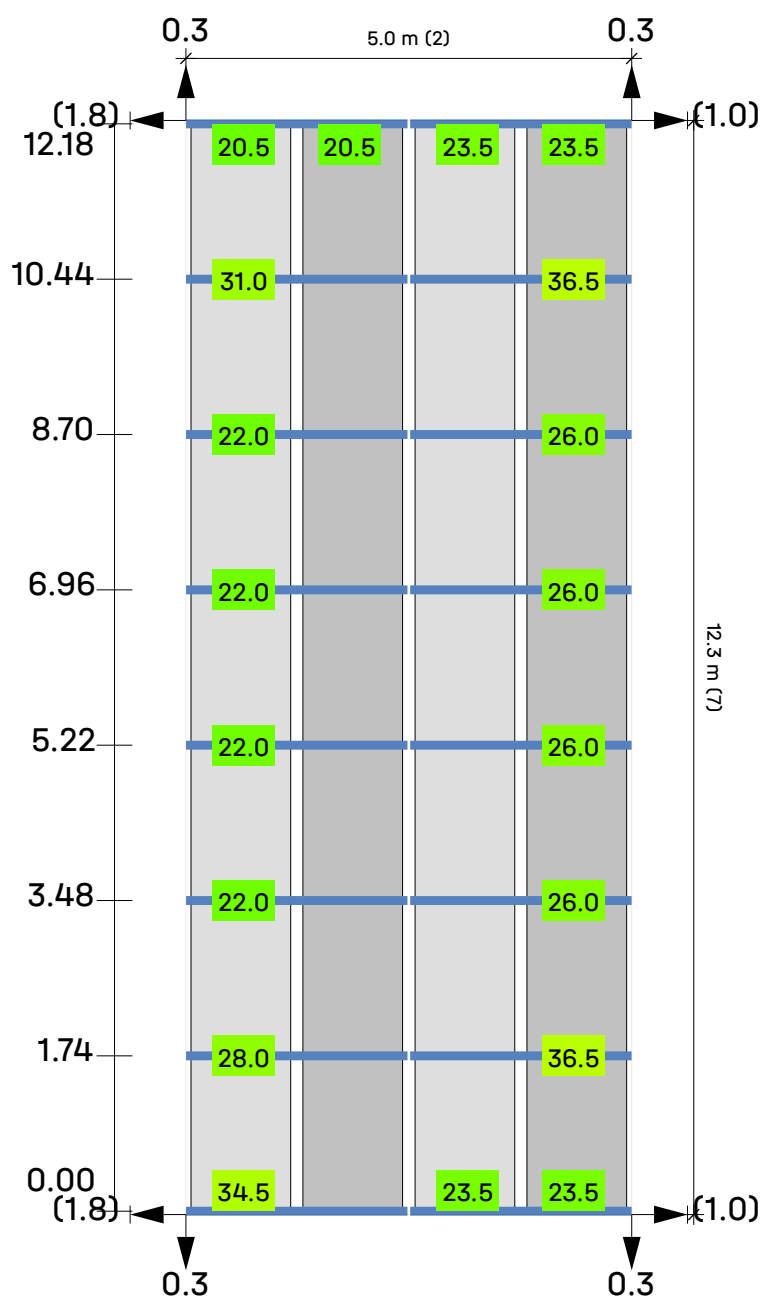
Modules 2 × 7 = 14

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 3 | Module array 1 | Module block 2

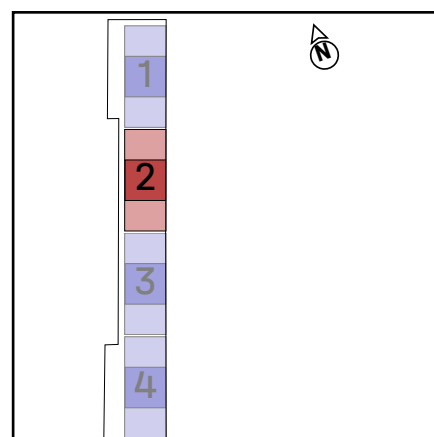


Roof ② Module array ① Module block ②

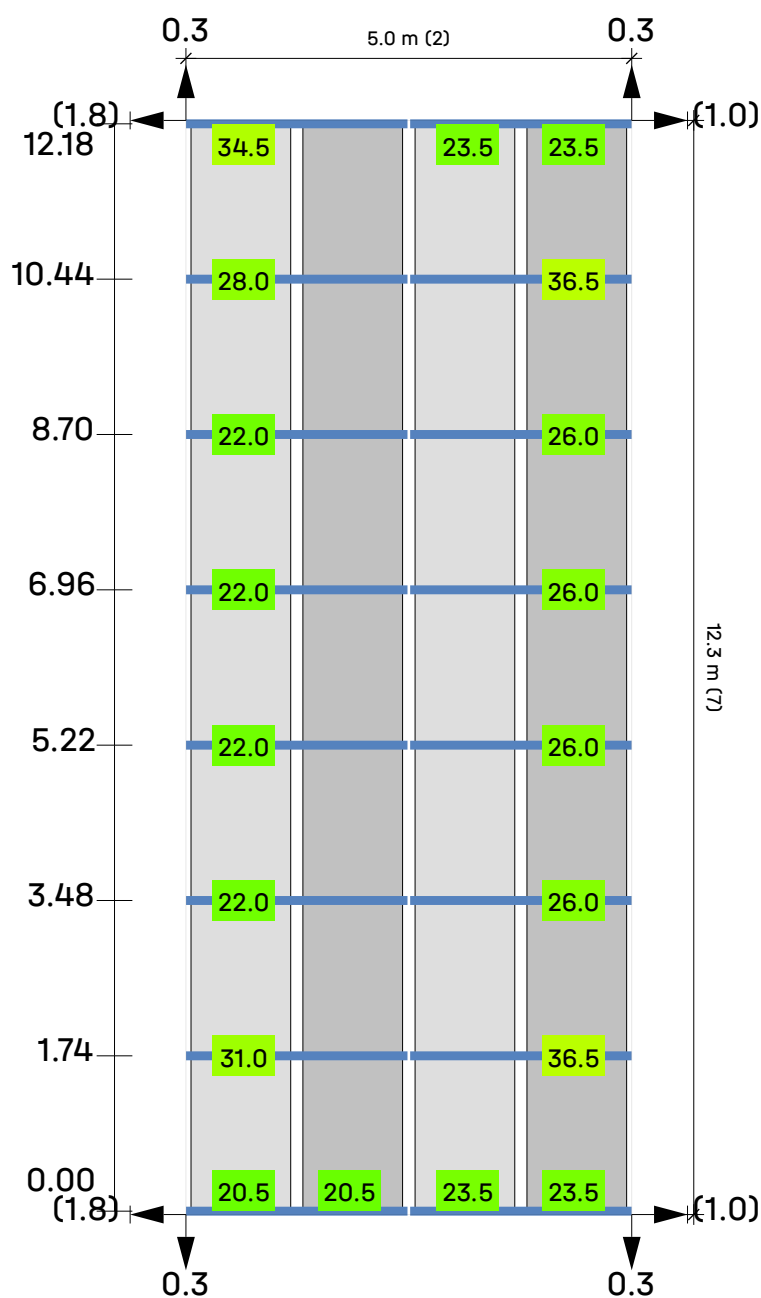
Modules $2 \times 7 = 14$

Legend

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



Roof 3 | Module array 1 | Module block 3

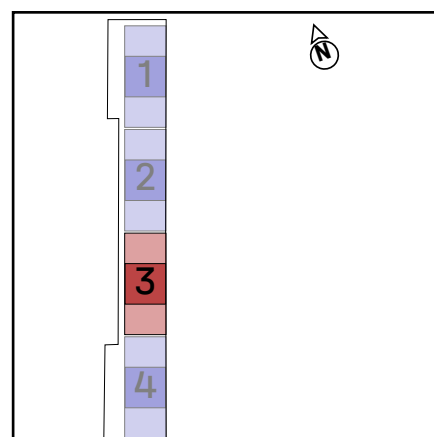


Roof ② Module array ① Module block 3

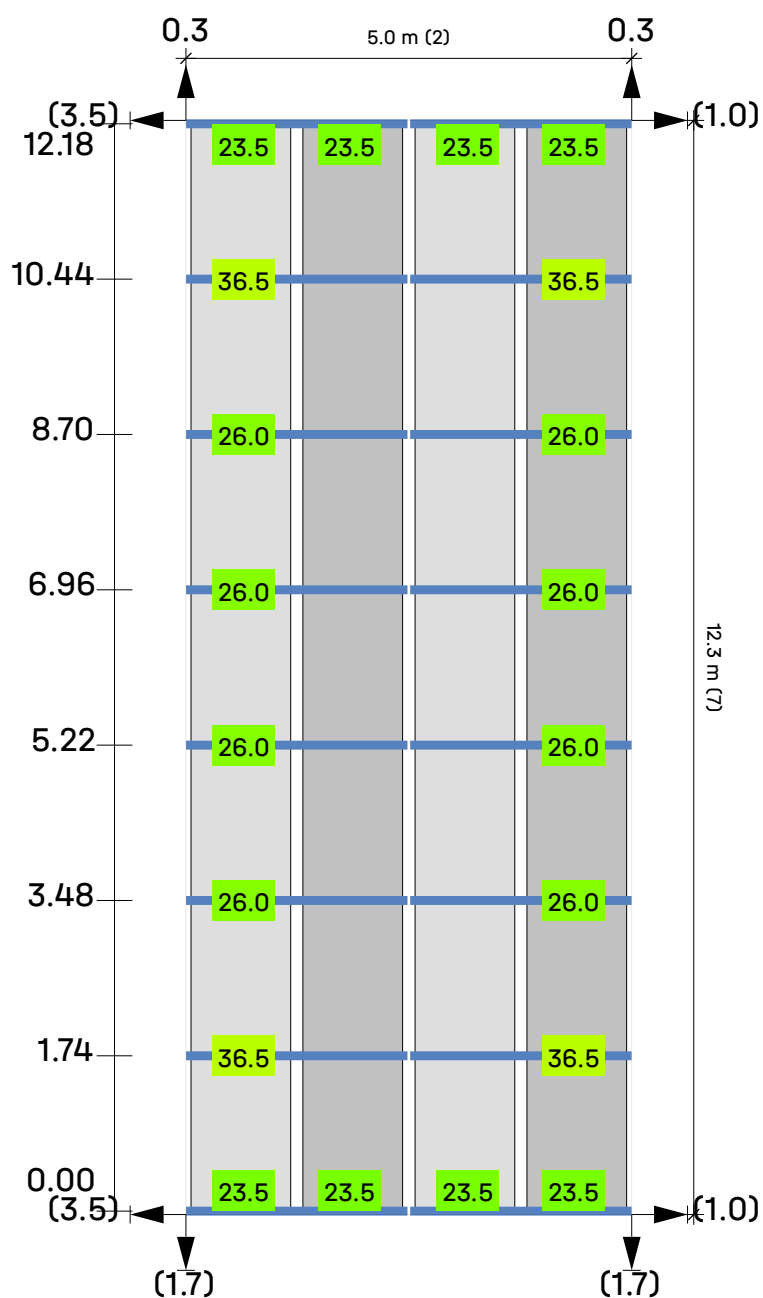
Modules $2 \times 7 = 14$

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 3 | Module array 1 | Module block 4

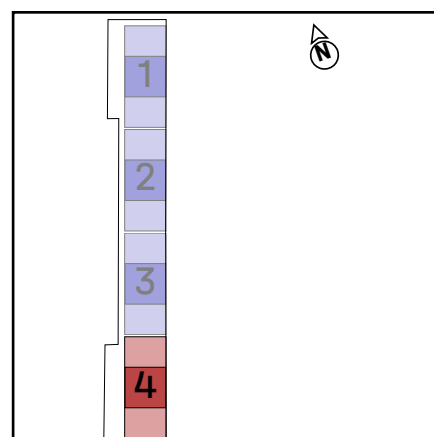


Roof ② Module array ① Module block ④

Modules $2 \times 7 = 14$

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 3

Roof	System	Module	Height	Quantity	Total power
Roof 3  Flat	D-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	112	48.16 kWp

Module

Name	DAS-DH108NA-430 (SchwarzThru)
Manufacturer	DAS Solar (Quzhou) Co., Ltd.
Output power	430 Wp
Dimensions	1,722×1,134×30 mm
Weight	20.5 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

pressure	31.76%
suction	76.32%

Loads on modules

Type	pressure	suction
ultimate limit state	2.14 kPa	-1.59 kPa
Serviceability	1.30 kPa	-0.92 kPa



Results | Roof 3

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	28	542.0	1,204.20	61.21 m ²	0.19	
Block 2	28	493.5	1,155.70	61.21 m ²	0.19	
Block 3	28	493.5	1,155.70	61.21 m ²	0.19	
Block 4	28	542.0	1,204.20	61.21 m ²	0.19	
Total	112	2,071.0	4,719.80			0.10



Results | Roof 3

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.
- Please note our General Terms and Conditions of Use (TCU-E) in their currently valid version, available at: <https://k2-systems.com/en/digital-services/general-terms-and-conditions-of-use-for-entrepreneurs-tcu-e/>

Please note in particular § 1, Special provisions for K2 Base, clause 3 ("Technical and specialist requirements on the Customer's premises."), § 6 ("Limitation of warranty") and § 7 ("Limitation of liability").



Structural analysis report | Roof 3

General information

Name	New project
Mounting System	D-Dome 6.10 Xpress
Author	james wynne

Location information

Address	Warrington Rd, Rainhill, UK
Ground elevation	64.60 m

Roof information

Building height	22.00 m
Roof type	Flat roof
Roof pitch	2°
Fastening method	with Ballast
Roof covering	Flat
Min. roof edge distance	1.00 m
Parapet wall height	0.50 m
Material	Concrete
Friction coefficient	1

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)	CC3
Design working life	25 years
Terrain category	Town Terrain
Distance to shoreline	17.00 km
Distance inside town terrain	1.00 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 1.080 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 1.000$
Velocity pressure, 25 years	$q_{p,25} = 0.994 \text{ kN/m}^2$



Structural analysis report | Roof 3

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	$d_i = 0.999$
Snow load on roof, 50 year	$s_{i,50} = 0.400 \text{ kN/m}^2$
Adjustment factor for service life	$f_s = 1.000$
Snow load on roof, 25 years	$s_{i,25} = 0.371 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 20.5 \text{ kg}$
Weight of mounting system per module	$= 3.15 \text{ kg}$
Module area	$A_M = 1.95 \text{ m}^2$
Dead weight of module per m^2	$= 10.50 \text{ kg/m}^2$
Dead weight of mounting system per m^2	$= 1.61 \text{ kg/m}^2$
Total Dead Load (excl. ballast) per m^2	$= 0.12 \text{ kN/m}^2$

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	$\kappa_{FI,G} = 1.10$
Importance factor variable	$\kappa_{FI,Q} = 1.10$
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 3

Static equilibrium

Uplift Verification	$LCC_{up} = \gamma_{G, stb} * G_k + \gamma_Q * \kappa_{Fl, Q} * W_{k, n, Uplift}$
Displacement verification	$LCC_{displ} = \gamma_{G, stb} * G_k + \gamma_Q * \kappa_{Fl, Q} * W_{k, n, Displacement}$

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	$LCC_{01_sls} = G_k + S_{i, n}$
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	$LCC_{06_sls} = G_k + W_{k, Suction}$

Max. Pressure on insulation

General information

dead load system	$g_{System} = 0.12 \text{ kN/m}^2$
aerodynamic coefficient	$C_{p, Pressure} = 0.20$

Load distribution underneath the building protection mat under Peak

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 1.95 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 31.0 \text{ kg}$

Load distribution underneath the building protection mat under SD

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 8.0 \text{ kg}$

Load Combinations

	$\sigma_{Ek, heat \text{ insulation, Peak}} [\text{Pa}]$	$\sigma_{Ek, heat \text{ insulation, SD}} [\text{Pa}]$
Load case combination 00	18,737	6,791
Load case combination 01	45,620	20,233

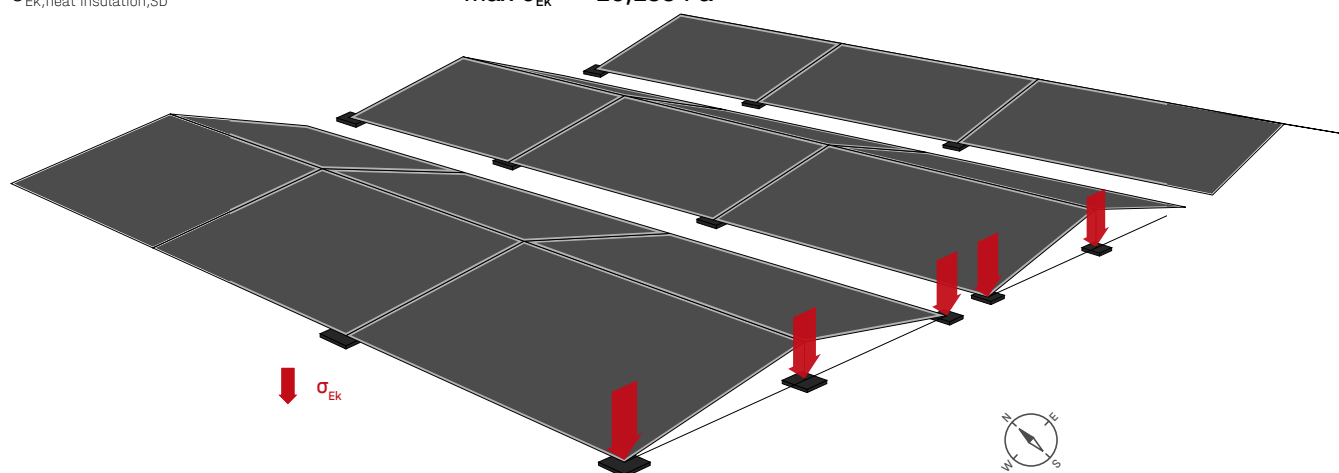
Structural analysis report | Roof 3

Actions from dead loads (PV system + ballast)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\sigma_{\text{Ek}} = 18,737 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\sigma_{\text{Ek}} = 6,791 \text{ Pa}$

Maximum actions (PV system + ballast + snow)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\max \sigma_{\text{Ek}} = 45,620 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\max \sigma_{\text{Ek}} = 20,233 \text{ Pa}$



Structural analysis report | Roof 3

Ballast Calculation

Ballast Calculation Uplift

Force per module pair perpendicular to the roof

$$F_z = q_p \cdot (-c_{pE} \cos(\alpha) A_M - c_{pW} \cos(\alpha) A_M)$$

F_z	uplift force per module unit in z-direction
q_p	local peak velocity pressure at roof height z
A_M	module area
α	module tilt angle
c_{pE}	cp-value of east module
c_{pW}	cp-value of west module

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_p	correction factor for parapet walls
k_s	correction factor for large modules
k_R	correction factor for large row spacings



Structural analysis report | Roof 3

Ballast Calculation Sliding

Force per module pair parallel to the roof

$$F_x = q_p \cdot (c_{pE} \sin(\alpha) A_M - c_{pW} \sin(\alpha) A_M)$$

$$F_y \approx 0$$

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_{pE} cp-value of east module

c_{pW} cp-value of west module

A_M module area

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_α correction factor for roof pitch

k_d correction factor for wind direction

k_p correction factor for parapet walls

k_s correction factor for large modules

k_R correction factor for large row spacings

Case	Highest ballast		Lowest ballast	
	Sliding	Uplift	Sliding	Uplift
c_{pW}	-0.231		-0.314	-0.230
c_{pE}	0.079		-0.029	0.092
k_α	1.04		1.00	1.04
k_d	0.90		0.90	0.90
k_p	1.03		1.03	1.03
k_s	1.03		1.03	1.03
k_R	1.00		1.00	1.00
A_M [m ²]	1.95		1.95	1.95



Structural analysis report | Roof 3

alpha [°]	10.0	10.0	10.0	10.0
qp [kN/m ²]	0.99	0.99	0.99	0.99
μ	1.0	-	1.0	-
Fx [kN]	0.104	-	0.108	-
Fz [kN]	0.290	0.656	0.264	0.352
m _{ballast} [kg]	25.7	69.7	21.6	18.3
m _{DL} [kg]	47.3	47.3	47.3	47.3

Structural analysis report | Roof 3

H-V-loads

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

General information

Total number of modules	112	
Roof areas covered with modules	A	= ca. 244.83 m ²
Dead Load	$g_{k, \text{System incl. ballast}}$	= 0.19 kN/m ²

Aerodynamic coefficients

	$C_{p, \text{Pressure}}$	= according to EN 1991-1-4
	$C_{F, x, \text{average}}$	= -0.03
	$C_{F, y, \text{averaged}}$	= 0.01
edge distance correction	$k_{s, xy}$	= 1.00
Parapet wall- correction coefficient	k_p	= 1.03
Factor building height		= 1.00

Horizontal pressure

$$W_{k, F, x} = -0.025 \text{ kN/m}^2$$

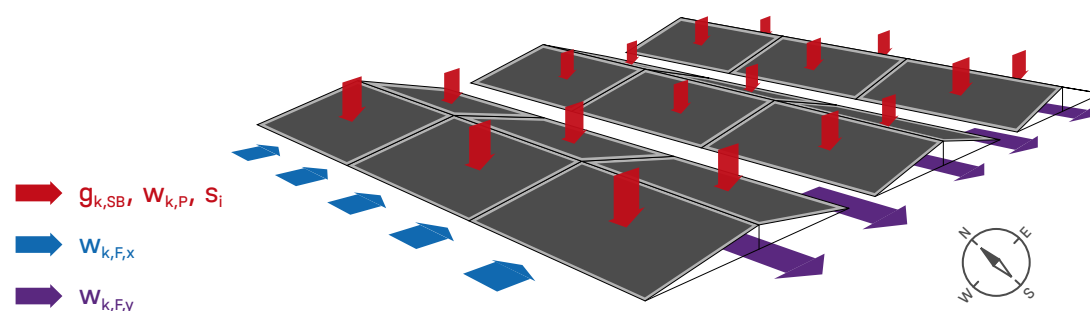
$$W_{k, F, y} = 0.009 \text{ kN/m}^2$$

Vertical pressure

$$g_{k, \text{System incl. ballast}} = 0.19 \text{ kN/m}^2$$

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

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



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.

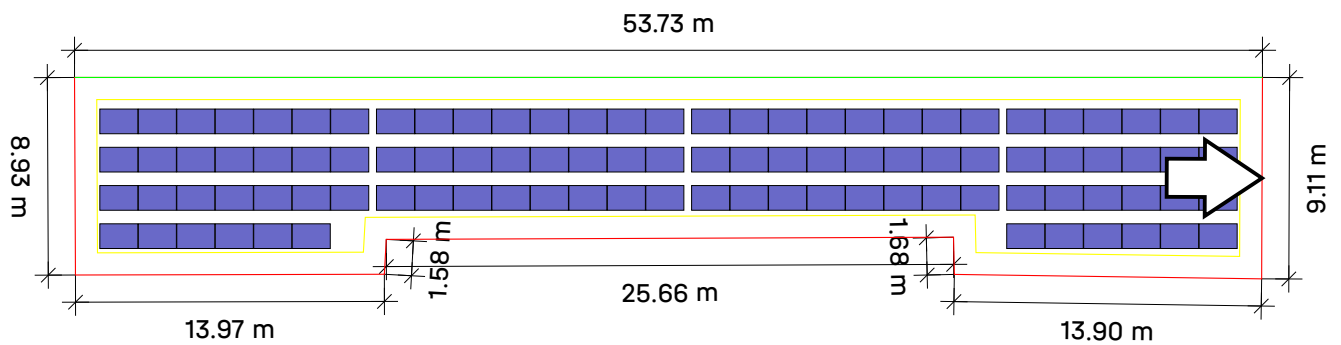


Roof 3 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003620	D-Dome 6.10 Base Set	64	201.1 kg
2	2004125	Dome 6.10 Peak	128	38.4 kg
3	2004123	Dome 6 Connector 195 Set	32	6.9 kg
4	2002870	K2 Solar Cable Manager	112	0.3 kg
5	2002609	DomeClamp Black MC Set 30-50	192	11.1 kg
6	2002610	DomeClamp Black EC Set 30-50	64	4.2 kg
7	2002300	Dome SpeedPorter	156	11.9 kg
Total				273.9 kg

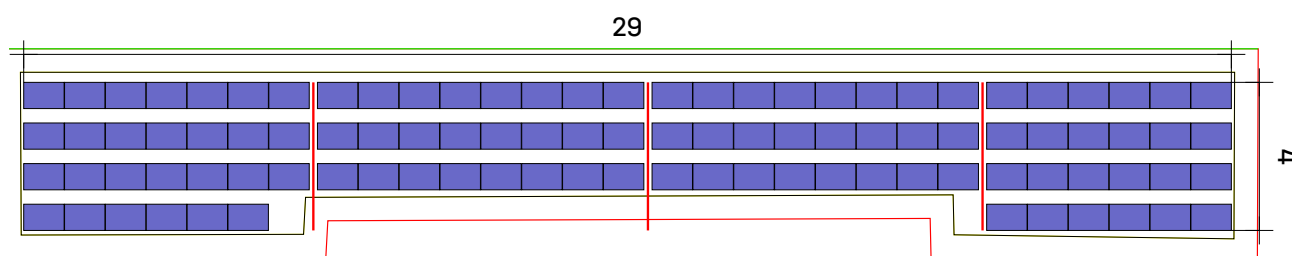


Roof 3 (1)



Roof	System	Module	Height	Quantity	Total power
<u>Roof 3 (1)</u>	<u>S-Dome 6.10</u>	DAS-DH108NA-430 (SchwarzThru)	22.00 m	99	42.57 kWp
 Flat	<u>Xpress</u>	1,722×1,134×30 mm 430 Wp			

Roof 3 (1) | Module array 1



Roof ③ Module array ①

Mounting System

[S-Dome 6.10 Xpress](#)

Module

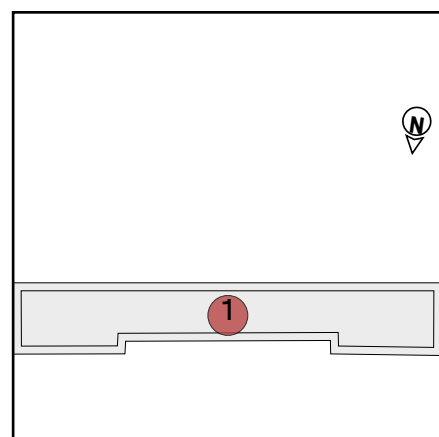
99(42.57 kWp) x DAS-DH108NA-430 (SchwarzThru)

Row spacing

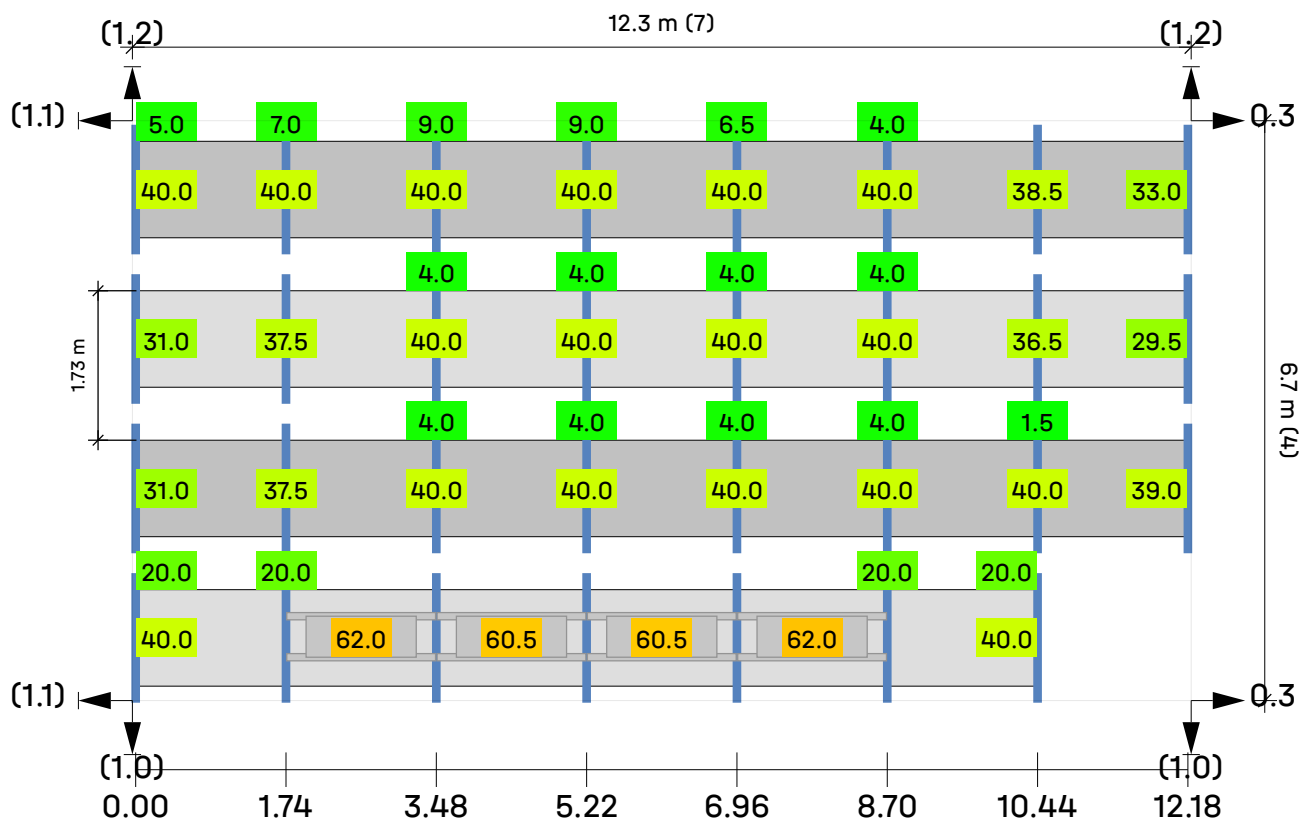
1.73 m

service corridor

0.61 m



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

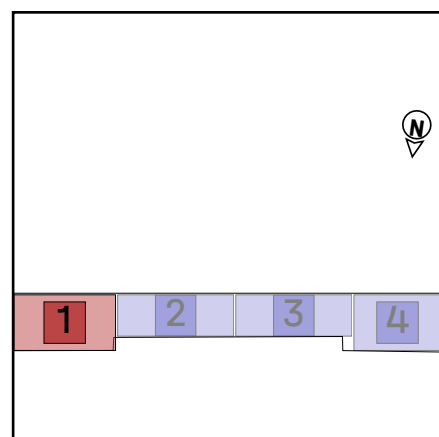


Roof ③ Module array ① Module block 1

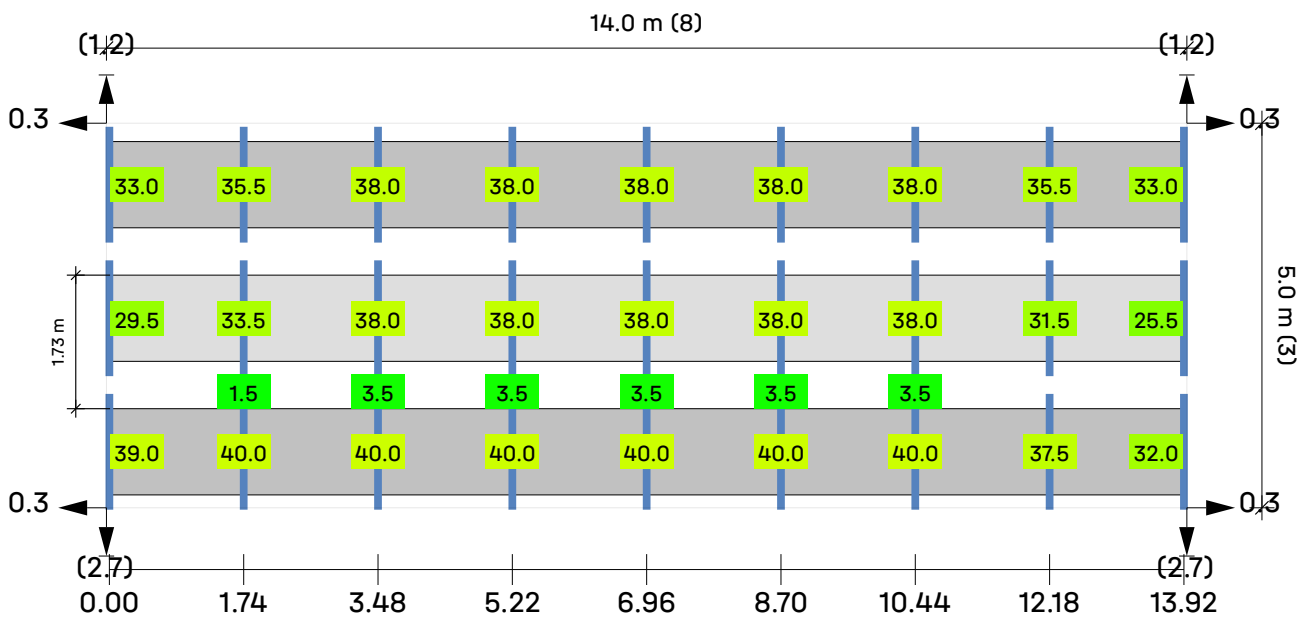
Modules (7 × 4) - 1 = 27

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

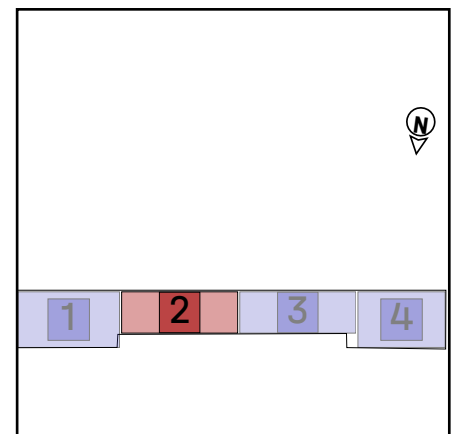


Roof ③ Module array ① Module block ②

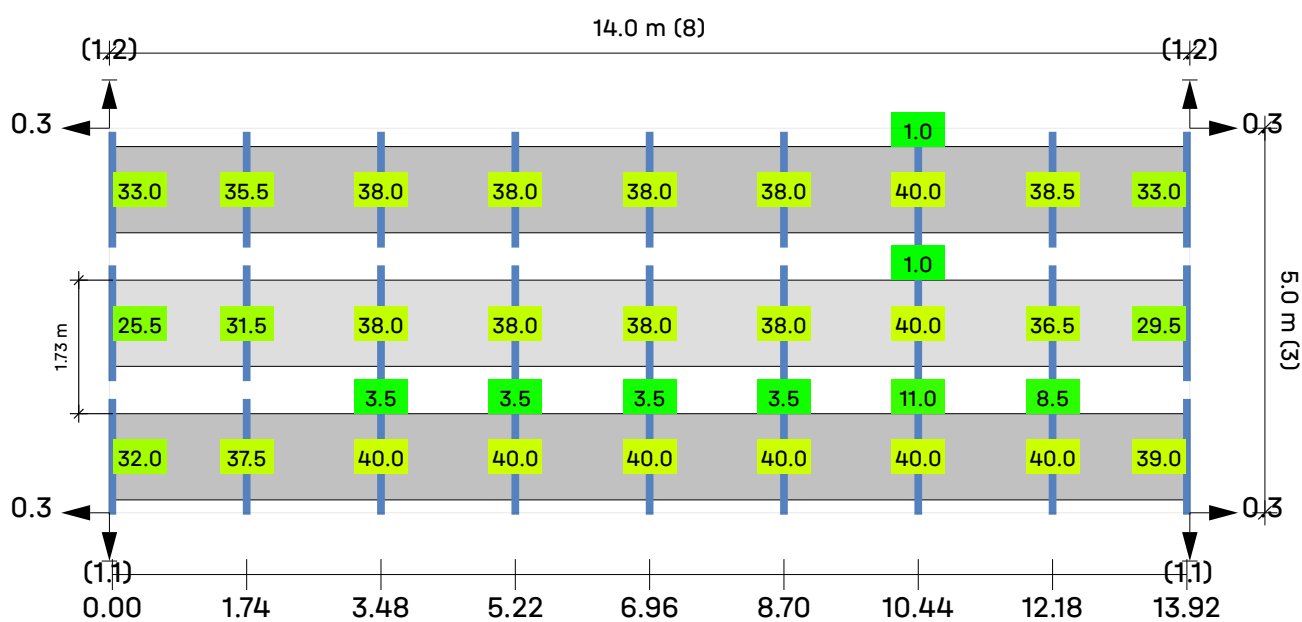
Modules $8 \times 3 = 24$

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 3 (1) | Module array 1 | Module block 3

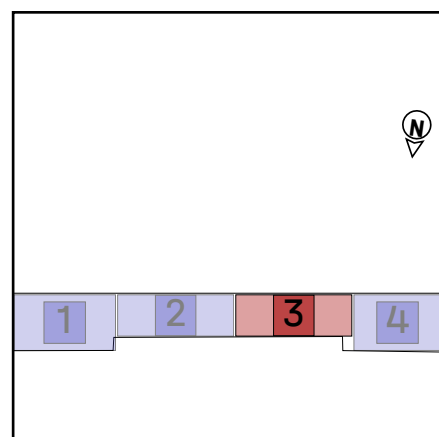


Roof ③ Module array ① Module block ③

Modules $8 \times 3 = 24$

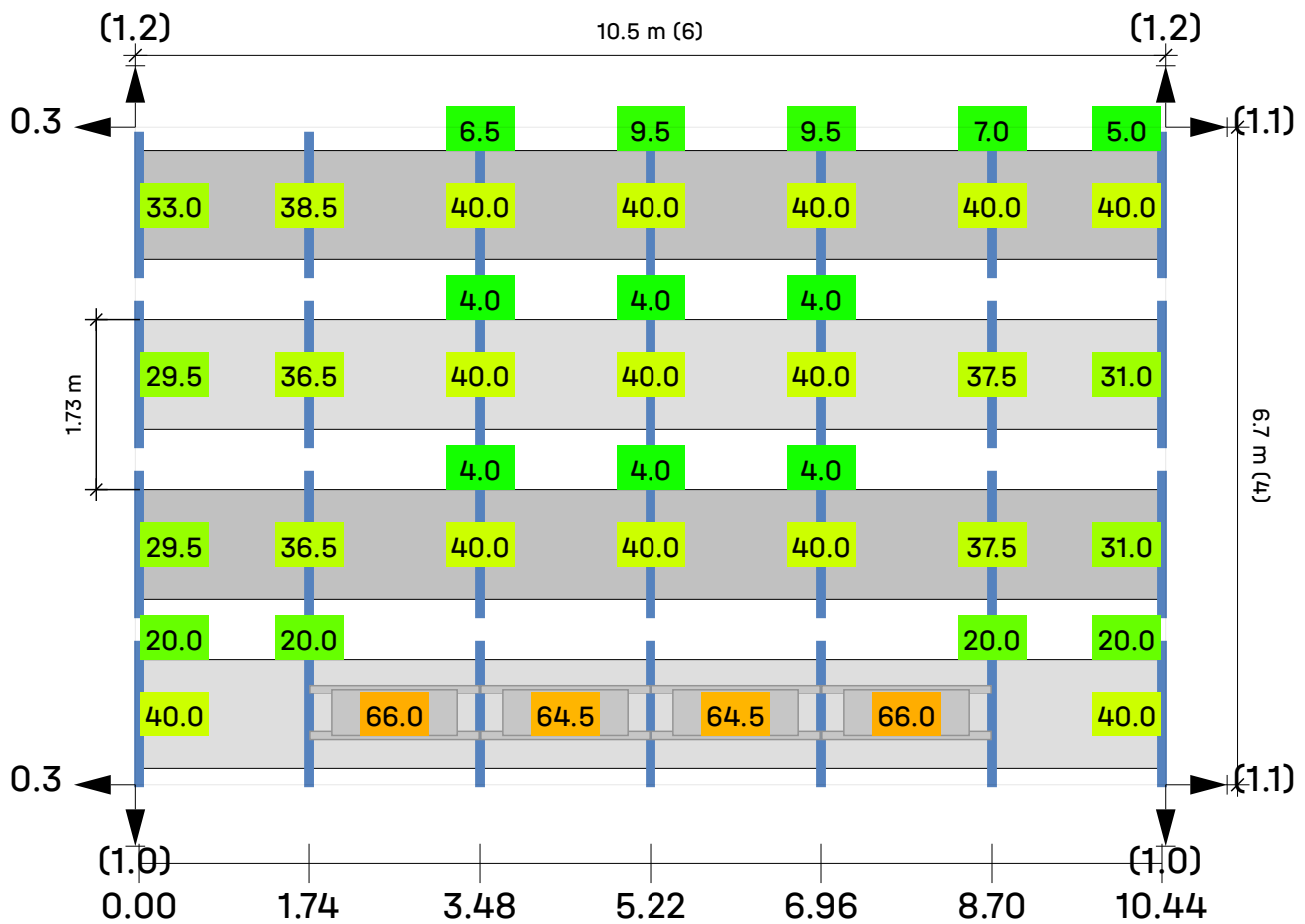
Legend

- 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 3 (1) | Module array 1 | Module block 4



Roof ③ Module array ① Module block ④

Modules $6 \times 4 = 24$

Legend



Mounting rail

Row distance [m]



Distance to Roof Edge [m]



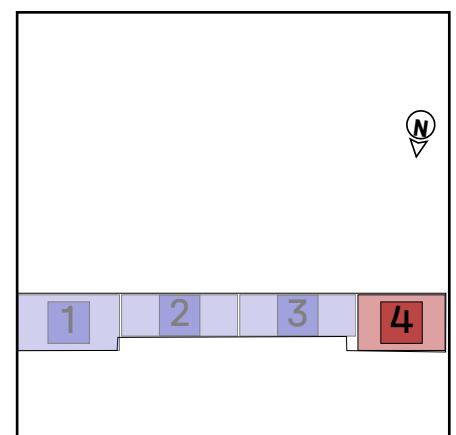
Dist. to neighbour module block/array [m]



Ballast in kilogram (kg)



Porter Ballast





Results | Roof 3 (1)

Roof	System	Module	Height	Quantity	Total power
Roof 3 (1)  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	99	42.57 kWp

Module

Name	DAS-DH108NA-430 (SchwarzThru)
Manufacturer	DAS Solar (Quzhou) Co., Ltd.
Output power	430 Wp
Dimensions	1,722×1,134×30 mm
Weight	20.5 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

pressure	50.98%
suction	88.43%

Loads on modules

Type	pressure	suction
ultimate limit state	2.42 kPa	-1.86 kPa
Serviceability	1.48 kPa	-1.09 kPa



Results | Roof 3 (1)

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	27	1,392.5	2,108.00	79.25 m ²	0.26	
Block 2	24	1,004.5	1,640.50	69.73 m ²	0.23	
Block 3	24	1,031.0	1,667.00	69.73 m ²	0.23	
Block 4	24	1,263.0	1,899.00	70.58 m ²	0.26	
Total	99	4,691.0	7,314.50			0.16



Results | Roof 3 (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.
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Structural analysis report | Roof 3 (1)

General information

Name	New project
Mounting System	S-Dome 6.10 Xpress
Author	james wynne

Location information

Address	Warrington Rd, Rainhill, UK
Ground elevation	64.60 m

Roof information

Building height	22.00 m
Roof type	Flat roof
Roof pitch	2°
Fastening method	with Ballast
Roof covering	Flat
Min. roof edge distance	1.00 m
Parapet wall height	0.50 m
Material	Concrete
Friction coefficient	1

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)	CC3
Design working life	25 years
Terrain category	Town Terrain
Distance to shoreline	17.00 km
Distance inside town terrain	1.00 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 1.080 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 1.000$
Velocity pressure, 25 years	$q_{p,25} = 0.994 \text{ kN/m}^2$



Structural analysis report | Roof 3 (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	$d_i = 0.999$
Snow load on roof, 50 year	$s_{i,50} = 0.400 \text{ kN/m}^2$
Adjustment factor for service life	$f_s = 1.000$
Snow load on roof, 25 years	$s_{i,25} = 0.371 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 20.5 \text{ kg}$
Weight of mounting system per module	$= 6.00 \text{ kg}$
Module area	$A_M = 1.95 \text{ m}^2$
Dead weight of module per m^2	$= 10.50 \text{ kg/m}^2$
Dead weight of mounting system per m^2	$= 3.07 \text{ kg/m}^2$
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	$\gamma_{G,sup} = 1.35$
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	$\kappa_{Fl,G} = 1.10$
Importance factor variable	$\kappa_{Fl,Q} = 1.10$
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	$LCC\ 06_{uls} = \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Suction}$

Structural analysis report | Roof 3 (1)

Static equilibrium

Uplift Verification	$LCC_{up} = \gamma_{G, stb} * G_k + \gamma_Q * \kappa_{Fl, Q} * W_{k, n, Uplift}$
Displacement verification	$LCC_{displ} = \gamma_{G, stb} * G_k + \gamma_Q * \kappa_{Fl, Q} * W_{k, n, Displacement}$

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	$LCC_{01_sls} = G_k + S_{i, n}$
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	$LCC_{06_sls} = G_k + W_{k, Suction}$

Max. Pressure on insulation

General information

dead load system	$g_{System} = 0.13 \text{ kN/m}^2$
aerodynamic coefficient	$C_{p, Pressure} = 0.20$

Load distribution underneath the building protection mat under Peak

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 46.4 \text{ kg}$

Load distribution underneath the building protection mat under SD

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 22.2 \text{ kg}$

Load Combinations

	$\sigma_{Ek, heat \text{ insulation, Peak}} [\text{Pa}]$	$\sigma_{Ek, heat \text{ insulation, SD}} [\text{Pa}]$
Load case combination 00	20,443	12,144
Load case combination 01	33,885	25,586

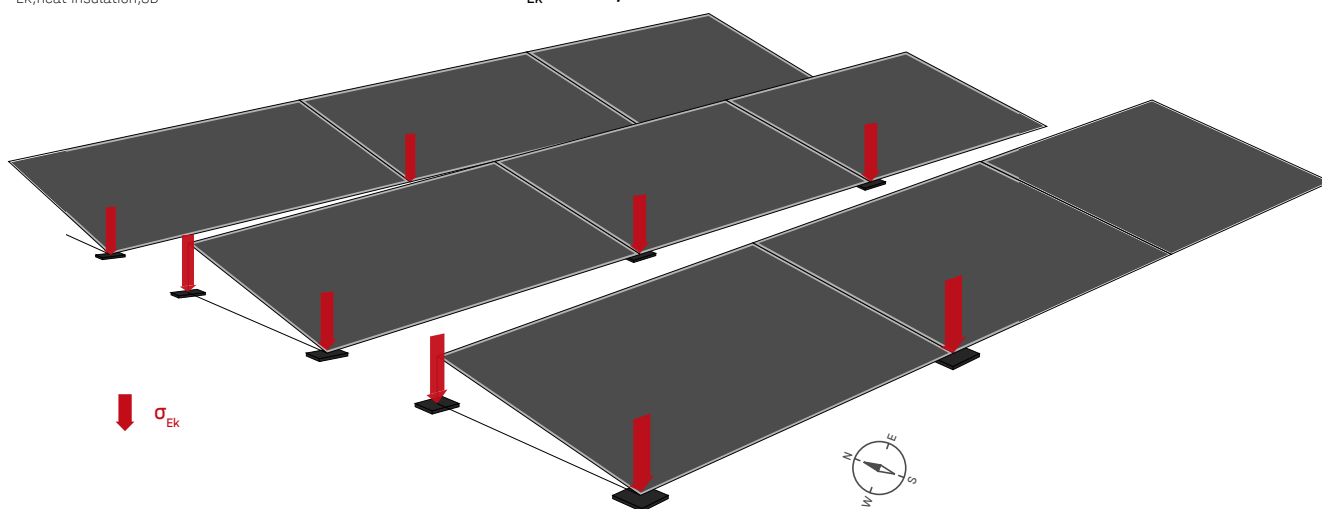
Structural analysis report | Roof 3 (1)

Actions from dead loads (PV system + ballast)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\sigma_{\text{Ek}} = 20,443 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\sigma_{\text{Ek}} = 12,144 \text{ Pa}$

Maximum actions (PV system + ballast + snow)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\max \sigma_{\text{Ek}} = 33,885 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\max \sigma_{\text{Ek}} = 25,586 \text{ Pa}$



Structural analysis report | Roof 3 (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 3 (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}	-0.174		-0.301	-0.130
c_{pD}	0.259		0.386	0.144
k_a	1.04		1.00	1.00
k_d	0.90		0.90	0.90

Structural analysis report | Roof 3 (1)

k_A	1.00	1.00	1.00	1.00
k_C	1.05	1.05	1.05	1.05
k_p	1.02	1.02	1.04	1.04
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]	1.95	1.95	1.95	1.95
A_D [m ²]	0.21	0.21	0.21	0.21
delta [°]	80.0	80.0	80.0	80.0
alpha [°]	10.0	10.0	10.0	10.0
qp [kN/m ²]	0.99	0.99	0.99	0.99
μ	1.0	-	1.0	-
Fx [kN]	0.113	-	0.074	-
Fz [kN]	0.324	0.561	0.243	0.242
$m_{ballast}$ [kg]	60.3	81.6	37.8	21.0
m_{DL} [kg]	26.5	26.5	26.5	26.5

Structural analysis report | Roof 3 (1)

H-V-loads

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

General information

Total number of modules	99	
Roof areas covered with modules	A	= ca. 289.28 m ²
Dead Load	$g_{k, \text{System incl. ballast}}$	= 0.25 kN/m ²

Aerodynamic coefficients

	$C_{p, \text{Pressure}}$	= according to EN 1991-1-4
	$C_{F, x, \text{average}}$	= 0.01
	$C_{F, y, \text{averaged}}$	= -0.03
edge distance correction	$k_{s, xy}$	= 1.00
Parapet wall- correction coefficient	k_p	= 1.01
Factor building height		= 1.00

Horizontal pressure

$$W_{k, F, x} = 0.009 \text{ kN/m}^2$$

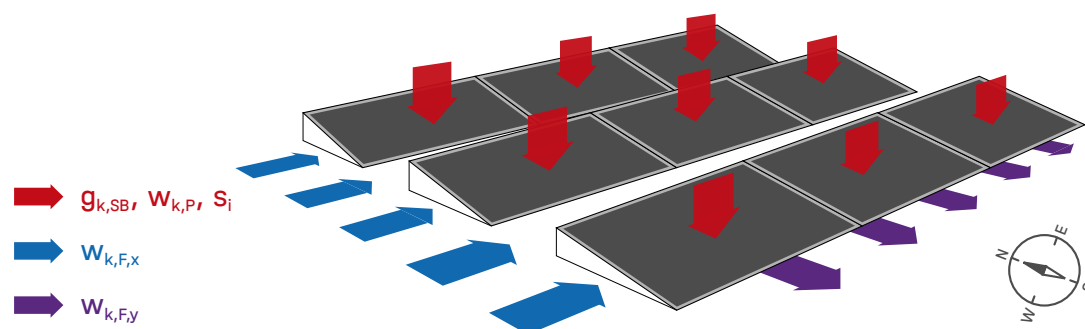
$$W_{k, F, y} = -0.023 \text{ kN/m}^2$$

Vertical pressure

$$g_{k, \text{System incl. ballast}} = 0.25 \text{ kN/m}^2$$

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

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



Comment:

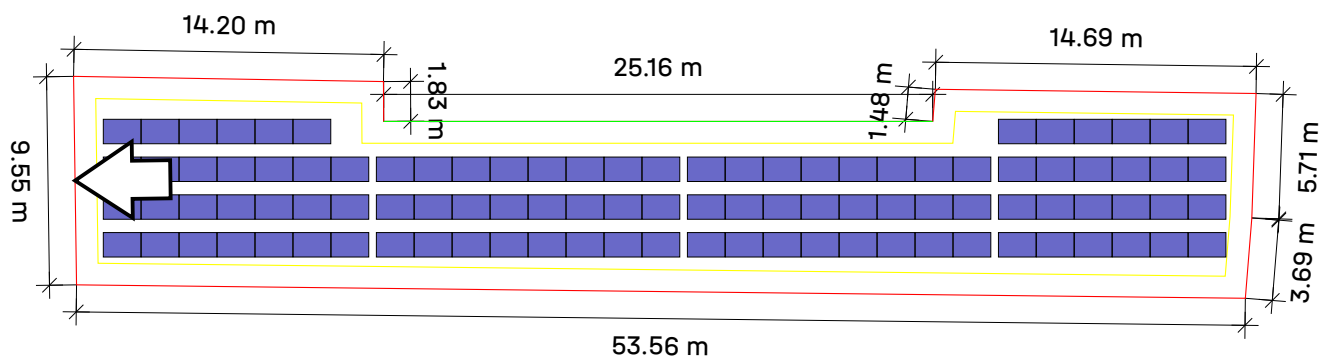
Flat roof vertical wind loads are essentially determined by its displacement effect and remain unchanged even with a flat pv structure. We advise using the aerodynamic coefficients according to DIN EN 1991-1-4 to calculate flat roofs.



Roof 3 (1) | Bill of material

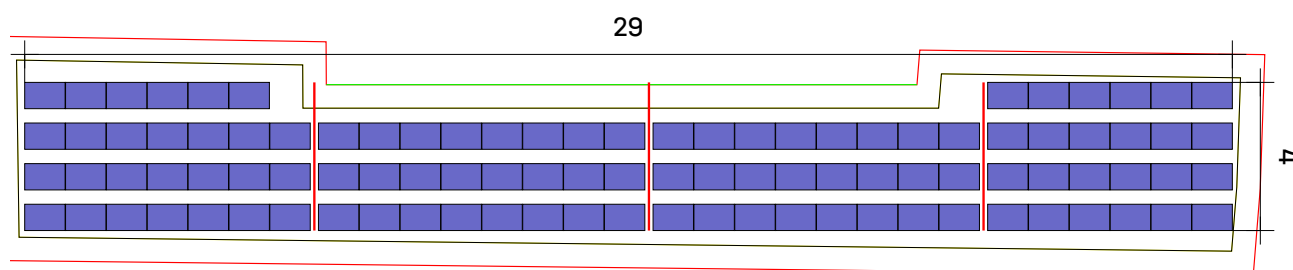
Position	Item no.	Item description	Quantity	Weight
1	2003621	S-Dome 6.10 Base Set	113	217.8 kg
2	2004125	Dome 6.10 Peak	113	33.9 kg
3	2004178	Dome 6 Connector 495mm Set	80	33.0 kg
4	2003249	S-Dome 6.10 Windbreaker short	99	178.2 kg
5	2002937	Thread-forming metal screw 6×25	226	1.6 kg
6	2002870	K2 Solar Cable Manager	99	0.3 kg
7	2002609	DomeClamp Black MC Set 30-50	170	9.9 kg
8	2002610	DomeClamp Black EC Set 30-50	56	3.7 kg
9	2003150	Dome Porter short	16	23.7 kg
10	1001643	MK2	32	0.6 kg
11	2001729	Socket Head Bolt serrated M8×20	32	0.4 kg
12	2002300	Dome SpeedPorter	302	23.0 kg
Total				525.9 kg

Roof 3 (2)



Roof	System	Module	Height	Quantity	Total power
Roof 3 (2)  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	99	42.57 kWp

Roof 3 (2) | Module array 1



Roof ④ Module array ①

Mounting System

[S-Dome 6.10 Xpress](#)

Module

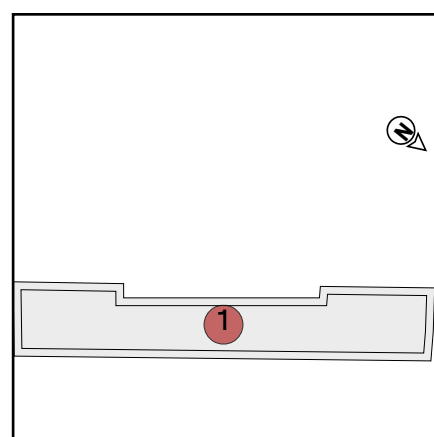
99(42.57 kWp) x DAS-DH108NA-430 (SchwarzThru)

Row spacing

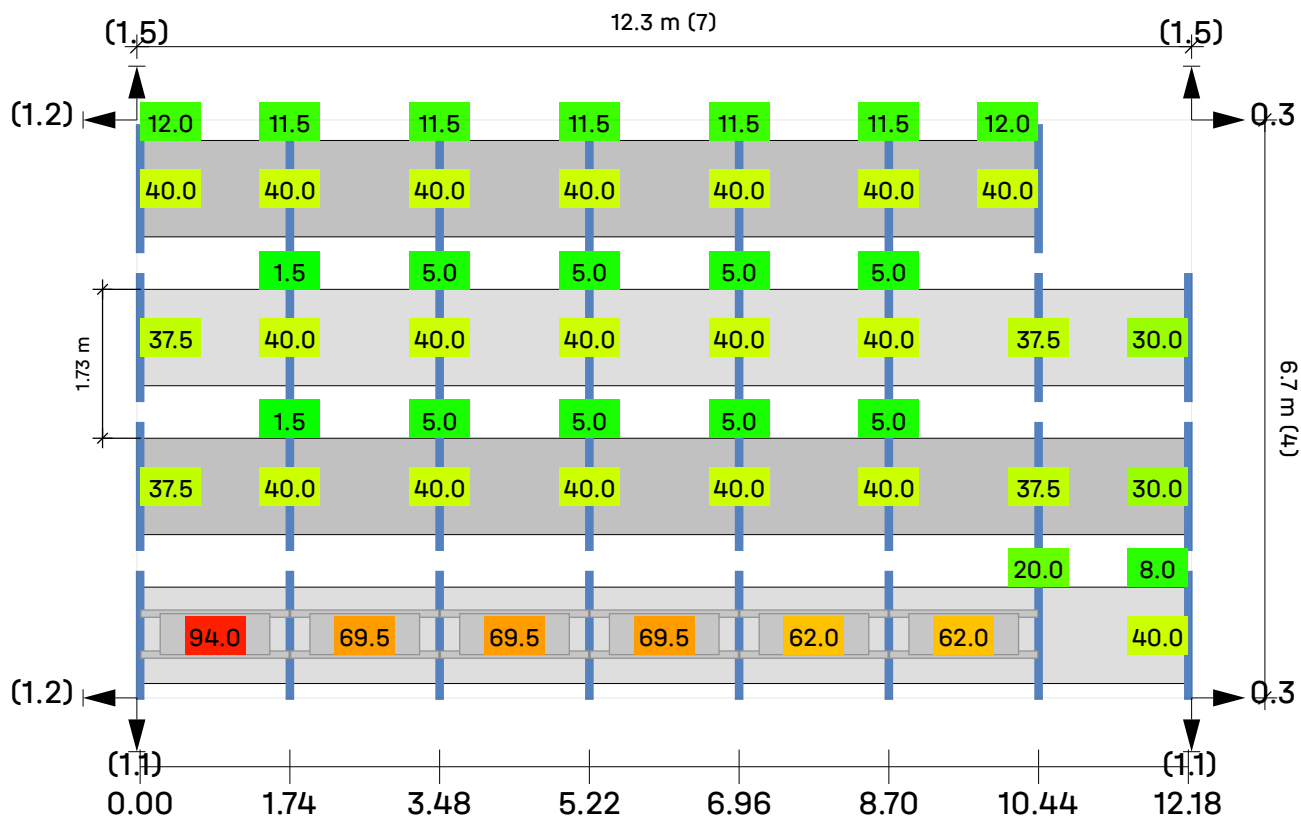
1.73 m

service corridor

0.61 m



Roof 3 (2) | Module array 1 | Module block 1

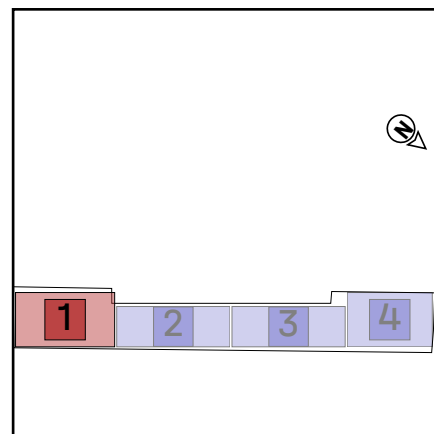


Roof ④ Module array ① Module block 1

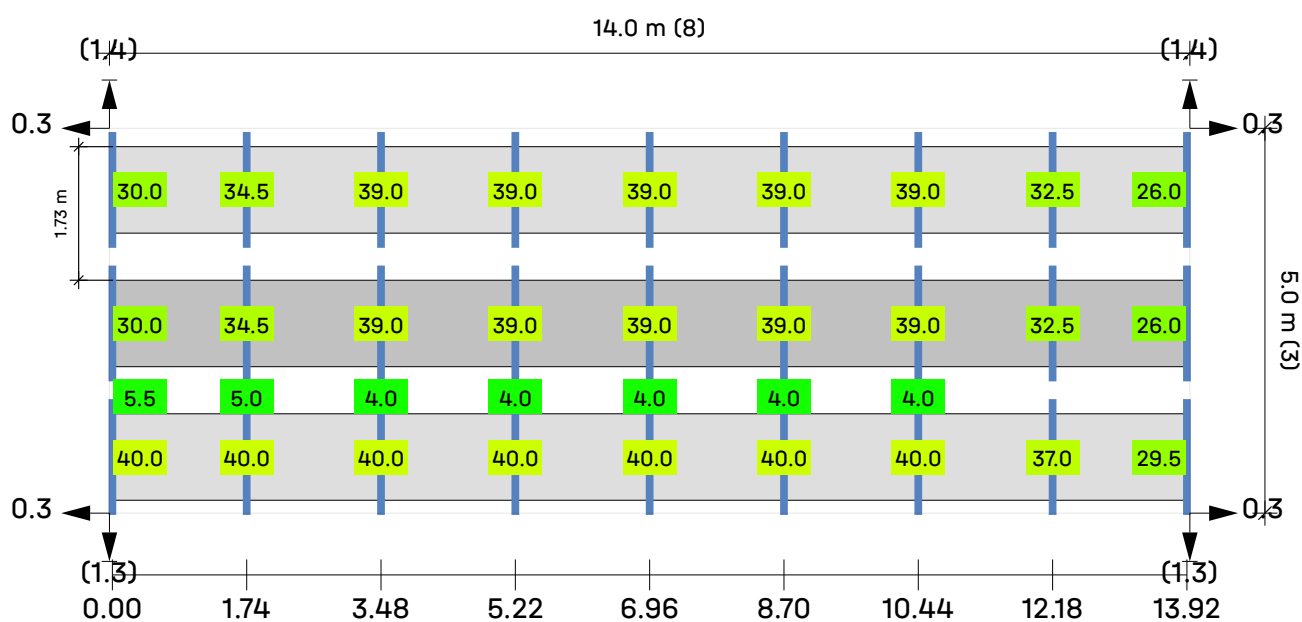
Modules (7 × 4) - 1 = 27

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

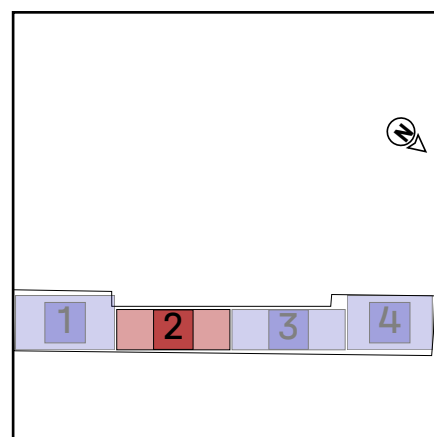


Roof ④ Module array ① Module block ②

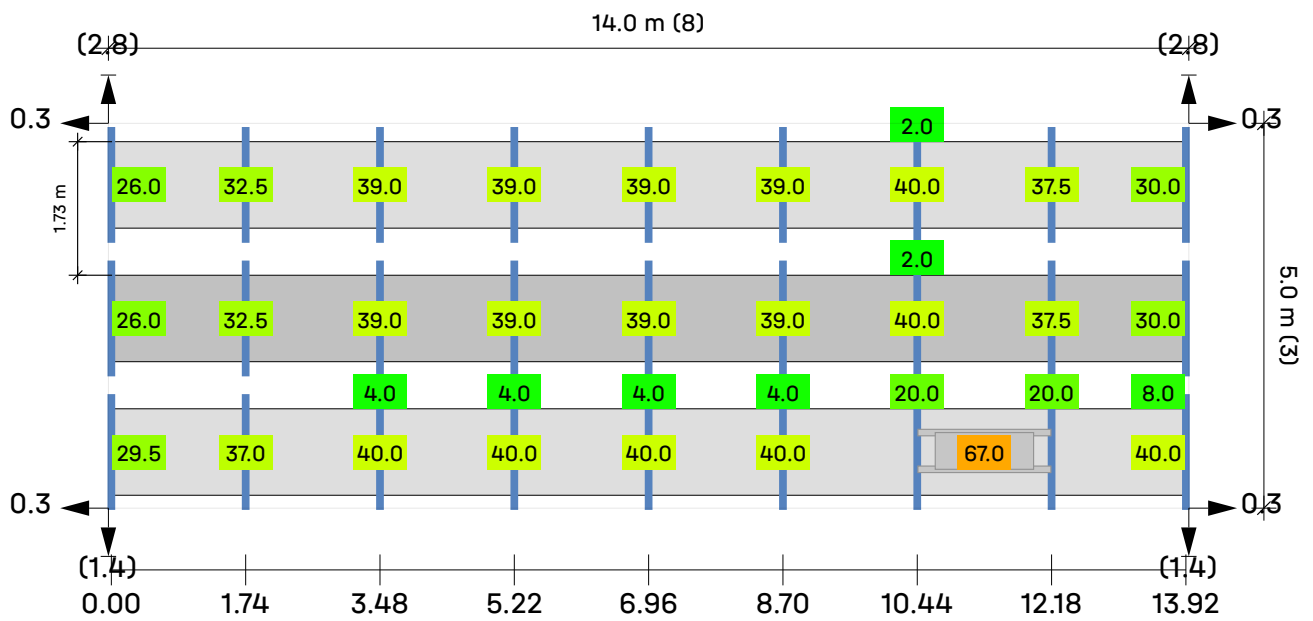
Modules $8 \times 3 = 24$

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 3 (2) | Module array 1 | Module block 3

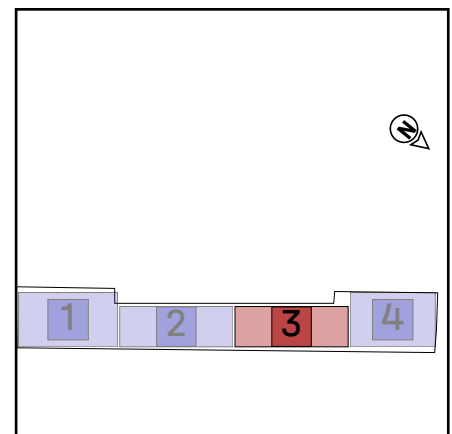


Roof ④ Module array ① Module block ③

Modules $8 \times 3 = 24$

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 3 (2)

Roof	System	Module	Height	Quantity	Total power
Roof 3 (2)  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	22.00 m	99	42.57 kWp

Module

Name	DAS-DH108NA-430 (SchwarzThru)
Manufacturer	DAS Solar (Quzhou) Co., Ltd.
Output power	430 Wp
Dimensions	1,722×1,134×30 mm
Weight	20.5 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

pressure	65.43%
suction	90.74%

Loads on modules

Type	pressure	suction
ultimate limit state	2.47 kPa	-1.91 kPa
Serviceability	1.51 kPa	-1.12 kPa



Results | Roof 3 (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	27	1,509.0	2,224.50	79.29 m ²	0.28	
Block 2	24	1,013.0	1,649.00	69.77 m ²	0.23	
Block 3	24	1,045.5	1,681.50	69.77 m ²	0.24	
Block 4	24	1,386.5	2,022.50	70.61 m ²	0.28	
Total	99	4,954.0	7,577.50			0.16



Results | Roof 3 (2)

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'.
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Structural analysis report | Roof 3 (2)

General information

Name	New project
Mounting System	S-Dome 6.10 Xpress
Author	james wynne

Location information

Address	Warrington Rd, Rainhill, UK
Ground elevation	64.60 m

Roof information

Building height	22.00 m
Roof type	Flat roof
Roof pitch	2°
Fastening method	with Ballast
Roof covering	Flat
Min. roof edge distance	1.00 m
Parapet wall height	0.50 m
Material	Concrete
Friction coefficient	1

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)	CC3
Design working life	25 years
Terrain category	Town Terrain
Distance to shoreline	17.00 km
Distance inside town terrain	1.00 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 1.080 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 1.000$
Velocity pressure, 25 years	$q_{p,25} = 0.994 \text{ kN/m}^2$



Structural analysis report | Roof 3 (2)

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	$d_i = 0.999$
Snow load on roof, 50 year	$s_{i,50} = 0.400 \text{ kN/m}^2$
Adjustment factor for service life	$f_s = 1.000$
Snow load on roof, 25 years	$s_{i,25} = 0.371 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 20.5 \text{ kg}$
Weight of mounting system per module	$= 6.00 \text{ kg}$
Module area	$A_M = 1.95 \text{ m}^2$
Dead weight of module per m^2	$= 10.50 \text{ kg/m}^2$
Dead weight of mounting system per m^2	$= 3.07 \text{ kg/m}^2$
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	$V_{G,stab} = 0.90$
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	$\kappa_{FI,G} = 1.10$
Importance factor variable	$\kappa_{FI,Q} = 1.10$
Characteristic dead weight	G_k
Characteristic snow load on the roof	$S_{i,n}$
Characteristic wind load	W_k
Load case combination 01	$LCC\ 01_{uls} = V_{G,sup} * \kappa_{FI,G} * G_k + V_Q * \kappa_{FI,Q} * S_{i,n}$
Load case combination 02	$LCC\ 02_{uls} = V_{G,sup} * \kappa_{FI,G} * G_k + V_Q * \kappa_{FI,Q} * W_{k,Pressure}$
Load case combination 03	$LCC\ 03_{uls} = V_{G,sup} * \kappa_{FI,G} * G_k + V_Q * \kappa_{FI,Q} * (W_{k,Pressure} + \psi_{0,S} * S_{i,n})$
Load case combination 04	$LCC\ 04_{uls} = V_{G,sup} * \kappa_{FI,G} * G_k + V_Q * \kappa_{FI,Q} * (S_{i,n} + \psi_{0,W} * W_{k,Pressure})$
Load case combination 06	$LCC\ 06_{uls} = V_{G,inf} * G_k + V_Q * \kappa_{FI,Q} * W_{k,Suction}$



Structural analysis report | Roof 3 (2)

Static equilibrium

Uplift Verification	$LCC_{up} = \gamma_{G,stab} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,n,Uplift}$
Displacement verification	$LCC_{displ} = \gamma_{G,stab} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,n,Displacement}$

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	$LCC_{01_sls} = G_k + S_{i,n}$
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	$LCC_{06_sls} = G_k + W_{k,Suction}$

Max. Pressure on insulation

General information

dead load system	$g_{System} = 0.13 \text{ kN/m}^2$
aerodynamic coefficient	$C_{p,Pressure} = 0.20$

Load distribution underneath the building protection mat under Peak

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 55.3 \text{ kg}$

Load distribution underneath the building protection mat under SD

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 28.5 \text{ kg}$

Load Combinations

	$\sigma_{Ek,heat \text{ insulation,Peak}} [\text{Pa}]$	$\sigma_{Ek,heat \text{ insulation,SD}} [\text{Pa}]$
Load case combination 00	23,485	14,300
Load case combination 01	36,966	27,781

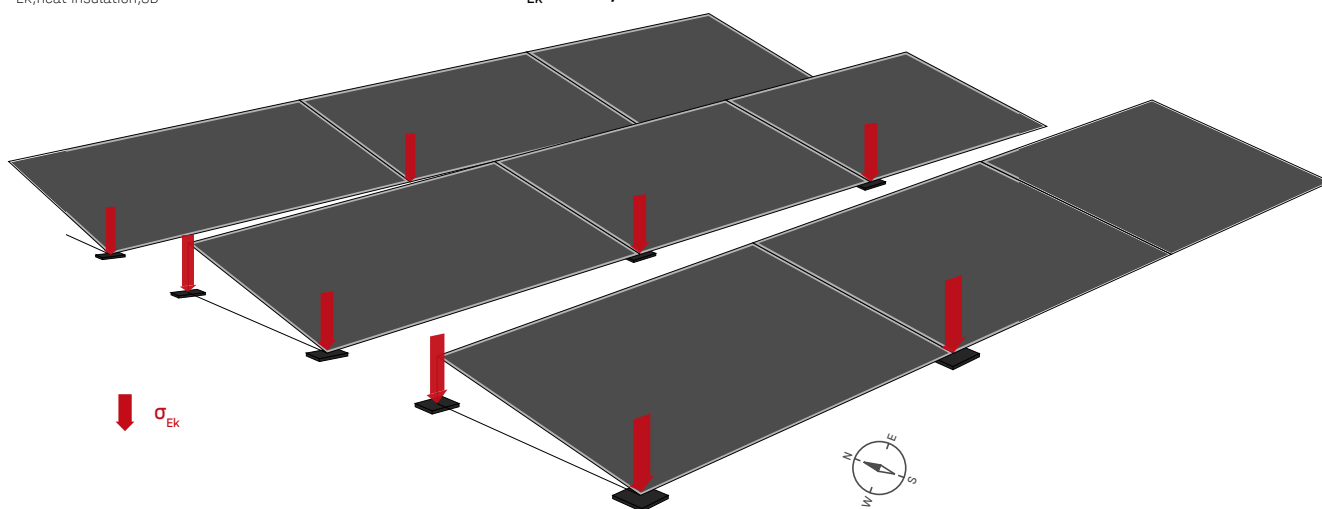
Structural analysis report | Roof 3 (2)

Actions from dead loads (PV system + ballast)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\sigma_{\text{Ek}} = 23,485 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\sigma_{\text{Ek}} = 14,300 \text{ Pa}$

Maximum actions (PV system + ballast + snow)

$\sigma_{\text{Ek,heat insulation,Peak}}$	$\max \sigma_{\text{Ek}} = 36,966 \text{ Pa}$
$\sigma_{\text{Ek,heat insulation,SD}}$	$\max \sigma_{\text{Ek}} = 27,781 \text{ Pa}$



Structural analysis report | Roof 3 (2)

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 3 (2)

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}	-0.190		-0.322	-0.130
c_{pD}	0.276		0.278	0.144
k_a	1.04		1.00	1.00
k_d	0.90		0.90	0.90

Structural analysis report | Roof 3 (2)

k_A	1.00	1.00	1.00	1.00
k_C	1.05	1.05	1.05	1.05
k_p	1.02	1.02	1.04	1.04
k_s	1.03	1.03	1.03	1.03
k_R	1.03	1.03	1.03	1.03
k_{RWS}	1.03	1.03	1.03	1.03
A_M [m ²]	1.95	1.95	1.95	1.95
A_D [m ²]	0.21	0.21	0.21	0.21
delta [°]	81.0	81.0	81.0	81.0
alpha [°]	9.0	9.0	9.0	9.0
qp [kN/m ²]	0.99	0.99	0.99	0.99
μ	1.0	-	1.0	-
Fx [kN]	0.115	-	0.070	-
Fz [kN]	0.355	0.609	0.245	0.243
$m_{ballast}$ [kg]	69.2	93.8	38.8	22.5
m_{DL} [kg]	26.5	26.5	26.5	26.5

Structural analysis report | Roof 3 (2)

H-V-loads

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

General information

Total number of modules	99	
Roof areas covered with modules	A	= ca. 289.44 m ²
Dead Load	$g_{k, \text{System incl. ballast}}$	= 0.26 kN/m ²

Aerodynamic coefficients

	$C_{p, \text{Pressure}}$	= according to EN 1991-1-4
	$C_{F, x, \text{average}}$	= 0.01
	$C_{F, y, \text{averaged}}$	= -0.02
edge distance correction	$k_{s, xy}$	= 1.00
Parapet wall- correction coefficient	k_p	= 1.03
Factor building height		= 1.00

Horizontal pressure

$$W_{k, F, x} = 0.009 \text{ kN/m}^2$$

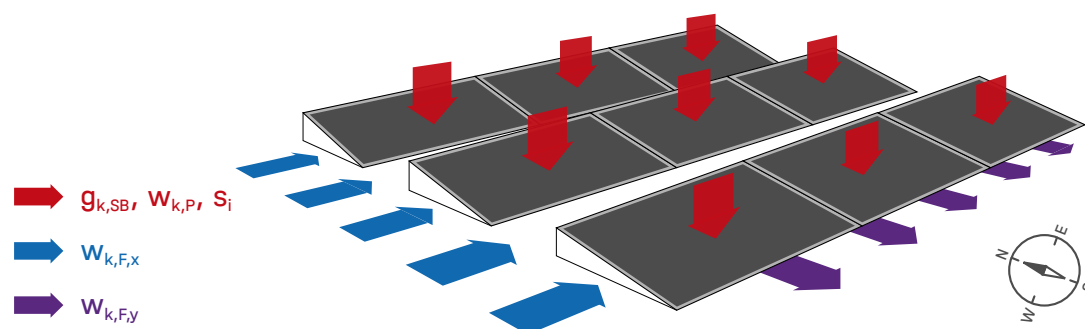
$$W_{k, F, y} = -0.021 \text{ kN/m}^2$$

Vertical pressure

$$g_{k, \text{System incl. ballast}} = 0.26 \text{ kN/m}^2$$

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

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



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.

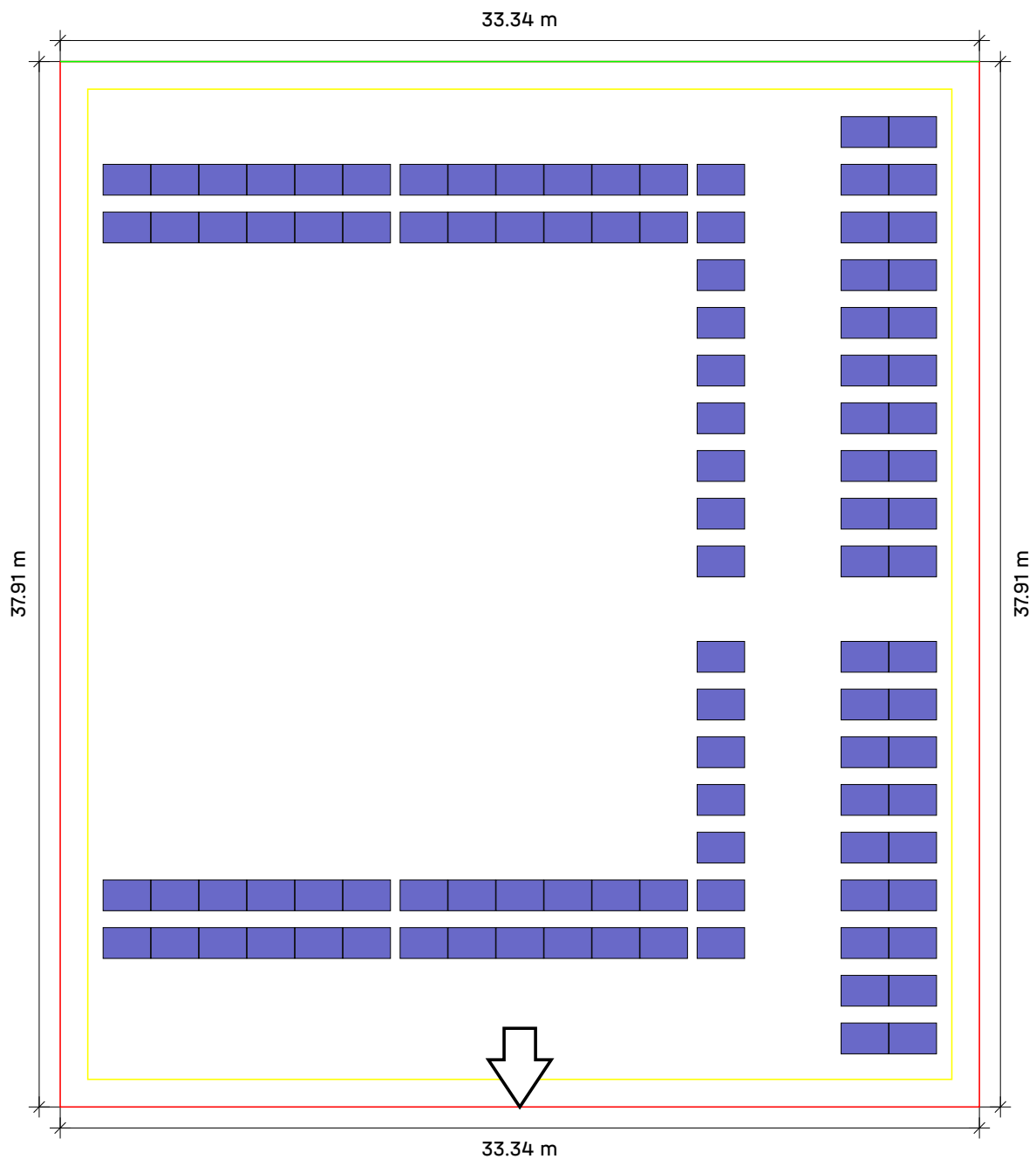


Roof 3 (2) | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2004096	S-Dome 6.10 Base Set L	113	212.4 kg
2	2004125	Dome 6.10 Peak	113	33.9 kg
3	2004178	Dome 6 Connector 495mm Set	80	33.0 kg
4	2003249	S-Dome 6.10 Windbreaker short	99	178.2 kg
5	2002937	Thread-forming metal screw 6×25	226	1.6 kg
6	2002870	K2 Solar Cable Manager	99	0.3 kg
7	2002609	DomeClamp Black MC Set 30-50	170	9.9 kg
8	2002610	DomeClamp Black EC Set 30-50	56	3.7 kg
9	2003150	Dome Porter short	24	35.5 kg
10	1001643	MK2	48	0.8 kg
11	2001729	Socket Head Bolt serrated M8×20	48	0.6 kg
12	2002300	Dome SpeedPorter	300	22.8 kg
Total				532.7 kg



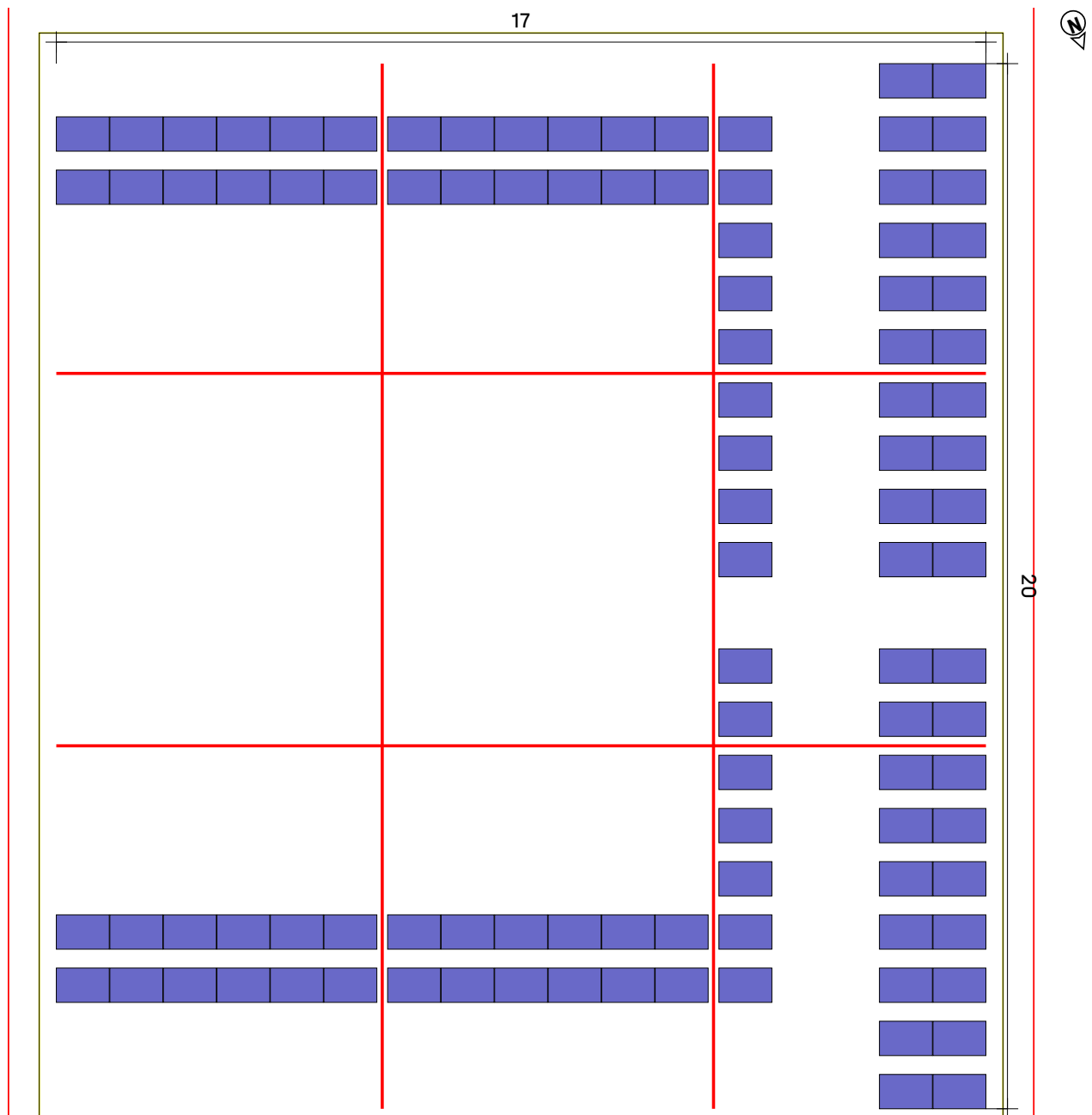
roof 4



Roof	System	Module	Height	Quantity	Total power
<u>roof 4</u>	<u>S-Dome 6.10</u>	DAS-DH108NA-430 (SchwarzThru)	15.00 m	102	43.86 kWp
 Flat	<u>Xpress</u>	1,722×1,134×30 mm 430 Wp			



roof 4 | Module array 1



Roof ⑤ Module array ①

Mounting System

Module

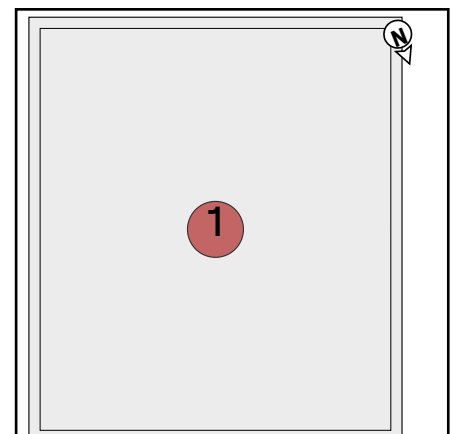
Row spacing

service corridor

[S-Dome 6.10 Xpress](#)102(43.86 kWp) x DAS-DH108NA-430
(SchwarzThru)

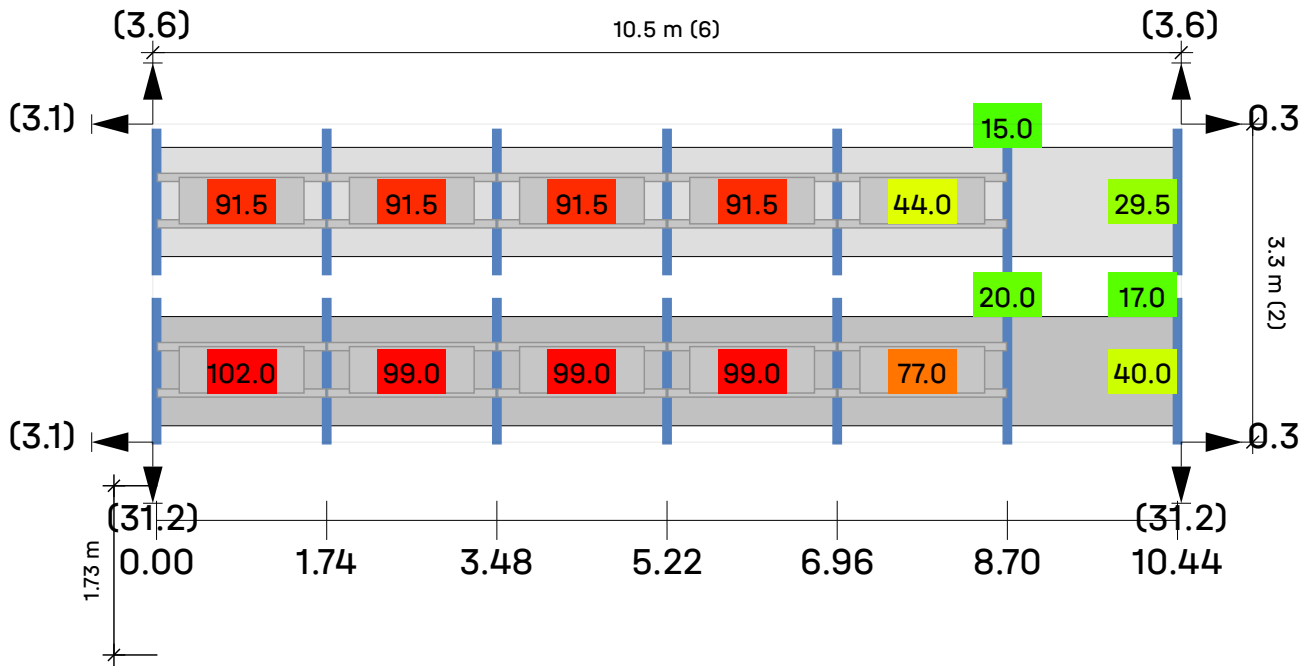
1.73 m

0.61 m





roof 4 | Module array 1 | Module block 1

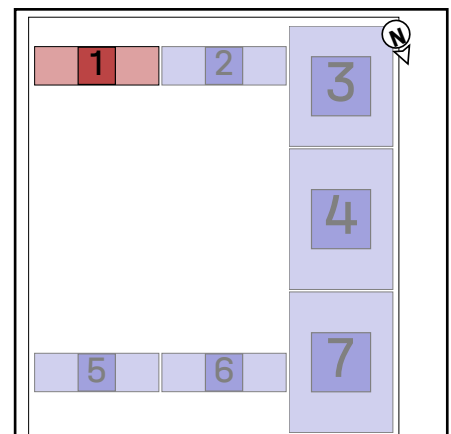


Roof ⑤ Module array ① Module block ①

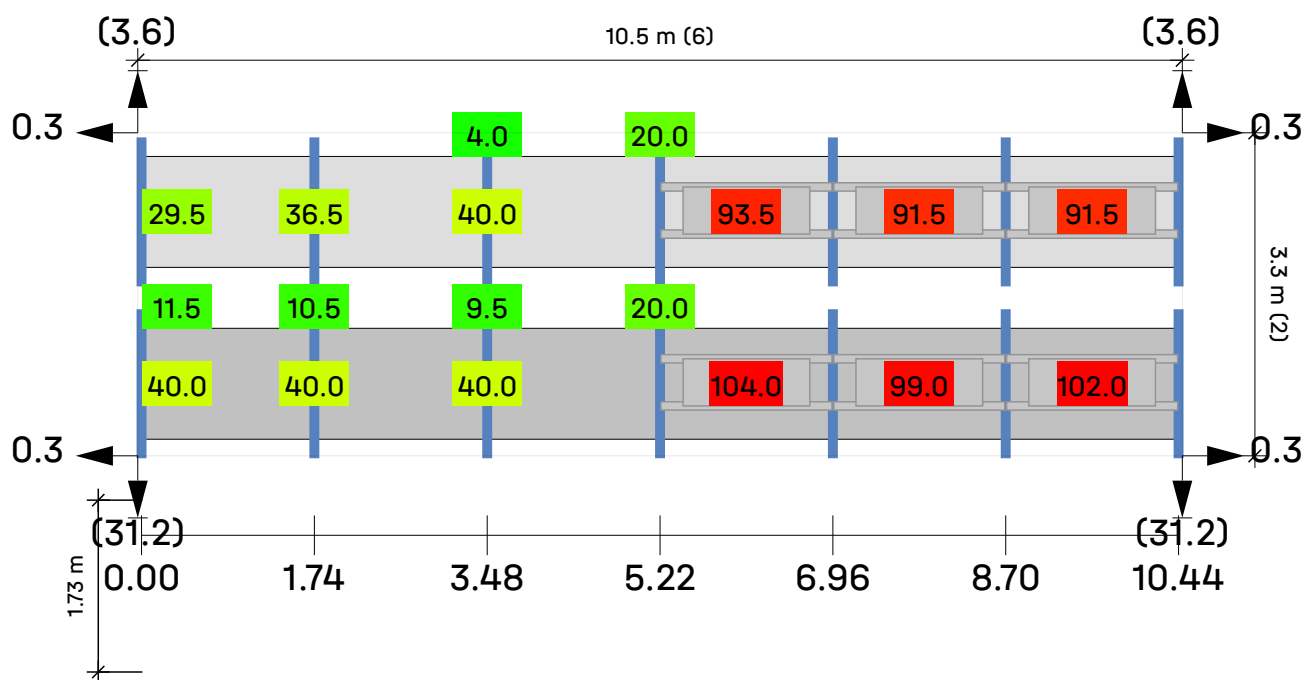
Modules $6 \times 2 = 12$

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 4 | Module array 1 | Module block 2

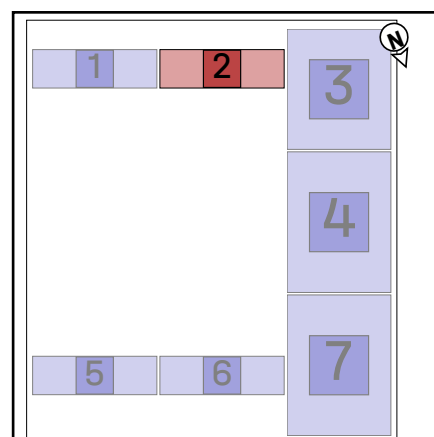


Roof ⑤ Module array ① Module block ②

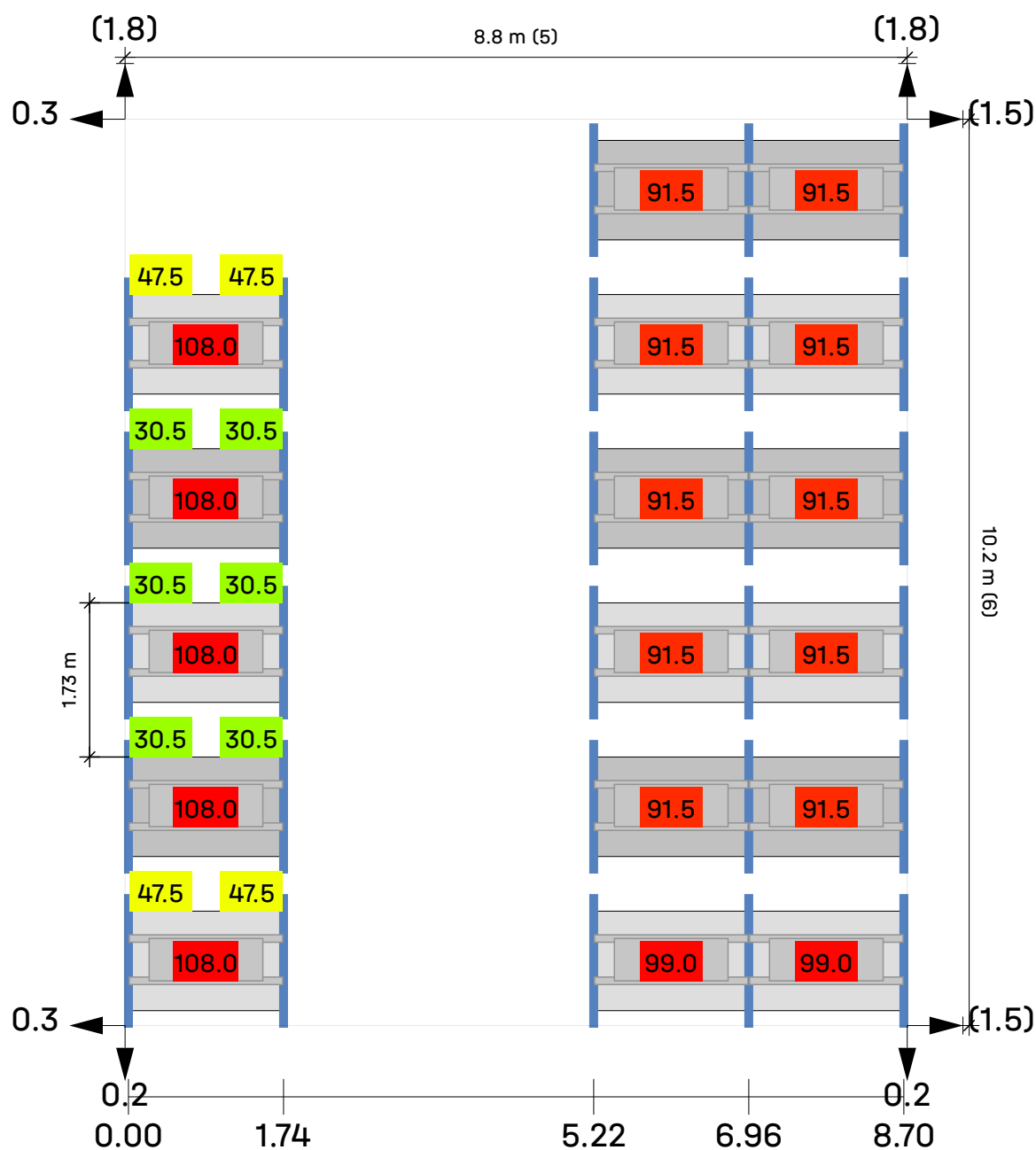
Modules $6 \times 2 = 12$

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 4 | Module array 1 | Module block 3

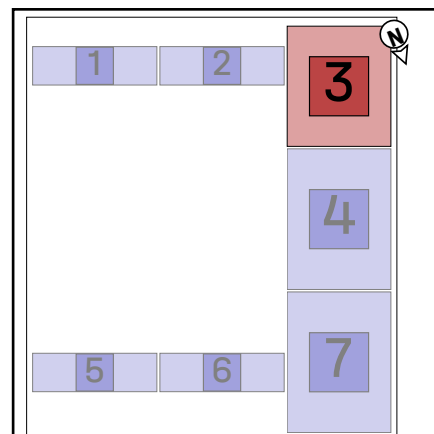


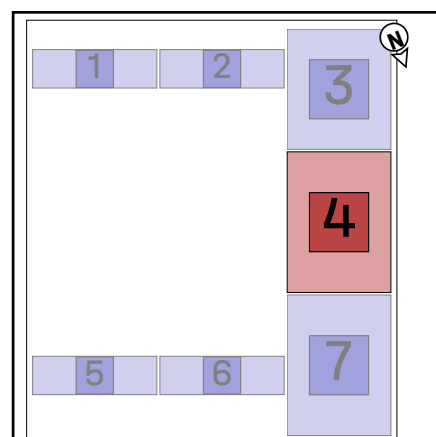
Roof (5) Module array (1) Module block (3)

Modules (5 × 6) - 13 = 17

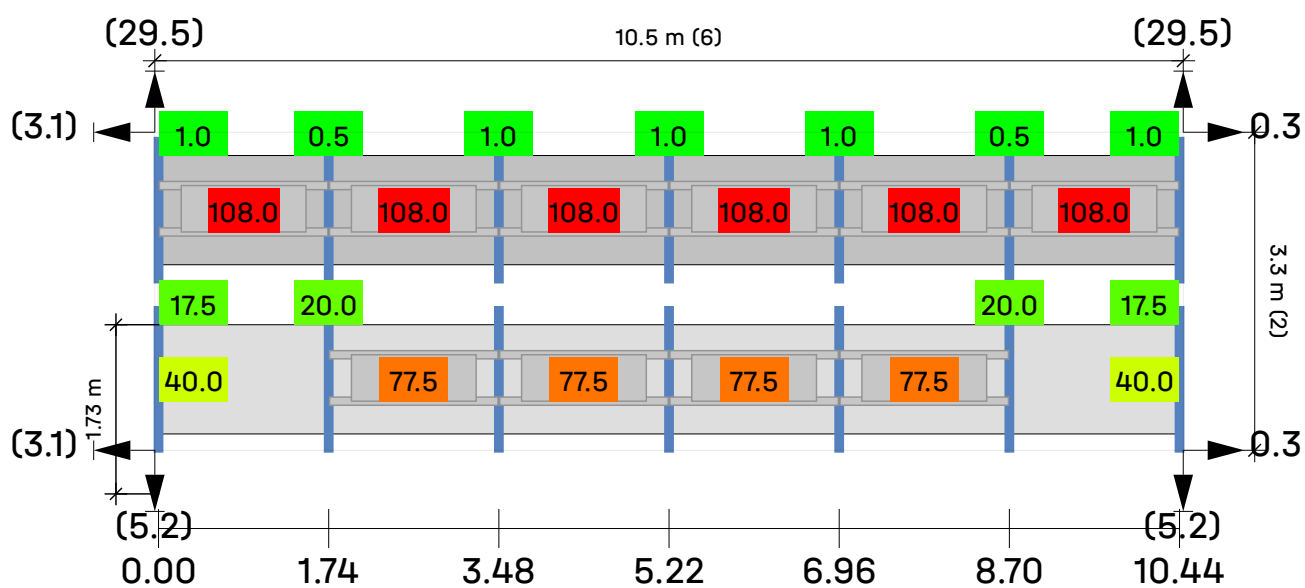
Legend

- 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 4 | Module array 1 | Module block 5

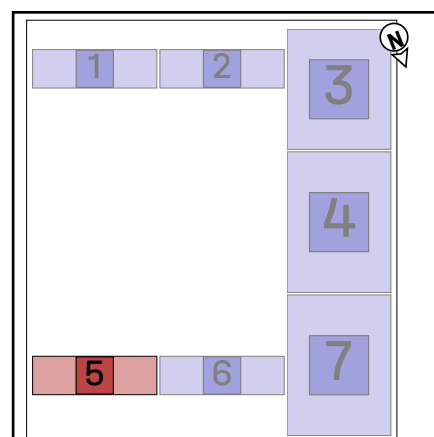


Roof **⑤** Module array **①** Module block **⑤**

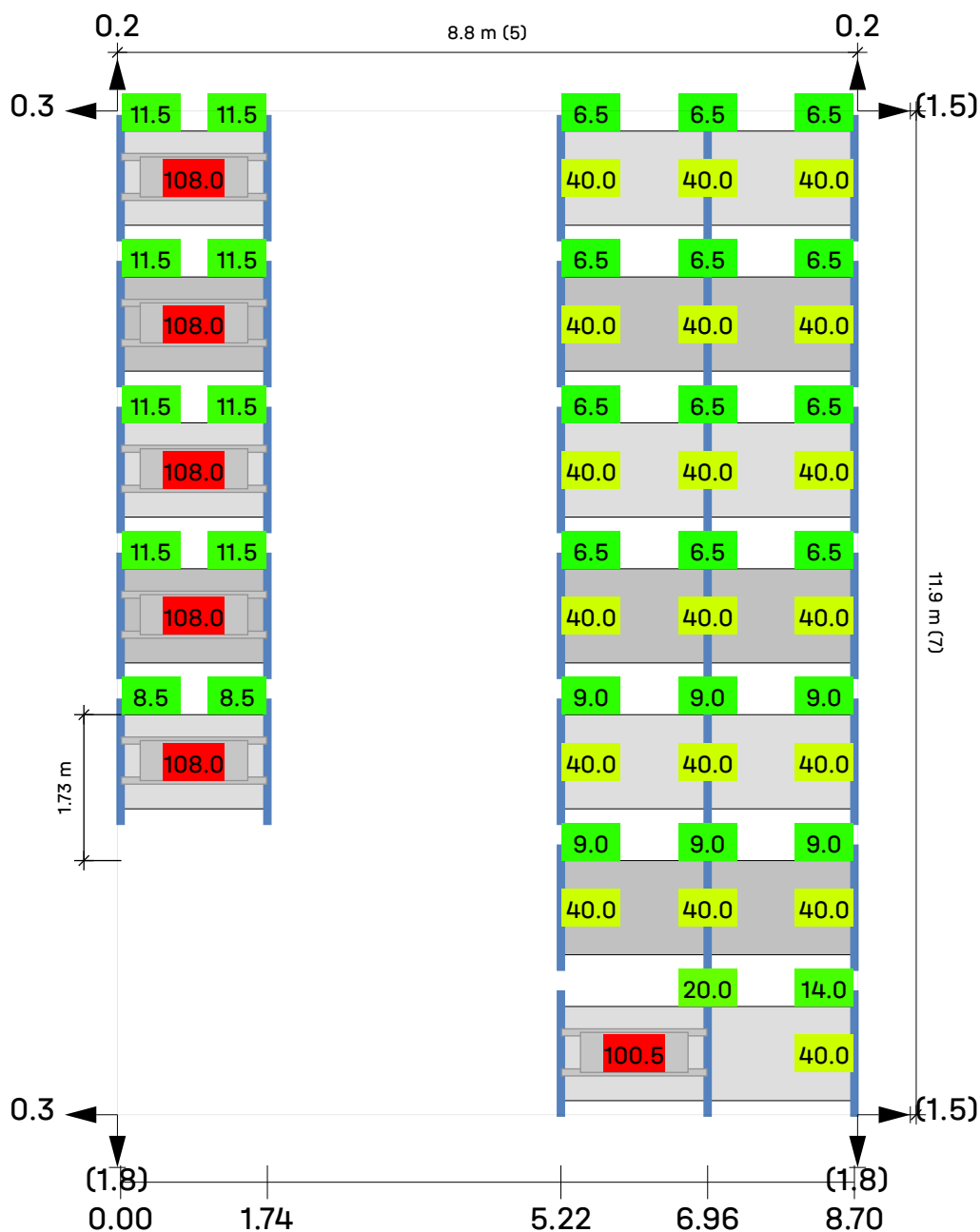
Modules $6 \times 2 = 12$

Legend

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



roof 4 | Module array 1 | Module block 7

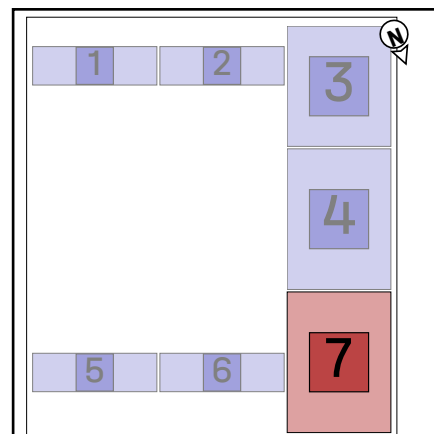


Roof ⑤ Module array ① Module block ⑦

Modules (5 × 7) - 16 = 19

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 4

Roof	System	Module	Height	Quantity	Total power
roof 4  Flat	S-Dome 6.10 Xpress	DAS-DH108NA-430 (SchwarzThru) 1,722×1,134×30 mm 430 Wp	15.00 m	102	43.86 kWp

Module

Name	DAS-DH108NA-430 (SchwarzThru)
Manufacturer	DAS Solar (Quzhou) Co., Ltd.
Output power	430 Wp
Dimensions	1,722×1,134×30 mm
Weight	20.5 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

pressure	41.17%
suction	116.80%

Loads on modules

Type	pressure	suction
ultimate limit state	2.20 kPa	-1.64 kPa
Serviceability	1.34 kPa	-0.96 kPa



Results | roof 4

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	12	1,007.5	1,325.50	34.19 m ²	0.38	
Block 2	12	883.0	1,201.00	34.19 m ²	0.34	
Block 3	17	2,026.0	2,476.50	51.50 m ²	0.47	
Block 4	18	2,748.0	3,225.00	53.52 m ²	0.59	
Block 5	12	1,119.0	1,437.00	34.19 m ²	0.41	
Block 6	12	943.5	1,261.50	34.19 m ²	0.36	
Block 7	19	1,675.5	2,179.00	57.65 m ²	0.37	
Total	102	10,402.5	13,105.50			0.10



Results | roof 4

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.
- Please note our General Terms and Conditions of Use (TCU-E) in their currently valid version, available at: <https://k2-systems.com/en/digital-services/general-terms-and-conditions-of-use-for-entrepreneurs-tcu-e/>

Please note in particular § 1, Special provisions for K2 Base, clause 3 ("Technical and specialist requirements on the Customer's premises."), § 6 ("Limitation of warranty") and § 7 ("Limitation of liability").

- One or more ballast values exceed the preset ballast capacities. Please ensure that the required ballast can be installed at the respective position.
- One or more components are overloaded. Please check and adjust the system utilisation and your input parameters.



Structural analysis report | roof 4

General information

Name	New project
Mounting System	S-Dome 6.10 Xpress
Author	james wynne

Location information

Address	Warrington Rd, Rainhill, UK
Ground elevation	64.60 m

Roof information

Building height	15.00 m
Roof type	Flat roof
Roof pitch	2°
Fastening method	with Ballast
Roof covering	Flat
Min. roof edge distance	1.00 m
Parapet wall height	0.50 m
Material	Concrete
Friction coefficient	1

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)	CC3
Design working life	25 years
Terrain category	Town Terrain
Distance to shoreline	17.00 km
Distance inside town terrain	1.00 km

Wind load

Velocity pressure, 50 years	$q_{p,50} = 0.957 \text{ kN/m}^2$
Adjustment factor for service life	$f_w = 0.921$
Velocity pressure, 25 years	$q_{p,25} = 0.882 \text{ kN/m}^2$



Structural analysis report | roof 4

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	$d_i = 0.999$
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	$s_{i,25} = 0.371 \text{ kN/m}^2$

Dead Load

Weight of module	$G_M = 20.5 \text{ kg}$
Weight of mounting system per module	$= 6.00 \text{ kg}$
Module area	$A_M = 1.95 \text{ m}^2$
Dead weight of module per m^2	$= 10.50 \text{ kg/m}^2$
Dead weight of mounting system per m^2	$= 3.07 \text{ kg/m}^2$
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	$\gamma_{G,sup} = 1.35$
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	$\kappa_{Fl,G} = 1.10$
Importance factor variable	$\kappa_{Fl,Q} = 1.10$
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	$LCC\ 06_{uls} = \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{Fl,Q} * W_{k,Suction}$

Structural analysis report | roof 4

Static equilibrium

Uplift Verification	$LCC_{up} = \gamma_{G, stb} * G_k + \gamma_Q * \kappa_{Fl, Q} * W_{k, n, Uplift}$
Displacement verification	$LCC_{displ} = \gamma_{G, stb} * G_k + \gamma_Q * \kappa_{Fl, Q} * W_{k, n, Displacement}$

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	$LCC_{01_sls} = G_k + S_{i, n}$
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	$LCC_{06_sls} = G_k + W_{k, Suction}$

Max. Pressure on insulation

General information

dead load system	$g_{System} = 0.13 \text{ kN/m}^2$
aerodynamic coefficient	$C_{p, Pressure} = 0.20$

Load distribution underneath the building protection mat under Peak

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 131.1 \text{ kg}$

Load distribution underneath the building protection mat under SD

Dimensions	$75.3 \times 380.0 \times 23.1 \text{ mm}$
	$A_{eff} = 28,614.00 \text{ mm}^2$
	$A_{load \text{ range area}} = 0.98 \text{ m}^2$
maximum ballast	$G_{ballast \text{ required}} = 36.7 \text{ kg}$

Load Combinations

	$\sigma_{Ek, heat \text{ insulation, Peak}} [\text{Pa}]$	$\sigma_{Ek, heat \text{ insulation, SD}} [\text{Pa}]$
Load case combination 00	49,486	17,126
Load case combination 01	61,973	29,613

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Actions from dead loads (PV system + ballast)

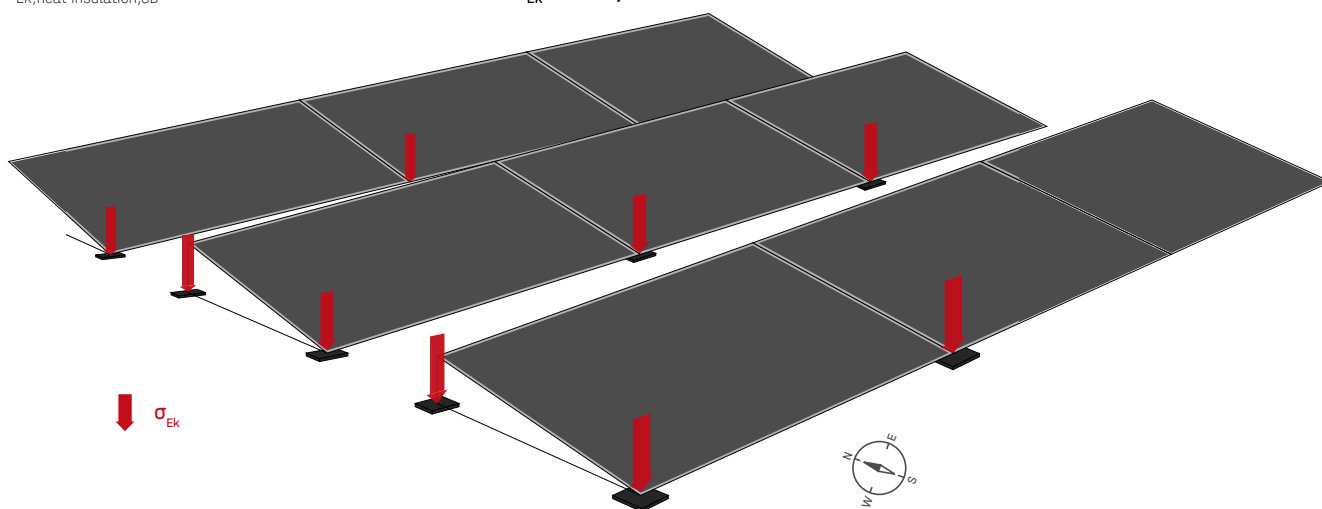
$$\sigma_{\text{Ek,heat insulation,Peak}} = 49,486 \text{ Pa}$$

$$\sigma_{\text{Ek,heat insulation,SD}} = 17,126 \text{ Pa}$$

Maximum actions (PV system + ballast + snow)

$$\sigma_{\text{Ek,heat insulation,Peak}} = \max \sigma_{\text{Ek}} = 61,973 \text{ Pa}$$

$$\sigma_{\text{Ek,heat insulation,SD}} = \max \sigma_{\text{Ek}} = 29,613 \text{ Pa}$$



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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



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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}	-0.768		-0.782	-0.159
c_{pD}	0.768		0.720	0.156
k_a	1.04		1.00	1.04
k_d	0.90		0.90	0.90

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k_A	1.00	1.00	1.00	1.00
k_C	1.05	1.05	1.05	1.05
k_p	1.01	1.01	1.06	1.06
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]	1.95	1.95	1.95	1.95
A_D [m ²]	0.21	0.21	0.21	0.21
delta [°]	80.0	80.0	80.0	80.0
alpha [°]	10.0	10.0	10.0	10.0
qp [kN/m ²]	0.88	0.88	0.88	0.88
μ	1.0	-	1.0	-
Fx [kN]	0.372	-	0.076	-
Fz [kN]	1.278	1.303	0.264	0.265
$m_{ballast}$ [kg]	298.7	222.4	43.7	26.7
m_{DL} [kg]	26.5	26.5	26.5	26.5

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H-V-loads

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

General information

Total number of modules	102	
Roof areas covered with modules	A	= ca. 299.46 m ²
Dead Load	$g_{k, \text{System incl. ballast}}$	= 0.43 kN/m ²

Aerodynamic coefficients

	$C_{p, \text{Pressure}}$	= according to EN 1991-1-4
	$C_{F, x, \text{average}}$	= 0.01
	$C_{F, y, \text{averaged}}$	= -0.05
edge distance correction	$k_{s, xy}$	= 1.00
Parapet wall- correction coefficient	k_p	= 1.02
Factor building height		= 1.00

Horizontal pressure

$$W_{k, F, x} = 0.008 \text{ kN/m}^2$$

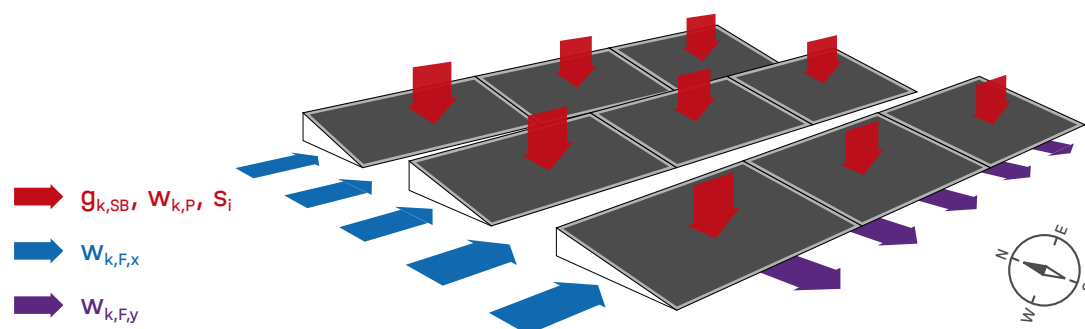
$$W_{k, F, y} = -0.041 \text{ kN/m}^2$$

Vertical pressure

$$g_{k, \text{System incl. ballast}} = 0.43 \text{ kN/m}^2$$

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

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



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 4 | Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003621	S-Dome 6.10 Base Set	145	279.4 kg
2	2004125	Dome 6.10 Peak	145	43.5 kg
3	2004178	Dome 6 Connector 495mm Set	97	40.1 kg
4	2003249	S-Dome 6.10 Windbreaker short	102	183.6 kg
5	2002937	Thread-forming metal screw 6×25	290	2.0 kg
6	2002870	K2 Solar Cable Manager	102	0.3 kg
7	2002609	DomeClamp Black MC Set 30-50	118	6.8 kg
8	2002610	DomeClamp Black EC Set 30-50	172	11.4 kg
9	2003150	Dome Porter short	150	221.7 kg
10	1001643	MK2	300	5.3 kg
11	2001729	Socket Head Bolt serrated M8×20	300	3.9 kg
12	2002300	Dome SpeedPorter	258	19.6 kg
Total				817.6 kg



Bill of material

Position	Item no.	Item description	Quantity	Weight
1	2003621	S-Dome 6.10 Base Set	385	741.9 kg
2	2004125	Dome 6.10 Peak	626	187.8 kg
3	2004178	Dome 6 Connector 495mm Set	344	142.1 kg
4	2003249	S-Dome 6.10 Windbreaker short	411	739.8 kg
5	2002937	Thread-forming metal screw 6×25	996	6.9 kg
6	2002870	K2 Solar Cable Manager	523	1.5 kg
7	2002609	DomeClamp Black MC Set 30-50	840	48.7 kg
8	2002610	DomeClamp Black EC Set 30-50	412	27.2 kg
9	2003150	Dome Porter short	214	316.3 kg
10	1001643	MK2	428	7.5 kg
11	2001729	Socket Head Bolt serrated M8×20	428	5.6 kg
12	2002300	Dome SpeedPorter	1,332	101.2 kg
13	2003620	D-Dome 6.10 Base Set	64	201.1 kg
14	2004123	Dome 6 Connector 195 Set	32	6.9 kg
15	2004096	S-Dome 6.10 Base Set L	113	212.4 kg
Total				2,746.9 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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