| Connecting Strength

ecoyield™

K2 Base Report

# Leeds, AI Compute + Solar

| | |
|---|---|
| Customer | EcoYield |
| Project address | Stanningley, Pudsey LS28 6QA, UK |
| Planned date of installation | 10/08/2025 |
| Company | JLM Energy |
| Address | Victoria Road Salts Mill, BD18 3LA, Saltaire |
| Tel. | +447876808289 |
| Website | https://www.jlmenergy.co.uk/ |
| E-Mail | info@jlmenergy.co.uk |
| Planner | Kye Barwell |
| Issue date | 08/11/2025 |
| Version | K2 Base Version 3.2.49.0 |

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# Contents

# About us

## K2 Systems. Innovative mounting system from a strong team.

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

### A knowledgeable and friendly team

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

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

### 10 locations and worldwide sales network

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

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

### Quality management and certificates

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

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


### Product guarantee

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

### In a nutshell

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

The static report is not including module and building verification.

# Project overview

## Roofs

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 1<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 45 | 20.25 kWp |
| Area 2<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 45 | 20.25 kWp |
| Area 3<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 55 | 24.75 kWp |
| Area 4<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 55 | 24.75 kWp |
| Area 5<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 28 | 12.6 kWp |
| Area 6<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 28 | 12.6 kWp |
| Area 7<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 30 | 13.5 kWp |
| Area 8<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |
| Area 9<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |
| Area 10<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |
| **Total** | | | | **334** | **150.30 kWp** |

## Project information

| | |
|---|---|
| Address | **Stanningley, Pudsey LS28 6QA, UK** |
| Planned date of installation | **10/08/2025** |
| Customer | **EcoYield** |
| Author | **Kye Barwell** |

# Project overview

## Load settings

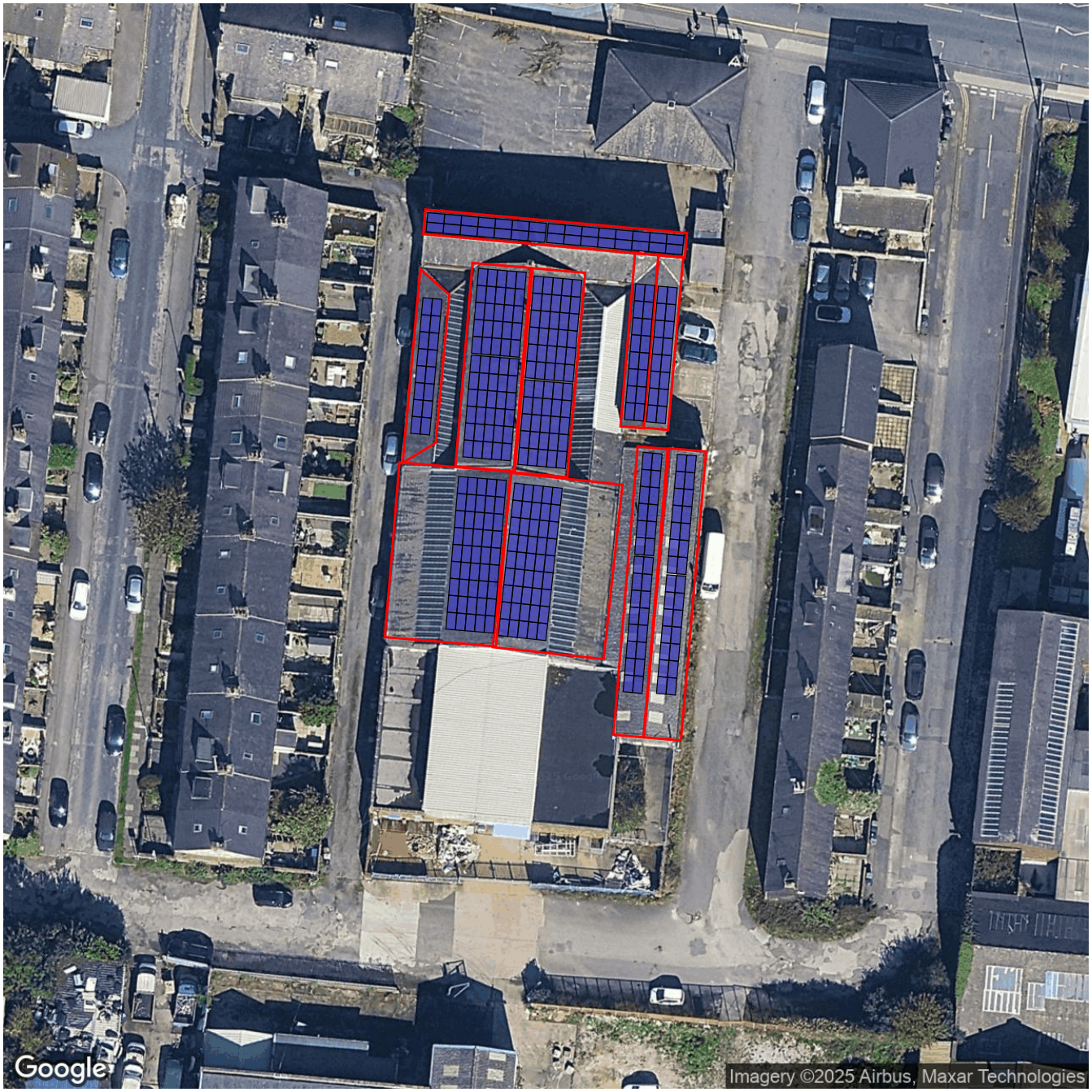
| | |
|---|---|
| Design method | **BS EN** |
| Failure consequence class | **CC2** |
| Design working life | **25 years** |
| Terrain category | **Town terrain** |
| Wind speed | **23.0 m/s** |
| Distance to shoreline | **65.70 km** |
| Distance inside town terrain | **0.14 km** |
| Snow load zone | **4** |
| Snow load on ground level | **0.68 kN/m²** |

## Material values

**For material information refer to the product catalogue:**
K2 Catalogue (k2-systems.com)

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

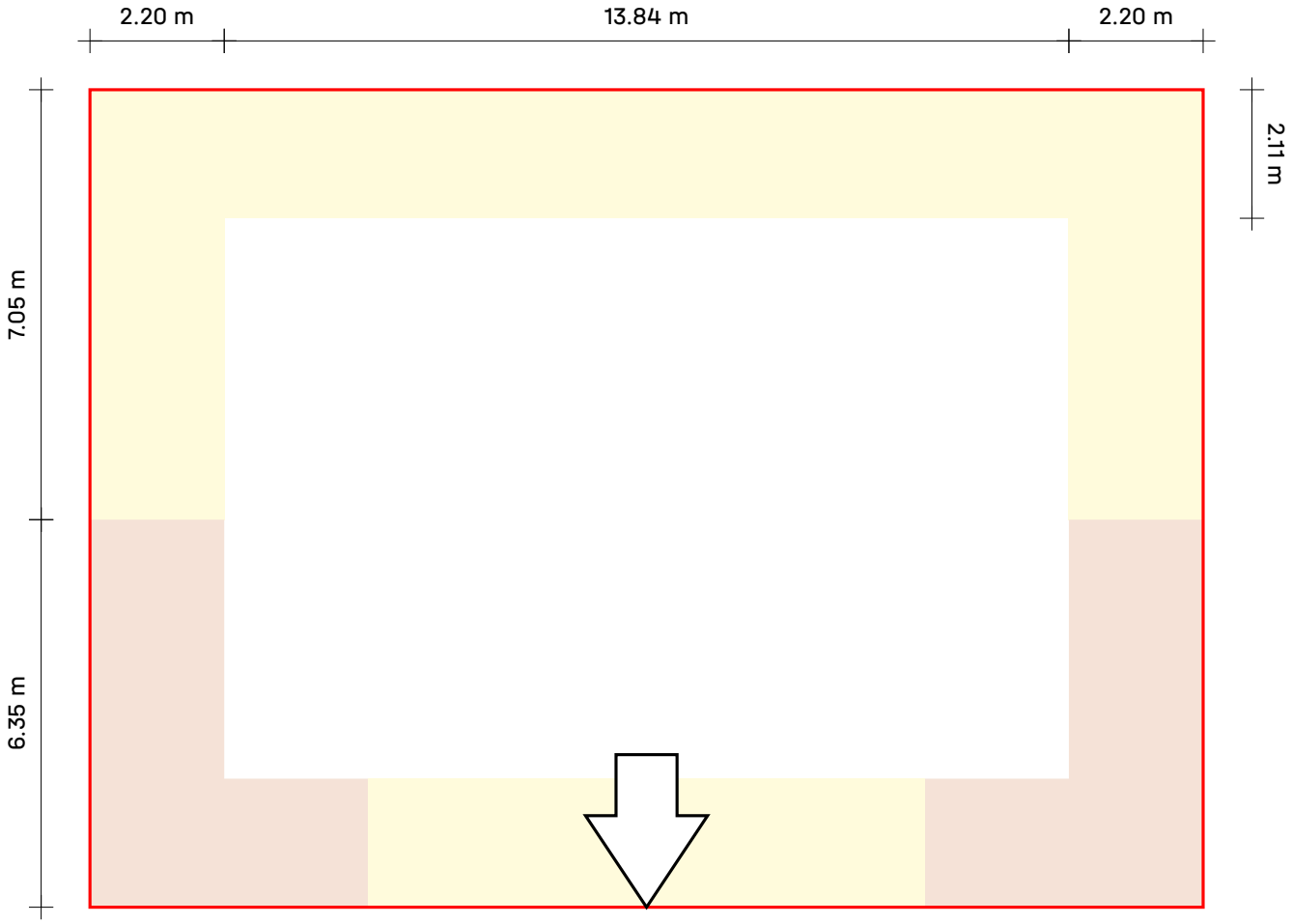
# EcoYield Pilot Project



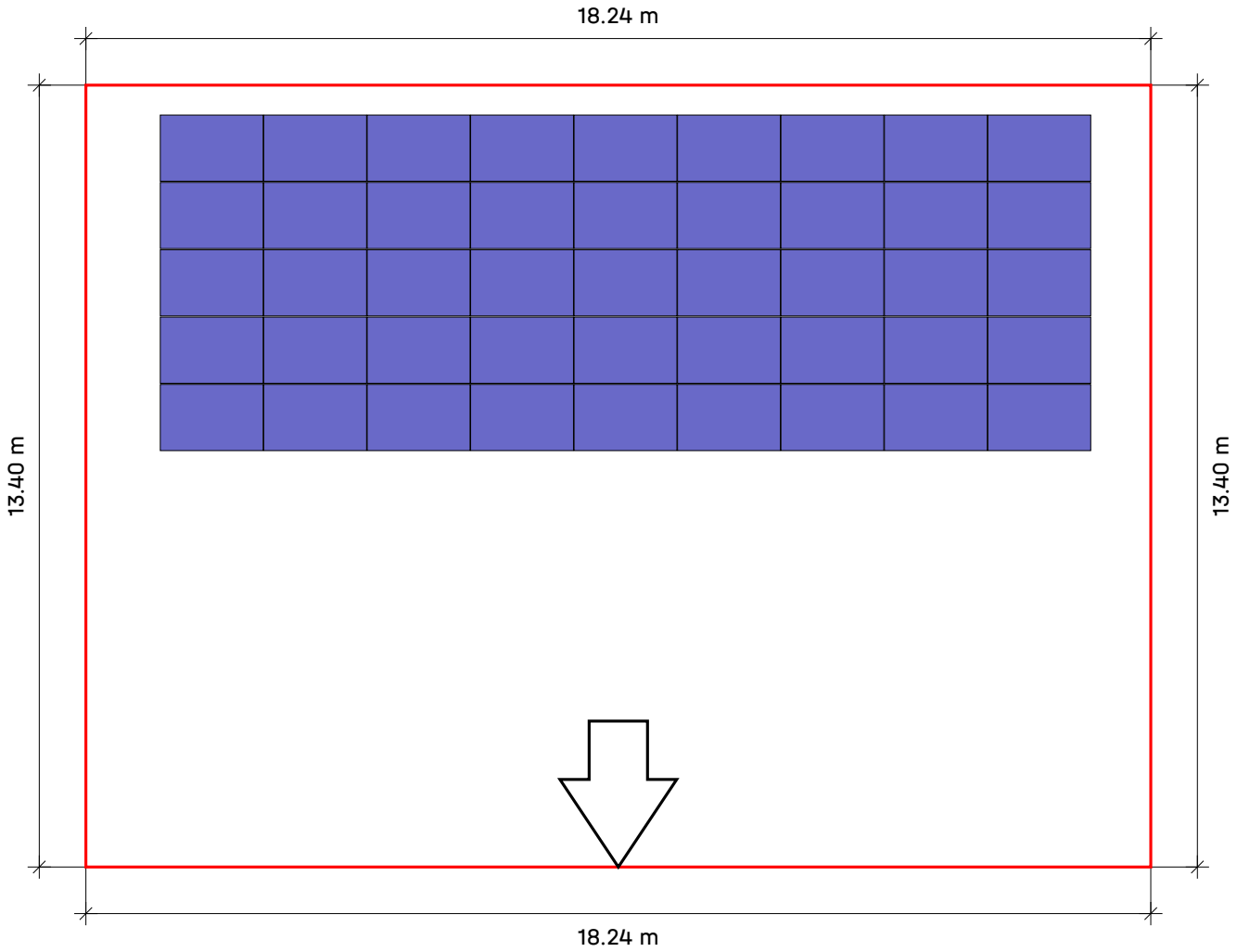

## Project information

| | |
|---|---|
| Address | **Stanningley, Pudsey LS28 6QA, UK** |
| Planned date of installation | **10/08/2025** |
| Customer | **EcoYield** |
| Author | **Kye Barwell** |

# Area 1



# Area 1




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 1<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 45 | 20.25 kWp |

# Area 1 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 2*A | 15.388 m | 4*3.65 m | 3.650 | 0.788 from 3.650 | 2.852 |
| 1*B | 15.388 m | 4*3.65 m | 2.852 | 0.788 from 2.852 | 2.054 |
| 1*C | 15.388 m | 4*3.65 m | 2.054 | 0.788 from 2.054 | 1.256 |
| 1*D | 15.388 m | 4*3.65 m | 1.256 | 0.788 from 1.256 | 0.458 |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 18*A | 5.850 m | 1*3.65 m | 3.650 | 2.200 from 3.650 | 1.440 |

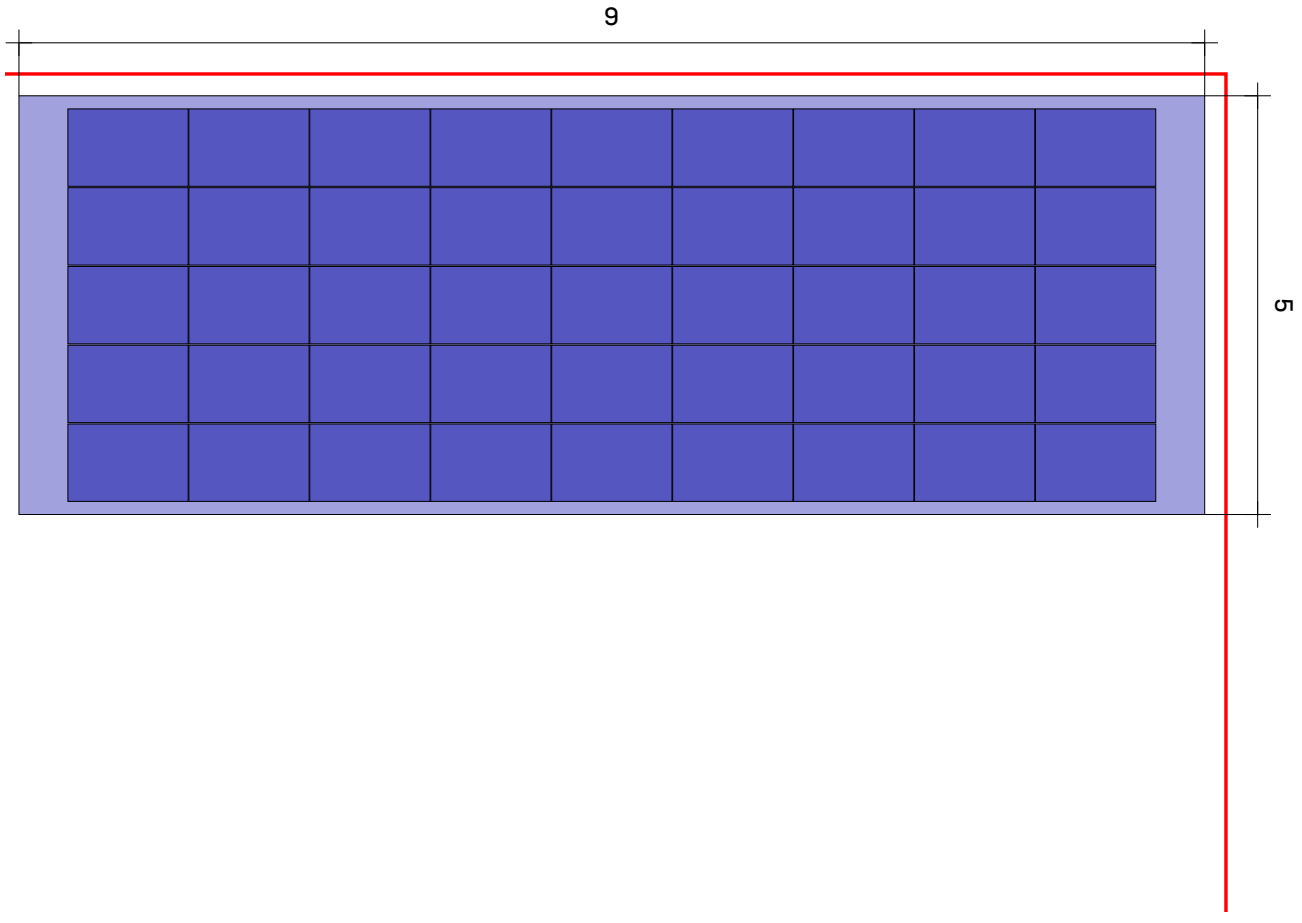
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| 1 | field area | 0.30 m | 0.300 | 0.393 |
| 1 | ridge | 0.30 m | 0.300 | 0.393 |
| 1 | gableboard | 0.30 m | 0.300 | 0.393 |

## Module arrays

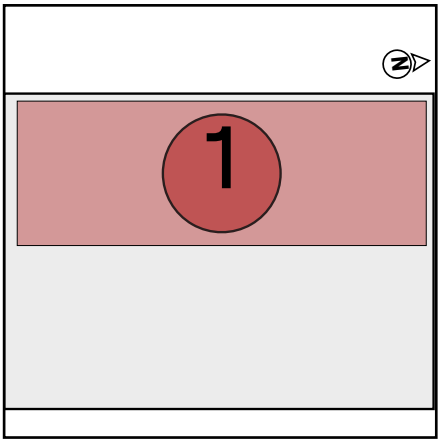
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| 1 | 15.94 | 5.75 | 9 | 5 |

# Area 1 | Module array 1

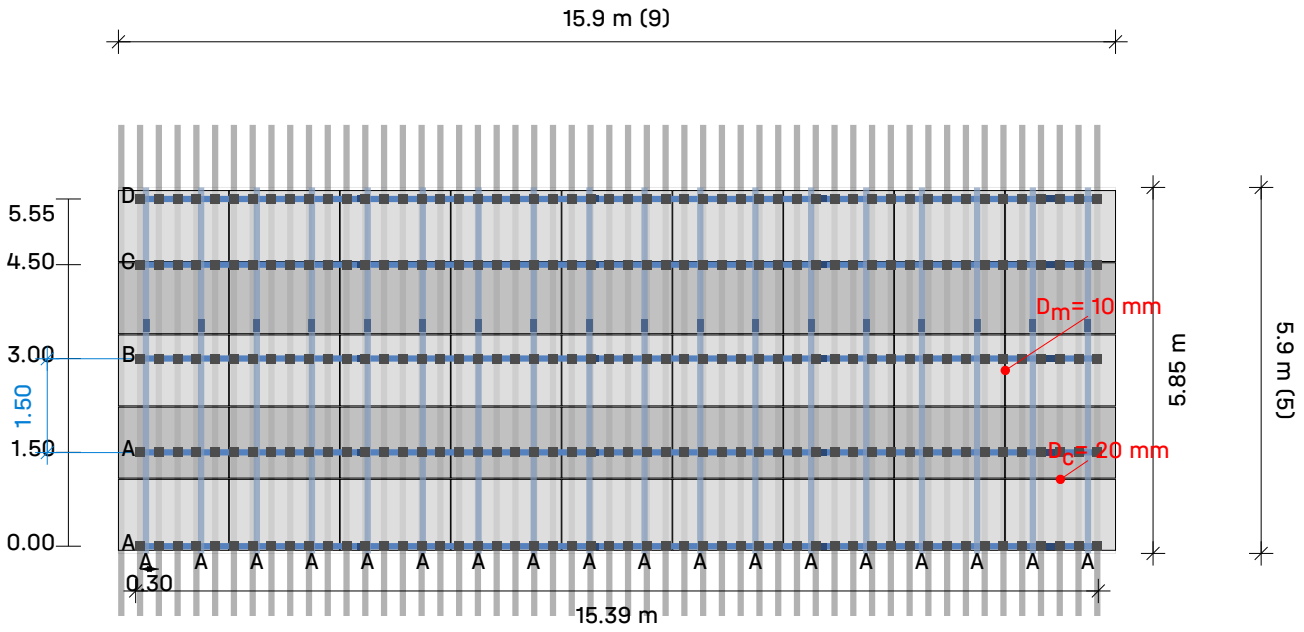



## Roof (1) Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 45(20.25 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 1 | Module array 1 | Module block 1

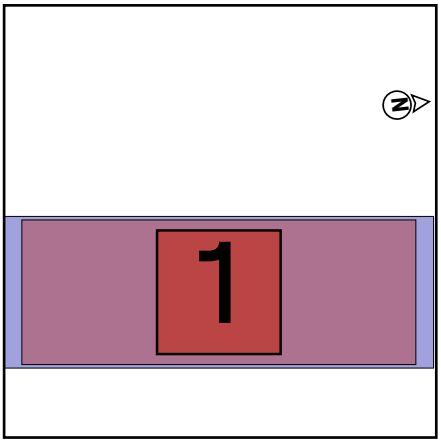



Roof (1) Module array 1 Module block 1

Modules 9 × 5 = **45**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Results | Area 1

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 1<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 45 | 20.25 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,345.1 | 582.0 | -727.5 | 66.5 | 908.3 | 394.7 | -446.6 | 66.5 |
| 1 | ridge | 2.00 | 1,345.1 | 582.0 | -1,148.8 | 66.5 | 908.3 | 394.7 | -727.5 | 66.5 |
| 1 | gableboard | 2.00 | 1,345.1 | 582.0 | -1,429.7 | 66.5 | 908.3 | 394.7 | -914.8 | 66.5 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 2.4 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |

# Results | Area 1

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 70.0 | 2.1 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 5.4 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 5.5 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 1

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 1

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 11.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 120.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 120.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 1.017 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.936 kN/m² |

# Structural analysis report | Area 1

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.375 | -0.562 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.375 | -0.843 |
| 1 | gableboard | 10.00 | 0.400 | -1.100 | 0.375 | -1.030 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 1

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $= \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,Suction}$ |

### Usability

| | |
|---|---|
| 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 [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.345 | 0.582 | -0.727 | 0.067 | 0.908 | 0.395 | -0.447 | 0.067 |
| 1 | ridge | 10.00 | 1.345 | 0.582 | -1.149 | 0.067 | 0.908 | 0.395 | -0.727 | 0.067 |
| 1 | gableboard | 10.00 | 1.345 | 0.582 | -1.430 | 0.067 | 0.908 | 0.395 | -0.915 | 0.067 |

# Structural analysis report | Area 1

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.636 | 0.275 | -0.344 | 0.031 | 0.429 | 0.186 | -0.211 | 0.031 |
| 1 | ridge | 10.00 | 0.636 | 0.275 | -0.543 | 0.031 | 0.429 | 0.186 | -0.344 | 0.031 |
| 1 | gableboard | 10.00 | 0.636 | 0.275 | -0.676 | 0.031 | 0.429 | 0.186 | -0.432 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 2.4 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |

# Structural analysis report | Area 1

## Upper Rail - Utilization result

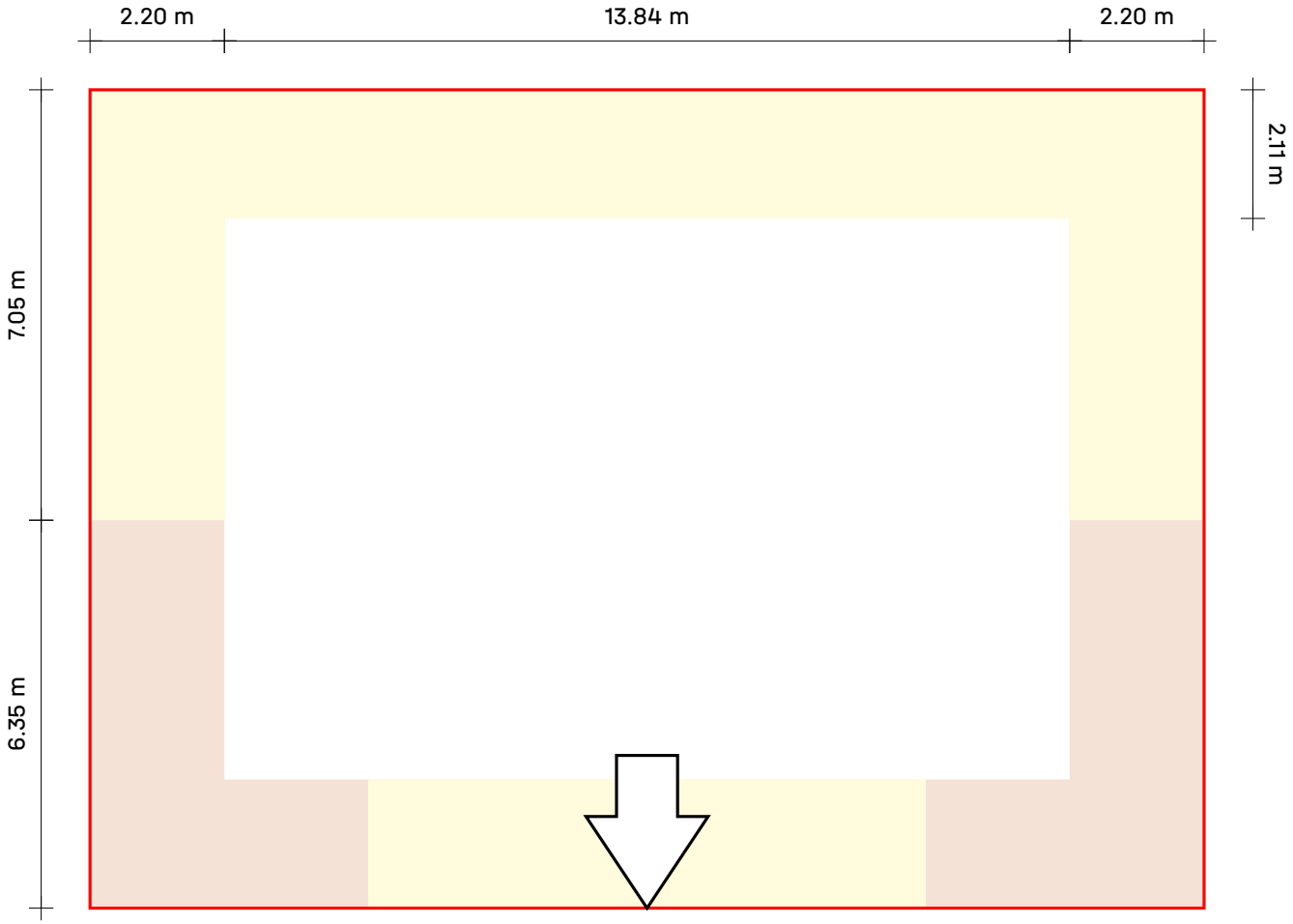
| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 70.0 | 2.1 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 5.4 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 5.5 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

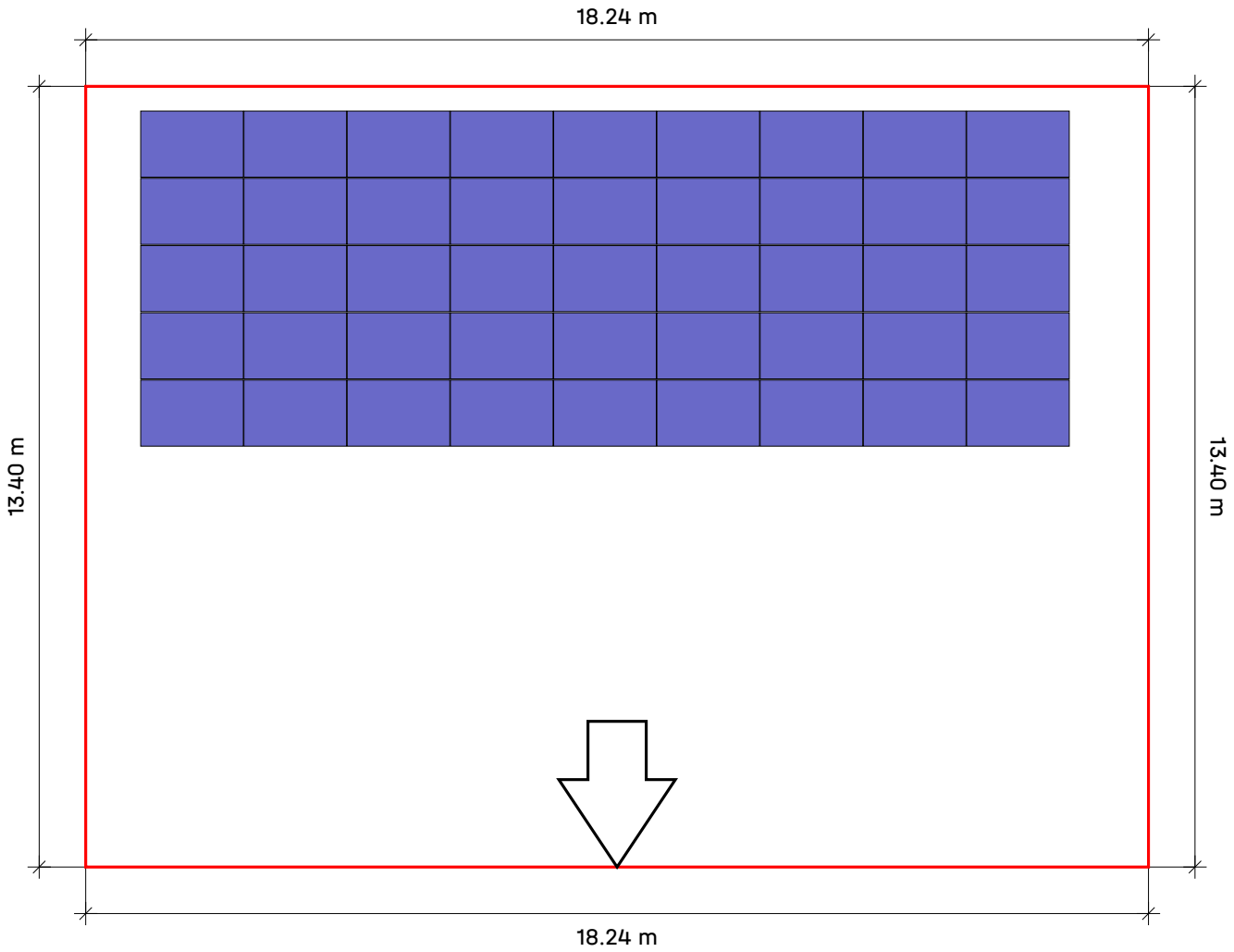
# Area 1 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 520 | 14.0 kg |
| 2 | 2004244 | SolidHook Vario 2 | 260 | 215.0 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 260 | 6.1 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 260 | 2.9 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 36 | 0.3 kg |
| 6 | 2003523 | BlackCover SingleRail 36 | 36 | 0.9 kg |
| 7 | 2002870 | K2 Solar Cable Manager | 45 | 0.1 kg |
| 8 | 2004264 | SolidRail UltraLight; 3.65 m | 22 | 56.5 kg |
| 9 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 20 | 4.5 kg |
| 10 | 2003145 | SingleRail Climber Set 36/50 | 90 | 6.0 kg |
| 11 | 2003072 | OneMid Black Set 30-42 | 72 | 5.7 kg |
| 12 | 2004545 | K2 Clamp EC 25-40 Black | 36 | 2.6 kg |
| 13 | 2004258 | SingleRail 36; 3.65 m | 36 | 101.2 kg |
| 14 | 2001976 | SingleRail 36 RailConnector Set | 18 | 6.8 kg |
| **Total** | | | | **422.5 kg** |

# Area 2



# Area 2




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 2<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 45 | 20.25 kWp |

# Area 2 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 2*A | 15.388 m | 4*3.65 m | 3.650 | 0.788 from 3.650 | 2.852 |
| 1*B | 15.388 m | 4*3.65 m | 2.852 | 0.788 from 2.852 | 2.054 |
| 1*C | 15.388 m | 4*3.65 m | 2.054 | 0.788 from 2.054 | 1.256 |
| 1*D | 15.388 m | 4*3.65 m | 1.256 | 0.788 from 1.256 | 0.458 |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 18*A | 5.850 m | 1*3.65 m | 3.650 | 2.200 from 3.650 | 1.440 |

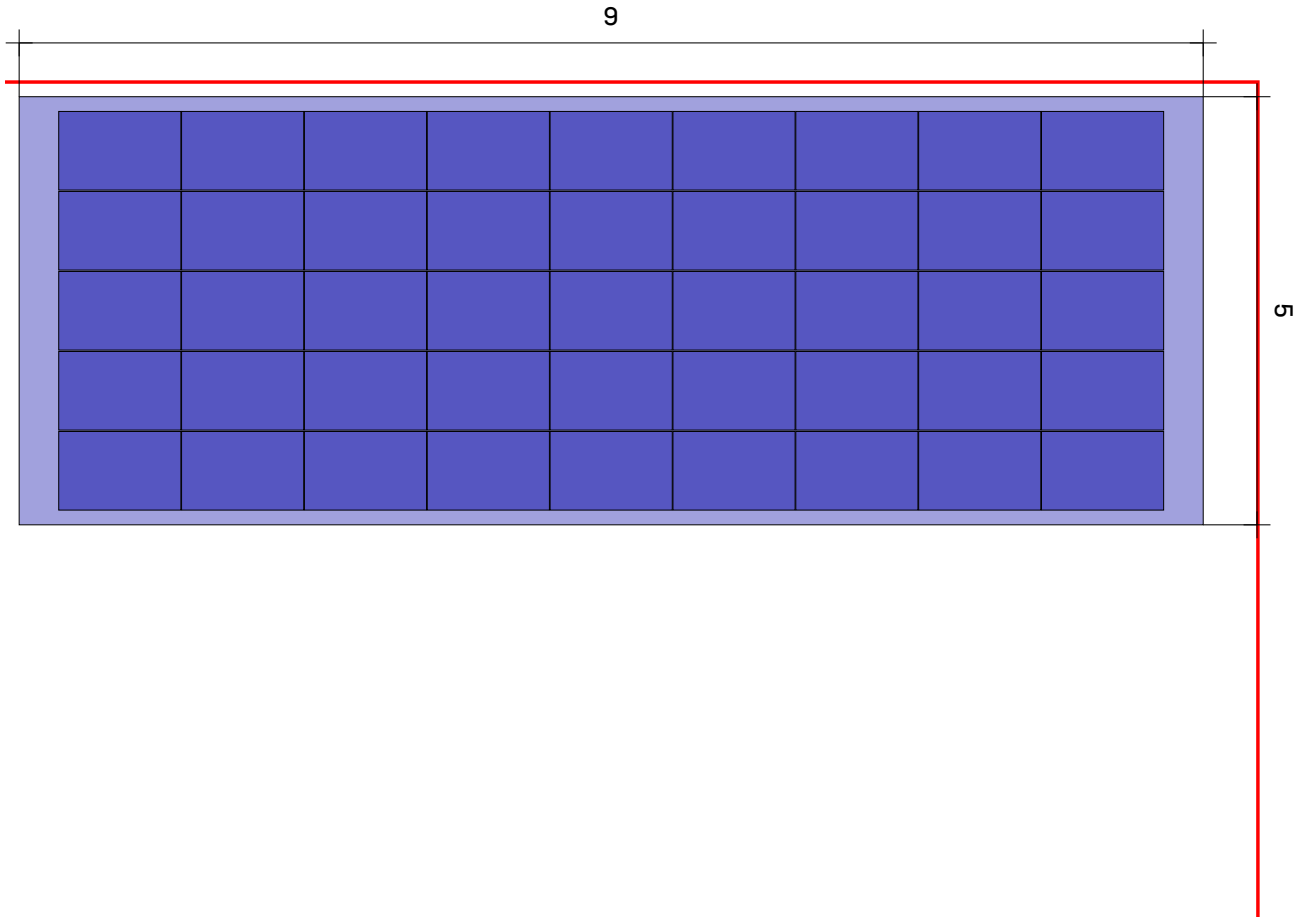
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| 1 | field area | 0.30 m | 0.300 | 0.393 |
| 1 | ridge | 0.30 m | 0.300 | 0.393 |
| 1 | gableboard | 0.30 m | 0.300 | 0.393 |

## Module arrays

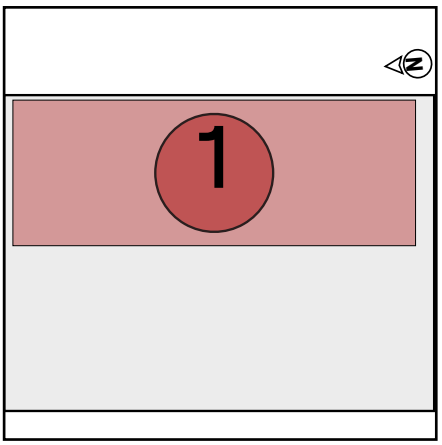
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| 1 | 15.94 | 5.75 | 9 | 5 |

# Area 2 | Module array 1

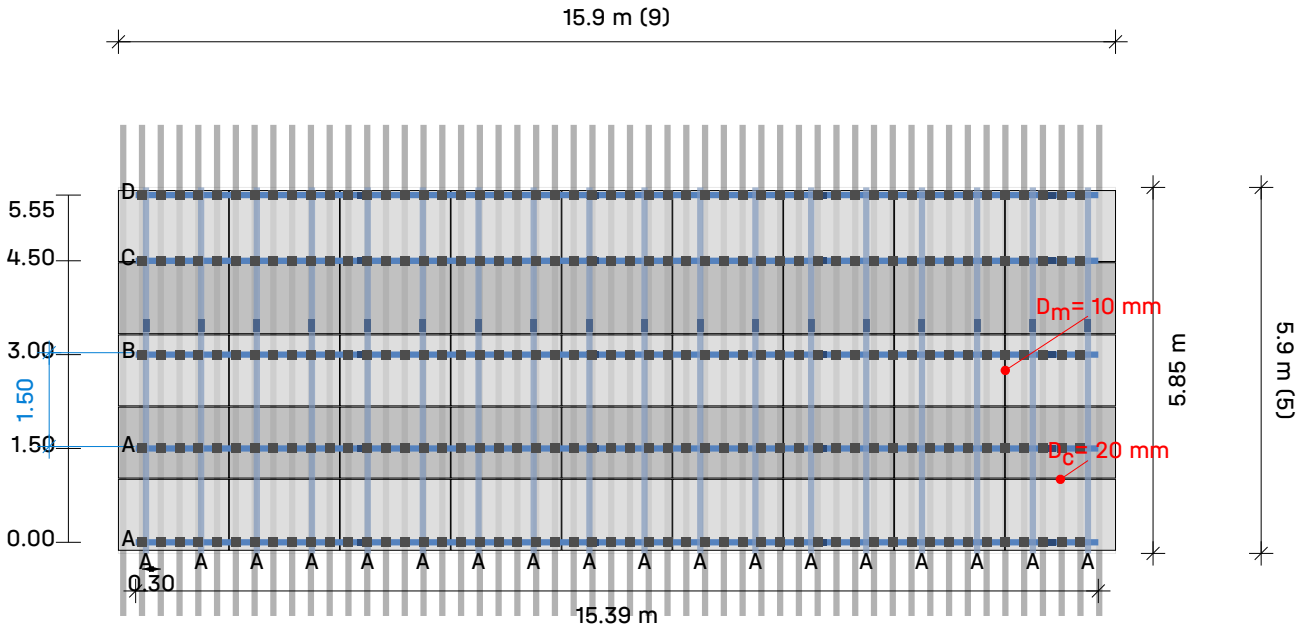



## Roof (2) Module array (1)

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 45(20.25 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 2 | Module array 1 | Module block 1

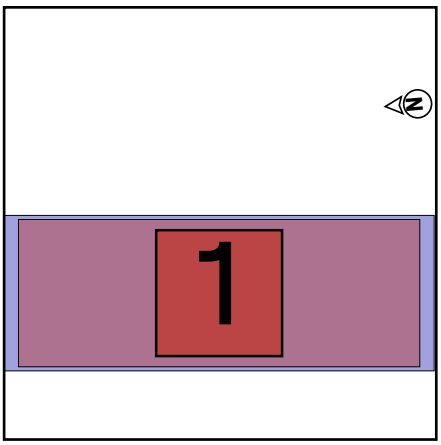



Roof (2) Module array (1) Module block 1

Modules 9 × 5 = **45**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Results | Area 2

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 2<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 45 | 20.25 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,345.1 | 582.0 | -727.5 | 66.5 | 908.3 | 394.7 | -446.6 | 66.5 |
| 1 | ridge | 2.00 | 1,345.1 | 582.0 | -1,148.8 | 66.5 | 908.3 | 394.7 | -727.5 | 66.5 |
| 1 | gableboard | 2.00 | 1,345.1 | 582.0 | -1,429.7 | 66.5 | 908.3 | 394.7 | -914.8 | 66.5 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 39.2 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |

# Results | Area 2

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 70.0 | 5.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 2.4 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 5.1 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 2

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 2

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 11.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 120.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 120.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 1.017 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.936 kN/m² |

# Structural analysis report | Area 2

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.375 | -0.562 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.375 | -0.843 |
| 1 | gableboard | 10.00 | 0.400 | -1.100 | 0.375 | -1.030 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 2

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $= \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,Suction}$ |

### Usability

| | |
|---|---|
| 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 [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.345 | 0.582 | -0.727 | 0.067 | 0.908 | 0.395 | -0.447 | 0.067 |
| 1 | ridge | 10.00 | 1.345 | 0.582 | -1.149 | 0.067 | 0.908 | 0.395 | -0.727 | 0.067 |
| 1 | gableboard | 10.00 | 1.345 | 0.582 | -1.430 | 0.067 | 0.908 | 0.395 | -0.915 | 0.067 |

# Structural analysis report | Area 2

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.636 | 0.275 | -0.344 | 0.031 | 0.429 | 0.186 | -0.211 | 0.031 |
| 1 | ridge | 10.00 | 0.636 | 0.275 | -0.543 | 0.031 | 0.429 | 0.186 | -0.344 | 0.031 |
| 1 | gableboard | 10.00 | 0.636 | 0.275 | -0.676 | 0.031 | 0.429 | 0.186 | -0.432 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 39.2 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |

# Structural analysis report | Area 2

## Upper Rail - Utilization result

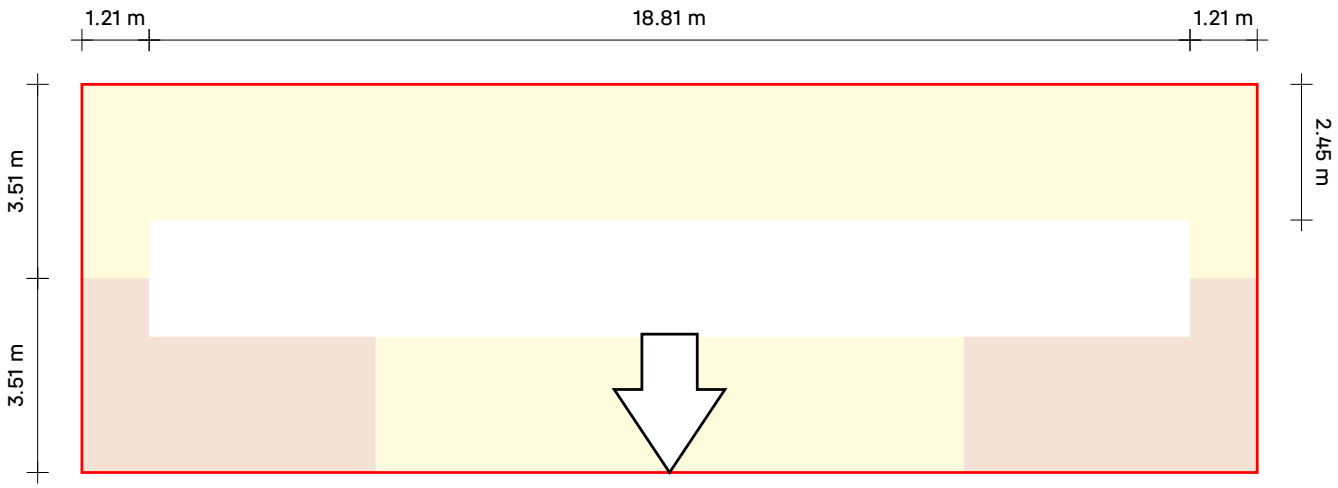
| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 70.0 | 5.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 2.4 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 5.1 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

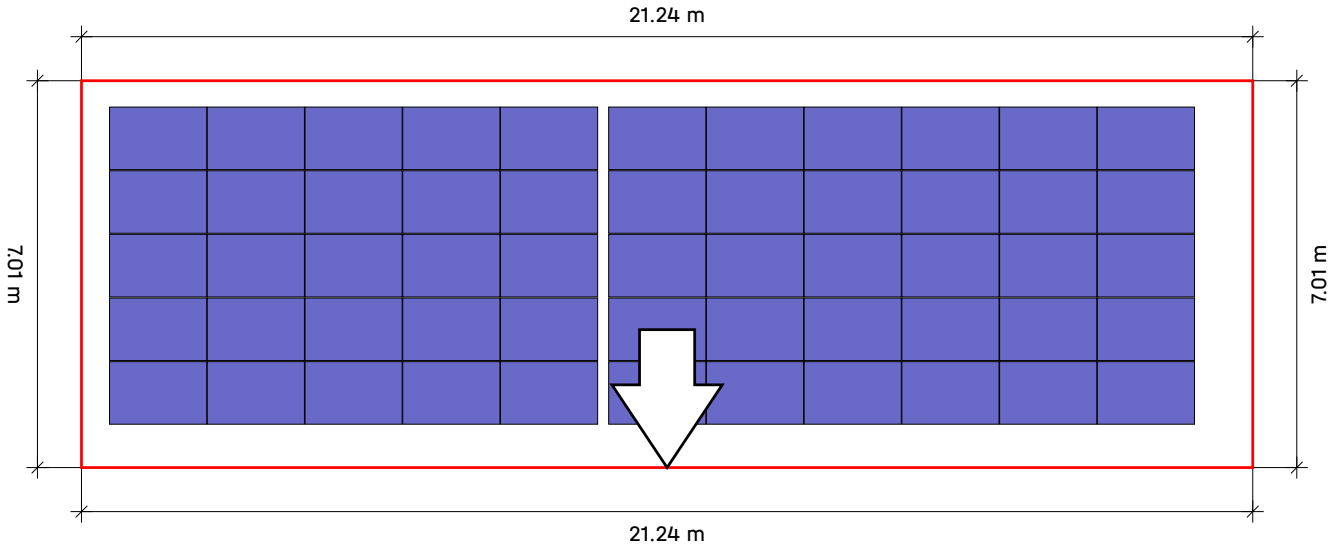
# Area 2 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 510 | 13.8 kg |
| 2 | 2004244 | SolidHook Vario 2 | 255 | 210.9 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 255 | 6.0 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 255 | 2.8 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 36 | 0.3 kg |
| 6 | 2003523 | BlackCover SingleRail 36 | 36 | 0.9 kg |
| 7 | 2002870 | K2 Solar Cable Manager | 45 | 0.1 kg |
| 8 | 2004264 | SolidRail UltraLight; 3.65 m | 22 | 56.5 kg |
| 9 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 20 | 4.5 kg |
| 10 | 2003145 | SingleRail Climber Set 36/50 | 90 | 6.0 kg |
| 11 | 2003072 | OneMid Black Set 30-42 | 72 | 5.7 kg |
| 12 | 2004545 | K2 Clamp EC 25-40 Black | 36 | 2.6 kg |
| 13 | 2004258 | SingleRail 36; 3.65 m | 36 | 101.2 kg |
| 14 | 2001976 | SingleRail 36 RailConnector Set | 18 | 6.8 kg |
| **Total** | | | | **418.0 kg** |

# Area 3



# Area 3




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 3<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 55 | 24.75 kWp |

# Area 3 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 5*A | 10.072 m | 2*3.65 m | 3.650 | 2.772 from 3.650 | 0.868 |
| 2*B | 8.300 m | 2*3.65 m | 3.650 | 1.000 from 3.650 | 2.640 |
| 2*C | 8.300 m | 2*3.65 m | 2.640 | 1.000 from 2.640 | 1.630 |
| 1*D | 8.300 m | 2*3.65 m | 1.630 | 1.000 from 1.630 | 0.620 |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 22*A | 5.850 m | 1*3.65 m | 3.650 | 2.200 from 3.650 | 1.440 |

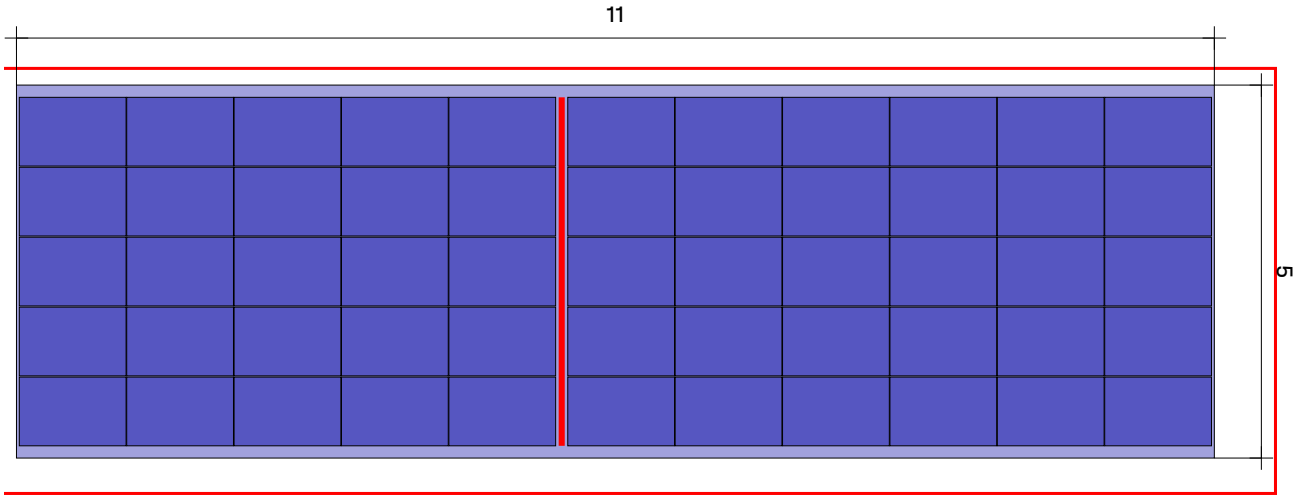
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| 1 | field area | 0.30 m | 0.300 | 0.393 |
| 1 | ridge | 0.30 m | 0.300 | 0.393 |
| 1 | gableboard | 0.30 m | 0.300 | 0.393 |
| 1 | corner region (eave) | 0.30 m | 0.300 | 0.326 |
| 1 | eaves | 0.30 m | 0.300 | 0.374 |

## Module arrays

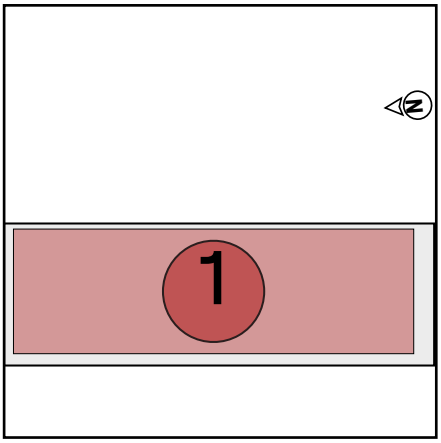
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| 1 | 19.67 | 5.75 | 11 | 5 |

# Area 3 | Module array 1

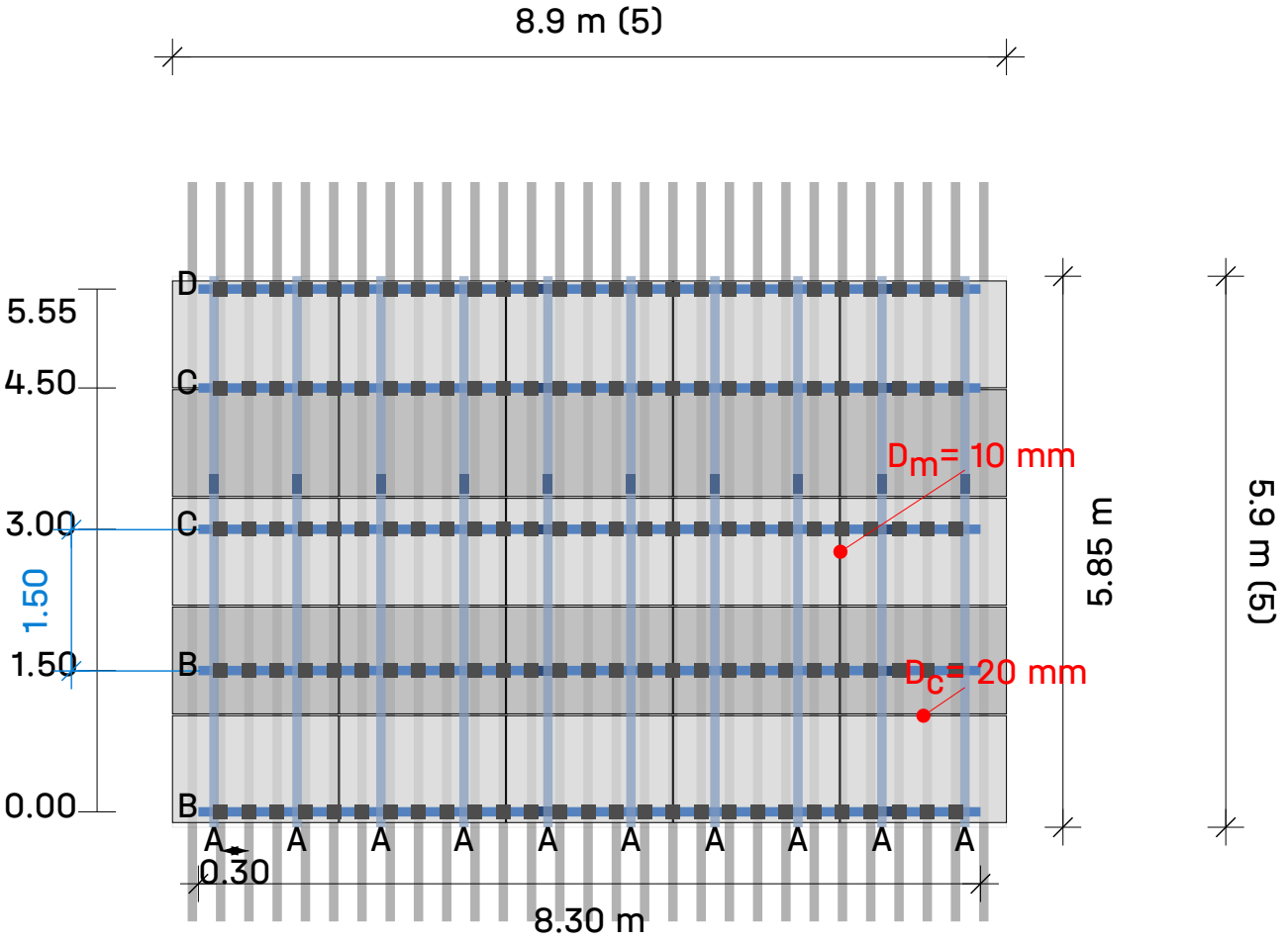



## Roof (3) Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 55(24.75 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 3 | Module array 1 | Module block 1

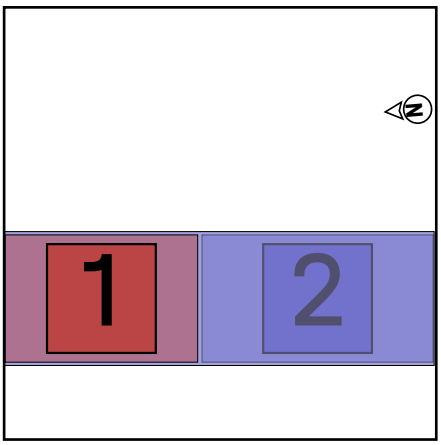



Roof (3) Module array (1) Module block 1

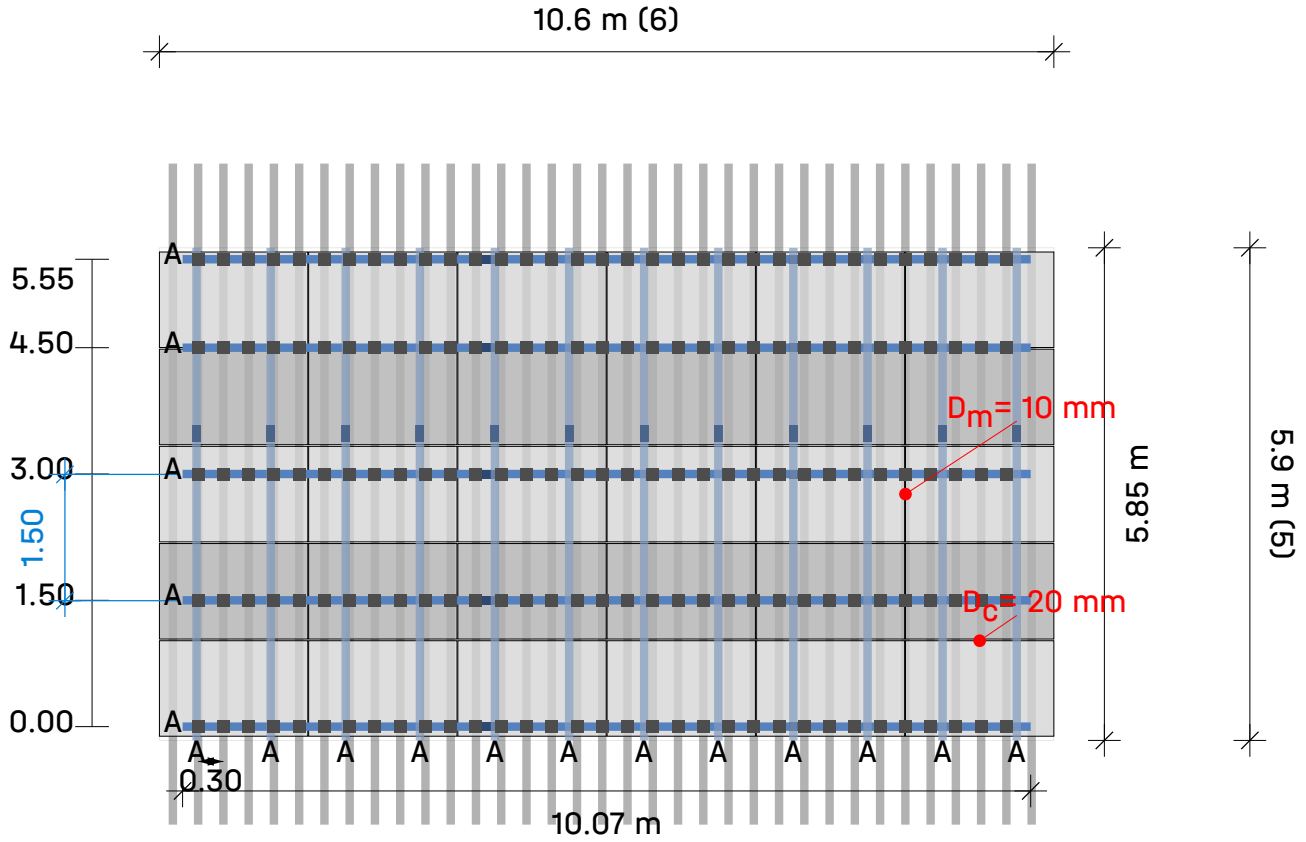
Modules 5 × 5 = **25**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- $D_c$ Distance for clamping between modules
- $D_m$ Distance between modules



# Area 3 | Module array 1 | Module block 2

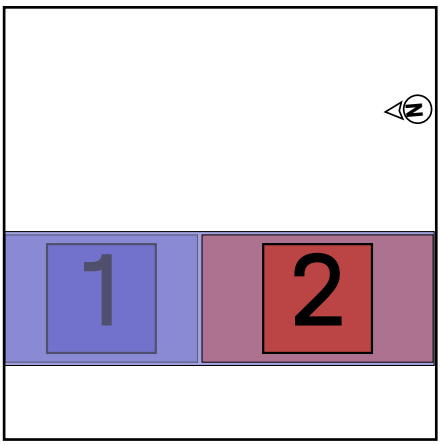



Roof (3) Module array (1) Module block 2

Modules 6 × 5 = **30**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- $D_c$ Distance for clamping between modules
- $D_m$ Distance between modules



# Results | Area 3

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 3<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 55 | 24.75 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,345.1 | 582.0 | -727.5 | 66.5 | 908.3 | 394.7 | -446.6 | 66.5 |
| 1 | ridge | 2.00 | 1,345.1 | 582.0 | -1,148.8 | 66.5 | 908.3 | 394.7 | -727.5 | 66.5 |
| 1 | gableboard | 2.00 | 1,345.1 | 582.0 | -1,429.7 | 66.5 | 908.3 | 394.7 | -914.8 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,705.4 | 582.0 | -1,570.2 | 66.5 | 1,148.4 | 394.7 | -1,008.4 | 66.5 |
| 1 | eaves | 2.00 | 1,429.4 | 582.0 | -727.5 | 66.5 | 964.5 | 394.7 | -446.6 | 66.5 |

# Results | Area 3

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 40.1 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 26.9 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 48.8 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 35.5 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 3.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 3.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 5.3 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 4.5 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 3

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 3

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 11.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 120.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 120.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 1.017 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.936 kN/m² |

# Structural analysis report | Area 3

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.375 | -0.562 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.375 | -0.843 |
| 1 | gableboard | 10.00 | 0.400 | -1.100 | 0.375 | -1.030 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.200 | 0.749 | -1.124 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.468 | -0.562 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | 4 | |
| Snow guard | No | |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 3

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $\kappa_{Fl,G}$ = 1.00 |
| Importance factor variable | $\kappa_{Fl,Q}$ = 1.00 |
| Characteristic dead weight | $G_k$ |
| Characteristic snow load on the roof | $S_{i,n}$ |
| Characteristic wind load | $W_k$ |

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

### Usability

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

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

# Structural analysis report | Area 3

## Maximum load on modules (Mounting system dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.345 | 0.582 | -0.727 | 0.067 | 0.908 | 0.395 | -0.447 | 0.067 |
| 1 | ridge | 10.00 | 1.345 | 0.582 | -1.149 | 0.067 | 0.908 | 0.395 | -0.727 | 0.067 |
| 1 | gableboard | 10.00 | 1.345 | 0.582 | -1.430 | 0.067 | 0.908 | 0.395 | -0.915 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.705 | 0.582 | -1.570 | 0.067 | 1.148 | 0.395 | -1.008 | 0.067 |
| 1 | eaves | 10.00 | 1.429 | 0.582 | -0.727 | 0.067 | 0.964 | 0.395 | -0.447 | 0.067 |

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.636 | 0.275 | -0.344 | 0.031 | 0.429 | 0.186 | -0.211 | 0.031 |
| 1 | ridge | 10.00 | 0.636 | 0.275 | -0.543 | 0.031 | 0.429 | 0.186 | -0.344 | 0.031 |
| 1 | gableboard | 10.00 | 0.636 | 0.275 | -0.676 | 0.031 | 0.429 | 0.186 | -0.432 | 0.031 |
| 1 | corner region (eave) | 10.00 | 0.806 | 0.275 | -0.742 | 0.031 | 0.543 | 0.186 | -0.476 | 0.031 |
| 1 | eaves | 10.00 | 0.675 | 0.275 | -0.344 | 0.031 | 0.456 | 0.186 | -0.211 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

# Structural analysis report | Area 3

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 40.1 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 26.9 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 48.8 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 35.5 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

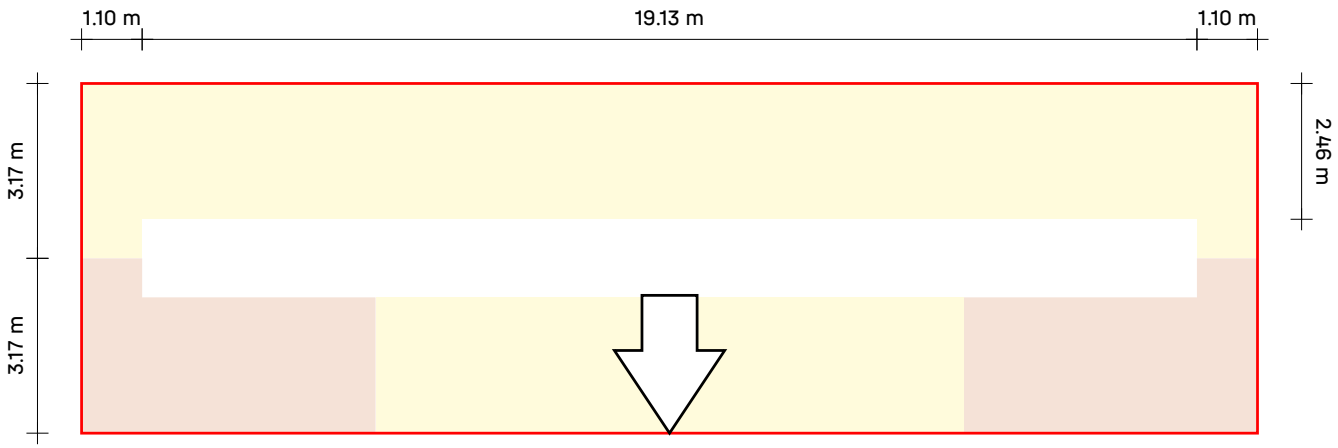
| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 3.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 3.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 5.3 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 4.5 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

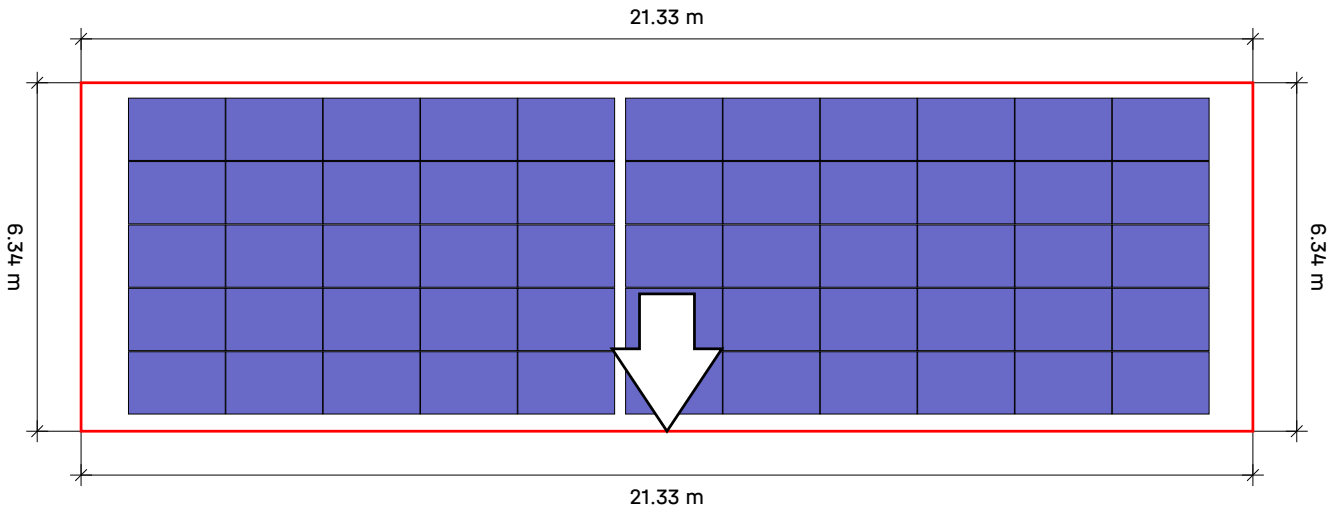
# Area 3 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 600 | 16.2 kg |
| 2 | 2004244 | SolidHook Vario 2 | 300 | 248.1 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 300 | 7.0 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 300 | 3.3 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 44 | 0.3 kg |
| 6 | 2002870 | K2 Solar Cable Manager | 55 | 0.2 kg |
| 7 | 2004264 | SolidRail UltraLight; 3.65 m | 27 | 69.3 kg |
| 8 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 20 | 4.5 kg |
| 9 | 2003145 | SingleRail Climber Set 36/50 | 110 | 7.4 kg |
| 10 | 2003072 | OneMid Black Set 30-42 | 88 | 7.0 kg |
| 11 | 2004545 | K2 Clamp EC 25-40 Black | 44 | 3.2 kg |
| 12 | 2004258 | SingleRail 36; 3.65 m | 44 | 123.6 kg |
| 13 | 2001976 | SingleRail 36 RailConnector Set | 22 | 8.3 kg |
| **Total** | | | | **498.3 kg** |

# Area 4



# Area 4




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 4<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 55 | 24.75 kWp |

# Area 4 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 5*A | 10.072 m | 2*3.65 m | 3.650 | 2.772 from 3.650 | 0.868 |
| 2*B | 8.300 m | 2*3.65 m | 3.650 | 1.000 from 3.650 | 2.640 |
| 2*C | 8.300 m | 2*3.65 m | 2.640 | 1.000 from 2.640 | 1.630 |
| 1*D | 8.300 m | 2*3.65 m | 1.630 | 1.000 from 1.630 | 0.620 |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 22*A | 5.850 m | 1*3.65 m | 3.650 | 2.200 from 3.650 | 1.440 |

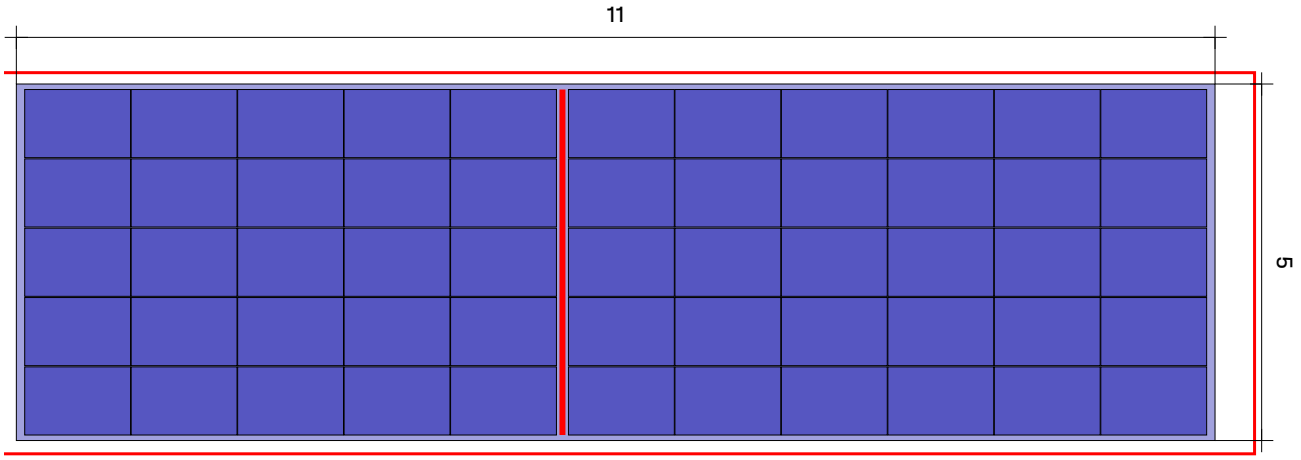
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| 1 | field area | 0.30 m | 0.300 | 0.393 |
| 1 | ridge | 0.30 m | 0.300 | 0.393 |
| 1 | gableboard | 0.30 m | 0.300 | 0.393 |
| 1 | corner region (eave) | 0.30 m | 0.300 | 0.326 |
| 1 | eaves | 0.30 m | 0.300 | 0.374 |

## Module arrays

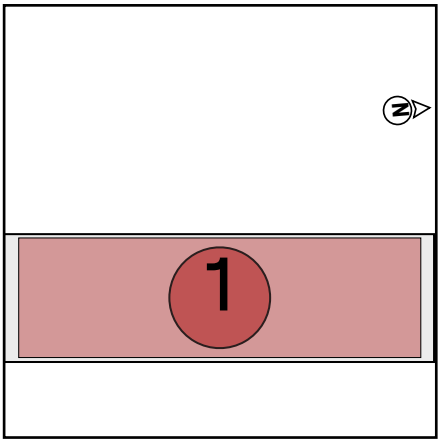
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| 1 | 19.67 | 5.75 | 11 | 5 |

# Area 4 | Module array 1

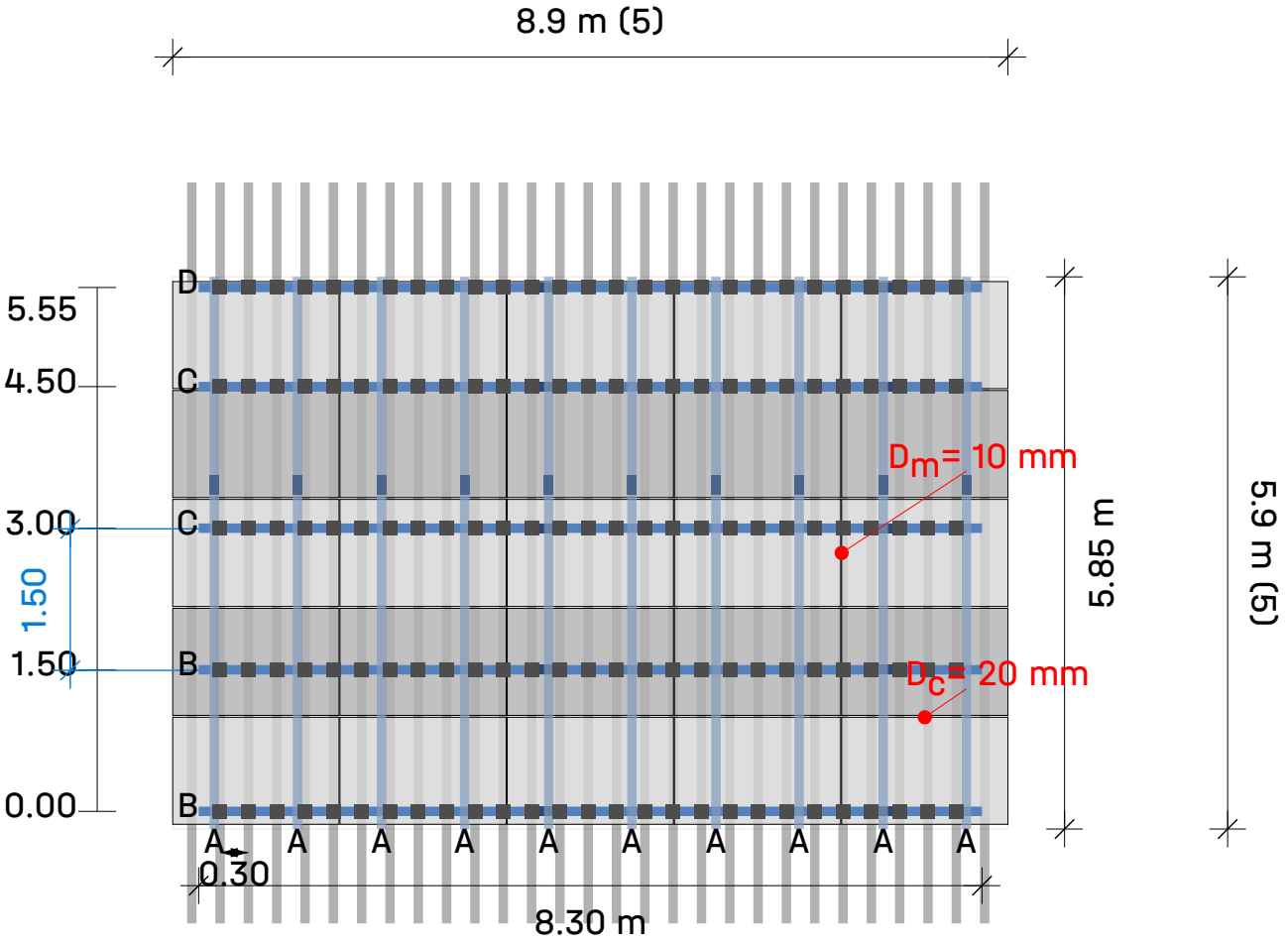



## Roof (4) Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 55(24.75 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 4 | Module array 1 | Module block 1

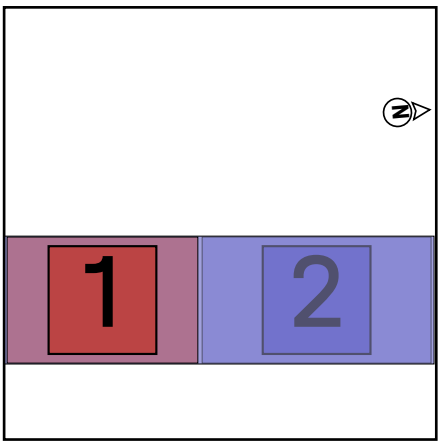



Roof 4 Module array 1 Module block 1

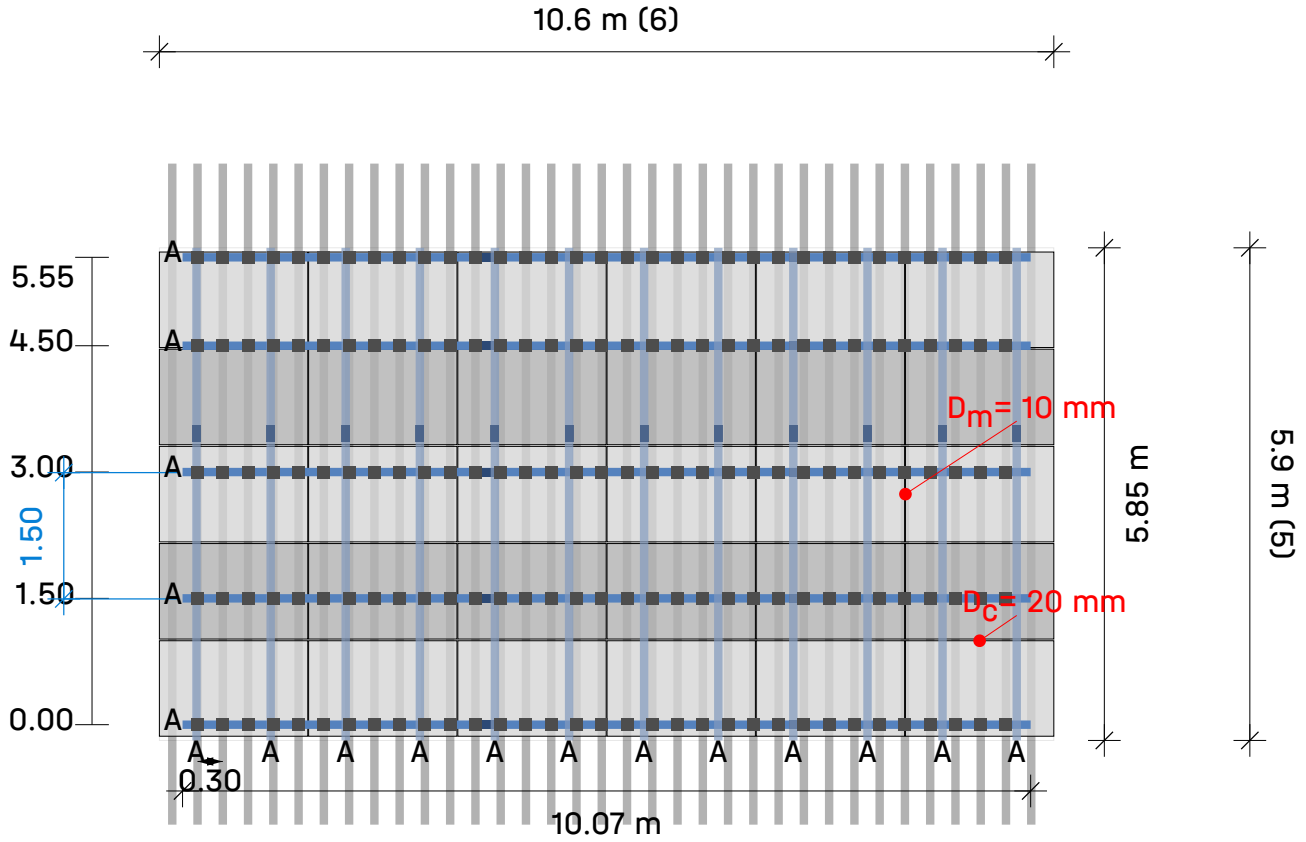
Modules 5 × 5 = **25**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Area 4 | Module array 1 | Module block 2

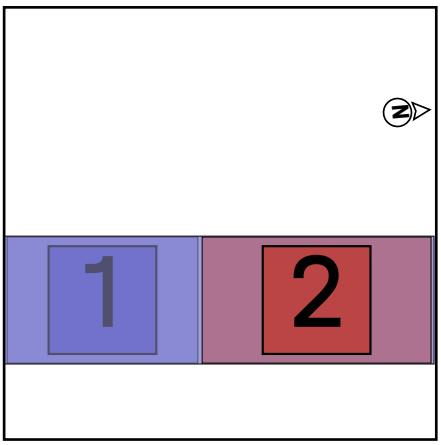



Roof (4) Module array 1 Module block 2

Modules 6 × 5 = **30**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- $D_c$ Distance for clamping between modules
- $D_m$ Distance between modules



# Results | Area 4

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 4<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 55 | 24.75 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,345.1 | 582.0 | -727.5 | 66.5 | 908.3 | 394.7 | -446.6 | 66.5 |
| 1 | ridge | 2.00 | 1,345.1 | 582.0 | -1,148.8 | 66.5 | 908.3 | 394.7 | -727.5 | 66.5 |
| 1 | gableboard | 2.00 | 1,345.1 | 582.0 | -1,429.7 | 66.5 | 908.3 | 394.7 | -914.8 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,705.4 | 582.0 | -1,570.2 | 66.5 | 1,148.4 | 394.7 | -1,008.4 | 66.5 |
| 1 | eaves | 2.00 | 1,429.4 | 582.0 | -727.5 | 66.5 | 964.5 | 394.7 | -446.6 | 66.5 |

# Results | Area 4

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 35.7 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 41.4 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 50.3 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 37.5 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 2.1 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 6.9 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 5.9 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

Pr **Profile**
Fst **Fastener**
σ **Stress**
f **deflection**
F **Force**
CL/$L_{max}$ **maximum cantilever length [m]**
Fst $D_{max}$ **maximum fastener spacing [m]**
BR **base rail**
UR **Upper rail**
Usab. **usability**
CL **Cantilever**

# Results | Area 4

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 4

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 11.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 165.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 165.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 1.017 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.936 kN/m² |

# Structural analysis report | Area 4

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.375 | -0.562 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.375 | -0.843 |
| 1 | gableboard | 10.00 | 0.400 | -1.100 | 0.375 | -1.030 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.200 | 0.749 | -1.124 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.468 | -0.562 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 4

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $\kappa_{Fl,G}$ = 1.00 |
| Importance factor variable | $\kappa_{Fl,Q}$ = 1.00 |
| Characteristic dead weight | $G_k$ |
| Characteristic snow load on the roof | $S_{i,n}$ |
| Characteristic wind load | $W_k$ |

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

### Usability

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

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

# Structural analysis report | Area 4

## Maximum load on modules (Mounting system dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.345 | 0.582 | -0.727 | 0.067 | 0.908 | 0.395 | -0.447 | 0.067 |
| 1 | ridge | 10.00 | 1.345 | 0.582 | -1.149 | 0.067 | 0.908 | 0.395 | -0.727 | 0.067 |
| 1 | gableboard | 10.00 | 1.345 | 0.582 | -1.430 | 0.067 | 0.908 | 0.395 | -0.915 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.705 | 0.582 | -1.570 | 0.067 | 1.148 | 0.395 | -1.008 | 0.067 |
| 1 | eaves | 10.00 | 1.429 | 0.582 | -0.727 | 0.067 | 0.964 | 0.395 | -0.447 | 0.067 |

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.636 | 0.275 | -0.344 | 0.031 | 0.429 | 0.186 | -0.211 | 0.031 |
| 1 | ridge | 10.00 | 0.636 | 0.275 | -0.543 | 0.031 | 0.429 | 0.186 | -0.344 | 0.031 |
| 1 | gableboard | 10.00 | 0.636 | 0.275 | -0.676 | 0.031 | 0.429 | 0.186 | -0.432 | 0.031 |
| 1 | corner region (eave) | 10.00 | 0.806 | 0.275 | -0.742 | 0.031 | 0.543 | 0.186 | -0.476 | 0.031 |
| 1 | eaves | 10.00 | 0.675 | 0.275 | -0.344 | 0.031 | 0.456 | 0.186 | -0.211 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

# Structural analysis report | Area 4

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 35.7 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 41.4 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 50.3 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 37.5 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

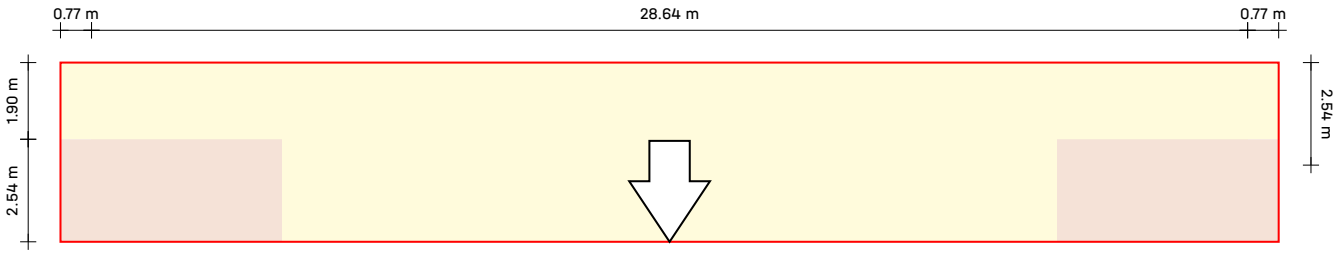
| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 2.1 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 6.9 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 5.9 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

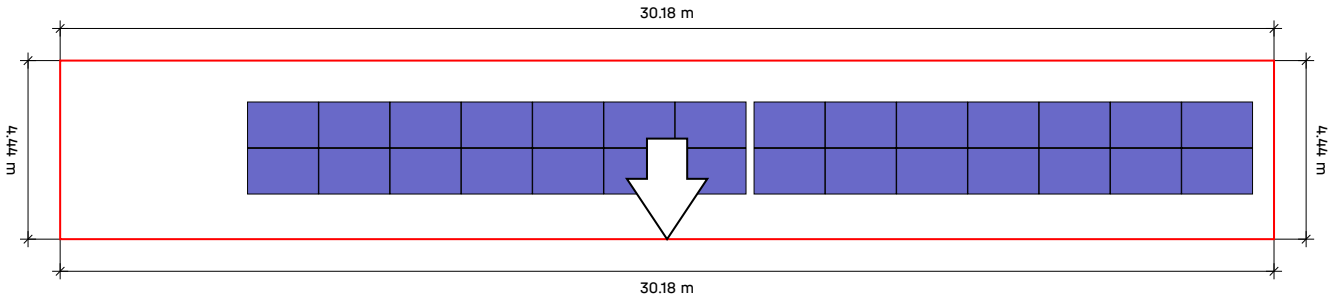
# Area 4 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 600 | 16.2 kg |
| 2 | 2004244 | SolidHook Vario 2 | 300 | 248.1 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 300 | 7.0 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 300 | 3.3 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 44 | 0.3 kg |
| 6 | 2002870 | K2 Solar Cable Manager | 55 | 0.2 kg |
| 7 | 2004264 | SolidRail UltraLight; 3.65 m | 27 | 69.3 kg |
| 8 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 20 | 4.5 kg |
| 9 | 2003145 | SingleRail Climber Set 36/50 | 110 | 7.4 kg |
| 10 | 2003072 | OneMid Black Set 30-42 | 88 | 7.0 kg |
| 11 | 2004545 | K2 Clamp EC 25-40 Black | 44 | 3.2 kg |
| 12 | 2004258 | SingleRail 36; 3.65 m | 44 | 123.6 kg |
| 13 | 2001976 | SingleRail 36 RailConnector Set | 22 | 8.3 kg |
| **Total** | | | | **498.3 kg** |

# Area 5



# Area 5




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 5<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 28 | 12.6 kWp |

# Area 5 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 2*A | 11.844 m | 3*3.65 m | 3.650 | 0.894 from 3.650 | 2.746 |
| 2*B | 11.844 m | 3*3.65 m | 2.746 | 0.894 from 2.746 | 1.842 |
| 1*C | 11.844 m | 3*3.65 m | 1.842 | 0.894 from 1.842 | 0.938 |
| 1*D | 11.844 m | 3*3.65 m | 0.938 | 0.894 from 0.938 | 0.034 |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 28*A | 2.388 m | | 3.650 | 2.388 from 3.650 | 1.252 |

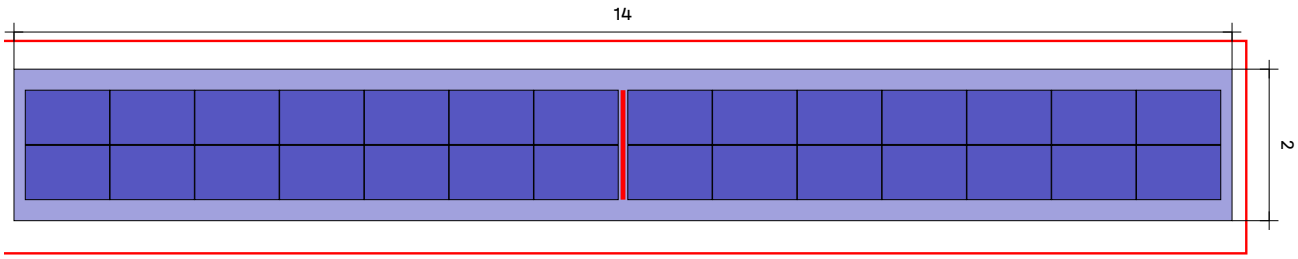
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| 1 | field area | 0.30 m | 0.300 | 0.393 |
| 1 | ridge | 0.30 m | 0.300 | 0.393 |
| 1 | gableboard | 0.30 m | 0.300 | 0.393 |
| 1 | corner region (eave) | 0.30 m | 0.300 | 0.326 |
| 1 | eaves | 0.30 m | 0.300 | 0.374 |

## Module arrays

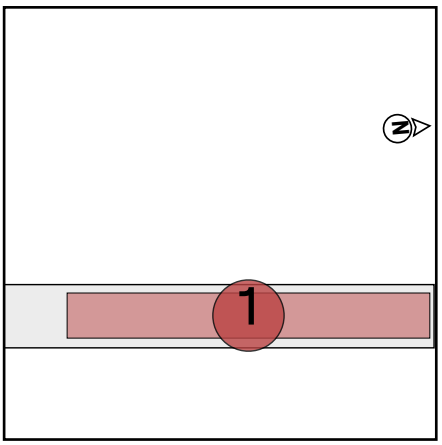
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| 1 | 24.99 | 2.29 | 14 | 2 |

# Area 5 | Module array 1

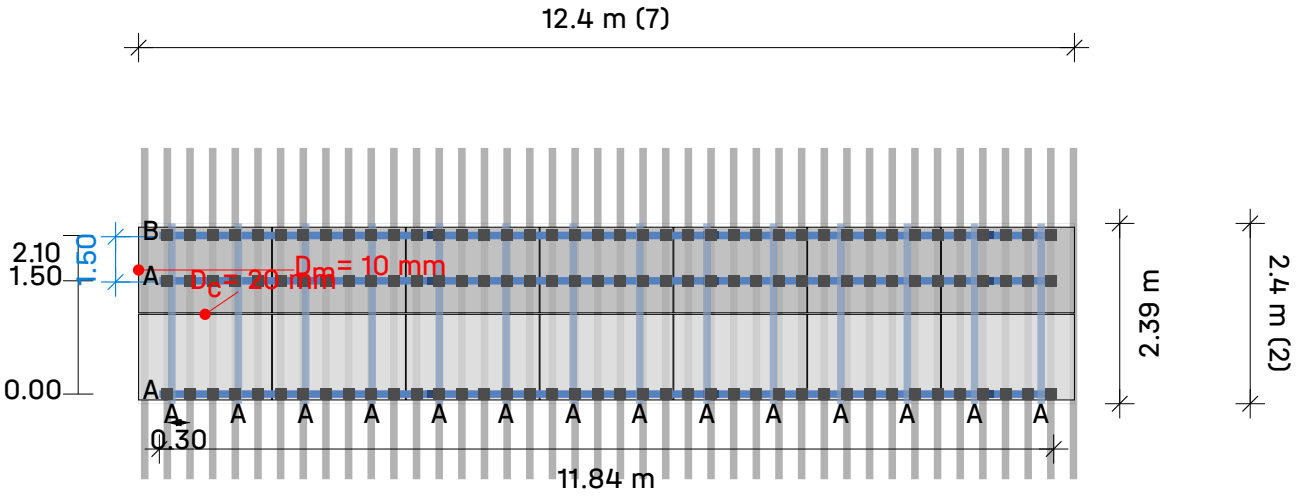



## Roof 5 Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 28(12.6 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 5 | Module array 1 | Module block 1

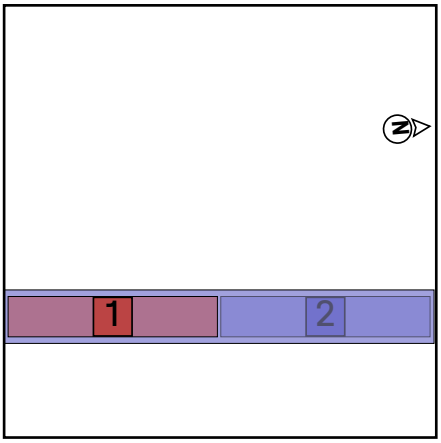



Roof 5 Module array 1 Module block 1

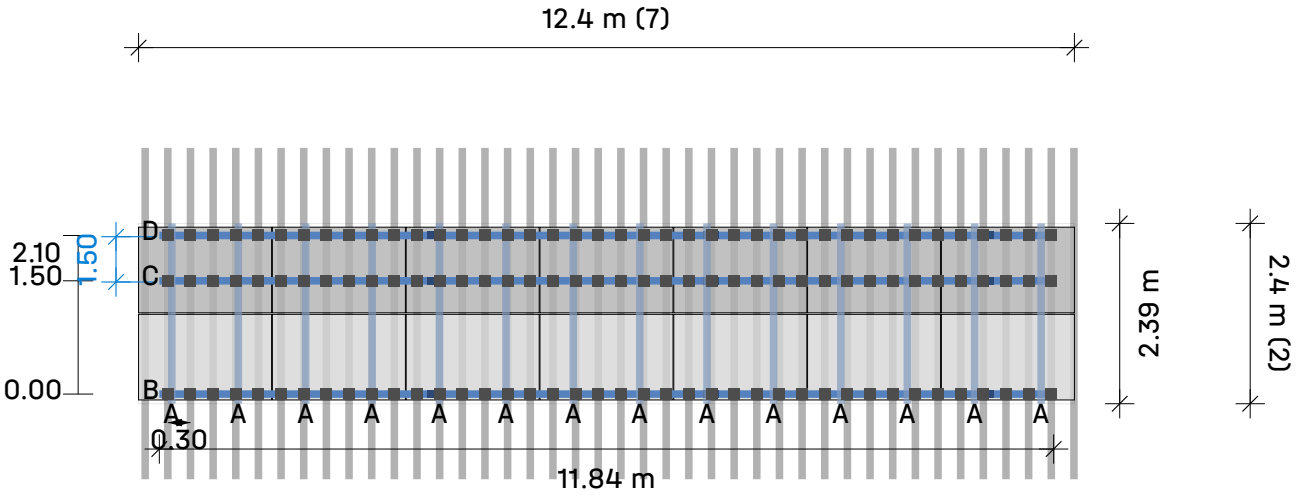
Modules 7 × 2 = **14**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Area 5 | Module array 1 | Module block 2

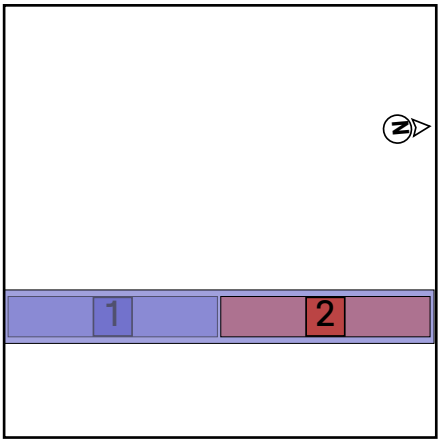



Roof (5) Module array (1) Module block 2

Modules 7 × 2 = **14**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- $D_c$ Distance for clamping between modules
- $D_m$ Distance between modules



# Results | Area 5

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 5<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 28 | 12.6 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,345.1 | 582.0 | -727.5 | 66.5 | 908.3 | 394.7 | -446.6 | 66.5 |
| 1 | ridge | 2.00 | 1,345.1 | 582.0 | -1,148.8 | 66.5 | 908.3 | 394.7 | -727.5 | 66.5 |
| 1 | gableboard | 2.00 | 1,345.1 | 582.0 | -1,429.7 | 66.5 | 908.3 | 394.7 | -914.8 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,705.4 | 582.0 | -1,570.2 | 66.5 | 1,148.4 | 394.7 | -1,008.4 | 66.5 |
| 1 | eaves | 2.00 | 1,429.4 | 582.0 | -727.5 | 66.5 | 964.5 | 394.7 | -446.6 | 66.5 |

# Results | Area 5

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 6.1 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 6.6 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 6.4 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 4.1 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 3.3 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 2.8 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

Pr **Profile**
Fst **Fastener**
σ **Stress**
f **deflection**
F **Force**
CL/$L_{max}$ **maximum cantilever length [m]**
Fst $D_{max}$ **maximum fastener spacing [m]**
BR **base rail**
UR **Upper rail**
Usab. **usability**
CL **Cantilever**

# Results | Area 5

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 5

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 11.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 240.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 240.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 1.017 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.936 kN/m² |

# Structural analysis report | Area 5

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.375 | -0.562 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.375 | -0.843 |
| 1 | gableboard | 10.00 | 0.400 | -1.100 | 0.375 | -1.030 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.200 | 0.749 | -1.124 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.468 | -0.562 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 5

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $\kappa_{Fl,G}$ = 1.00 |
| Importance factor variable | $\kappa_{Fl,Q}$ = 1.00 |
| Characteristic dead weight | $G_k$ |
| Characteristic snow load on the roof | $S_{i,n}$ |
| Characteristic wind load | $W_k$ |

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

### Usability

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

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

# Structural analysis report | Area 5

## Maximum load on modules (Mounting system dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.345 | 0.582 | -0.727 | 0.067 | 0.908 | 0.395 | -0.447 | 0.067 |
| 1 | ridge | 10.00 | 1.345 | 0.582 | -1.149 | 0.067 | 0.908 | 0.395 | -0.727 | 0.067 |
| 1 | gableboard | 10.00 | 1.345 | 0.582 | -1.430 | 0.067 | 0.908 | 0.395 | -0.915 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.705 | 0.582 | -1.570 | 0.067 | 1.148 | 0.395 | -1.008 | 0.067 |
| 1 | eaves | 10.00 | 1.429 | 0.582 | -0.727 | 0.067 | 0.964 | 0.395 | -0.447 | 0.067 |

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.636 | 0.275 | -0.344 | 0.031 | 0.429 | 0.186 | -0.211 | 0.031 |
| 1 | ridge | 10.00 | 0.636 | 0.275 | -0.543 | 0.031 | 0.429 | 0.186 | -0.344 | 0.031 |
| 1 | gableboard | 10.00 | 0.636 | 0.275 | -0.676 | 0.031 | 0.429 | 0.186 | -0.432 | 0.031 |
| 1 | corner region (eave) | 10.00 | 0.806 | 0.275 | -0.742 | 0.031 | 0.543 | 0.186 | -0.476 | 0.031 |
| 1 | eaves | 10.00 | 0.675 | 0.275 | -0.344 | 0.031 | 0.456 | 0.186 | -0.211 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

# Structural analysis report | Area 5

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 6.1 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 6.6 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 6.4 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

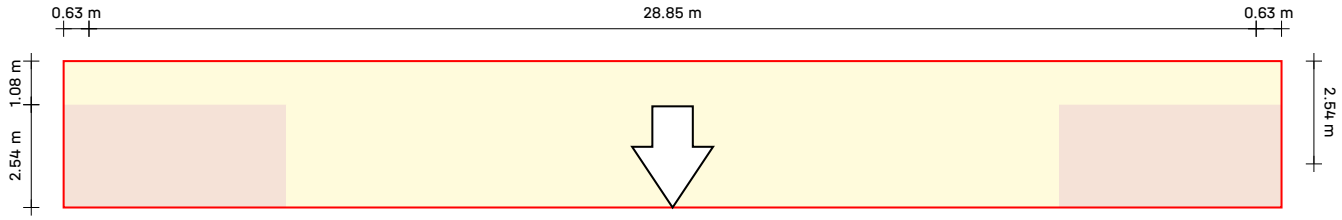
| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 4.1 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 3.3 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 2.8 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

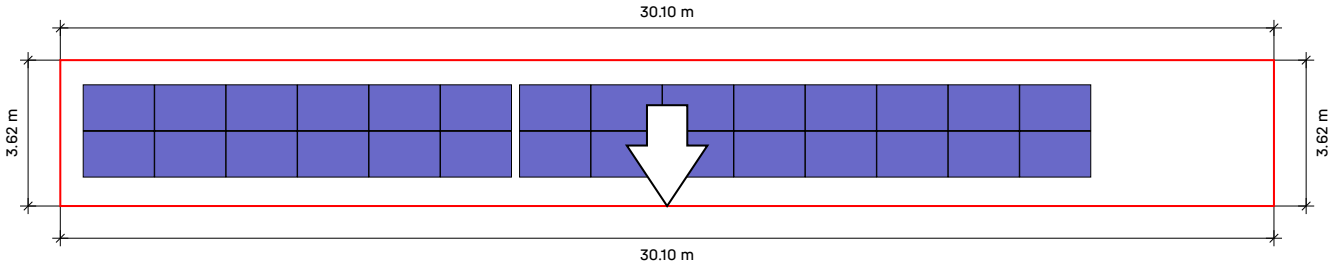
# Area 5 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 480 | 13.0 kg |
| 2 | 2004244 | SolidHook Vario 2 | 240 | 198.5 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 240 | 5.6 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 240 | 2.6 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 56 | 0.4 kg |
| 6 | 2003523 | BlackCover SingleRail 36 | 56 | 1.5 kg |
| 7 | 2002870 | K2 Solar Cable Manager | 28 | 0.1 kg |
| 8 | 2004264 | SolidRail UltraLight; 3.65 m | 20 | 51.4 kg |
| 9 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 18 | 4.1 kg |
| 10 | 2003145 | SingleRail Climber Set 36/50 | 84 | 5.6 kg |
| 11 | 2003072 | OneMid Black Set 30-42 | 28 | 2.2 kg |
| 12 | 2004545 | K2 Clamp EC 25-40 Black | 56 | 4.0 kg |
| 13 | 2004258 | SingleRail 36; 3.65 m | 28 | 78.7 kg |
| **Total** | | | | **367.6 kg** |

# Area 6



# Area 6




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 6<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 28 | 12.6 kWp |

# Area 6 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 3*A | 10.072 m | 2*3.65 m | 3.650 | 2.772 from 3.650 | 0.868 |
| 3*B | 13.616 m | 3*3.65 m | 3.650 | 2.666 from 3.650 | 0.974 |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 28*A | 2.388 m | | 3.650 | 2.388 from 3.650 | 1.252 |

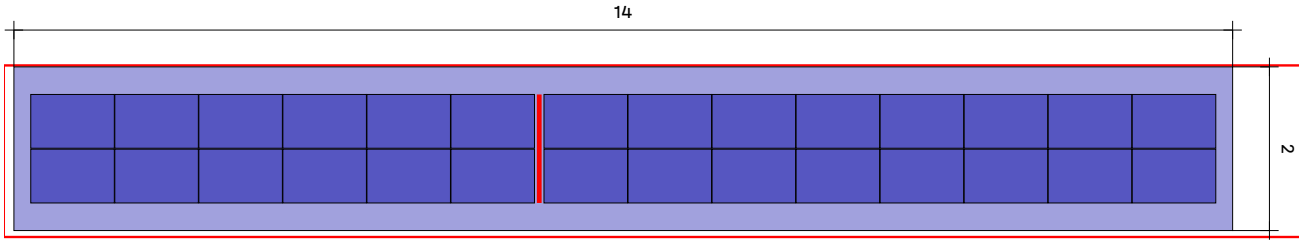
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| 1 | field area | 0.30 m | 0.300 | 0.393 |
| 1 | ridge | 0.30 m | 0.300 | 0.393 |
| 1 | gableboard | 0.30 m | 0.300 | 0.393 |
| 1 | corner region (eave) | 0.30 m | 0.300 | 0.326 |
| 1 | eaves | 0.30 m | 0.300 | 0.374 |

## Module arrays

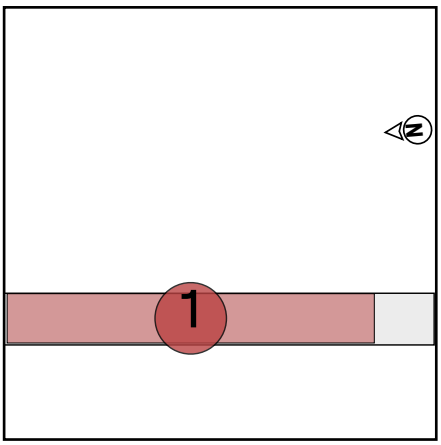
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| 1 | 24.99 | 2.29 | 14 | 2 |

# Area 6 | Module array 1

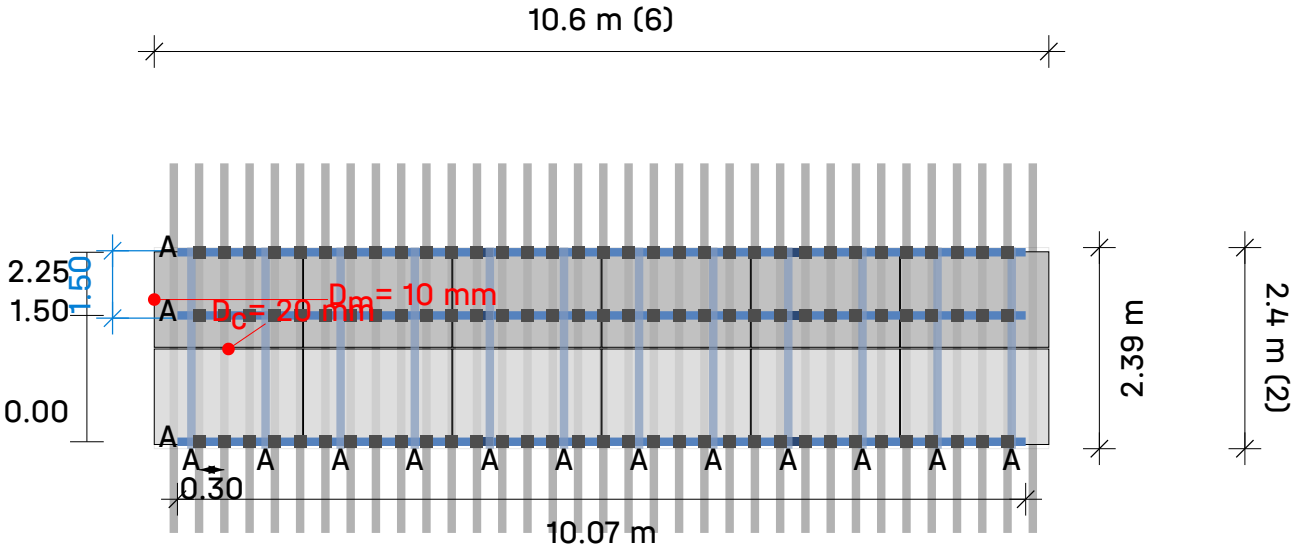



## Roof 6 Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 28(12.6 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 6 | Module array 1 | Module block 1

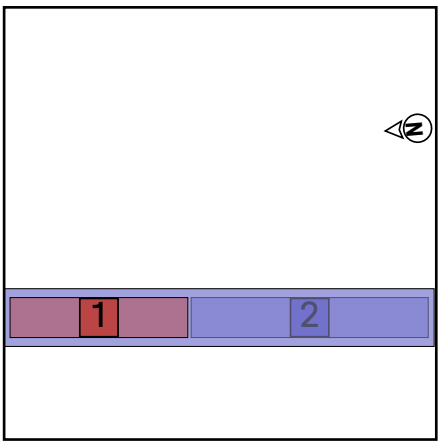



Roof 6 Module array 1 Module block 1

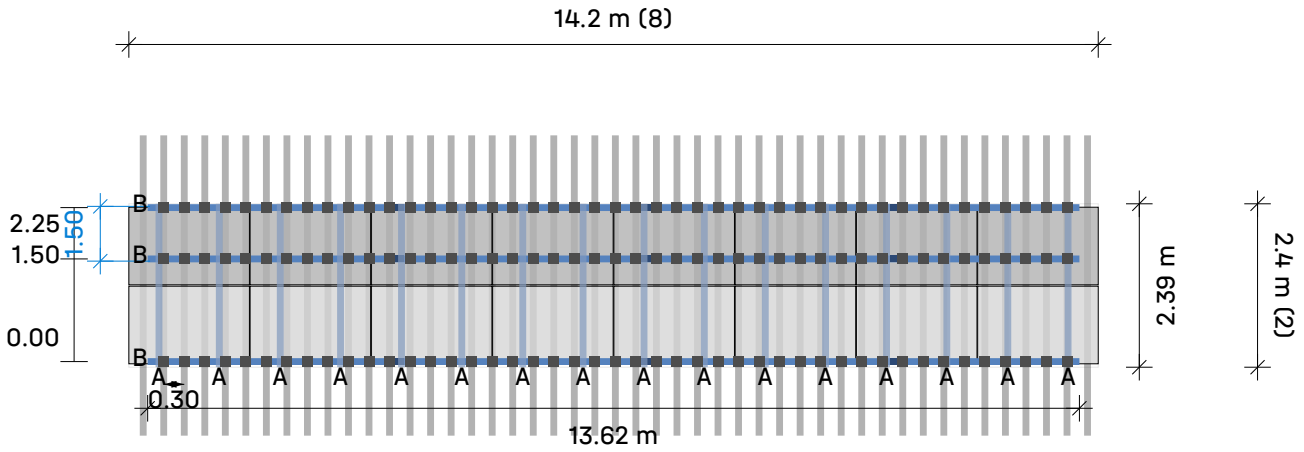
Modules 6 × 2 = **12**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Area 6 | Module array 1 | Module block 2

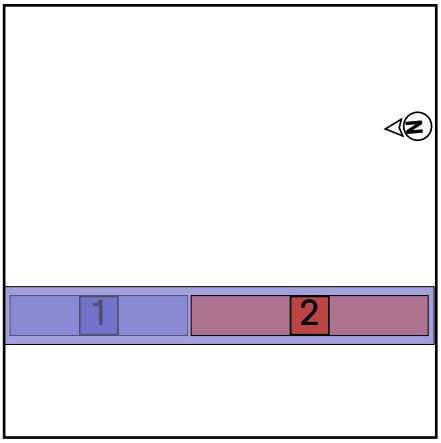



Roof 6 Module array 1 Module block 2

Modules 8 × 2 = **16**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Results | Area 6

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 6<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 28 | 12.6 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,345.1 | 582.0 | -727.5 | 66.5 | 908.3 | 394.7 | -446.6 | 66.5 |
| 1 | ridge | 2.00 | 1,345.1 | 582.0 | -1,148.8 | 66.5 | 908.3 | 394.7 | -727.5 | 66.5 |
| 1 | gableboard | 2.00 | 1,345.1 | 582.0 | -1,429.7 | 66.5 | 908.3 | 394.7 | -914.8 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,705.4 | 582.0 | -1,570.2 | 66.5 | 1,148.4 | 394.7 | -1,008.4 | 66.5 |
| 1 | eaves | 2.00 | 1,429.4 | 582.0 | -727.5 | 66.5 | 964.5 | 394.7 | -446.6 | 66.5 |

# Results | Area 6

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 31.8 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 38.7 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 27.9 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 0.5 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 1.4 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 1.2 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 6

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 6

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 11.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 200.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 200.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 1.017 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.936 kN/m² |

# Structural analysis report | Area 6

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.375 | -0.562 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.375 | -0.843 |
| 1 | gableboard | 10.00 | 0.400 | -1.100 | 0.375 | -1.030 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.200 | 0.749 | -1.124 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.468 | -0.562 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 6

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $\kappa_{Fl,G}$ = 1.00 |
| Importance factor variable | $\kappa_{Fl,Q}$ = 1.00 |
| Characteristic dead weight | $G_k$ |
| Characteristic snow load on the roof | $S_{i,n}$ |
| Characteristic wind load | $W_k$ |

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

### Usability

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

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

# Structural analysis report | Area 6

## Maximum load on modules (Mounting system dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.345 | 0.582 | -0.727 | 0.067 | 0.908 | 0.395 | -0.447 | 0.067 |
| 1 | ridge | 10.00 | 1.345 | 0.582 | -1.149 | 0.067 | 0.908 | 0.395 | -0.727 | 0.067 |
| 1 | gableboard | 10.00 | 1.345 | 0.582 | -1.430 | 0.067 | 0.908 | 0.395 | -0.915 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.705 | 0.582 | -1.570 | 0.067 | 1.148 | 0.395 | -1.008 | 0.067 |
| 1 | eaves | 10.00 | 1.429 | 0.582 | -0.727 | 0.067 | 0.964 | 0.395 | -0.447 | 0.067 |

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.636 | 0.275 | -0.344 | 0.031 | 0.429 | 0.186 | -0.211 | 0.031 |
| 1 | ridge | 10.00 | 0.636 | 0.275 | -0.543 | 0.031 | 0.429 | 0.186 | -0.344 | 0.031 |
| 1 | gableboard | 10.00 | 0.636 | 0.275 | -0.676 | 0.031 | 0.429 | 0.186 | -0.432 | 0.031 |
| 1 | corner region (eave) | 10.00 | 0.806 | 0.275 | -0.742 | 0.031 | 0.543 | 0.186 | -0.476 | 0.031 |
| 1 | eaves | 10.00 | 0.675 | 0.275 | -0.344 | 0.031 | 0.456 | 0.186 | -0.211 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

# Structural analysis report | Area 6

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 31.8 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 38.7 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 27.9 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

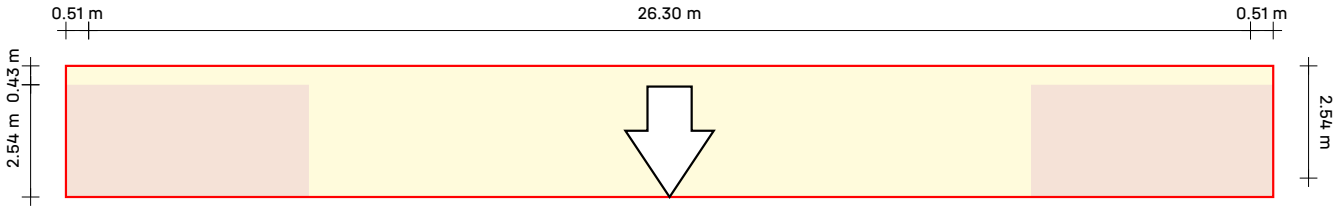
| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 0.5 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 1.4 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 1.2 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

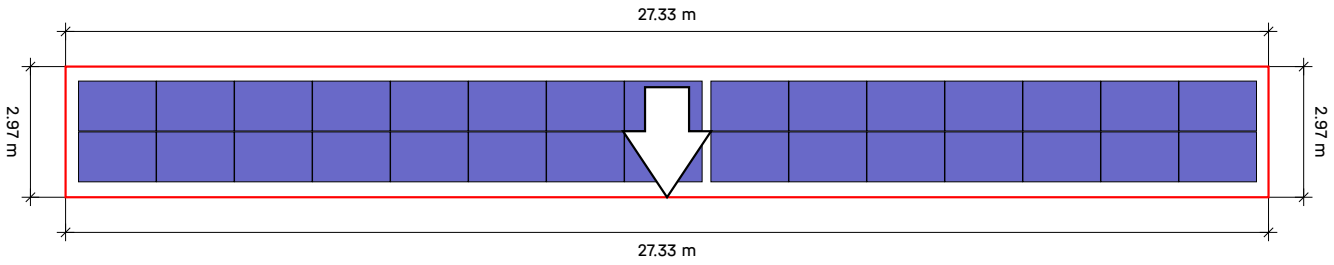
# Area 6 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 468 | 12.6 kg |
| 2 | 2004244 | SolidHook Vario 2 | 234 | 193.5 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 234 | 5.5 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 234 | 2.6 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 56 | 0.4 kg |
| 6 | 2002870 | K2 Solar Cable Manager | 28 | 0.1 kg |
| 7 | 2004264 | SolidRail UltraLight; 3.65 m | 21 | 53.9 kg |
| 8 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 15 | 3.4 kg |
| 9 | 2003145 | SingleRail Climber Set 36/50 | 84 | 5.6 kg |
| 10 | 2003072 | OneMid Black Set 30-42 | 28 | 2.2 kg |
| 11 | 2004545 | K2 Clamp EC 25-40 Black | 56 | 4.0 kg |
| 12 | 2004258 | SingleRail 36; 3.65 m | 28 | 78.7 kg |
| **Total** | | | | **362.5 kg** |

# Area 7



# Area 7




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 7<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 30 | 13.5 kWp |

# Area 7 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 3*A | 13.616 m | 3*3.65 m | 3.650 | 2.666 from 3.650 | 0.974 |
| 3*B | 11.844 m | 3*3.65 m | 0.974 | 0.894 from 0.974 | 0.070 |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| 30*A | 2.388 m | | 3.650 | 2.388 from 3.650 | 1.252 |

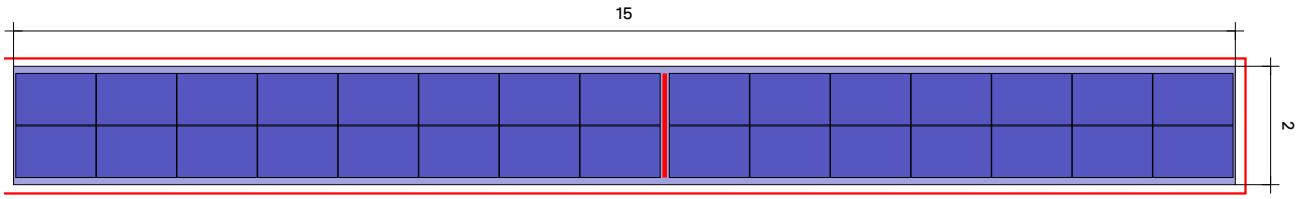
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| 1 | field area | 0.30 m | 0.300 | 0.393 |
| 1 | ridge | 0.30 m | 0.300 | 0.393 |
| 1 | gableboard | 0.30 m | 0.300 | 0.393 |
| 1 | corner region (eave) | 0.30 m | 0.300 | 0.326 |
| 1 | eaves | 0.30 m | 0.300 | 0.374 |

## Module arrays

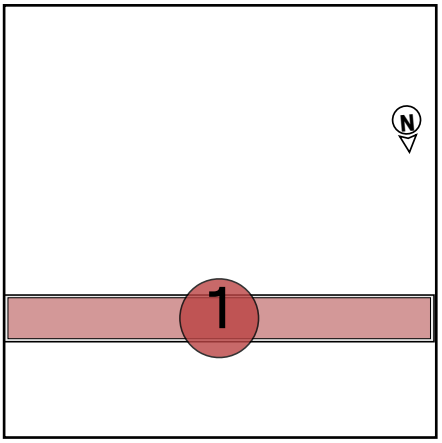
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| 1 | 26.76 | 2.29 | 15 | 2 |

# Area 7 | Module array 1

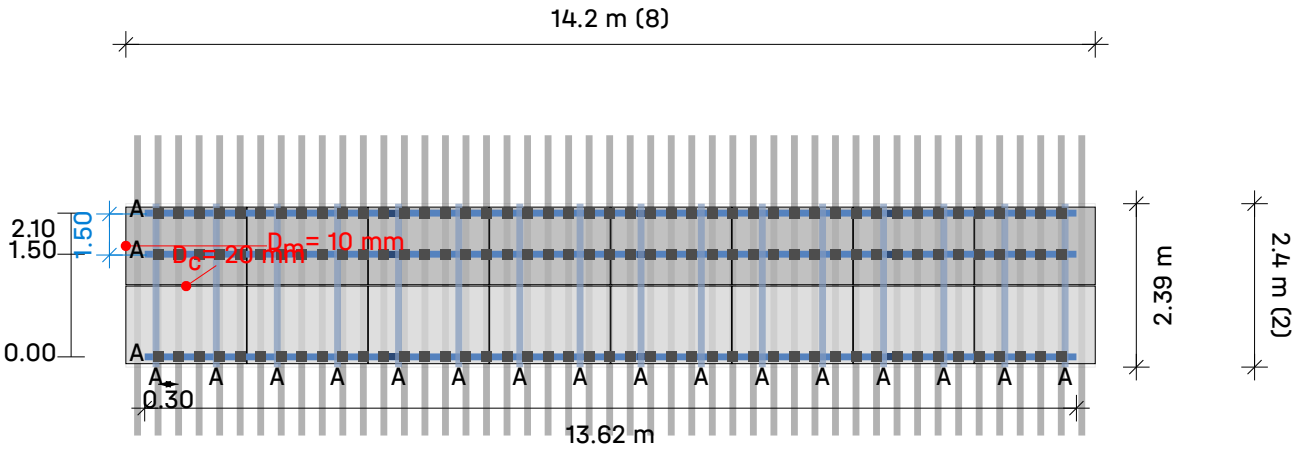



## Roof 7 Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 30(13.5 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 7 | Module array 1 | Module block 1

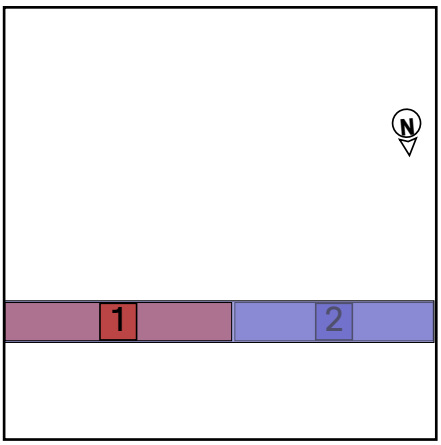



Roof 7 Module array 1 Module block 1

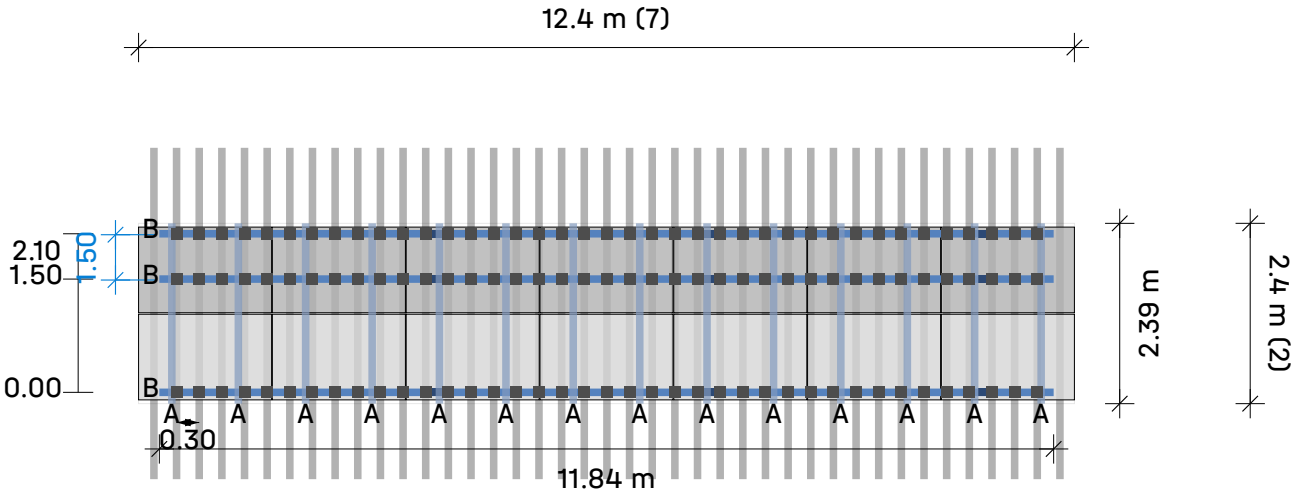
Modules 8 × 2 = **16**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Area 7 | Module array 1 | Module block 2

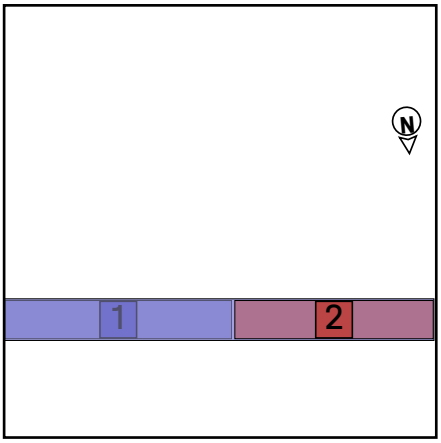



Roof (7) Module array (1) Module block 2

Modules 7 × 2 = **14**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dist. to neighbour module block/array [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Results | Area 7

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 7<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 11.00 m | 30 | 13.5 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,345.1 | 582.0 | -727.5 | 66.5 | 908.3 | 394.7 | -446.6 | 66.5 |
| 1 | ridge | 2.00 | 1,345.1 | 582.0 | -1,148.8 | 66.5 | 908.3 | 394.7 | -727.5 | 66.5 |
| 1 | gableboard | 2.00 | 1,345.1 | 582.0 | -1,429.7 | 66.5 | 908.3 | 394.7 | -914.8 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,705.4 | 582.0 | -1,570.2 | 66.5 | 1,148.4 | 394.7 | -1,008.4 | 66.5 |
| 1 | eaves | 2.00 | 1,429.4 | 582.0 | -727.5 | 66.5 | 964.5 | 394.7 | -446.6 | 66.5 |

# Results | Area 7

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 25.1 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 0.0 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 0.0 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 3.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 4.5 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 3.8 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 7

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 7

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 11.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 165.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 165.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 1.017 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.936 kN/m² |

# Structural analysis report | Area 7

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.375 | -0.562 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.375 | -0.843 |
| 1 | gableboard | 10.00 | 0.400 | -1.100 | 0.375 | -1.030 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.200 | 0.749 | -1.124 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.468 | -0.562 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | 4 | |
| Snow guard | No | |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 7

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $\kappa_{Fl,G}$ = 1.00 |
| Importance factor variable | $\kappa_{Fl,Q}$ = 1.00 |
| Characteristic dead weight | $G_k$ |
| Characteristic snow load on the roof | $S_{i,n}$ |
| Characteristic wind load | $W_k$ |

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

### Usability

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

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

# Structural analysis report | Area 7

## Maximum load on modules (Mounting system dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.345 | 0.582 | -0.727 | 0.067 | 0.908 | 0.395 | -0.447 | 0.067 |
| 1 | ridge | 10.00 | 1.345 | 0.582 | -1.149 | 0.067 | 0.908 | 0.395 | -0.727 | 0.067 |
| 1 | gableboard | 10.00 | 1.345 | 0.582 | -1.430 | 0.067 | 0.908 | 0.395 | -0.915 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.705 | 0.582 | -1.570 | 0.067 | 1.148 | 0.395 | -1.008 | 0.067 |
| 1 | eaves | 10.00 | 1.429 | 0.582 | -0.727 | 0.067 | 0.964 | 0.395 | -0.447 | 0.067 |

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.636 | 0.275 | -0.344 | 0.031 | 0.429 | 0.186 | -0.211 | 0.031 |
| 1 | ridge | 10.00 | 0.636 | 0.275 | -0.543 | 0.031 | 0.429 | 0.186 | -0.344 | 0.031 |
| 1 | gableboard | 10.00 | 0.636 | 0.275 | -0.676 | 0.031 | 0.429 | 0.186 | -0.432 | 0.031 |
| 1 | corner region (eave) | 10.00 | 0.806 | 0.275 | -0.742 | 0.031 | 0.543 | 0.186 | -0.476 | 0.031 |
| 1 | eaves | 10.00 | 0.675 | 0.275 | -0.344 | 0.031 | 0.456 | 0.186 | -0.211 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

# Structural analysis report | Area 7

## Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | ridge | 8.7 | 25.1 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | gableboard | 8.7 | 0.0 | 76.3 | 1.5 | 0.300 | 1.500 | 0.300 | 0.393 |
| 1 | corner region (eave) | 10.5 | 0.0 | 92.0 | 1.9 | 0.300 | 1.500 | 0.300 | 0.326 |
| 1 | eaves | 9.1 | 0.0 | 80.2 | 1.6 | 0.300 | 1.500 | 0.300 | 0.374 |

## Upper Rail - Utilization result

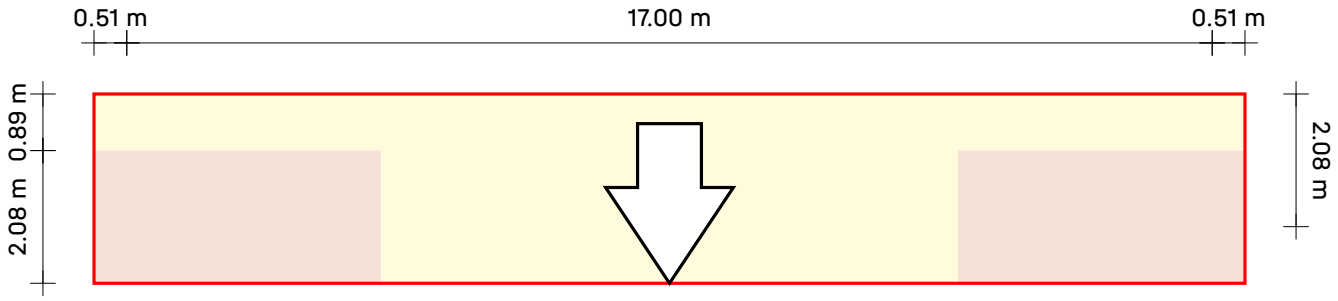
| No. Module Array | roof areas | load-bearing capacity | | | Usab. | Distances | | maximum values | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pr σ[%] | CL σ[%] | Fst F[%] | Pr f[%] | Fst [m] | UR [m] | CL $L_{max}$[m] | Fst $D_{max}$[m] |
| 1 | field area | 70.0 | 0.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | ridge | 70.0 | 3.0 | --- | 65.3 | 1.500 | --- | 0.471 | 1.669 |
| 1 | gableboard | 73.0 | 0.0 | --- | 65.7 | 1.500 | --- | 0.470 | 1.666 |
| 1 | corner region (eave) | 88.4 | 4.5 | --- | 82.5 | 1.500 | --- | 0.441 | 1.574 |
| 1 | eaves | 74.3 | 3.8 | --- | 69.3 | 1.500 | --- | 0.463 | 1.644 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

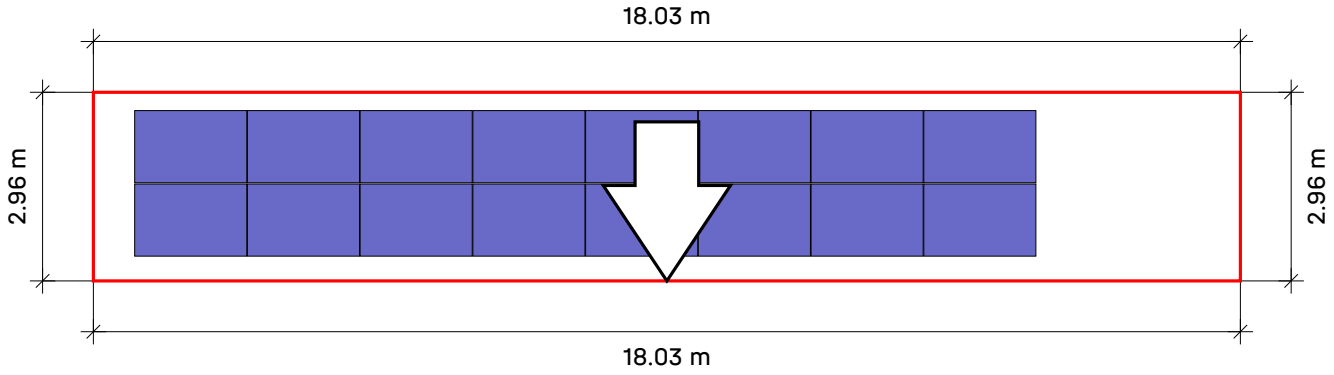
# Area 7 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 504 | 13.6 kg |
| 2 | 2004244 | SolidHook Vario 2 | 252 | 208.4 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 252 | 5.9 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 252 | 2.8 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 60 | 0.4 kg |
| 6 | 2002870 | K2 Solar Cable Manager | 30 | 0.1 kg |
| 7 | 2004264 | SolidRail UltraLight; 3.65 m | 21 | 53.9 kg |
| 8 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 18 | 4.1 kg |
| 9 | 2003145 | SingleRail Climber Set 36/50 | 90 | 6.0 kg |
| 10 | 2003072 | OneMid Black Set 30-42 | 30 | 2.4 kg |
| 11 | 2004545 | K2 Clamp EC 25-40 Black | 60 | 4.3 kg |
| 12 | 2004258 | SingleRail 36; 3.65 m | 30 | 84.3 kg |
| **Total** | | | | **386.2 kg** |

# Area 8



# Area 8




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 8<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |

# Area 8 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| **3*A** | **13.616 m** | **3*3.65 m** | **3.650** | **2.666 from 3.650** | **0.974** |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| **16*A** | **2.388 m** | | **3.650** | **2.388 from 3.650** | **1.252** |

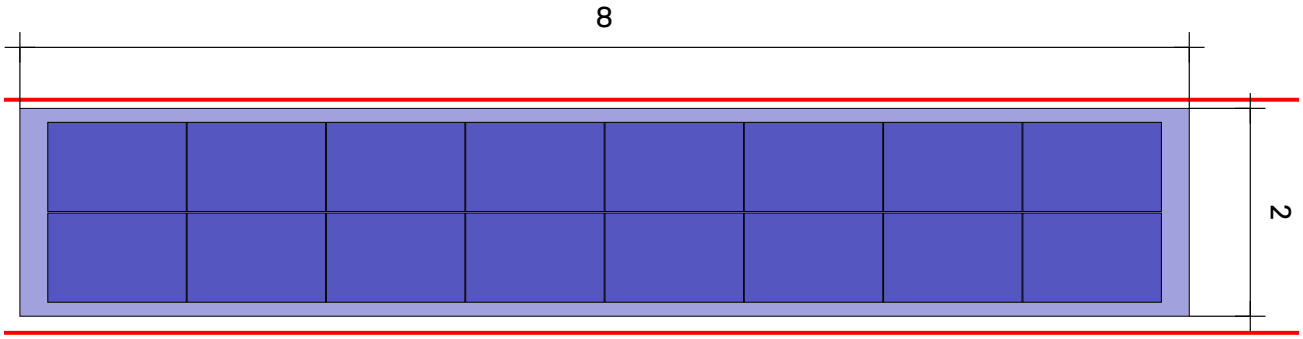
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| **1** | **field area** | **0.30 m** | **0.300** | **0.397** |
| **1** | **ridge** | **0.30 m** | **0.300** | **0.397** |
| **1** | **corner region (eave)** | **0.30 m** | **0.300** | **0.331** |
| **1** | **eaves** | **0.30 m** | **0.300** | **0.379** |

## Module arrays

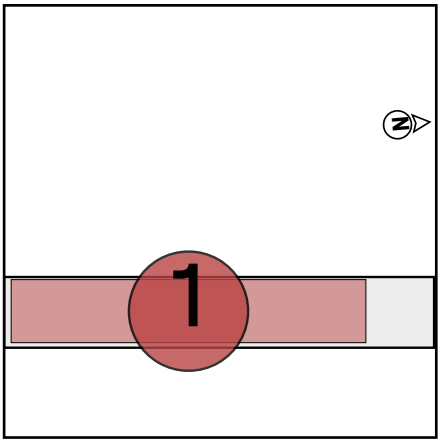
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| **1** | **14.17** | **2.29** | **8** | **2** |

# Area 8 | Module array 1

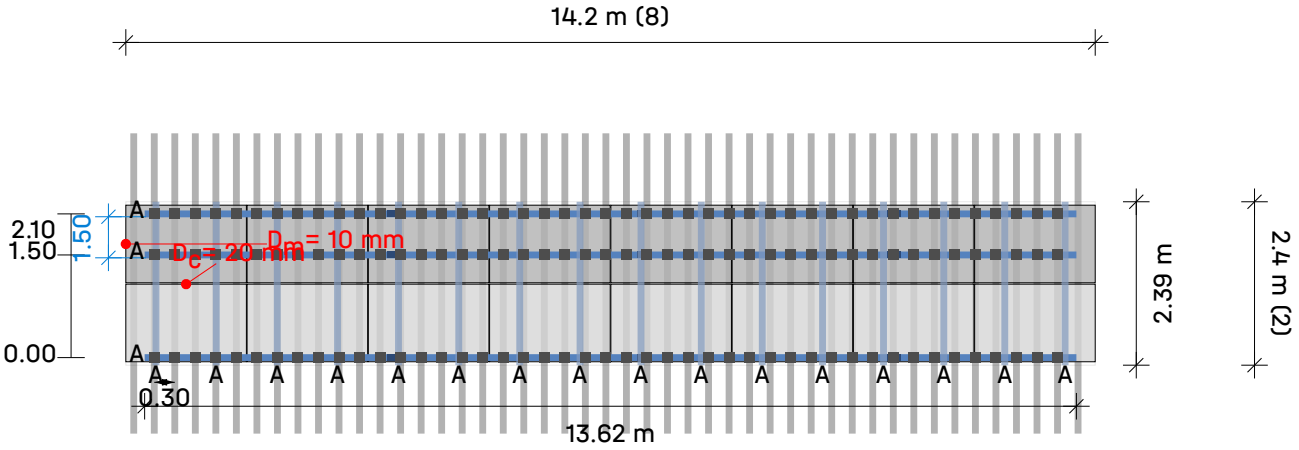



## Roof (8) Module array (1)

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 16(7.2 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 8 | Module array 1 | Module block 1

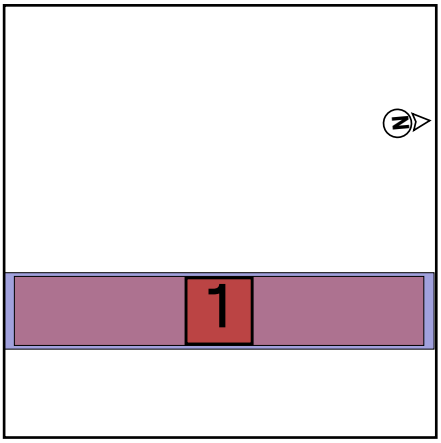



Roof 8 Module array 1 Module block 1

Modules 8 × 2 = **16**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Results | Area 8

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 8<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,328.7 | 582.0 | -686.4 | 66.5 | 897.3 | 394.7 | -419.2 | 66.5 |
| 1 | ridge | 2.00 | 1,328.7 | 582.0 | -1,087.2 | 66.5 | 897.3 | 394.7 | -686.4 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,650.5 | 582.0 | -1,488.0 | 66.5 | 1,111.9 | 394.7 | -953.6 | 66.5 |
| 1 | eaves | 2.00 | 1,408.8 | 582.0 | -686.4 | 66.5 | 950.7 | 394.7 | -419.2 | 66.5 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.6 | 0.0 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | ridge | 8.6 | 36.2 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | corner region (eave) | 10.3 | 43.3 | 90.5 | 1.9 | 0.300 | 1.500 | 0.300 | 0.331 |
| 1 | eaves | 9.0 | 0.0 | 79.3 | 1.6 | 0.300 | 1.500 | 0.300 | 0.379 |

# Results | Area 8

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 69.2 | 0.0 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | ridge | 69.2 | 4.9 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | corner region (eave) | 85.6 | 2.4 | --- | 79.9 | 1.500 | --- | 0.445 | 1.587 |
| 1 | eaves | 73.3 | 2.1 | --- | 68.3 | 1.500 | --- | 0.465 | 1.650 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 8

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 8

## General information

| | |
|---|---|
| Name | EcoYield Pilot Project |
| Mounting System | SolidRail |
| Author | Kye Barwell |

## Location information

| | |
|---|---|
| Address | Stanningley, Pudsey LS28 6QA, UK |
| Ground level | 141.89 m |

## Roof information

| | |
|---|---|
| Building height | 9.00 m |
| Roof type | Gable roof |
| Roof pitch | 30° |
| Roof covering | Tile |
| min. roof edge distance | 0.00 m |
| Rafter spacing | 0.300 m |
| Rafter width | 40.0 mm |
| Set rafter to left edge | No |
| Rafter spacing left | 165.0 mm |
| Set rafter to right edge | No |
| Rafter spacing right | 165.0 mm |
| Batten spacing | 150.0 mm |

## Loads

| | |
|---|---|
| Design method | BS EN |
| Failure consequence class | CC2 |
| Design working life | 25 years |
| Terrain category | Town terrain |
| Distance to shoreline | 65.70 km |
| Distance inside town terrain | 0.14 km |

### Wind load

| | |
|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ = 0.967 kN/m² |
| Adjustment factor for service life | $f_w$ = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ = 0.891 kN/m² |

# Structural analysis report | Area 8

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.356 | -0.534 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.356 | -0.802 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.200 | 0.713 | -1.069 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.445 | -0.534 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 8

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $= \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,Suction}$ |

### Usability

| | |
|---|---|
| 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 [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.329 | 0.582 | -0.686 | 0.067 | 0.897 | 0.395 | -0.419 | 0.067 |
| 1 | ridge | 10.00 | 1.329 | 0.582 | -1.087 | 0.067 | 0.897 | 0.395 | -0.686 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.651 | 0.582 | -1.488 | 0.067 | 1.112 | 0.395 | -0.954 | 0.067 |
| 1 | eaves | 10.00 | 1.409 | 0.582 | -0.686 | 0.067 | 0.951 | 0.395 | -0.419 | 0.067 |

# Structural analysis report | Area 8

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.628 | 0.275 | -0.324 | 0.031 | 0.424 | 0.186 | -0.198 | 0.031 |
| 1 | ridge | 10.00 | 0.628 | 0.275 | -0.514 | 0.031 | 0.424 | 0.186 | -0.324 | 0.031 |
| 1 | corner region (eave) | 10.00 | 0.780 | 0.275 | -0.703 | 0.031 | 0.525 | 0.186 | -0.451 | 0.031 |
| 1 | eaves | 10.00 | 0.666 | 0.275 | -0.324 | 0.031 | 0.449 | 0.186 | -0.198 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.6 | 0.0 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | ridge | 8.6 | 36.2 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | corner region (eave) | 10.3 | 43.3 | 90.5 | 1.9 | 0.300 | 1.500 | 0.300 | 0.331 |
| 1 | eaves | 9.0 | 0.0 | 79.3 | 1.6 | 0.300 | 1.500 | 0.300 | 0.379 |

# Structural analysis report | Area 8

## Upper Rail - Utilization result

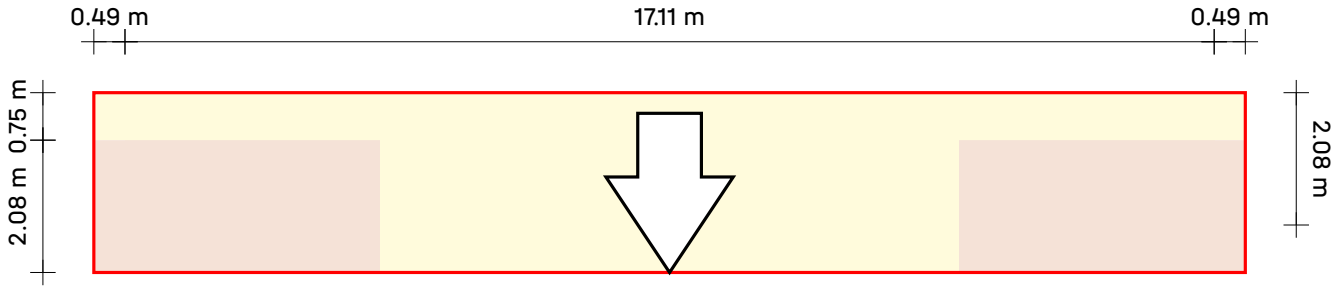
| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 69.2 | 0.0 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | ridge | 69.2 | 4.9 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | corner region (eave) | 85.6 | 2.4 | --- | 79.9 | 1.500 | --- | 0.445 | 1.587 |
| 1 | eaves | 73.3 | 2.1 | --- | 68.3 | 1.500 | --- | 0.465 | 1.650 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

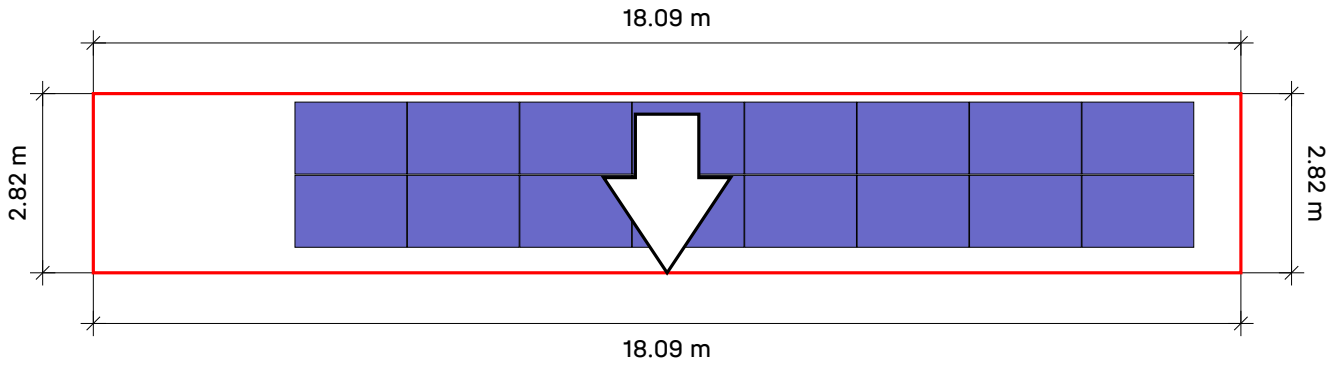
# Area 8 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 270 | 7.3 kg |
| 2 | 2004244 | SolidHook Vario 2 | 135 | 111.6 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 135 | 3.2 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 135 | 1.5 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 32 | 0.2 kg |
| 6 | 2002870 | K2 Solar Cable Manager | 16 | 0.0 kg |
| 7 | 2004264 | SolidRail UltraLight; 3.65 m | 12 | 30.8 kg |
| 8 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 9 | 2.0 kg |
| 9 | 2003145 | SingleRail Climber Set 36/50 | 48 | 3.2 kg |
| 10 | 2003072 | OneMid Black Set 30-42 | 16 | 1.3 kg |
| 11 | 2004545 | K2 Clamp EC 25-40 Black | 32 | 2.3 kg |
| 12 | 2004258 | SingleRail 36; 3.65 m | 16 | 45.0 kg |
| **Total** | | | | **208.4 kg** |

# Area 9



# Area 9




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 9<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |

# Area 9 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| **3*A** | **13.616 m** | **3*3.65 m** | **3.650** | **2.666 from 3.650** | **0.974** |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| **16*A** | **2.388 m** | | **3.650** | **2.388 from 3.650** | **1.252** |

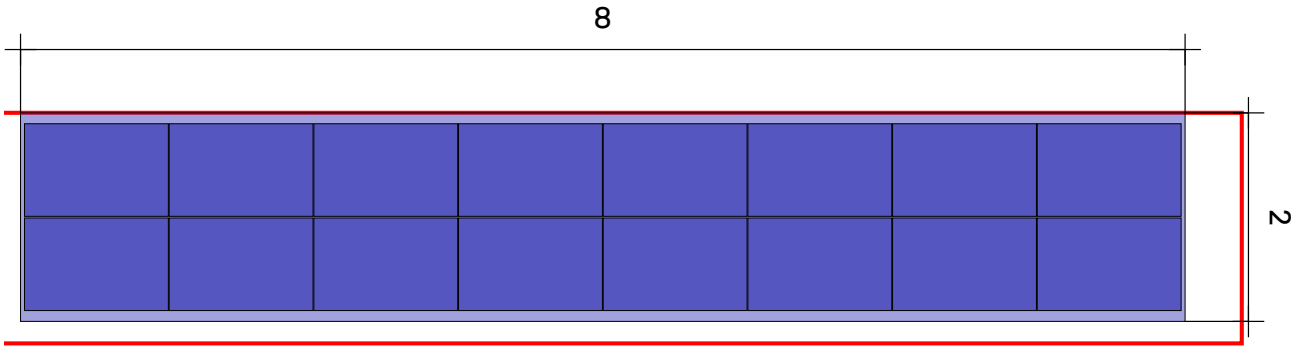
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| **1** | **field area** | **0.30 m** | **0.300** | **0.397** |
| **1** | **ridge** | **0.30 m** | **0.300** | **0.397** |
| **1** | **corner region (eave)** | **0.30 m** | **0.300** | **0.331** |
| **1** | **eaves** | **0.30 m** | **0.300** | **0.379** |

## Module arrays

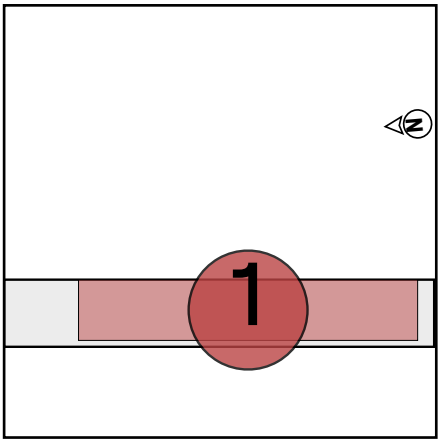
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| **1** | **14.17** | **2.29** | **8** | **2** |

# Area 9 | Module array 1

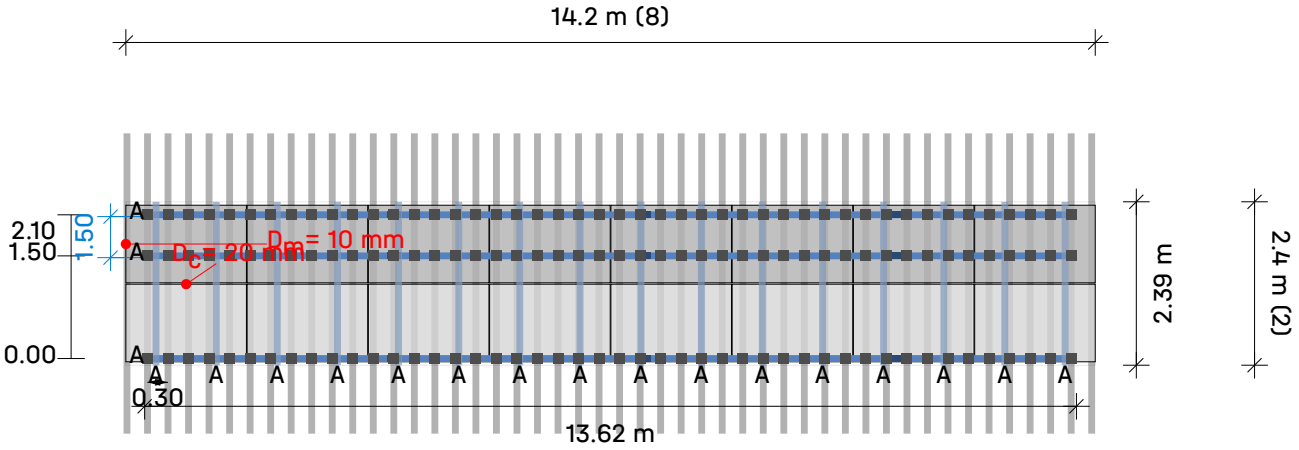



## Roof 9 Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 16(7.2 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 9 | Module array 1 | Module block 1

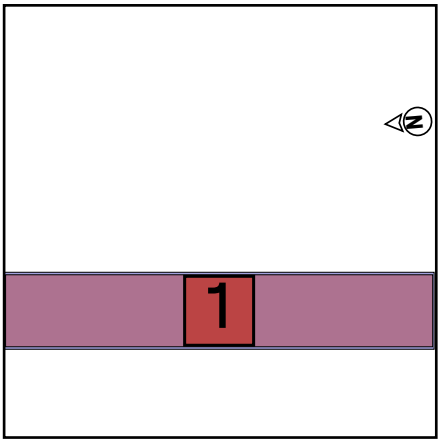



Roof 9 Module array 1 Module block 1

Modules 8 × 2 = **16**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Results | Area 9

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 9<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 2.00 | 1,328.7 | 582.0 | -686.4 | 66.5 | 897.3 | 394.7 | -419.2 | 66.5 |
| 1 | ridge | 2.00 | 1,328.7 | 582.0 | -1,087.2 | 66.5 | 897.3 | 394.7 | -686.4 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,650.5 | 582.0 | -1,488.0 | 66.5 | 1,111.9 | 394.7 | -953.6 | 66.5 |
| 1 | eaves | 2.00 | 1,408.8 | 582.0 | -686.4 | 66.5 | 950.7 | 394.7 | -419.2 | 66.5 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.6 | 0.0 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | ridge | 8.6 | 2.8 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | corner region (eave) | 10.3 | 3.4 | 90.5 | 1.9 | 0.300 | 1.500 | 0.300 | 0.331 |
| 1 | eaves | 9.0 | 0.0 | 79.3 | 1.6 | 0.300 | 1.500 | 0.300 | 0.379 |

# Results | Area 9

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 69.2 | 0.0 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | ridge | 69.2 | 5.6 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | corner region (eave) | 85.6 | 1.9 | --- | 79.9 | 1.500 | --- | 0.445 | 1.587 |
| 1 | eaves | 73.3 | 1.6 | --- | 68.3 | 1.500 | --- | 0.465 | 1.650 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 9

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 9

## General information

| | |
|---|---|
| Name | **EcoYield Pilot Project** |
| Mounting System | **SolidRail** |
| Author | **Kye Barwell** |

## Location information

| | |
|---|---|
| Address | **Stanningley, Pudsey LS28 6QA, UK** |
| Ground level | **141.89 m** |

## Roof information

| | |
|---|---|
| Building height | **9.00 m** |
| Roof type | **Gable roof** |
| Roof pitch | **30°** |
| Roof covering | **Tile** |
| min. roof edge distance | **0.00 m** |
| Rafter spacing | **0.300 m** |
| Rafter width | **40.0 mm** |
| Set rafter to left edge | **No** |
| Rafter spacing left | **195.0 mm** |
| Set rafter to right edge | **No** |
| Rafter spacing right | **195.0 mm** |
| Batten spacing | **150.0 mm** |

## Loads

| | |
|---|---|
| Design method | **BS EN** |
| Failure consequence class | **CC2** |
| Design working life | **25 years** |
| Terrain category | **Town terrain** |
| Distance to shoreline | **65.70 km** |
| Distance inside town terrain | **0.14 km** |

### Wind load

| | | |
|---|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ | = 0.967 kN/m² |
| Adjustment factor for service life | $f_w$ | = 1.000 |
| Velocity pressure, 25 years | $q_{p,25}$ | = 0.891 kN/m² |

# Structural analysis report | Area 9

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | field area | 10.00 | 0.400 | -0.600 | 0.356 | -0.534 |
| 1 | ridge | 10.00 | 0.400 | -0.900 | 0.356 | -0.802 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.200 | 0.713 | -1.069 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.445 | -0.534 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 1.000 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 9

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $= \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,Suction}$ |

### Usability

| | |
|---|---|
| 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 [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 1.329 | 0.582 | -0.686 | 0.067 | 0.897 | 0.395 | -0.419 | 0.067 |
| 1 | ridge | 10.00 | 1.329 | 0.582 | -1.087 | 0.067 | 0.897 | 0.395 | -0.686 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.651 | 0.582 | -1.488 | 0.067 | 1.112 | 0.395 | -0.954 | 0.067 |
| 1 | eaves | 10.00 | 1.409 | 0.582 | -0.686 | 0.067 | 0.951 | 0.395 | -0.419 | 0.067 |

# Structural analysis report | Area 9

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | field area | 10.00 | 0.628 | 0.275 | -0.324 | 0.031 | 0.424 | 0.186 | -0.198 | 0.031 |
| 1 | ridge | 10.00 | 0.628 | 0.275 | -0.514 | 0.031 | 0.424 | 0.186 | -0.324 | 0.031 |
| 1 | corner region (eave) | 10.00 | 0.780 | 0.275 | -0.703 | 0.031 | 0.525 | 0.186 | -0.451 | 0.031 |
| 1 | eaves | 10.00 | 0.666 | 0.275 | -0.324 | 0.031 | 0.449 | 0.186 | -0.198 | 0.031 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | 8.6 | 0.0 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | ridge | 8.6 | 2.8 | 75.5 | 1.5 | 0.300 | 1.500 | 0.300 | 0.397 |
| 1 | corner region (eave) | 10.3 | 3.4 | 90.5 | 1.9 | 0.300 | 1.500 | 0.300 | 0.331 |
| 1 | eaves | 9.0 | 0.0 | 79.3 | 1.6 | 0.300 | 1.500 | 0.300 | 0.379 |

# Structural analysis report | Area 9

## Upper Rail - Utilization result

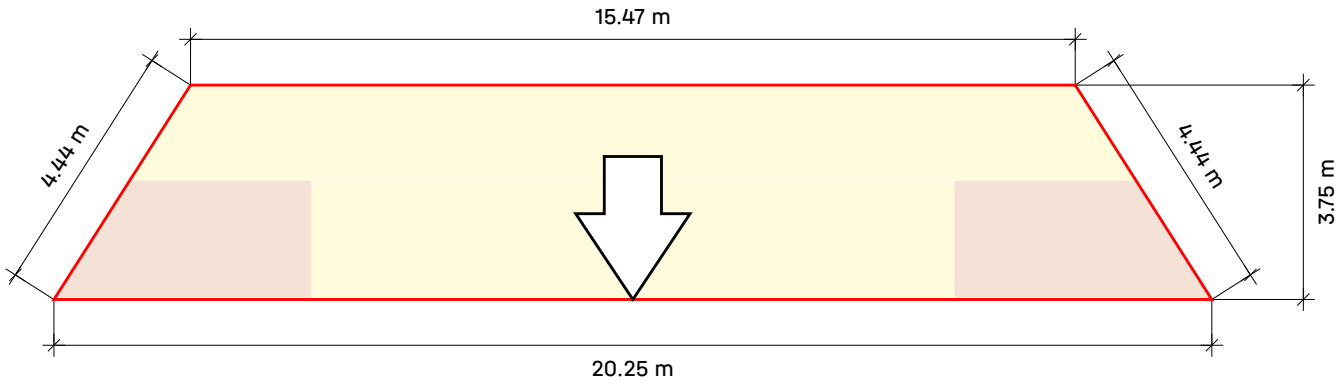
| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | field area | 69.2 | 0.0 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | ridge | 69.2 | 5.6 | --- | 64.5 | 1.500 | --- | 0.473 | 1.674 |
| 1 | corner region (eave) | 85.6 | 1.9 | --- | 79.9 | 1.500 | --- | 0.445 | 1.587 |
| 1 | eaves | 73.3 | 1.6 | --- | 68.3 | 1.500 | --- | 0.465 | 1.650 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

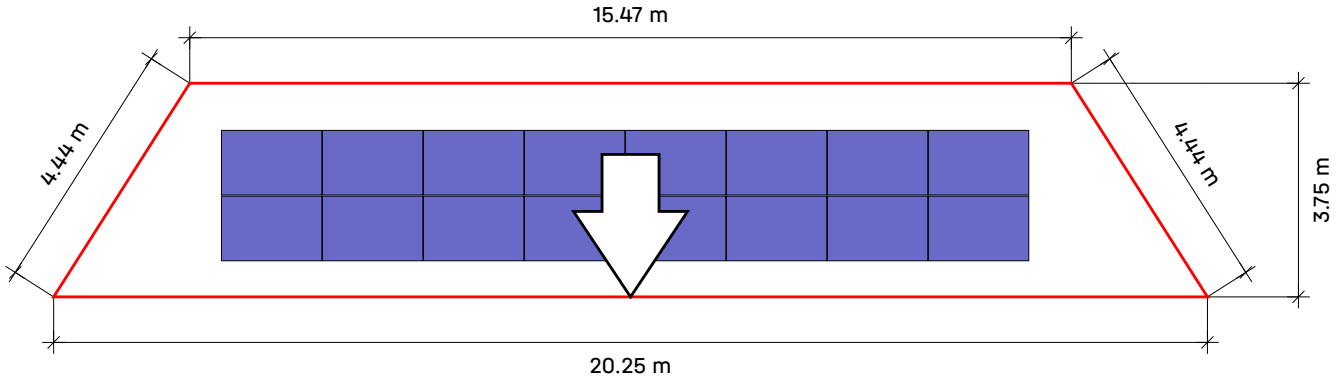
# Area 9 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 276 | 7.5 kg |
| 2 | 2004244 | SolidHook Vario 2 | 138 | 114.1 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 138 | 3.2 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 138 | 1.5 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 32 | 0.2 kg |
| 6 | 2002870 | K2 Solar Cable Manager | 16 | 0.0 kg |
| 7 | 2004264 | SolidRail UltraLight; 3.65 m | 12 | 30.8 kg |
| 8 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 9 | 2.0 kg |
| 9 | 2003145 | SingleRail Climber Set 36/50 | 48 | 3.2 kg |
| 10 | 2003072 | OneMid Black Set 30-42 | 16 | 1.3 kg |
| 11 | 2004545 | K2 Clamp EC 25-40 Black | 32 | 2.3 kg |
| 12 | 2004258 | SingleRail 36; 3.65 m | 16 | 45.0 kg |
| **Total** | | | | **211.2 kg** |

# Area 10



# Area 10




| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 10<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |

# Area 10 | Assembly plan

## Base Rails

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| **3*A** | **13.616 m** | **3*3.65 m** | **3.650** | **2.666 from 3.650** | **0.974** |

1 cm is viewed as lost for each cutting

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

## Upper Rail

| | Whole Rails | | Rail cutting | | |
|---|---|---|---|---|---|
| Type | Total Rail Length | Quantity 3.65 m | Part of Rail / Rest | Length | Rest |
| **16*A** | **2.388 m** | | **3.650** | **2.388 from 3.650** | **1.252** |

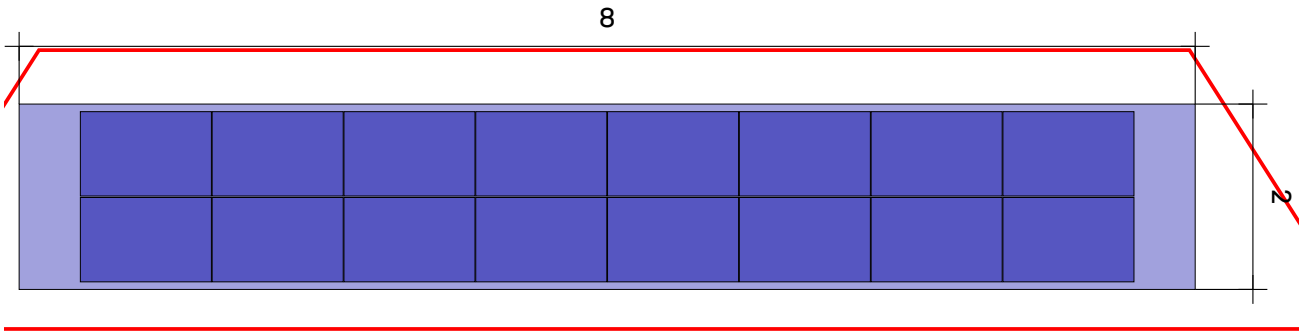
## Fastener Spacing

| Module | Array | Distance | maximum cantilever length [m] | maximum fastener spacing [m] |
|---|---|---|---|---|
| **1** | **ridge** | **0.30 m** | **0.300** | **0.438** |
| **1** | **gableboard** | **0.30 m** | **0.300** | **0.438** |
| **1** | **eaves** | **0.30 m** | **0.300** | **0.417** |
| **1** | **corner region (eave)** | **0.30 m** | **0.300** | **0.366** |

## Module arrays

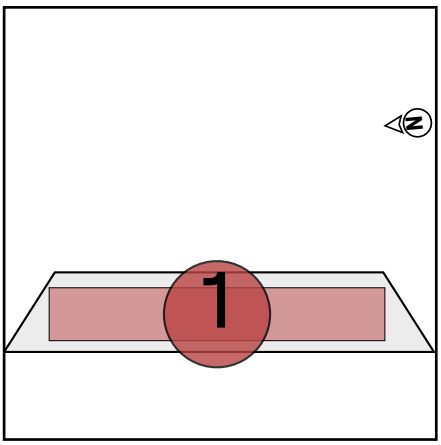
| Module array | Width[m] | Length[m] | Width in modules | Length in modules |
|---|---|---|---|---|
| **1** | **14.17** | **2.29** | **8** | **2** |

# Area 10 | Module array 1

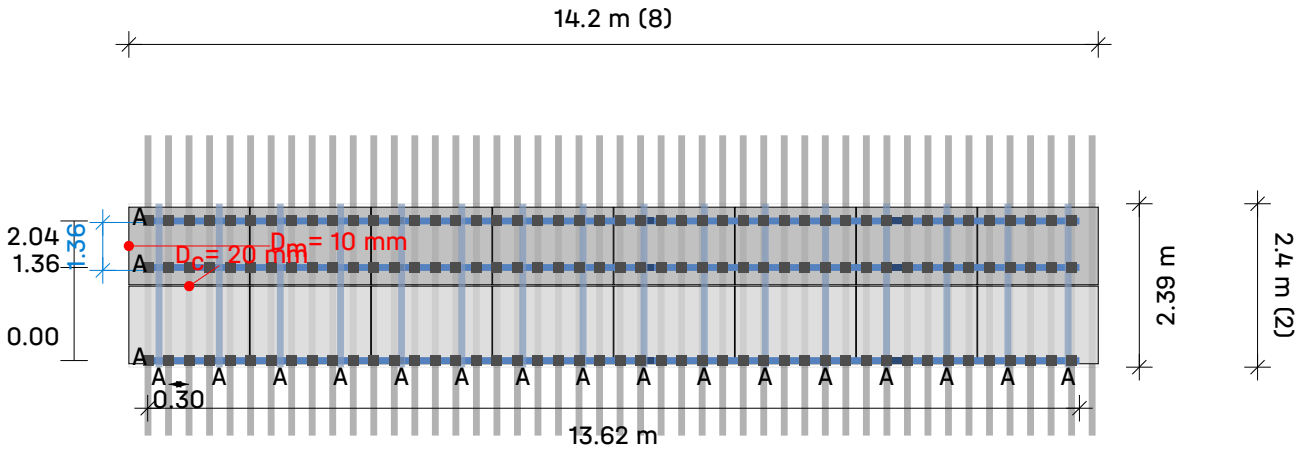



## Roof (10) Module array 1

| | |
|---|---|
| Mounting System | SolidRail |
| Module | 16(7.2 kWp) x JAM54D40-450/LB |
| Row spacing | 1.77 m |



# Area 10 | Module array 1 | Module block 1

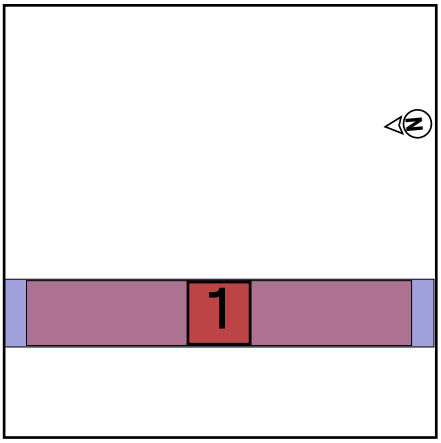



Roof (10) Module array 1 Module block 1

Modules 8 × 2 = **16**

Legend

- Fastener
- Mounting rail: K2 SolidRail UltraLight 32
- Mounting rail (Upper): K2 SingleRail 36
- Rail Distance [m]
- Dc Distance for clamping between modules
- Dm Distance between modules



# Results | Area 10

| Roof | System | Module | Height | Quantity | Total power |
|---|---|---|---|---|---|
| Area 10<br>Tile | SolidRail | JAM54D40-450/LB<br>1,762×1,134×30 mm<br>450 Wp | 9.00 m | 16 | 7.2 kWp |

## Module

| | |
|---|---|
| Name | JAM54D40-450/LB |
| Manufacturer | Shanghai JA Solar Technology Co. Ltd. |
| Output power | 450 Wp |
| Dimensions | 1,762×1,134×30 mm |
| Weight | 22.0 kg |

## Components

| | |
|---|---|
| Fastener | SolidHook Vario 2 |
| Base rails | K2 SolidRail UltraLight 32 |
| Upper Rail | K2 SingleRail 36 |

## Loads on modules (module dimensioning)

| No. Module Array | Array | A-TrA [m²] | ultimate state [Pa] | | | | serviceability [Pa] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | ridge | 2.00 | 1,328.7 | 582.0 | -953.6 | 66.5 | 897.3 | 394.7 | -597.3 | 66.5 |
| 1 | gableboard | 2.00 | 1,328.7 | 582.0 | -1,621.6 | 66.5 | 897.3 | 394.7 | -1,042.6 | 66.5 |
| 1 | eaves | 2.00 | 1,408.8 | 582.0 | -686.4 | 66.5 | 950.7 | 394.7 | -419.2 | 66.5 |
| 1 | corner region (eave) | 2.00 | 1,650.5 | 582.0 | -1,621.6 | 66.5 | 1,111.9 | 394.7 | -1,042.6 | 66.5 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | ridge | 7.8 | 0.0 | 68.5 | 1.4 | 0.300 | 1.360 | 0.300 | 0.438 |
| 1 | gableboard | 7.8 | 5.7 | 68.5 | 1.6 | 0.300 | 1.360 | 0.300 | 0.438 |
| 1 | eaves | 8.2 | 0.0 | 71.9 | 1.5 | 0.300 | 1.360 | 0.300 | 0.417 |
| 1 | corner region (eave) | 9.3 | 6.7 | 82.1 | 1.7 | 0.300 | 1.360 | 0.300 | 0.366 |

# Results | Area 10

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ridge | 57.0 | 9.8 | --- | 48.1 | 1.360 | --- | 0.483 | 1.674 |
| 1 | gableboard | 68.1 | 11.6 | --- | 55.8 | 1.360 | --- | 0.463 | 1.612 |
| 1 | eaves | 60.3 | 1.6 | --- | 50.9 | 1.360 | --- | 0.475 | 1.650 |
| 1 | corner region (eave) | 70.5 | 1.8 | --- | 59.5 | 1.360 | --- | 0.455 | 1.587 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Results | Area 10

## Note

- The dimensioning of the timber construction screws is not part of this structual 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, fW, is according to DIN EN 1991-1-4/ NA, NDP for 4.2 (2P) note 5, table 3
- Adjustment factor for snow load regarding service life period, fS, is according to DIN EN 1991-1-3/ annex D, table 4
- The structural design complies with BS EN 1990 - Basis of Structural Design.
- The snow loads are determined according to the national appendix BS NA EN 1991-1-3 (2018) - 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 | Area 10

## General information

| | |
|---|---|
| Name | **EcoYield Pilot Project** |
| Mounting System | **SolidRail** |
| Author | **Kye Barwell** |

## Location information

| | |
|---|---|
| Address | **Stanningley, Pudsey LS28 6QA, UK** |
| Ground level | **141.89 m** |

## Roof information

| | |
|---|---|
| Building height | **9.00 m** |
| Roof type | **Hip roof** |
| Roof pitch | **30°** |
| Roof covering | **Tile** |
| min. roof edge distance | **0.00 m** |
| Rafter spacing | **0.300 m** |
| Rafter width | **40.0 mm** |
| Set rafter to left edge | **No** |
| Rafter spacing left | **225.0 mm** |
| Set rafter to right edge | **No** |
| Rafter spacing right | **225.0 mm** |
| Batten spacing | **340.0 mm** |

## Loads

| | |
|---|---|
| Design method | **BS EN** |
| Failure consequence class | **CC2** |
| Design working life | **25 years** |
| Terrain category | **Town terrain** |
| Distance to shoreline | **65.70 km** |
| Distance inside town terrain | **0.14 km** |

### Wind load

| | | |
|---|---|---|
| Velocity pressure, 50 years | $q_{p,50}$ | = 0.967 kN/m² |
| Adjustment factor for service life | $f_w$ | = 0.921 |
| Velocity pressure, 25 years | $q_{p,25}$ | = 0.891 kN/m² |

# Structural analysis report | Area 10

## Roof areas

| No.<br>Module Array | Array | load impact area [m²] | maxCpe | minCpe | wind pressure [kN/m²] | wind uplift [kN/m²] |
|---|---|---|---|---|---|---|
| 1 | ridge | 10.00 | 0.400 | -0.800 | 0.356 | -0.713 |
| 1 | gableboard | 10.00 | 0.400 | -1.300 | 0.356 | -1.158 |
| 1 | eaves | 10.00 | 0.500 | -0.600 | 0.445 | -0.534 |
| 1 | corner region (eave) | 10.00 | 0.800 | -1.300 | 0.713 | -1.158 |

## Snow load

| | | |
|---|---|---|
| Snow load zone | | 4 |
| Snow guard | | No |
| Snow load on ground level | $s_k$ | = 0.680 kN/m² |
| Shape Coefficient for Snow | $\mu_i$ | = 1.200 |
| Factor for roof pitch | $d_i$ | = 0.866 |
| Snow load on roof, 50 year | $s_{i,50}$ | = 0.706 kN/m² |
| Adjustment factor for service life | $f_s$ | = 0.929 |
| Snow load on roof, 25 years | $s_{i,25}$ | = 0.656 kN/m² |

## Dead Load

| | | |
|---|---|---|
| Weight of module | $G_M$ | = 22.0 kg |
| Weight of mounting system per module | | = 5.1 kg |
| Module area | $A_M$ | = 2.00 m² |
| Dead weight of module per m² | | = 11.01 kg/m² |
| Dead weight of mounting system per m² | | = 2.55 kg/m² |
| Total Dead Load (excl. ballast) per m² | | = 0.13 kN/m² |

# Structural analysis report | Area 10

## Load Combinations

### Load-bearing capacity

| | |
|---|---|
| Partial safety factor unfavorable permanent load | $\gamma_{G,sup}$ = 1.35 |
| Partial safety factor favorable permanent load | $\gamma_{G,inf}$ = 1.00 |
| Partial safety factor destabilising permanent load | $\gamma_{G,dst}$ = 1.10 |
| Partial safety factor stabilising permanent load | $\gamma_{G,stb}$ = 0.90 |
| Partial safety factor variable loads | $\gamma_{Q}$ = 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 | $= \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,Suction}$ |

### Usability

| | |
|---|---|
| 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 [m²] | ultimate state [kN/m²] | | | | serviceability [kN/m²] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | ridge | 10.00 | 1.329 | 0.582 | -0.954 | 0.067 | 0.897 | 0.395 | -0.597 | 0.067 |
| 1 | gableboard | 10.00 | 1.329 | 0.582 | -1.622 | 0.067 | 0.897 | 0.395 | -1.043 | 0.067 |
| 1 | eaves | 10.00 | 1.409 | 0.582 | -0.686 | 0.067 | 0.951 | 0.395 | -0.419 | 0.067 |
| 1 | corner region (eave) | 10.00 | 1.651 | 0.582 | -1.622 | 0.067 | 1.112 | 0.395 | -1.043 | 0.067 |

# Structural analysis report | Area 10

## Max. load on fastener

| No. Module Array | Array | A-TrA [m²] | ultimate state [kN] | | | | serviceability [kN] | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ | Pressure ⊥ | Pressure ∥ | Uplift ⊥ | Uplift ∥ |
| 1 | ridge | 10.00 | 0.569 | 0.249 | -0.409 | 0.028 | 0.384 | 0.169 | -0.256 | 0.028 |
| 1 | gableboard | 10.00 | 0.569 | 0.249 | -0.695 | 0.028 | 0.384 | 0.169 | -0.447 | 0.028 |
| 1 | eaves | 10.00 | 0.604 | 0.249 | -0.294 | 0.028 | 0.407 | 0.169 | -0.180 | 0.028 |
| 1 | corner region (eave) | 10.00 | 0.707 | 0.249 | -0.695 | 0.028 | 0.476 | 0.169 | -0.447 | 0.028 |

## Resistance Values of Components

### Base Rails

| Base Rails | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SolidRail UltraLight 32 | 2.610 | 2.59 | 5.54 | 1.57 | 2.84 |

### Upper rail

| Upper rail | A [cm²] | $I_y$ [cm⁴] | $I_z$ [cm⁴] | $W_y$ [cm³] | $W_z$ [cm³] |
|---|---|---|---|---|---|
| K2 SingleRail 36 | 2.850 | 4.02 | 6.37 | 2.14 | 3.09 |

### Fastener

| Fastener | $R_{D,Uplift,Perpendicular}$ [kN] | $R_{D,Pressure,Perpendicular}$ [kN] | $R_{D,Pressure,Parallel}$ [kN] |
|---|---|---|---|
| SolidHook Vario 2 | 1.36 | 1.01 | 2.06 |

### Base Rails - Utilization result

| No. Module Array | roof areas | load-bearing capacity | | | 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 | ridge | 7.8 | 0.0 | 68.5 | 1.4 | 0.300 | 1.360 | 0.300 | 0.438 |
| 1 | gableboard | 7.8 | 5.7 | 68.5 | 1.6 | 0.300 | 1.360 | 0.300 | 0.438 |
| 1 | eaves | 8.2 | 0.0 | 71.9 | 1.5 | 0.300 | 1.360 | 0.300 | 0.417 |
| 1 | corner region (eave) | 9.3 | 6.7 | 82.1 | 1.7 | 0.300 | 1.360 | 0.300 | 0.366 |

# Structural analysis report | Area 10

## Upper Rail - Utilization result

| No. Module Array | roof areas | load-bearing capacity Pr σ[%] | load-bearing capacity CL σ[%] | load-bearing capacity Fst F[%] | Usab. Pr f[%] | Distances Fst [m] | Distances UR [m] | maximum values CL $L_{max}$[m] | maximum values Fst Fst $D_{max}$[m] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ridge | 57.0 | 9.8 | --- | 48.1 | 1.360 | --- | 0.483 | 1.674 |
| 1 | gableboard | 68.1 | 11.6 | --- | 55.8 | 1.360 | --- | 0.463 | 1.612 |
| 1 | eaves | 60.3 | 1.6 | --- | 50.9 | 1.360 | --- | 0.475 | 1.650 |
| 1 | corner region (eave) | 70.5 | 1.8 | --- | 59.5 | 1.360 | --- | 0.455 | 1.587 |

| | | | |
|---|---|---|---|
| Pr | **Profile** | Fst $D_{max}$ | **maximum fastener spacing [m]** |
| Fst | **Fastener** | BR | **base rail** |
| σ | **Stress** | UR | **Upper rail** |
| f | **deflection** | Usab. | **usability** |
| F | **Force** | CL | **Cantilever** |
| CL/$L_{max}$ | **maximum cantilever length [m]** | | |

# Area 10 | Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 276 | 7.5 kg |
| 2 | 2004244 | SolidHook Vario 2 | 138 | 114.1 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 138 | 3.2 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 138 | 1.5 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 32 | 0.2 kg |
| 6 | 2002870 | K2 Solar Cable Manager | 16 | 0.0 kg |
| 7 | 2004264 | SolidRail UltraLight; 3.65 m | 12 | 30.8 kg |
| 8 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 9 | 2.0 kg |
| 9 | 2003145 | SingleRail Climber Set 36/50 | 48 | 3.2 kg |
| 10 | 2003072 | OneMid Black Set 30-42 | 16 | 1.3 kg |
| 11 | 2004545 | K2 Clamp EC 25-40 Black | 32 | 2.3 kg |
| 12 | 2004258 | SingleRail 36; 3.65 m | 16 | 45.0 kg |
| **Total** | | | | **211.2 kg** |

# Bill of material

| Position | Item no. | Item description | Quantity | Weight |
|---|---|---|---|---|
| 1 | 2004112 | Wood screw 8×100 | 4,504 | 121.6 kg |
| 2 | 2004244 | SolidHook Vario 2 | 2,252 | 1,862.4 kg |
| 3 | 1000041 | T-Bolt 28/15 M10×30 | 2,252 | 52.7 kg |
| 4 | 1000042 | Hexagon flange nut M10 | 2,252 | 24.8 kg |
| 5 | 1004767 | SingleRail 36 End Cap | 428 | 3.0 kg |
| 6 | 2003523 | BlackCover SingleRail 36 | 128 | 3.3 kg |
| 7 | 2002870 | K2 Solar Cable Manager | 334 | 0.9 kg |
| 8 | 2004264 | SolidRail UltraLight; 3.65 m | 196 | 503.3 kg |
| 9 | 1004107 | SolidRail UtraLight+Light RailConnector Set | 158 | 35.5 kg |
| 10 | 2003145 | SingleRail Climber Set 36/50 | 802 | 53.7 kg |
| 11 | 2003072 | OneMid Black Set 30-42 | 454 | 35.9 kg |
| 12 | 2004545 | K2 Clamp EC 25-40 Black | 428 | 30.7 kg |
| 13 | 2004258 | SingleRail 36; 3.65 m | 294 | 826.1 kg |
| 14 | 2001976 | SingleRail 36 RailConnector Set | 80 | 30.1 kg |
| **Total** | | | | **3,584.1 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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