

ANALYSIS

Middle clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 21699 \text{ mm}$ $y = 13109 \text{ mm}$

Loads: $V_{x,d} = 0.01 \text{ kN}$

$V_{y,d} = 0.31 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.01/1.84; 0.31/1.29) = 0.24 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 21699 \text{ mm}$ $y = 13109 \text{ mm}$

Loads: $V_{x,d} = 0.02 \text{ kN}$

$V_{y,d} = 0.24 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.02/1.84; 0.24/1.29) = 0.19 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 21699 \text{ mm}$ $y = 11892 \text{ mm}$

Loads: $N_d = -0.53 \text{ kN}$

$V_{x,d} = 0.00 \text{ kN}$

$V_{y,d} = 0.36 \text{ kN}$

Comparison stress: $N_d/F_{R,d,x} + \text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = 0.53/3.41 + \text{MAX} (0.00/1.72; 0.36/1.20) = 0.46 < 1$

ANALYSIS

End clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 24070 \text{ mm}$ $y = 5513 \text{ mm}$

Loads: $V_{x,d} = 0.01 \text{ kN}$

$V_{y,d} = 0.15 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.01/0.95; 0.15/1.32) = 0.12 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 24070 \text{ mm}$ $y = 5513 \text{ mm}$

Loads: $V_{x,d} = 0.01 \text{ kN}$

$V_{y,d} = 0.12 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.01/0.95; 0.12/1.32) = 0.09 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 24070 \text{ mm}$ $y = 4296 \text{ mm}$

Loads: $N_d = -0.28 \text{ kN}$

$V_{x,d} = 0.00 \text{ kN}$

$V_{y,d} = 0.18 \text{ kN}$

Comparison stress: $N_d/F_{R,d,x} + \text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = 0.28/3.08 + \text{MAX} (0.00/0.93; 0.18/1.28) = 0.23 < 1$

ANALYSIS

Fastener

General

The resistances were determined on the user's own responsibility.

Design values of load capacity

$$\begin{aligned}F_{R,d,x} &= 5.00 \text{ kN} \\F_{R,d,-x} &= 3.50 \text{ kN} \\F_{R,d,y} &= 2.50 \text{ kN} \\F_{R,d,z} &= 2.50 \text{ kN}\end{aligned}$$

LCC 1

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 21699 \text{ mm}$ $y = 13007 \text{ mm}$

Loads: $N_d = 0.61 \text{ kN}$
 $V_{x,d} = 0.02 \text{ kN}$
 $V_{y,d} = 0.52 \text{ kN}$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} + V_{y,d}/F_{R,d,z} = 0.61/5.00 + 0.02/2.50 + 0.52/2.50 = 0.34 < 1$

LCC 2

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 21699 \text{ mm}$ $y = 13007 \text{ mm}$

Loads: $N_d = 0.98 \text{ kN}$
 $V_{x,d} = 0.03 \text{ kN}$
 $V_{y,d} = 0.31 \text{ kN}$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} + V_{y,d}/F_{R,d,z} = 0.98/5.00 + 0.03/2.50 + 0.31/2.50 = 0.33 < 1$

LCC 3

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 21699 \text{ mm}$ $y = 13007 \text{ mm}$

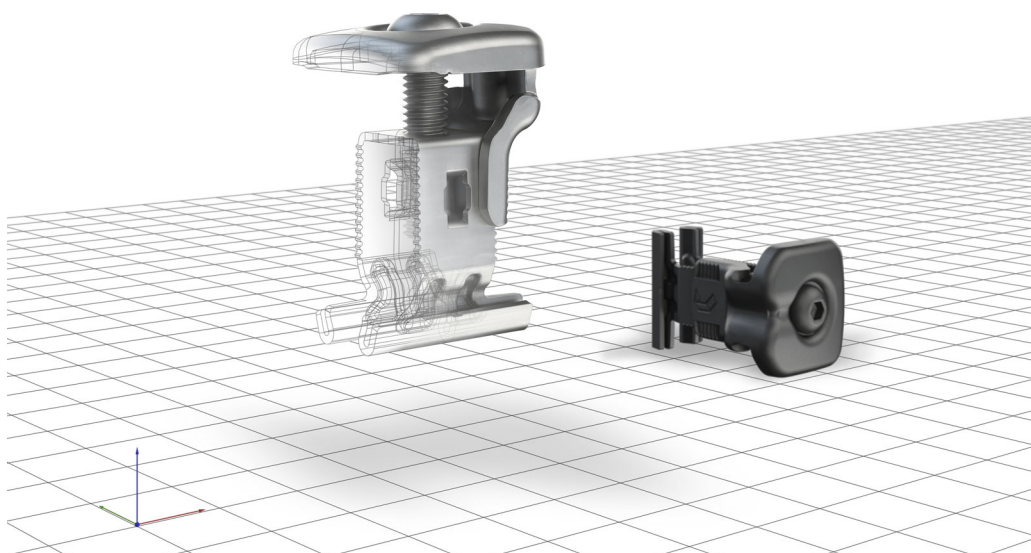
Loads: $N_d = -1.17 \text{ kN}$
 $V_{x,d} = 0.01 \text{ kN}$
 $V_{y,d} = 0.52 \text{ kN}$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} + V_{y,d}/F_{R,d,z} = 1.17/3.50 + 0.01/2.50 + 0.52/2.50 = 0.54 < 1$

Technical project overview

Echo Street, Manchester, M1 7DP

Building project	Echo Street, Manchester, M1 7DP
Address	Echo Street 17, M1 3AL
Country	United Kingdom
Module Type	Canadian Solar Inc. - CS6.1-72TB-610
Number of modules	38
Rated output	23.18 kWp
Mounting system	FixedFS10EW
Editor	Renusol Europe GmbH



LOCATION

Street	Echo Street 17
City	M1 3AL
Country	United Kingdom

SURROUNDINGS

Code	Eurocode NA GB
Terrain height above sealevel	47,00 m
Snow load zone	Zone 3
Use Pressure coefficients from BRE 489 2014 roof pitch 0 -45°	yes
Terrain category	City
Distance to coast	40,00 km
Distance to edge of city	3,00 km
Surroundings	normal
Service life of PV system	25 years
Failure consequence class	2

LOAD CALCULATION RESULT

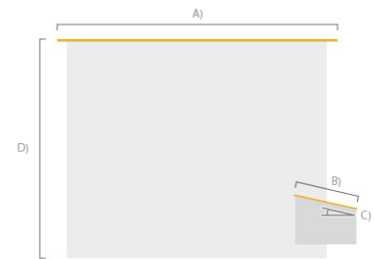
Peak velocity pressure	1,16 kN/m ²
Snow load	0,46 kN/m ²
Snow load on roof	0,37 kN/m ²
Base wind speed ($V_{b,0}$)	22,50 m/s

TOPOGRAPHY

Topography	Not exposed
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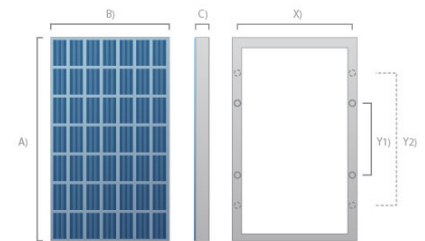
ROOF PROPERTIES

Roof type	Flat roof
Coverage type	Foil
C) Roof pitch	2,00 °
D) Building height	87,00 m
Parapet height	0,00 mm
Parapet width	0,00 mm



MODULE PARAMETERS

Manufacturer	Canadian Solar Inc.
Name	CS6.1-72TB-610
Length	2382 mm
Width	1134 mm
Height	30 mm
Weight	33.6 kg
Rated output	610 W _{peak}



Please check the compatibility of clamping positions with module manufacturer advice.

FASTENER PARAMETERS

Name	Rooftrak IFP-HM/MW
Manufacturer	Nicholson
Pressure load capacity	5,00 kN
Tensile load capacity	3,50 kN
Lateral force	2,50 kN
Interaction	Linear

The third party product(s) listed above, is (are) not (a) product of Renusol but, from third party Manufacturer(s) (Manufacturer). The PV-Configurator uses static properties of this fastener provided by this Manufacturer. The Manufacturer is responsible for the accurateness and correctness of the static values provided by him, Renusol does not assume any liability regarding the product of the Manufacturer and its static properties.

SYSTEM

System type	Fixed
System	FixedFS10EW



Please check the entered row distance for an ideal yield calculation with a correct calculation including consideration of the shading.

FASTENER DETAILS

Mounting rotation	Eave (0°)
Fastener type	Custom fastener
X) Row distance	2462mm

CLAMPS

Clamp type	RS1
Clamp colour	silver
Max value middle clamps	49 %
Max value end clamps	24 %

STATIC VALIDATION

Your project was validated by our statics check successfully.

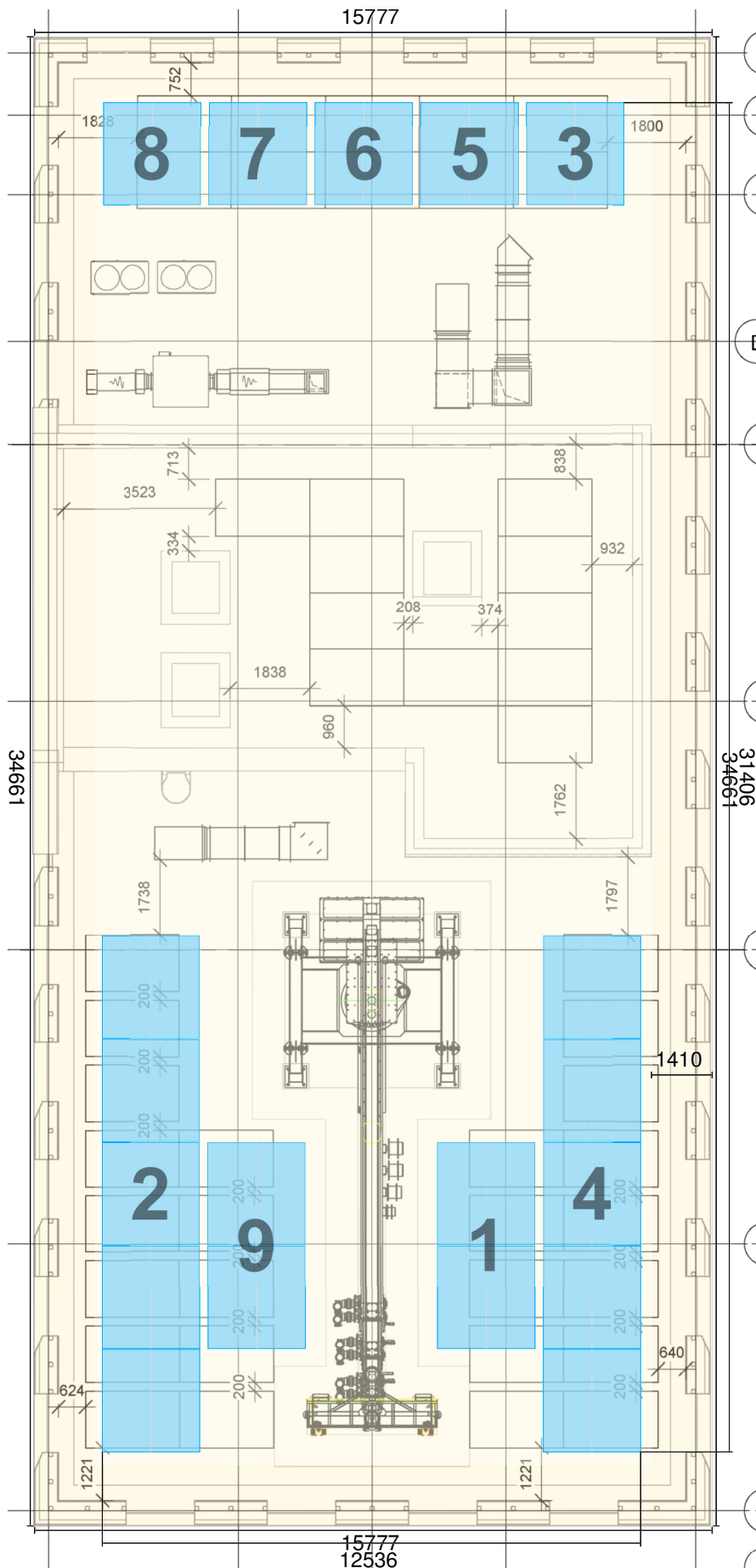
Static utilization factor: 58%

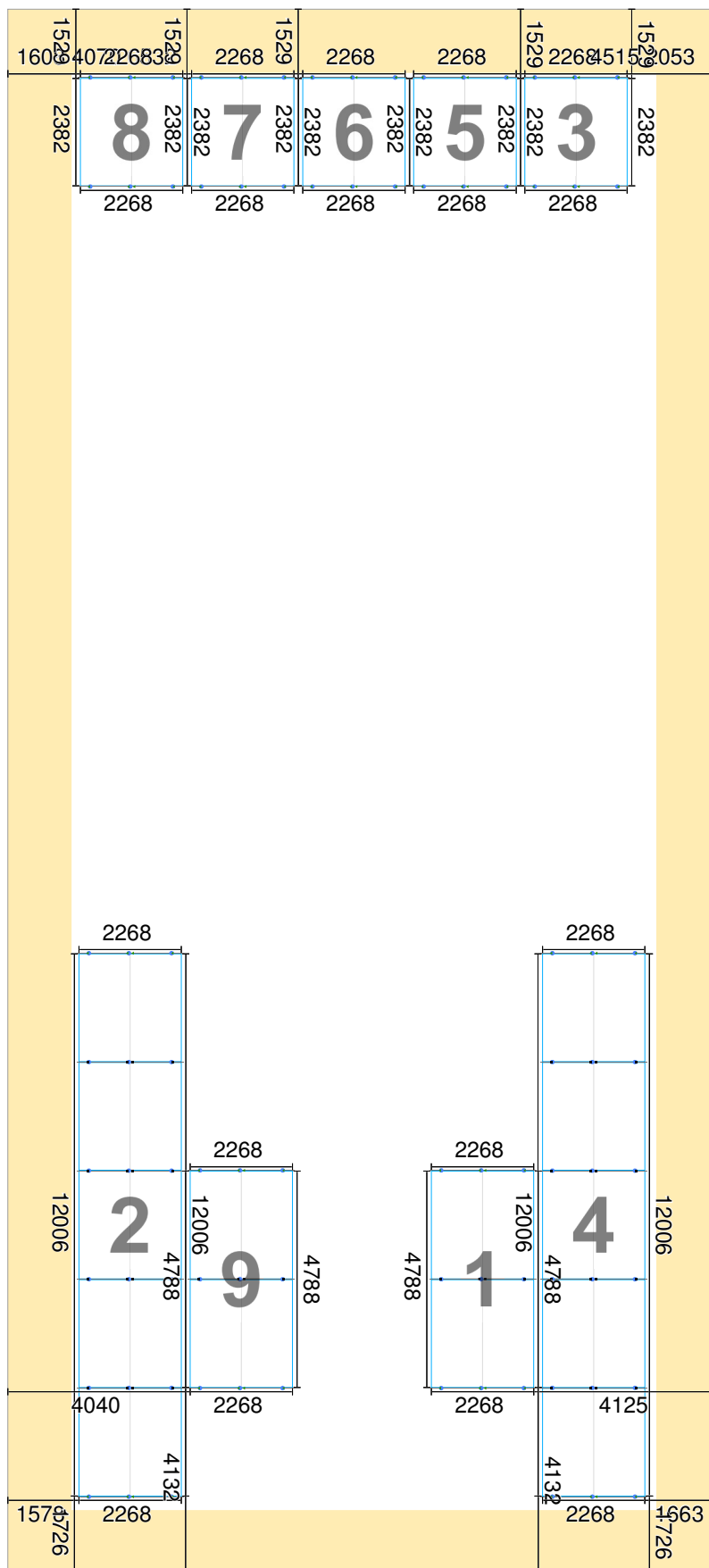
Static utilization fastener: 58%

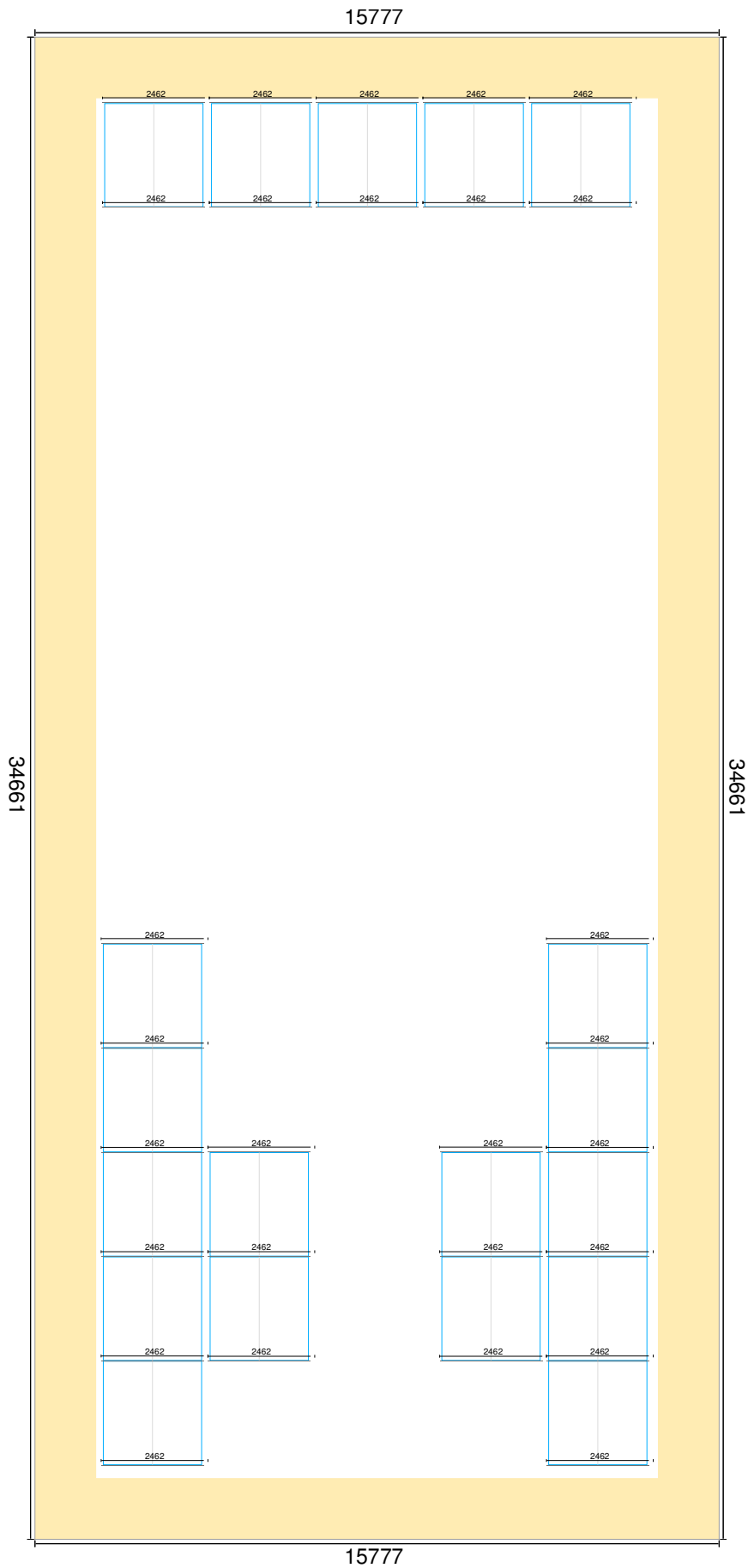
Static utilization clamp: 49%

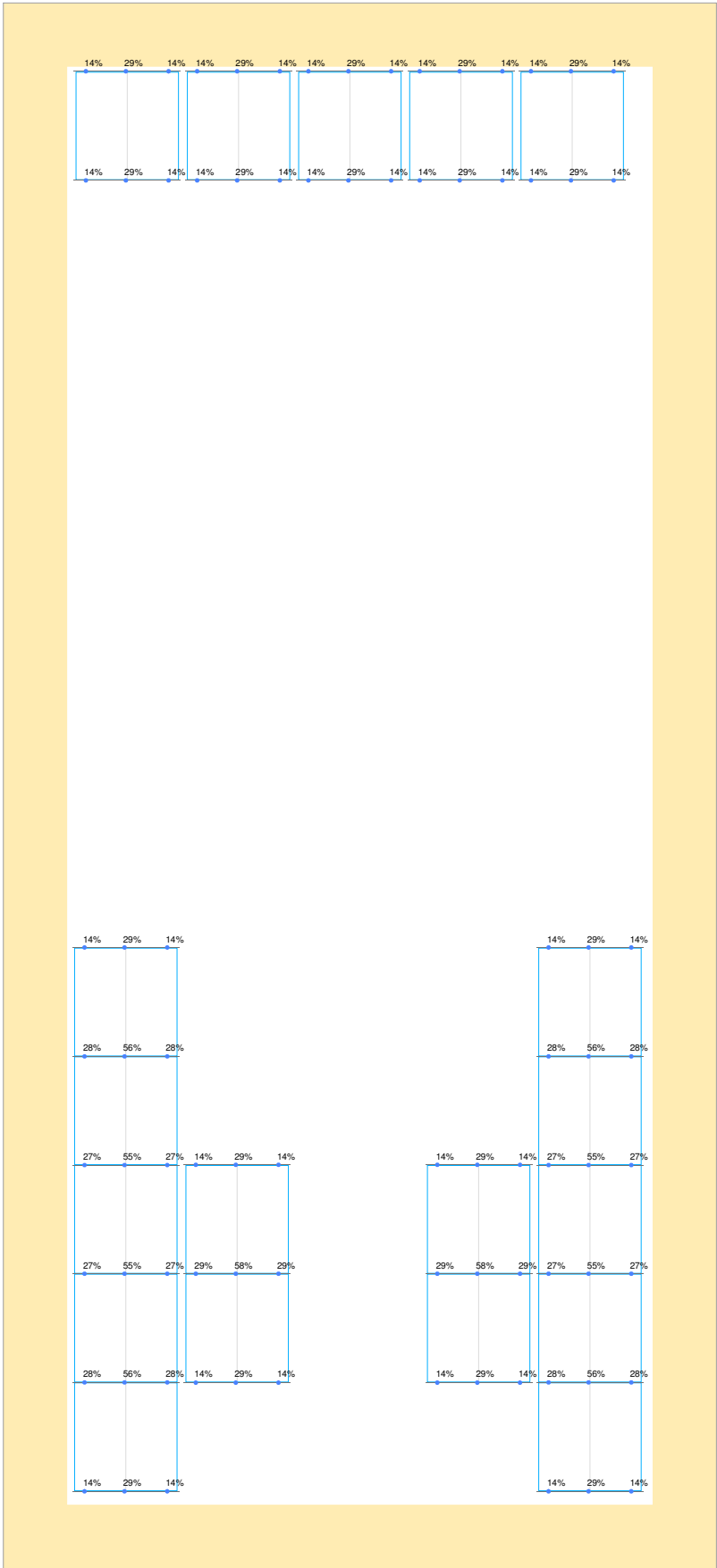
The predefined default values for input fields have to be compared with the conditions of the project. Necessary changes to adapt to local conditions must be carried out. The following relevant input fields contain their default value:

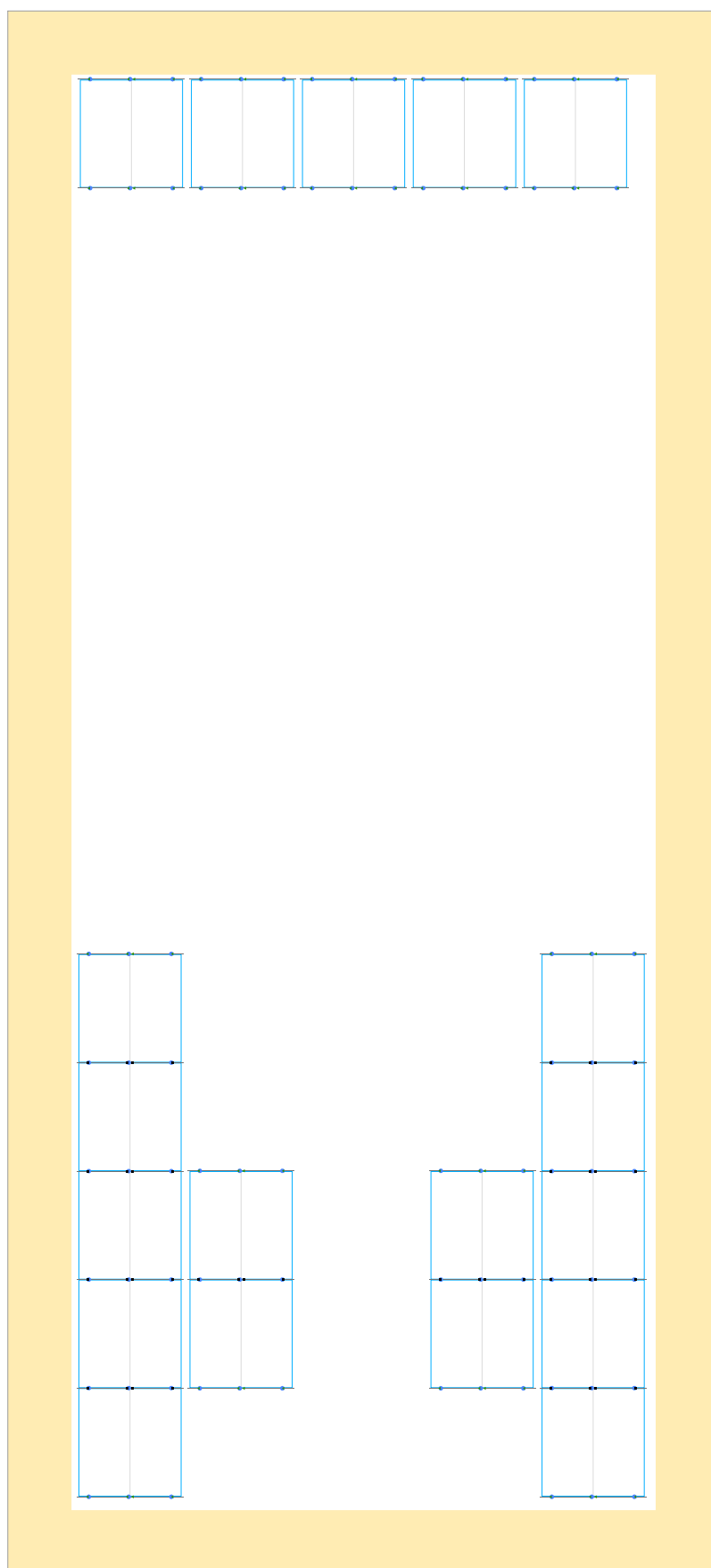
- Service life of PV system: 25 years
- Failure consequence class: 2



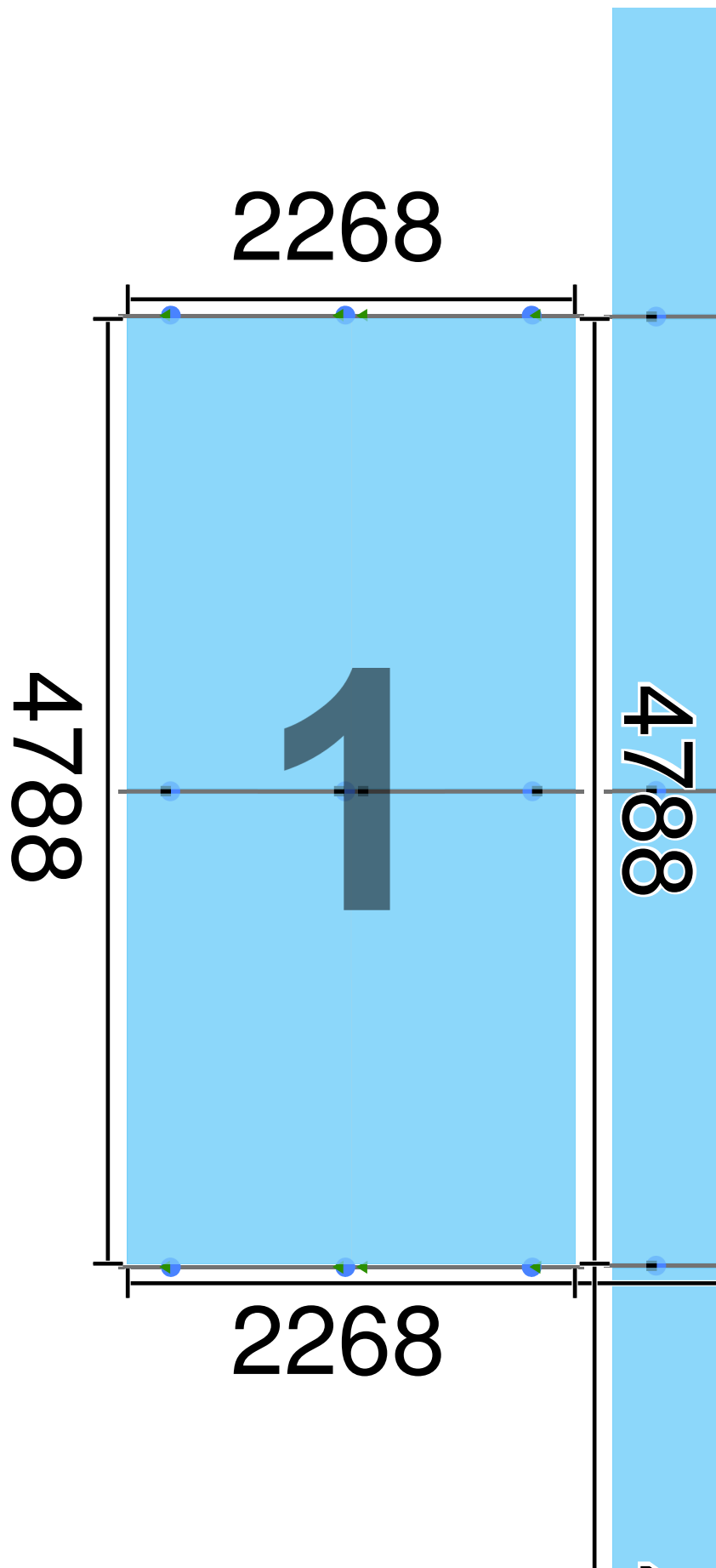


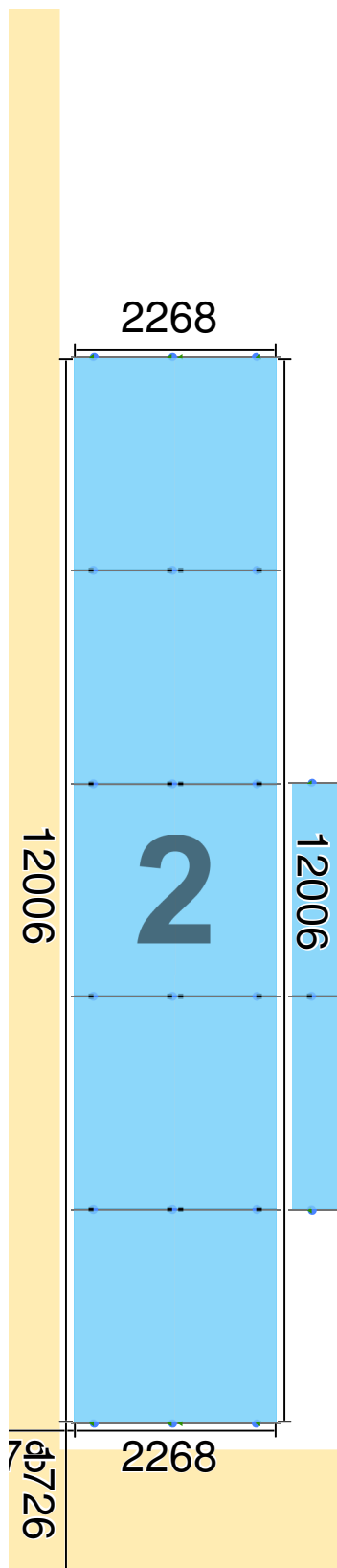


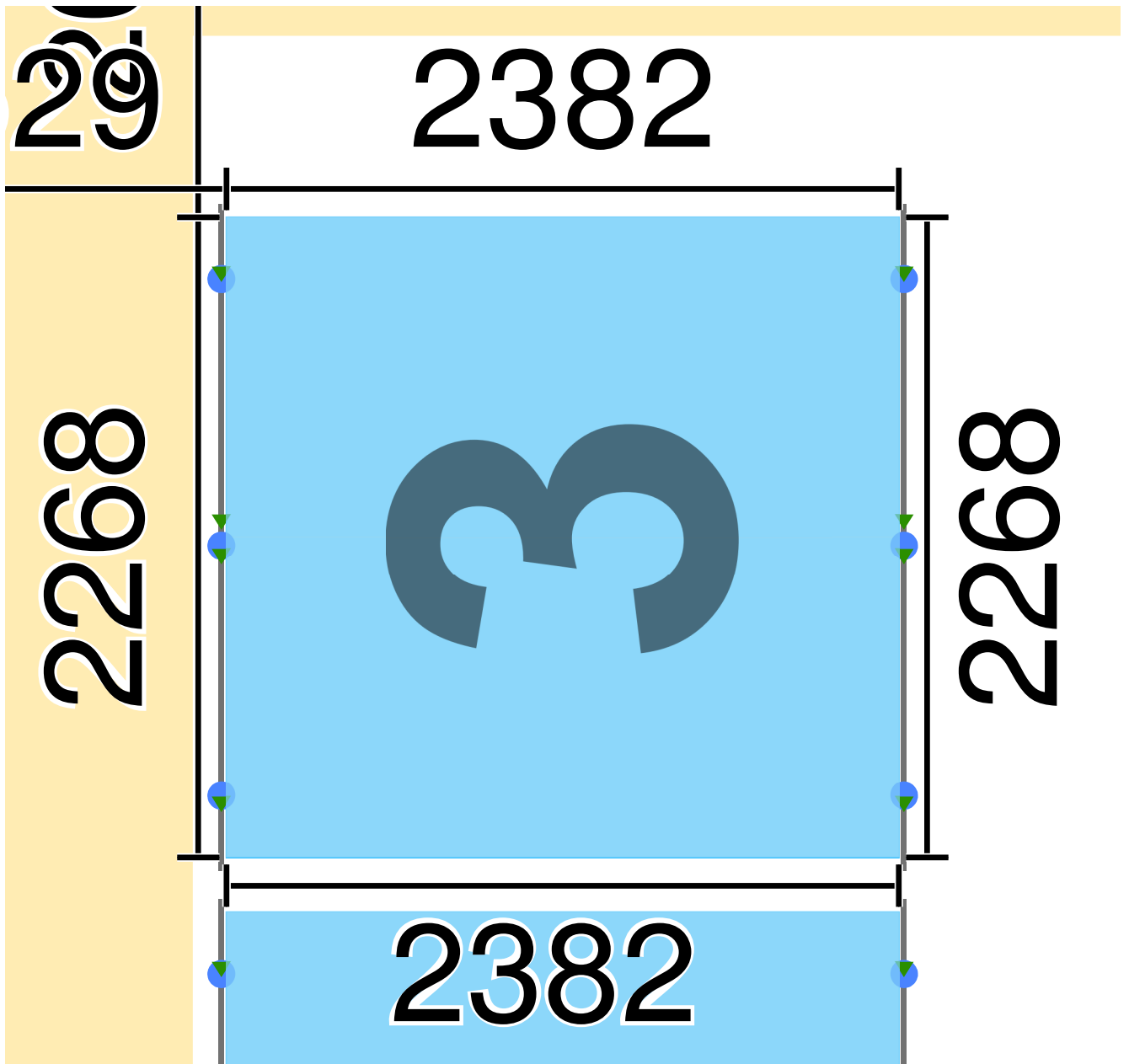


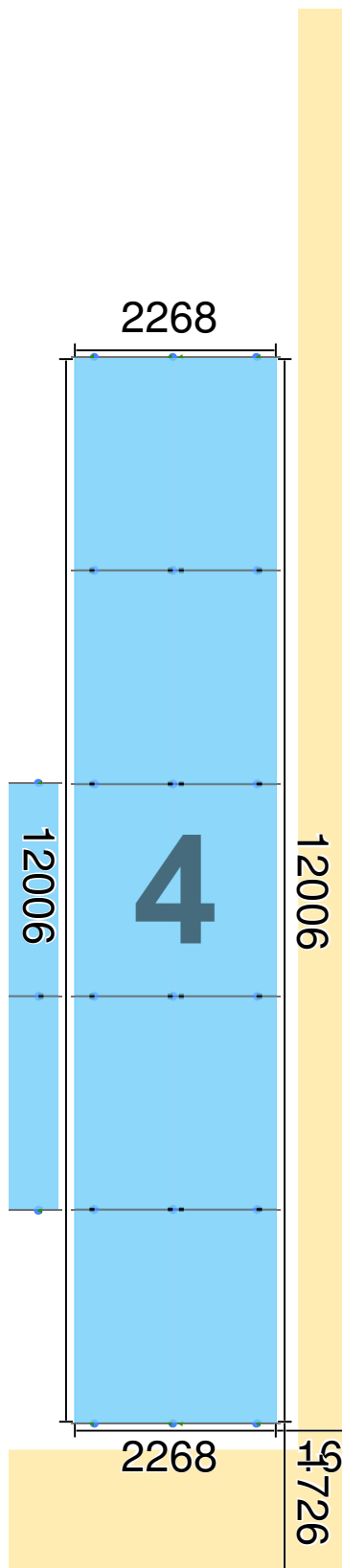


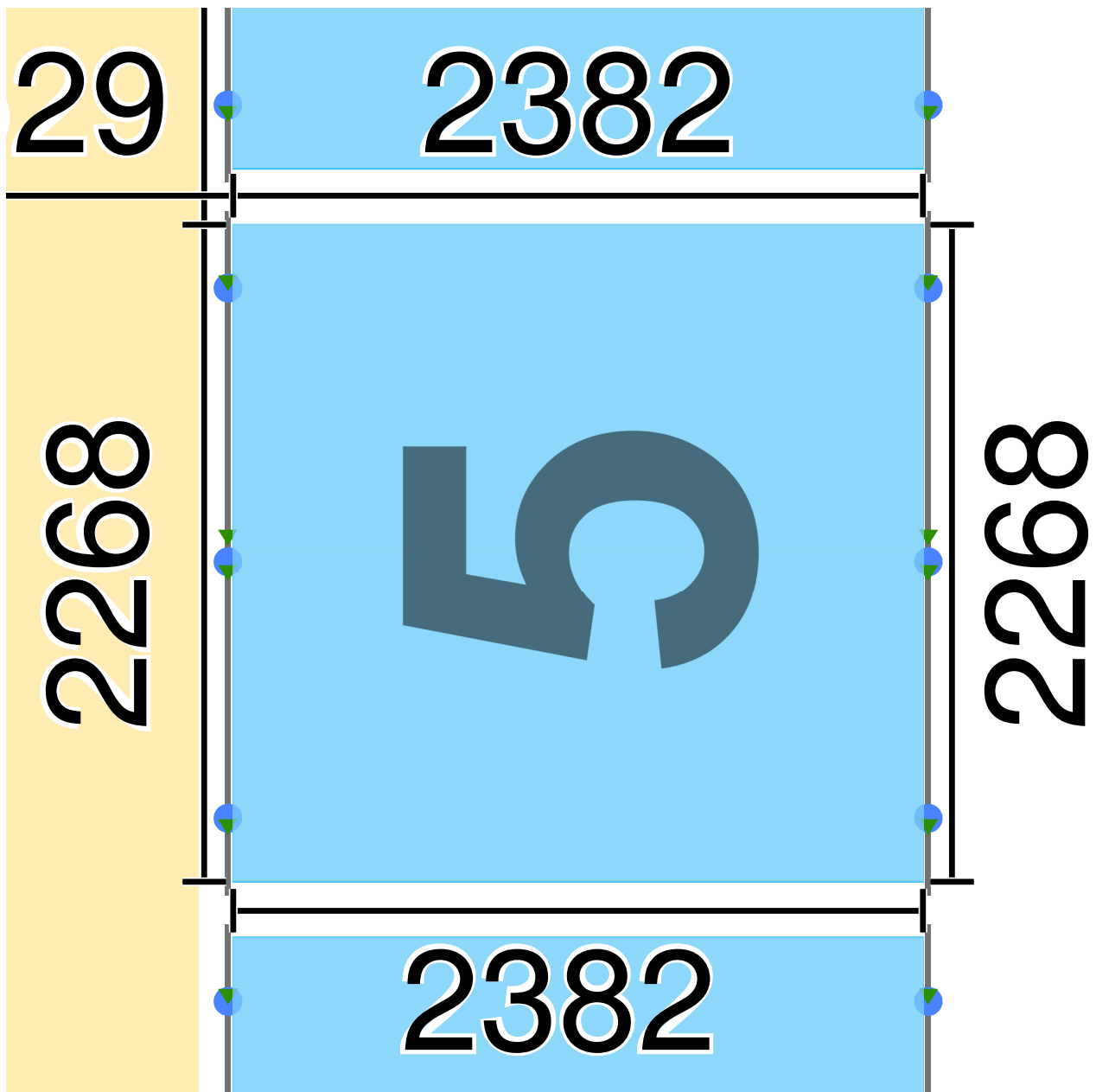


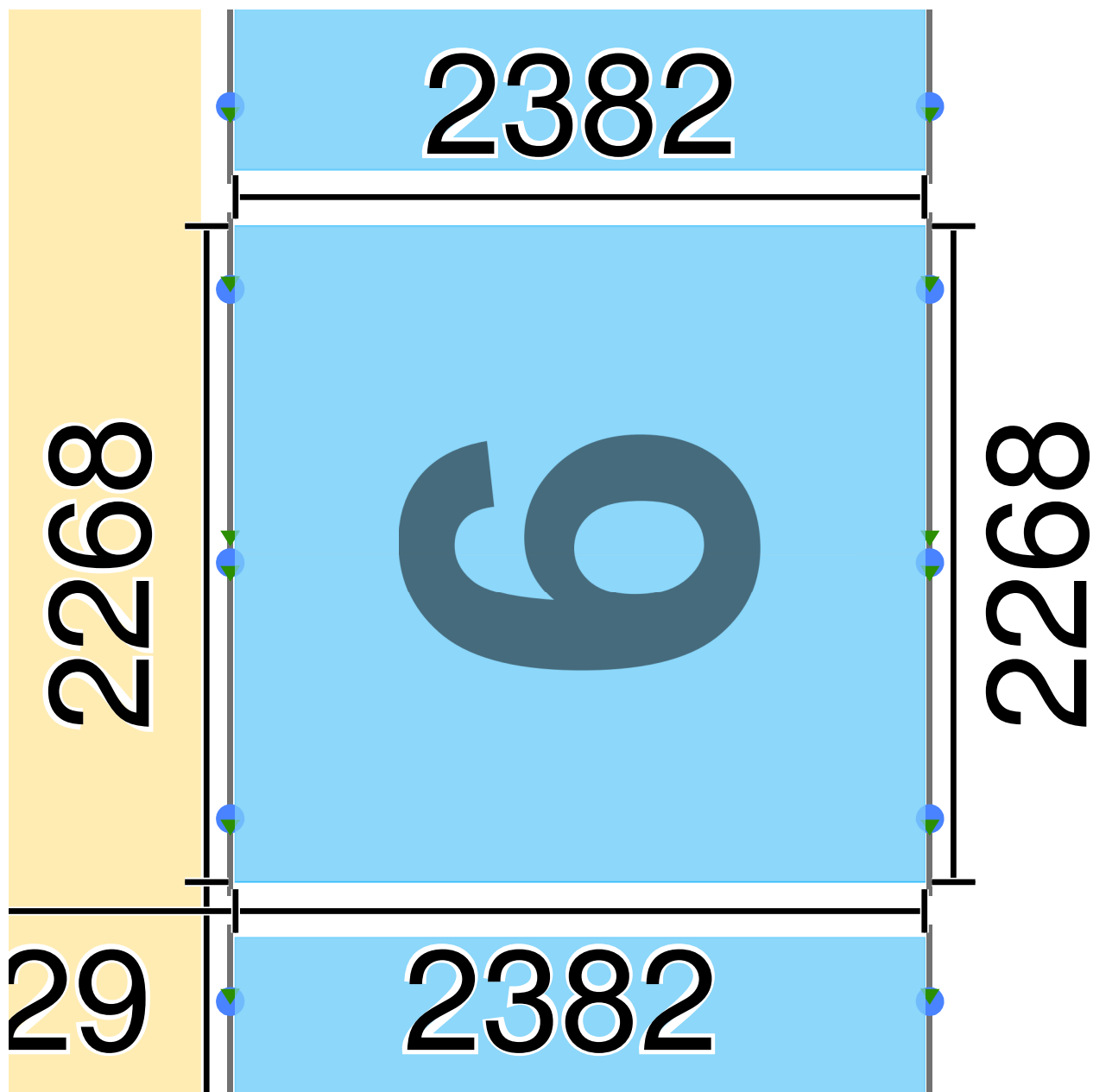


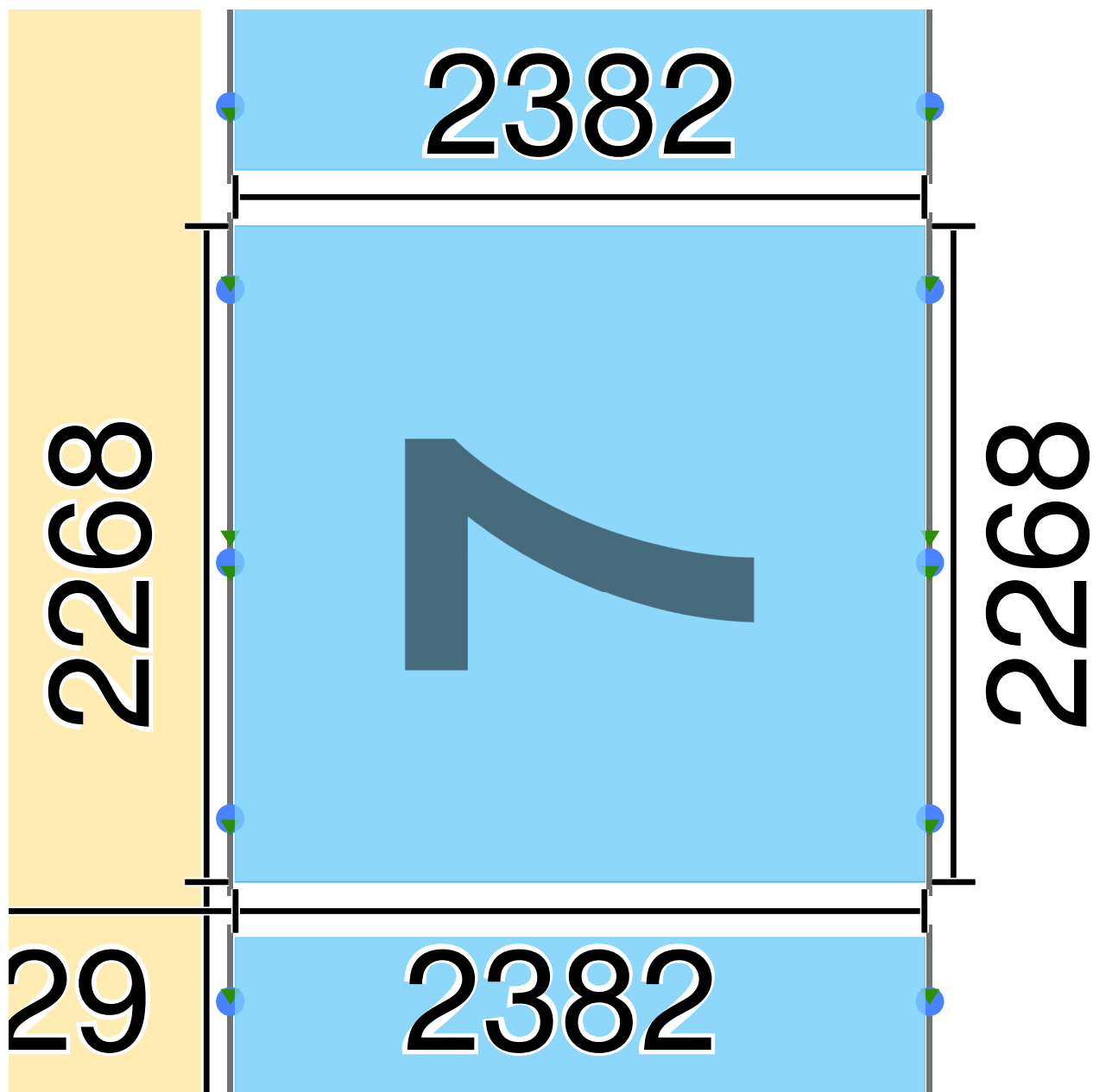


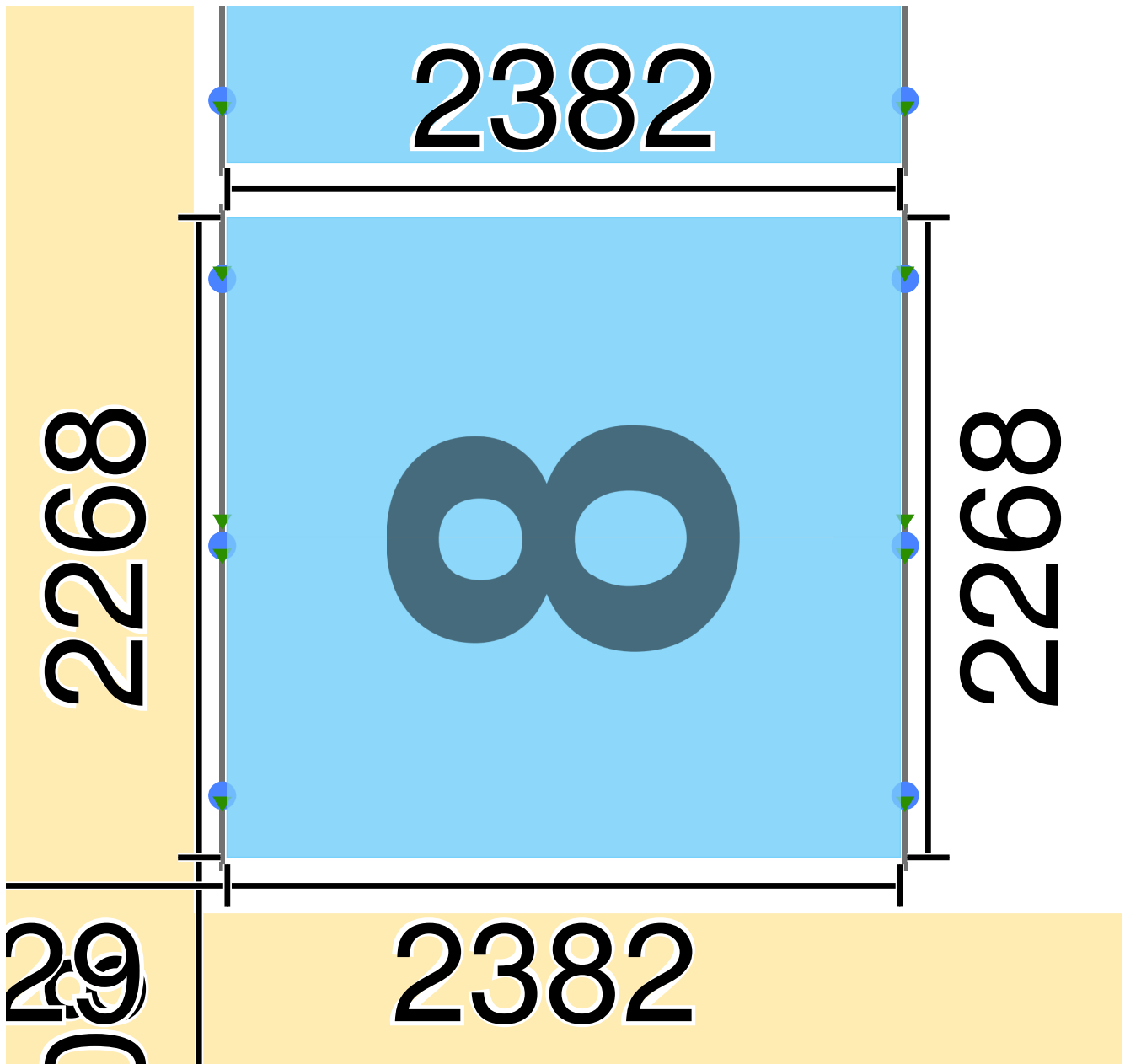


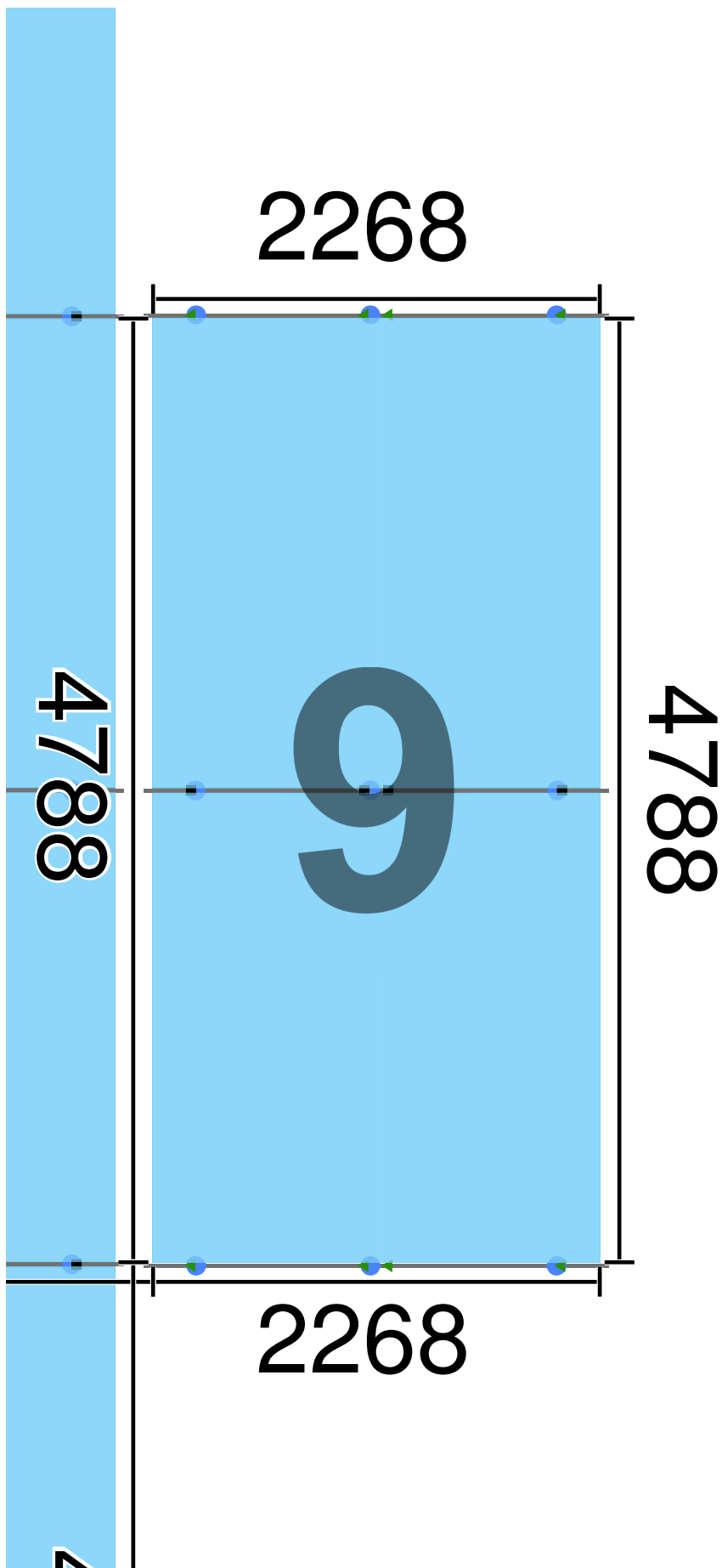












BILL OF MATERIAL

Article No.	Article	Quantity	Ordering Unit	Weight/Piece	Weight
R420080	RS1	112	1	0,083 kg	9,296 kg
R500419	Eave support XL	56	1	0,049 kg	2,744 kg
R500423	Ridge support 10° XL	28	1	0,443 kg	12,404 kg
R500499	Base rail FS10-EW XL 2362 mm	28	1	1,660 kg	46,480 kg
R900314	Socket bolt 6 x 110 mm	84	1	0,009 kg	0,756 kg
					Total Weight: 71,680 kg
Third party parts		Quantity			
Rooftrak IFP-HM/MW		84			

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LOAD ASSUMPTIONS

Dead load

Solar modules type CS6.1-72TB-610 are used.

The modules are angled horizontally on the roof and are fastened on the larger module edges on the vertical rails with module clamps.

Dimensions: 2382 mm x 1134 mm
Weight: $G = 33.6 \text{ kg}$
 $F_G = 33.6 \text{ kg} \cdot 9.81 \text{ m/s}^2 = 0.330 \text{ kN}$

Snow load

The determination of the snow load is carried out according to BS EN 1991-1-3:2003/NA:2010-06.

Snow-trap formation or snow-load accumulations are not considered in the calculation. Please contact Renusol if necessary.

Height above sea level: 47 m
Snow load zone: 3
Roof pitch: $\alpha = 2^\circ$
Module elevation: $\beta = 10^\circ$
total pitch: 10.2°

Period of use: 25 Year
Snow load: $s_k = s_{k,50} \cdot f_s = 0.50 \text{ kN/m}^2 \cdot 0.93 = 0.46 \text{ kN/m}^2$
 $\mu_{r1} = 0.800$
 $s_1 = \mu_{r1} \cdot s_k = 0.8 \cdot 0.46 \text{ kN/m}^2 = 0.371 \text{ kN/m}^2$
 $s_{1,10^\circ} = 0.371 \text{ kN/m}^2 \cdot \cos(10.2^\circ) = 0.371 \text{ kN/m}^2$
 $F_{S,k} = 0.371 \text{ kN/m}^2 \cdot 2.38 \text{ m} \cdot 1.13 \text{ m} = 0.987 \text{ kN}$

Wind load

The determination of the wind load is carried out according to BS EN 1991-1-4:2005/NA:2011-01.

Building height roof ridge: 87 m
Terrain category: Town terrain
Basic wind velocity: 22.50 m/s
Distance to shoreline: 40.000 km
Distance inside town terrain: 3.000 km
Period of use: 25 Year
Pressure of the gusts velocity: $q(z) = 1.160 \text{ kN/m}^2$

ANALYSIS

Load cases and load case combinations

Load cases

The respective loads are taken from the load assumptions and converted to a reference system perpendicular to the roof area.

LC 1	Dead load
LC 2	Snow load
LC 3	Wind pressure
LC 4	Wind suction

Significant load case combinations
according to: EN 1990:2012

Ultimate state of load-bearing capacity

LCC 1	Predominant action wind pressure $E_{d,LCC 1} = 1.35 * E_{GK,LC 1} + 1.50 * (E_{QK,LC 3} + 0.5 * E_{QK,LC 2})$
LCC 2	Predominant action snow $E_{d,LCC 2} = 1.35 * E_{GK,LC 1} + 1.50 * (E_{QK,LC 2} + 0.6 * E_{QK,LC 3})$
LCC 3	Predominant action wind suction (lifting) $E_{d,LCC 3} = 1.00 * E_{GK,LC 1} + 1.50 * (E_{QK,LC 4})$

Ultimate state of serviceability

LCC 4	Predominant action wind pressure $E_{d,LCC 4} = 1.00 * E_{GK,LC 1} + 1.00 * (E_{QK,LC 3} + 0.5 * E_{QK,LC 2})$
LCC 5	Predominant action snow $E_{d,LCC 5} = 1.00 * E_{GK,LC 1} + 1.00 * (E_{QK,LC 2} + 0.6 * E_{QK,LC 3})$
LCC 6	Predominant action wind suction $E_{d,LCC 6} = 1.00 * E_{GK,LC 1} + 1.00 * (E_{QK,LC 4})$

ANALYSIS

Middle clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 28135 \text{ mm}$ $y = 5391 \text{ mm}$

Loads: $V_{x,d} = 0.01 \text{ kN}$

$V_{y,d} = 0.32 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.01/1.84; 0.32/1.29) = 0.25 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 28135 \text{ mm}$ $y = 5391 \text{ mm}$

Loads: $V_{x,d} = 0.02 \text{ kN}$

$V_{y,d} = 0.24 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.02/1.84; 0.24/1.29) = 0.19 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 28135 \text{ mm}$ $y = 4174 \text{ mm}$

Loads: $N_d = -0.58 \text{ kN}$

$V_{x,d} = 0.00 \text{ kN}$

$V_{y,d} = 0.38 \text{ kN}$

Comparison stress: $N_d/F_{R,d,x} + \text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = 0.58/3.41 + \text{MAX} (0.00/1.71; 0.38/1.19) = 0.49 < 1$

ANALYSIS

End clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 25724 \text{ mm}$ $y = 5391 \text{ mm}$

Loads: $V_{x,d} = 0.01 \text{ kN}$

$V_{y,d} = 0.16 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.01/0.95; 0.16/1.32) = 0.12 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 25724 \text{ mm}$ $y = 5391 \text{ mm}$

Loads: $V_{x,d} = 0.01 \text{ kN}$

$V_{y,d} = 0.12 \text{ kN}$

Comparison stress: $\text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = \text{MAX} (0.01/0.95; 0.12/1.32) = 0.09 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 25724 \text{ mm}$ $y = 4174 \text{ mm}$

Loads: $N_d = -0.29 \text{ kN}$

$V_{x,d} = 0.00 \text{ kN}$

$V_{y,d} = 0.19 \text{ kN}$

Comparison stress: $N_d/F_{R,d,x} + \text{MAX} (V_{x,d}/F_{R,d,y}; V_{y,d}/F_{R,d,z}) = 0.29/3.08 + \text{MAX} (0.00/0.93; 0.19/1.28) = 0.24 < 1$

ANALYSIS

Fastener

General

The resistances were determined on the user's own responsibility.

Design values of load capacity

$$F_{R,d,x} = 5.00 \text{ kN}$$

$$F_{R,d,-x} = 3.50 \text{ kN}$$

$$F_{R,d,y} = 2.50 \text{ kN}$$

$$F_{R,d,z} = 2.50 \text{ kN}$$

LCC 1

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 28135 \text{ mm}$ $y = 5289 \text{ mm}$

Loads: $N_d = 0.61 \text{ kN}$

$$V_{x,d} = 0.02 \text{ kN}$$

$$V_{y,d} = 0.54 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} + V_{y,d}/F_{R,d,z} = 0.61/5.00 + 0.02/2.50 + 0.54/2.50 = 0.35 < 1$

LCC 2

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 28135 \text{ mm}$ $y = 5289 \text{ mm}$

Loads: $N_d = 0.98 \text{ kN}$

$$V_{x,d} = 0.03 \text{ kN}$$

$$V_{y,d} = 0.32 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} + V_{y,d}/F_{R,d,z} = 0.98/5.00 + 0.03/2.50 + 0.32/2.50 = 0.34 < 1$

LCC 3

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 28135 \text{ mm}$ $y = 5289 \text{ mm}$

Loads: $N_d = -1.26 \text{ kN}$

$$V_{x,d} = 0.01 \text{ kN}$$

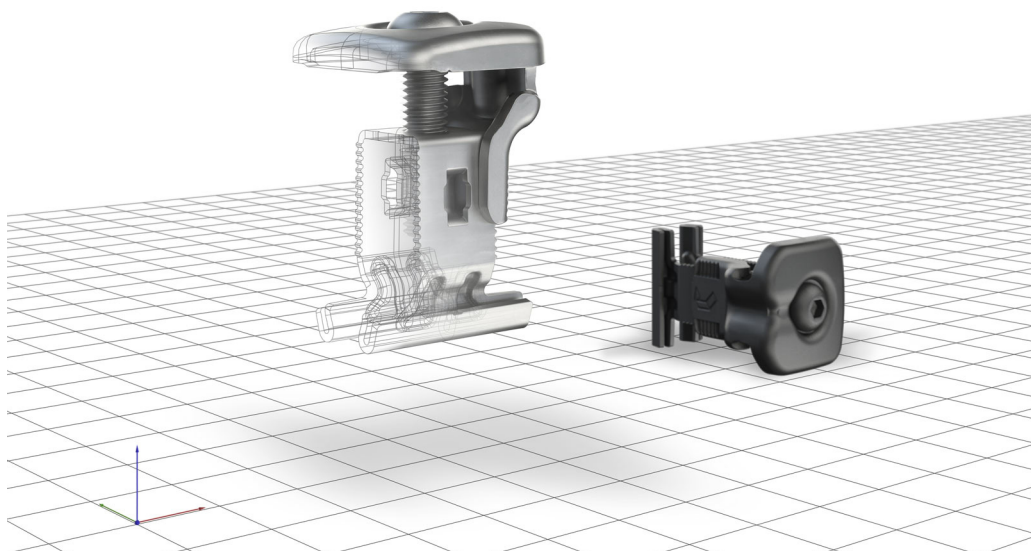
$$V_{y,d} = 0.54 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} + V_{y,d}/F_{R,d,z} = 1.26/3.50 + 0.01/2.50 + 0.54/2.50 = 0.58 < 1$

Technical project overview

Echo Street, Manchester, M1 7DP

Building project	Echo Street, Manchester, M1 7DP
Address	Echo Street 17, M1 3AL
Country	United Kingdom
Module Type	Canadian Solar Inc. - CS6.1-72TB-610
Number of modules	9
Rated output	5.49 kWp
Mounting system	VarioSole+
Editor	Renusol Europe GmbH



LOCATION

Street	Echo Street 17
City	M1 3AL
Country	United Kingdom

SURROUNDINGS

Code	Eurocode NA GB
Terrain height above sealevel	47,00 m
Snow load zone	Zone 3
Use Pressure coefficients from BRE 489 2014 roof pitch 0 -45°	yes
Terrain category	City
Distance to coast	40,00 km
Distance to edge of city	3,00 km
Surroundings	normal
Service life of PV system	25 years
Failure consequence class	2

LOAD CALCULATION RESULT

Peak velocity pressure	1,07 kN/m ²
Snow load	0,46 kN/m ²
Snow load on roof	0,37 kN/m ²
Base wind speed ($V_{b,0}$)	22,50 m/s

TOPOGRAPHY

Topography	Not exposed
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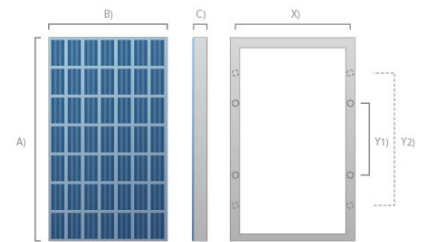
ROOF PROPERTIES

Roof type	Mono pitch roof
Coverage type	Shingles
Spacing x	1000,00 mm
First at x	100,00 mm
skipXForCalculation	yes
Spacing y	1146,00 mm
First at y	1800,00 mm
skipYForCalculation	no
C) Roof pitch	3,00 °
D) Building height	52,00 m



MODULE PARAMETERS

Manufacturer	Canadian Solar Inc.
Name	CS6.1-72TB-610
Length	2382 mm
Width	1134 mm
Height	30 mm
Weight	33.6 kg
Rated output	610 W _{peak}



Please check the compatibility of clamping positions with module manufacturer advice.

FASTENER PARAMETERS

Name	Rooftrak IFP-HM/MW
Manufacturer	Nicholson
Pressure load capacity	5,00 kN
Tensile load capacity	3,50 kN
Lateral force	2,50 kN
Interaction	Linear

The third party product(s) listed above, is (are) not (a) product of Renusol but, from third party Manufacturer(s) (Manufacturer). The PV-Configurator uses static properties of this fastener provided by this Manufacturer. The Manufacturer is responsible for the accurateness and correctness of the static values provided by him, Renusol does not assume any liability regarding the product of the Manufacturer and its static properties.

SYSTEM

System	VarioSole+
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Please check the entered row distance for an ideal yield calculation with a correct calculation including consideration of the shading.

FASTENER DETAILS

Mounting direction of modules	Landscape
Fastener type	Custom fastener

MODULE RAIL

Fastening rails	Single layer
Rail orientation	Vertical
Mounting rail	50x37 mm
Fixations only under module surface	No
Use alternating roof hooks	No
Rail length	3600mm
Maximum cantilever length	300,00 mm
Rail colour	silver
Rail count per module	2
Optimize fasteners	Roof wise

CLAMPS

Clamp type	RS1
Clamp colour	silver
Max value middle clamps	28 %
Max value end clamps	15 %

STATIC VALIDATION

Your project was validated by our statics check successfully.

Static utilization factor: 84%

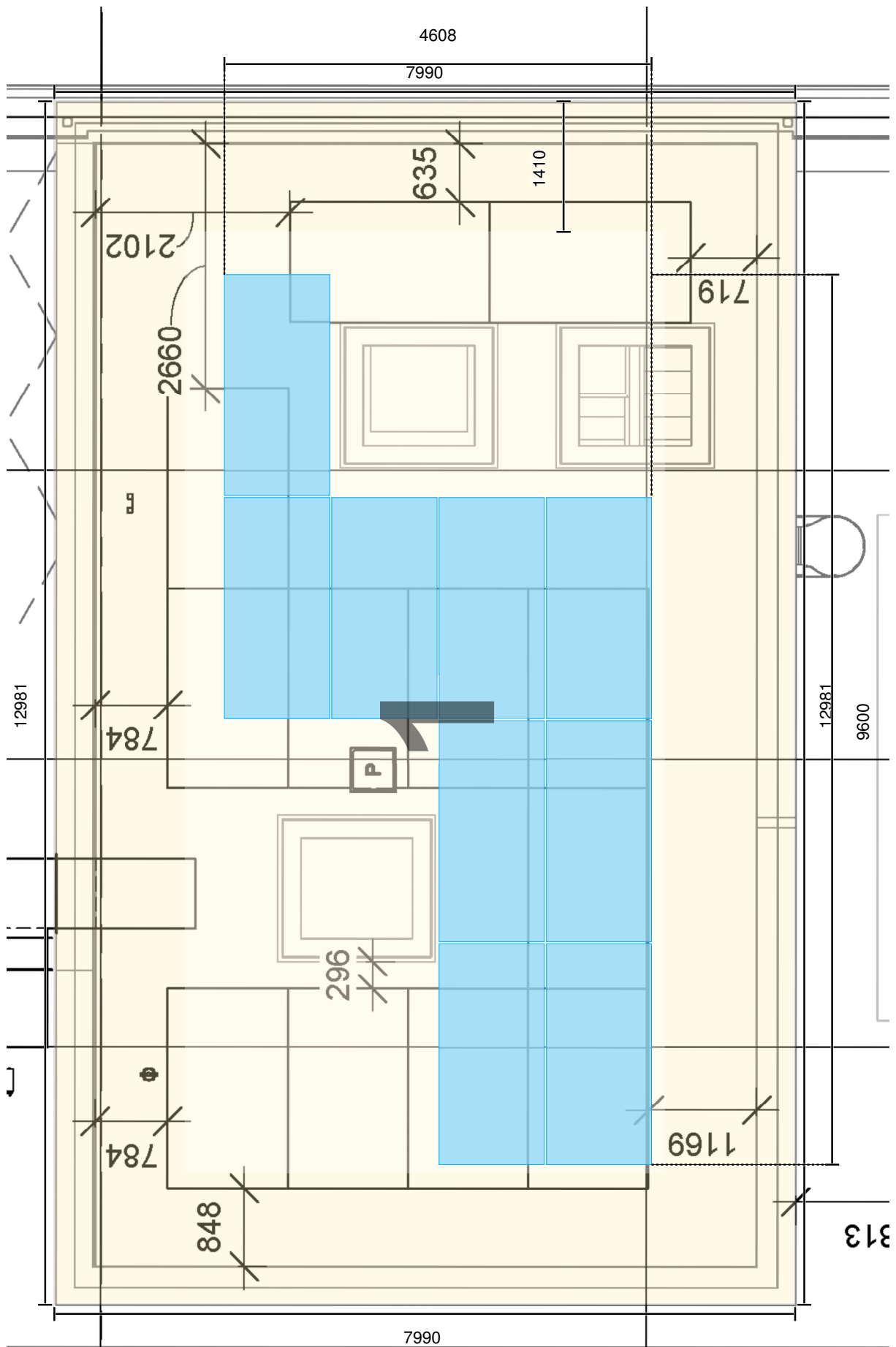
Static utilization fastener: 61%

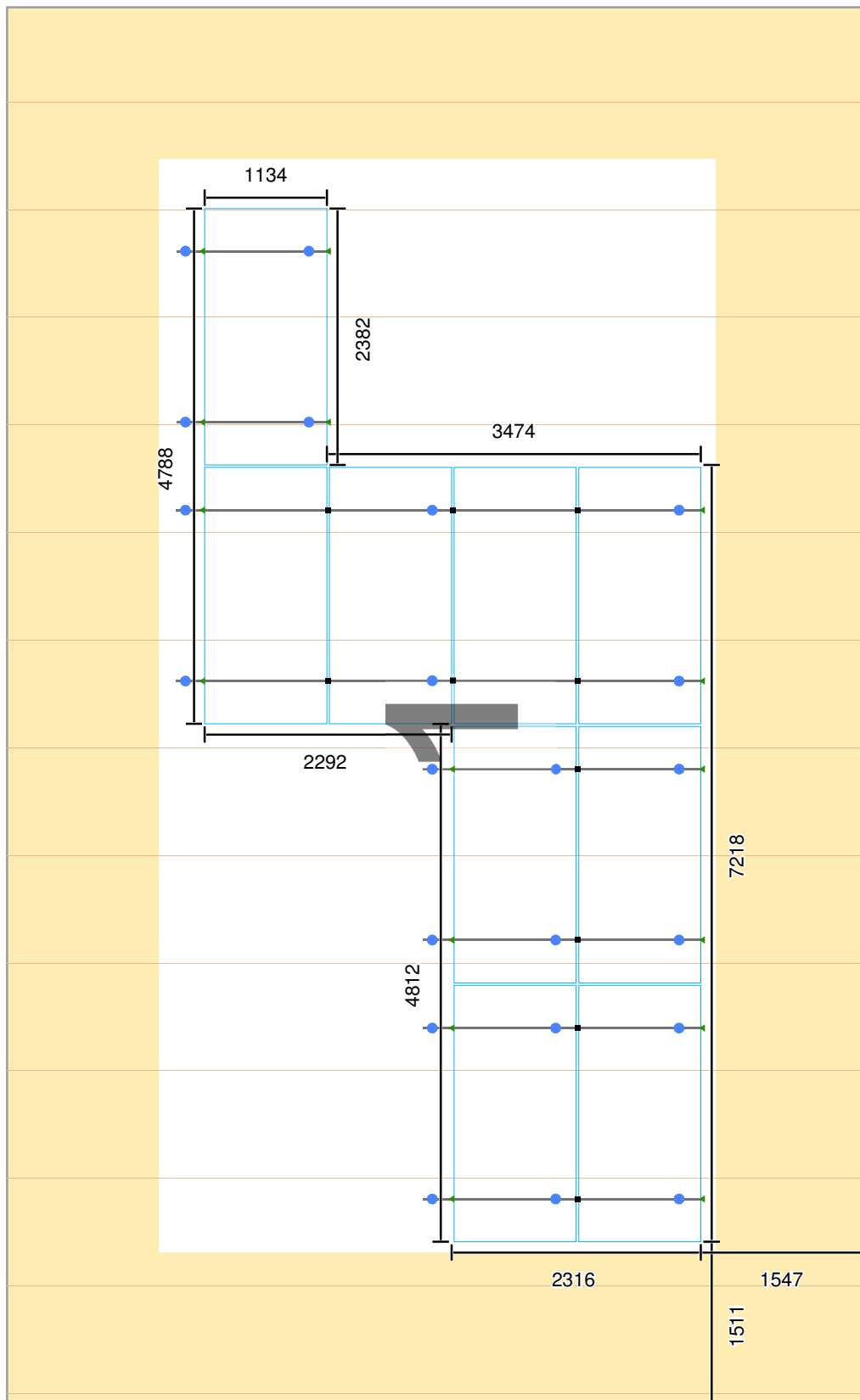
Static utilization clamp: 28%

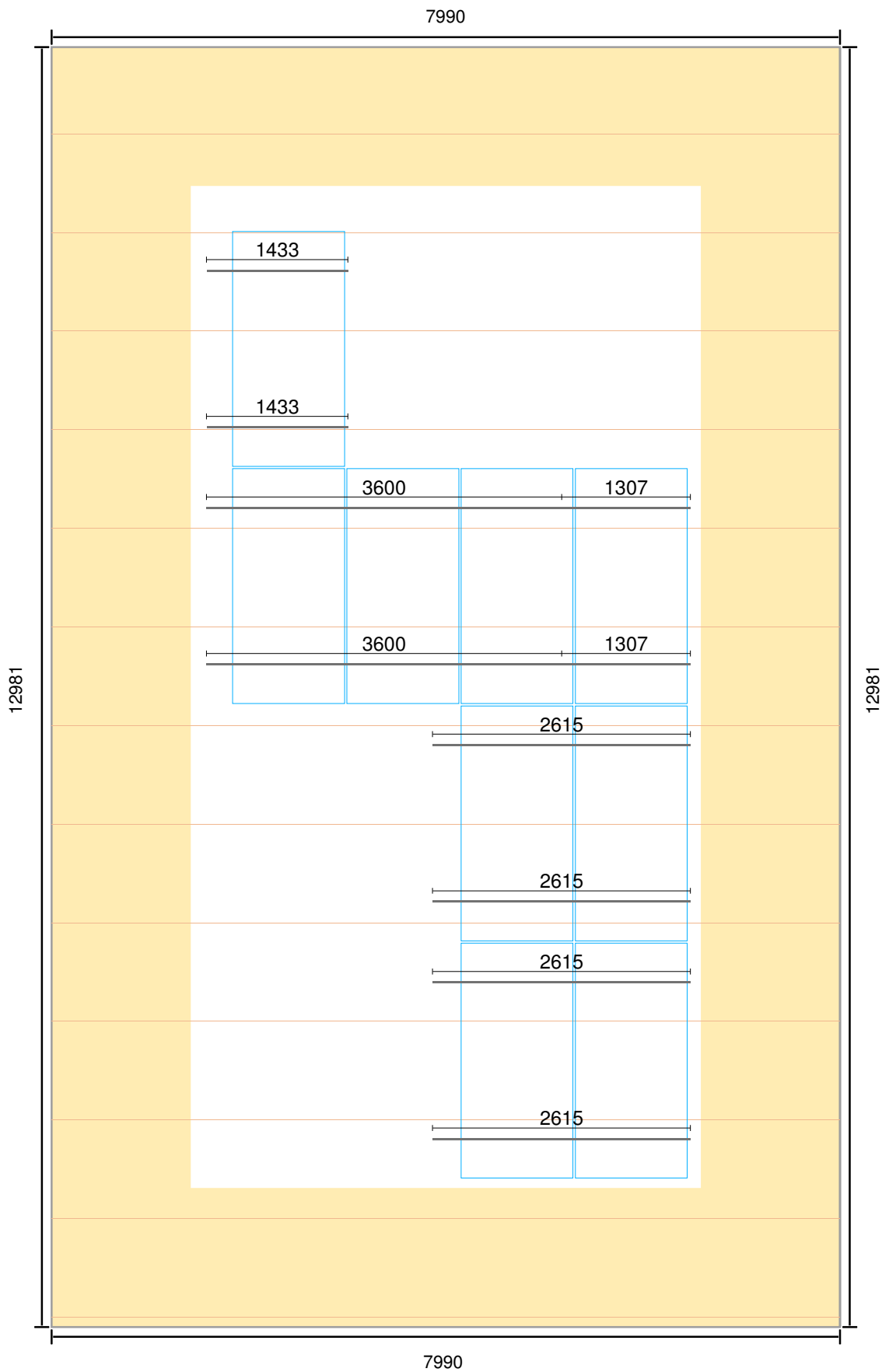
Static utilization base rail: 84%

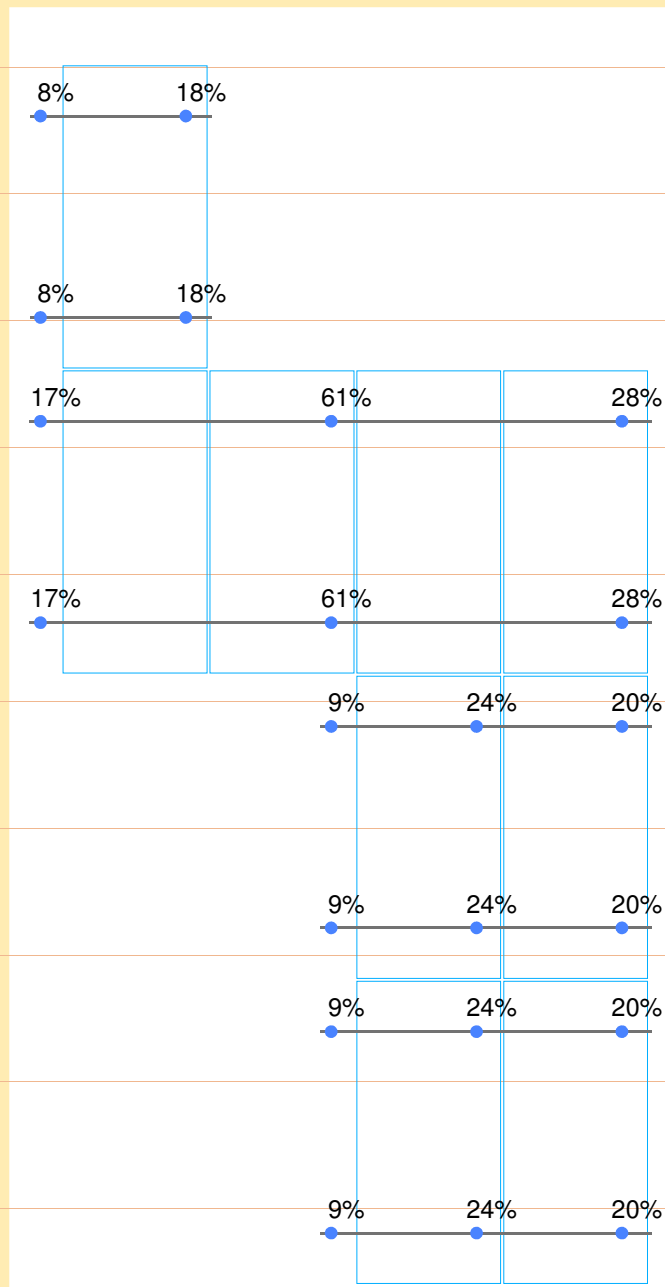
The predefined default values for input fields have to be compared with the conditions of the project. Necessary changes to adapt to local conditions must be carried out. The following relevant input fields contain their default value:

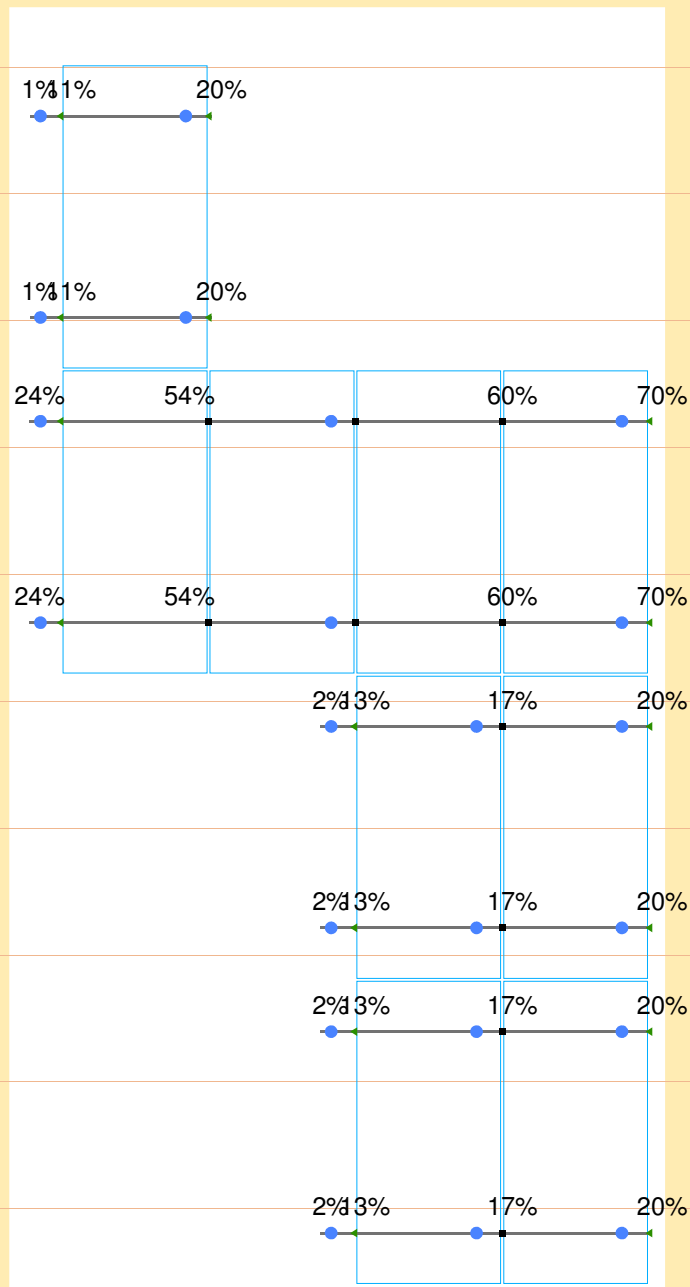
- Service life of PV system: 25 years
- Failure consequence class: 2

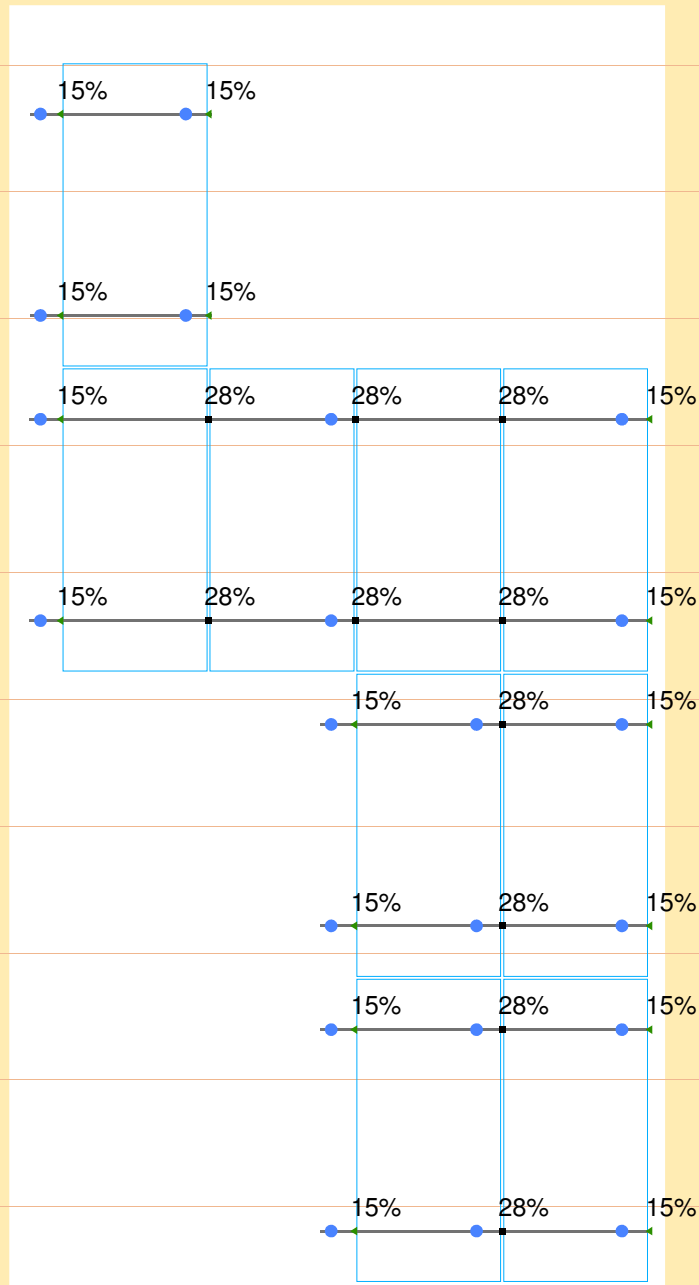


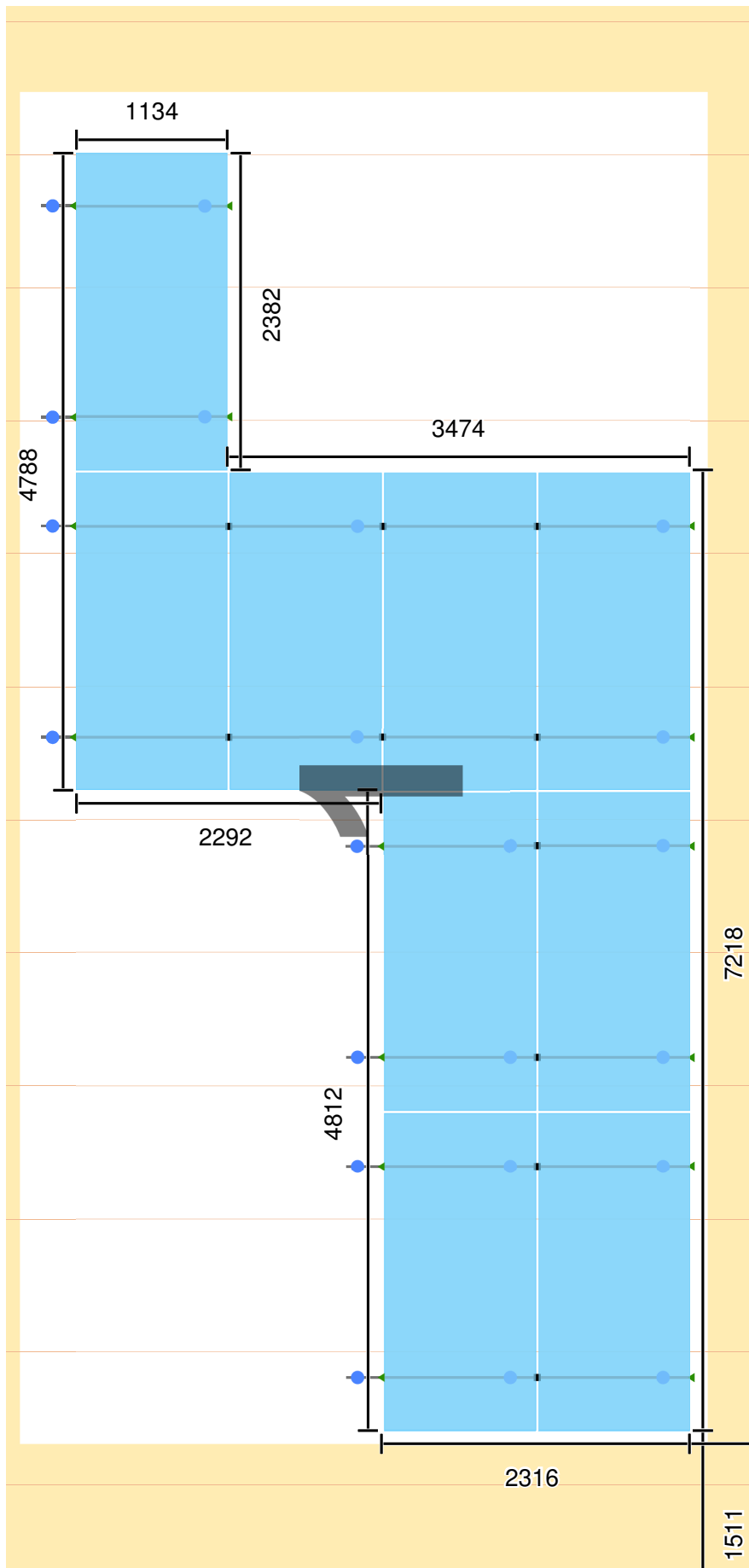












BILL OF MATERIAL

Article No.	Article	Quantity	Ordering Unit	Weight/Piece	Weight
R400532	VS+ Rail connector 50 x 37	2	1	0,193 kg	0,386 kg
R400570	VS+ Mounting rail 50 x 37 x 3600 mm	8	1	9,108 kg	72,864 kg
R420024	Bracket IFP M8/M10, set(1pc.)	22	1	0,090 kg	1,980 kg
R420080	RS1	26	1	0,083 kg	2,158 kg
R920044	End Cap RIGHT / LEFT (grey) 50x37	8	1	0,015 kg	0,120 kg
				Total Weight: 77,508 kg	
Third party parts		Quantity			
Rooftrak IFP-HM/MW		22			

The third party product(s) listed above, is (are) not (a) product of Renusol but, from third party Manufacturer(s) (Manufacturer). The PV-Configurator uses static properties of this fastener provided by this Manufacturer. The Manufacturer is responsible for the accurateness and correctness of the static values provided by him, Renusol does not assume any liability regarding the product of the Manufacturer and its static properties.

GENERAL

Technical regulations

Eurocode 0: 'Basis of structural design' EN 1990:2012
Eurocode 1: 'Action on Structures'
Part 1-3: 'General Actions, Snow Loads' EN 1991-1-3:2015
National Annex BS EN 1991-1-3:2003/NA:2010-06
Part 1-4: 'General Actions, Wind Loads' EN 1991-1-4:2010
National Annex BS EN 1991-1-4:2005/NA:2011-01
Eurocode 9: 'Design of Aluminium Structures'
Part 1-1: 'General Structural Rules' EN 1999-1-1:2007
Report BRE DG 489 (revised 2014)

Materials

Aluminium extruded sections, EN AW 6063 T6, $t \leq 10\text{mm}$
Rail connector EN AW 6063 T6

Used documents

Schneider 'Bautabellen für Ingenieure', Werner-Verlag
SAPA 'Handbuch für Konstrukteure', Beuth Verlag

LOAD ASSUMPTIONS

Dead load

Solar modules type CS6.1-72TB-610 are used.

The modules are angled horizontally on the roof and are fastened on the larger module edges on the vertical rails with module clamps.

Dimensions:	2382 mm x 1134 mm
Weight:	$G = 33.6 \text{ kg}$
Load per longitudinal module side:	$F_G = 33.6 \text{ kg} * 9.81 \text{ m/s}^2 / 2 = 0.33 \text{ kN} / 2 = 0.165 \text{ kN}$

Mounting rails

Weight:	$0.70 \text{ kg/m} * 9.81 \text{ m/s}^2 = 0.007 \text{ kN/m}$
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Snow load

The determination of the snow load is carried out according to BS EN 1991-1-3:2003/NA:2010-06.

Snow-trap formation or snow-load accumulations are not considered in the calculation. Please contact Renusol if necessary.

Height above sea level:	47 m
Snow load zone:	3
Roof pitch:	$\alpha = 3^\circ$

Period of use:	25 Year
----------------	---------

Snow load:	$s_k = s_{k,50} * f_s = 0.50 \text{ kN/m}^2 * 0.93 = 0.46 \text{ kN/m}^2$ $\mu_1 = 0.800$
------------	--

$$s_1 = \mu_1 * s_k = 0.8 * 0.46 \text{ kN/m}^2 = 0.371 \text{ kN/m}^2$$

$$s_{1,3^\circ} = 0.371 \text{ kN/m}^2 * \cos(3.0^\circ) = 0.371 \text{ kN/m}^2$$

Load per longitudinal module side:	$F_{S,k} = 0.371 \text{ kN/m}^2 * 2.38 \text{ m} * 1.13 \text{ m} / 2 = 0.501 \text{ kN}$
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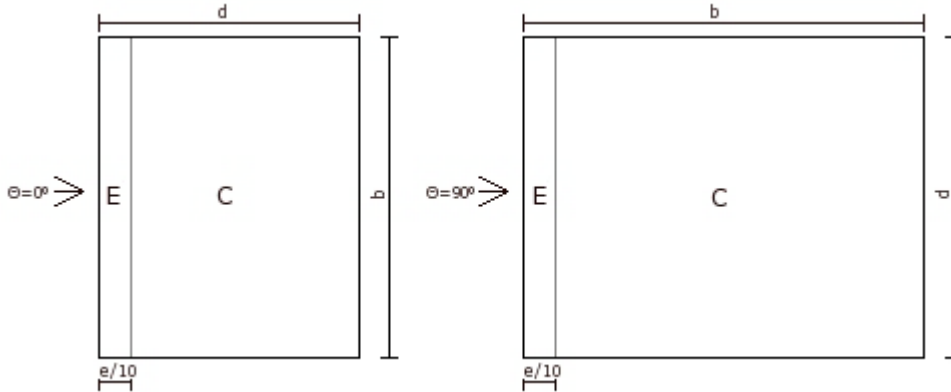
Wind load

The determination of the wind load is carried out according to BS EN 1991-1-4:2005/NA:2011-01.

Building height roof ridge:	52 m
Terrain category:	Town terrain
Basic wind velocity:	22.50 m/s
Distance to shoreline:	40.000 km
Distance inside town terrain:	3.000 km
Style of roof	
Period of use:	25 Year
Pressure of the gusts velocity:	$q(z) = 1.068 \text{ kN/m}^2$

LOAD ASSUMPTIONS

All oncoming flow directions



Main roof

$$b = 12.98\text{m}$$

$$d = 7.98\text{m}$$

$$h = 52.00\text{m}$$

Ventilation direction 0° and 180°:

$$e = \min(b, 2h) = \min(12.98\text{m}, 104.00\text{m}) = 12.98\text{m}$$

Ventilation direction 90° and 270°:

$$e = \min(d, 2h) = \min(7.98\text{m}, 104.00\text{m}) = 7.98\text{m}$$

The coefficients of pressure and suction for the individual roof areas are interpolated for the roof pitch of 3 obtained from the report BRE Digest 489.

Wind pressure:

Wind pressure not existent

Wind suction:

Edge area of roof (E) $c_p = -1.20$ Area is not relevant

Middle area of roof (C) $c_p = -0.50$ $W_s = (-0.50) \cdot 1.068\text{kN/m}^2 \cdot 2.38\text{m} \cdot 1.13\text{m} / 2 = -0.722\text{ kN}$

ANALYSIS

Load cases and load case combinations

Load cases

The respective loads are taken from the load assumptions and converted to a reference system perpendicular to the roof area.

LC 1	Dead load
LC 2	Snow load
LC 3	Wind pressure (by roof area)
LC 4	Wind suction (by roof area)

Significant load case combinations
according to: EN 1990:2012

Ultimate state of load-bearing capacity

LCC 1	Predominant action wind pressure $E_{d,LCC 1} = 1.35 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 3} + 0.5 * E_{Qk,LC 2})$
LCC 2	Predominant action snow $E_{d,LCC 2} = 1.35 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 2} + 0.6 * E_{Qk,LC 3})$
LCC 3	Predominant action wind suction (lifting) $E_{d,LCC 3} = 1.00 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 4})$

Ultimate state of serviceability

LCC 4	Predominant action wind pressure $E_{d,LCC 4} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 3} + 0.5 * E_{Qk,LC 2})$
LCC 5	Predominant action snow $E_{d,LCC 5} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 2} + 0.6 * E_{Qk,LC 3})$
LCC 6	Predominant action wind suction $E_{d,LCC 6} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 4})$

ANALYSIS

Area load on module:

Due to the building geometry and the location, the following area loads result for the module surface according to the standard calculation.

[kN/m²]		Section	Edge
LCC 1 Design	⊥	0.44	0.44
	//	0.02	0.02
LCC 2 Design	⊥	0.72	0.72
	//	0.04	0.04
LCC 3 Design	⊥	-0.68	-1.80
	//	0.01	0.01
LCC 4 Characteristic	⊥	0.31	0.31
	//	0.02	0.02
LCC 5 Characteristic	⊥	0.49	0.49
	//	0.03	0.03
LCC 6 Characteristic	⊥	-0.41	-1.16
	//	0.01	0.01

Maximum values

[kN/m²]	Characteristic	Design
Pressure	0.49	0.72
Suction	-1.16	-1.80
In parallel to the roof	0.03	0.04

ANALYSIS

Middle clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 5297 \text{ mm}$ $y = 8667 \text{ mm}$
 Loads: $V_{x,d} = 0.03 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.03/1.29 = 0.02 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 5297 \text{ mm}$ $y = 8667 \text{ mm}$
 Loads: $V_{x,d} = 0.05 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.05/1.29 = 0.04 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 5297 \text{ mm}$ $y = 8667 \text{ mm}$
 Loads: $N_d = -0.92 \text{ kN}$
 $V_{x,d} = 0.01 \text{ kN}$
 Comparison stress: $N_d/F_{R,d,x} + V_{x,d}/F_{R,d,y} = 0.92/3.41 + 0.01/1.13 = 0.28 < 1$

ANALYSIS

End clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 4133 \text{ mm}$ $y = 8667 \text{ mm}$
 Loads: $V_{x,d} = 0.02 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.02/1.32 = 0.01 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 4133 \text{ mm}$ $y = 8667 \text{ mm}$
 Loads: $V_{x,d} = 0.03 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.03/1.32 = 0.02 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 4133 \text{ mm}$ $y = 8667 \text{ mm}$
 Loads: $N_d = -0.46 \text{ kN}$
 $V_{x,d} = 0.00 \text{ kN}$
 Comparison stress: $N_d/F_{R,d,x} + V_{x,d}/F_{R,d,y} = 0.46/3.08 + 0.00/1.26 = 0.15 < 1$

ANALYSIS

Mounting rails

General

An extruded section is used as load bearing rail.

It consists of material grade EN AW 6063 T6. At the joints, the rails are connected deflection resistant through an insertion profile (connector with rivet) with the same static parameters as the load bearing rails.

Cross section



Static analysis

The static system is a continuous beam. The single loads due to the load combinations are introduced into the supporting rails in a spacing specified by the module. The continuous beams are supported by the roof hooks or set screws.

The software analyses all rails but only the rail utilised maximally is shown (maximum stress utilisation and maximum deformation).

Analysis

LCC 1

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID:	100005
Beginning of rail:	x = 1571 mm y = 6261 mm
End of rail:	x = 6478 mm y = 6261 mm
Position:	x = 3898 mm y = 6261 mm

Loads:	$N_d = 0.04 \text{ kN}$
	$V_{y,d} = 0.00 \text{ kN}$
	$V_{z,d} = -0.88 \text{ kN}$
	$M_{y,d} = 306.86 \text{ Nm} = 30.686 \text{ kNcm}$
	$M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis:	$\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$ $(0.04/2.60 + 30.686/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 9.46 \text{ kN/cm}^2$
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Utilisation:	$\sigma_{x,d}/\sigma_{R,d} = 9.46/18.18 = 0.52 < 1$
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ANALYSIS

LCC 2

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100006
Beginning of rail: x = 1571 mm y = 4673 mm
End of rail: x = 6478 mm y = 4673 mm
Position: x = 3898 mm y = 4673 mm

Loads: $N_d = 0.07 \text{ kN}$
 $V_{y,d} = 0.00 \text{ kN}$
 $V_{z,d} = -1.42 \text{ kN}$
 $M_{y,d} = 495.75 \text{ Nm} = 49.575 \text{ kNcm}$
 $M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis: $\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$
 $(0.07/2.60 + 49.575/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 15.29 \text{ kN/cm}^2$

Utilisation: $\sigma_{x,d}/\sigma_{R,d} = 15.29/18.18 = 0.84 < 1$

LCC 3

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100006
Beginning of rail: x = 1571 mm y = 4673 mm
End of rail: x = 6478 mm y = 4673 mm
Position: x = 3898 mm y = 4673 mm

Loads: $N_d = 0.01 \text{ kN}$
 $V_{y,d} = 0.00 \text{ kN}$
 $V_{z,d} = 1.32 \text{ kN}$
 $M_{y,d} = -457.98 \text{ Nm} = -45.798 \text{ kNcm}$
 $M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis: $\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$
 $(0.01/2.60 + 45.798/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 14.10 \text{ kN/cm}^2$

Utilisation: $\sigma_{x,d}/\sigma_{R,d} = 14.10/18.18 = 0.78 < 1$

LCC 4

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100005
Beginning of rail: x = 1571 mm y = 6261 mm
End of rail: x = 6478 mm y = 6261 mm
Position: x = 6478 mm y = 6261 mm
Deformation: u = 2.53 mm
permitted deformation: $u_{zul} = l/50 = 287.59 \text{ mm} / 50 = 5.8 \text{ mm}$
Utilisation: $u/u_{zul} = 2.53 / 5.75 = 0.44 < 1$

LCC 5

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100006
Beginning of rail: x = 1571 mm y = 4673 mm
End of rail: x = 6478 mm y = 4673 mm
Position: x = 6478 mm y = 4673 mm
Deformation: u = 4.00 mm
permitted deformation: $u_{zul} = l/50 = 287.59 \text{ mm} / 50 = 5.8 \text{ mm}$
Utilisation: $u/u_{zul} = 4.00 / 5.75 = 0.70 < 1$

ANALYSIS

LCC 6

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID:	100006
Beginning of rail:	x = 1571 mm y = 4673 mm
End of rail:	x = 6478 mm y = 4673 mm
Position:	x = 6478 mm y = 4673 mm
Deformation:	u = 3.22 mm
permitted deformation:	$u_{zul} = l/50 = 287.59 \text{ mm} / 50 = 5.8 \text{ mm}$
Utilisation:	$u/u_{zul} = 3.22 / 5.75 = 0.56 < 1$

ANALYSIS

Fastener

General

The resistances were determined on the user's own responsibility.

Design values of load capacity

$$F_{R,d,x} = 5.00 \text{ kN}$$

$$F_{R,d,-x} = 3.50 \text{ kN}$$

$$F_{R,d,y} = 2.50 \text{ kN}$$

LCC 1

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 3898 \text{ mm}$ $y = 4673 \text{ mm}$

Loads: $N_d = 1.41 \text{ kN}$

$$V_{x,d} = 0.06 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 1.41/5.00 + 0.06/2.50 = 0.31 < 1$

LCC 2

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 3898 \text{ mm}$ $y = 4673 \text{ mm}$

Loads: $N_d = 2.27 \text{ kN}$

$$V_{x,d} = 0.10 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 2.27/5.00 + 0.10/2.50 = 0.49 < 1$

LCC 3

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 3898 \text{ mm}$ $y = 4673 \text{ mm}$

Loads: $N_d = -2.10 \text{ kN}$

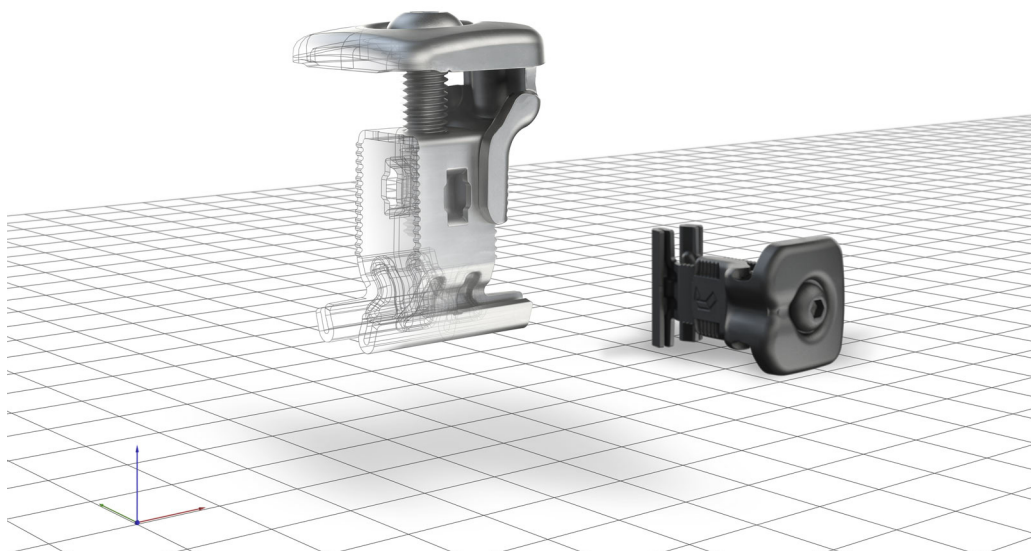
$$V_{x,d} = 0.02 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 2.10/3.50 + 0.02/2.50 = 0.61 < 1$

Technical project overview

Echo Street, Manchester, M1 7DP

Building project	Echo Street, Manchester, M1 7DP
Address	Echo Street 17, M1 3AL
Country	United Kingdom
Module Type	Canadian Solar Inc. - CS6.1-72TB-610
Number of modules	11
Rated output	6.71 kWp
Mounting system	VarioSole+
Editor	Renusol Europe GmbH



LOCATION

Street	Echo Street 17
City	M1 3AL
Country	United Kingdom

SURROUNDINGS

Code	Eurocode NA GB
Terrain height above sealevel	47,00 m
Snow load zone	Zone 3
Use Pressure coefficients from BRE 489 2014 roof pitch 0 -45°	yes
Terrain category	City
Distance to coast	40,00 km
Distance to edge of city	3,00 km
Surroundings	normal
Service life of PV system	25 years
Failure consequence class	2

LOAD CALCULATION RESULT

Peak velocity pressure	1,12 kN/m ²
Snow load	0,46 kN/m ²
Snow load on roof	0,37 kN/m ²
Base wind speed ($V_{b,0}$)	22,50 m/s

TOPOGRAPHY

Topography	Not exposed
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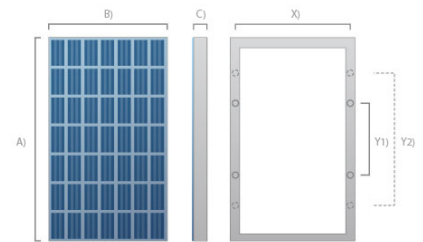
ROOF PROPERTIES

Roof type	Mono pitch roof
Coverage type	Shingles
Spacing x	1000,00 mm
First at x	100,00 mm
skipXForCalculation	yes
Spacing y	1146,00 mm
First at y	1500,00 mm
skipYForCalculation	no
C) Roof pitch	3,00 °
D) Building height	70,00 m



MODULE PARAMETERS

Manufacturer	Canadian Solar Inc.
Name	CS6.1-72TB-610
Length	2382 mm
Width	1134 mm
Height	30 mm
Weight	33.6 kg
Rated output	610 W _{peak}



Please check the compatibility of clamping positions with module manufacturer advice.

FASTENER PARAMETERS

Name	Rooftrak IFP-HM/MW
Manufacturer	Nicholson
Pressure load capacity	5,00 kN
Tensile load capacity	3,50 kN
Lateral force	2,50 kN
Interaction	Linear

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SYSTEM

System	VarioSole+
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Please check the entered row distance for an ideal yield calculation with a correct calculation including consideration of the shading.

FASTENER DETAILS

Mounting direction of modules	Landscape
Fastener type	Custom fastener

MODULE RAIL

Fastening rails	Single layer
Rail orientation	Vertical
Mounting rail	50x37 mm
Fixations only under module surface	No
Use alternating roof hooks	No
Rail length	3600mm
Maximum cantilever length	1000,00 mm
Rail colour	silver
Rail count per module	2
Optimize fasteners	Material optimized

CLAMPS

Clamp type	RS1
Clamp colour	silver
Max value middle clamps	29 %
Max value end clamps	16 %

STATIC VALIDATION

Your project was validated by our statics check successfully.

Static utilization factor: 67%

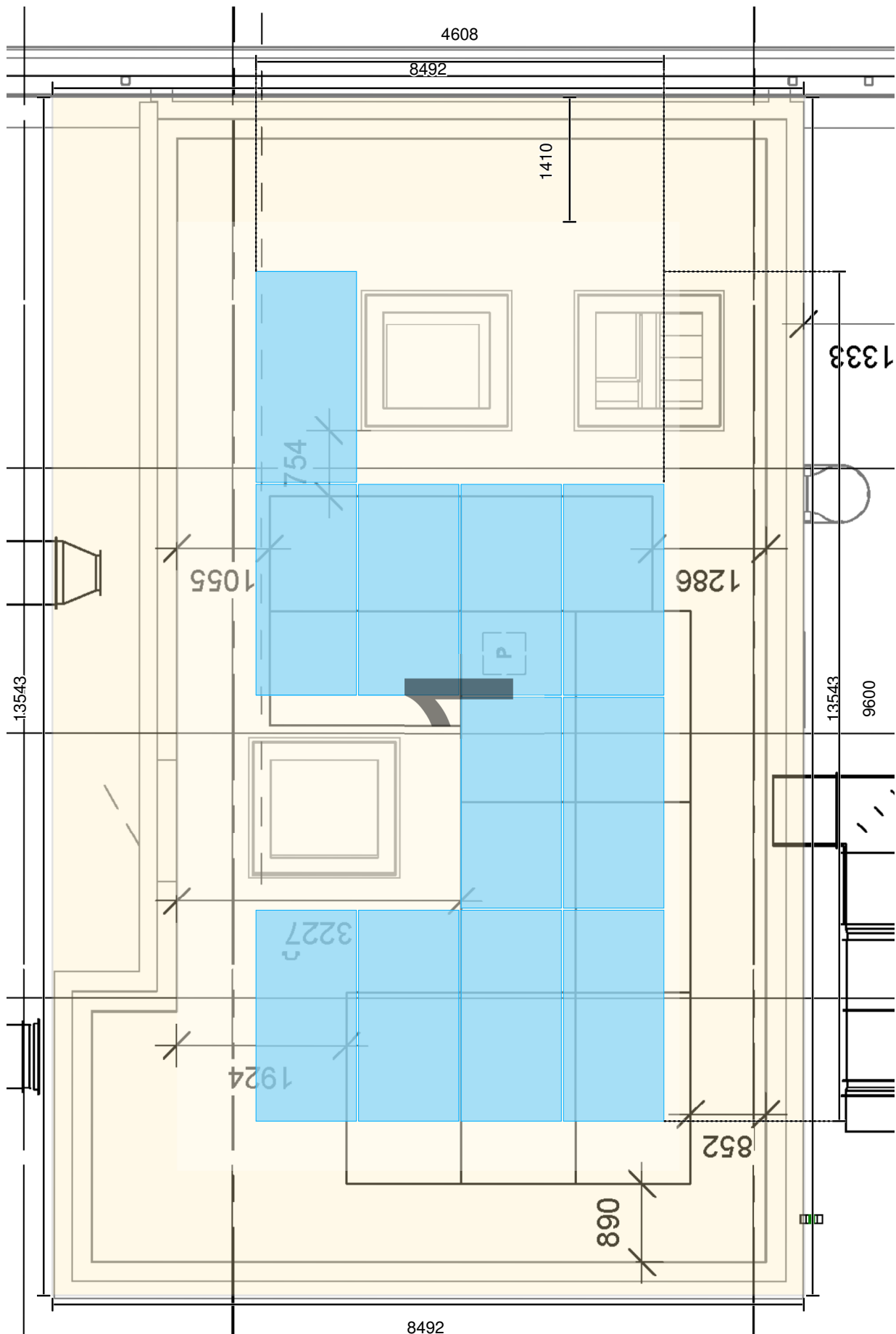
Static utilization fastener: 51%

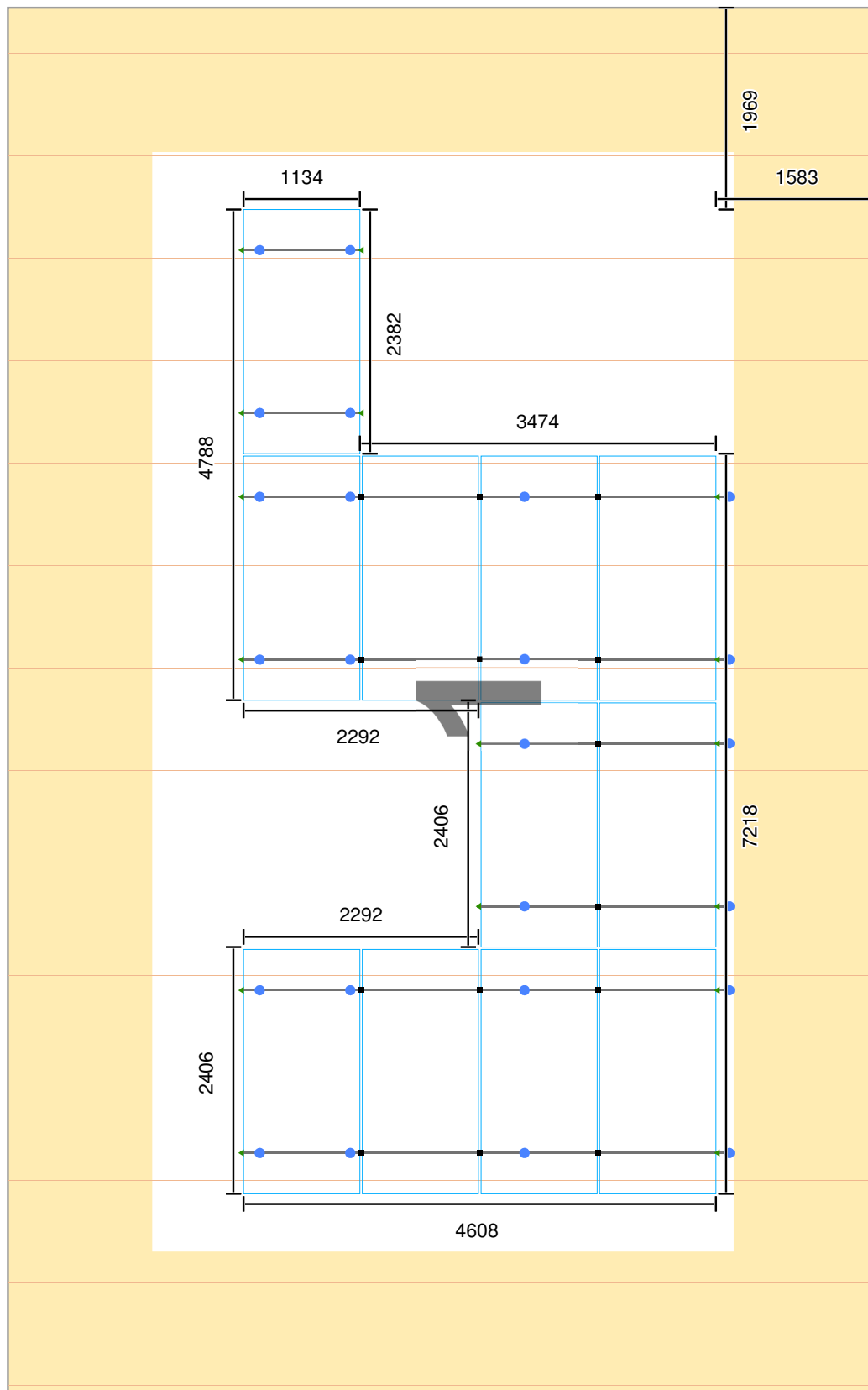
Static utilization clamp: 29%

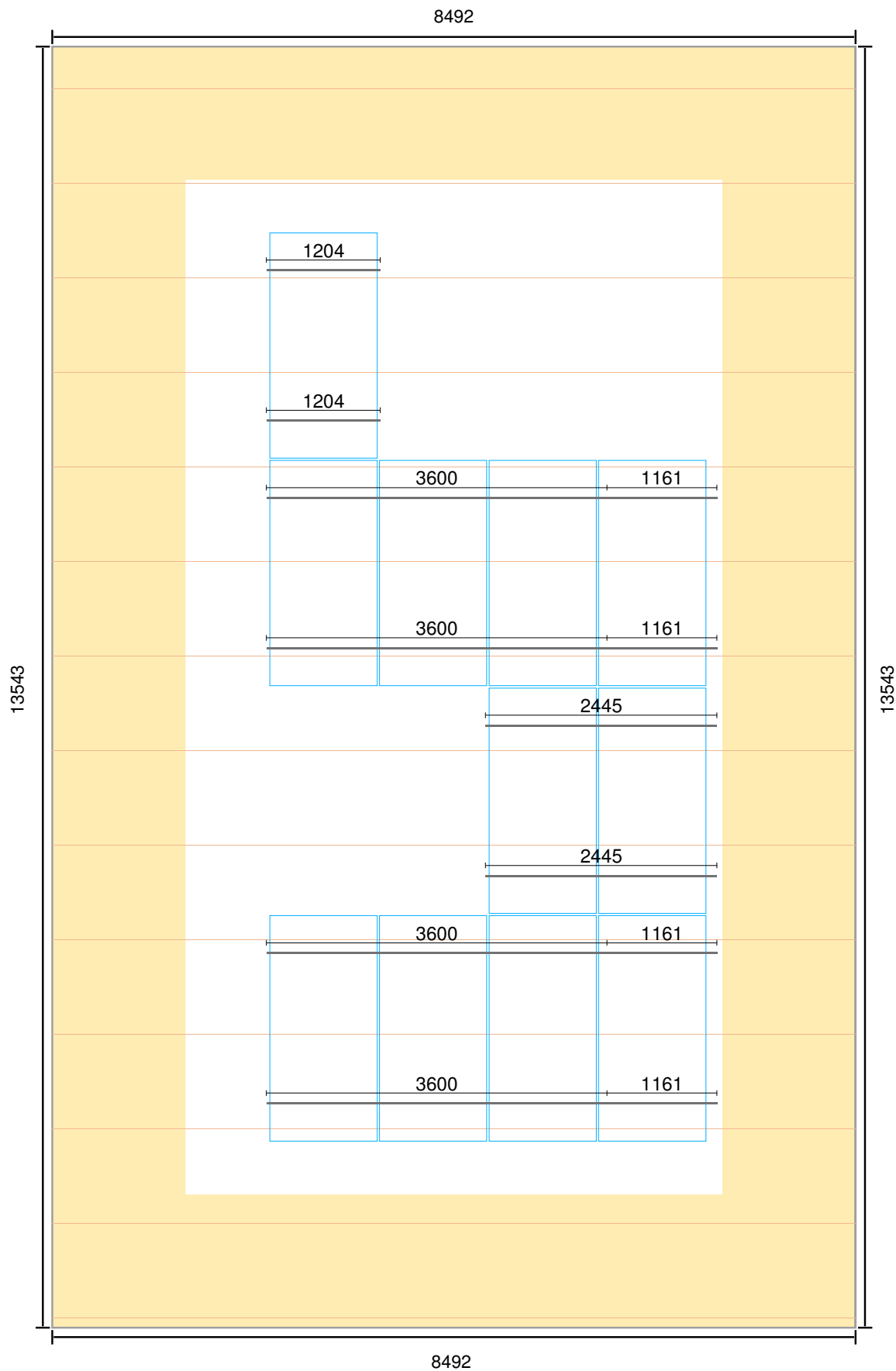
Static utilization base rail: 67%

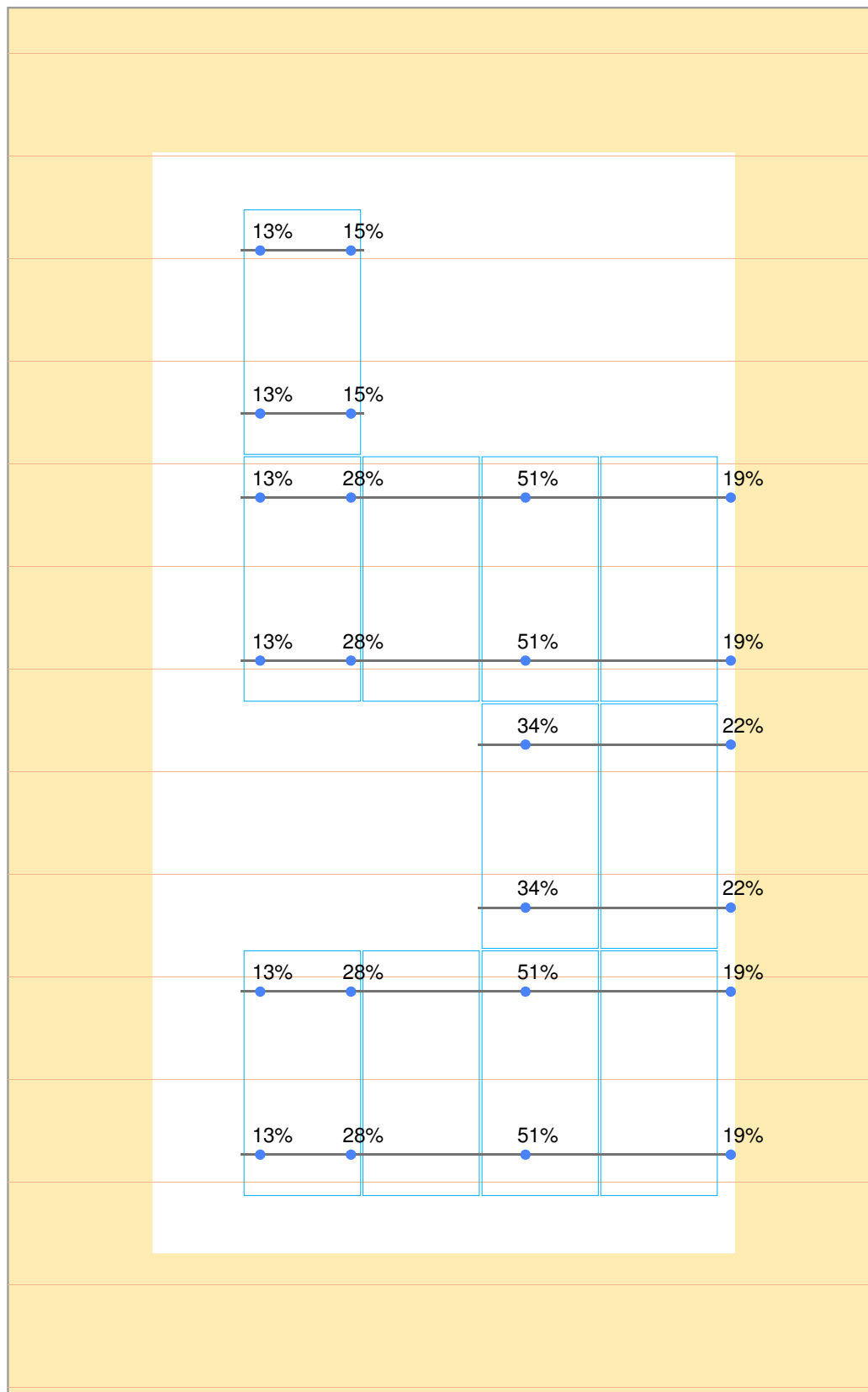
The predefined default values for input fields have to be compared with the conditions of the project. Necessary changes to adapt to local conditions must be carried out. The following relevant input fields contain their default value:

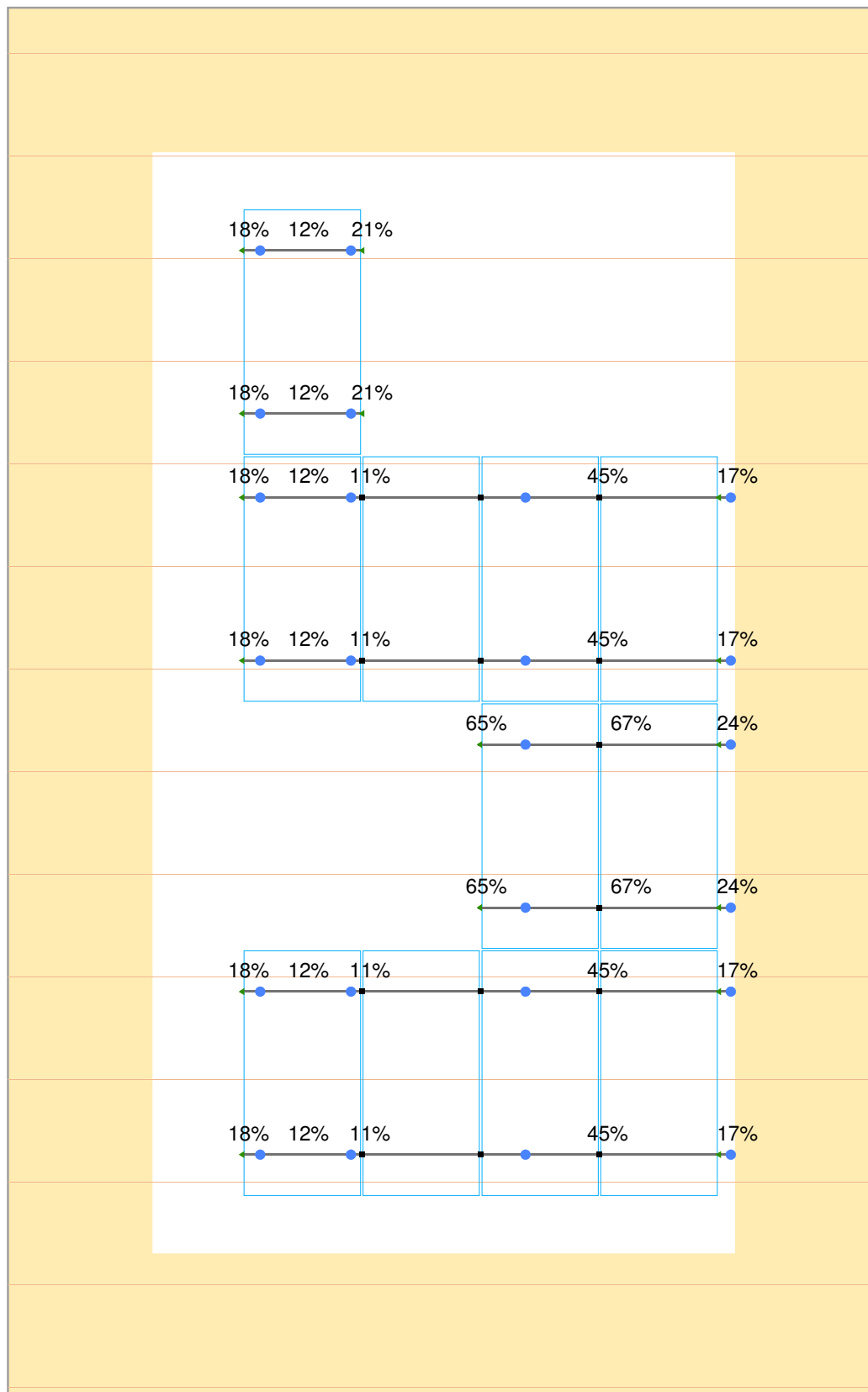
- Service life of PV system: 25 years
- Failure consequence class: 2

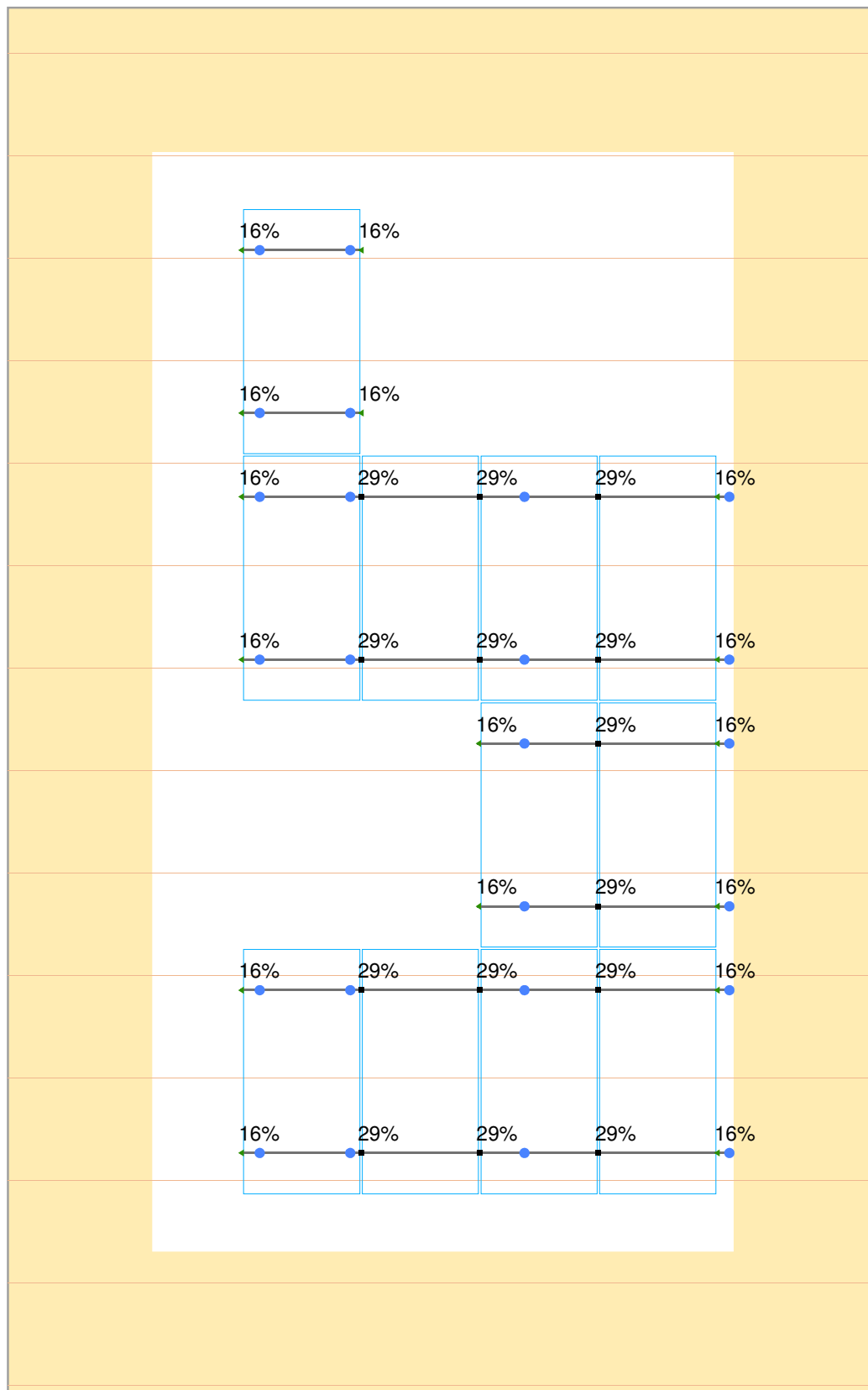


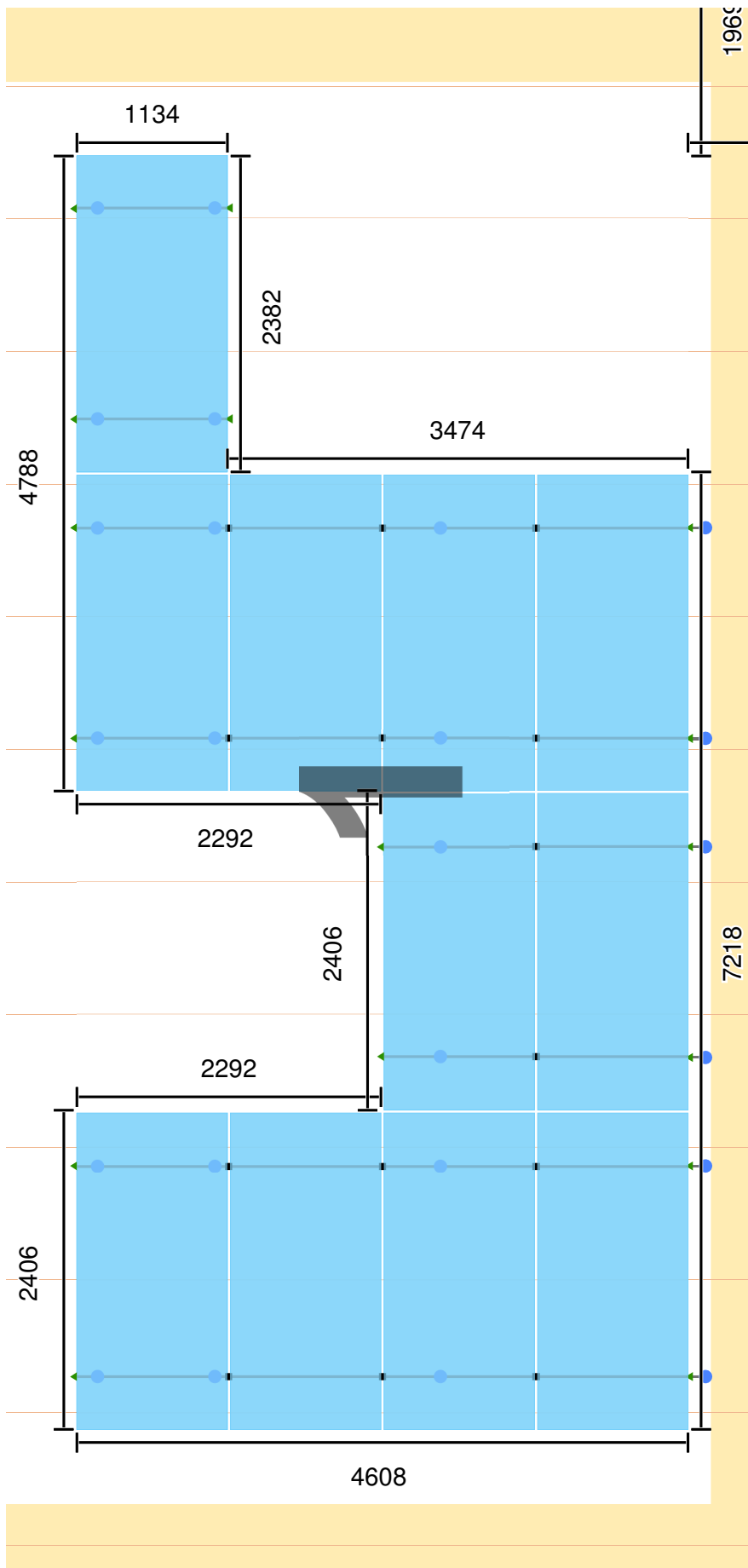












BILL OF MATERIAL

Article No.	Article	Quantity	Ordering Unit	Weight/Piece	Weight
R400532	VS+ Rail connector 50 x 37	4	1	0,193 kg	0,772 kg
R400570	VS+ Mounting rail 50 x 37 x 3600 mm	8	1	9,108 kg	72,864 kg
R420024	Bracket IFP M8/M10, set(1pc.)	24	1	0,090 kg	2,160 kg
R420080	RS1	30	1	0,083 kg	2,490 kg
R920044	End Cap RIGHT / LEFT (grey) 50x37	8	1	0,015 kg	0,120 kg
					Total Weight: 78,406 kg
Third party parts		Quantity			
Rooftrak IFP-HM/MW		24			

The third party product(s) listed above, is (are) not (a) product of Renusol but, from third party Manufacturer(s) (Manufacturer). The PV-Configurator uses static properties of this fastener provided by this Manufacturer. The Manufacturer is responsible for the accurateness and correctness of the static values provided by him, Renusol does not assume any liability regarding the product of the Manufacturer and its static properties.

GENERAL

Technical regulations

Eurocode 0: 'Basis of structural design' EN 1990:2012
Eurocode 1: 'Action on Structures'
Part 1-3: 'General Actions, Snow Loads' EN 1991-1-3:2015
National Annex BS EN 1991-1-3:2003/NA:2010-06
Part 1-4: 'General Actions, Wind Loads' EN 1991-1-4:2010
National Annex BS EN 1991-1-4:2005/NA:2011-01
Eurocode 9: 'Design of Aluminium Structures'
Part 1-1: 'General Structural Rules' EN 1999-1-1:2007
Report BRE DG 489 (revised 2014)

Materials

Aluminium extruded sections, EN AW 6063 T6, $t \leq 10\text{mm}$
Rail connector EN AW 6063 T6

Used documents

Schneider 'Bautabellen für Ingenieure', Werner-Verlag
SAPA 'Handbuch für Konstrukteure', Beuth Verlag

LOAD ASSUMPTIONS

Dead load

Solar modules type CS6.1-72TB-610 are used.

The modules are angled horizontally on the roof and are fastened on the larger module edges on the vertical rails with module clamps.

Dimensions:	2382 mm x 1134 mm
Weight:	$G = 33.6 \text{ kg}$
Load per longitudinal module side:	$F_G = 33.6 \text{ kg} * 9.81 \text{ m/s}^2 / 2 = 0.33 \text{ kN} / 2 = 0.165 \text{ kN}$

Mounting rails

Weight:	$0.70 \text{ kg/m} * 9.81 \text{ m/s}^2 = 0.007 \text{ kN/m}$
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Snow load

The determination of the snow load is carried out according to BS EN 1991-1-3:2003/NA:2010-06.

Snow-trap formation or snow-load accumulations are not considered in the calculation. Please contact Renusol if necessary.

Height above sea level:	47 m
Snow load zone:	3
Roof pitch:	$\alpha = 3^\circ$

Period of use:	25 Year
----------------	---------

Snow load:	$s_k = s_{k,50} * f_s = 0.50 \text{ kN/m}^2 * 0.93 = 0.46 \text{ kN/m}^2$ $\mu_1 = 0.800$ $s_1 = \mu_1 * s_k = 0.8 * 0.46 \text{ kN/m}^2 = 0.371 \text{ kN/m}^2$ $s_{1,3^\circ} = 0.371 \text{ kN/m}^2 * \cos(3.0^\circ) = 0.371 \text{ kN/m}^2$ $F_{S,k} = 0.371 \text{ kN/m}^2 * 2.38 \text{ m} * 1.13 \text{ m} / 2 = 0.501 \text{ kN}$
Load per longitudinal module side:	

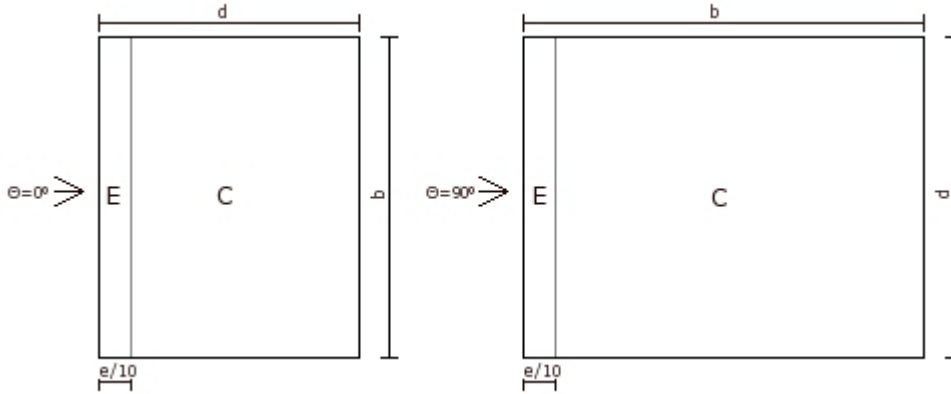
Wind load

The determination of the wind load is carried out according to BS EN 1991-1-4:2005/NA:2011-01.

Building height roof ridge:	70 m
Terrain category:	Town terrain
Basic wind velocity:	22.50 m/s
Distance to shoreline:	40.000 km
Distance inside town terrain:	3.000 km
Style of roof	
Period of use:	25 Year
Pressure of the gusts velocity:	$q(z) = 1.123 \text{ kN/m}^2$

LOAD ASSUMPTIONS

All oncoming flow directions



Main roof

$$b = 13.54\text{m}$$

$$d = 8.48\text{m}$$

$$h = 70.00\text{m}$$

Ventilation direction 0° and 180°:

$$e = \min(b, 2h) = \min(13.54\text{m}, 140.00\text{m}) = 13.54\text{m}$$

Ventilation direction 90° and 270°:

$$e = \min(d, 2h) = \min(8.48\text{m}, 140.00\text{m}) = 8.48\text{m}$$

The coefficients of pressure and suction for the individual roof areas are interpolated for the roof pitch of 3 obtained from the report BRE Digest 489.

Wind pressure:

Wind pressure not existent

Wind suction:

Edge area of roof (E)	$c_p = -1.20$	Area is not relevant
Middle area of roof (C)	$c_p = -0.50$	$W_s = (-0.50) * 1.123\text{kN/m}^2 * 2.38\text{m} * 1.13\text{m} / 2 = -0.758\text{ kN}$

ANALYSIS

Load cases and load case combinations

Load cases

The respective loads are taken from the load assumptions and converted to a reference system perpendicular to the roof area.

LC 1	Dead load
LC 2	Snow load
LC 3	Wind pressure (by roof area)
LC 4	Wind suction (by roof area)

Significant load case combinations
according to: EN 1990:2012

Ultimate state of load-bearing capacity

LCC 1	Predominant action wind pressure $E_{d,LCC 1} = 1.35 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 3} + 0.5 * E_{Qk,LC 2})$
LCC 2	Predominant action snow $E_{d,LCC 2} = 1.35 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 2} + 0.6 * E_{Qk,LC 3})$
LCC 3	Predominant action wind suction (lifting) $E_{d,LCC 3} = 1.00 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 4})$

Ultimate state of serviceability

LCC 4	Predominant action wind pressure $E_{d,LCC 4} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 3} + 0.5 * E_{Qk,LC 2})$
LCC 5	Predominant action snow $E_{d,LCC 5} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 2} + 0.6 * E_{Qk,LC 3})$
LCC 6	Predominant action wind suction $E_{d,LCC 6} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 4})$

ANALYSIS

Area load on module:

Due to the building geometry and the location, the following area loads result for the module surface according to the standard calculation.

[kN/m²]		Section	Edge
LCC 1 Design	⊥	0.44	0.44
	//	0.02	0.02
LCC 2 Design	⊥	0.72	0.72
	//	0.04	0.04
LCC 3 Design	⊥	-0.72	-1.90
	//	0.01	0.01
LCC 4 Characteristic	⊥	0.31	0.31
	//	0.02	0.02
LCC 5 Characteristic	⊥	0.49	0.49
	//	0.03	0.03
LCC 6 Characteristic	⊥	-0.44	-1.23
	//	0.01	0.01

Maximum values

[kN/m²]	Characteristic	Design
Pressure	0.49	0.72
Suction	-1.23	-1.90
In parallel to the roof	0.03	0.04

ANALYSIS

Middle clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 3447 \text{ mm}$ $y = 4772 \text{ mm}$
 Loads: $V_{x,d} = 0.03 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.03/1.29 = 0.02 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 3447 \text{ mm}$ $y = 4772 \text{ mm}$
 Loads: $V_{x,d} = 0.05 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.05/1.29 = 0.04 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 3447 \text{ mm}$ $y = 4772 \text{ mm}$
 Loads: $N_d = -0.97 \text{ kN}$
 $V_{x,d} = 0.01 \text{ kN}$
 Comparison stress: $N_d/F_{R,d,x} + V_{x,d}/F_{R,d,y} = 0.97/3.41 + 0.01/1.12 = 0.29 < 1$

ANALYSIS

End clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 2284 \text{ mm}$ $y = 4772 \text{ mm}$
 Loads: $V_{x,d} = 0.02 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.02/1.32 = 0.01 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 2284 \text{ mm}$ $y = 4772 \text{ mm}$
 Loads: $V_{x,d} = 0.03 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.03/1.32 = 0.02 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 2284 \text{ mm}$ $y = 4772 \text{ mm}$
 Loads: $N_d = -0.49 \text{ kN}$
 $V_{x,d} = 0.00 \text{ kN}$
 Comparison stress: $N_d/F_{R,d,x} + V_{x,d}/F_{R,d,y} = 0.49/3.08 + 0.00/1.26 = 0.16 < 1$

ANALYSIS

Mounting rails

General

An extruded section is used as load bearing rail.

It consists of material grade EN AW 6063 T6. At the joints, the rails are connected deflection resistant through an insertion profile (connector with rivet) with the same static parameters as the load bearing rails.

Cross section



Static analysis

The static system is a continuous beam. The single loads due to the load combinations are introduced into the supporting rails in a spacing specified by the module. The continuous beams are supported by the roof hooks or set screws.

The software analyses all rails but only the rail utilised maximally is shown (maximum stress utilisation and maximum deformation).

Analysis

LCC 1

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID:	100004
Beginning of rail:	x = 4582 mm y = 7178 mm
End of rail:	x = 7027 mm y = 7178 mm
Position:	x = 5763 mm y = 7178 mm

Loads:	$N_d = 0.02 \text{ kN}$
	$V_{y,d} = 0.00 \text{ kN}$
	$V_{z,d} = -0.44 \text{ kN}$
	$M_{y,d} = -222.37 \text{ Nm} = -22.237 \text{ kNcm}$
	$M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis:

$$\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z = (0.02/2.60 + 22.237/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 6.85 \text{ kN/cm}^2$$

Utilisation:

$$\sigma_{x,d}/\sigma_{R,d} = 6.85/18.18 = 0.38 < 1$$

ANALYSIS

LCC 2

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100004
Beginning of rail: x = 4582 mm y = 7178 mm
End of rail: x = 7027 mm y = 7178 mm
Position: x = 5763 mm y = 7178 mm

Loads: $N_d = 0.03 \text{ kN}$
 $V_{y,d} = 0.00 \text{ kN}$
 $V_{z,d} = -0.71 \text{ kN}$
 $M_{y,d} = -359.52 \text{ Nm} = -35.952 \text{ kNcm}$
 $M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis: $\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$
 $(0.03/2.60 + 35.952/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 11.08 \text{ kN/cm}^2$

Utilisation: $\sigma_{x,d}/\sigma_{R,d} = 11.08/18.18 = 0.61 < 1$

LCC 3

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100004
Beginning of rail: x = 4582 mm y = 7178 mm
End of rail: x = 7027 mm y = 7178 mm
Position: x = 5763 mm y = 7178 mm

Loads: $N_d = 0.01 \text{ kN}$
 $V_{y,d} = 0.00 \text{ kN}$
 $V_{z,d} = 0.71 \text{ kN}$
 $M_{y,d} = 352.91 \text{ Nm} = 35.291 \text{ kNcm}$
 $M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis: $\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$
 $(0.01/2.60 + 35.291/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 10.87 \text{ kN/cm}^2$

Utilisation: $\sigma_{x,d}/\sigma_{R,d} = 10.87/18.18 = 0.60 < 1$

LCC 4

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100004
Beginning of rail: x = 4582 mm y = 7178 mm
End of rail: x = 7027 mm y = 7178 mm
Position: x = 5992 mm y = 7178 mm
Deformation: u = 8.43 mm
permitted deformation: $u_{zul} = l/100 = 2000.00 \text{ mm} / 100 = 20.0 \text{ mm}$
Utilisation: $u/u_{zul} = 8.43 / 20.00 = 0.42 < 1$

LCC 5

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100004
Beginning of rail: x = 4582 mm y = 7178 mm
End of rail: x = 7027 mm y = 7178 mm
Position: x = 5992 mm y = 7178 mm
Deformation: u = 13.38 mm
permitted deformation: $u_{zul} = l/100 = 2000.00 \text{ mm} / 100 = 20.0 \text{ mm}$
Utilisation: $u/u_{zul} = 13.38 / 20.00 = 0.67 < 1$

ANALYSIS

LCC 6

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID:	100004
Beginning of rail:	x = 4582 mm y = 7178 mm
End of rail:	x = 7027 mm y = 7178 mm
Position:	x = 5992 mm y = 7178 mm
Deformation:	u = 11.53 mm
permitted deformation:	$u_{zul} = l/100 = 2000.00 \text{ mm} / 100 = 20.0 \text{ mm}$
Utilisation:	$u/u_{zul} = 11.53 / 20.00 = 0.58 < 1$

ANALYSIS

Fastener

General

The resistances were determined on the user's own responsibility.

Design values of load capacity

$$F_{R,d,x} = 5.00 \text{ kN}$$

$$F_{R,d,-x} = 3.50 \text{ kN}$$

$$F_{R,d,y} = 2.50 \text{ kN}$$

LCC 1

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 4992 \text{ mm}$ $y = 4772 \text{ mm}$

Loads: $N_d = 1.11 \text{ kN}$

$$V_{x,d} = 0.05 \text{ kN}$$

$$\text{Comparison stress: } N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 1.11/5.00 + 0.05/2.50 = 0.24 < 1$$

LCC 2

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 4992 \text{ mm}$ $y = 4772 \text{ mm}$

Loads: $N_d = 1.80 \text{ kN}$

$$V_{x,d} = 0.08 \text{ kN}$$

$$\text{Comparison stress: } N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 1.80/5.00 + 0.08/2.50 = 0.39 < 1$$

LCC 3

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 4992 \text{ mm}$ $y = 4772 \text{ mm}$

Loads: $N_d = -1.77 \text{ kN}$

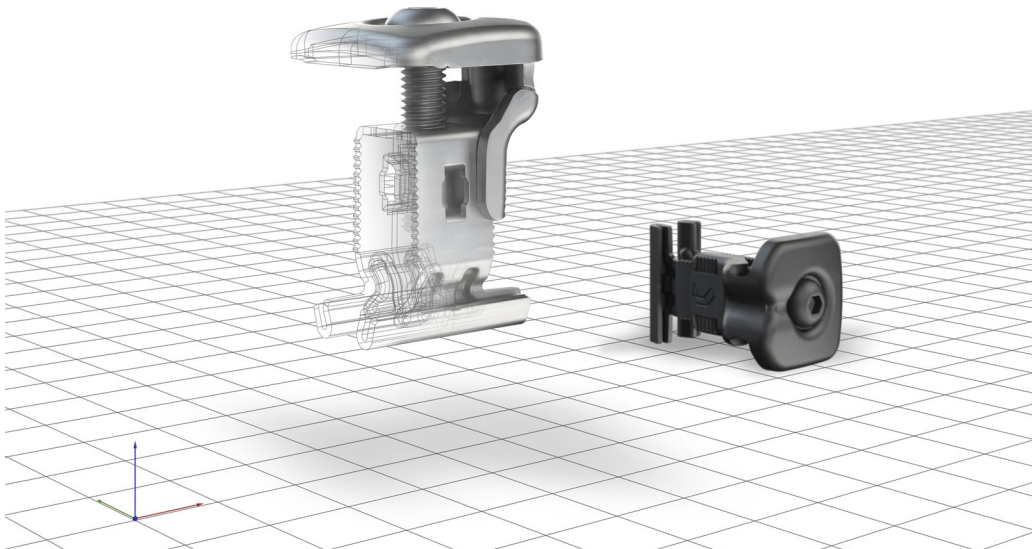
$$V_{x,d} = 0.01 \text{ kN}$$

$$\text{Comparison stress: } N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 1.77/3.50 + 0.01/2.50 = 0.51 < 1$$

Technical project overview

Echo Street, Manchester, M1 7DP

Building project	Echo Street, Manchester, M1 7DP
Address	Echo Street 17, M1 3AL
Country	United Kingdom
Module Type	Canadian Solar Inc. - CS6.1-72TB-610
Number of modules	12
Rated output	7.32 kWp
Mounting system	VarioSole+
Editor	Renusol Europe GmbH



LOCATION

Street	Echo Street 17
City	M1 3AL
Country	United Kingdom

SURROUNDINGS

Code	Eurocode NA GB
Terrain height above sealevel	47,00 m
Snow load zone	Zone 3
Use Pressure coefficients from BRE 489 2014 roof pitch 0 -45°	yes
Terrain category	City
Distance to coast	40,00 km
Distance to edge of city	3,00 km
Surroundings	normal
Service life of PV system	25 years
Failure consequence class	2

LOAD CALCULATION RESULT

Peak velocity pressure	1,16 kN/m ²
Snow load	0,46 kN/m ²
Snow load on roof	0,37 kN/m ²
Base wind speed ($V_{b,0}$)	22,50 m/s

TOPOGRAPHY

Topography	Not exposed
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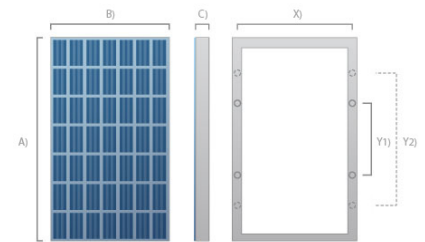
ROOF PROPERTIES

Roof type	Mono pitch roof
Coverage type	Shingles
Spacing x	1000,00 mm
First at x	100,00 mm
skipXForCalculation	yes
Spacing y	1146,00 mm
First at y	1500,00 mm
skipYForCalculation	no
C) Roof pitch	3,00 °
D) Building height	87,00 m



MODULE PARAMETERS

Manufacturer	Canadian Solar Inc.
Name	CS6.1-72TB-610
Length	2382 mm
Width	1134 mm
Height	30 mm
Weight	33.6 kg
Rated output	610 W _{peak}



Please check the compatibility of clamping positions with module manufacturer advice.

FASTENER PARAMETERS

Name	Rooftrak IFP-HM/MW
Manufacturer	Nicholson
Pressure load capacity	5,00 kN
Tensile load capacity	3,50 kN
Lateral force	2,50 kN
Interaction	Linear

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SYSTEM

System	VarioSole+
--------	------------



Please check the entered row distance for an ideal yield calculation with a correct calculation including consideration of the shading.

FASTENER DETAILS

Mounting direction of modules	Landscape
Fastener type	Custom fastener

MODULE RAIL

Fastening rails	Single layer
Rail orientation	Vertical
Mounting rail	50x37 mm
Fixations only under module surface	No
Use alternating roof hooks	No
Rail length	3600mm
Maximum cantilever length	300,00 mm
Rail colour	silver
Rail count per module	2
Optimize fasteners	Roof wise

CLAMPS

Clamp type	RS1
Clamp colour	silver
Max value middle clamps	30 %
Max value end clamps	17 %

STATIC VALIDATION

Your project was validated by our statics check successfully.

Static utilization factor: 82%

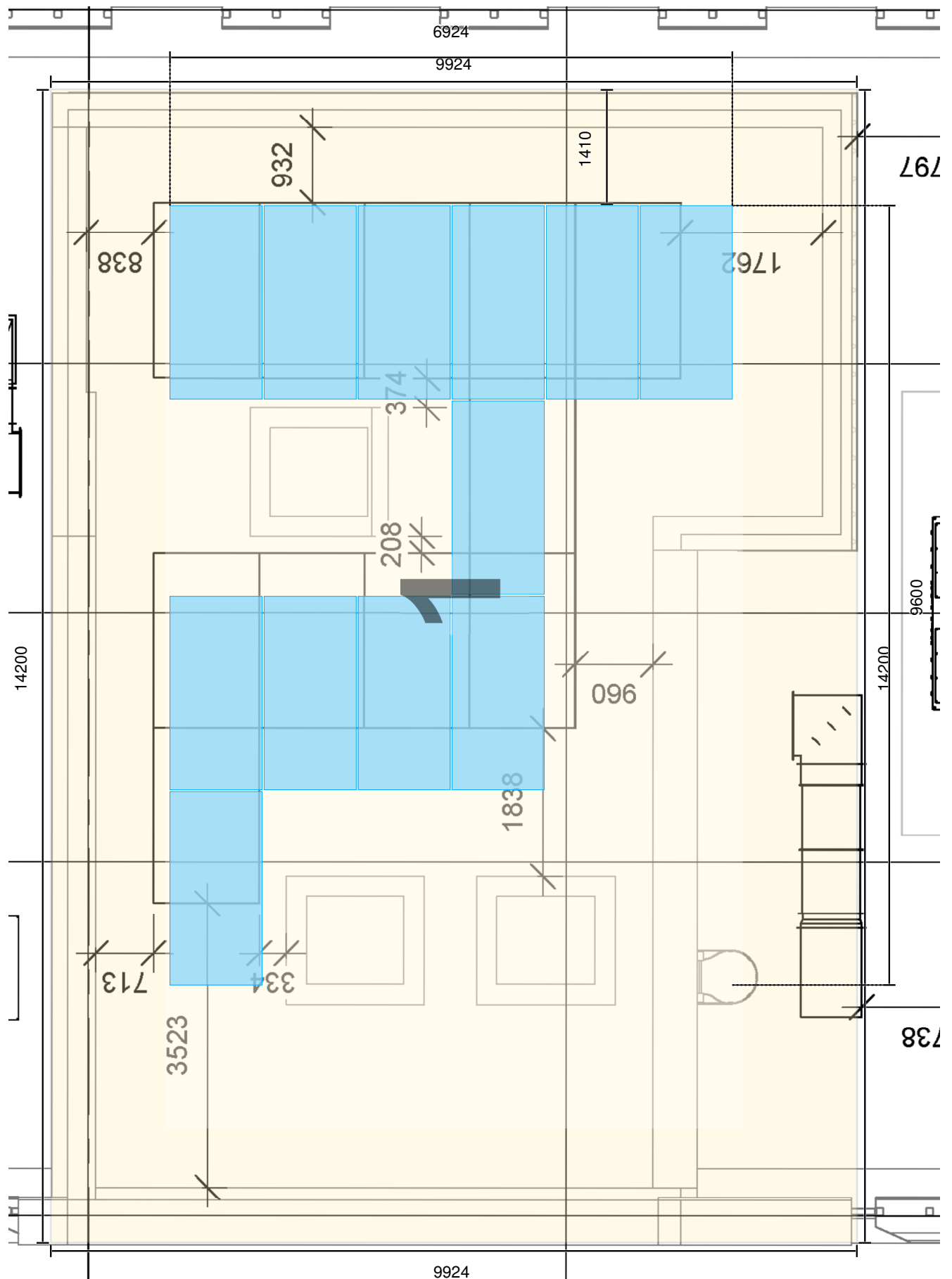
Static utilization fastener: 68%

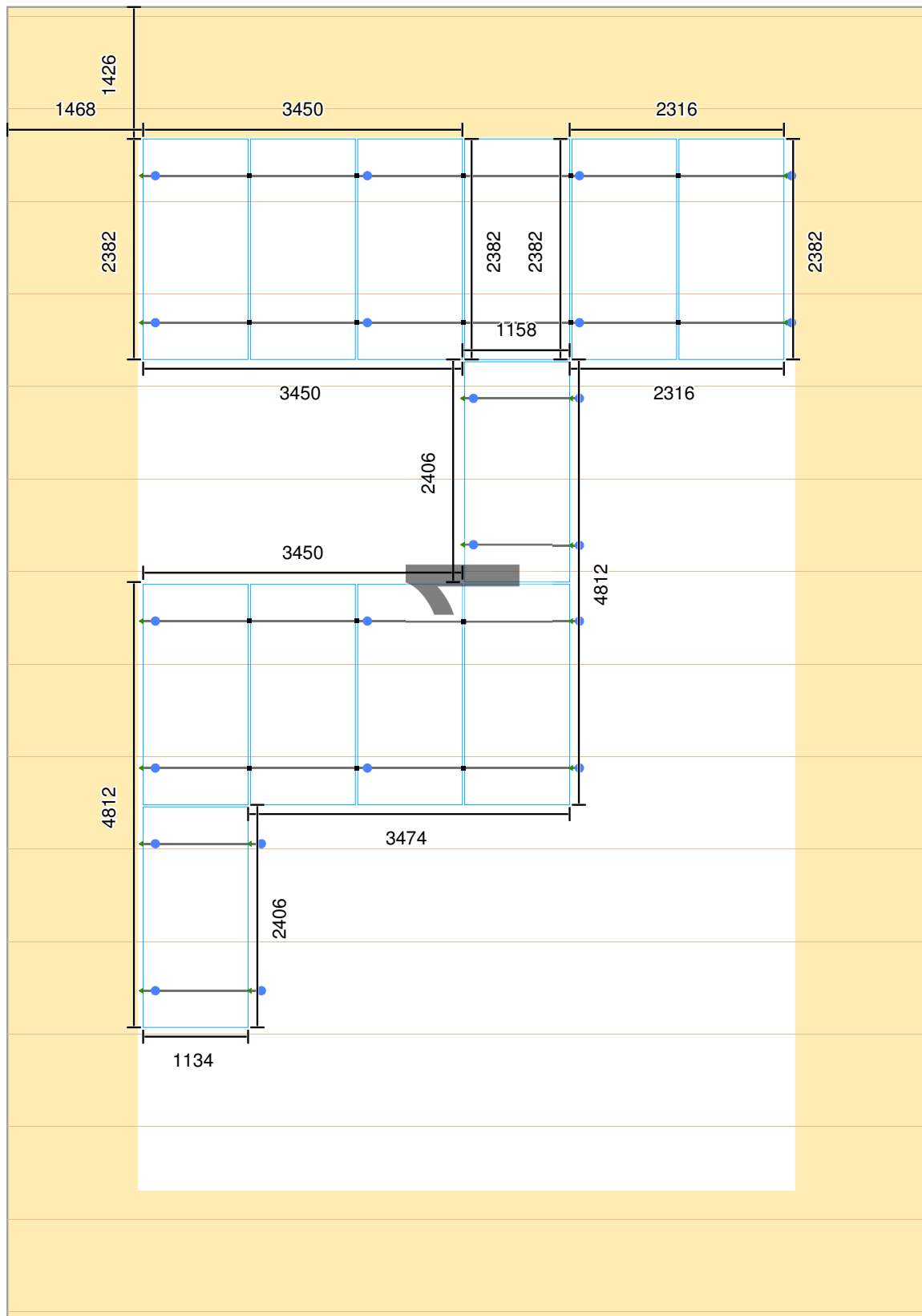
Static utilization clamp: 30%

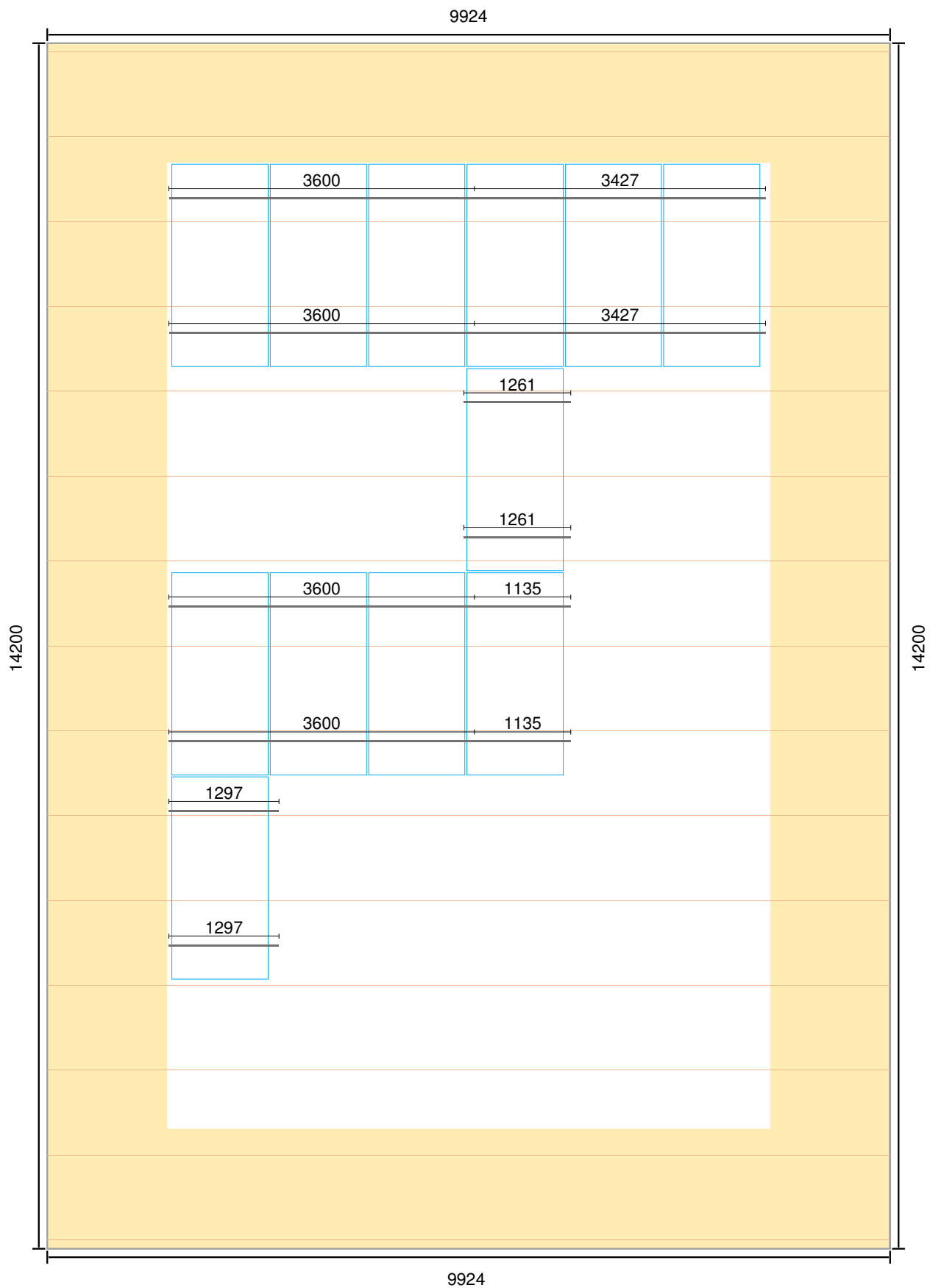
Static utilization base rail: 82%

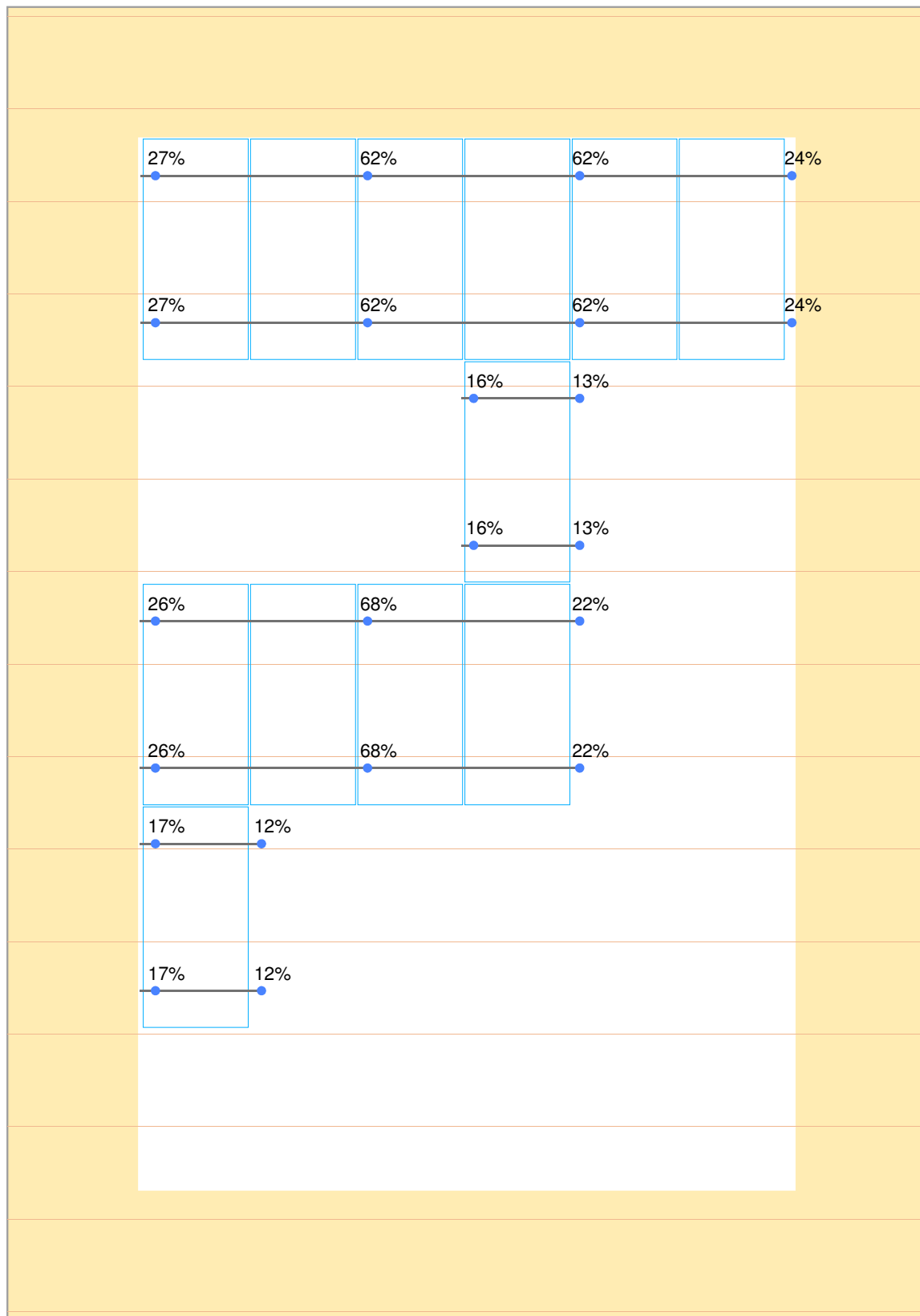
The predefined default values for input fields have to be compared with the conditions of the project. Necessary changes to adapt to local conditions must be carried out. The following relevant input fields contain their default value:

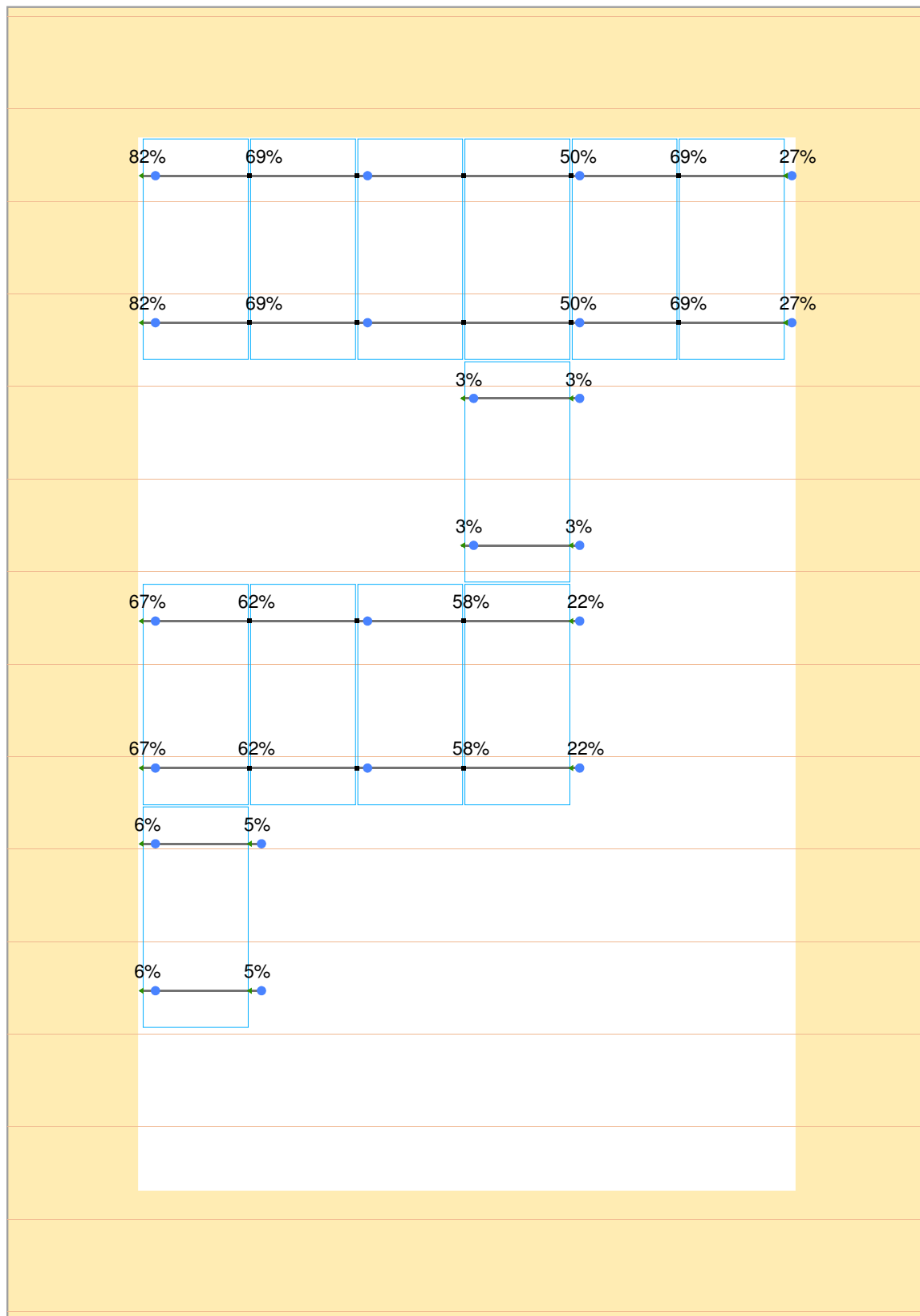
- Service life of PV system: 25 years
- Failure consequence class: 2

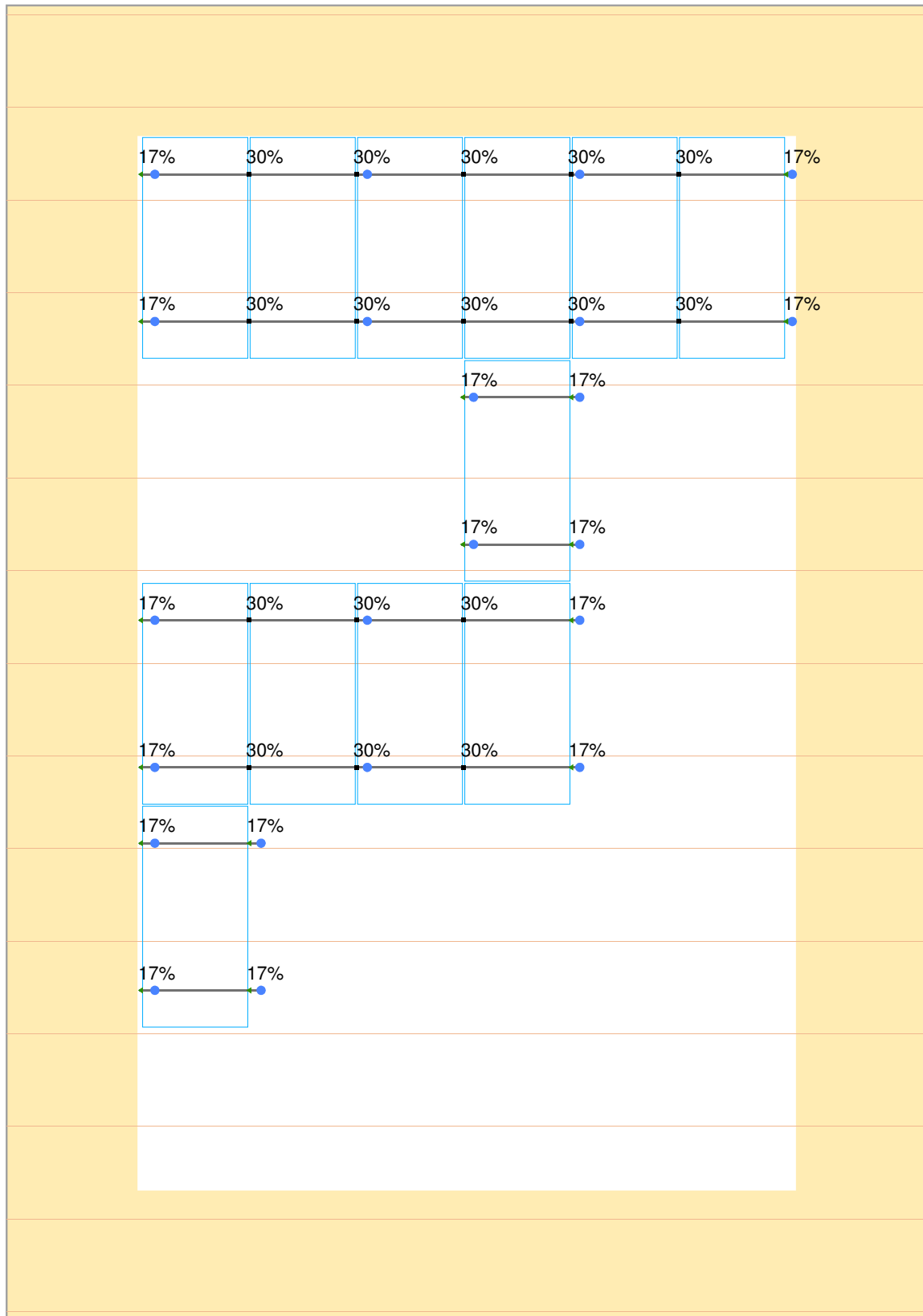


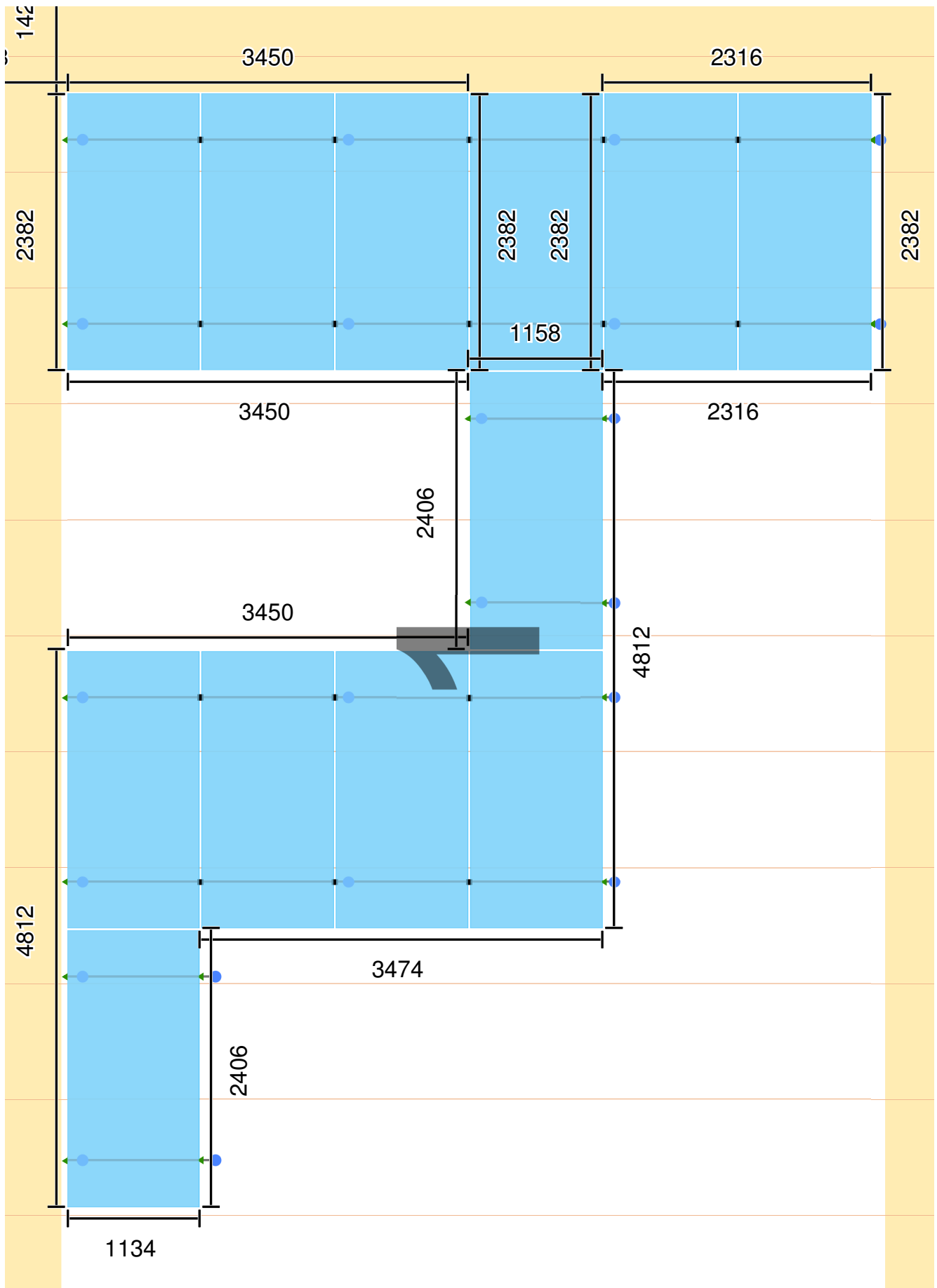












BILL OF MATERIAL

Article No.	Article	Quantity	Ordering Unit	Weight/Piece	Weight
R400532	VS+ Rail connector 50 x 37	4	1	0,193 kg	0,772 kg
R400570	VS+ Mounting rail 50 x 37 x 3600 mm	9	1	9,108 kg	81,972 kg
R420024	Bracket IFP M8/M10, set(1pc.)	22	1	0,090 kg	1,980 kg
R420080	RS1	32	1	0,083 kg	2,656 kg
R920044	End Cap RIGHT / LEFT (grey) 50x37	8	1	0,015 kg	0,120 kg
					Total Weight: 87,500 kg
Third party parts		Quantity			
Rooftrak IFP-HM/MW		22			

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GENERAL

Technical regulations

Eurocode 0: 'Basis of structural design' EN 1990:2012
Eurocode 1: 'Action on Structures'
Part 1-3: 'General Actions, Snow Loads' EN 1991-1-3:2015
National Annex BS EN 1991-1-3:2003/NA:2010-06
Part 1-4: 'General Actions, Wind Loads' EN 1991-1-4:2010
National Annex BS EN 1991-1-4:2005/NA:2011-01
Eurocode 9: 'Design of Aluminium Structures'
Part 1-1: 'General Structural Rules' EN 1999-1-1:2007
Report BRE DG 489 (revised 2014)

Materials

Aluminium extruded sections, EN AW 6063 T6, $t \leq 10\text{mm}$
Rail connector EN AW 6063 T6

Used documents

Schneider 'Bautabellen für Ingenieure', Werner-Verlag
SAPA 'Handbuch für Konstrukteure', Beuth Verlag

LOAD ASSUMPTIONS

Dead load

Solar modules type CS6.1-72TB-610 are used.

The modules are angled horizontally on the roof and are fastened on the larger module edges on the vertical rails with module clamps.

Dimensions:	2382 mm x 1134 mm
Weight:	$G = 33.6 \text{ kg}$
Load per longitudinal module side:	$F_G = 33.6 \text{ kg} * 9.81 \text{ m/s}^2 / 2 = 0.33 \text{ kN} / 2 = 0.165 \text{ kN}$

Mounting rails

Weight:	$0.70 \text{ kg/m} * 9.81 \text{ m/s}^2 = 0.007 \text{ kN/m}$
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Snow load

The determination of the snow load is carried out according to BS EN 1991-1-3:2003/NA:2010-06.

Snow-trap formation or snow-load accumulations are not considered in the calculation. Please contact Renusol if necessary.

Height above sea level:	47 m
Snow load zone:	3
Roof pitch:	$\alpha = 3^\circ$

Period of use:	25 Year
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Snow load:	$s_k = s_{k,50} * f_s = 0.50 \text{ kN/m}^2 * 0.93 = 0.46 \text{ kN/m}^2$ $\mu_1 = 0.800$ $s_1 = \mu_1 * s_k = 0.8 * 0.46 \text{ kN/m}^2 = 0.371 \text{ kN/m}^2$ $s_{1,3^\circ} = 0.371 \text{ kN/m}^2 * \cos(3.0^\circ) = 0.371 \text{ kN/m}^2$ $F_{S,k} = 0.371 \text{ kN/m}^2 * 2.38 \text{ m} * 1.13 \text{ m} / 2 = 0.501 \text{ kN}$
Load per longitudinal module side:	

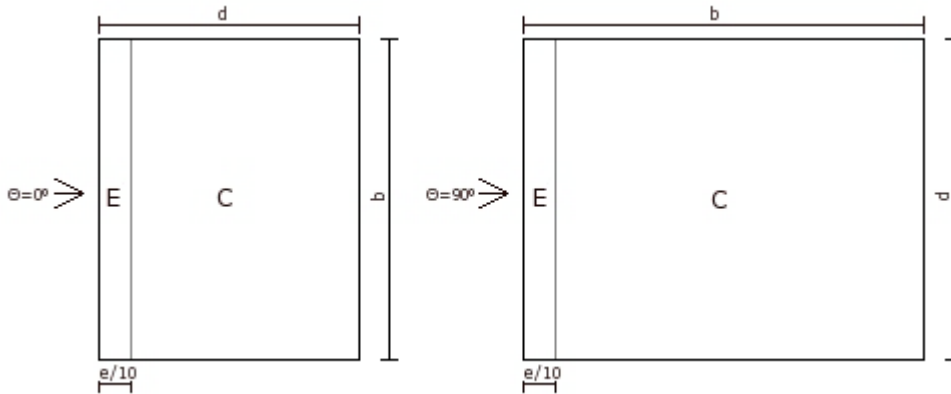
Wind load

The determination of the wind load is carried out according to BS EN 1991-1-4:2005/NA:2011-01.

Building height roof ridge:	87 m
Terrain category:	Town terrain
Basic wind velocity:	22.50 m/s
Distance to shoreline:	40.000 km
Distance inside town terrain:	3.000 km
Style of roof	
Period of use:	25 Year
Pressure of the gusts velocity:	$q(z) = 1.160 \text{ kN/m}^2$

LOAD ASSUMPTIONS

All oncoming flow directions



Main roof

$$b = 14.20\text{m}$$

$$d = 9.91\text{m}$$

$$h = 87.00\text{m}$$

Ventilation direction 0° and 180°:

$$e = \min(b, 2h) = \min(14.20\text{m}, 174.00\text{m}) = 14.20\text{m}$$

Ventilation direction 90° and 270°:

$$e = \min(d, 2h) = \min(9.91\text{m}, 174.00\text{m}) = 9.91\text{m}$$

The coefficients of pressure and suction for the individual roof areas are interpolated for the roof pitch of 3 obtained from the report BRE Digest 489.

Wind pressure:

Wind pressure not existent

Wind suction:

Edge area of roof (E) $c_p = -1.20$ Area is not relevant

Middle area of roof (C) $c_p = -0.50$ $W_s = (-0.50) * 1.160\text{kN/m}^2 * 2.38\text{m} * 1.13\text{m} / 2 = -0.784\text{ kN}$

ANALYSIS

Load cases and load case combinations

Load cases

The respective loads are taken from the load assumptions and converted to a reference system perpendicular to the roof area.

LC 1	Dead load
LC 2	Snow load
LC 3	Wind pressure (by roof area)
LC 4	Wind suction (by roof area)

Significant load case combinations
according to: EN 1990:2012

Ultimate state of load-bearing capacity

LCC 1	Predominant action wind pressure $E_{d,LCC 1} = 1.35 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 3} + 0.5 * E_{Qk,LC 2})$
LCC 2	Predominant action snow $E_{d,LCC 2} = 1.35 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 2} + 0.6 * E_{Qk,LC 3})$
LCC 3	Predominant action wind suction (lifting) $E_{d,LCC 3} = 1.00 * E_{Gk,LC 1} + 1.50 * (E_{Qk,LC 4})$

Ultimate state of serviceability

LCC 4	Predominant action wind pressure $E_{d,LCC 4} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 3} + 0.5 * E_{Qk,LC 2})$
LCC 5	Predominant action snow $E_{d,LCC 5} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 2} + 0.6 * E_{Qk,LC 3})$
LCC 6	Predominant action wind suction $E_{d,LCC 6} = 1.00 * E_{Gk,LC 1} + 1.00 * (E_{Qk,LC 4})$

ANALYSIS

Area load on module:

Due to the building geometry and the location, the following area loads result for the module surface according to the standard calculation.

[kN/m²]		Section	Edge
LCC 1 Design	⊥	0.44	0.44
	//	0.02	0.02
LCC 2 Design	⊥	0.72	0.72
	//	0.04	0.04
LCC 3 Design	⊥	-0.75	-1.97
	//	0.01	0.01
LCC 4 Characteristic	⊥	0.31	0.31
	//	0.02	0.02
LCC 5 Characteristic	⊥	0.49	0.49
	//	0.03	0.03
LCC 6 Characteristic	⊥	-0.46	-1.27
	//	0.01	0.01

Maximum values

[kN/m²]	Characteristic	Design
Pressure	0.49	0.72
Suction	-1.27	-1.97
In parallel to the roof	0.03	0.04

ANALYSIS

Middle clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 2614 \text{ mm}$ $y = 1823 \text{ mm}$
 Loads: $V_{x,d} = 0.03 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.03/1.29 = 0.02 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 2614 \text{ mm}$ $y = 1823 \text{ mm}$
 Loads: $V_{x,d} = 0.05 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.05/1.29 = 0.04 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 2614 \text{ mm}$ $y = 1823 \text{ mm}$
 Loads: $N_d = -1.01 \text{ kN}$
 $V_{x,d} = 0.01 \text{ kN}$
 Comparison stress: $N_d/F_{R,d,x} + V_{x,d}/F_{R,d,y} = 1.01/3.41 + 0.01/1.12 = 0.30 < 1$

ANALYSIS

End clamp

General

The module clamps consist of bent parts made of the material S500 MC, EN 10149-2. The lower part of the module clamps consists of a click profile made of S500 MC, EN 10149-2, which is attached to the module carrying profile and transfers the loads by form closure. On it the module end clamp or module middle clamp is fastened by a screw. When tightening the screw the module clamp presses the module to the rail.

Sketch



Static analysis

The maximum loads established in the load combinations of the tension loads perpendicular to the roof area and the respective shear loads parallel to the roof area or the maximum shear loads in combination with the corresponding tensile loads perpendicular to the roof area are significant for the analysis. Pressure loads perpendicular to the roof area are transferred by contact bearing.

Analysis

LCC 1

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 1450 \text{ mm}$ $y = 1823 \text{ mm}$
 Loads: $V_{x,d} = 0.02 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.02/1.32 = 0.01 < 1$

LCC 2

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 1450 \text{ mm}$ $y = 1823 \text{ mm}$
 Loads: $V_{x,d} = 0.03 \text{ kN}$
 Comparison stress: $V_{x,d}/F_{R,d,y} = 0.03/1.32 = 0.02 < 1$

LCC 3

Regarding the calculation the following module clamp at the following position is significant.

Position: $x = 1450 \text{ mm}$ $y = 1823 \text{ mm}$
 Loads: $N_d = -0.51 \text{ kN}$
 $V_{x,d} = 0.00 \text{ kN}$
 Comparison stress: $N_d/F_{R,d,x} + V_{x,d}/F_{R,d,y} = 0.51/3.08 + 0.00/1.26 = 0.17 < 1$

ANALYSIS

Mounting rails

General

An extruded section is used as load bearing rail.

It consists of material grade EN AW 6063 T6. At the joints, the rails are connected deflection resistant through an insertion profile (connector with rivet) with the same static parameters as the load bearing rails.

Cross section



Static analysis

The static system is a continuous beam. The single loads due to the load combinations are introduced into the supporting rails in a spacing specified by the module. The continuous beams are supported by the roof hooks or set screws.

The software analyses all rails but only the rail utilised maximally is shown (maximum stress utilisation and maximum deformation).

Analysis

LCC 1

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID:	100003
Beginning of rail:	x = 1433 mm y = 8223 mm
End of rail:	x = 6167 mm y = 8223 mm
Position:	x = 3840 mm y = 8223 mm

Loads:	$N_d = -0.05 \text{ kN}$
	$V_{y,d} = 0.00 \text{ kN}$
	$V_{z,d} = 0.98 \text{ kN}$
	$M_{y,d} = 275.97 \text{ Nm} = 27.597 \text{ kNcm}$
	$M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis:	$\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$ $(0.05/2.60 + 27.597/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 8.51 \text{ kN/cm}^2$
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Utilisation:	$\sigma_{x,d}/\sigma_{R,d} = 8.51/18.18 = 0.47 < 1$
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ANALYSIS

LCC 2

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100003
Beginning of rail: x = 1433 mm y = 8223 mm
End of rail: x = 6167 mm y = 8223 mm
Position: x = 3840 mm y = 8223 mm

Loads:
 $N_d = -0.07 \text{ kN}$
 $V_{y,d} = 0.00 \text{ kN}$
 $V_{z,d} = 1.58 \text{ kN}$
 $M_{y,d} = 445.41 \text{ Nm} = 44.541 \text{ kNcm}$
 $M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis:
 $\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$
 $(0.07/2.60 + 44.541/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 13.74 \text{ kN/cm}^2$

Utilisation:
 $\sigma_{x,d}/\sigma_{R,d} = 13.74/18.18 = 0.76 < 1$

LCC 3

Stress analysis

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100003
Beginning of rail: x = 1433 mm y = 8223 mm
End of rail: x = 6167 mm y = 8223 mm
Position: x = 3840 mm y = 8223 mm

Loads:
 $N_d = -0.01 \text{ kN}$
 $V_{y,d} = 0.00 \text{ kN}$
 $V_{z,d} = -1.62 \text{ kN}$
 $M_{y,d} = -452.33 \text{ Nm} = -45.233 \text{ kNcm}$
 $M_{z,d} = 0.00 \text{ Nm} = 0.000 \text{ kNcm}$

Stress analysis:
 $\sigma_{x,d} = N_d/A + M_{y,d}/W_y + M_{z,d}/W_z =$
 $(0.01/2.60 + 45.233/3.25 + 0.000/2.24) \text{ kN/cm}^2 = 13.93 \text{ kN/cm}^2$

Utilisation:
 $\sigma_{x,d}/\sigma_{R,d} = 13.93/18.18 = 0.77 < 1$

LCC 4

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100001
Beginning of rail: x = 1433 mm y = 3411 mm
End of rail: x = 8459 mm y = 3411 mm
Position: x = 1433 mm y = 3411 mm
Deformation: u = 1.55 mm
permitted deformation: $u_{zul} = 3.0 \text{ mm}$
Utilisation: $u/u_{zul} = 1.55 / 3.00 = 0.52 < 1$

LCC 5

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID: 100002
Beginning of rail: x = 1433 mm y = 1823 mm
End of rail: x = 8459 mm y = 1823 mm
Position: x = 1433 mm y = 1823 mm
Deformation: u = 2.45 mm
permitted deformation: $u_{zul} = 3.0 \text{ mm}$
Utilisation: $u/u_{zul} = 2.45 / 3.00 = 0.82 < 1$

ANALYSIS

LCC 6

Serviceability

Regarding the calculation the following rail at the following position is significant.

Rail ID:	100002
Beginning of rail:	x = 1433 mm y = 1823 mm
End of rail:	x = 8459 mm y = 1823 mm
Position:	x = 1433 mm y = 1823 mm
Deformation:	u = 2.21 mm
permitted deformation:	$u_{zul} = 3.0 \text{ mm}$
Utilisation:	$u/u_{zul} = 2.21 / 3.00 = 0.74 < 1$

ANALYSIS

Fastener

General

The resistances were determined on the user's own responsibility.

Design values of load capacity

$$F_{R,d,x} = 5.00 \text{ kN}$$

$$F_{R,d,-x} = 3.50 \text{ kN}$$

$$F_{R,d,y} = 2.50 \text{ kN}$$

LCC 1

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 3840 \text{ mm}$ $y = 6635 \text{ mm}$

Loads: $N_d = 1.42 \text{ kN}$

$$V_{x,d} = 0.06 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 1.42/5.00 + 0.06/2.50 = 0.31 < 1$

LCC 2

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 3840 \text{ mm}$ $y = 8223 \text{ mm}$

Loads: $N_d = 2.30 \text{ kN}$

$$V_{x,d} = 0.10 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 2.30/5.00 + 0.10/2.50 = 0.50 < 1$

LCC 3

Regarding the calculation the following fastener at the following position is significant.

Position: $x = 3840 \text{ mm}$ $y = 8223 \text{ mm}$

Loads: $N_d = -2.35 \text{ kN}$

$$V_{x,d} = 0.02 \text{ kN}$$

Comparison stress: $N_d/F_{R,d,-x} + V_{x,d}/F_{R,d,y} = 2.35/3.50 + 0.02/2.50 = 0.68 < 1$

TOTAL BILL OF MATERIAL

Article No.	Article	Quantity	Ordering Unit	Weight/Piece	Weight
R400532	VS+ Rail connector 50 x 37	10	1	0,193 kg	1,930 kg
R400570	VS+ Mounting rail 50 x 37 x 3600 mm	25	1	9,108 kg	227,700 kg
R420024	Bracket IFP M8/M10, set(1pc.)	68	1	0,090 kg	6,120 kg
R420080	RS1	324	1	0,083 kg	26,892 kg
R500419	Eave support XL	118	1	0,049 kg	5,782 kg
R500423	Ridge support 10° XL	59	1	0,443 kg	26,137 kg
R500499	Base rail FS10-EW XL 2362 mm	59	1	1,660 kg	97,940 kg
R900314	Socket bolt 6 x 110 mm	177	1	0,009 kg	1,593 kg
R920044	End Cap RIGHT / LEFT (grey) 50x37	24	1	0,015 kg	0,360 kg
Total Weight: 394,454 kg					
Third party parts		Quantity			
Rooftrak IFP-HM/MW		245			

The third party product(s) listed above, is (are) not (a) product of Renusol but, from third party Manufacturer(s) (Manufacturer). The PV-Configurator uses static properties of this fastener provided by this Manufacturer. The Manufacturer is responsible for the accurateness and correctness of the static values provided by him, Renusol does not assume any liability regarding the product of the Manufacturer and its static properties.

IMPORTANT NOTES

The Project Report is a result of information provided by the Customer ("Customer" means customer of Renusol ordering this Project Report from the technical service of Renusol or user of the PV Configurator creating this Project Report himself). Renusol has neither verified the accurateness nor the completeness of the information and data provided by the Customer, which form the basis of this Project Report. It is the responsibility of the Customer to check and verify all input variables (including but not limited to those input variables which had been pre-set with proposed values) and assumptions used in the Project for their accuracy and correctness.

These verifications shall include but not be limited to the following aspects: (a) Wind and snow loads are proposed by the PV Configurator using respective wind and snow load maps. It should be verified that the local conditions do not deviate from the values used in the Configuration (e.g. location on mountain with higher snow load). (b) The Customer shall check and verify the Failure Consequence Class ("CC"). Typical residential and commercial buildings require CC 2. The Customer shall use higher CC in sensitive local environment (e.g. public building, high frequency of visitors, vicinity with potential for severe damages). (c) The service lifetime of the PV installation shall be verified by the Customer depending on the expectation of the ultimate user of the PV installation as well as the lifetime of the other components used in the installation. If the lifetime is expected beyond the service lifetime used for this Project Report, all relevant structural properties as well as input variables and assumptions shall be re-checked using the then expected service lifetime. (d) For flat roof systems: The Customer shall in any case measure and document the friction coefficient of the PV system on the location-specific roof cover it is placed on. The measurement shall be performed in various, at least three roof areas. (e) For flat roof systems: The PV Configurator proposes a ballast calculation. The ballast forms, together with the weight of the PV mounting system itself and the weight of the module, the total weight of the system. The actual ballast applied may in no case be lower than the values proposed by the PV Configurator. The ballast applied shall furthermore be documented. If the ballast applied cannot be precisely determined, a safety factor increasing the ballast is to be applied.

To the extent values of input variables measured or observed by the Customer differ from values used in this Project Report, the configuration of the PV installation shall be re-iterated using the respective correct values.

To the extent this Project Report includes a data concerning structural properties, it is the responsibility of the Customer to professionally verify (have verified) the structural data with regards to its compliance with the applicable local laws and properties of the location for which the Project Report has been prepared.

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