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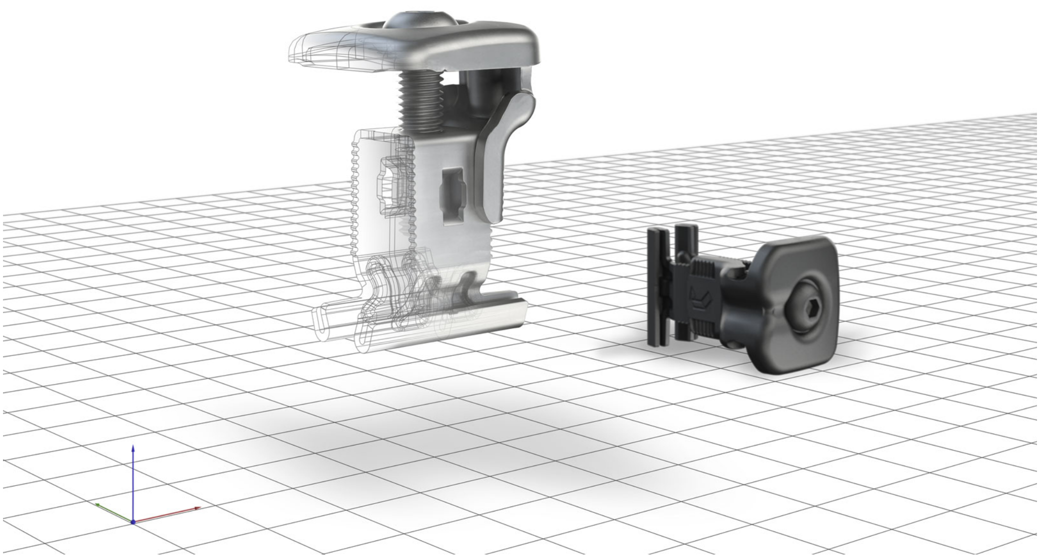
Technical project overview

Leevaku HEJ, katusepark

Building project	Leevaku HEJ, katusepark
Date	07.07.2023
In-house project no.	PA_230707_530853
Own project number	23271
Comment	Roof-top
Editor	Mahe NRG OÜ
Link to configurator	Open link
Number of modules	56
Rated output	22.96 kWp



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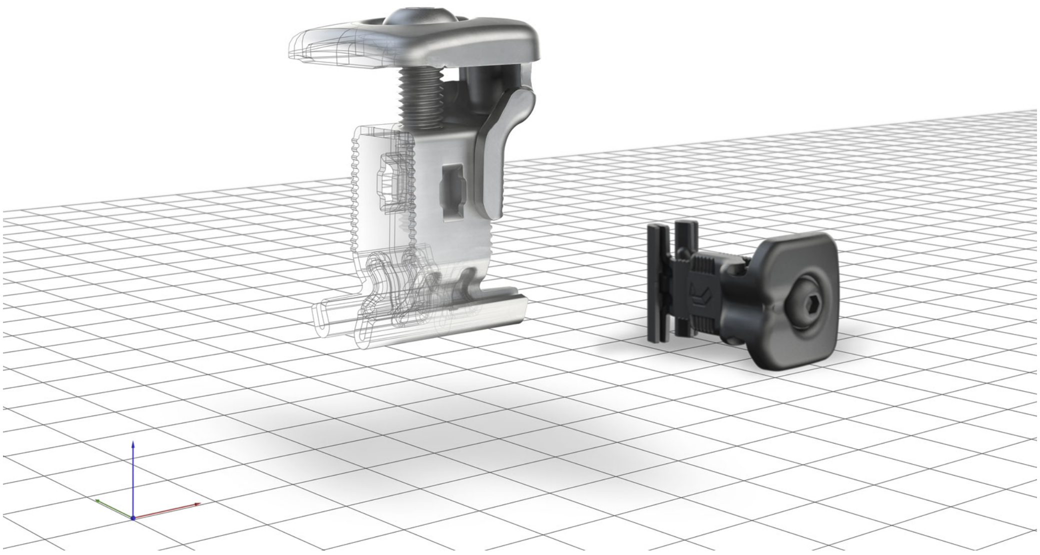
Technical project overview

Leevaku HEJ, katusepark

Building project	Leevaku HEJ, katusepark
Address	64428 Leevaku
Country	Estonia
Module Type	Longi Solar - LR5-54HIH-410M
Number of modules	56
Rated output	22.96 kWp
Mounting system	MetaSole+
Editor	Mahe NRG OÜ



LOCATION

Street	
City	64428 Leevaku
Country	Estonia

SURROUNDINGS

Code	Eurocode NA EE
Terrain height above sealevel	41,00 m
Snow load zone	Zone 1,5 kN/m²
Wind load zone	Entire country
Reduction of wind load for pitched roofs by wind tunnel tests (till 20° roof pitch)	yes
Terrain category	Terrain II
Service life of PV system	25 years
Failure consequence class	2
Partial safety factor dead load (ballast)	1

LOAD CALCULATION RESULT

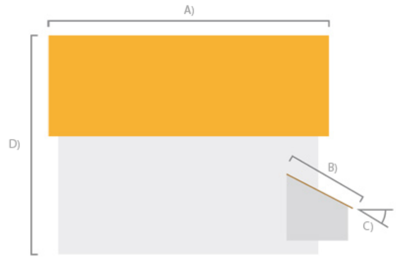
Peak velocity pressure	0,60 kN/m^2
Snow load	1,39 kN/m^2
Snow load on roof	0,76 kN/m^2
Base wind speed ($V_{b,0}$)	21,00 m/s

TOPOGRAPHY

Topography	Not exposed

ROOF PROPERTIES

Roof type	Gable roof
Coverage type	Corrugated profile
A) Corrugated flute spacing	183,00 mm
First corrugated flute at	100,00 mm
B) Corrugated flute height	24,00 mm
Corrugated flute quality	Steel ≥ S320GD
Sheet thickness	0.50mm
A) Roof length	17,30 m
B) Roof segment width	8,00 m
C) Roof pitch	35,00 º
D) Building height	10,00 m

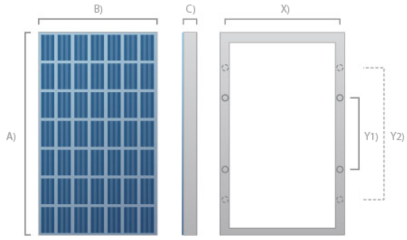


SUBSTRUCTURE

Substructure type	Rafters
Material of substructure	Wood
Spacing of substructure	600,00 mm
First substructure at	300,00 mm
Substructure thickness	200,00 mm

MODULE PARAMETERS

Manufacturer	Longi Solar
Name	LR5-54HIH-410M
Length	1722 mm
Width	1134 mm
Height	30 mm
Weight	20.8 kg
Rated output	410 W_{peak}
Color	black
Datasheet	Open datasheet



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

The module data was taken from a database. Please check whether this data corresponds to your actual module order. If necessary, please correct the data using the editing function.

SYSTEM

System	MetaSole+
Mounting direction of modules	Portrait
Fastener type	MS+: corrugated 0.40-1.25mm

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

MODULE RAIL

Optimize fasteners	Mounting optimized

CLAMPS

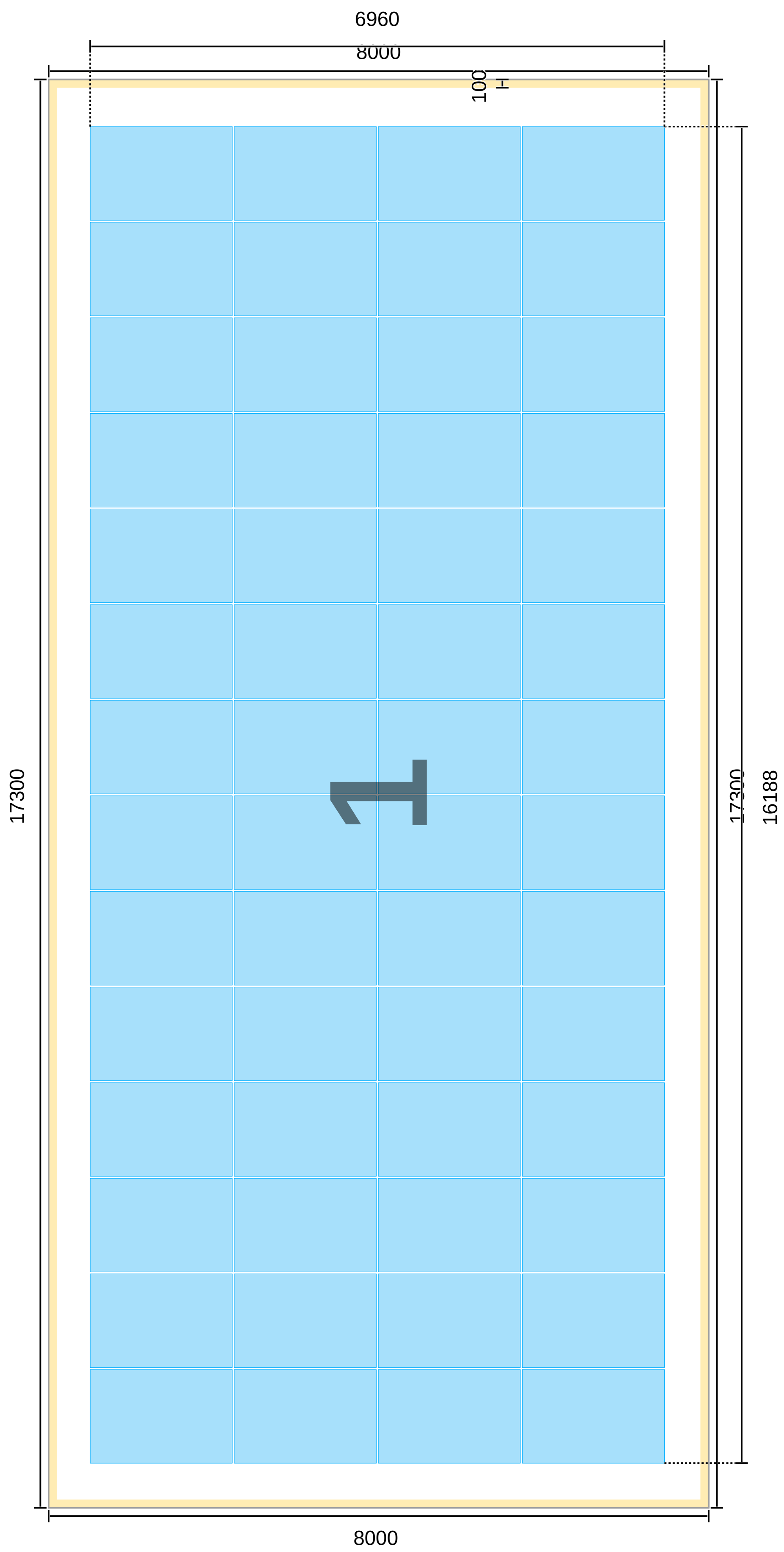
Clamp type	Mid clamps+ / End clamps+
Clamp colour	black
Max value middle clamps	73 %
Max value end clamps	51 %

STATIC VALIDATION

Your project was validated by our statics check successfully.

Static utilization factor: 103%

Static utilization fastener: 103%
Static utilization clamp: 73%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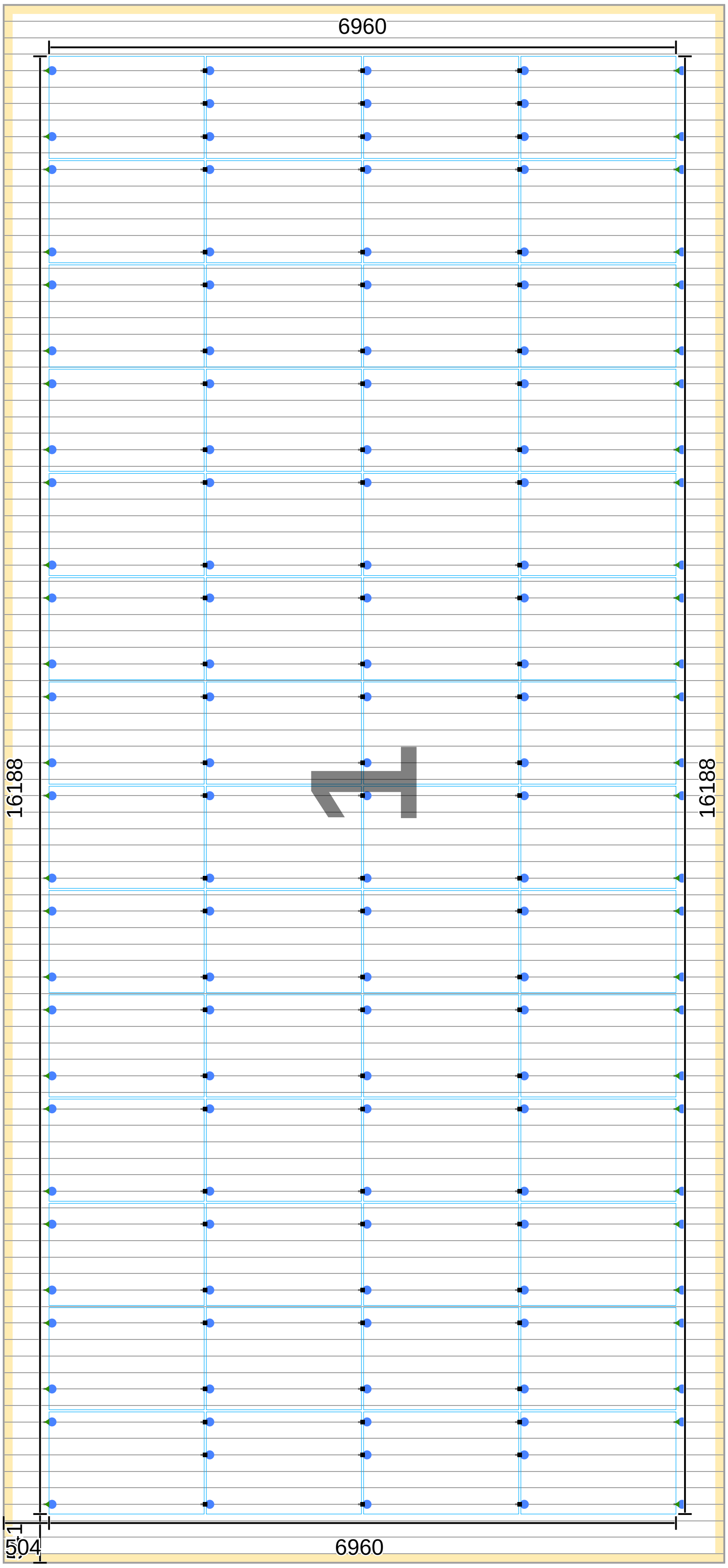
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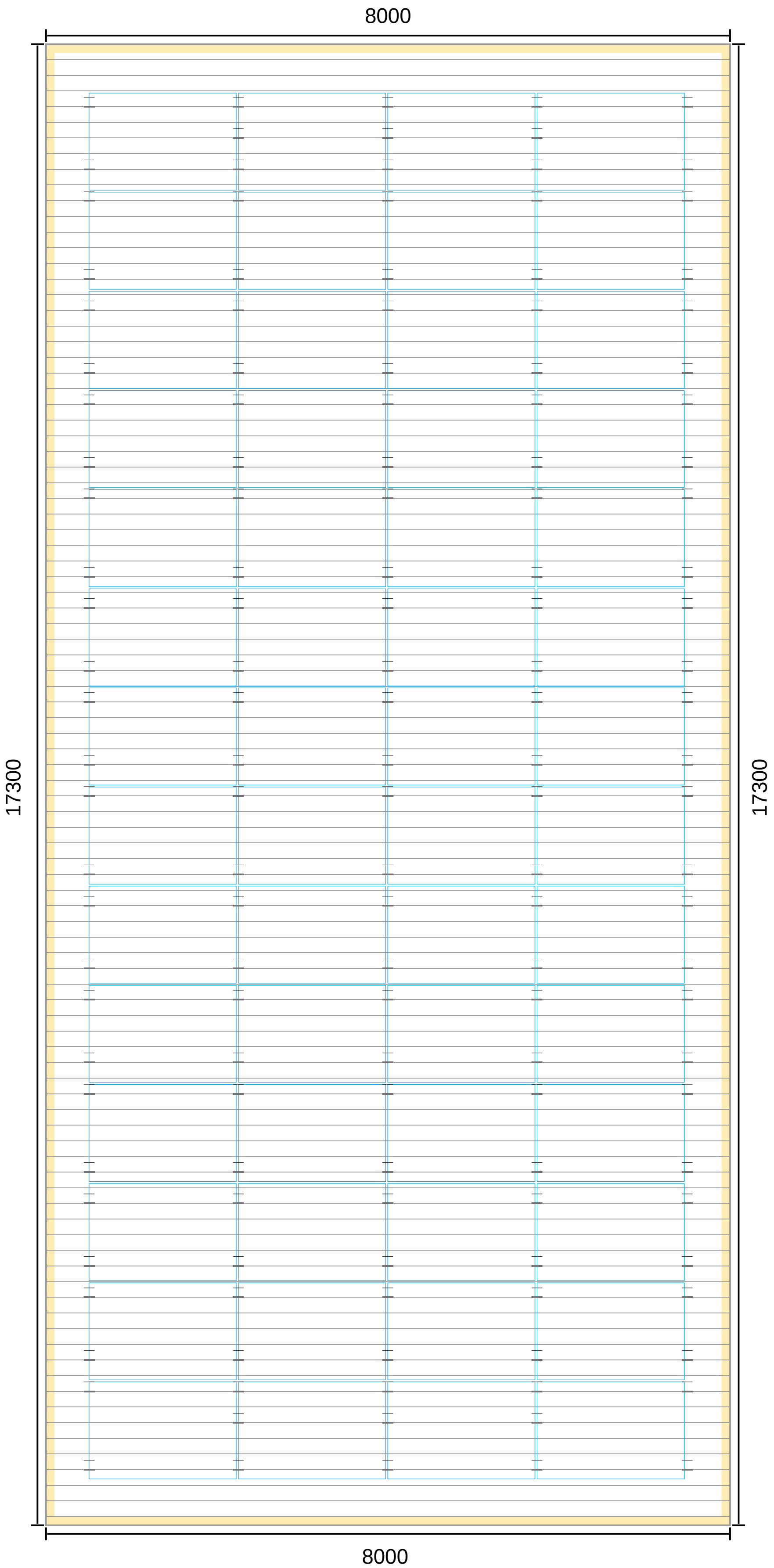
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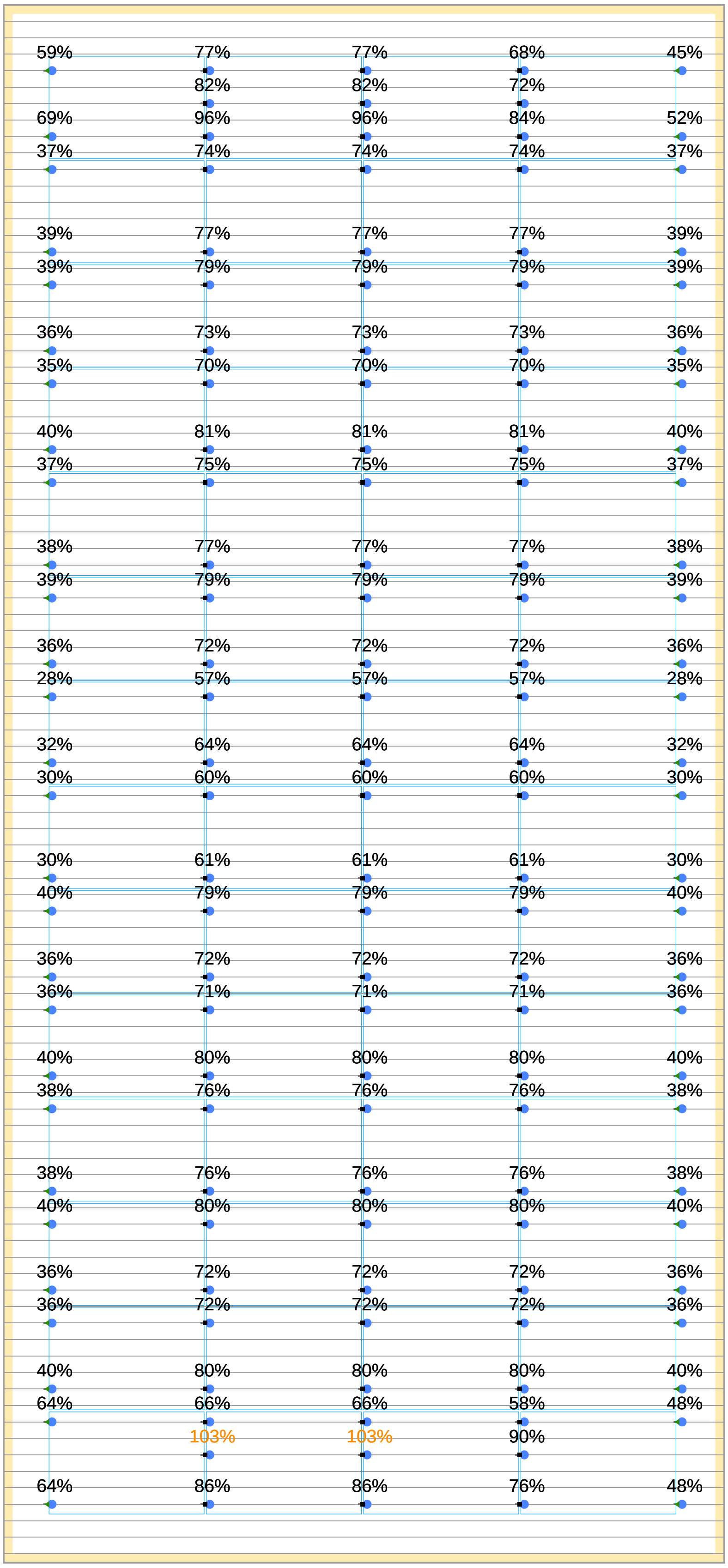
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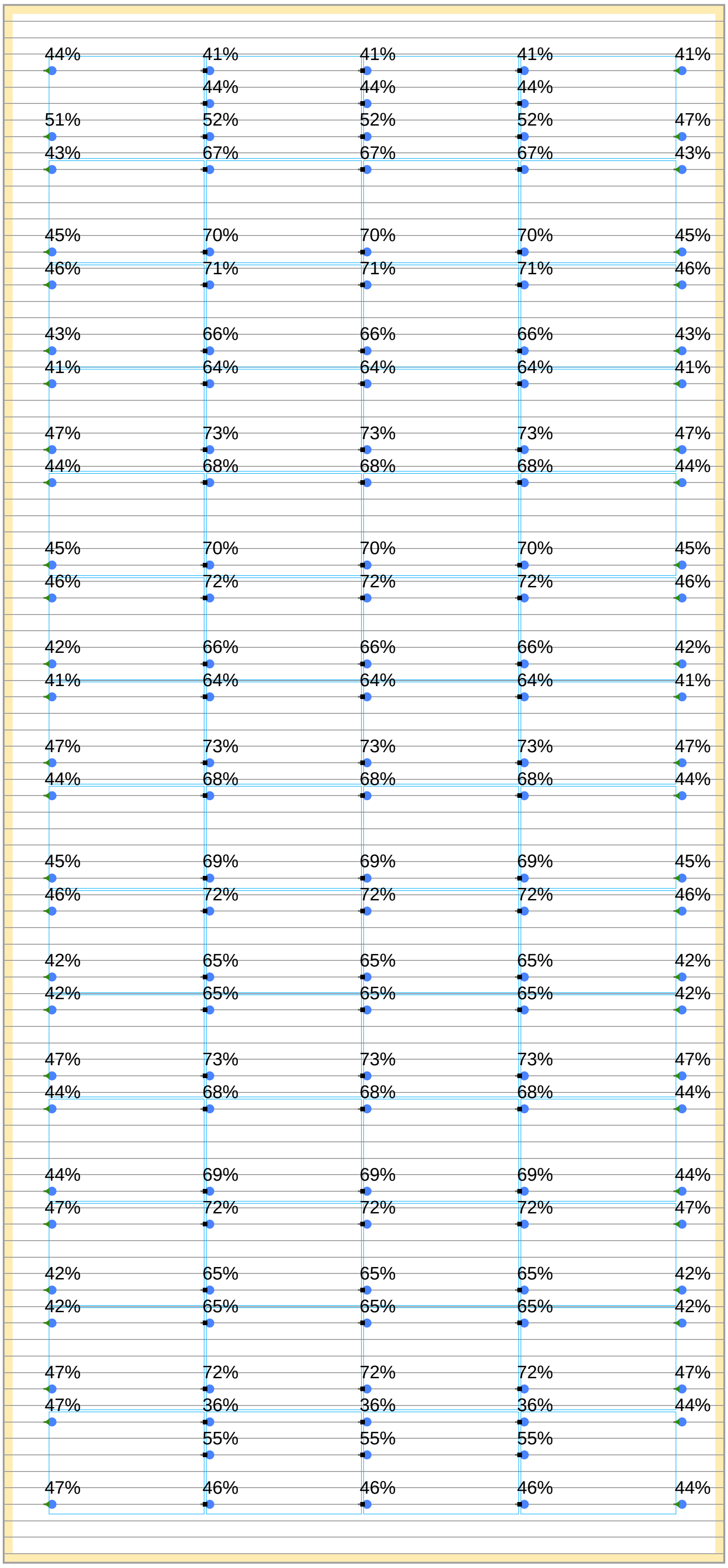
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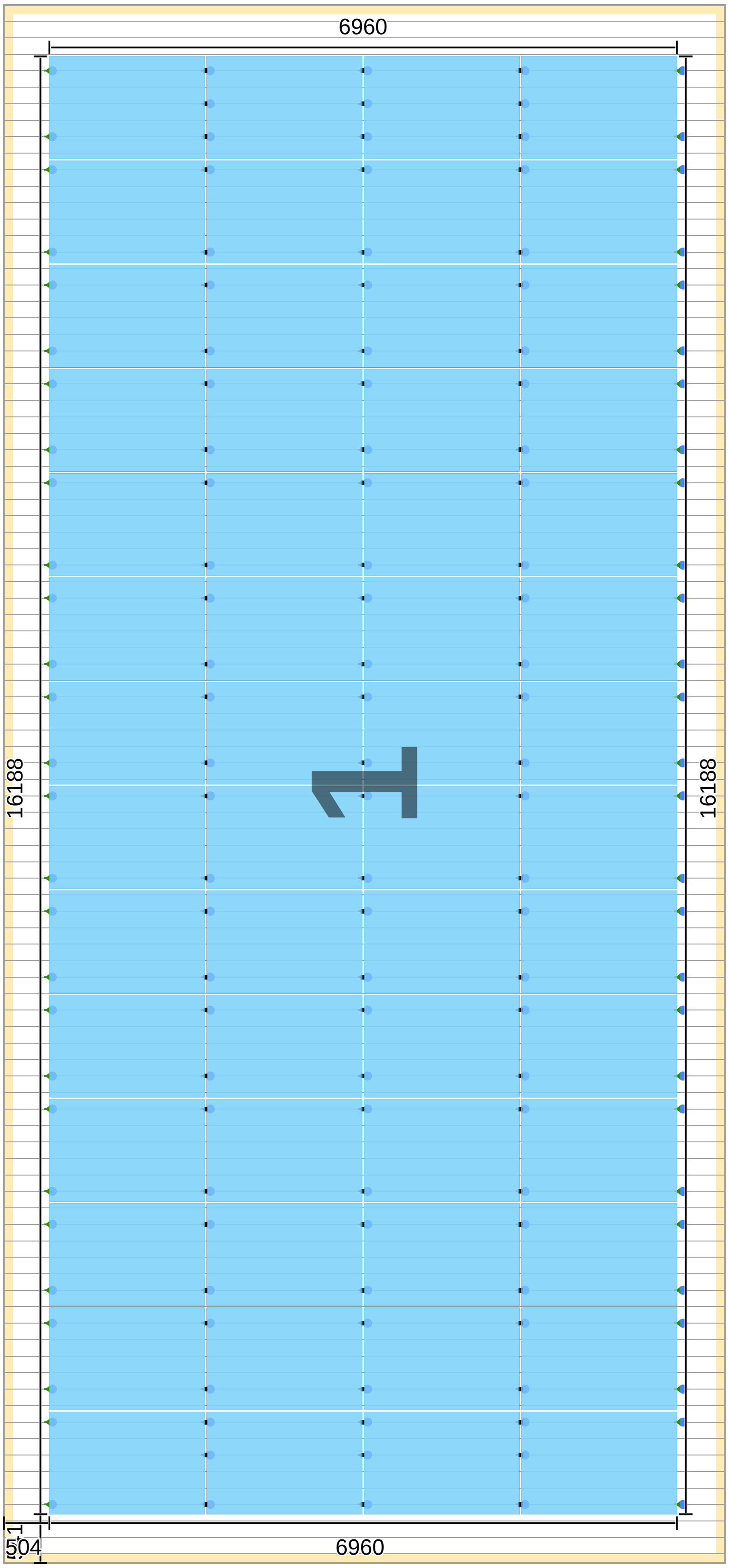
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BILL OF MATERIAL

Article No.	Article	Quantity	Ordering Unit	Weight/Piece	Weight
R420081-BE	End clamp+ (black)	56	1	0,064 kg	3,584 kg
R420082-BE	Middle clamp+ (black)	90	1	0,063 kg	5,670 kg
R420411	MS+ corrugated sheet radius 24	146	1	0,080 kg	11,680 kg
					Total Weight: 20,934 kg

LOAD ASSUMPTIONS

Dead load

Solar modules type LR5-54HIH-410M 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:	1722 mm x 1134 mm
Weight:	G = 20.8 kg
Load per longitudinal module side:	F_G = 20.8 kg * 9.81 m/s² / 2 = 0.20 kN / 2 = 0.102 kN

Snow load

The determination of the snow load is carried out according to EVS-EN 1991-1-3:2006/NA:2016.
Snow-trap formation or snow-load accumulations are not considered in the calculation. Please contact Renusol if necessary.

Height above sea level:	41 m
Snow load zone:	1,5 kN/m²
Roof pitch:	α = 35°
Period of use:	25 Year
Snow load:	$s_k = s_{k,50} * f_s^{(}$ = 1.50 kN/m² * 0.93 = 1.39 kN/m²
	μ_1 = 0.667
	$s_1 = \mu_1 * s_k$ = 0.667 * 1.39 kN/m² = 0.928 kN/m²
	$s_{1,35°}$ = 0.928 kN/m² * cos(35.0°) = 0.760 kN/m²
Load per longitudinal module side:	$F_{S,k}$ = 0.760 kN/m² * 1.72m * 1.13m / 2 = 0.742 kN

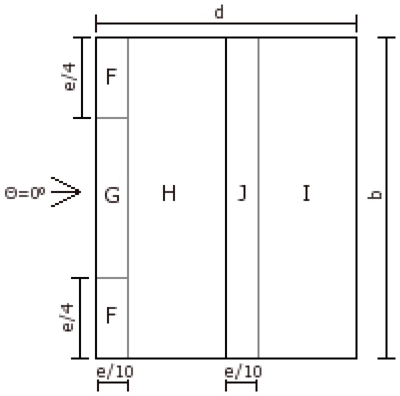
Wind load

The determination of the wind load is carried out according to EVS-EN 1991-1-4/NA:2007.

Building height roof ridge:	10 m
Terrain category:	II
Style of roof:	Gable roof
Period of use:	25 Year
Pressure of the gusts velocity:	q(z) = 0.597 kN/m²

LOAD ASSUMPTIONS

Ventilation direction 0° and 180°



Main roof

b = 17.30m

h = 10.00m

e = min(b,2h) = min(17.30m, 20.00m) = 17.30m

The coefficients for pressure and suction for the corresponding roof areas and a roof pitch of 35° are interpolated from the tables of EVS-EN 1991-1-4/NA:2007 for Pitched and butterfly roofs. With this, 1,95 m² is set as a value for the load introduction surface.

Wind pressure:

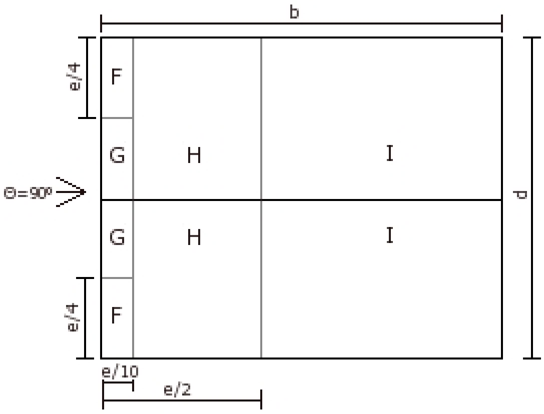
Area F	c_p=0.70	W_D = 0.70*0.597kN/m²*1.72m*1.13m/2 = 0.408 kN
Area G	c_p=0.70	W_D = 0.70*0.597kN/m²*1.72m*1.13m/2 = 0.408 kN
Area H	c_p=0.47	W_D = 0.47*0.597kN/m²*1.72m*1.13m/2 = 0.272 kN

Wind suction:

Area F	c_p=-0.81	Area is not relevant
Area G	c_p=-0.81	W_s = (-0.81)*0.597kN/m²*1.72m*1.13m/2 = -0.470 kN
Area H	c_p=-0.13	Area is not relevant
Area I	c_p=-0.33	Area is not relevant
Area J	c_p=-0.43	Area is not relevant

LOAD ASSUMPTIONS

Ventilation direction 90° and 270°



Main roof

d = 13.11m

h = 10.00m

e = min(d,2h) = min(13.11m, 20.00m) = 13.11m

The coefficients for pressure and suction for the corresponding roof areas and a roof pitch of 35° are interpolated from the tables of EVS-EN 1991-1-4/NA:2007 for Pitched and butterfly roofs. With this, 1,95 m² is set as a value for the load introduction surface.

Wind pressure:

Wind pressure not existent

Wind suction:

Area F 90°	c_p=-1.38	W_s = (-1.38)*0.597kN/m²*1.72m*1.13m/2 = -0.807 kN
Area G 90°	c_p=-1.83	W_s = (-1.83)*0.597kN/m²*1.72m*1.13m/2 = -1.064 kN
Area H 90°	c_p=-1.09	W_s = (-1.09)*0.597kN/m²*1.72m*1.13m/2 = -0.637 kN
Area I 90°	c_p=-0.50	W_s = (-0.50)*0.597kN/m²*1.72m*1.13m/2 = -0.292 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		Corner
			Verge	Eave	Eave
LCC 1 Design	⊥	1.00	1.00	1.21	1.21
	//	0.41	0.41	0.41	0.41
LCC 2 Design	⊥	1.30	1.30	1.43	1.43
	//	0.73	0.73	0.73	0.73
LCC 3 Design	⊥	-0.89	-1.55	-0.89	-1.15
	//	0.06	0.06	0.06	0.06
LCC 4 Characteristic	⊥	0.68	0.68	0.81	0.81
	//	0.28	0.28	0.28	0.28
LCC 5 Characteristic	⊥	0.88	0.88	0.96	0.96
	//	0.50	0.50	0.50	0.50
LCC 6 Characteristic	⊥	-0.57	-1.00	-0.57	-0.74
	//	0.06	0.06	0.06	0.06

Maximum values

[kN/m²]	Characteristic	Design
Pressure	0.96	1.43
Suction	-1.00	-1.55
In parallel to the roo	0.50	0.73

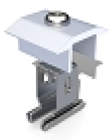
ANALYSIS

Middle clamp

General

The module clamps consist of extruded aluminium sheaths material grade EN-AW 6063 T66. 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

Plate thickness:	0,5 mm

LCC 1

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

Position:	x = 5730 mm y = 4939 mm
Loads:	$V_{x,d}$ = 0.43 kN
Comparison stress:	$V_{x,d}/F_{R,d,y}$ = 0.43/1.05 = 0.41 < 1

LCC 2

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

Position:	x = 5730 mm y = 4939 mm
Loads:	$V_{x,d}$ = 0.77 kN
Comparison stress:	$V_{x,d}/F_{R,d,y}$ = 0.77/1.05 = 0.73 < 1

LCC 3

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

Position:	x = 3984 mm y = 16102 mm
Loads:	N_d = -1.22 kN
	$V_{x,d}$ = 0.05 kN
Comparison stress:	$N_d/F_{R,d,x}$ + $V_{x,d}/F_{R,d,y}$ = 1.22/3.22 + 0.05/0.79 = 0.44 < 1

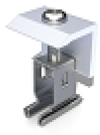
ANALYSIS

End clamp

General

The module clamps consist of extruded aluminium sheaths material grade EN-AW 6063 T66. 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 = 7482 mm y = 1462 mm
Loads:	$V_{x,d}$ = 0.21 kN
Comparison stress:	$V_{x,d}/F_{R,d,y}$ = 0.21/0.81 = 0.26 < 1

LCC 2

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

Position:	x = 7482 mm y = 1462 mm
Loads:	$V_{x,d}$ = 0.39 kN
Comparison stress:	$V_{x,d}/F_{R,d,y}$ = 0.39/0.81 = 0.47 < 1

LCC 3

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

Position:	x = 487 mm y = 1462 mm
Loads:	N_d = -0.81 kN
	$V_{x,d}$ = 0.03 kN
Comparison stress:	$N_d/F_{R,d,x}$ + $V_{x,d}/F_{R,d,y}$ = 0.81/1.75 + 0.03/0.74 = 0.51 < 1

ANALYSIS

MetaSole

General

To calculate the maximum load capacity per MetaSole, the support forces per longitudinal module side are used for the decisive combinations of loading cases. For this purpose, the exact position of the module clamp and with this, of the MetaSole is considered using a bar chart. The resulting support forces are checked against the permitted forces (for MetaSole and the module clamps).

Sketch

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.

Plate thickness:	0,5 mm

LCC 1

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

Position:	x = 5730 mm y = 4939 mm
Loads:	N_d = 1.15 kN
	$V_{x,d}$ = 0.43 kN
Comparison stress:	$V_{x,d}/F_{R,d,y}$ = 0.43/1.19 = 0.36 < 1

LCC 2

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

Position:	x = 5730 mm y = 4939 mm
Loads:	N_d = 1.42 kN
	$V_{x,d}$ = 0.77 kN
Comparison stress:	$V_{x,d}/F_{R,d,y}$ = 0.77/1.19 = 0.65 < 1

LCC 3

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

Position:	x = 3984 mm y = 16102 mm
Loads:	N_d = -1.22 kN
	$V_{x,d}$ = 0.05 kN
Comparison stress:	$N_d/F_{R,d,-x}$ + $V_{x,d}/F_{R,d,y}$ = 1.22/1.23 + 0.05/1.19 = 1.03 > 1

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.

Furthermore the Terms of Use of the Renusol PV Configurator (https://www.pv-configurator.com/pages/terms) and the General Terms and Conditions (https://www.renusol.com/files/content/Downloads/Rechtliche%20Dokumente/Renusol_AGB_EN_110406.pdf) apply. The General Installation Guidelines of Renusol as well as the Installation Manuals and Data Sheets of the respective Renusol products, have likewise to be complied to.

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