Plant details

Date:	05/03/2015
Customer:	Magnusson
Order:	
Plant:	2 R à 4 Mod

Module selection

Producer:	Luxor
Module:	200 M
Peak power:	200 W
Height:	1580 mm
Width:	808 mm
Thickness:	35.0 mm
Framing:	Gerahmt

Module arrangement

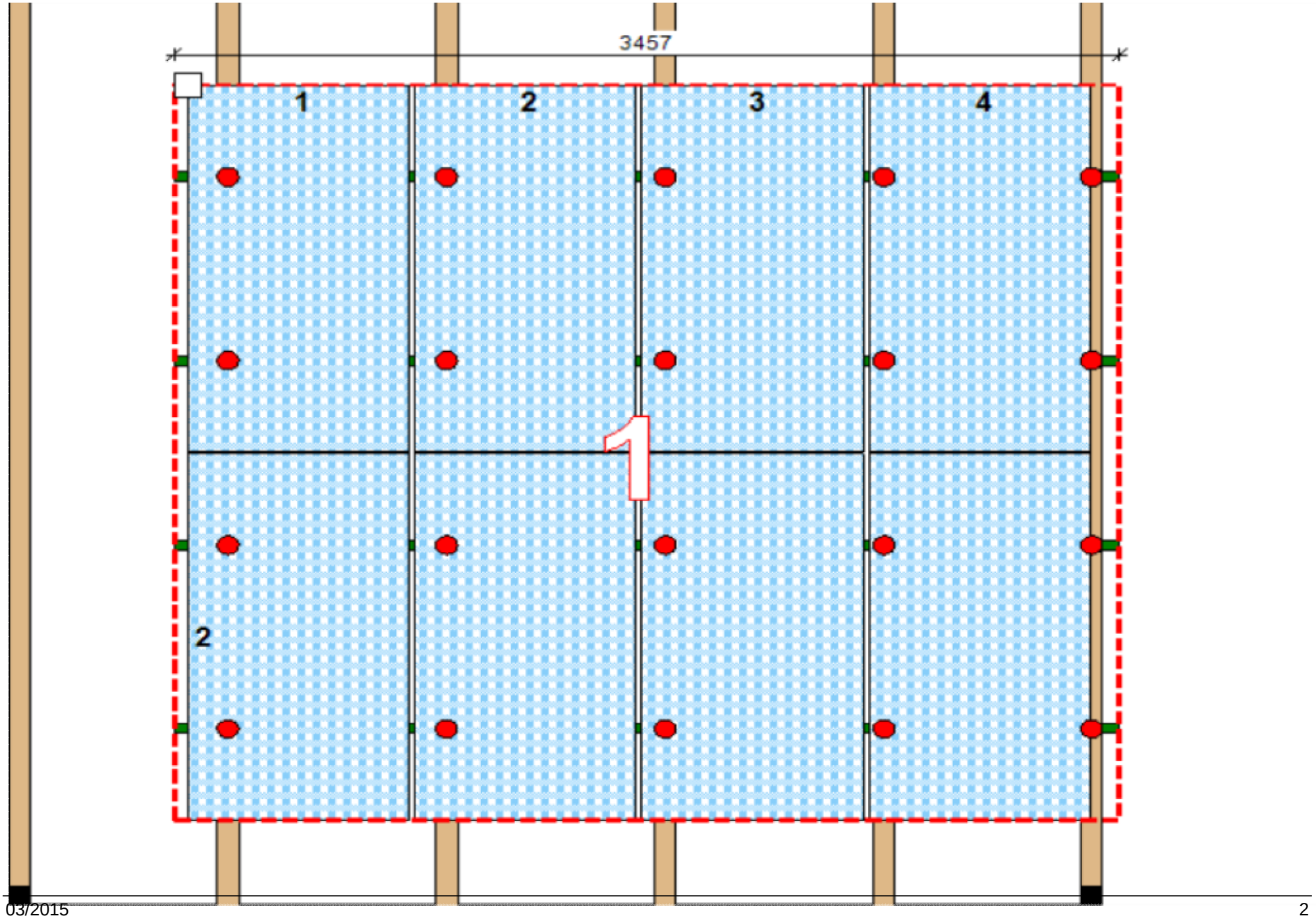
Modules per row:	4
Module rows:	2
Number of modules:	8
Chosen distance of supports:	800 mm
Cantilever:	400 mm
Number of identical module fields:	1

Basic configuration

System selection:	
Module beam:	Solo Light
Clamp type:	RapidErdung
fastening:	Rapid 2+ 45

Results: Plant details

Peak power:	1.60 kW


3457
1
2
3
4
1
2

Customer: Magnusson
Project: Magnusson

Bill of Materials: Pitched Roof System 2V

Pos. #	Part number	Item	Amount	Length mm	Unit	Weight kg
1	120005-004	Module bearing rail Solo05 light - 4m	4		ST	13.116
2	129011-000	Plastic end cap Solo Profi05	8		ST	0.064
3	101001-000	Roof hook Rapid2+ 45	20		ST	19.780
4	943208-120	Screw 8x120 TX VA wafer-head wood	40		ST	1.160
5	135002-000	Grndng mdl clamp Rapid2+ 30-39 mount.	12		ST	1.020
6	131001-035	End clamp Rapid2+ 35mm	8		ST	0.712
7	I400001GB	Brochure mounting and project planning	1			0.100
8	I400105GB	ID plate Solar Mounting Systems	1			0.100
		Total				**36.052**

Date	05.03.2015
Version	2.7.5.8

SCHLETTER GmbH

Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (camber and sag), additional expert examinations concerning the higher assumable wind loads are required.

Customer Magnusson

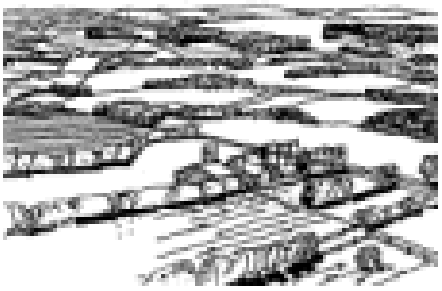
Order

postal codes of installation site **: 45532 Munkedal**
58.4830 ° northern latitude
11.6830 ° eastern longitude

module mounting

tilt	α	**14.0**	°
module height	h	**1.58**	m
height above sea level	H	**53**	m
ridge height above top ground surface	z	**4.00**	m
height of roof parapet	h_p	**0.00**	m
cantilever of module beam	a_{kr}	**0.40**	m
span of module beam	a	**0.80**	m

terrain category II



statical system
gable roof

module mounting
Solo Light

Load assumptions acc. to SS EN 1991-1

module weight	g	**0.15**	kN/m²
snow load	s	**1.12**	kN/m²
terrain category		**II**	

Gebiete mit niedriger Vegetation wie Gras und einzelnen Hindernissen (Bäume, Gebäude) mit Abständen von mindestens der 20-fachen Hindernishöhe

peak velocity pressure q **0.70** kN/m²

Systemkonfigurator

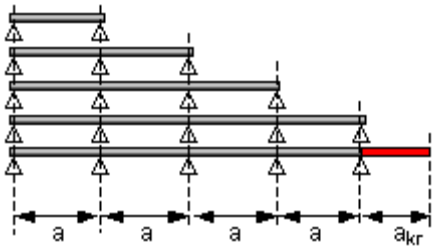
Date	05.03.2015
Version	2.7.5.8

Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (camber and sag), additional expert examinations concerning the higher assumable wind loads are required.

admissible distances between supports in different roof zone areas

statical system



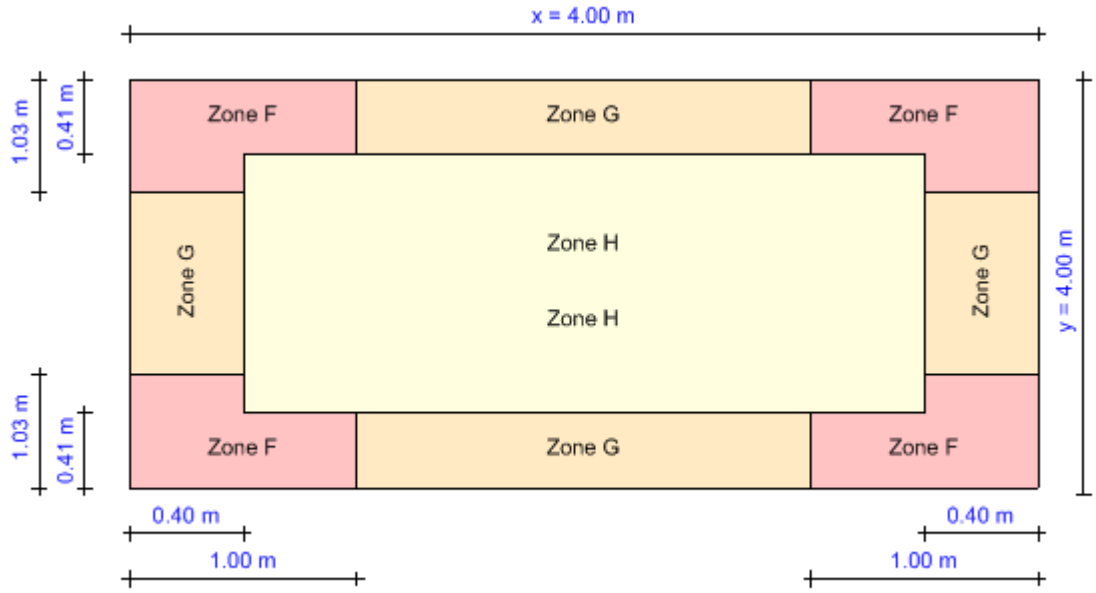
utilization of module beams

zone H	zone G	zone F
29.6 %	29.6 %	29.6 %
29.6 %	29.6 %	29.6 %
27.3 %	27.3 %	27.3 %
28.3 %	28.3 %	28.3 %
29.6 %	29.6 %	29.6 %

The dimensioning of fixations onto the substructure
can be significant for the determination of admissible spans!

roof dimensions
in a plan view

x = **4.00** m
y = **4.00** m



verification of the module beam profile (allowable spans) Solo Light (120005)

Applicable for roof mounting central area

tilt	α	14	°
module height	h	1.58	m
module weight	g	0.15	kN/m²
ridge height above top ground surface	z	4.00	m
span	a	0.80	m
cantilever	a_{kr}	0.40	m

sin = 0.242	cos = 0.970
c_{f1} = 0.18	c_{f2} = -0.61
peak velocity pressure	0.70 kN/m²
snow load	1.12 kN/m²

load assembly

dead load modules

$g_v = 0.15 \cdot 1.00 \cdot 1.00 = 0.15$ kN/m²
$g_z = 0.15 \cdot 0.970 = 0.15$ kN/m²
$g_y = 0.15 \cdot 0.242 = 0.04$ kN/m²

snow load

$s_v = 1.12 \cdot 1.00 \cdot 0.970 = 1.09$ kN/m²
$s_z = 1.09 \cdot 0.970 = 1.05$ kN/m²
$s_y = 1.09 \cdot 0.242 = 0.26$ kN/m²

wind pressure

$w_{dz} = 0.70 \cdot 0.18 = 0.13$ kN/m²
$w_{sz} = 0.70 \cdot -0.61 = -0.43$ kN/m²

$W_{dz} = 0.13 \cdot 0.79 = 0.10$ kN/m
$W_{sz} = -0.43 \cdot 0.79 = -0.34$ kN/m

profile parameters

total area A = 3.01 cm²
section modulus W_y = 2.79 cm³
section modulus W_z = 2.55 cm³

Safetyfactors and Combinationfactors

γ_g = 1.35
γ_q = 1.50
$\Psi_{0,w}$ = 0.60
$\Psi_{0,s}$ = 0.50

γ_g = 0.90 for favourable load action

Initial forces factors for single and multispan beams

n	$M_{1,total}$	$M_{1,partial}$	$M_{2,total}$	$M_{2,partial}$	$M_{B,total}$	$M_{B,partial}$	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$	Q_{total}	$Q_{partial}$
1	0.125	0.125	0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.500	0.500
2	0.070	0.096	0.000	0.000	-0.125	-0.125	0.375	0.438	1.250	1.250	0.625	0.625
3	0.080	0.101	0.025	0.075	-0.100	-0.117	0.400	0.450	1.100	1.200	0.600	0.617
4	0.077	0.100	0.036	0.080	-0.107	-0.121	0.393	0.446	1.143	1.223	0.607	0.621

intersection forces vertical

	load combination 1				load combination 2				load combination 3			
n	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A
1	0.120	0.000	-0.120	1.196	0.074	0.000	-0.074	0.744	-0.032	0.000	0.012	-0.324
2	0.089	-0.120	-0.120	1.495	0.055	-0.074	-0.074	0.930	-0.027	0.032	0.012	-0.405
3	0.095	-0.110	-0.120	1.423	0.058	-0.068	-0.074	0.880	-0.028	0.031	0.012	-0.397
4	0.093	-0.114	-0.120	1.453	0.057	-0.071	-0.074	0.900	-0.027	0.032	0.012	-0.403

horizontal section forces

	load combination 1				load combination 2				load combination 3			
n	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A
1	0.028	0.000	-0.028	0.280	0.016	0.000	-0.016	0.156	0.002	0.000	-0.002	0.021
2	0.021	-0.028	-0.028	0.350	0.011	-0.016	-0.016	0.194	0.001	-0.002	-0.002	0.026
3	0.022	-0.026	-0.028	0.333	0.012	-0.014	-0.016	0.184	0.001	-0.002	-0.002	0.023
4	0.022	-0.027	-0.028	0.340	0.012	-0.015	-0.016	0.188	0.001	-0.002	-0.002	0.024

conclusion

	midspan stress				stress support section			
n	LC1	LC2	LC3	**max**	LC1	LC2	LC3	**max**
1	5.387	3.278	-1.081	**5.39**	0.000	0.000	0.000	**0.00**
2	4.019	2.400	-0.909	**4.02**	-5.387	-3.278	1.081	**5.39**
3	4.258	2.554	-0.937	**4.26**	-4.965	-2.991	1.063	**4.97**
4	4.205	2.518	-0.934	**4.21**	-5.151	-3.110	1.089	**5.15**
stress cantilever moment					5.387	3.278	0.513	**5.39**

utilization ratio

$f_{y,d}$ = 18.2 kN/cm²

single span	η = 30 %
two span	η = 30 %
three span	η = 27 %
multi-span beam	η = 28 %
cantilever	η = 30 %

verification of the module beam profile (allowable spans) Solo Light (120005)

Applicable for roof mounting border zone

tilt	α	14	°
module height	h	1.58	m
module weight	g	0.15	kN/m²
ridge height above top ground surface	z	4.00	m
span	a	0.80	m
cantilever	a_{kr}	0.40	m

sin = 0.242	cos = 0.970
c_{f1} = 0.18	c_{f2} = -1.30
peak velocity pressure	0.70 kN/m²
snow load	1.12 kN/m²

load assembly

dead load modules

$g_v = 0.15 \cdot 1.00 \cdot 1.00 = 0.15$ kN/m²
$g_z = 0.15 \cdot 0.970 = 0.15$ kN/m²
$g_y = 0.15 \cdot 0.242 = 0.04$ kN/m²

snow load

$s_v = 1.12 \cdot 1.00 \cdot 0.970 = 1.09$ kN/m²
$s_z = 1.09 \cdot 0.970 = 1.05$ kN/m²
$s_y = 1.09 \cdot 0.242 = 0.26$ kN/m²

wind pressure

$w_{dz} = 0.70 \cdot 0.18 = 0.13$ kN/m²
$w_{sz} = 0.70 \cdot -1.30 = -0.91$ kN/m²

$W_{dz} = 0.13 \cdot 0.79 = 0.10$ kN/m
$W_{sz} = -0.91 \cdot 0.79 = -0.72$ kN/m

profile parameters

total area $A = 3.01$ cm²
section modulus $W_y = 2.79$ cm³
section modulus $W_z = 2.55$ cm³

Safetyfactors and Combinationfactors

$\gamma_g = 1.35$
$\gamma_q = 1.50$
$\Psi_{0,w} = 0.60$
$\Psi_{0,s} = 0.50$
$\gamma_g = 0.90$ for favourable load action

Initial forces factors for single and multispan beams

n	$M_{1,total}$	$M_{1,partial}$	$M_{2,total}$	$M_{2,partial}$	$M_{B,total}$	$M_{B,partial}$	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$	Q_{total}	$Q_{partial}$
1	0.125	0.125	0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.500	0.500
2	0.070	0.096	0.000	0.000	-0.125	-0.125	0.375	0.438	1.250	1.250	0.625	0.625
3	0.080	0.101	0.025	0.075	-0.100	-0.117	0.400	0.450	1.100	1.200	0.600	0.617
4	0.077	0.100	0.036	0.080	-0.107	-0.121	0.393	0.446	1.143	1.223	0.607	0.621

intersection forces vertical

	load combination 1				load combination 2				load combination 3			
n	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A
1	0.120	0.000	-0.120	1.196	0.074	0.000	-0.074	0.744	-0.078	0.000	0.035	-0.784
2	0.089	-0.120	-0.120	1.495	0.055	-0.074	-0.074	0.930	-0.062	0.078	0.035	-0.980
3	0.095	-0.110	-0.120	1.423	0.058	-0.068	-0.074	0.880	-0.065	0.075	0.035	-0.949
4	0.093	-0.114	-0.120	1.453	0.057	-0.071	-0.074	0.900	-0.064	0.077	0.035	-0.965

horizontal section forces

	load combination 1				load combination 2				load combination 3			
n	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A
1	0.028	0.000	-0.028	0.280	0.016	0.000	-0.016	0.156	0.002	0.000	-0.002	0.021
2	0.021	-0.028	-0.028	0.350	0.011	-0.016	-0.016	0.194	0.001	-0.002	-0.002	0.026
3	0.022	-0.026	-0.028	0.333	0.012	-0.014	-0.016	0.184	0.001	-0.002	-0.002	0.023
4	0.022	-0.027	-0.028	0.340	0.012	-0.015	-0.016	0.188	0.001	-0.002	-0.002	0.024

conclusion

	midspan stress				stress support section			
n	LC1	LC2	LC3	**max**	LC1	LC2	LC3	**max**
1	5.387	3.278	-2.731	**5.39**	0.000	0.000	0.000	**0.00**
2	4.019	2.400	-2.176	**4.02**	-5.387	-3.278	2.731	**5.39**
3	4.258	2.554	-2.270	**4.26**	-4.965	-2.991	2.608	**4.97**
4	4.205	2.518	-2.254	**4.21**	-5.151	-3.110	2.686	**5.15**
stress cantilever moment					5.387	3.278	1.338	**5.39**

utilization ratio

$f_{y,d} = 18.2$ kN/cm²

single span	$\eta = 30$ %
two span	$\eta = 30$ %
three span	$\eta = 27$ %
multi-span beam	$\eta = 28$ %
cantilever	$\eta = 30$ %

verification of the module beam profile (allowable spans) Solo Light (120005)

Applicable for roof mounting corner zone

tilt	α	14	°
module height	h	1.58	m
module weight	g	0.15	kN/m²
ridge height above top ground surface	z	4.00	m
span	a	0.80	m
cantilever	a_{kr}	0.40	m

sin = 0.242	cos = 0.970
c_{f1} = 0.18	c_{f2} = -1.34
peak velocity pressure	0.70 kN/m²
snow load	1.12 kN/m²

load assembly

dead load modules

$g_v = 0.15 \cdot 1.00 \cdot 1.00 = 0.15$ kN/m²
$g_z = 0.15 \cdot 0.970 = 0.15$ kN/m²
$g_y = 0.15 \cdot 0.242 = 0.04$ kN/m²

snow load

$s_v = 1.12 \cdot 1.00 \cdot 0.970 = 1.09$ kN/m²
$s_z = 1.09 \cdot 0.970 = 1.05$ kN/m²
$s_y = 1.09 \cdot 0.242 = 0.26$ kN/m²

wind pressure

$w_{dz} = 0.70 \cdot 0.18 = 0.13$ kN/m²
$w_{sz} = 0.70 \cdot -1.34 = -0.94$ kN/m²

$W_{dz} = 0.13 \cdot 0.79 = 0.10$ kN/m
$W_{sz} = -0.94 \cdot 0.79 = -0.74$ kN/m

profile parameters

total area A = 3.01 cm²
section modulus W_y = 2.79 cm³
section modulus W_z = 2.55 cm³

Safetyfactors and Combinationfactors

γ_g = 1.35
γ_q = 1.50
$\Psi_{0,w}$ = 0.60
$\Psi_{0,s}$ = 0.50

γ_g = 0.90 for favourable load action

Initial forces factors for single and multispan beams

n	$M_{1,total}$	$M_{1,partial}$	$M_{2,total}$	$M_{2,partial}$	$M_{B,total}$	$M_{B,partial}$	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$	Q_{total}	$Q_{partial}$
1	0.125	0.125	0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.500	0.500
2	0.070	0.096	0.000	0.000	-0.125	-0.125	0.375	0.438	1.250	1.250	0.625	0.625
3	0.080	0.101	0.025	0.075	-0.100	-0.117	0.400	0.450	1.100	1.200	0.600	0.617
4	0.077	0.100	0.036	0.080	-0.107	-0.121	0.393	0.446	1.143	1.223	0.607	0.621

intersection forces vertical

	load combination 1				load combination 2				load combination 3			
n	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A
1	0.120	0.000	-0.120	1.196	0.074	0.000	-0.074	0.744	-0.081	0.000	0.036	-0.811
2	0.089	-0.120	-0.120	1.495	0.055	-0.074	-0.074	0.930	-0.064	0.081	0.036	-1.013
3	0.095	-0.110	-0.120	1.423	0.058	-0.068	-0.074	0.880	-0.067	0.077	0.036	-0.981
4	0.093	-0.114	-0.120	1.453	0.057	-0.071	-0.074	0.900	-0.066	0.079	0.036	-0.998

horizontal section forces

	load combination 1				load combination 2				load combination 3			
n	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A	$M_{z\text{-midspan}}$	$M_{z\text{-support}}$	$M_{z\text{-cantilever}}$	A
1	0.028	0.000	-0.028	0.280	0.016	0.000	-0.016	0.156	0.002	0.000	-0.002	0.021
2	0.021	-0.028	-0.028	0.350	0.011	-0.016	-0.016	0.194	0.001	-0.002	-0.002	0.026
3	0.022	-0.026	-0.028	0.333	0.012	-0.014	-0.016	0.184	0.001	-0.002	-0.002	0.023
4	0.022	-0.027	-0.028	0.340	0.012	-0.015	-0.016	0.188	0.001	-0.002	-0.002	0.024

conclusion

	midspan stress				stress support section			
n	LC1	LC2	LC3	**max**	LC1	LC2	LC3	**max**
1	5.387	3.278	-2.827	**5.39**	0.000	0.000	0.000	**0.00**
2	4.019	2.400	-2.250	**4.02**	-5.387	-3.278	2.827	**5.39**
3	4.258	2.554	-2.348	**4.26**	-4.965	-2.991	2.697	**4.97**
4	4.205	2.518	-2.331	**4.21**	-5.151	-3.110	2.779	**5.15**
stress cantilever moment					5.387	3.278	1.386	**5.39**

utilization ratio

$f_{y,d}$ = 18.2 kN/cm²

single span	η = 30 %
two span	η = 30 %
three span	η = 27 %
multi-span beam	η = 28 %
cantilever	η = 30 %

Date	05.03.2015
Version	2.7.5.8

SCHLETTER GmbH

Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (camber and sag), additional expert examinations concerning the higher assumable wind loads are required.

Customer Magnusson

Order

postal codes of installation site **45532 Munkedal**
58.4830 ° northern latitude
11.6830 ° eastern longitude

statical system
gable roof ☐ rest on roof

Rapid 2+ 45

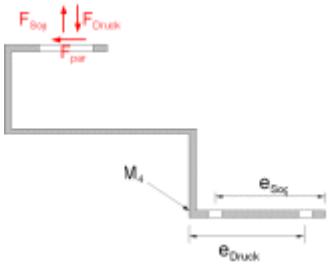
Load assumptions acc. to SS EN 1991-1

module weight	g	**0.15**	kN/m²
snow load	s	**1.12**	kN/m²
peak velocity pressure	q	**0.70**	kN/m²

required number of roof hooks

required number roof hooks (center)	1,45 Stk.
allowable cantilever (edge)	0,44 m
screwing depth	60 mm
compaction end zone	100 %
compaction corner zone	100 %

vertical
55,3 kg
horizontal
13,0 kg



verification of roof hook Rapid 2+ 45 (101001-000)

Applicable for roof installation on gable roof zone H

tilt	α	14	°	sin = 0.242	cos = 0.970
snow load	s	1.12	kN/m²	c_{p1} = 0.18	c_{p2} = -0.61
total roof height	z	4.00	m	peak velocity pressure 0.70 kN/m²	
module height	h	1.58	m	span width	0.80 m
module weight	g	0.15	kN/m²	cantilever	0.40 m

load assembly per square meter roof area

module weight

$g_v = 0.15 \cdot 1.00 \cdot 1.00 = 0.15$ kN/m²
$g_z = 0.15 \cdot 0.970 = 0.15$ kN/m²
$g_y = 0.15 \cdot 0.242 = 0.04$ kN/m²

snow load

$s_v = 1.12 \cdot 1.00 \cdot 0.970 = 1.09$ kN/m²
$s_z = 1.09 \cdot 0.970 = 1.05$ kN/m²
$s_y = 1.09 \cdot 0.242 = 0.26$ kN/m²

wind pressure

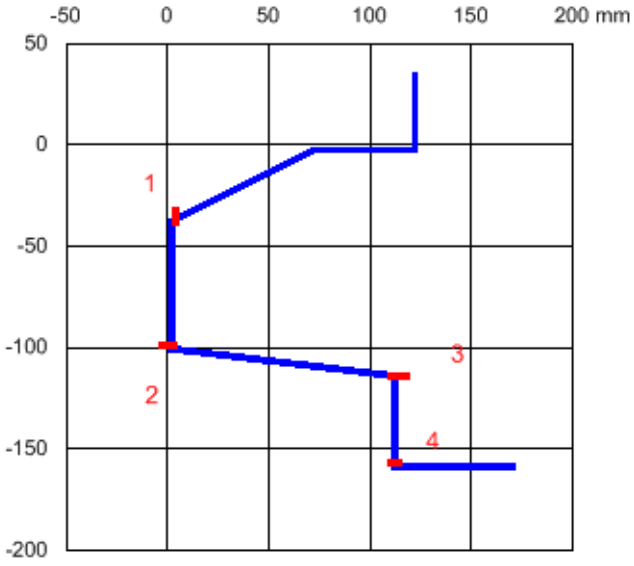
$w_{dz} = 0.70 \cdot 0.18 = 0.13$ kN/m²

uplift

$w_{sz} = 0.70 \cdot -0.61 = -0.43$ kN/m²

profile parameters

schematical plan view of profile with declaration of critical zones:



sheet thickness	t =	0.6	cm
section area	A =	2.1	cm²
hook width	b =	3.5	cm
section modulus	W =	0.210	cm³

When determining the loads, the impediment of twistings of the upper bracket by the absorbing girder profile is considered. The calculation assumes a partial fixation of 70 %.

Factors for determination of initial forces for single span, two span and three span beams

	force factors			
n	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$
1	0.500	0.500	0.000	0.000
2	0.375	0.438	1.250	1.250
3	0.400	0.450	1.100	1.200

load combinations

load combination 1: 1.35 · g + 1.50 · s + 0.60 · 1.50 · w
load combination 2: 1.35 · g + 0.50 · 1.50 · s + 1.50 · w
load combination 3: 0.90 · g + 1.50 · w

	load combination 1				load combination 2				load combination 3			
	vertical		horizontal		vertical		horizontal		vertical		horizontal	
n	A	B	A	B	A	B	A	B	A	B	A	B
1	1.196	1.196	0.280	0.280	0.744	0.744	0.156	0.156	-0.324	-0.324	0.021	0.021
2	1.114	1.495	0.261	0.350	0.690	0.930	0.144	0.194	-0.309	-0.405	0.018	0.026
3	1.130	1.423	0.265	0.333	0.701	0.880	0.146	0.184	-0.312	-0.397	0.019	0.023

Initial forces for three span

Partial fixation due to deformation impediment by cross beams 70 %

		load combination 1		load combination 2		load combination 3		rel. comb.	
		support A	support B	support A	support B	support A	support B	A	B
section 1	e_{hor} mm	140		140		140		abs. value	
	e_{vert} mm	86		86		86			
	M kNcm	8.73	10.99	5.46	6.86	2.62	3.33	8.73	10.99
	N kN	-0.26	-0.33	-0.15	-0.18	-0.02	-0.02	-0.26	-0.33
section 2	e_{hor} mm	140		140		140			
	e_{vert} mm	116		116		125			
	M kNcm	7.95	10.01	5.02	6.31	2.68	3.40	7.95	10.01
	N kN	-1.13	-1.42	-0.70	-0.88	0.31	0.40	-1.13	-1.42
section 3	e_{hor} mm	-30		-30		-30			
	e_{vert} mm	125		125		125			
	M kNcm	4.73	5.95	2.82	3.54	0.74	0.94	4.73	5.95
	N kN	-1.13	-1.42	-0.70	-0.88	0.31	0.40	-1.13	-1.42
section 4	e_{hor} mm	-30		-30		-30			
	e_{vert} mm	170		170		170			
	M kNcm	5.92	7.45	3.48	4.37	0.65	0.84	5.92	7.45
	N kN	-1.13	-1.42	-0.70	-0.88	0.31	0.40	-1.13	-1.42
							max. load M =	**8.73**	**10.99**
							N =	**-1.13**	**-1.42**

stress

σ = N / A + M / W A = 2.10 cm² W = 0.210 cm³

Except a possibly existing welded joint in section 4, a plastical reserve of

W_{pl} = 1.25 W_{el} can be assumed. foot plate welded yes

$R_{p0,2}$ = 46.00 kN/cm²

allowable stress zul σ = 46.00 kN/cm²

(safety factors for components without buckling actions)

load activation area per hook A = zul σ_e / vorh σ

required number of hooks n = 1 / A

allowable cantilever a_{kr} = 0.439 m

(Edge supports have a lower load level due to the multispan action)

	support A		support B	
	σ kN/cm²	n	σ kN/cm²	n
section 1	33.39	0.7	42.04	0.9
section 2	30.83	0.7	38.82	0.8
section 3	18.55	0.4	23.35	0.5
section 4	28.72	0.6	36.16	0.8
max n		**0.7**		**0.9**

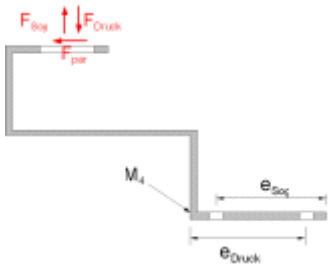
central support 0.9 roof hooks per 0.63 m²

edge support 0.7 roof hooks per 0.63 m²

span width a = 0.80 m

module height h = 1.58 m

t_{erf} mm	support A	support B
section 1	4.7	5.3
section 2	4.5	5.0
section 3	3.5	3.9
section 4	4.7	5.3
max n	**4.7**	**5.3**



Fixation to the sustructure: (acc. to DIN 1052) e_D = 50 mm e_S = 50 mm

load	parallel zur DF: $P_{d,par}$ / 1.5 = 0.24 kN	$F_{shear\ failure}$ =	0.24	kN	characteristical
	pressure M_{4D} = 5.44 kNcm $\Rightarrow$	$F_{Tension}$ = M_{4D} / $e_{pressure}$ =	1.09	kN	characteristical
	Tension M_{4S} = 0.61 kNcm $\Rightarrow$	$F_{Tension}$ = M_{4S} / $e_{Tension}$ =	0.20	kN	characteristical

selected	2 timber screws $\varnothing$ 8.0		
shear failure	zul N_A = n · 1.25 · 17 · ds² · s / (8 · d_s) =	2.55	kN
Tension	zul N_Z = n_{Zug} · 3 · s_g · d_s =	1.44	kN

connection depth	s_{min} = 46	mm
	s_{gew} = 60	mm
	s_{max} = 96	mm

verification of roof hook Rapid 2+ 45 (101001-000)

Applicable for roof installation on gable roof zone G

tilt	α	14	°	sin = 0.242	cos = 0.970
snow load	s	1.12	kN/m²	c_{p1} = 0.18	c_{p2} = -1.30
total roof height	z	4.00	m	peak velocity pressure 0.70 kN/m²	
module height	h	1.58	m	span width	0.80 m
module weight	g	0.15	kN/m²	cantilever	0.40 m

load assembly per square meter roof area

module weight

$g_v = 0.15 \cdot 1.00 \cdot 1.00 = 0.15$ kN/m²
$g_z = 0.15 \cdot 0.970 = 0.15$ kN/m²
$g_y = 0.15 \cdot 0.242 = 0.04$ kN/m²

snow load

$s_v = 1.12 \cdot 1.00 \cdot 0.970 = 1.09$ kN/m²
$s_z = 1.09 \cdot 0.970 = 1.05$ kN/m²
$s_y = 1.09 \cdot 0.242 = 0.26$ kN/m²

wind pressure

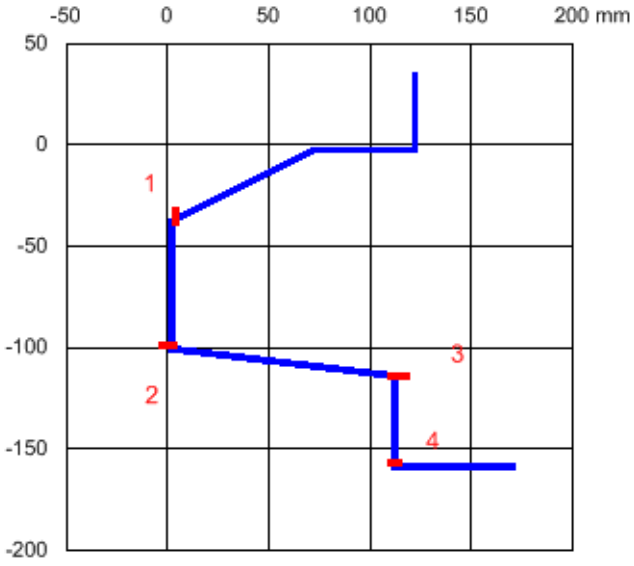
$w_{dz} = 0.70 \cdot 0.18 = 0.13$ kN/m²

uplift

$w_{sz} = 0.70 \cdot -1.30 = -0.91$ kN/m²

profile parameters

schematical plan view of profile with declaration of critical zones:



sheet thickness	t =	0.6	cm
section area	A =	2.1	cm²
hook width	b =	3.5	cm
section modulus	W =	0.210	cm³

When determining the loads, the impediment of twistings of the upper bracket by the absorbing girder profile is considered. The calculation assumes a partial fixation of 70 %.

Factors for determination of initial forces for single span, two span and three span beams

	force factors			
n	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$
1	0.500	0.500	0.000	0.000
2	0.375	0.438	1.250	1.250
3	0.400	0.450	1.100	1.200

load combinations

load combination 1: 1.35 · g + 1.50 · s + 0.60 · 1.50 · w
load combination 2: 1.35 · g + 0.50 · 1.50 · s + 1.50 · w
load combination 3: 0.90 · g + 1.50 · w

	load combination 1				load combination 2				load combination 3			
	vertical		horizontal		vertical		horizontal		vertical		horizontal	
n	A	B	A	B	A	B	A	B	A	B	A	B
1	1.196	1.196	0.280	0.280	0.744	0.744	0.156	0.156	-0.784	-0.784	0.021	0.021
2	1.114	1.495	0.261	0.350	0.690	0.930	0.144	0.194	-0.741	-0.980	0.018	0.026
3	1.130	1.423	0.265	0.333	0.701	0.880	0.146	0.184	-0.749	-0.949	0.019	0.023

Initial forces for three span

Partial fixation due to deformation impediment by cross beams 70 %

		load combination 1		load combination 2		load combination 3		rel. comb.	
		support A	support B	support A	support B	support A	support B	A	B
section 1	e_{hor} mm	140		140		140		abs. value	
	e_{vert} mm	86		86		86			
	M kNcm	8.73	10.99	5.46	6.86	6.23	7.90	8.73	10.99
	N kN	-0.26	-0.33	-0.15	-0.18	-0.02	-0.02	-0.26	-0.33
section 2	e_{hor} mm	140		140		140			
	e_{vert} mm	116		116		125			
	M kNcm	7.95	10.01	5.02	6.31	6.29	7.97	7.95	10.01
	N kN	-1.13	-1.42	-0.70	-0.88	0.75	0.95	-1.13	-1.42
section 3	e_{hor} mm	-30		-30		-30			
	e_{vert} mm	125		125		125			
	M kNcm	4.73	5.95	2.82	3.54	1.93	2.45	4.73	5.95
	N kN	-1.13	-1.42	-0.70	-0.88	0.75	0.95	-1.13	-1.42
section 4	e_{hor} mm	-30		-30		-30			
	e_{vert} mm	170		170		170			
	M kNcm	5.92	7.45	3.48	4.37	1.85	2.35	5.92	7.45
	N kN	-1.13	-1.42	-0.70	-0.88	0.75	0.95	-1.13	-1.42
							max. load M =	**8.73**	**10.99**
							N =	**-1.13**	**-1.42**

stress

σ = N / A + M / W A = 2.10 cm² W = 0.210 cm³

Except a possibly existing welded joint in section 4, a plastical reserve of W_{pl} = 1.25 W_{el} can be assumed.

foot plate welded yes

$R_{p0,2}$ = 46.00 kN/cm²

allowable stress zul σ = 46.00 kN/cm²

(safety factors for components without buckling actions)

load activation area per hook A = zul σ_e / vorh σ

required number of hooks n = 1 / A

allowable cantilever a_{kr} = 0.439 m

(Edge supports have a lower load level due to the multispan action)

	support A		support B	
	σ kN/cm²	n	σ kN/cm²	n
section 1	33.39	0.7	42.04	0.9
section 2	30.83	0.7	38.82	0.8
section 3	18.55	0.4	23.35	0.5
section 4	28.72	0.6	36.16	0.8
max n		**0.7**		**0.9**

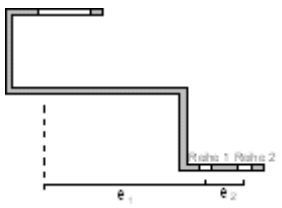
central support 0.9 roof hooks per 0.63 m²

edge support 0.7 roof hooks per 0.63 m²

span width a = 0.80 m

module height h = 1.58 m

t_{erf} mm	support A	support B
section 1	4.7	5.3
section 2	4.5	5.0
section 3	3.5	3.9
section 4	4.7	5.3
max n	**4.7**	**5.3**



Fixation to the sustructure: (acc. to DIN 1052) e_D = 50 mm e_S = 50 mm

load	parallel zur DF: $P_{d,par}$ / 1.5 = 0.24 kN	$F_{shear\ failure}$ =	0.24	kN	characteristical
	pressure M_{4D} = 5.44 kNcm $\Rightarrow$	$F_{Tension}$ = M_{4D} / $e_{pressure}$ =	1.09	kN	characteristical
	Tension M_{4S} = 1.71 kNcm $\Rightarrow$	$F_{Tension}$ = M_{4S} / $e_{Tension}$ =	0.53	kN	characteristical

selected	2 timber screws $\varnothing$ 8.0		
shear failure	zul N_A = n · 1.25 · 17 · ds² · s / (8 · d_s) =	2.55	kN
Tension	zul N_Z = n_{Zug} · 3 · s_g · d_s =	1.44	kN

connection depth	s_{min} = 46	mm
	s_{gew} = 60	mm
	s_{max} = 96	mm

verification of roof hook Rapid 2+ 45 (101001-000)

Applicable for roof installation on gable roof zone F

tilt	α	14	°	sin = 0.242	cos = 0.970
snow load	s	1.12	kN/m²	c_{p1} = 0.18	c_{p2} = -1.34
total roof height	z	4.00	m	peak velocity pressure 0.70 kN/m²	
module height	h	1.58	m	span width	0.80 m
module weight	g	0.15	kN/m²	cantilever	0.40 m

load assembly per square meter roof area

module weight

$g_v = 0.15 \cdot 1.00 \cdot 1.00 = 0.15$ kN/m²
$g_z = 0.15 \cdot 0.970 = 0.15$ kN/m²
$g_y = 0.15 \cdot 0.242 = 0.04$ kN/m²

snow load

$s_v = 1.12 \cdot 1.00 \cdot 0.970 = 1.09$ kN/m²
$s_z = 1.09 \cdot 0.970 = 1.05$ kN/m²
$s_y = 1.09 \cdot 0.242 = 0.26$ kN/m²

wind pressure

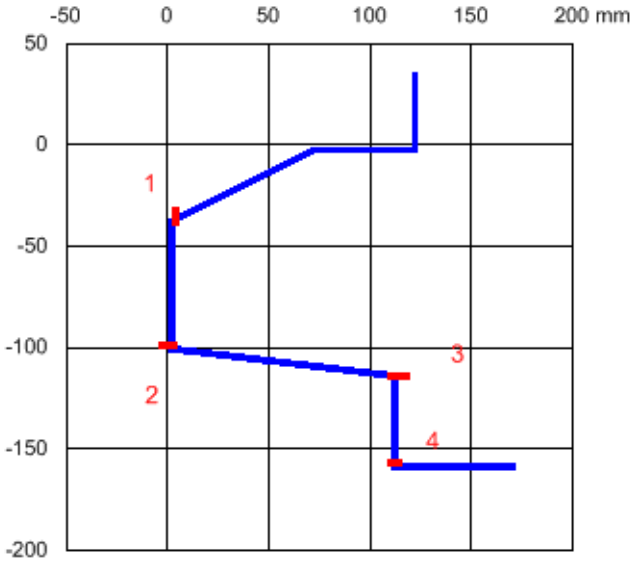
$w_{dz} = 0.70 \cdot 0.18 = 0.13$ kN/m²

uplift

$w_{sz} = 0.70 \cdot -1.34 = -0.94$ kN/m²

profile parameters

schematical plan view of profile with declaration of critical zones:



sheet thickness	t =	0.6	cm
section area	A =	2.1	cm²
hook width	b =	3.5	cm
section modulus	W =	0.210	cm³

When determining the loads, the impediment of twistings of the upper bracket by the absorbing girder profile is considered. The calculation assumes a partial fixation of 70 %.

Factors for determination of initial forces for single span, two span and three span beams

	force factors			
n	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$
1	0.500	0.500	0.000	0.000
2	0.375	0.438	1.250	1.250
3	0.400	0.450	1.100	1.200

load combinations

load combination 1: 1.35 · g + 1.50 · s + 0.60 · 1.50 · w
load combination 2: 1.35 · g + 0.50 · 1.50 · s + 1.50 · w
load combination 3: 0.90 · g + 1.50 · w

	load combination 1				load combination 2				load combination 3			
	vertical		horizontal		vertical		horizontal		vertical		horizontal	
n	A	B	A	B	A	B	A	B	A	B	A	B
1	1.196	1.196	0.280	0.280	0.744	0.744	0.156	0.156	-0.811	-0.811	0.021	0.021
2	1.114	1.495	0.261	0.350	0.690	0.930	0.144	0.194	-0.766	-1.013	0.018	0.026
3	1.130	1.423	0.265	0.333	0.701	0.880	0.146	0.184	-0.774	-0.981	0.019	0.023

Initial forces for three span

Partial fixation due to deformation impediment by cross beams 70 %

		load combination 1		load combination 2		load combination 3		rel. comb.	
		support A	support B	support A	support B	support A	support B	A	B
section 1	e_{hor} mm	140		140		140		abs. value	
	e_{vert} mm	86		86		86			
	M kNcm	8.73	10.99	5.46	6.86	6.44	8.16	8.73	10.99
	N kN	-0.26	-0.33	-0.15	-0.18	-0.02	-0.02	-0.26	-0.33
section 2	e_{hor} mm	140		140		140			
	e_{vert} mm	116		116		125			
	M kNcm	7.95	10.01	5.02	6.31	6.50	8.23	7.95	10.01
	N kN	-1.13	-1.42	-0.70	-0.88	0.77	0.98	-1.13	-1.42
section 3	e_{hor} mm	-30		-30		-30			
	e_{vert} mm	125		125		125			
	M kNcm	4.73	5.95	2.82	3.54	2.00	2.54	4.73	5.95
	N kN	-1.13	-1.42	-0.70	-0.88	0.77	0.98	-1.13	-1.42
section 4	e_{hor} mm	-30		-30		-30			
	e_{vert} mm	170		170		170			
	M kNcm	5.92	7.45	3.48	4.37	1.92	2.44	5.92	7.45
	N kN	-1.13	-1.42	-0.70	-0.88	0.77	0.98	-1.13	-1.42
							max. load M =	**8.73**	**10.99**
							N =	**-1.13**	**-1.42**

stress

σ = N / A + M / W A = 2.10 cm² W = 0.210 cm³

Except a possibly existing welded joint in section 4, a plastical reserve of W_{pl} = 1.25 W_{el} can be assumed.

foot plate welded yes

$R_{p0,2}$ = 46.00 kN/cm²

allowable stress zul σ = 46.00 kN/cm²

(safety factors for components without buckling actions)

load activation area per hook A = zul σ_e / vorh σ

required number of hooks n = 1 / A

allowable cantilever a_{kr} = 0.439 m

(Edge supports have a lower load level due to the multispan action)

	support A		support B	
	σ kN/cm²	n	σ kN/cm²	n
section 1	33.39	0.7	42.04	0.9
section 2	30.83	0.7	38.82	0.8
section 3	18.55	0.4	23.35	0.5
section 4	28.72	0.6	36.16	0.8
max n		**0.7**		**0.9**

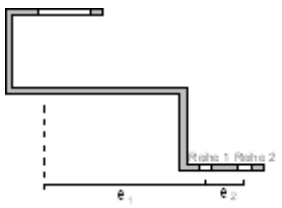
central support 0.9 roof hooks per 0.63 m²

edge support 0.7 roof hooks per 0.63 m²

span width a = 0.80 m

module height h = 1.58 m

t_{erf} mm	support A	support B
section 1	4.7	5.3
section 2	4.5	5.0
section 3	3.5	3.9
section 4	4.7	5.3
max n	**4.7**	**5.3**



Fixation to the sustructure: (acc. to DIN 1052) e_D = 50 mm e_S = 50 mm

load	parallel zur DF: $P_{d,par}$ / 1.5 = 0.24 kN	$F_{shear\ failure}$ =	0.24	kN	characteristical
	pressure M_{4D} = 5.44 kNcm $\Rightarrow$	$F_{Tension}$ = M_{4D} / $e_{pressure}$ =	1.09	kN	characteristical
	Tension M_{4S} = 1.78 kNcm $\Rightarrow$	$F_{Tension}$ = M_{4S} / $e_{Tension}$ =	0.55	kN	characteristical

selected	2 timber screws $\varnothing$ 8.0		
shear failure	zul N_A = n · 1.25 · 17 · ds² · s / (8 · d_s) =	2.55	kN
Tension	zul N_Z = n_{Zug} · 3 · s_g · d_s =	1.44	kN

connection depth	s_{min} = 46	mm
	s_{gew} = 60	mm
	s_{max} = 96	mm

Verification of joints and fixations

Tilt	α	14	°
Snow load	s	1.12	kN/m²
height above terrain	z	4.00	m
Module height	h	1.58	m
Module weight	g	0.15	kN/m²

sin = 0.242	cos = 0.970
Peak velocity pressure	0.70 kN/m²

zone F $c_{p,1}$ = -2.02
zone G $c_{p,1}$ = -2.00 pressure coefficients $C_{pe,1}$
zone H $c_{p,1}$ = -1.20

Load assembly

dead load modules

$g_v = 0.15 \cdot 1.00 \cdot 1.00 = 0.15$ kN/m²
$g_z = 0.15 \cdot 0.970 = 0.15$ kN/m²
$g_y = 0.15 \cdot 0.242 = 0.04$ kN/m²

snow load

$s_v = 1.12 \cdot 1.00 \cdot 0.970 = 1.09$ kN/m²
$s_z = 1.09 \cdot 0.970 = 1.05$ kN/m²
$s_y = 1.09 \cdot 0.242 = 0.26$ kN/m²

wind suction

$w_{dz} = 0.70 \cdot 0.18 = 0.13$ kN/m²
$w_{sz} = 0.70 \cdot c_{p1}$

Module clamps according to general technical aproval

Middle clamps		Edge clamps	
$F_{R,d}$ kN	$V_{R,d}$ kN	$F_{R,d}$ kN	$V_{R,d}$ kN
4.96	0.53	2.36	0.78

Module area A = 1.28 m²
Reibschluss V = 0.17 kN ($F_{S,d} \cdot \mu$)

Section forces at module clamps

	$V_{S,d}$ kN	$F_{S,d}$ kN		
		zone F	zone G	zone H
Middle clamps	0.11	1.23	1.22	0.68
Edge clamps	0.06	0.62	0.61	0.34

$V_{S,d} = V_{S,dy} - F_{S,dz} \cdot \mu$ (μ= 0.25)

utilization ratio 24.9 %
utilization ratio 26.2 %

Screw fixations according to general technical aproval Z-14.4-639 annex 7

strength Z_{Rd} = 5.10 kN
Shear strength V_{Rd} = 2.00 kN

Design values of according forces

	kN	LC1	LC2	zone F	zone G	zone H	η
Vertical forces	$N_{S,d}$	1.42	0.88	-0.40	-0.95	-0.98	8.9
shear forces	$V_{S,d}$	0.33	0.18	0.02	0.02	0.02	16.7