Schletter GmbH

Gewerbegebiet B15
Alustraße 1
D-83527 Kirchdorf/Haag i. OB

Phone: +498072 9191-0
Fax: +498072 9191-9100

info.de@schletter-group.com

https://www.schletter.eu/

Planning documentation for the bearing system
Pitched roof system for solar modules

Project: VOYVODINOVO, 11.13 kWp

Module type: Q.PRO BFR-G4 265 1670 x 1000 mm

By order

FILKAB Solar OOD

www.filkab.solar,
office@filkab.solar
+359 32 277298

October 2017

Project planning and auto-calculation

Version: 2.9.7.2

SCHLETTER
The Solar Mounting Group

Plant details

Date:	05/10/2017
Customer:	FILKAB Solar OOD
Order:	VOYVODINOVO, 11.13 kWp
Plant:	6 R à 7 Mod

Module selection

Manufacturer:	Hawha Q.Cells GmbH
Module:	Q.PRO BFR-G4 265
Peak power:	265 W
Height:	1670 mm
Width:	1000 mm
Thickness:	35.0 mm
Framing:	Gerahmt

Module arrangement

Modules per row:	7
Module rows:	6
Number of modules:	42
Number of identical module fields:	1

Basic configuration

System selection:	
Clamp type:	Rapid
Fastening:	SingleFix HU 20 - Set

Results: Plant details

Peak power:	11.13 kW

Customer	FILKAB Solar OOD
Project	VOYVODINOVO, 11.13 kWp

Bill of Materials: Pitched Roof System 6H

Pos	Item number	Item	Quantity	Length mm	Unit	Weight kg
1	113011-101	SingleFix HU 20 - Set	100 (98)		ST	18.816
2	131003-000	Middle clamp Rapid2+ 30 - 39mm	100 (70)		ST	5.810
3	131001-035	End clamp Rapid2+ 35mm	100 (28)		ST	2.492
4	119015-002	Punched mount.tape 6 - 50m	2		ST	3.672
5	943000-700	EJOT fastener JF3-2-5.5x25 E16 A2 galv.	100 (100)		ST	0.600
		Total				31.390

System configurator

Status	05.10.2017
Version	2.9.7.2

SCHLETTER
The Solar Mounting Group

Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (with special terrain formation), the consideration of higher wind loads is required. In these cases,

Customer FILKAB Solar OOD

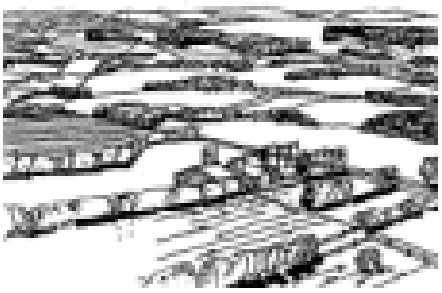
Order VOYVODINOVO, 11.13 kWp

Postal code construction site **: 4135 Vojvodinovo**
42.2000 ° northern latitude
24.8000 ° eastern longitude

Tilt angle	α	**25.0**	°
Module height	h	**1.67**	m
Ridge height above ground	z	**6.00**	m
Height of roof parapet	h_p	**0.00**	m

Terrain category II

Structural system
Gable roof (double pitch roof)



Load assumptions acc. to ДБА EN 1991-1-3/NA

Module weight	g	**0.11**	kN/m²
Snow load	s	**0.96**	kN/m²
Terrain category		**II**	

Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights

Peak velocity pressure q **0.78** kN/m²

Equivalent substitute loads:

q_k kN/m²	q_d kN/m²
0.12	0.16

Calculation sheet Annex 1

Status	05.10.2017
Version	2.9.7.2

SingleFix HU 20 - Set (113011-101)

SCHLETTER The Solar Mounting Group

Preliminary remarks

The following design calculations apply for multi-span mounting systems in midland areas with regular conditions. In coastal areas and exposed locations (with special terrain formation), the consideration of higher wind loads is required. In these cases,

Customer	FILKAB Solar OOD
Order	VOYVODINOVO, 11.13 kWp
Postal code construction site	**4135** Vojvodinovo

42.2000 ° northern latitude
24.8000 ° eastern longitude

Structural system
Gable roof (double pitch roof)

Type of fastening
SingleFix HU 20 - Set

b_o	40 mm
b_u	90 mm
Substructure	Substructure
Substructure material	Steel
Strength	280 N/mm²
Thickness	0.55 mm

Required number of fastenings in the different roof zones

(Actually installed) 1.40 Pc(s)/m²

Required number of fastenings / m² (Center)	1.00 Pc(s)
Compaction Border zone	100 %
Compaction Corner zone	100 %

Verification of the fastening system SingleFix HU 20 - Set (113011-101)

Applicable for Gable roof (double pitch roof) Central area

Tilt angle	α	25	°
Snow load	s	0.96	kN/m²
Height above ground	z	6.00	m
Module height	h	1.67	m
Module weight	g	0.11	kN/m²

sin = 0.423	cos = 0.906
c_{p1} = 0.33	c_{p2} = -0.73
Peak velocity pressure	0.78 kN/m²
Module width	1.00 m

Overview load per Square meter Roof area

Module weight

$g_v = 0.11 \cdot 1.00 \cdot 1.00 = 0.11$ kN/m²
$g_z = 0.11 \cdot 0.906 = 0.10$ kN/m²
$g_y = 0.11 \cdot 0.423 = 0.05$ kN/m²

Snow load

$s_v = 0.96 \cdot 1.00 \cdot 0.906 = 0.87$ kN/m²
$s_z = 0.87 \cdot 0.906 = 0.79$ kN/m²
$s_y = 0.87 \cdot 0.423 = 0.37$ kN/m²

Wind pressure

$w_{dz} = 0.78 \cdot 0.33 = 0.26$ kN/m²

Wind suction

$w_{sz} = 0.78 \cdot -0.73 = -0.57$ kN/m²

Section forces factors for single, double or triple-span girders

	Force factors			
n	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$
1	0.500	0.500	0.000	0.000
2	0.500	0.500	1.000	1.000
3	0.500	0.500	1.000	1.000

Importance/reliability factor K_{FI} = 1.00 (RC2)

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

	Central roof area											
	Load combination 1				Load combination 2				Load combination 3			
	Vertical/portrait		Horizontal/landscape		Vertical/portrait		Horizontal/landscape		Vertical/portrait		Horizontal/landscape	
n	A	B	A	B	A	B	A	B	A	B	A	B
1	0.649	0.649	0.257	0.257	0.468	0.468	0.142	0.142	-0.321	-0.321	0.018	0.018
2	0.649	1.299	0.257	0.514	0.468	0.935	0.142	0.284	-0.321	-0.642	0.018	0.036
3	0.649	1.299	0.257	0.514	0.468	0.935	0.142	0.284	-0.321	-0.642	0.018	0.036

Resume of the relevant combinations (3-span girder)

	LC 1	LC 2	LC 3	
A_V	0.65	0.47	-0.32	kN
A_H	0.26	0.14	0.02	kN
B_V	1.30	0.94	-0.64	kN
B_H	0.51	0.28	0.04	kN

	Center	Edge / Border zone	Load distribution
Compressive force	N_D = 1.30 kN	N_D = 0.65 kN	P = 1.30 kN
Perm. shear force	N_H = 0.51 kN	N_H = 0.26 kN	H = 0.51 kN
Tensile force	N_Z = -0.64 kN	N_Z = -0.32 kN	P = 0.65 kN
Perm. shear force	N_H = 0.04 kN	N_H = 0.02 kN	H = 0.26 kN

Verification of the fastening system SingleFix HU 20 - Set (113011-101)

Applicable for Gable roof (double pitch roof) Border zone

Tilt angle	α	25	°
Snow load	s	0.96	kN/m²
Height above ground	z	6.00	m
Module height	h	1.67	m
Module weight	g	0.11	kN/m²

sin = 0.423	cos = 0.906
c_{p1} = 0.53	c_{p2} = -1.37
Peak velocity pressure	0.78 kN/m²
Module width	1.00 m

Overview load per Square meter Roof area

Module weight

$g_v = 0.11 \cdot 1.00 \cdot 1.00 = 0.11$ kN/m²
$g_z = 0.11 \cdot 0.906 = 0.10$ kN/m²
$g_y = 0.11 \cdot 0.423 = 0.05$ kN/m²

Snow load

$s_v = 0.96 \cdot 1.00 \cdot 0.906 = 0.87$ kN/m²
$s_z = 0.87 \cdot 0.906 = 0.79$ kN/m²
$s_y = 0.87 \cdot 0.423 = 0.37$ kN/m²

Wind pressure

$w_{dz} = 0.78 \cdot 0.53 = 0.42$ kN/m²

Wind suction

$w_{sz} = 0.78 \cdot -1.37 = -1.07$ kN/m²

Section forces factors for single, double or triple-span girders

	Force factors			
n	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$
1	0.500	0.500	0.000	0.000
2	0.500	0.500	1.000	1.000
3	0.500	0.500	1.000	1.000

Importance/reliability factor K_{FI} = 1.00 (RC2)

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

	Central roof area											
	Load combination 1				Load combination 2				Load combination 3			
	Vertical/portrait		Horizontal/landscape		Vertical/portrait		Horizontal/landscape		Vertical/portrait		Horizontal/landscape	
n	A	B	A	B	A	B	A	B	A	B	A	B
1	0.708	0.708	0.257	0.257	0.566	0.566	0.142	0.142	-0.631	-0.631	0.018	0.018
2	0.708	1.416	0.257	0.514	0.566	1.131	0.142	0.284	-0.631	-1.262	0.018	0.036
3	0.708	1.416	0.257	0.514	0.566	1.131	0.142	0.284	-0.631	-1.262	0.018	0.036

Resume of the relevant combinations (3-span girder)

	LC 1	LC 2	LC 3	
A_V	0.71	0.57	-0.63	kN
A_H	0.26	0.14	0.02	kN
B_V	1.42	1.13	-1.26	kN
B_H	0.51	0.28	0.04	kN

	Center	Edge / Border zone	Load distribution
Compressive force	N_D = 1.42 kN	N_D = 0.71 kN	P = 1.42 kN
Perm. shear force	N_H = 0.51 kN	N_H = 0.26 kN	H = 0.51 kN
Tensile force	N_Z = -1.26 kN	N_Z = -0.63 kN	P = 0.71 kN
Perm. shear force	N_H = 0.04 kN	N_H = 0.02 kN	H = 0.26 kN

Verification of the fastening system SingleFix HU 20 - Set (113011-101)

Applicable for Gable roof (double pitch roof) Corner zone

Tilt angle	α	25	°
Snow load	s	0.96	kN/m²
Height above ground	z	6.00	m
Module height	h	1.67	m
Module weight	g	0.11	kN/m²

sin = 0.423	cos = 0.906
c_{p1} = 0.53	c_{p2} = -1.17
Peak velocity pressure	0.78 kN/m²
Module width	1.00 m

Overview load per Square meter Roof area

Module weight

$g_v = 0.11 \cdot 1.00 \cdot 1.00 = 0.11$ kN/m²
$g_z = 0.11 \cdot 0.906 = 0.10$ kN/m²
$g_y = 0.11 \cdot 0.423 = 0.05$ kN/m²

Snow load

$s_v = 0.96 \cdot 1.00 \cdot 0.906 = 0.87$ kN/m²
$s_z = 0.87 \cdot 0.906 = 0.79$ kN/m²
$s_y = 0.87 \cdot 0.423 = 0.37$ kN/m²

Wind pressure

$w_{dz} = 0.78 \cdot 0.53 = 0.42$ kN/m²

Wind suction

$w_{sz} = 0.78 \cdot -1.17 = -0.91$ kN/m²

Section forces factors for single, double or triple-span girders

	Force factors			
n	A_{total}	$A_{partial}$	B_{total}	$B_{partial}$
1	0.500	0.500	0.000	0.000
2	0.500	0.500	1.000	1.000
3	0.500	0.500	1.000	1.000

Importance/reliability factor K_{FI} = 1.00 (RC2)

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

	Central roof area											
	Load combination 1				Load combination 2				Load combination 3			
	Vertical/portrait		Horizontal/landscape		Vertical/portrait		Horizontal/landscape		Vertical/portrait		Horizontal/landscape	
n	A	B	A	B	A	B	A	B	A	B	A	B
1	0.708	0.708	0.257	0.257	0.566	0.566	0.142	0.142	-0.533	-0.533	0.018	0.018
2	0.708	1.416	0.257	0.514	0.566	1.131	0.142	0.284	-0.533	-1.066	0.018	0.036
3	0.708	1.416	0.257	0.514	0.566	1.131	0.142	0.284	-0.533	-1.066	0.018	0.036

Resume of the relevant combinations (3-span girder)

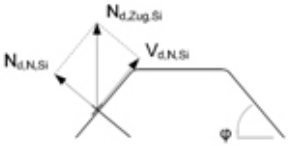
	LC 1	LC 2	LC 3	
A_V	0.71	0.57	-0.53	kN
A_H	0.26	0.14	0.02	kN
B_V	1.42	1.13	-1.07	kN
B_H	0.51	0.28	0.04	kN

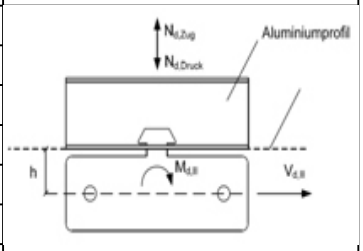
	Center	Edge / Border zone	Load distribution
Compressive force	N_D = 1.42 kN	N_D = 0.71 kN	P = 1.42 kN
Perm. shear force	N_H = 0.51 kN	N_H = 0.26 kN	H = 0.51 kN
Tensile force	N_Z = -1.07 kN	N_Z = -0.53 kN	P = 0.71 kN
Perm. shear force	N_H = 0.04 kN	N_H = 0.02 kN	H = 0.26 kN

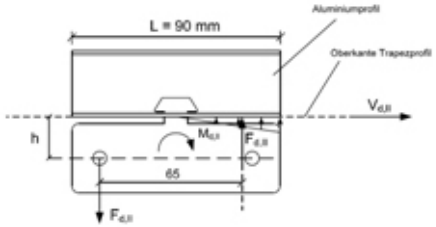
Verification of trapezoidal clamps SingleFix HU 20 - Set according to German general technical approval Z 14.4-646

Type of fastening		SingleFix HU 20 - Set	
Basic sheet material		Steel	
Sheet metal thickness	t	0.55	mm
Raster	b	250	mm
Crown/beading height	h	100	mm
Corrugation top (crown)	b_p	40	mm
Corrugation valley	b_u	90	mm
Web tilt	φ	59.0	°
Rotation	β	0	°
Fix length	S_s	50	mm

E	210,000	N/mm²
f_{yb}	280	N/mm²
r	2	mm
γ_{M1}	1.10	Sheet metal
γ_{M1}	1.33	Screws/bolts



		LK1	LK2	LK3				Formula
				H	G	F		
Loads	$N_{d;Pressure}$	1.30	0.94	0.00	0.00	0.00	kN	
	$N_{d;Traction}$	0.00	0.00	0.64	1.26	1.07	kN	
	$V_{d,II}$	0.51	0.28	0.04	0.04	0.04	kN	
Geometry	h_b	40					mm	
	h_z	5					mm	
	b	65					mm	
	h	25					mm	$0.5 \cdot h_b + h_z$
Moments	$M_{d,II}$	12.85	7.10	0.89	0.89	0.89	kNmm	$V_{d,II} \cdot h$
Clamps	$N_{R,k}$	7.05					kN	Z-14.1-645 Chapter 3.2.3.2
	γ_M	1.20					-	
	$V_{R,k}$	11.22					kN	
	γ_{M1}	1.20					-	
Verification		0.05	0.03	0.11	0.22	0.19	-	$N_{d,Zug}\gamma_M / N_{R,k} + V_{d,II} \cdot \gamma_M / V_{R,k} \leq 1.0$
Forces	$N_{d,s}$	0.05	0.03	0.09	0.17	0.14	kN	Z-14.1-645 Chapter 3.2.3.5
	$V_{d,s}$	0.15	0.09	0.14	0.28	0.23	kN	
	f_i	0.25					-	
Screws/bolts	$N_{R,k}$	0.44					kN	Z-14.1-537
	$V_{R,k}$	0.89					kN	
Verification		0.38	0.21	0.48	0.92	0.78	-	$N_{d,S}\gamma_M / N_{R,k} + V_{d,S}\gamma_M / V_{R,k} \leq 1.0$
Trapezoidal sheet metal	$R_{w,Rd,zen}$	1.34					kN	$\alpha = 0.150$ $l_a = 10$ mm
	$R_{w,Rd,lin}$	0.40					kN	$\alpha = 0.150$ $l_a = s_s$
Verification		0.81	0.53	0.02	0.02	0.02	-	Z-14.1-645 Chapter 3.2.3.4



Verification of connections

Tilt angle	α	25	°
Snow load	s	0.96	kN/m²
Ridge height above ground	z	6.00	m
Module height	h	1.67	m
Module weight	g	0.11	kN/m²

sin = 0.423	cos = 0.906
Peak velocity pressure	0.78 kN/m²

Zone F $c_{p,1}$ = -1.67
Zone G $c_{p,1}$ = -2.00
Zone H $c_{p,1}$ = -1.20

Pressure coefficients $C_{pe,1}$

Load overview

Dead load Modules

g_v = 0.11 · 1.00 · 1.00 = 0.11 kN/m²
g_z = 0.11 · 0.906 = 0.10 kN/m²
g_y = 0.11 · 0.423 = 0.05 kN/m²

Snow load

s_v = 0.96 · 1.00 · 0.906 = 0.87 kN/m²
s_z = 0.87 · 0.906 = 0.79 kN/m²
s_y = 0.87 · 0.423 = 0.37 kN/m²

Wind suction

w_{dz} = 0.78 · 0.33 = 0.26 kN/m²
w_{sz} = 0.78 · c_{p1}

Module clamps according to general technical approval Z-14.4-631

Middle clamps		End clamps	
$F_{R,d}$ kN	$V_{R,d}$ kN	$F_{R,d}$ kN	$V_{R,d}$ kN
4.96	0.80	2.36	1.59

Module surface A = 1.67 m²
Frictional connection V = 0.33 kN ($F_{S,d} \cdot \mu$)

Internal forces at module clamps

	$V_{S,d}$ kN	$F_{S,d}$ kN		
		Zone F	Zone G	Zone H
Middle clamps	0.18	1.52	1.84	1.06
End clamps	0.09	0.76	0.92	0.53

$V_{S,d} = V_{S,dy} - F_{S,dz} \cdot \mu$ (μ = 0.50)

Utilization ratio 37.2 %
Utilization ratio 39.1 %