ERBY – STATIKA STAVIEB ,s.r.o. zapísaná na Okr. súde Košice I, oddiel :Sro, Vložka číslo:16825/V
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Statický výpočet a posúdenie

Názov stavby:	**Fotovoltaická elektráreň**
Miesto stavby:	**areál DALTON s.r.o, Napájadlá 1837/1, Košice**
Stavebník:	**DALTON, s.r., Napájadlá 1837/1, Košice**
Spracovateľ	**Ing. Marián Erby**
	Ing. Marek Gaži
Objednávateľ:	
Dátum spracovania:	**04.2022**
Zákazkové číslo:	**04/22**

1. Úvod

Predmetom tohto statického výpočtu je jestvujúca strešná konštrukcia halového objektu na ktorej dôjde k osadeniu fotovoltaických panelov. Halový objekt je v areáli spoločnosti DALTON, s.r.o.. na ulici Napájadlá 1837/1 v Košiciach.

Statický výpočet uvažuje so stálym a náhodilým zaťažením ako aj zaťaženiami vetrom a snehom.

Pri návrhoch a výpočtoch konštrukcií boli použité nasledovné normy a literatúra:

STN EN 1991-1-1 – Zaťaženia konštrukcií
STN 73 0035 – Zaťaženia konštrukcií
Výrobné katalógy prefabrikovaných hál ZIPP (1979)

2. Strecha

Jedná sa o jestvujúci halový objekt realizovaný v halovom systéme ZIPP. Objekt je halový prízemný tvorený celkovo dvojloďovou halou s rozponom lodí 17,0m. V pozdĺžnom smere je objekt tvorený 10-timi modulmi po 6,0m. Takže jeho celková dĺžka je 60m. Na rozpon 17m sú ukladané predpäté strešné sedlové väzníky. Na tieto panely sú v pozdĺžnom smere haly ukladané škrupinové strešné dosky šírky 1200 a 1500m, pričom tieto sú prerušované svetlíkmi. Pre posúdenie strechy na nové priťaženie je smerodajné posúdenie strešných dosiek.

Minimálne dovolené priťaženie strešnej dosky Qdov = 2,412kN/bm pri ohybovom momente Mb=16,99kNm

Priťaženie strešnej dosky bude 0,262kN/bm (0,20-0,34kN/m2 – dominantné 0,24kN/m2)

- strešné vrstvy:	- betónový poter	-	0,92kN/m2 z toho 1,104kN/bm
	- tepelná izolácia	-	0,05kN/m2 z toho 0,06kN/bm
	- hydroizolácia	-	0,12kN/m2 z toho 0,144kN/bm
	(podľa bežných údajov údržby – nutné overiť!)		
- zaťaženie snehom			0,7 kN/m2 z toho 0,84kN/bm

Priťaženie súčasné celkom: 2,148kN/bm

Priťaženie nové po osadení FVE: 2,410 kN/bm

Na základe porovnania hodnoty 2,410 a 2,412 možno konštatovať nasledovné. Strešná konštrukcia má v súčasnosti rezervu v zaťažiteľnosti avšak táto bude po osadení FVE panelov s príťažou vyčerpaná a ďalšie priťažovanie konštrukcie strechy už nebude možné. Príťaž je nutné

situovať do polôh nad samotné nosné rebro dosky resp. do polohy jeho uloženia na prefabrikovaný väzník a to najmä v krajných radoch kde je potrebné väčšie množstvo balastného priťaženia.

Zriadením FVE na streche budú vyčerpané súčasné rezervy únosnosti strešnej konštrukcie. Na základe realizovaného statického výpočtu možno konštatovať, že konštrukcia strechy vyhovuje aj na nové zaťažovacie parametre.

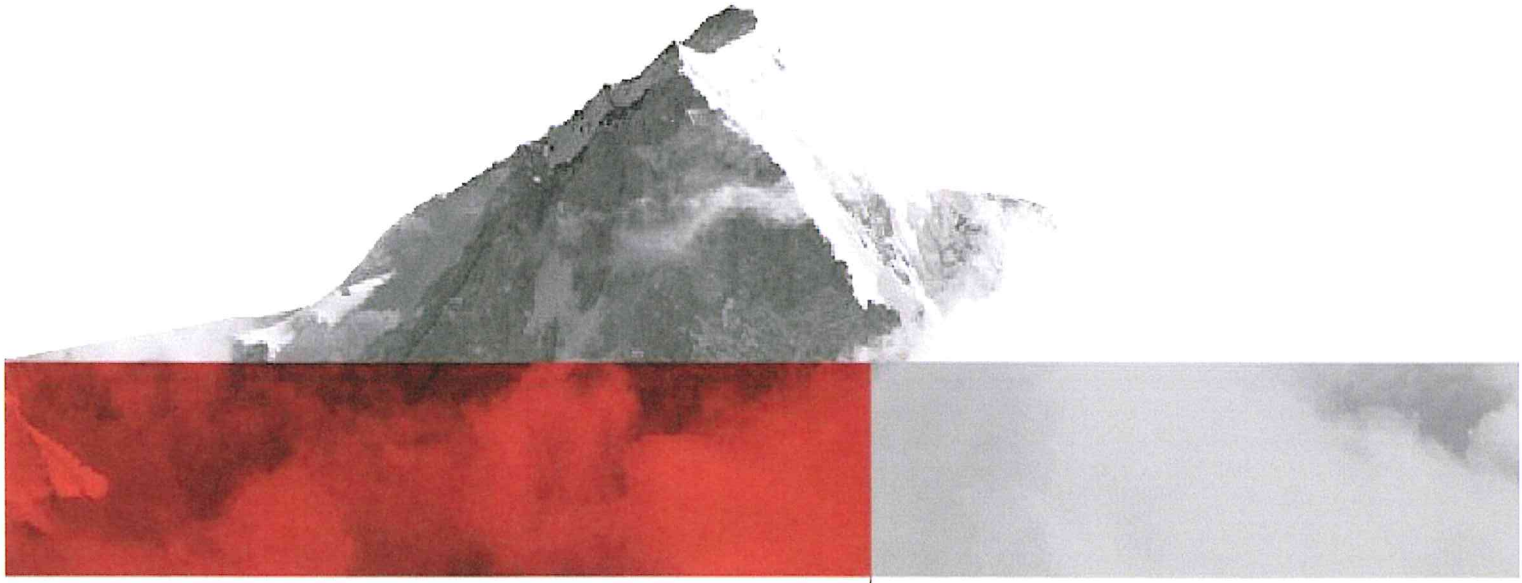
3. Prílohy

K2 Systems GMBH – calculation basis

Dokument obsahuje 2+15 strán.

Vypracoval: Ing. Marián ERBY
Ing. Marek GAŽI

Mounting systems for solar technology



K2 SYSTEMS GMBH

CALCULATION BASIS

PROJECT: Dalton

AUTHOR: Lukas Jenco

DATE: 02/03/2022

PROJECT DATA

GENERAL INFORMATION

Name	Dalton
Mounting System	S-Dome 6.10 Xpress
Customer	Dalton
Author	Lukas Jenco

LOCATION

Address	Napájadlá, 040 12 Košice-Nad jazerom
Ground elevation	191.18 m
Roof type	Flat roof
Fastening method	with Ballast
Roof covering	Flat
Building height	5.00 m
Parapet wall height	0.30 m
Roof pitch	2 °
Min. roof edge distance	0.60 m
Material	Single ply membrane
Friction coefficient	0.50

The friction coefficients given here must be checked onsite. If a lower value is found, this must be specified here for the ballast calculation!

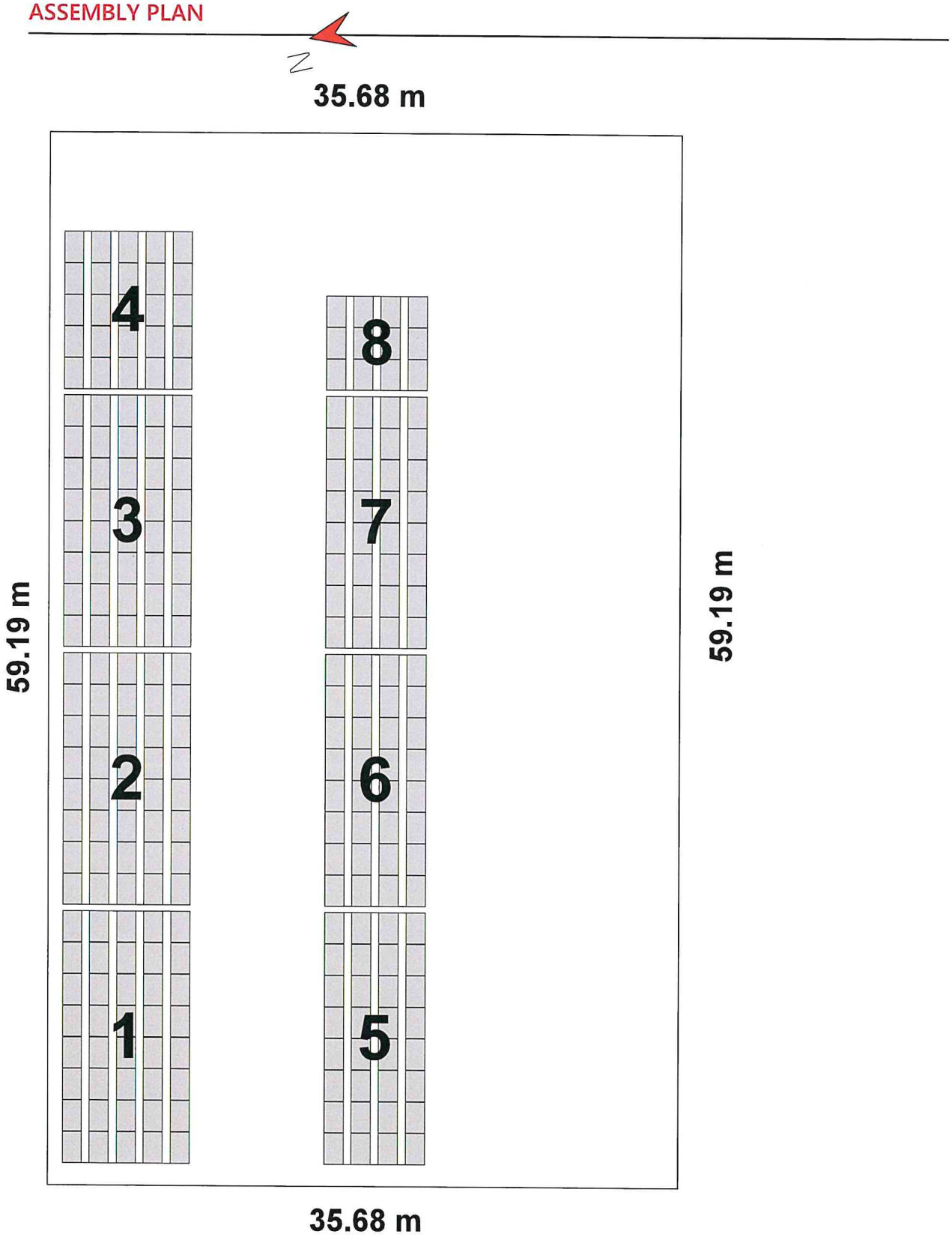
LOADS

Design method	DIN EN		
Failure consequence class (CC)	CC2	Design working life	25 years
Peak velocity pressure	$q_{p,25}$= 0.721 kN/m²		
Snow load on ground level	s_k = 1.000 kN/m²		

MODULES

Manufacturer	Trina Solar Energy	Quantity	253
Name	TSM-395DE09.08 (Vertex S)	Output power	99.935 kWp
Dimensions LxWxH	1754 x 1096 x 30.00 mm		
Weight	21.0 kg		
Output power	395 W		

ASSEMBLY PLAN



Dimensions in [m]

LEGEND

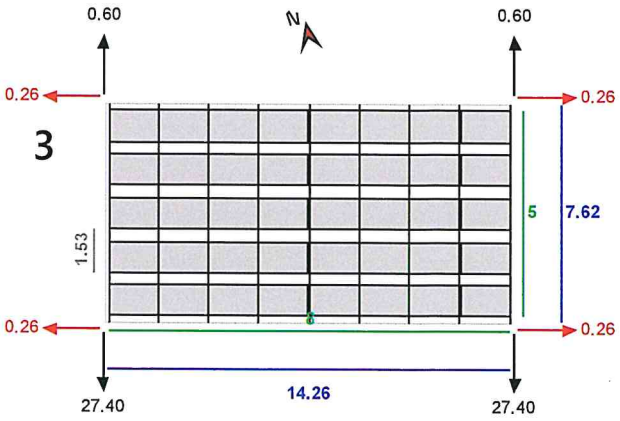
Distance to neighbouring module array [m]

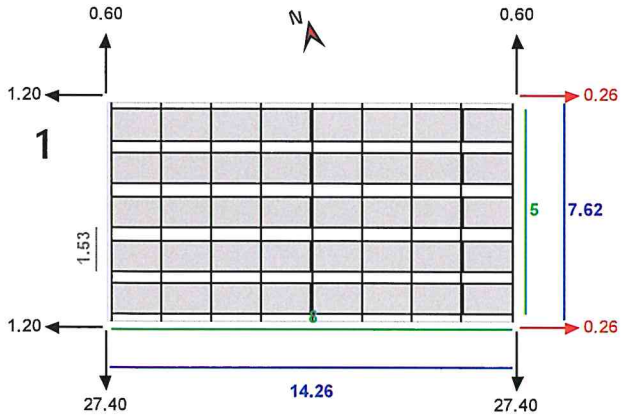
Distance to roof edge [m]

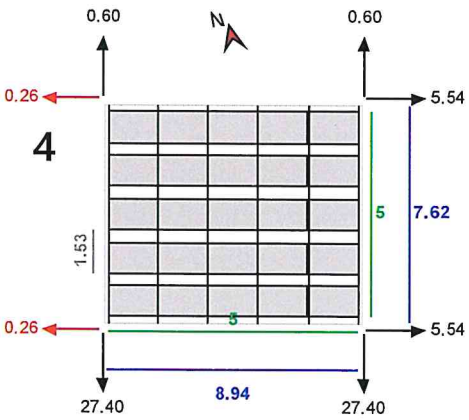
Number of modules

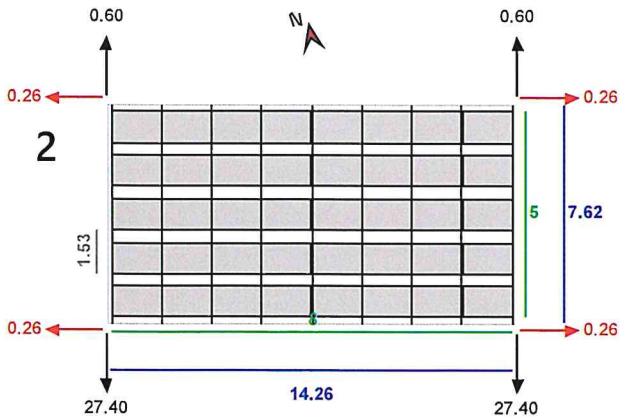
Length/width of module array [m]

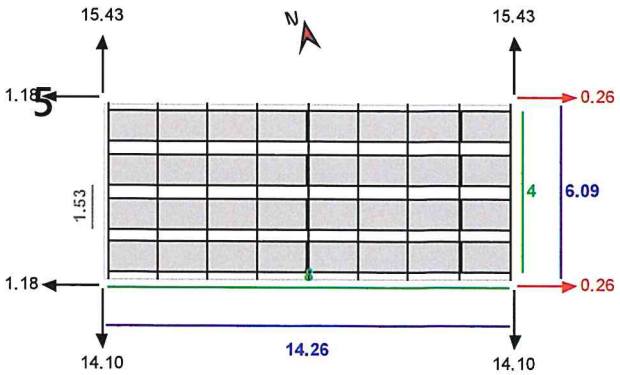
Row distance [m]

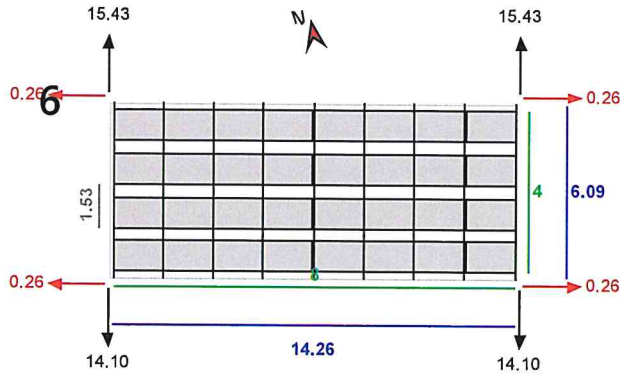


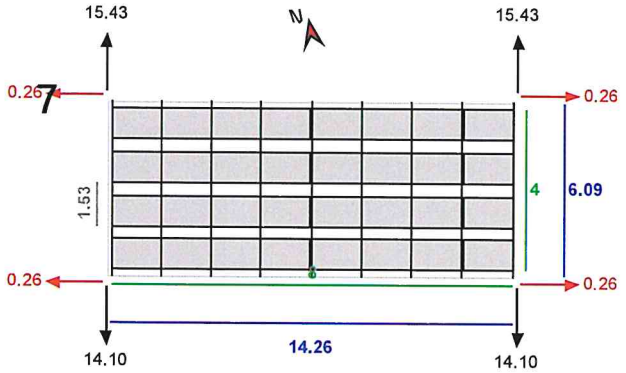









15.43
N
15.43
6
0.26
0.26
1.53
4
6.09
0.26
0.26
3
14.26
14.10
14.10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15.43
7
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4
6.09
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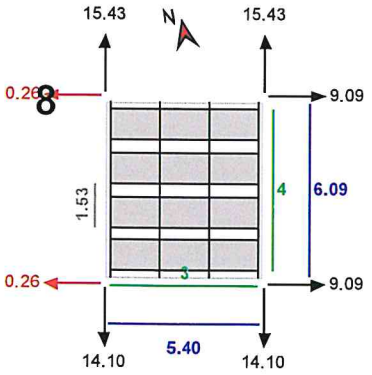
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N
15.43
8
0.26
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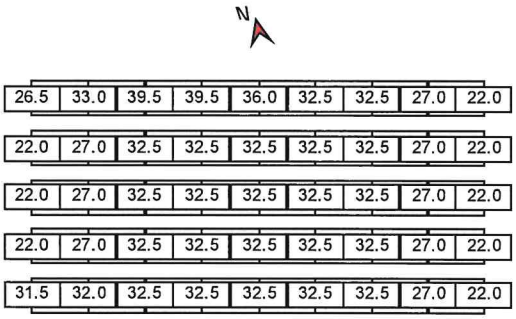
1.53
4
6.09
0.26
9.09
3
5.40
14.10
14.10

BALLAST PLAN

1



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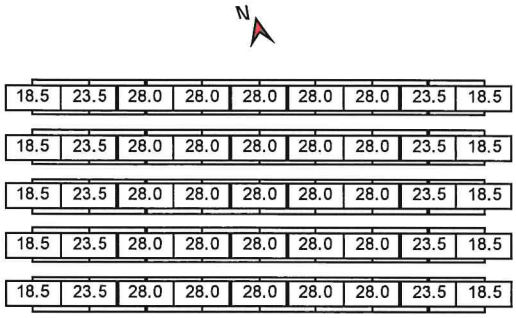

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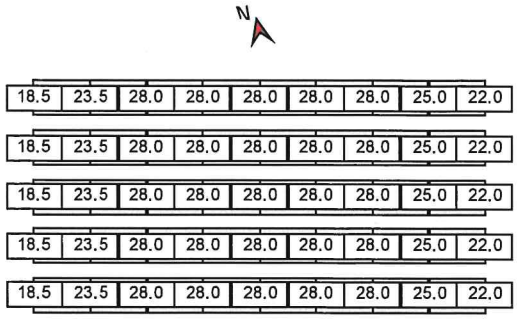

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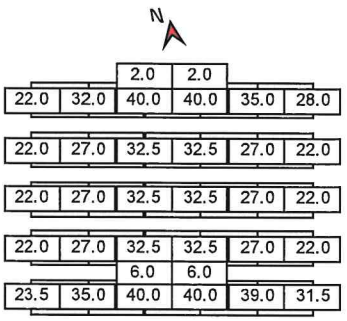

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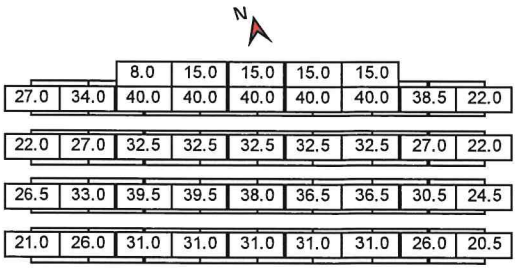

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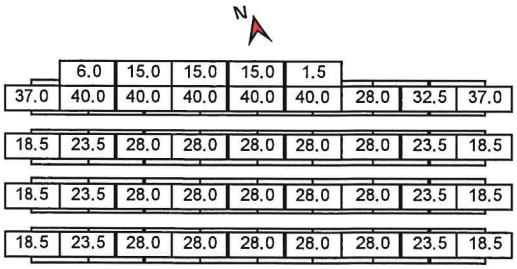

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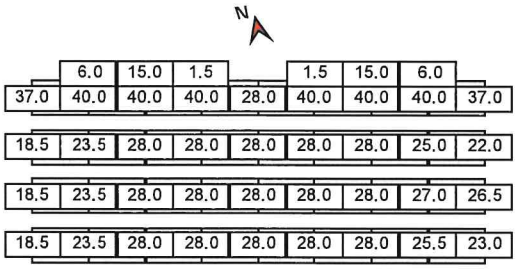
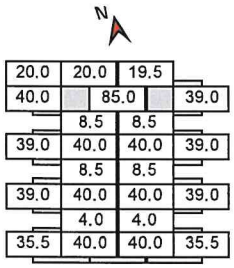

N
6.0 15.0 1.5 1.5 15.0 6.0
37.0 40.0 40.0 40.0 28.0 40.0 40.0 40.0 37.0
18.5 23.5 28.0 28.0 28.0 28.0 28.0 25.0 22.0
18.5 23.5 28.0 28.0 28.0 28.0 28.0 27.0 26.5
18.5 23.5 28.0 28.0 28.0 28.0 28.0 25.5 23.0

8


N
20.0 20.0 19.5
40.0 85.0 39.0
8.5 8.5
39.0 40.0 40.0 39.0
8.5 8.5
39.0 40.0 40.0 39.0
4.0 4.0
35.5 40.0 40.0 35.5

RESULTS

BALLAST CAPACITY

Speed Porter	40.0 kg
Porter	108.0 kg
module clamp	MiniClamp MC Set 30-50
end clamp	MiniClamp EC Set 30-50

VERIFICATION SYSTEM UTILISATION

Verification system utilisation [%]	pressure	51.35
	suction	46.84
Loads on modules (ultimate state) [Pa]	pressure	2051
	suction	-1150
Loads on modules (Serviceability) [Pa]	pressure	1378
	suction	-731

SPECIFIC LOADS

Index (module block)	No. of modules (module block)	--- ---	Ballast [kg] (module block)	Dead weight [kg] (module block)	Dead Load [kN/m²] (module block)	Dead Load [kN/m²] (roof surface area)	Own weight [kN/m²]
module array 1	40	---	1345.0	2349.0	0.23	---	---
module array 2	40	---	1120.0	2124.0	0.20	---	---
module array 3	40	---	1145.0	2149.0	0.21	---	---
module array 4	25	---	911.0	1538.5	0.24	---	---
module array 5	32	---	1203.0	2006.2	0.24	---	---
module array 6	32	---	1059.0	1862.2	0.23	---	---
module array 7	32	---	1082.0	1885.2	0.23	---	---
module array 8	12	---	732.5	1033.7	0.34	---	---
all Blocks	**253**	**---**	**8597.5**	**14947.8**	**---**	**0.07**	**---**

NOTES

- The proof of position safety and load capacity of the system are carried out by checking the load cases lifting and shifting by wind and by further static calculations. You will find a short version of the wind tunnel report and a certificate for the further static calculations on our homepage.
- The design rules comply with the Eurocode EN 1990 - Basis of structural design.
- The determination of snow loads is based on the National Annex to DIN EN 1991-1-3/NA - Snow Loads.
- The determination of wind loads is based on the National Annex to DIN EN 1991-1-4/NA - Wind Loads.
- Service life is recognised according to 'Eurocode EN 1991 – Action on structures, Snow loads' and 'Eurocode EN 1991 – Actions on structures, Wind actions'. Subject to the Building Regulations and for security-relevant reasons the installation has to be dismantled at the end of its service life.
- Failure consequence class is considered according to 'Eurocode EN 1990 – Basis of structural design'.
- Data and results must be verified with regard to local conditions and checked by a suitably qualified person. Please see our TCU under https://k2-systems.com/en/base-tcu , in particular § 2 ("technical and specialist requirements for the customer"), § 7 ("warranty provisions") and § 8 ("limitation of liability").

STRUCTURAL ANALYSIS REPORT

GENERAL INFORMATION

Name	Dalton
Mounting System	S-Dome 6.10 Xpress
Customer	Dalton
Author	Lukas Jenco

LOCATION

Address	Napájadlá, 040 12 Košice-Nad jazerom
Ground elevation	191.18 m
Roof type	Flat roof
Fastening method	with Ballast
Roof covering	Flat
Building height	5.00 m
Parapet wall height	0.30 m
Roof pitch	2 °
Min. roof edge distance	0.60 m
Material	Single ply membrane
Friction coefficient	0.50

LOADS

Design method	DIN EN		
Failure consequence class (CC)	CC2	Design working life	25 years

Peak velocity pressure	$q_{p,50}$= 0.800 kN/m²
Adjustment factor for service life	f_w = 0.901
Peak velocity pressure	$q_{p,25}$= 0.721 kN/m²

Snow load on ground level	s_k = 1.000 kN/m²
Shape Coefficient for Snow	μ_i = 0.800
Factor for roof pitch	d_i = 0.999
Snow load on roof	$s_{i,50}$ = 0.800 kN/m²
Adjustment factor for service life	f_s = 0.929
Snow load on roof	$s_{i,25}$ = 0.743 kN/m²

DEAD LOAD

Weight module	G_M = 21.0 kg	Dead weight module	= 10.92 kg/m²
Weight mounting system	= 4.1 kg	Dead weight mounting system	= 2.13 kg/m²
Module area	A_M = 1.92 m²	Total Dead Weight (excl. ballast)	= 0.13 kN/m²

LOAD COMBINATIONS

ULTIMATE LIMIT STATE

Partial safety factor unfavourable permanent load	$\gamma_{G,sup}$	1.35
Partial safety factor favourable permanent load	$\gamma_{G,inf}$	1.00
Partial safety factor destabilising permanent load	$\gamma_{G,dst}$	1.10
Partial safety factor stabilising permanent load	$\gamma_{G,stb}$	0.90
Partial safety factor first variable load	γ_Q	1.50
Partial safety factor variable loads	γ_Q	1.50
Combination coefficient with regards to wind	$\psi_{0,W}$	0.60
Combination coefficient with regards to wind (additional varying influences)	$\psi_{1,W}$	0.20
Combination coefficient with regards to Snow	$\psi_{0,S}$	0.50
Importance factor variable	$\kappa_{FI,Q}$	1.00
Characteristic dead weight	G_k	
Characteristic snow load on the roof	$S_{i,n}$	
Characteristic wind load	W_k	

Load case combination 00:	$E_d = \gamma_{G,sup} * \kappa_{FI,G} * G_k + \gamma_Q * \kappa_{FI,Q} * S_{i,n}$
Load case combination 02:	$E_d = \gamma_{G,sup} * \kappa_{FI,G} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,Pressure}$
Load case combination 03:	$E_d = \gamma_{G,sup} * \kappa_{FI,G} * G_k + \gamma_Q * \kappa_{FI,Q} * (W_{k,Pressure} + \psi_{0,S} * S_{i,n})$
Load case combination 04:	$E_d = \gamma_{G,sup} * \kappa_{FI,G} * G_k + \gamma_Q * \kappa_{FI,Q} * (S_{i,n} + \psi_{0,W} * W_{k,Pressure})$
Load case combination 06:	$E_d = \gamma_{G,inf} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,Suction}$
Uplift Verification:	$E_d = \gamma_{G,stb} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,n,Uplift}$
Displacement verification:	$E_d = \gamma_{G,stb} * G_k + \gamma_Q * \kappa_{FI,Q} * W_{k,n,Displacement}$

SERVICEABILITY LIMIT STATE

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

Load case combination 00:	$E_d = G_k$
Load case combination 01:	$E_d = G_k + S_{i,n}$
Load case combination 02:	$E_d = G_k + W_{k,Pressure}$
Load case combination 03:	$E_d = G_k + W_{k,Pressure} + \psi_{0,S} * S_{i,n}$
Load case combination 04:	$E_d = G_k + S_{i,n} + \psi_{0,W} * W_{k,Pressure}$
Load case combination 06:	$E_d = G_k + W_{k,Suction}$

THE SYSTEM HAS BEEN SUCCESSFULLY CALCULATED.

MAX. PRESSURE ON INSULATION

GENERAL INFORMATION

dead load system	g_{System} = 0.13 kN/m²
aerodynamic coefficient	$c_{p,Pressure}$ = 0.2

LOAD DISTRIBUTION ON THE BUILDING PROTECTION MAT UNDER .45 °

Dimensions	75.3 * 380.0 * 23.1 mm
A_{eff} =	28614 mm²
$A_{load\ range\ area}$ =	0.96 m²
maximum ballast	$G_{Ballast}$ = 48.1 kg

LOAD DISPERSION ON THE BUILDING PROTECTION MAT UNDER SD, 45°

Dimensions	75.3 * 380.0 * 23.1 mm
A_{eff} =	28614 mm²
$A_{load\ range\ area}$ =	0.96 m²
maximum ballast	$G_{Ballast}$ = 14.5 kg

LOAD COMBINATIONS

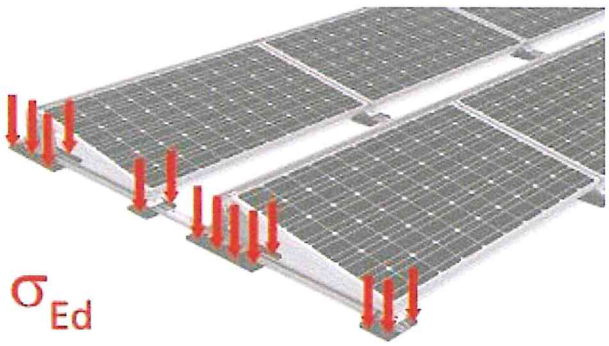
Array	Load case combination 0 0	Load case combination 0 1	Load case combination 0 2	Load case combination 0 3	Load case combination 0 4	Load case combination 0 5
$\sigma_{Ek,insulation,S6\_10}$ [Pa]	20769	45427	25613	37942	48334	---
$\sigma_{Ek,insulation,SD}$ [Pa]	9253	33911	14098	26427	36818	---

DEAD LOADS (PV SYSTEM + BALLAST)

$\sigma_{Ek,insulation,S6\_10}$	σ_{Ek} = 20769 Pa
$\sigma_{Ek,insulation,SD}$	σ_{Ek} = 9253 Pa

MAXIMUM ACTIONS (SUM OF DEAD LOADS AND THE MAXIMUM VARIABLE ACTIONS FROM WIND AND SNOW)

$\sigma_{Ek,insulation,S6\_10}$	max σ_{Ek} = 48334 Pa
$\sigma_{Ek,insulation,SD}$	max σ_{Ek} = 36818 Pa



H-V-LOADS - WIND LOADS FROM THE PV SYSTEM ONTO THE STRUCTURE

According to wind tunnel report by I.F.I. Institut für Industrieaerodynamik GmbH

GENERAL INFORMATION

Number of modules in the middle area	124
Number of modules in the edge area	129
Total number of modules	253
Roof areas covered with modules	A = ca. 685.92 m²
Dead Load	$g_{k,System\ incl.\ ballast}$ = 0.21 kN/m²

AERODYNAMIC COEFFICIENTS

$C_{p,\ Pressure}$	according to EN 1991-1-4
$C_{F,x,averaged}$	-0.02
$C_{F,y,averaged}$	0.01
edge distance correction	k_{Slxy} = 1
Parapet wall- correction coefficient	k_p = 1.07

HORIZONTAL PRESSURE

$W_{k,F,x}$ = 0.030 kN/m²

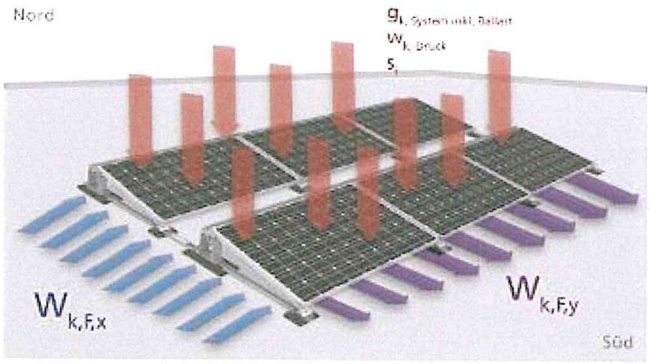
$W_{k,F,y}$ = 0.007 kN/m²

VERTICAL PRESSURE

$g_{k,System\ incl.\ ballast}$ = 0.21 kN/m²

$W_{k,Pressure}$ - according to EN 1991-1-4

s_i - according to EN 1991-1-3



Comment:
Flat roof vertical wind loads are essentially determined by its displacement effect and remain unchanged even with a flat pv structure. We advise using the aerodynamic coefficients according to DIN EN 1991-1-4 to calculate flat roofs.

TOTAL BILL OF MATERIALS (ROOF 1)

Position	Item no.	Item description	Quantity	Weight
1	2004096	S-Dome 6.10 Base Set L	289	543.3 kg
2	2004125	Dome 6.10 Peak	289	86.7 kg
3	2004123	Dome 6.10 Connector Bonding Set	225	48.6 kg
4	2003249	S-Dome 6.10 Windbreaker short	253	455.4 kg
5	1005207	Thread-forming metal screw 6.0x25	578	3.5 kg
6	2002870	K2 Solar Cable Manager	253	0.7 kg
7	2002558	MiniClamp MC Set 30-50	434	25.2 kg
8	2002559	MiniClamp EC Set 30-50	144	9.5 kg
9	2003150	Dome Porter short	2	3.0 kg
10	1001643	MK2	4	0.1 kg
11	2001729	Socket Head Bolt serrated M8x20	4	0.1 kg
12	2002300	Dome SpeedPorter	632	48.0 kg
Total				**1224.1 kg**